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ABSTRACT

Increases in uncertainty have ambiguous effects on the rate of investment in complete contracts models. Consequently, in order to model the adverse effects of high inflation on capital accumulation, macro models overimpose a CIA constraint to buy capital goods. The fall in investment is thus due to an increase in the effective price of capital goods, and not due to inflation uncertainty.
In incomplete contracts models, the effects of uncertainty on investment decisions are unambiguously negative, in the absence of long-term contracts (LTCs). Since one of the main effects of high inflation is to provide the incentives for those contracts to vanish, this paper models this feature, endogeneizing LTCs disappearance in an incomplete contracts setup, and by so doing permits to explain a fall in investment that is entirely due to inflation uncertainty.

JEL Classification: E31, E22, O12, O42, D92.

This paper investigates why and through which mechanisms could inflation have adverse effects on capital accumulation, as the economy moves to a state of 'maximum inflationary uncertainty', when crucial aspects of that uncertainty are non-contractible. Typical accounts of high inflation episodes remark these last two features of the inflationary process with emphasis[2].

When we are asked why high inflation could harm capital accumulation, we like to respond things in the following spirit (Lloyd Thomas's *Money, Banking, and Financial Markets*, pp. 442-443, 1996):

"Because inflation creates uncertainty and impairs investment spending, it is essential that [the central bank] remain vigilant against inflation, if satisfactory long-run growth is to be achieved"

But in our prototypical macroeconomic model, the Ramsey model of growth, we impose a CIA constraint on firms for their purchase of capital goods, so that (anticipated)

[1] I have benefited from comments from Roger Betancourt, Fernando Broner, and Rachel Kranton on a previous version of this paper, and have received useful suggestions from seminar participants in the International and the Development student seminars at the University of Maryland at College Park. Errors, inconsistencies and omissions are my sole responsibility.

[2] See Bresciani Turroni (1937) for a review of the case of the German high inflation preceding the hyperinflation of 1923, and Heymann and Leijonhufvud (1995) for more recent experiences in Latin America during the 1980s.

inflation harms capital accumulation because it introduces a wedge on the price of capital goods.

Why does this state of affairs prevail? It may be because we have been modeling the effects of inflation in contexts where contracting over all possible contingencies was allowed[3]. One main reason why we do not try to explain many (relevant) things is just because we do not have the tools available, as recently emphasized by Lucas in his Nobel lecture. By the time high inflation was a major challenge –the 1980s- important developments in the theory of the firm under incomplete contracting had not been produced.

Whatever the reasons for that state of affairs could be, high inflation episodes provide abundant evidence on the increase in environmental uncertainty and on the increasing difficulty that parties face when they need to write contracts. In particular, three important non-neutralities of money during high inflation episodes have been recently documented in the literature: (i) the reduction in the maturity structure of contracts; (ii) the reduction in specialization in production; (iii) the fall in the investment rate[4]. The incomplete contracts model that I present below will be able to explain these three important non-neutralities of money.

As remarked by Lucas in his Nobel lecture [Lucas, 1996] money's neutrality or non-neutrality depends, among other things, on how it is introduced into the system.

One of the main ways through which money is introduced in a high inflation economy is through state enterprises' expenditures in the market for goods. Monetary finance of chronically deficit-proned state enterprises is a common element in almost every case study of high inflations during the 1980s. Accordingly, money is introduced in this paper through state enterprises' policies regarding their purchases of inputs from private suppliers. The state sector typically has certain 'promotion' policies in place and use state enterprises' purchases of inputs to enforce them. At times, the state sector engages in activist 'employment policies'. At some other times, the state sector promotes 'industrial policies' that privilege the use of knowledge, and so on. When the state sector seeks to

[3] See a discussion in Guerrero (2000).

[4] The first of those issues is raised formally in Neumeyer [JEDC, 1999], the third is systematically documented in De Gregorio [EER, 1992] and Barro (1997). The second is systematically documented in one of the empirical papers of my PhD dissertation (Guerrero, 2001).

promote employment, say, it demands inputs manufactured by private suppliers by means of technologies that use labor intensively (relative to knowledge, say), and taxes heavily the use (by private producers of final goods) of all inputs other than the ones being promoted.

The key element will be that the private sector will not know in advance which 'promotion' policy will be in place at each moment. The problem in a high inflation environment is twofold. On the one hand, a meaningful ex-ante state budget is a missing institution; the state budget is just an ex-post authorization of expenditures by the legislature. The lack of a meaningful, ex-ante budget for the state sector in general, and for the sector of state enterprises in particular thus makes the level and the structure of public sector demand unknown for the private sector. Another related problem is that decisions involving issues like 'promotion' policies become highly erratic in a high inflation environment. As discussed in Dornbusch (1993, chapter 1), or Heymann and Leijonhufvud (1995, chapter 4), for instance, inflation becomes the most important, dominant public policy issue. And it becomes so to such an extent that decisions involving all other public policy issues, including 'promotion' policies, are all made under strong conditionality: the best policy regarding any public policy issue z different from inflation will be adopted, only if it does not compromise the achievement of a rate of inflation within a certain targeted range. Otherwise, policies involving issue z will be restricted to the set consistent with the targeted level of inflation, even if that implies any of the following:

-a reversal of a previous policy announcement regarding issue z.

-a reversal of a previously implemented policy regarding issue z.

-adopting a suboptimal policy regarding issue z.

Thus, state 'promotion' policies and their different mechanisms of enforcement, including state enterprises' purchases of inputs, turn out to be extremely volatile and highly unpredictable in a high inflation economy. It is not unusual, indeed, that within a year many sudden policy changes are introduced to 'promotion' policies, usually –but not necessarily- in the context of a new stabilization package.

The combination of highly erratic state 'promotion' policies, the absence of an ex-ante state budget, and inflationary finance of state purchases in goods markets –the three defining characteristics of what this paper calls high inflation- will generate uncertainty about the structure of input demands that private suppliers will face. At very high rates of growth of the money supply, the scope for arbitrariness and unpredictability in state enterprises' purchases will also be very high, eventually inducing the disappearance of long-term contracts between private suppliers and private firms producing final goods. Private suppliers will have one specialized technology for each input they produce and one unspecialized technology that will permit to produce any input. Specialized technologies typically require time to yield output and also require commitment to a certain specific type of input before uncertainty is resolved. For these reasons, specialized technologies will be enforced by long-term contracts. The unspecialized technology will permit to produce after uncertainty is resolved (for this reason it will be called the flexible technology, given that it does not require commitment to any specific type of input before uncertainty resolution, and will be enforced by the use of short-term contracts), but it will have a cost in terms of production efficiency.

At very high rates of money growth, arbitrariness and unpredictability in state enterprises' input demands will be so high that specialized technologies will ceased to be used (with them vanishing, long-term contracts will also disappear).

An important adverse effect of long-term contract disappearance will be reflected in the relationship between private suppliers and their buyers in the private sector. Since investment decisions by final good producers in the private sector will be specific to the relationship they have with their private suppliers, and will have to be made before uncertainty is resolved, the absence of long-term contracts will set the stage for ex-post expropriation of surplus. Acting in anticipation of ex-post expropriation, producers of final goods in the private sector will optimally reduce investment below the socially optimum level.

The rest of the paper is organized as follows. Section 2 presents the description of the model. Section 3 presents the choice of contract/technology by private suppliers in the context of state enterprises-induced uncertainty. Section 4 presents the choice of investment by private producers of final goods. Section 5 concludes with some brief final remarks.

2. Model Description

This model has two main building blocks. In the first one, suppliers –affected by state enterprises-induced uncertainty- will choose the type of technology/contract that will link them with private producers of final goods. This decision will be shown in section 3 of this paper. Section 3 will show how a very uncertain environment leads to a reduction in contract length. Conditions are derived under which the limiting case of long-term contracts (LTCs) disappearance arises. This part borrows ideas on how to treat the effects of uncertainty from Jones and Ostroy [RES, 1983] and apply them in the context of high inflation. The second main building block presents how private producers of final goods choose the optimal level of investment. This decision will be shown in section 4. Section 4 will show how in the absence of LTCs, if parties cannot contract directly on the level of investment, a sub-optimally low level of investment could arise. This part borrows heavily from Hart and his co-authors [Grossman and Hart, JPE 1986, Hart.and Moore, JPE 1990, Hart 1995].

The three main agents of this economy are the state sector, a sector of private suppliers, and a sector of private producers of final goods (that will be called Firms).

All the action will take place during two time periods. The first time period runs from t= 0 to t=1, and the second runs from t=1 to t=2. Most of the action will take place in the first period. The state sector (state enterprises, say) and private final goods producers both demand inputs from the sector of private suppliers.

State enterprises finance their purchases of inputs by asking the central bank to print fiat money on their behalf, once they get authorization for that from the Treasury. No ex-ante state budget exists. In high inflation economies the budget is just an ex-post authorization of expenditures by the legislature. As a consequence, neither the structure nor the level of nominal purchases from the state sector are known ex-ante.

There will exist n different states of the world at t=1, that are unknown to the private sector from the perspective of t=0. Each state of the world will be associated with a different decision by state enterprises in terms of their input demands. In each state of the world, a different input will be 'the correct one', ex-post (say, the one that will be more in demand by state enterprises. To keep things simple, and without loss of generality, it can be assumed that state enterprises end up just picking one of the inputs). Uncertainty will be revealed at t=1, at the time when private suppliers have to deliver the input to their private buyers. This feature tries to capture the essential uncertainty that the lack of a meaningful ex-ante budget (and the corresponding use of inflationary finance) introduces into state enterprises' purchases of input policies.

Each private supplier produces a certain family of inputs (each family contains n different possible inputs). Each family of inputs is specific to the production of a single final good. A firm can use any of the inputs belonging to the family that matches its final good and still produce at full production efficiency, but the state sector taxes them in an expropriatory fashion, if ex-post 'incorrect' (relative to what the state sector seeks to 'promote') inputs are used. The assumption is that the state sector has certain 'promotion' policies in place, as discussed in the introduction to this paper.

A firm demands inputs of a certain given type produced by its supplier and would like to absorb the whole production of its supplier. However, ex-post, firms will only absorb a fraction a, while state enterprises will absorb the fraction 1-a.

State enterprises limit themselves to announce their orders of purchases at t=1. The purchasing orders are of the following form. At t=1 the input that state enterprises seek to 'promote' is announced, and the purchasing order is distributed uniformly among all suppliers. Intuitively, the larger is the value of the purchasing order (and thus, the larger the issuance of fiat money from the central bank), the larger the scope for unexpected volatility in the value of state enterprises' input demand will be. This will be the source of the uncertainty faced by the private sector.

Each private supplier has available n specialized technologies (one for each input). All of them take one period to yield output. Hence, production using these technologies have to be started at t=0, if the input is to be delivered at t=1. Therefore, the use of specialized technologies involves committing at t=0 to produce a certain specific input.

Each private supplier also has available one unspecialized technology to produce all the different inputs. The unspecialized technology does not require time to yield output (that is, production can be done instantly at t=1 after uncertainty is resolved, without pre-commitment to any specific input at t=0), but at a cost in terms of efficiency in production.

When production takes time, as is the case of specialized technologies, long-term contracts (LTCs) are needed to enforce their use. Otherwise, specialized technologies would vanish due to a time inconsistency problem. That is, in the absence of binding long-term contracts specifying in t=0 a fixed price for the input to be delivered in t=1, firms would not have incentives to pay a positive price for ex-post 'incorrect' inputs. In anticipation of this, suppliers would never use specialized technologies. For this reason, LTCs have to be used to enforce the use of specialized technologies. Since the unspecialized technology does not require time to yield output, it can be enforced by a short-term contract.

What a contract specifies

A long-term contract signed at t=0, thus specifies:

* A fixed price (agreed upon at t=0, when the contract is signed) for the input to be traded at t=1. This involves setting a contract price in advance both for the case in which the (ex-post) good state of the world occurs, and also for the cases in which the (ex-post) bad states of the world happen to occur. By assumption, the contract price for an input that matches the (ex-post) good state of nature will be higher than the contract price for an input that ends up being ex-post 'incorrect'.
* The type of input (within a family X) to be delivered at t=1.
* The time of delivery (t=1)
* Moment in which the input is paid (t=2, after sales are realized)

A short-term contract signed at t=0 only specifies:

* Time of delivery (t=1), and
* Moment in which the input is paid (t=1)

Notice: price will be a floating one in a short-term contract.

Timing of the model

At t=0 a contract is signed between a private supplier and a private producer of final goods. Immediately after the contract is signed, private producers of final goods have to make an investment decision. Investment is specific to the relationship that each firm has with its supplier

At t=1 uncertainty is revealed (the state sector reveals its orders of purchases; state enterprises finance their purchases using newly issued fiat money). Immediately after uncertainty is revealed, negotiations about the price of the input take place between private suppliers and private producers of final goods, if no long-term contracts are available. Production of final goods finally takes place.

3. Suppliers' Choice of Technology/Contract

Given the structure just outlined, suppliers will face a well-defined trade-off between efficiency and flexibility when choosing the type of technology/contract to use. Specialized technologies require commitment to a specific input at t=0, but they ensure production efficiency. Unspecialized technologies are inefficient, but they do not require commitment before uncertainty is resolved. This section shows that even risk-neutral suppliers will eventually shy away from specialized technologies/long-term contracts, if uncertainty is high enough. In Jones and Ostroy's terminology [Jones and Ostroy, RES 1983], in the face of an increase in uncertainty there will be an increase in the demand for flexibility. Moreover, at some point when uncertainty is high enough, the benefits from flexibility outweigh the costs in terms of production efficiency, and even if the returns of flexibility are not directly affected, long-term contracts enforcing specialized technologies will disappear.

The n specialized technologies available to private producers are of the form:

[1] $$V^{h,j} = f^{h,j}(l^j);\, f_l^{h,j}(.) > 0,\, f_{ll}^{h,j}(.) < 0; h = 1...H,\ j = 1...n$$

Where V represents the quantity produced by supplier h, l represents labor, h indexes suppliers (and also the number of final goods in the economy, since there is one firm per supplier and each firm only produces a single final good), and j the type of input. Notice that the quantity of labor does not vary across suppliers, it varies only across goods. That is, symmetry is imposed for simplicity.

A useful, special case of [1] is given by:

[1'] $$V^{h,j} = A_h^j l_j^{\theta j}; \theta_j < 1$$

that makes clear that l and theta are assumed to be equal for all suppliers, but A varies across suppliers, capturing the specific knowledge that is necessary to produce the input specific to final good h.

Similarly, the unspecialized technology can be written as:

[2] $$V^{h,u}(l^u);\ u = 1, h = 1...H$$

Besides:

[3] $$f^{h,j}(.) - f^{h,u}(.) = D > 0,\ \forall l, \forall h, \forall j; h = 1,..., H;\ j = 1...n$$

That is, for every quantity of labor, all the inputs can be produced more efficiently by means of specialized technologies.

Turning to the distribution of state enterprises' purchases of inputs at t=1,

$$[4] \quad \begin{aligned} &z_1 > \{z_2, z_3, ..., z_n\}, \textit{with probability } t_1 \\ &z_2 > \{z_1, z_2, ..., z_n\}, \textit{with probability } t_2 \\ &. \\ &. \\ &. \\ &z_n > \{z_1, z_2, ..., z_{n-1}\}, \textit{with probability } t_n \end{aligned}$$

$$\textit{Where, } t_j \in [0,1] \; \forall j, \textit{and} \sum_{j=1}^{n} t_j = 1$$

And the z's denote the level of state enterprises' purchases of different inputs

With the idea of capturing a situation in which the economy is moving to a state of 'maximum uncertainty' (see Appendix 1 for a rigorous definition of what is meant by 'maximum uncertainty'), the following assumption regarding the distribution of state enterprises' input purchases is introduced:

$$[5] \quad \textit{For } s >> 0,$$

$$\textit{If} \quad t_j(s) > \frac{1}{n} \Rightarrow t'(s) < 0 \quad \forall j, \; j = 1...n$$

$$\textit{If} \quad t_j(s) < \frac{1}{n} \Rightarrow t'(s) > 0 \; \forall j, \; j = 1...n$$

$$\textit{Where } s \equiv \frac{\sum_j \left| z_j - \bar{z} \right|}{n}$$

The idea of the previous assumption is to show that as the uncertainty about the behavior of the state sector[5] increases, the precision with which private agents forecast future events decreases. In the limit, all events become equally likely, and uncertainty is maximized[6]. Technically, the degree of uniformity of the probability distribution of z is increased as uncertainty increases. Since the uniform probability assignment represents a

[5] Represented here by sigma.
[6] See Appendix 1.

state of mind completely noncommittal with regard to all possibilities, it is intuitive to impose the uniform distribution as a limiting case to an economy that, like a high inflation one, is in the move to a state of maximum uncertainty[7].

To show suppliers' choice of technology/contract and the effects of uncertainty on long-term contracts enforcing specialized technologies, it suffices to consider the simple case of two states and two specialized technologies.

Assume that as of t=0, z1=z2=1, known with certainty.

But, from the perspective of t=0, in t=1 the two dimensional case of assumption [5] holds. If suppliers are risk neutral, they will choose the type of technology/contract that gives the higher expected return. Hence, if tau>1/2, suppliers always choose specialized technology 1 over the unspecialized technology so long as:

$$[6a] \qquad [E(R_{h,1}) - R_{h,u}] = \{t(s).w_{LTC,good}.f^{h,1}(.) + [1 - t(s)].w_{LTC,bad}.f^{h,1}(.)\} - w_{STC}.f^{h,u}(.) > 0, \quad \forall h,\ h = 1,\dots,H$$

Where w is the contract price that a supplier receives from a firm. Expression [6a] makes clear that if the (ex-post) good state of the world -in which the input produced with specialized technologies matches the input that the state sector promoted- happens to occurs, the long-term contract price is different (higher) than if the bad states of the world occur.

Similarly, if tau<1/2, suppliers always choose specialized technology 2 over the unspecialized technology so long as:

$$[6b] \qquad [E(R_{h,2}) - R_{h,u}] = \{t(s).w_{LTC,good}.f^{h,2}(.) + [1 - t(s)].w_{LTC,bad}.f^{h,2}(.)\} - w_{STC}\, f^{h,u}(.) > 0, \quad \forall h,\ h = 1,\dots,H$$

Assuming that tau is differentiable, the following proposition can be established:

[7] The existence and uniqueness of a consistent measure of the uniformity of a probability distribution and the demonstration that its value is maximized when the distribution is uniform are shown in Appendix 1, where it is also shown that any change toward the equalization of the probabilities increases the "amount of uncertainty".

Proposition 1: As public sector-induced uncertainty increases, the attractiveness of long-term contracts enforcing the use of specialized technologies decreases.
Proof. See Appendix 2.

The intuition behind proposition 1 is straightforward. The returns of the specialized technologies decline relative to the return accruing to the unspecialized technology as public sector-induced uncertainty increases, even if the return of the unspecialized technology is not directly affected. Flexibility becomes more attractive when uncertainty increases.
When public sector-induced uncertainty is high enough, the following corollary can be established:

Corollary:

[7] $$If, \quad w_{STC}.f^{h,u}(.) \geq t(s).w_{LTC}.f^{h,j}(.) + [1-t(s)].w_{LTC}.f^{h,j}(.);$$
$$\forall h, h = 1,...,H; \forall j,\ j = 1,2$$

Then: LTCs enforcing specialized technologies will vanish.

That is, if the expected benefits from flexibility in production outweigh the expected benefits from efficiency in production, long-term contracts enforcing specialized technologies will disappear in an uncertain environment, even if (input) producers are risk-neutral. One important implication of this, that is worth keeping in mind, is that if long-term contracts disappear (that is, if [7] holds), no fixed–price contract will be available in the economy; contracting will require the use of floating price contracts.
In the case of 'maximum uncertainty', when tau=1/2, the following limiting condition for long-term contract disappearance can be obtained:

$$[7'] \qquad If \quad \frac{f^{h,j}}{f^{h,u}} < \frac{2.w_{good}}{w_{good} + w_{bad}}, \forall h, \forall j; h = 1,..., H; \ j = 1, 2$$

Then: Long-term contracts enforcing specialized technologies will vanish. In other words, if gains from specialization in production are less than the value on the right hand side of [7'], the benefits from flexibility outweigh the benefits from specialization, and long-term contracts enforcing specialized technologies go out of use.

The Use of Inflationary Finance by the State Sector

The next step is to declare how state enterprises finance their purchases of inputs at t=1. That will connect public sector induced uncertainty with its second main component: inflationary finance. Technically, sigma –the unexpected volatility of state enterprises' input purchases- will be shown to be a monotonically increasing function of the rate of money growth when state enterprises finance their purchases of inputs to the private sector using newly printed fiat money. State enterprises hold money in t-1 (t=0) to be able purchase inputs at t (=1). Thus, the central bank prints money at t=0 and gives that money to state enterprises, that use it at t=1. Since money is assumed to be legal tender in all transactions with the public sector, private suppliers are 'forced' to accept fiat money in exchange for their inputs at t=1. Suppliers will be able to use that money to pay taxes on the transfer price they receive from firms in exchange for the input delivered.
At t=1, prices rise in response to the excess demand generated by state enterprises. Hence, at t=1, the 'flow budget constraint' of state enterprises results:

[8] $$z_t = \sum_j b_t^j . z_t^j = \frac{M_t}{W_{t-1}} = \frac{M_t}{M_{t-1}} \frac{M_{t-1}}{W_{t-1}} = m_t . \frac{M_{t-1}}{W_{t-1}} = m_t . m_{t-1} \,,$$

$Where: \; z_t^j = z^j + e_t^j \; ; \; b_t^j = b^j + x_t \; ; \quad j = 1, ..., n \, , \; and: \; m_t = m + f_t$

Where the betas are the shares of each input in state enterprises' spending, e, x, and f are random shocks, M is the stock of nominal money balances, and W is an index of input prices.

The definition of sigma given in [5] and the fact that [8] links the rate of money growth and public sector input purchases in a linear fashion, permit us to establish the following proposition:

Proposition 2: The level of public sector-induced uncertainty is a monotonically increasing function of the rate of money growth.

Proof. See Appendix 3.

4. Firms' Choice of Investment

Assuming that condition [7] above holds –so that no fixed price contract is available-, this section presents the fundamental hold-up problem that may arise between firms producing final goods and private suppliers in the absence of LTCs, if both parties cannot contract directly on the level of investment when investment is specific in their relationship (that is, if the value of the project is less outside than within the relationship). The impossibility of contracting on the level of investment directly could arise for example if investment is observable by both parties, but not verifiable by third parties, such as courts. In this case, investment cannot be part of an enforceable contract. This assumption is a usual one in the incomplete contracts literature (Cf. Grossman and Hart, 1986, or Hart, 1995, chapters 2 and 4) and is also a sensible one in the case of high inflation economies, where contract enforcement by courts is known to be extremely weak. Dornbusch (1993, chapter 6) discusses informally some of the implications that this feature could have for the aggregate rate of investment. In the monetary economics literature, Reagan and Stultz (JMCB 1993) use a similar assumption in their model of inflation and contract length reduction.

The absence of long-term contracts implies that no fixed price can be set in advance as of t=0 for the input to be traded at t=1. Under short-term, variable price contracts, the price of the input will have to be negotiated at t=1 between the supplier and the firm, at the moment when state enterprises enter the market for inputs. This entrance provides suppliers with an attractive outside option that will act increasing their bargaining power over variable price, short-term contracts signed with firms, giving suppliers the incentives to act opportunistically, threatening firms with not delivering the input, unless those firms convene to share their ex-post profits. Acting in anticipation of this, firms under-invest in t=0. The intuition for the under-investment result is as follows: if firms invest a little more, this increases potential gains from trade in full (point-by-point with the increase in investment). However, given ex-post expropriation of surplus by suppliers, firms' profits only increase by a fraction of the investment contribution to profits. Being self-interested, firms do not take suppliers' payoffs into account and hence invest too little.

I focus on a highly stylized one sided investment story in which there are just two assets, that is, the assets of a supplier and the assets of a firm, and two managers operating them. Suppose the assets are already in place as of date 0, so that the investments are in making those assets more productive. Ignore issues of asset ownership, for now. Denote a firm's specific investment at date 0 by I, where I represents the level of investment. The manager of the firm requires a widget from its supplier at date 1, which yields a gross return of R(I), if the firm has made a prior investment of I at date 0 and trade occurs at date 1. The parties have symmetric information throughout. Also, there is no uncertainty about the parties' cost or benefits. However, there is uncertainty about the type of widget that the firm will receive at date 1.

If trade occurs, a firm's *ex-post* payoff is R(I)-w, where w is the agreed input price. If trade does not occur, the firm buys the input from an outside supplier, that is a 'non-specific' input from the spot market at price w(S), say. This non-specific input leads to a loss in firms' production efficiency. A firm's revenues in the case of no trade are $r < R$.

We also assume that R (I=0) > C (so that there are always ex-post gains from trade), where C is a fixed number representing a supplier's costs of production.

A firm's revenues in the case in which trade takes place are assumed to be increasing and concave in the level of investment. That is: $R'(I) > 0$ and $R''(I) < 0$, for all $I>0$. Finally, firms are assumed to have rational expectations about the negotiation process when they have to make their investment decisions at date 0. In particular, they can make correct calculations about the expected return from any action.

Given this setup, consider what happens at t=1 (the ex-post stage). Since there are always ex-post gains from trade to be made (equal to R-C), and parties have symmetric information, it is reasonable to expect them to realize the gains through negotiations. Assuming costless negotiations, I follow a standard procedure in the incomplete contracts literature[8] and impose a Nash bargaining solution where ex-post gains from trade (R-C) are divided 50:50. Such a strategy is implemented to circumvent the issues of bargaining between the parties. Since the main points of this paper are unconnected with the bargaining process between a firm and its supplier, adopting this 'reduced form' solution greatly simplify the analysis, without imposing any significant cost. Therefore, given Nash-bargaining, the ex-post division of surplus when there is trade between a firm and its supplier imply that both parties obtain: ½.(R-C) + outside option; While a firm's outside option is zero, since the firm has no alternative supplier, a supplier's outside option is positive: w(S) > 0 –the spot price paid by state enterprises-. This will be exactly reflected in the transfer price. Hence, firms' *ex-post* profits are: R-w = ½. (R-C)- w(S), and suppliers' ex-post profits are: w-C = w(S) + ½ (R-C). Therefore, the input price implied by Nash bargaining at the ex-post stage is:

[9] $$w = w(S) + \frac{1}{2}[R(I) - C]$$

If firms have rational expectations, they will anticipate the outcome of the ex-post stage when they have to plan their investment at date 0. As of t=0 firms' *ex-ante* choice of investment satisfy:

[8] See Grossman and Hart (1986), or Hart (1995, chapters 2 and 4), for instance.

[10] $\underset{I}{Max}\ \{R(I) - w.V^{u} - I\}$

Normalizing V to unity, inserting [9] into [10] and taking the first order necessary and sufficient condition for a maximum, we get:

[11] $\frac{1}{2}R'(I) = 1$

For each additional unit of investment to be made, firms only internalize half of investment's marginal contribution to revenues, since the rest will be appropriated by suppliers, given Nash bargaining. Denote the implicit value of investment from this optimal program by I^. How can this result be compared against the first best choice of I as of date 0? A social planner would choose investment to maximize total net surplus. That is:

[12] $\underset{I}{Max}\ \{R(I) - I - C\}$

Which yields the following first order necessary and sufficient condition for a maximum:

[13] $R'(I) = 1$

In the first best scenario, firms internalize the full amount of the marginal contribution of investment to revenues. Denote the social optimal value of I stemming from [13] as I*. Clearly, given the increasing concavity of R, I^ < I*. That is, firms under-invest (relative to the social optimum level of investment) in the absence of long-term contracts. The reason is straightforward: in the decentralized solution where long-term contracts are missing, self-interested firms fail to internalize suppliers' payoffs in their decisions, and acting in anticipation of ex-post expropriation, they under-invest.
Therefore, a new proposition has been established and demonstrated already.

Proposition 3: In the presence of investment specificity, long-term contract disappearance leads to a sub-optimally low level of investment, if parties cannot contract directly on that level.

Discussion:

This section discusses the adequacy of different arrangements to remove or mitigate the ex-ante investment inefficiency in the context of a high inflation economy. Among the most prominent ones, cost and revenue sharing schemes, contractual solutions of different types, and the role of ownership are discussed below.

Since R and or C are verifiable[9], *revenue or cost sharing contracts* are feasible. That is, the parties can write a contract that makes a firm's payment to its supplier depend on his costs or on the firm's revenues. However, these contracts do not solve the holdup problem (as pointed out by Hart, 1995, p. 79). To see why, let w0 be the price that a firm must pay if no trade occurs. Call w0 the 'no-trade outcome'. Then, the supplier can trigger the 'no-trade outcome' with the intention of renegotiating by just turning down firm's request. The point is that revenue/cost sharing contracts give a firm and its supplier an *option* to trade under the existing contract, but do not force them to trade under the existing contract. Thus, the hold-up problem remains.

A *performance contract*, in which the input type is described in advance and a fixed price w* for it is agreed upon as of date 0, would also solve the hold-up problem. With a contract like this a firm's ex-ante net return would be: R(I)-w*-I. To maximize this expression, the firm would choose I=I*. The problem with this solution is that in a high inflation economy neither the input type can be described in advance, nor a fixed price can be set as of t=0. Therefore, this solution to the holdup problem does not apply in the present case.

If the problem were only that the input type cannot be described in advance, the parties could write a contingent contract stating which input should be supplied in each state of the world. The problem is that this solution makes little sense in a high inflation environment, in which there are a large (but finite) number of equally likely states of the world and a large number of possible inputs to be delivered at date 1.

[9] This is the case here, since we only assumed that investment was not contractible.

Edlin and Reichelstein [AER, 1996] propose a solution to the holdup problem that is a mix of a non-contingent fixed-price contract and a breach remedy (like expectation damages or specific performance type of remedies). They find that a well-designed fixed-price contract can give firms efficient investment incentives under either expectation damages or specific performance. The problem with this solution in the present context is, as we have seen, the disappearance of fixed price contracts in the present high inflation environment.

The types of contracting solutions reviewed so far do not solve the holdup problem, but as stressed by Rogerson [RES, 1992, p. 778]: "the holdup problem does not necessarily cause inefficiencies. Rather inefficiencies occur if certain environmental properties are not satisfied or certain type of contracts cannot be written". Indeed Rogerson himself shows (Rogerson [RES 1992]) that first-best contractual solutions to the holdup problem exist in general, even in extremely complex environments. The requirements for Rogerson's contractual solution to apply are: (i) that there be no externalities associated with each agent's investment (i.e. that each agent's investment must directly affect only his/her own payoff), a requirement that is satisfied in the present case; (ii) that arbitrarily complex contracts can be signed, which is also o.k. in this context; (iii) that contracts can prevent renegotiation. Here, the characteristics of the present high inflation environment render Rogerson's solution inapplicable. First, when high inflation uncertainty is high enough that long-term contracts vanish, parties will be forced to negotiate over the input price at t=1, because no fixed price contract can be signed at t=0. Second, given the uncertainty about the input type to be delivered at t=1, any contract specifying a precise input type as of date 0 (when the contract is signed) would prove too costly for a firm (as stated before, expropriation would be the price to pay), if the input type delivered at date 1 turns out to be ex-post 'incorrect', given the state 'promotion' policy put in place at date 1. Hence, the 'perfect enforceability' of contracts required by Rogerson's solution would break down here.

Once we know that contractual solutions will not preclude ex-ante investment inefficiencies from arising in the present context, a natural candidate to solve the holdup problem is vertical integration. Indeed, according to transaction costs economics, vertical integration could be thought of as a functional substitute for long-term contracts. If firms are assumed to have unlimited amounts of initial wealth (an assumption that the literature usually makes to circumvent financing and financial structure issues, of course), firms could purchase their suppliers, if it pays them to do so[10]. The problem with this line of reasoning is that it does not explain why by making its supplier an employee will the firm correct the incentives that led to ex-ante inefficiencies in the disintegrated solution. If the incentives of the manager running the supplier's plant do not change, even if ownership does, the first order condition characterizing equilibrium (equation [11]) will remain unaltered. More precisely, call I(d) the choice of investment in the disintegrated solution. Hence, the first order necessary and sufficient condition characterizing equilibrium would be:

[11'] $$\frac{1}{2}R'(I(d)) = 1$$

Similarly, if incentives remain the same, calling I(i) the choice of investment under vertical integration, the first order necessary and sufficient condition characterizing equilibrium would be:

[11''] $$\frac{1}{2}R'(I(i)) = 1$$

And hence the ex-ante investment inefficiency would remain. Indeed, what is needed for vertical integration to change the incentives to holdup is that both firms and suppliers' profits be ex-ante contractible. The key is that in a set up of incomplete contracts, ownership means residual rights to control. That is, the right to control everything *not* included in the contract. If profits are not ex-ante contractible, ownership will not be able to change the incentives to holdup[11].

In any case, the experience of countries of high inflation economies do show an increase in vertical integration as a response to the disappearance of long-term contracts. An interesting accounts of facts in this respect is the one provided by Bresciani Turroni for

[10] The potential violation of this assumption in practice will not be, in general, an obstacle for vertical integration, since it is not unusual that the sector of suppliers be composed of a bunch of small firms (relative to the size of the producers of final goods).

the German big inflation of the early 1920s (see Bresciani Turroni, 1937, pp. 202-222). More recently, Kosacoff et al (1998, p.119, table 20) found, in a survey of industrial firms in Argentina after the 1991 stabilization, that among the major corporate strategies in the new stable environment a prominent one was vertical disintegration. That is, high inflation had led to 'too much' disintegration, relative to what is optimal in a more stable environment.

Given this, an important question is why, if we accept that there is some scope for vertical integration to mitigate the extent of the holdup problem, this strategy is generally seen as a poor substitute for LTCs in high inflation economies[12].

The model presented in this paper can shed light on this issue[13]. Assume that profits are ex-ante contractible, so that ownership matters. An important thing to notice is that the state sector can co-participate in the ex-post division of surplus by taxing the transfer price. Once the tax on the transfer price is in place, the state has incentives to build firewalls that impede vertical integration. There is, indeed, some anecdotal evidence consistent with this line of argument. On April 2nd, 2001, *La Nación* (one of the main Argentine newspapers) reports that with the goal of removing obstacles to investment, the Argentine government had introduced a decree to relax strict regulations that have governed mergers and acquisitions of firms for decades. Under the new regulation, when the amount of the purchase is less than 20 million dollars, authorization from the government is no longer required[14]. Roughly a decade of stability was needed to undo regulations designed to operate in an environment of high inflation. Just another piece of anecdotal evidence on the (persistent) non-neutralities stemming from high inflation!

5. Final Remarks

Taking the view that a high inflation episode can be summarized by a combination of inflationary finance of state enterprises' expenditures, the absence of an ex-ante state

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[11] See Grossman and Hart (1986) for a fully articulated theory of integration (both vertical and lateral) in the context of incomplete contracts.

[12] Again, see the discussion in Bresciani Turroni (1937) for a review of the German experience, or for a more recent account of the facts -with an eye in the Latin American experience with high inflation-, see Heymann and Leijonhufvud (1995).

[13] Any real world situation is, of course, much more complex than the model. I will therefore interpret my model with considerable latitude in what follows.

[14] Recall the content of footnote 5.

sector budget, and the existence of 'promotion' policies put in place by the state sector, this paper is able to explain three stylized facts of high inflation episodes: (i) a swift reduction in contract length, (ii) a reduction in specialization in production, and (iii) a fall in corporate investment.

The simple model presented in this paper has some main advantages. First, the model is explicit about the non-neutral way in which money is introduced into the system: through public enterprises' expenditures; indeed, this is one of the main ways in which money is introduced into the economic system in high inflation episodes. Second, the setup is explicit in modeling the relevant tradeoffs that corporations face in production and investment decisions in the highly uncertain environments characterizing high inflation episodes, in which some key aspects of that uncertainty are non-contractible. Moreover, the model is explicit about what those non-contractible aspects are.

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APPENDIX 1

This appendix contains the technicalities behind formula [5] in the text. It is designed to show why [5] makes sense on technical grounds.

Suppose we have a set of possible events whose probabilities of occurrence are tau 1, tau 2,…, tau n. These probabilities are known, but this is all we know concerning which event will occur. Is it possible to find a measure of how uncertain we are of the outcome? If there is such a measure, say S(tau1, tau 2,…, tau n), it is reasonable to require the following regularity conditions:

(i) S is continuous in the probabilities

(ii) If all the probabilities are equal, then S should be a monotonically increasing function of n, that is:

$$(A1-1) \qquad If \quad t_j = \frac{1}{n} \quad \Rightarrow S'(n) > 0$$

That is, with equally likely events there is more uncertainty when there are more possible events.

(iii) We require S to be a consistent measure of uncertainty in the following sense. If there is more than one way of working out its value, we must get the same value for every possible way. In other words, if a choice is broken down into successive choices, the original S should be the weighted sum of the individual values of S. suppose the agent perceives two alternatives, to which he/she assigns probabilities tau 1 and q=(1-tau 1). then the "amount of uncertainty" represented by this distribution is represented by S(tau 1,q). But now the agent learns that the second alternative really consists of two possibilities and he/she assigns probabilities tau 2, tau 3 to them, satisfying: tau 2 + tau 3=q. The process of deciding which alternative is true can be broken down into two steps. First, decide whether the first possibility is or is not true; the uncertainty removed by this decision is the original S(tau 1,q). Then, with probability q he/she encounters an additional uncertainty as to events 2, 3 leading to:

$$(A1-2) \qquad S(t_1, t_2, t_3) = S(t_1, q) + q\,.S(\frac{t_2}{q}, \frac{t_3}{q})$$

as the condition that we will get the same net uncertainty for either method of calculation.

Now, the following result can be established:

Shannon Theorem (Shannon, 1948)

The only S satisfying the three conditions stated above is of the form:

$$(A1-3) \qquad S = -K\sum_{j=1}^{n} t_i \log t_i$$

Where K is a positive constant.

The proof is a well-known, standard one, so I do not repeat it here. The interested reader is referred to Shannon (1948, appendix 2, pp. 28-29) or to a Probability Theory textbook, such as Jaynes (2000), chapter 11, pp. 1104-1113.

The information entropy of a probability distribution in the case of two events with probabilities tau and (1-tau) collapses to:

$$(A1-4) \qquad S = -[t \log t + (1-t)\log(1-t)]$$

It is straightforward to show that (A4) is maximized when tau=(1-tau)=1/2, that is when the probability distribution is uniform.

<u>Some interesting properties of S</u>

It is straightforward to show that S has some interesting properties which further substantiate it as a reasonable measure of uncertainty.

(i) S=0 if and only if all the tau's but one are zero, this one having the value unity. Thus, only when we are certain of the outcome does S vanish. Otherwise, S is positive.
(ii) For a given n, S is a maximum and equal to log n when all the tau's are equal to the reciprocal of n (1/n), which is intuitively the most uncertain situation as well.
(iii) Any change toward the equalization of the probabilities (the tau's) increases S. Thus if tau 1 < tau 2 and we increase tau 1 decreasing tau 2 an equal amount so that tau 1 and tau 2 are more nearly equal, then S increases.

These properties –very especially properties (ii) and (iii)- substantiate assumption [5] as a technically correct and meaningful one. They show that there is a well-defined maximum for uncertainty (technically, the information entropy of the probability distribution has a well defined, unique maximum), and the tendency towards the equalization of the probabilities imposed in [5] does indeed move the system in the direction of the unique maximum of the information entropy of the probability distribution.

APPENDIX 2

We need to prove that the attractiveness of long-term contracts enforcing the use of specialized technologies diminishes as public sector-induced uncertainty increases. Assume that tau is continuous and twice differentiable in sigma. Rearranging both [6a] and [6b] slightly and differentiating each of them with respect to sigma, yields:

$$[A2-1] \qquad \frac{d}{d\sigma}[E(R_1 - R_u)] = \tau'(\sigma).[w_{LTC,good} - w_{LTC,bad}].f^1(.) < 0,$$

$$Since\, \tau'(\sigma) < 0, when\, \tau > \frac{1}{2}$$

$$[A2-2] \qquad \frac{d}{d\sigma}[E(R_2 - R_u] = -\tau'(\sigma).[w_{LTC,good} - w_{LTC,bad}].f^2(.) < 0,$$

$$Since\, \tau'(\sigma) > 0, when\, \tau < \frac{1}{2}$$

Which completes the proof.

APPENDIX 3

We need to prove that, under the assumptions made in the text, public sector-induced uncertainty is a monotonically increasing function of the rate of money growth. This can be easily shown just by inspection of [5] and [8]. From [5] we know that sigma and z are linked in a linearly increasing fashion, as are -by [8]- z and the rate of money growth as well.

Proposition 2 can be also shown by elementary manipulation of [5] and [8]. Without loss of generality, normalize the average level of input purchases by the state sector to zero (assume that there are sales and purchases of inputs by the state corporations, and the balance is exactly zero) and assume that the state enterprises end up demanding only input j at t=1 (of course, this is not known as of t=0). Thus, using [5] and [8], we obtain (suppressing time sub-indexes):

$$[A3-1] \qquad s = \frac{m.m}{n}$$

An expression that admits differentiation with respect to the money growth rate:

$$[A3-2] \qquad \frac{d}{dm}[\frac{m.m}{n}] = \frac{m}{n} > 0$$

Given that n is a finite, positive number.

Which completes the proof.