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DISORGANIZATION AND FINANCIAL COLLAPSE

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ABSTRACT

Disorganization and Financial Collapse*

Recently, Blanchard and Kremer (BK) argued that disorganization has led to the output decline in the former Soviet Union. In this Paper we introduce liquidity and credit constraints into the BK model and show how these problems can alleviate the hold-up problem. We argue further that barter creates a hostage, which allows disorganization to be dealt with, when credit enforcement is prohibitively costly. The theory helps to explain how the three observed phenomena of output decline, inter-firm arrears and barter in transition economies are connected. Based on a survey of 165 barter deals in the Ukraine in 1997, we reproduce the BK result with firm level and deal-specific data and show that in addition to the input shortage the financial shortage and barter have each an important effect on output growth.

JEL Classification: D20, G30, O10, P30
Keywords: transition, financial crisis, output fall, credit constraint, barter, hold-up

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NON-TECHNICAL SUMMARY

There are three dominant features which distinguish the development of the countries of the former Soviet Union from those of the early Transition Economies (TE) like Hungary, Poland and the Czech Republic. First, the decline in output has been much more pronounced in the former Soviet Union as compared to the early TE. Second, inter-firm arrears are much larger and growing much faster in the Republics of the former Soviet Union as compared to Central Europe. Third, barter trade has become an important phenomenon in the domestic economy in the former Soviet Union while being absent in Central Europe. These developments raise the question as to whether there is a connection between these three observations. More specifically, what is the relationship between the output decline and the inter-firm arrears on the one hand and inter-firm arrears and barter on the other? Has the presence of barter in the former Soviet Union and its absence in Central Europe something to do with the fact that inter-firm arrears are much larger and output declined much more sharply in the former Soviet Union?

In this Paper we explore these questions based on a model which combines two arguments given in the transition literature for the output decline in transition economies. In a recent paper Blanchard and Kremer (BK) (1997) argue that the large decline in output in the former Soviet Union has been caused by 'disorganization' and hold-up problems. Disorganization arises when old relationships break down before new ones can be established. In such a 'no future' environment a typical mechanism to constrain opportunistic behaviour does not work. Specificity in the relations between firms together with incompleteness of contracts results in disorganization in which intermediate producers in a chain of production refuse to deliver inputs which in turn leads to the collapse of output.

Calvo and Coricelli (1995) in turn have argued that the output losses in the early TE have been caused by a lack of credit. They suggest that inter-firm arrears in the early TE have been a response to the liquidity squeeze in the economy. Due to the lack of bank credit, firms turn to trade credit from other firms to alleviate the financial squeeze.

In this Paper, we combine the input shortage explanation of BK with the financial shortage explanation of Calvo and Coricelli to show that when both problems are present one can help with the other rather than making things worse. More specifically, we introduce liquidity and credit constraints into the BK model and show how the credit constraint can alleviate the hold-up problem. The fact that the input seller has to make sure to get paid when the input purchaser is short of cash to pay for these inputs gives the input purchaser bargaining power. This bargaining power in turn reduces the

possibility that the input supplier can exploit the input purchaser's need for the input. Our result that the lack of cash can alleviate the hold-up problem stands in contrast to BK's model who, if at all, see a positive role of cash as a commitment device to solve the coordination problem of firms.

We argue further that barter (a payment in goods rather than money) can help to relax the credit constraint and by doing so it provides a mechanism to deal with disorganization when a firm's creditworthiness problem is severe. Barter trade is an inter-firm credit, which is repaid in goods rather than money. Because goods are less anonymous than money, a claim on goods is easier to enforce than a claim on cash. Barter can be used to collateralize a trade credit when firms' creditworthiness problem is severe and thus allows them to finance business activities which otherwise would not take place. Through this credit channel barter helps to smoothe the output decline and thus prevents output from falling even further.

The Paper establishes a link between the output decline, inter-firm arrears, and barter in the former Soviet Union. Inter-firm arrears are seen to be more pronounced in the former Soviet Union as compared to the early TE because firms can use arrears to avoid the problems associated with complexity and specificity. The fact that input suppliers have to worry about being paid when they extend trade credits to their buyers means that they cannot exploit their buyers' dependence on these inputs. This way, the presence of arrears helps to avoid the output to collapse even more than it actually has.

However, very large arrears become counterproductive for maintaining production because credit enforcement becomes very costly and thus input suppliers will refuse to extend credit to their buyers. Under these circumstances, barter trade is the only way to maintain production. The collateral function of barter explains why firms are able to give loans to each other when the banking sector is reluctant to provide capital.

Furthermore, the model is able to explain the pattern of arrears and barter over time in Russia. The arrears crisis started between 1992 and 1993 in Russia, reaching almost 10% of GDP while barter started to rise in 1994. The theory predicts barter to exist when arrears reach a critical level at which credit enforcement becomes so costly that only barter can maintain production. Our data suggest that arrears reached this critical level at around 30–40% of firms' sales. Thus, we argue that the explosive increase of barter in Russia since 1994 (from 5% of sales in 1993 to around 60% of sales in 1998) has been triggered by a level of arrears at which production was unsustainable.

Thus, the model provides an explanation for why barter is present in the former Soviet Union while being absent in the early TE. Disorganization and

specificity have posed a more severe problem for more insulated economies like the former Soviet Union, while in open economies like Central Europe, entry of foreign firms alleviated the problems of small numbers. In the former Soviet Union mechanisms other than international trade and foreign direct investment must have been at work to limit the adverse effect of specificity. The Paper argues that inter-firm arrears and barter can be seen as such mechanisms of smoothing the transition from the ‘old’ to the ‘new’ regime. Barter is observed in the former Soviet Union while being absent in Central Europe because disorganization and the output decline are more severe in the former than the latter region.

1 Introduction

There are three dominant features which distinguish the development of the countries of the former Soviet Union from those of the early Transition Economies (TE) like Hungary, Poland, and the Czech Republic.

1. The decline in output has been much more pronounced in the former Soviet Union as compared to the early TE. In Russia, Belarus, and Ukraine, GDP for 1997 is estimated to stand at roughly half of its 1989 level.[1]

2. Inter-firm arrears are much larger and growing much faster in the Republics of the former Soviet Union as compared to the early TE (Rostowski, 1993).

3. Barter trade has become an important phenomenon in the domestic economy in Russia, Ukraine, Kasachstan, and Romania, while being absent in Central Europe. According to a recent survey in Russia, barter accounts for 60 percent of the economic activity in 1998. Our survey in the Ukraine gives an estimate of barter of 51 percent of total industrial sales in 1997.[2]

These developments raise the question whether there is a connection between these three observations. More specifically, what is the relationship between the output decline and the inter-firm arrears on the one hand and inter-firm arrears and barter on the other? Has the presence of barter in the former Soviet Union and its absence in Central Europe something to do with the fact that inter-firm arrears are much larger and output declined much more sharply in the former Soviet Union?

In this paper we explore these questions based on a model which combines two arguments given in the transition literature for the output decline in transition economies. In a recent paper Blanchard and Kremer (BK) (1997) argue that the large decline in output in the former Soviet Union has been caused by "disorganization" and hold-up problems. Disorganization arises when old relationships break down before new ones can be established. In such a "no future" environment a typical mechanism to constrain

[1] See Transition Report 1998, Table 3.1, p. 50.

[2] See Commander and Mummsen (1998) for Russia and Marin, Kaufmann and Gorochowskiy (1998) for the Ukraine.

opportunistic behavior such as reputation does not work. Specificity in the relations between firms together with incompleteness of contracts results in disorganization in which intermediate producers in a chain of production refuse to deliver inputs which in turn leads to the collapse of output.[3]

Calvo and Coricelli (1995a,b) in turn have argued that the output losses in the early Transition Economies like Hungary, Poland, and the Czech Republic have been caused by a lack of credit. They suggest that inter-firm arrears in the early Transition Economies have been a response to the liquidity squeeze in the economy. Due to the lack of bank credits firms turn to trade credits from other firms to alleviate the financial squeeze.

In this paper, we combine the input shortage explanation of BK with the financial shortage explanation of Calvo and Coricelli to show that when both problems are present one can help with the other, rather than making things worse. More specifically, we introduce liquidity and credit constraints into the BK model and show how the credit constraint can alleviate the hold-up problem. The fact that the input seller has to make sure to get paid when the input purchaser is short of cash to pay for these inputs gives the input purchaser bargaining power. This bargaining power in turn reduces the possibility that the input supplier can exploit the input purchaser's need for the input. Our result that the lack of cash can alleviate the hold-up problem stands in contrast to BK's model who, if at all, see a positive role of cash as a commitment device to solve the coordination problem of firms.

We argue further that barter - a payment in goods rather than money - can help to relax the credit constraint and by doing so it provides a mechanism to deal with disorganization when firms' creditworthiness problem is severe. This argument draws on ideas presented in earlier work on international countertrade by Marin and Schnitzer (1995,1997), in which we show that international barter can be seen as an efficient institution to solve moral hazard problems which arise in the technology transfer to developing countries and in international trade which highly indebted countries. The contribution of the present paper is to point to the potential importance of the institution of barter in the context of transition. Barter trade is an inter-firm credit which is repaid in goods rather than money. Because goods are less anonymous than money, a claim on goods is easier to

[3]A similar argument is made by Roland and Verdier (1997). In their model, output may fall because of market imperfections due to search frictions and Williamsonian relationship specific investments.

enforce than a claim on cash. Thus, barter can be used to collateralize a trade credit when firms' creditworthiness problem is severe and allows to finance business activities which otherwise would not take place. Through this credit channel barter helps to smoothen the output decline and thus prevents output from falling even further.

Our theory helps to explain how the three observed phenomena of output decline, inter-firm arrears and barter, are connected. Based on a survey of 165 barter deals among firms in the Ukraine in 1997, we empirically reproduce the BK result with firm level data and we show that in addition to the input shortage the financial shortage and barter have each an important effect on output growth. Furthermore, we show with deal-specific data how disorganization and the financial shortage affect the terms of trade in barter deals.

The paper is organized as follows. In section 2 we develop a chain of production model with credit constraints along the lines of BK (1997) and derive the conditions under which the credit constraint prevents the output from declining in the presence of the hold-up problem. In section 3, we show that barter helps to maintain production when the credit problem becomes so severe that the input supplier refuses to deliver the input. In sections 4 and 5 we test the predictions of the model with firm and deal specific data of 165 barter deals which we have collected in the Ukraine in 1997. Section 6 concludes.

2 A chain of production with liquidity constraints

Consider a good which requires n steps of production. Each production step is carried out by a different firm. One unit of the input good gives, after n steps of production, one unit of the final good. Each buyer along the chain can negotiate only with his supplier. This leads to n bargaining problems along the chain. We assume Nash bargaining at each step with both parties equally sharing the joint surplus, whenever possible. The value of the final good is denoted by $v > 0$. Intermediate goods j produced at production step $j = 1, ..., n-1$ have a value of $v_j \leq v$ if sold as input good for the next production step but they have a value of zero if sold to someone outside the production chain. Within the production chain, the value of intermediate good j, v_j, is determined by the payment its producer B_j receives when selling it to the next producer along the chain of production, B_{j+1}.

Bargaining at each production step

We now look at the production steps in more detail. Consider the parties involved in the first step of production, the supplier of the original input good, S_1, and the buyer, B_1. We assume that B_1 needs to make a relationship specific investment i at date 0.9. This investment could be thought of as the time and money B_1 spends in order to find an adequate supplier and establish a business relationship. Alternatively we could think of this investment as an investment in B_1's machines such that they can operate with S_1's input goods. The problem is that at the time of this investment, the two firms cannot write a contract which commits S_1 to deliver the input good for a particular price in the future. This leads to a hold up problem in the bargaining of the price when the input good is actually delivered.

At date 1, the two parties can negotiate about the delivery of S_1's input good and about the price. To save on notation we normalize S_1's opportunity cost of delivering the input to zero and we assume that S_1 delivers the input only if he expects a strictly positive surplus from the transaction. As specified above, v_1 denotes the value of the input good to B_1. This value is determined by the future bargainings and solved recursively below.

We assume that B_1 cannot pay cash at the time of delivery because he is liquidity constrained. This assumption reflects a common problem in transition economies. In many countries of the former Soviet Union the liquidity squeeze has led to the phenomenon of inter-firm arrears which accounts for more than 20 percent of GDP in Russia in 1997 (see for example Transition Report 1997, p.26). Thus, S_1 has to deliver the input good on a credit basis, if at all. B_1 will be able to pay when he is paid v_1 by the next buyer in the second production step. But of course, enforcing credit repayment in transition economies is notoriously difficult. We capture this notion by assuming that S_1 has to incur some (arbitrarily high) cost $x(p)$ to enforce repayment of p. This cost could be thought of as the cost of using the legal system, including lawyer fees and potentially bribes for judges or public authorities or the cost of private enforcement, including the use of Mafia etc. These costs are higher the less developed the legal system and the more indebted B_1. In general, $x(p_1)$ will be a non-decreasing function of p_1, including some fixed cost. Our point is made most simply, without loss of any insights, if we restrict attention to fixed

enforcement cost $x(p_1) \equiv x$.[4]

If S_1 has decided to deliver the input good at date 1, B_1 can try to exploit the fact that credit enforcement is costly and renegotiate p_1 at date 1.1. Let $\tilde{p}_1$ denote the renegotiation price fixed by S_1 and B_1 at this date. Figure 2 summarizes the time sequence of the bargaining at production step 1.

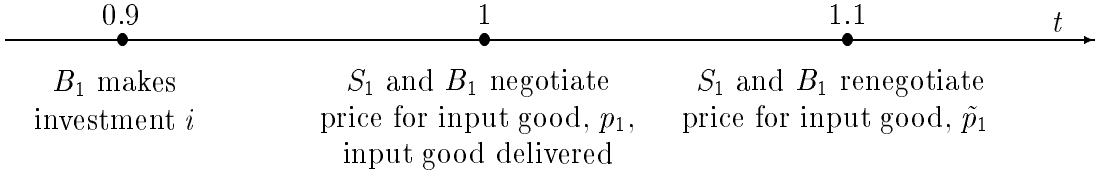

Figure 2: Bargaining at production step 1

This first production step is repeated at steps 2 to n, with good 1 being used as an input good sold by B_1 (now called S_2) to B_2, and so on. Note that buyers B_2 up to B_n may have to undertake a similar relationship specific investment i_j, $j = 2, ..., n$, and may be similarly credit constrained as B_1. For notational convenience we restrict attention to investment levels i_j, $j = 2, ..., n$, such that $i_j \leq i$ for all subsequent buyers. Similarly, the enforcement costs x are the same in all production steps (see Footnote 6 above).

When production is finished after n steps and the value of the final good is realized, B_n can use the revenues from selling this good to pay $\tilde{p}_{n-1}$, the price renegotiated after delivery of the intermediate good $n-1$. Similarly, when S_n is paid, he can use his revenues for paying S_{n-1} and so on. We assume that the maximum payment that can be enforced at each production step j is equal to the revenues v_j generated from selling the good to the next production step.[5]

The credit problem and price renegotiation

[4] This allows us to solve the bargaining problem in each step of the production by simple analogy. It is straightforward to extend our analysis to enforcement costs that are increasing in the payment to be enforced. In this case, the problem of creditworthiness becomes more severe at later production steps which makes it more difficult to guarantee S_1's participation in the deal earlier on.

[5] B_j might be involved in other production chains with revenues v'_j. But we assume that S_j has no knowledge about B_j's revenues outside this particular production chain and thus cannot use those revenues to enforce payment. Note, however, that this is without loss of generality. Allowing for higher enforceable payments leads only to level effects but does not affect the qualitative results of our model, as long as the maximum enforceable payment is finite.

Let us now solve production step 1 recursively, taking as given the value of the good to be produced at this step, v_1. At date 1.1, when S_1 has delivered the input good, the bargaining power shifts from S_1 to B_1. B_1 can try to take advantage of the fact that S_1's has to incur enforcement costs if he wants to enforce payment of p_1. B_1 can renegotiate his payment for the input good by offering to pay $\tilde{p}_1 = p_1 - x$ instead of p_1. S_1 can either accept or enforce p_1 at cost x. In equilibrium he will accept B_1's offer.[6]

At date 1, the two parties have to agree on a price p_1. Since B_1's investment i is already sunk at this date, this investment is not taken into account in the bargaining. This is what constitutes the hold-up problem of buyer B_1. However, the two parties anticipate the price renegotiation that takes place at date 1.1 when bargaining at date 1. Recall that we have assumed Nash bargaining whenever possible. This implies that a price p_1 is chosen such that

$$v_1 - (p_1 - x) = p_1 - x \iff p_1 = \frac{v_1}{2} + x \tag{1}$$

i.e., in anticipating B_1's future price renegotiation, S_1 marks up p_1 in the first place, if this is possible.

However, as we have argued above, this is not always possible. The problem is that the maximum payment that can be enforced at cost x is bounded above by the total value of what B_1 will be paid himself by the second buyer, i.e. v_1. Thus,

$$p_1 = \min[\frac{v_1}{2} + x; v_1] \tag{2}$$

Only if enforcement costs are low, i.e. $x < v_1/2$, will S_1 be able to pass on x in the price mark-up. In this case, the fact that B_1 is liquidity constrained does not prevent S_1's and B_1's equally sharing the surplus, v_1. If x is larger, i.e. $x > v_1/2$, then this is no longer possible. In this case, B_1 can exploit the fact that he is liquidity constrained to capture more than half of the surplus. If the enforcement cost excede the total value of the transaction, i.e. $x \geq v_1$, then B_1 captures the entire surplus and S_1 cannot guarantee himself a positive payoff. The following payoff functions summarize these three cases. If S_1 delivers the input good, then for a given v_1, the payoff of B_1 is

$$\Pi_B^1 = \begin{cases} \frac{v_1}{2} - i & \text{if} \quad x \leq \frac{v_1}{2} \\ x - i \geq \frac{v_1}{2} - i & \text{if} \quad \frac{v_1}{2} \leq x \leq v_1 \\ v_1 - i & \text{if} \quad x > v_1 \end{cases} \tag{3}$$

[6]Note that we assume here that B_1 can make a take-it-or-leave-it offer for price $\tilde{p}_1$. It is straightforward to carry out the modified analysis with Nash bargaining instead of a take-it-or-leave-it offer at this point.

Similarly, the payoff of S_1 is given by

$$\Pi_S^1 = \begin{cases} \frac{v_1}{2} & \text{if} \quad x < \frac{v_1}{2} \\ v_1 - x < \frac{v_1}{2} & \text{if} \quad \frac{v_1}{2} \leq x \leq v_1 \\ 0 & \text{if} \quad x > v_1 \end{cases} \tag{4}$$

Thus, B_1's liquidity constraint gives him some bargaining advantage because credit enforcement is not costless to S_1 and the maximum payment that can be enforced is finite. If credit enforcement is a sufficiently severe problem, B_1 can use his bargaining power to shift the surplus in his favor. Otherwise, the bargaining is either not affected by the presence of enforcement costs (when x is low) or S_1 refuses to participate in the deal (when x is very large).

So far we have taken the value of the first production step, v_1, as given. We still have to determine how v_1 is affected by the value of the final product, v, by the number of production stepts, n, and by the fact that all buyers are liquidity constrained and that credit enforcement is costly. For this purpose, we have to solve the game recursively. The following Lemma characterizes v_1 as a function of v, n and x.

Lemma 1 *The value of production at step 1 is*

$$\begin{aligned} v_1(x,n,v) &= \tfrac{v}{2^{n-1}} \quad \textit{if} \quad x < \tfrac{v}{2^{n-1}} \\ v_1(x,n,v) &< \tfrac{v}{2^{n-1}} \quad \textit{if} \quad x \geq \tfrac{v}{2^{n-1}} \end{aligned} \tag{5}$$

Proof: See Appendix

The important thing to note here is that if x is small enough it does not affect the value of production at step 1. The reason is that in all subsequent production steps x can be fully covered by a price mark-up and hence does not affect the equal sharing of the surplus.

Disorganization, financial constraint and output fall

We can now state the conditions under which production takes place at the first and all subsequent production steps. S_1 agrees to deliver the input good at date 1 on a credit basis if and only if $\Pi_S^1 > 0$. This is the case if and only if

$$\frac{v}{2^{n-1}} > x \ , \tag{6}$$

because in this case $v_1 = v/2^{n-1}$ by Lemma 1 and $x < v_1$, so that $\Pi_S^1 = v_1 - x > 0$ (see equation (4)). If $x \geq v/2^{n-1}$ instead, then $v_1 < v/2^{n-1}$ and hence $x > v_1$, so that $\Pi_S^1 = 0$ (see equation (4)).

At date 0, B_1 is willing to engage in the up-front investment i if and only if (6) is satisfied and in addition

$$i \leq \max[x; \frac{v}{2^n}] \tag{7}$$

Note that B_1's payoff is $v/2^n - i$ if $x < v/2^n$, following from Lemma 1 and equation (3), and it is $x - i$ if $v/2^n < x < v/2^{n-1}$.

The following proposition states under which conditions production will take place in the presence of both the hold-up problem and the credit problem.

Proposition 1 *(i) Suppose there exists a hold-up problem, but no credit problem, i.e. $i > 0$ and $x = 0$. Then production takes place if and only if*

$$\frac{v}{2^n} > i \tag{8}$$

(ii) Suppose there exists a credit problem but no hold-up problem, i.e. $i = 0$ and $x > 0$. Then production takes place if and only if

$$\frac{v}{2^{n-1}} > x \tag{9}$$

(iii) Suppose there exist both a hold-up problem and a credit problem, i.e. $i > 0$ and $x > 0$.

- *If $x \leq \frac{v}{2^n}$ then production takes place if and only if*

$$\frac{v}{2^n} \geq i \tag{10}$$

– *If* $\frac{v}{2^n} < x < \frac{v}{2^{n-1}}$ *then production takes place if and only if*

$$x \geq i \tag{11}$$

– *If* $\frac{v}{2^{n-1}} < x$ *then no production takes place.*

Proof: See Appendix

The first part of this proposition restates the BK result. The larger the number of production steps, the smaller the value of production at step 1 and thus the more severe the hold-up problem. The second part of the proposition shows that even in the absence of a hold-up problem the number of production steps may have an adverse effect on production due to the credit problem. Again, as the value of the surplus decreases when production becomes more complex the presence of enforcement costs make it less and less attractive for S_1 to grant a credit to B_1.

The last part of the proposition is particularly interesting. It shows that the presence of a credit constraint can alleviate B_1's hold-up problem. This is the case if and only if

$$\frac{v}{2^n} < i \leq x < \frac{v}{2^{n-1}} \tag{12}$$

Without a liquidity constraint and enforcement costs, B_1's payoff would be $v/2^n$, i.e. half the value of production at the first production step, and if $i > v/2^n$ then no production would take place at all. However, if enforcement costs are sufficiently high, B_1 can exploit this fact to capture more than one half of the production value. B_1's ex-post bargaining power has to be sufficiently large to cover his ex-ante investment; i.e. $i \leq x$ in order for production to take place. Since S_1 needs a positive payoff, enforcement costs may not be too high, either; i.e. $x < v/2^{n-1}$. Thus, production takes place if $i \leq x < v/2^{n-1}$.

3 Creating a hostage

As we have seen, S_1 may not be willing to deliver the input good if the credit problem is too severe, i.e. if $x \geq v/2^{n-1}$. Thus, if the buyer has no cash and the legal system to enforce payment is poorly developed a potentially valuable transaction does not take place. In this section we investigate to what extent barter can help under these circumstances. We

will show that barter can be used as a hostage, i.e. as a commitment device that prevents the buyer from fully exploiting his bargaining power due to the enforcement cost. In this sense barter creates a dealspecific collateral that helps to alleviate the hold-up problem when credit enforcement is prohibitively costly.

Suppose B_1 can produce one unit of a barter good, but only after date 1.[7] Let w denote the value of the barter good and let k denote B_1's production cost. If B_1 sells this barter good to someone outside the production chain he does so at a cash price $p_B^C = \frac{w+k}{2}$, assuming again Nash bargaining. This would give B_1 a payoff of $(w-k)/2$. However, B_1 can also use this barter good as a hostage to improve his creditworthiness. In this case, B_1 promises to deliver the barter good to S_1 when credit repayment is due. The price for this barter good, p_B, is fixed together with p_1 before S_1 decides about his input delivery.

Of course, given that the two parties engage in Nash bargaining whenever possible they negotiate prices p_1 and p_B such that they split the surplus of both transactions equally, taking into account the renegotiation on p_1 at date 1.1. This means that p_1 and p_B have to be fixed such that

$$(p_1 - x) + w - p_B = v_1 - (p_1 - x) + p_B - k \tag{13}$$

where the left hand side represents S_1's payoff and the right hand side B_1's payoff from carrying out both transactions. Solving this equation for p_1 leads to

$$p_1 = \frac{v_1}{2} + x - \left(\frac{w+k}{2} - p_B\right) = \frac{v_1}{2} + x - (p_B^C - p_B) \ , \tag{14}$$

where $p_B^C = \frac{w+k}{2}$ is the price for the barter good in a cash transaction, as argued above. Recall that the price p_1 that can be enforced is bounded above by v_1. Thus, for $x > v_1/2$, i.e. when enforcement cost prevent an equal split of the surplus in the input trade, an increase in x must be compensated by a reduction in $(w+k)/2 - p_B$ to induce the Nash bargaining solution. What this effectively means is that the inclusion of the barter trade allows B_1 to shift some of the profit back to S_1 by discounting the price of the barter good p_B by an amount of $p_B^C - p_B$.

Note, however, that p_B cannot be chosen arbitrarily small because B_1 cannot be forced to deliver the barter good as promised, but has to be induced to do so voluntarily.

[7] If B_1 could deliver the barter good right away he would not be liquidity constrained because he could use the barter good as payment in kind.

If B_1 cheats on S_1 and refuses to deliver, all S_1 can do, given that B_1 has signed a contract that promises delivery of the barter good, is to try to prevent a sale of the barter good to someone else. We assume that S_1 succeeds with such an attempt with probability $(1-\pi)$ which reduces B_1's potential payoff from selling the barter good to $\pi\frac{w-k}{2}$, where $\pi \leq 1$. This implies that B_1 voluntarily delivers the barter good if and only if

$$p_B - k \geq \pi\frac{w-k}{2} \tag{15}$$

i.e. his payoff from delivering the barter good to S_1 must be at least as high as his payoff from trying to sell it to someone else. Rearranging this expression leads to

$$\left(\frac{w+k}{2} - p_B\right) \leq (1-\pi)\frac{w-k}{2} \equiv z \ , \tag{16}$$

i.e., B_1 will discount the price for the barter good by an amount which equals at most what S_1 can take away from him due to the fact that B_1 has signed the barter contract. Using (16) in (14) we see that this constraint puts a lower bound on the mark-up for price p_1, if the surplus is to be split equally, i.e.

$$p_1 \geq \frac{v_1}{2} + x - z \ . \tag{17}$$

We can interprete z as the commitment value or hostage created by the barter contract. The larger this value z, the less the credit enforcement cost negatively affects S_1's willingness to participate in this input deal.

Considering now B_1's decision at date 0, under what conditions will he be willing to make investment i in the relationship with S_1? Note that the alternative to investing i and carry out both the production of good 1 and the barter good is to produce only the barter good and sell it for price $p_B^C = (w+k)/2$. This implies B_1 will undertake the investment if and only if the prices p_B and p_1 chosen at date 1 are such that

$$v_1 - (p_1 - x) + p_B - k - i \geq \frac{w+k}{2} - k \tag{18}$$

The following proposition characterizes how barter affects the production decision.

Proposition 2 *Suppose there exists a hold-up problem and a credit problem. Suppose further that S_1 and B_1 can use barter to create a hostage of a given size z, where $z \equiv \frac{w-k}{2}(1-\pi)$.*

- *If $x - z \leq \frac{v}{2^n}$ then production takes place if and only if*

$$\frac{v}{2^n} \geq i \tag{19}$$

- *If $\frac{v}{2^n} < x - z < \frac{v}{2^{n-1}}$ then production takes place if and only if*

$$x - z \geq i \tag{20}$$

- *If $\frac{v}{2^{n-1}} < x - z$ then no production takes place.*

Proof: See Appendix.

Note first that the size of the hostage z created by barter depends on two things. First, it depends on the value of the good offered as a means of payment in barter. When sold on the market outside of barter, this value is $(w-k)/2$ for the buyer (always assuming Nash bargaining). Second, the size of z depends on B_1's payoff when signing the barter contract and defaulting on payment which is expressed by $\pi(w-k)/2$. The difference between these two payoffs is determined by the parameter π and captures the commitment value which B_1 achieves by agreeing to repay the trade credit with goods rather than cash. By doing so B_1 reduces his chances to sell the barter good to someone else than S_1. $(1-\pi)$ is the probability of being caught when B_1 cheats on repayment and sells the barter good to someone else than S_1. The parameter π can be thought of as a measure of how well the input seller can label the barter good as belonging to him. The smaller π, the less "anonymous" the barter good and the smaller B_1's cheating surplus from defaulting on payment. Thus, the smaller π, the larger the commitment value of barter and the larger the hostage z.[8] B_1 uses the barter contract as a commitment to give

[8] See Marin and Schnitzer (1997) who discuss the property of anonymity of the barter good in the context of a theory of money. Note that the mechanism by which a hostage is created here differs from the one described in Marin and Schnitzer (1995). Here a hostage to control the credit enforcement problem is created when the buyer agrees to repay the loan in goods rather than money. There a hostage to control the technology transfer problem is created when the technology buyer in the developing country has not enough cash in his pocket and thus is unable to produce the good when the seller in the industrial country offers inferior technology.

S_1 more than half of the value of the barter transaction, as a compensation for the fact that S_1's payoff in the input transaction is too low due to credit enforcement cost. As a consequence, barter reduces the creditworthiness problem caused by the enforcement costs x. This is reflected in the proposition by a shift of the parameter range for which the input transaction takes place. The benchmark is no longer x but $x - z$.

4 Evidence on output decline from firm level data

In this section we explore the predictions from our model with data of 165 barter deals in the Ukraine in 1997.

The Appendix shows summary statistics of the variables used. We interviewed 55 firms to obtain information on 165 barter deals. Each firm provided us with 3 barter deals. Each barter deal involved 2 firms, the seller and the buyer. Many of the firms were well informed about the financial and economic conditions of the firms they traded with because they served as financiers. This is why we could obtain data on more than the 55 interviewed firms. Thus, depending on the variable, the firm information in our sample varies between 69 and 160 observations.

Our model implies, similar to BK that firms with more complex production will experience a more pronounced output loss. This can be seen by considering conditions (8), (10) and (11). The model implies further that the output decline will be less pronounced for firms short of cash. If firms are short of cash, they can use the credit constraint in the bargaining to prevent to be held up by the input supplier. However, if the financial constraint becomes too large it may be too costly for the supplier to enforce payment and thus he may not be willing to deliver the input good. The condition for the credit problem to alleviate the hold-problem given in equation (12) states that credit enforcement costs have to be just right. They have to be sufficiently high to give the input purchaser sufficient bargaining power to allow him to cover his ex-ante investment, but they may not be too high, otherwise the input supplier will refuse to participate in the deal. Thus, we expect an inversely U-shaped relationship between financial constraints and output growth.

The model implies also that the financial constraint should be less binding for bar-

tering firms. Again, we expect an inversely U-shaped relationship between barter and output. If the financial constraint is too severe for the input supplier to participate in the deal, barter contributes to maintaining production by relaxing this constraint. However, when the barter exposure becomes large it might reduce the credit problem by so much that the input purchaser fails to be effective in capturing some of the rents from the input supplier and thus may not prevent the input purchaser from being held up.[9]

In Table 1 we take a first look at the relationship between the output growth of the firm, the liquidity squeeze and barter. We ask the question whether firms with large firm arrears, total arrears and with a big exposure to barter did relatively better in terms of output growth as compared to the economy as a whole. We take arrears as evidence that the firm faced a liquidity constraint and therefore turned to other firms for credit.[10]

Insert Table 1 here

We measure the relative growth performance of the firm by the mean percentage deviation of the output growth of the firm between 1994 and 1996 relative to GDP growth in the Ukraine in the same period. The table shows that the firms of our sample experienced the same growth rate as GDP of the Ukraine economy. However, firms with total arrears of more than 25 percent of output did substantially better in terms of output than firms with total arrears of less than 25 percent. When total arrears are decomposed into tax, wage and firm arrears, a slightly different picture emerges for wage and firm arrears. When wage and firm arrears become very large (over 9 percent and over 50 percent of output, respectively) then the firm's output performance becomes worse than that of the economy as a whole.

A similar picture emerges for the firm's barter exposure. Firms with a barter share of output over 70 percent did less well and those with a barter share of over 30 percent performed better compared to the economy as a whole. The data seem to confirm the

[9]Note that this empirical prediction also holds if barter does not involve a credit relationship but if the goods used as payment are available right away.

[10]Marin, Kaufmann and Gorochowskij (1998) provide evidence that arrears can indeed be taken as a measure for the credit constraint. They show that inter-enterprise credit is negatively associated with bank credit for private firms. They infer from this negative association between these two types of credit that inter-firm credit cushioned the liquidity contraction induced by lower bank credit.

inversely U-shaped behavior between output growth on the one hand and firm arrears and barter on the other.

In order to explore this relationship in more detail we regressed the relative output growth of the firm on BK's index of complexity, total arrears, and the barter share of the firm. The results are reported in Table 2. Column 1 reports the result of a regression that includes only BK's index of complexity. BK use the complexity variable as a measure for the severity of the hold-up problem. Complexity is an index that takes the value of zero if the sector uses only one input and approaches one when the sector uses several inputs from other sectors. We matched the ISIC sector of our bartering firms with the sector of the complexity index given by BK. The measure of complexity is constructed on the basis of the 1990 "100-sector" input-output table for Russia. We use this variable for the Ukraine, since both economies have very similar input-ouput structures. The ISIC classification of our sample could not always be perfectly matched with BK's classification of the index which might have introduced some noise into the complexity measure.

Insert Table 2 here

The variable is negative and highly significant, which confirms BK's results.[11] However, as equations (8) and (9) of Proposition 1 show, the degree of complexity (the number of production steps n) worsens both the hold-up problem as well as the credit problem. Thus, the estimated effect of complexity on output growth might be due to the fact that firms are short of cash and face a credit constraint rather than due to the fact that they have no trust in their business partners. In order to distinguish between the two problems we introduce total arrears of the firm into the equation as a proxy for the firm's credit constraint (column 2-6).[12] Arrears can be seen as a proxy for the credit enforcement costs x which increase with the firm's indebtedness. As expected, the arrears variable has a positive sign and is highly significant. The positive sign suggests that indeed the credit constraint enables the firm to deal with specificity.

[11]Note that Konings and Walsh (1998) instead find that disorganization did not constrain employment and productivity growth in newly established private firms in the Ukraine.

[12]See also Ickes and Ryterman (1993).

Next, we include the firms' barter share into the equation (column 4). The variable turns out to have a negative and significant effect on output growth. We also include a quadratic term of the barter share into the equation to capture the inversely U-shaped relationship between output growth and barter which is significant and positive.

In order to look at the inversely U-shaped relationship between arrears and barter on the one hand and output growth on the other in more detail, we divided the data into the following subsamples: high barter firms with a barter share of over 70 percent, low barter firms with a barter share of less than 30 percent, and high debt firms with total arrears of more than 40 percent of output. We also look at those firms in the sample which performed better than the economy as a whole. Consider first the results for the two barter subsamples which are given in columns 7 to 14 of Table 2. The regressions indeed give a positive effect of barter on output growth for low barter firms and a negative one for high barter firms. It is interesting to note that for the sample of low barter firms the inclusion of the arrears variable in the equation reduces the estimated effect of complexity on output substantially and the effect becomes insignificant at conventional levels. Apparently, for these firms the complexity variable seems to be capturing more of a financial shortage than that of an input shortage.

Consider next the results for the sample of high arrears firms given in columns 15 to 18. For highly indebted firms arrears do not appear to play a role for output growth. These firms appear to have too large credit enforcement costs to make it worthwhile for the input supplier to participate in the deal. Moreover, these firms seem to be so little creditworthy that even barter cannot help them to maintain production by getting trade credits from other firms.

The results for the sample of high growth firms are given in columns 19 to 22. It appears that these firms showed a favorable growth performance because they used their credit constraint and barter activity effectively to avoid an input and financial shortage.

Finally, we include the share of bank debt in percent of the firm's output in the output growth regressions given in columns 6, 10, 14, 18, and 22 of Table 2. This is an alternative way to capture whether or not firms faced a credit contraction problem. The positive and significant coefficient of the share of bank debt supports Calvo and Coricelli's view that credit contraction and the associated liquidity shortage have caused the output

decline in Eastern Europe.[13]

5 Evidence on Specificity and Credit Constraints with Deal-Specific Data

In this section we turn to the deal specific predictions of our model which we would like to test. We need to evaluate how the hold-up problem and the credit constraint specified in the previous sections are reflected in the terms of the barter contract. We have argued above that the hold-up problem can be alleviated if the input buyer faces a credit constraint and that barter is used if credit enforcement becomes too costly for the seller. Thus, we expect these problems to be reflected in the prices chosen in barter contracts as compared to the prices in cash deals where no such problems are present.

Recall from equation (2) that the price chosen for the input good in barter is equal to

$$p_1 = \min[\frac{v_1}{2} + x; v_1] \ . \tag{21}$$

Compare this price with the usual cash price for the input good with no such problems. In this case the investment costs i can be contracted on before investment takes place, and the buyer has no liquidity constraint and thus cannot use it to renegotiate the input price. Splitting of the surplus implies a cash price p_1^C

$$p_1^C - i = v_1 - p_1^C \quad \leftrightarrow \quad p_1^C = \frac{v_1 - i}{2} \ . \tag{22}$$

Thus, $p_1^C = \frac{v_1 - i}{2} < \min[\frac{v_1}{2} + x; v_1] = p_1$ because the cash price reflects the investment cost i and does not include a mark-up for the credit enforcement cost x. Similarly, if p_1 cannot be increased anymore because it reaches its upper bound v_1, then we expect a discount on p_B as compared to the cash price p_B^C, as specified in equation (14) given below

$$p_1 = \frac{v_1}{2} + x - \left(\frac{w+k}{2} - p_B\right) = \frac{v_1}{2} + x - (p_B^C - p_B) \ . \tag{23}$$

[13] Calvo and Coricelli run a similar regression between output and credit for Poland. They get a point estimate between 0.2 and 0.6 depending on specification which suggests that a 10 percent contraction of credit results in an output decline between 2 and 6 percent. Note further that BK report evidence based on a survey among 500 firms in Russia which suggests that the financial constraint was the most important shortage experienced by enterprises (see their Table IV). Between 1993 and 1995 over 60 percent of the firms experienced a shortage of financial resources compared with only over 20 percent of the firms experiencing shortages of material.

Thus, we expect that the hold-up problem and the credit problem both shift the terms of trade of the barter contract in favor of the input supplier, either by an increase of p_1 as compared to p_1^C or by a decrease of p_B as compared to p_B^C or both.

Our model predicts further that the price discount on the barter good will be larger the larger the hostage z, i.e. the smaller π and the larger $(w-k)/2$, as can be seen in equations (15) and (16). Thus, the more specific (the smaller π) and the more liquid (the larger $(w-k)/2$) the barter good the larger the discount on p_B and thus the more shifts the terms of trade in favour of the input supplier.

To measure the shift of the terms of trade in barter relative to the prices prevalent in cash transactions we use the variable TOT. TOT is defined as the difference of SCASH and PCASH, where SCASH and PCASH are the percentage differences of barter prices as compared to cash prices for the input good and the barter good, respectively. Let p_1^C and p_1 denote the price for the input good in cash and barter transactions, respectively. Similarly, let the price for the barter good in cash and in barter transactions be p_B^C and p_B. Thus, the percentage price change for the input good is $(p_1 - p_1^C)/p_1^C$ and the percentage price change for the barter good is $(p_B - p_B^C)/p_B^C$. The net terms of trade effect is measured by TOT = SCASH - PCASH.

In order to obtain a proxy for the severity of the hold up problem (a measure for n) on the input deal we have classified the input good and the barter good of each transaction according to the complexity index given by BK. With this method we constructed a deal-specific complexity measure for both goods exchanged, SCOMPLEX and PCOMPLEX. Furthermore, we use as a proxy for the creditworthiness (as a measure for x) of the input purchaser her total outstanding debt (firm arrears, wage arrears and tax arrears), PARREARS. The data allow us to distinguish whether the firm is on the selling or buying end of the transaction.

Insert Table 3 here

We first look at the price effect on each of the deals separately and then in a next step focus on the net effect on the terms of trade of both transactions together. Consider

first the regression on the percentage price change on the input deal SCASH given in columns 1 to 7 in Table 3. The more complex the input good the more severe is the hold-up problem in the input deal and thus the larger the barter price p_1 relative to the cash price p_1^C. Thus we expect a positive sign on the complexity index for the input good SCOMPLEX. This is supported by the regressions. The input specific complexity measure is positive and significant independent of the specification. Furthermore, we expect the input purchaser's indebtedness (PARREARS) to have a positive effect on SCASH, since the input seller will inflate the barter input price p_1 relative to the cash price p_1^C to cover the anticipated credit enforcement costs x. The coefficient on PARREARS is zero and insignificant suggesting that the input supplier has not been able to pass on these costs on the input purchaser. Our theory predicts for this case that the input purchaser will need to shift some of the profit back to the input supplier in order to make him participate in the deal by discounting the price for the barter good. Thus, we expect a negative sign on the PARREARS variable in the regressions for PCASH. Looking at the regression results for the percentage price change on the barter good PCASH given in columns 8 to 14 this is indeed confirmed by the data. PARREARS is negative and highly significant.

Consider next the net terms of trade effect of both transactions given in columns 15 to 22 of Table 3. We expect a positive sign for SCOMPLEX and PARREARS in the TOT regressions, since a larger SCASH due to the hold-up problem and a smaller PCASH due to the credit problem imply both a larger TOT. This is indeed the case. The data suggest then that the hold-up problem is reflected in an inflated price on the input deal and the input purchaser's credit problem appears to have been so severe that it had to be taken care of by price concessions on the barter side of the contract. Both problems have shifted the terms of trade in favour of the input seller.

We predict two more variables to have affected the terms of the contract: the liquidity w and the anonymity π of the barter good. The more liquid and the less anonymous the barter good, the larger the hostage value of barter and thus the larger the discount on the price of the barter good p_B relative to the cash price p_B^C. Thus, we expect a negative coefficient of liquidity and anonymity in the PCASH regressions and a positive coefficient for the same variables in the TOT regressions.

We measure the liquidity and anonymity of the barter good by PCOKE and PCOM-

PLEX.[14] PCOKE is a dummy variable taking the value of one if the barter good is coke or petroleum. Coke is a liquid good (everybody uses it for heating) which can be sold easily on the market at a known price. PCOMPLEX measures the complexity of the barter good. We use it as a proxy for the degree of specificity of the barter good. If the complexity index for the barter good is large and thus there are many production steps to get from the raw input to the final good, we infer that the barter good can be potentially used only by a small number of firms. The more specific the good is for the creditor's use, the harder it will be for the debtor to cheat on repayment and to sell the good to someone else than the creditor. We therefore expect a negative coefficient on PCOMPLEX in the PCASH regressions and a positive coefficient in the TOT regressions.

Turning to the results given in Table 3 PCOKE has the wrong sign but is not significant. PCOMPLEX has the expected sign and is highly significant in all regressions.

Additionally, we include the variables SSTATE and PDISTORT to control for other distortions in the economy which might have influenced the terms of the contract. SSTATE is a dummy variable taking the value of one if the selling firm is a state owned enterprise. PDISTORT is a dummy of value one if the market for the barter good is regulated and thus p_B^C does not reflect market forces. It appears that when the seller is a state enterprise the input price is discounted and the barter price is inflated suggesting that the state firms subsidized their buyers. In contrast, when the price for the barter good is regulated, then the contract is used to shift the terms of trade in favour of the seller rather than the buyer.

Finally, we use the variables REPEAT and RELATION which capture the terms of the relationship between the input supplier and purchaser. RELATION is a dummy that takes the value of one if the seller is an energy or other input provider and zero otherwise. REPEAT is a dummy with the value of one if there is a history in the relationship between the input seller and the purchaser. RELATION measures the quality of the relationship and REPEAT the duration of the relationship between the parties. We expect both variables to have enhanced trust among the parties involved in the deal and thus to have an impact on the terms of the contract. Both variables are, however, not significant in

[14]For the concept of liquidity in an incentive theory of money see Banerjee and Maskin (1997); see Marin and Schnitzer (1997) who use the liquidity and anonymity properties of goods to explain the trade pattern of barter in international trade.

any of the regressions. In times of historic change, reputation does not appear to have governed the behaviour of the parties.

6 Conclusion

In this paper we establish a link between the output decline, inter-firm arrears, and barter in the former Soviet Union. We claim that inter-firm arrears are more pronounced in the former Soviet Union as compared to the early transition economies because firms can use arrears to avoid the problems associated with complexity and specificity. The fact that input suppliers have to worry about being paid when they extend trade credits to their buyers means that they cannot exploit their buyers' dependence on these inputs. This way, the presence of arrears helps to avoid the output to collapse even more than it actually has.

However, very large arrears become counterproductive for maintaining production because credit enforcement becomes very costly and thus input suppliers will refuse to extend credit to their buyers. Under these circumstances, barter trade is the only way to maintain production. Barter trade is an inter-firm credit which is repaid in goods rather than money. Barter creates a hostage which can be used to collateralize a trade credit when firms' creditworthiness problem is severe. This function of barter explains why firms are able to give loans to each other when the banking sector is reluctant to provide capital.

Furthermore, the model is able to explain the pattern of arrears and barter over time in Russia. The arrears crisis started in 1992 - 19993 in Russia, reaching almost 10 percent of GDP (firm and tax arrears) while barter started to rise in 1994. The theory predicts barter to exist when arrears reach a critical level at which credit enforcement becomes so costly that only barter can maintain production. Our data suggest that arrears reached this crititcal level at around 30 to 40 percent of firms' sales. Thus, we argue that the explosive increase of barter in Russia since 1994 (from 5 percent of sales in 1993 to around 60 percent of sales in 1998) has been triggered by a level of arrears at which production was unsustainable.

Thus, the model provides an explanation for why barter is present in the former Soviet Union while being absent in the early transition economies. Disorganization and

specificity have posed a more severe problem for more insulated economies like the former Soviet Union, while in open economies like Central Europe entry of foreign firms alleviated the problems of small numbers. In the former Soviet Union other mechanisms than international trade and foreign direct investment must have been at work to limit the adverse effect of specificity. We argue in this paper that inter-firm arrears and barter can be seen as such mechanisms of smoothening the transition from the "old" to the "new" regime. Barter is observed in the former Soviet Union while being non-existent in Eastern Europe because disorganization and the output decline are more severe in the former than the latter region.

Appendix

Proof of Lemma 1:

Suppose that all buyers are liquidity constrained and thus have to delay repayment. Consider now the final step of production. This is exactly like the first step, with the only exception that B_n does not have to make an up-front investment. Then the two parties share the joint surplus as follows: S_n receives $p_n - x = v/2$ and B_n receives $v - p_n + x = v/2$, provided $x \leq v/2$. If $v/2 < x < v$, then B_n receives x and S_n receives $v - x$. If $x \geq v$, then no production takes place at the final step. The value of production at step $n-1$ is equal to the payoff of the seller at the last production step. Solving the game recursively this leads to the following value of production at step $j, j = 1, ..., n-1$

$$v_j = \begin{cases} \frac{v}{2^{n-j}} & \text{if} \quad x \leq \frac{v}{2^{n-j}} \\ \frac{v}{2^{n-j-1}} - x & \text{if} \quad \frac{v}{2^{n-j}} < x < \frac{v}{2^{n-j-1}} \\ 0 & \text{if} \quad \frac{v}{2^{n-j-1}} \leq x \end{cases} \tag{24}$$

Note that if $x > \frac{v}{2^{n-j-1}}$ production will not take place at step $j+1$ because the seller S_{j+1} will not be able to guarantee himself a positive payoff. Thus, the value of production at step j is zero. *Q.E.D.*

Proof of Proposition 1

Production takes place if and only equations (6) and (7) are satisfied.

(i) If $x = 0$, equation (6) is satisfied by assumption and (7) is satisfied if and only if $i \leq v/2^n$.

(ii) If $i = 0$, equation (7) is satisfied by assumption and (6) is satisfied if and only if $x < v/2^{n-1}$.

(iii) Suppose $i > 0$ and $x > 0$. If $x \leq v/2^n$, then (6) is satisfied by assumption and and (7) is satisfied if and only if $i \leq v/2^n$. If $v/2^n < x < v/2^{n-1}$, then (6) is satisfied by assumption and and (7) is satisfied if and only if $i \leq x$. If $x > v/2^{n-1}$, then (6) is violated and no production takes place.

Q.E.D.

Proof of Proposition 2

Note first that we can determine the value of v_1, just like in Lemma 1, with the only difference that now the enforcement cost x are reduced by the hostage z. Of course, barter needs to take place only at those production steps j, where $x > v_j/2$, i.e. the liquidity constraint prevents an equal sharing of the surplus at production stage j. With this in mind, we can solve the game recursively as done in Lemma 1, with the only difference that now instead of x we have to consider $x - z$, whenever x is hitting this constraint.

Thus, we have $v_1(x,z) = \frac{v}{2^{n-1}}$ if $x - z \leq \frac{v}{2^{n-1}}$ and $v_1(x,z) < \frac{v}{2^{n-1}}$ if $x - z > \frac{v}{2^{n-1}}$.

Recall that p_1 and p_B are fixed such that the parties share the surplus equally whenever possible. This implies to set

$$p_B = \frac{w+k}{2} - z \tag{25}$$

which allows in turn to set

$$p_1 = \min[\frac{v_1}{2} + x - z; v_1] \ . \tag{26}$$

Note that both S_1 and B_1 need to be willing to participate and make the necessary investment. This requires for B_1 that

$$v_1 - (p_1 - x) + p_B - k - i \leq \frac{w-k}{2} \tag{27}$$

and for S_1 it requires

$$(p_1 - x) + w - p_B > \frac{w-k}{2} \ . \tag{28}$$

Suppose $x - z < \frac{v}{2^{n-1}}$. Then $v_1 = \frac{v}{2^{n-1}}$. Suppose furthermore that $x - z < \frac{2^n}{=}\frac{v_1}{2}$. Then, using the equations for p_1 and p_B, (27) requires that

$$\frac{v_1}{2} = \frac{v}{2^n} \geq i \tag{29}$$

and (28) requires that

$$\frac{v_1}{2} = \frac{v}{2^n} > 0 \tag{30}$$

Note that this is condition (19) in Proposition 2.

Suppose next that $x - z < \frac{v}{2^{n-1}}$, so that $v_1 = \frac{v}{2^{n-1}}$, but that $\frac{v}{2^n} = \frac{v_1}{2} < x - z < \frac{v}{2^{n-1}} = v_1$. Then, using the equations for p_1 and p_B, (27) requires that

$$x - z \geq i \tag{31}$$

and (28) requires that

$$v_1 = \frac{v}{2^{n-1}} > x - z \tag{32}$$

Note that this is condition (20) in Proposition 2.

Finally, note that if $x - z > \frac{v}{2^{n-1}}$, then $v_1 < \frac{v}{2^{n-1}}$ and it is not possible to satisfy (28) so that no production takes place as specified in Proposition 2. *Q.E.D.*

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Definition of Variables and Sample Statistics

Variable	Observations	Description	Mean	Min.	Max.	Std Dev.
arrears	138	share of firm's arrears (tax, wage and firm arrears) in percent of output	41.40	1.00	687.90	101.068
parrears	69	total arrears of purchasing firm in percent of output	65.30	0.00	687.90	157.947
bankdebt	150	firm's bank debt in percent of output	6.31	0.00	104.20	15.955
tax arrears	150	firm's tax arrears in percent of output	7.15	0.00	121.50	19.306
wage arrears	150	firm's wage arrears in percent of output	3.38	0.00	38.60	6.001
firm arrears	138	firm's inter-firm arrears in percent of output	30.15	0.70	626.00	90.887
relative firm growth	153	percentage deviation of firm's output growth relative to the growth rate of GDP between 1994 and 1996	0.01	-2.03	25.43	4.215
barter	165	share of firm's barter in percent of output	45.21	1.00	100.00	28.181
complexity	141	complexity index of the industrial sector of the firm; the index is equal to zero if there is only one input and tends to one if the sector uses many inputs.	0.80	0.34	0.92	0.116
scomplex	142	complexity of input good; the index is equal to zero if there is only one input and tends to one if input good is produced with many inputs	0.77	0.30	0.92	0.139
pcomplex	145	complexity of barter good; the index is equal to zero if there is only one input and tends to one if barter good is produced with many inputs.	0.75	0.19	0.92	0.134

Definition of Variables and Sample Statistics Continued

tot	163	net difference between cash and barter price in percent (scash-pcash)	4.59	-168.00	50.00	18.075
Variable	Observations	Description	Mean	Min.	Max.	Std Dev.
scash	163	difference between the cash price and barter price in percent of the cash price for the input good	3.43	-16.70	49.00	8.302
pcash	163	difference between the cash price and barter price in percent of the cash price for the barter good	-1.16	-50.00	186.00	18.633
sstate	165	dummy variable equal to one if selling firm is state owned		D=1, 49 observations		
pdistort	165	dummy variable equal to one if market for barter good is regulated		D=1, 36 observations		
pcoke	148	dummy variable equal to one if barter good is coke or petroleum		D=1, 16 observations		
relation	164	dummy variable equal to 1 if seller is input supplier		D=1, 88 observations		
repeat	165	dummy variable equal to 1 if seller and buyer have interacted frequently		D=1, 87 observations		

Table 1 - The inverse U-curve: Output Growth, Arrears and Barter[1]

		mean	std dev.	cases[2]			mean	std dev.	cases[2]
					firms with				
total arrears	< 25 %	-0.48	1.9	81	total arrears	< 50%	-0.32	2.4	120
	> 25 %	1.05	6.4	57		> 50%	3.24	10.2	18
bank debt	$= 0$	-1.12	0.7	63	bank debt	< 10%	-0.42	2.3	135
	> 0	0.87	5.4	87		> 10%	4.08	11.1	15
tax arrears	< 5%	-0.17	2.5	111	tax arrears	< 20%	-0.40	2.3	135
	> 5%	0.61	7.3	39		> 20%	3.88	11.2	15
wage arrears	$= 0$	-0.05	2.5	75	wage arrears	< 9%	0.13	4.4	141
	> 0%	0.11	5.5	75		> 9%	-1.49	0.6	9
firm arrears	< 10%	-0.58	1.7	58	firm arrears	< 50%	0.26	4.6	126
	> 10%	0.67	5.6	80		> 50%	-1.00	0.3	12
barter share	< 30%	-0.79	2.0	98	barter share	< 70%	0.27	4.6	128
	> 30%	1.44	6.3	55		> 70%	-1.34	0.4	25
total sample		0.01		153					

1) Output growth is the percentage deviation of firm's output growth relative to growth rate of GDP between 1994 and 1996.
2) The number of cases may exceed the number of interviewed firms because each barter deal involves a selling as well as a buying firm.
Source: Survey of 165 barter deals in the Ukraine in 1997.

Table 2 - Output Fall and Financial Collapse

Dependent variable: relative firm growth[1)]

	all firms						barter < 30 %				barter > 70 %				arrears > 40 %				high growth firms[2)]			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
complexity	-10.60	-10.48	-6.58	-11.20	-11.42	-0.57	-30.92	-5.70	-4.76	-0.91	-0.90	-1.84	-3.69	-2.27	-18.36	-19.46	-12.26	-2.82	-59.96	-21.20	-30.00	-26.91
	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.80)	(0.00)	(0.25)	(0.34)	(0.85)	(0.44)	(0.08)	(0.00)	(0.02)	(0.05)	(0.05)	(0.08)	(0.00)	(0.00)	(0.00)	(0.00)	0.00)
arrears		0.00	0.07	0.01	0.01	-0.01		0.16	0.16	0.05		0.00	0.00	-0.01		0.00	0.01	-0.30		0.12	0.10	0.08
		(0.22)	(0.00)	(0.04)	(0.02)	(0.00)		(0.00)	(0.00)	(0.14)		(0.01)	(0.00)	(0.07)		(0.64)	(0.40)	(0.67)		(0.00)	(0.00)	(0.01)
arrears^2			0.00																			
			(0.00)																			
barter				-0.05	-0.23	-0.02			0.10	0.13			-0.04	0.00			-0.27	0.03			0.08	0.08
				(0.00)	(0.00)	(0.04)			(0.22)	(0.09)			(0.00)	(0.97)			(0.00)	(0.01)			(0.00)	(0.00)
barter^2					2.18																	
					(0.01)																	
bankdebt						0.23				0.15				0.11				0.29				0.04
						(0.00)				(0.00)				(0.04)				(0.00)				(0.32)
R^2 Adj.	0.07	0.07	0.19	0.14	0.17	0.62	0.28	0.75	0.76	0.80	-0.02	0.32	0.80	0.84	0.12	0.09	0.57	0.99	0.77	0.93	0.95	0.95
N^3	141	135	135	135	135	135	52	49	49	49	19	19	19	19	24	24	24	24	27	27	27	27

1) Percentage deviation of firm's output growth relative to the growth rate of GDP between 1994 and 1996.
2) Firms with higher output growth than the growth rate of GDP.
The number of cases exceeds the number of interviewed firms because each barter deal involves a selling and a buying firm.
Source: Survey of 165 barter deals in the Ukraine in 1997.

Table 3 - Terms of Trade Effects

	scash							pcash							tot							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
scomplex	0.21	0.20	0.19	0.18	0.19	0.19	0.20	-0.11	-0.10	-0.10	-0.09	-0.09	-0.08	-0.08	0.31	0.32	0.30	0.29	0.27	0.28	0.28	0.28
	(0.02)	(0.03)	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.16)	(0.18)	(0.24)	(0.27)	(0.25)	(0.30)	(0.31)	(0.16)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
parrears	0.00	0.00	0.00	0.00	0.01	0.01	0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02		0.03	0.03	0.02	0.03	0.03	0.03	0.03
	(0.60)	(0.73)	(0.75)	(0.54)	(0.42)	(0.36)	(0.35)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
pcomplex		11.28	11.49	9.69	10.77	11.42	11.04		-11.10	-13.42	-12.72	-13.30	-12.56	-12.90			22.38	24.92	22.41	24.06	23.98	23.94
		(0.14)	(0.15)	(0.22)	(0.15)	(0.13)	(0.15)		(0.10)	(0.08)	(0.10)	(0.08)	(0.10)	(0.09)			(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
pcoke			-3.16	-1.74	-5.14	-4.10	-4.03			2.12	1.57	3.40	4.57	4.63				-5.28	-3.31	-8.53	-8.66	-8.66
			(0.40)	(0.64)	(0.18)	(0.29)	(0.30)			(0.55)	(0.66)	(0.38)	(0.24)	(0.24)				(0.24)	(0.45)	(0.05)	(0.05)	(0.06)
sstate				-3.66	-3.62	-3.41	-3.46				1.43	1.41	1.65	1.60					-5.09	-5.03	-5.06	-5.06
				(0.06)	(0.05)	(0.07)	(0.07)				(0.45)	(0.45)	(0.38)	(0.40)					(0.30)	(0.02)	(0.02)	(0.02)
pdistort					7.99	7.14	7.22					-4.30	-5.25	-5.19						12.29	12.40	12.41
					(0.01)	(0.03)	(0.03)					(0.17)	(0.10)	(0.11)						(0.00)	(0.00)	(0.00)
repeat						-1.80	-1.77						-2.03	-2.00							0.23	0.23
						(0.24)	(0.25)						(0.19)	(0.20)							(0.90)	(0.90)
relation							-1.98							-1.77								-0.21
							(0.68)							(0.72)								(0.97)
R^2 Adj.	0.06	0.08	0.08	0.12	0.21	0.22	0.21	0.19	0.21	0.21	0.20	0.21	0.23	0.21	0.01	0.21	0.27	0.30	0.35	0.47	0.46	0.45
N^3	65	64	58	58	58	58	58	65	64	58	58	58	58	58	142	65	64	58	58	58	58	58

Source: Survey of 165 barter deals in the Ukraine in 1997.