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High inflation: resource misallocations and growth effects

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Abstract

I formalize some of the disruptive effects of inflation on the organization of markets. I also provide a rationale for the large number of bankruptcies and large turnover rates following successful inflation stabilization programs, like those of Israel, Bolivia and Argentina. Finally, I relate these "industrial organization" effects of inflation to the empirical findings on inflation and growth.

Rapid inflation induces buyers to speed up purchases, inhibiting the selection of more adequate trading partners through search. This has the effect of blurring the distinction across agents of different productivities, and leads to resource misallocations. The incentives to become more efficient are thus discouraged, and lower growth results.

1 Introduction

Mankiw (1994) quotes the following excerpts from an article on Bolivia in the *Wall Street Journal* (August 13, 1985, page 1): "When Edgar Miranda gets

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his monthly teacher's pay of 25 million pesos, he hasn't a moment to lose. Every hour pesos drop in value. So while his wife rushes to market to lay in a month's supply of rice and noodles, he is off with the rest of the pesos to change them into black-market dollars." "We don't produce anything. We are all currency speculators," a heavy-equipment dealer in La Paz says. "People don't know what's good and bad anymore. We have become an amoral society..."

Casella and Feinstein (1990) provide several anecdotes describing daily life during the German hyperinflation, telling how people armed with bundles of notes rushed into stores to buy the first thing they found. A similar pattern, at a lower frequency, is described in Heymann and Leijonhufvud (1993, specially chapter V "Living with high inflation") for the prolonged high-inflation experiences of Argentina, Brazil and Israel.

In this paper, I study the implications of one of the most salient characteristics of inflationary processes: depreciation of nominal balances induces buyers to speed up purchases. To capture this, I model product markets as search market. To participate, individuals have to carry nominal balances that depreciate with inflation. This depreciation induces buyers to hasten their decisions, in a way increasing the cost of selecting more adequate partners through search. One of the mechanisms by which a price system induces more efficient allocations is severed. In this way, I formalize the commonly held view that "inflation shortens agents' horizons," and I provide one rationale for the "disruptive role of inflation on the organization of markets."

It is common in countries that successfully stabilize their inflation rates, such as Bolivia and Israel in 1985 and Argentina in 1991, that substantial restructuring takes place. Bruno and Meridor (1991) describe a large number of bankruptcies and liquidations in Israel after disinflation, coupled with expansions in employment and output by other firms. They cite evidence that job turnover was higher in the years following the stabilization than in the four preceding years. Of course, stabilization programs (specially, successful ones) are a bundle of several complementary policy measures, including layoffs in the public sector and trade liberalization. It is commonly believed that, on top of the effects of these other measures, low inflation *per se* brings to light a set of real inefficiencies necessitating structural adjustment. In this paper I also formalize that view; in my model, the allocation of resources is a function of the inflation rate. In particular, at higher inflation more resources are channeled through less-efficient firms. In such a world, lowering inflation induces reshuffling of resources.

Several recent studies (for instance Fischer 1993) find a robust negative correlation of high inflation with growth. The model here provides one other rationale for those findings. The noise induced by inflation tends to reduce the relative profitability of more efficient firms. If growth is the outcome of the deliberate efforts of entrepreneurs to improve profits via innovation (cost reduction), then inflation leads to lower growth by reducing the return to efficiency-enhancing activities.

The formal study of high inflation cases can help to bridge the gap (Driffill et al., 1990) between people's intuition of the costs of inflation, and formal analysis. Mankiw (1994) includes the question of how costly is inflation and how costly its reduction, as one of the four most important unresolved questions of macroeconomics. Furthermore, as Orphanides and Solow (1990, p. 258) observe "the money-and-growth literature generally neglects issues that are taken seriously in studies of hyperinflation. To the extent that inflation damages the efficiency of transactions technology, the net productivity of real capital will be lower and so will the demand for capital. It seems unsatisfactory to treat such questions by simple dichotomy: to say that they matter at "high" rates of inflation and not at all at "low" rates of inflation. A more unified treatment will have implications for monetary growth theory."

2 Description of the Economy

I consider a discrete-time economy populated by an infinite sequence of three period lived overlapping generations. The model is phrased in this fashion for expositional and analytical simplicity. It should be interpreted as a sequence of paydays in which workers receive salaries and then go shopping. Each "generation" is identical in size and composition and consists of a continuum of agents with unit mass. Each agent is endowed with one unit of an input which he supplies inelastically to a centralized "labor" market.

Each agent is characterized by two parameters: a technology parameter θ (input requirement coefficient) and a preference (search) parameter β. Each individual sets up his own firm which produces with the technology

$$X = L/\theta.$$

L is the amount of input employed (purchased in the centralized market) and

X is output.

The parameter $\beta \leq 1$ captures a utility cost of search (impatience). In the tradition of the search literature, I use linear preferences[1]

$$U = X_1 + \beta X_2.$$

X_1 is consumption during the first search period (at "age" 2) and X_2 is consumption in the second search period (at age 3).

The inverse-of-productivity θ and the impatience factor β are independently distributed. In each generation, $\theta = \theta_L$ for half of the agents and $\theta = \theta_H > \theta_L$ for the other half, and β is distributed $\Phi(\beta)$.

The timing of actions over an individual's "lifetime" is the following. During the first period he sells his labor in a centralized input market and operates his firm (hiring labor, producing and selling output). In the second period, with cash in his pocket, he is matched to a seller (firm). At that point he has to decide whether or not to purchase from the seller (the decision depends on the price, to be determined). If he accepts the price, given the linearity of preferences, he spends all his cash there. If he rejects the price, in the third period he is randomly matched to another firm.

The product (search) market is where the model's action occurs.[2] On the monetary side, inflation will be introduced via monetary expansion. We will assume that the frequency of price changes is greater than the frequency with which agents receive their income. Although there are ways to protect assets against inflationary erosion, such protection is costly. The existence of such costs is a sufficient condition for the qualitative nature of our results to obtain. In terms of actual experiences, the descriptions in Casella and Feinstein (1990) and in Heymann and Leijonhufvud (1993) match our assumption.

Operationally, I assume the exchange technology depicted in Figure 1. Agents set up their firms at age 1. They receive customers who pay cash and order output. With part of that cash (profits are possible), the entrepreneur buys labor in the centralized input market, and then produces to fill the

[1] All the results are obtained at the extensive margin, with every agent at a corner –from linear preferences and a continuum of agents. As shown in the Appendix, the same aggregate results can be obtained with a strictly concave utility function and every agent at an interior solution. Notice also that this is a high-inflation model, so that the time between trips can be small, in which case perfect substitutability is a good approximation.

[2] The most vivid descriptions of people's suffering during episodes of hyperinflation are those of product markets.

order.[3] At the end of the period, agents of age 1 have cash (nominal income which equals wages plus profits). Also, some agents of age 2 (those who did not buy) carry their money balances into the next period.

The action starts again next period in which every agent of (now) age 2 (previous firm-owners/workers) receives a government transfer of $\mu^t - \mu^{t-1}$ pesos, with $\mu \geq 1$. This injection of money every period is the source of inflation. (Aggregate nominal money supply at time t equals μ^t, since each cohort has a unit mass of agents.)

3 Consumer Problem

Let I be the consumer's income which is the sum of wages, profits and a (real) government transfer T, which is received at the beginning of the second period of life, right before the first search. All variables will be expressed in terms of real purchasing power of first time searchers, so that

$$I = \frac{w}{\pi} + \frac{B}{\pi} + T, \tag{1}$$

where B are profits and π equals one plus the inflation rate.[4] Notice that profits and hence income will differ across individuals (wages and government transfers will not). In this section I refers to income of the individual under analysis. Given the simple functional forms chosen (see footnote 1) only average income will matter for equilibrium, so that in the next section I will stand for average (aggregate) income.

As I discuss below, we will be looking at an equilibrium in which half of the sellers (those with $\theta = \theta_L$) charge p_L and the other half charge p_H, where $p_H > p_L$. The product market has a "sequential search" structure. Buyers know the distribution of prices but not which price is charged by each store unless they go there and observe the price. A buyer is matched to a seller in his first "search" or "consumption" period and observes the price p_L or p_H. In principle, the set of feasible choices for X_1 is $[0, I/p]$. Given the linearity

[3] Notice that we are assuming that the exchange of labor for money as well as production take place instantaneously upon order. This simplifies the analysis by eliminating the role of inventories.

[4] I will be looking at a stationary monetary steady state, with a constant inflation rate equal to the rate of money creation.

of preferences, choice reduces to 0 or I/p, either not purchasing anything or spending all income. In this simple case of only two prices, consumers will always accept a quotation of p_L – in steady state the distribution of real prices is constant, and there are impatience and inflation losses from waiting to hear another price.

Turning to p_H, if the consumer accepts a high price he receives utility I/p_H, while if he rejects p_H his expected utility is

$$\beta\frac{I}{\pi}E(\frac{1}{p}) = \beta\frac{I}{\pi}\left[\frac{1}{2}\frac{1}{p_L} + \frac{1}{2}\frac{1}{p_H}\right].$$

With a more general price distribution, the equalization of the values of acceptance and rejection determines a reservation price as a function of parameters β and π. In this two-price distribution, impatient consumers accept any price and patient consumers accept only low prices. The marginal consumer is characterized by

$$\widehat{\beta} = \frac{2\pi}{\frac{p_H}{p_L} + 1}. \tag{2}$$

In this class of models (Benabou 1988, Tommasi 1994) consumer welfare is inversely related to reservation prices. In this two-price case, average consumer welfare is negatively related to the fraction $\widehat{\Phi}$ of non searchers, which is given by

$$\widehat{\Phi} = \Phi(\widehat{\beta}).$$

Two implications are already apparent from (2). First, consumer welfare is increasing in $\frac{p_H}{p_L}$ which is a measure of price dispersion. As it is common in the search literature, a spread is beneficial given the possibility of truncating the undesirable part of the distribution, as in Benabou (1988). Second, and more to the point, consumer welfare is decreasing in inflation, since $\widehat{\beta}$ increases with π. At higher inflation rates more consumers prefer to buy at the high price rather than waiting to hear a second quotation while their purchasing power depreciates.

4 Firms and Equilibrium

In order to compute the expected quantity sold by each type of firm, we have to consider the possible search outcomes for each type of buyer. Consumers with $\beta < \widehat{\beta}$ always accept the price they find in their first search, which equals p_L with probability 1/2 and p_H with probability 1/2. Consumers with $\beta > \widehat{\beta}$ accept any price in their second match; in the first match they only accept p_L; hence they purchase at p_L with probability 3/4, and at p_H with probability 1/4. Given the stationarity of the environment, the cross-sectional distribution of matches for the firms and the time-series distribution of matches for buyers are the same. From this we can easily compute the expected (and average) number of buyers that will purchase from any type of firm (i.e., the *extensive margin*). It is given by

$$n_L = \frac{1}{2}\widehat{\Phi} + \frac{3}{4}(1 - \widehat{\Phi}) = \frac{1}{2} + \frac{(1 - \widehat{\Phi})}{4} \tag{3}$$

and

$$n_H = \frac{1}{2}\widehat{\Phi} + \frac{1}{4}(1 - \widehat{\Phi}). \tag{4}$$

Low price firms have more customers (n_L) than high price firms (n_H) due to the behavior of *searchers* who are more likely to purchase at low prices. Equations (3) and (4) show that inflation, by increasing the fraction of non-searchers $\widehat{\Phi}$, has a *composition effect* in the wrong direction: more people buy from low productivity firms. In the end, given limited resources (inputs), this implies lower output and lower welfare.

In order to express total sales by firms of each type (X_L and X_H), we have to incorporate the *intensive margin* –the number of units sold to each buyer– which leads to:

$$X_L = \frac{1}{2}\frac{I}{p_L} + \frac{(1 - \widehat{\Phi})}{4}\frac{I}{\pi p_L} = \frac{I}{2p_L}\left[1 + \frac{(1 - \widehat{\Phi})}{2\pi}\right] \tag{5}$$

and

$$X_H = \frac{\widehat{\Phi}}{2}\frac{I}{p_H} + \frac{(1 - \widehat{\Phi})}{4}\frac{I}{\pi p_H} = \frac{I}{2p_H}\left[\widehat{\Phi} + \frac{(1 - \widehat{\Phi})}{2\pi}\right], \tag{6}$$

where I is average income (average purchasing power of agents in their second period). X_i represents *total* sales by all firms of type i. Expected sales for an individual firm of type i are $2X_i$.

Equations (5) and (6) characterize two points of what in a more general formulation would be a downward sloping demand (see for instance Tommasi 1992). Sales are decreasing in price due to the intensive and extensive margins. The usual way to study equilibria in these markets is to find the firm's optimal pricing given that demand curve, and to find the (fixed point) distribution of prices that makes the decisions of every consumer and every firm consistent. To simplify the exposition, I assume in the text that pricing policies are of the form $p = (1+m)\theta w$, a fixed markup rule with price equal $(1+m)$ times marginal cost (input requirement coefficient times input price). In the Appendix I discuss equilibria more generally.[5]

Input price w is obtained from the labor market equilibrium. Labor supply is inelastic at 1, and labor demand equals

$$X_L(w)\theta_L + X_H(w)\theta_H = \frac{I}{(1+m)w}\left\{\frac{1}{2} + \frac{(1-\widehat{\Phi})}{4\pi} + \frac{\widehat{\Phi}}{2} + \frac{(1-\widehat{\Phi})}{4\pi}\right\}$$

so that

$$w = \frac{I}{2(1+m)}\left\{1 + \widehat{\Phi} + \frac{(1-\widehat{\Phi})}{\pi}\right\}. \tag{7}$$

Aggregate profits equal

$$B = mw = \frac{mI}{2(1+m)}\left\{1 + \widehat{\Phi} + \frac{(1-\widehat{\Phi})}{\pi}\right\}. \tag{8}$$

Notice that if there is no inflation (no government transfers), then $\pi = 1$ and the wage bill plus profits equals aggregate income, $w\,(1+m) = I$.

Transfers from the government equal revenue from the inflation tax,

$$T \equiv \frac{(\mu^t - \mu^{t-1})}{P_t} = (\pi - 1)\frac{\mu^{t-1}}{P_t} \tag{9}$$

where P_t is the price level at time t, $(\pi - 1)$ is the inflation rate and

$$\frac{\mu^{t-1}}{P_t} = \frac{1}{\pi}\left[w + B + \left(\frac{1-\widehat{\Phi}}{2}\right) I\right] \tag{10}$$

are real balances.

It is easy (though tedious) to verify, using (7), (8), (9) and (10), that aggregate expenditure I equals aggregate income $(w/\pi + B/\pi + T)$. The

[5]There is no loss of generality in assuming the markup to be the same across firms with different θ. As explained in the Appendix, the results do not change if $m_L \neq m_H$, as long as $-\infty < \frac{d(\frac{p_H}{p_L})}{d\pi} < \frac{\frac{p_H}{p_L}+1}{\pi}$ in equilibrium.

rate of inflation ($\pi - 1$) equals the rate of money creation ($\mu - 1$),[6] and the demand for real balances μ^{t-1}/P_t is negatively related to the inflation rate, through the dependence of $\widehat{\Phi}$ on π. This velocity effect is a traditional *assumption* of high-inflation models, here (as in Casella and Feinstein 1990) derived endogenously.

5 The Effect of Inflation on the Efficiency of the Price System

It is widely believed, yet seldom analyzed formally,[7] that inflation affects the efficiency of the price system. Axel Leijonhufvud and David Laidler [8] have been advocating for a long time the view that inflation strikes at the heart of the price system in a monetary economy. More recently, Ball and Romer (1992) and Tommasi (1994) stress that one of the implications of (high) inflation is a reduced ability of the price system to screen out less efficient agents. They argue that, due to unstable real prices at high inflation, agents are more likely to enter the "wrong" relationships. In this paper I obtain a similar implication from the fact that inflation makes consumers eager to get rid of their money holdings. This increases the average reservation value at which they buy in such a way that the relative demand for goods from low-productivity firms increases –a *composition effect*.

From (5) and (6) we see that inflation increases the relative demand of high-cost firms. Given limited inputs (labor in this case), such a composition effect decreases output and welfare.[9] Total output is the sum of output from

[6]As stated before, I am ignoring all (expectationally-induced overlapping generations) equilibria other than the stationary monetary one.

[7]Notable exceptions are Cukierman (1982) and Katz and Rosemberg (1983). See also Carlton (1983) and Cukierman (1984). Fershtman and Fishman (1993) is a recent paper close in spirit to this one; they also focus on the microeconomics of trade under inflation, and on the disruption generated by currency depreciation.

[8]See for instance Leijonhufvud (1981) and Laidler (1978).

[9]The heterogeneous productivities in this model can be reinterpreted as firms having the same physical productivity (units of output per unit of input), but producing units of different quality (utility value). Alternatively, we can have heterogeneous tastes along a product space. In each of these interpretations, measured output can still be independent of, but welfare decreasing in, inflation. A close analog would be a marriage market in which we introduce an extra element of impatience. We will still have the same number

low- and high-cost firms. From (5) and (6),

$$\frac{\partial(X_L+X_H)}{\partial\pi}=\left[\frac{1}{p_H}-\frac{1}{2\pi}(\frac{1}{p_L}+\frac{1}{p_H})\right]\frac{I}{2}\frac{\partial\widehat{\Phi}}{\partial\pi}-\frac{1-\widehat{\Phi}}{4\pi^2}(\frac{I}{p_L}+\frac{I}{p_H}).$$

The second term captures the *intensive margin* and is, of course, negative. For $\pi<\overline{\pi}\equiv(p_L+p_H)/2p_L$,

$$\frac{\partial\widehat{\Phi}}{\partial\pi}=\frac{2p_L}{(p_H+p_L)}\Phi'(\widehat{\beta})>0$$

and $\left[\frac{1}{p_H}-\frac{1}{2\pi}(\frac{1}{p_L}+\frac{1}{p_H})\right]<0$, so that the first term is also negative (*extensive margin*). For $\pi\geq\overline{\pi}$, all consumers become non-searchers and further inflation has no extensive margin effect ($\frac{\partial\widehat{\Phi}}{\partial\pi}=0$ when $\widehat{\Phi}=1$).

6 High Inflation and Economic Growth

High inflation has a negative effect on economic growth. Recent papers that report such findings are Bruno (1993), Cardoso and Fischlow (1989), De Gregorio (1992), Fischer (1991) and (1993), Grier and Tullock (1989), Kormendi and Meguire (1985), and Wynne (1993). De Gregorio (1993) concludes that if inflation rates in Latin America had been half of 1950-1985 levels, per capita GDP growth would have been at least 25 percent higher.

Orphanides and Solow (1990) review the conventional Tobin-Sidrauski literature and conclude that Tobin-like effects are unlikely to be quantitatively significant when compared to the disorganizing consequences of rapid inflation. More recently, authors have been searching for channels through which high inflation negatively affects growth. Azariadis and Smith (1993) emphasize the impact of inflation on financial markets.[10] De Gregorio (1993) shows,

of marriages, but people will end up with less desirable partners on average.

[10]There is also an effect of high inflation on financial markets that operates through the phenomenom I characterize here: inflation introduces noise in the price system in such a way that makes it more difficult to screen agents of different productivities. De Gregorio and Sturzenegger (1993), building on the model of this paper, show how inflation moves the financial market in the direction of pooling equilibria -the ability of financial intermediaries to screen heterogeneous firms is reduced- which compounds the negative welfare effects described here.

following Stockman (1985), that the increased cost of holding money which is used to purchase new capital, increases the total cost of capital. Also, inflation tends to be associated with general macroeconomic uncertainty which Pindyck and Solimano (1993) show reduces the incentives to invest. (See also Huizinga 1993.) Another channel is the direct reallocation of resources (mainly entrepreneurial) to inflation-related activities, such as speculation and rent-seeking as firms and individuals spend valuable time trying to accelerate collections, delay payments, keep informed of the evolution of the exchange rate, etc. Sturzenegger and Tommasi (1993) study the growth implications of the allocation of entrepreneurs' time with special reference to Argentina. Furthermore, there could be an impact of chronic inflation on growth through a diminished degree of specialization when market transactions become more costly (see Cole and Stockman 1992 for a framework with specialization and endogenous transactions technologies).

This paper highlights an understudied channel by which inflation hurts growth. The "static" inefficiencies described in the previous section reduce the profitability of growth- enhancing entrepreneurial activities. One of the main implications of the model of the previous section is that the difference in profits between low-cost and high-cost firms is reduced.[11] Notice that profits of a firm of type i are

$$B_i = m\theta_i 2X_i \tag{11}$$

where $i = L, H$ and w is normalized to 1. From (5), (6) and (11) the difference in profits between low- and high-cost firms is $(1-\widehat{\Phi})\frac{mI}{(1+m)}$ which is decreasing in $\widehat{\Phi}$ and, therefore, in π.

From that blurring effect it is easy to see why high inflation negatively impacts growth. Following Grossman and Helpman (1991) and Schumpeter (1942), imagine that growth is the outcome of deliberate efforts by firms to improve their technology: lower costs, increase quality and/or create new products. In the model I will concentrate on lowering production costs.

[11] Inflation tends to blur the distinction among agents of different productivities. Several authors have argued that the inflation tax is a regressive one, given a superior ability of the rich to avoid it. Notice that I provide in this paper an argument by which inflation hits harder on more productive (hence richer) agents. There is evidence that, even after controlling for possible trade-offs with unemployment, people's aversion to inflation is increasing in income (see Mueller 1989, p. 289 and Mora y Araujo 1988.)

Assume that all firms start with a technology parameter θ_H. Before setting up production the entrepreneur/firm can spend resources trying to lower production costs, an activity subject to an uncertain return. If a firm devotes effort e (investment), it has a probability of 1/2 of lowering its costs from θ_H to $\theta_L = \theta_H/G(e)$, where $G(0) = 1$, $G' > 0$ and $G''' < 0$. There is a utility (leisure) cost of such effort, $c(e)$, where $c' > 0$ and $c'' > 0$. Old technologies can be copied freely by new firms (with a one period lag, not contemporaneously), so that $\theta_{Ht} = \theta_{Lt-1}$ and $\theta_{Lt} = \theta_{Lt-1}/G(e)$.[12]

The entrepreneur faces the decision of how much to invest trying to lower costs. I will analyze a symmetric (stationary) Nash equilibrium in which all firms in all generations invest the same amount e.[13]

Each firm solves

$$Max\{\frac{1}{2}[B_L(\theta_H/G(e)) + B_H] - c(e)\}$$

by choice of e, given the amount of effort chosen by all other firms. $B_L(\theta_H/G(e))$, the expected profit of a firm that invests effort e and is successful in lowering costs, equals

$$B_L(\theta_H/G(e)) = [p_L - \frac{\theta_H}{G(e)}]2X_L = [p_L - \frac{\theta_H}{G(e)}]\frac{I}{p_L}\left[1 + \frac{(1-\widehat{\Phi})}{2\pi}\right].$$

The solution to the investment problem requires equalization of the marginal cost and expected marginal benefit of investment:

$$2c'(e) = G'(e)\frac{\theta_H}{G^2(e)}\frac{I}{p_L}\left[1 + \frac{(1-\widehat{\Phi})}{2\pi}\right].$$

The left-hand side of the above equation is increasing in e (marginal cost) while the right-hand side (marginal benefit) is decreasing in e. The right-hand side is also decreasing in the inflation rate (remember that $\widehat{\Phi}$ is increasing in π), so that investment in cost reduction is decreasing in inflation.

[12]This assumption is made in order to obtain a stationary solution.

[13]The equilibrium is also a fixed point in π since now $\pi = \mu - g$ and the rate of growth g is itself a function of π through $\widehat{\beta}(\pi)$ and hence the differential profitability of low and high-cost firms.

To see that inflation negatively affects growth, notice that aggregate output equals $[X_{Lt} + X_{Ht}]$, and that

$$\frac{X_{Lt+1}}{X_{Lt}} = \frac{\theta_{Lt}}{\theta_{Lt+1}} = G(e) = \frac{\theta_{Ht}}{\theta_{Ht+1}} = \frac{X_{Ht+1}}{X_{Ht}}.$$

The rate of growth of the economy, $G(e) - 1$, is decreasing in inflation.

7 Concluding Remarks

Macroeconomists have been traditionally more concerned with the possible (positive) effects of inflation on output in the short run. On the other hand, development economists (and practitioners) agree on the negative impact of inflation on output and growth in the long run. This paper takes the task of formalizing some of these latter views, via comparative statics on the inflation rate in a model of steady inflation.

Inflation affects transaction technologies in ways that blur some of the efficiency properties of a market economy. In this paper traders speed up transactions to avoid the inflation tax. Hence, they spend less time in the search for an adequate match – which in the paper is a high productivity firm, but it represents any instance in which the social value of the transaction is match-specific. Aggregate welfare diminishes due to inadequate matching.

If growth is the result of entrepreneurs who try to distinguish themselves through better products, lower prices, etc., and inflation flattens the profile of rewards, then entrepreneurial activity and growth will be dampened.

One implication of the model is that if a country is successful in bringing down its inflation rate, substantial reallocations of resources and reshuffling of firms will occur.

The driving force of the results is the depreciation of currency inducing faster (and hence less-informed) decisions. However, the model has a building-blocks structure. If one were to replace currency depreciation with another mechanism forcing people to enter into trades with less information, the implications go through. One such mechanism is provided in Tommasi (1994) and Ball and Romer (1992) by the instability of relative prices induced by inflation. Ball and Romer frame and calibrate their model to moderate inflations. Hence, the results of this paper may also apply (to a lesser extent and for a smaller set of transactions) to moderate inflations.

8 Appendix

The results in the paper were obtained under the assumption that (real) prices are determined as a fixed markup over marginal cost. As usual, this was chosen for tractability. In a more full analysis, it would be standard to analyze a product market like the one in the paper with an equilibrium sequential search (ESS) model. That is, firms playing a Nash noncooperative game among themselves and a Stackelberg game against the buyers, who take prices as given. There are problems in trying to apply such protocol to this model. First, given the nature of the intensive margin (customers with unit-elasticity demands, fixed total expenditure), the optimal price with constant unit cost will be infinite. (This is particularly easy to see when thinking about old consumers.) Hence, we will need to add some frictions in order to get finite "monopoly" prices. Second, even with finite monopoly prices, a version of the problem known as the Paradox of Diamond appears: as long as the monopoly price is independent of the (heterogenous) marginal cost, there is no dispersed price equilibrium.[14]

Below, I provide an example in which I introduce a second (walrasian) good, as well as allowing for concave utility functions. I show that the results in the text - namely (1) price dispersion exists and (2) inflation induces a composition effect against good firms - obtain in a fully optimizing "search" setup.

8.1 Example:

Consumers:

We introduce now a second good Y, traded in a walrasian market, with price normalized to 1. Also, we make preferences strictly convex in X_1 and X_2. The general formulation of preferences is now

$$U_1(X_1, Y_1) + \beta U_2(X_2, Y_2).$$

It is intuitively clear that, since convexity of preferences leads to interior choices, the heterogeneity of discount factors is no longer necessary for our results. To save on notation we will assume $\beta = 1$.

[14] See McMillan and Rothschild (1993), Bagwell and Ramey (1992), and Benabou (1990 and 1993) for a fuller treatment of conditions for existence of dispersed price equilibria in sequential search models.

As before, we will have two types of firms (1/2 of each type) and two prices in equilibrium. Consumers are matched to one firm each period. Consumers have memory of prices, so that once they find a low-price location, they patronize it repeatedly (see Tommasi 1994). In such a set up, consumers will face a low price with probability 1/2 the first period, and with probability 3/4 the second period. If we had a longer horizon, the sequence will continue 7/8, 15/16, 31/32 and so forth. The chances of finding a low price are increasing over time and become 1 in the limit. In order to simplify the algebra and without loss of generality, I will capture this result by assuming that consumers are matched with a high-price store (with probability 1) in their first search, and with a low-price store (with probability 1) in their last (second) search. Notice that this implies $X_1 = X_H$ and $X_2 = X_L$.

Think for a minute about the second search. The fact that we have now another good will give us a finite equilibrium price (p_L in this case) if and only if the elasticity of substitution is greater than one (Cobb-Douglas utility functions give elasticities of substitution of 1, constant expenditure on each good, and hence infinite monopoly prices.) The simplest case is that of perfect substitutes (infinite elasticity of substitution), in which case we pin down $p_L = p_y = 1$.[15]

To simplify the exposition we specify the utility function to take the form:

$$\frac{1}{\alpha}\left[(X_1)^\alpha + (X_2 + Y_2)^\alpha\right], \tag{12}$$

with $\alpha \in (0, 1)$. We omit Y from first period preferences by assuming that it is available only to old consumers.[16]

All of the above, together with the extra assumption that when $p_L = p_y$ consumers purchase just X and no Y, leads to Y not being produced in equilibrium. Hence, our general equilibrium analysis in the text needs no modification.

Then, and specifying $\alpha = 1/2$, we can rewrite (12) as

[15] By pinning down the low price and allowing the high price to be increasing in inflation we are taking the worst possible scenario for our case, since only p_H/p_L sufficiently increasing in inflation could revert our "composition" results.

[16] If we were to assume X_1 and Y_1 perfect substitutes, we would be pinning down also p_1 and we will not be able to tell our imperfect-competition story. Introducing Y_1 as an imperfect substitute will just add to the algebra without substantial changes in the results.

$$2\left[(X_1)^{1/2} + (\frac{I - p_H X_1}{\pi})^{1/2}\right].$$

Maximizing with respect to X_1 gives

$$X_1^* = \frac{I}{\frac{p_H^2}{\pi} + p_H} \tag{13}$$

and

$$X_2^* = \frac{p_H}{\pi(\pi + p_H)} I. \tag{14}$$

Firms:

Remember that $X_1 = X_H$ and $X_2 = X_L$. From (13) and (14) it seems that X_L is decreasing, and X_H increasing, in π. We proceed now to solve for the optimal price p_H, to verify that the results obtain when we allow for the endogeneity of prices.

Using (13) we can write the profit function of high-cost firms as

$$B_H(p_H) = \frac{(p_H - \theta_H)}{\frac{p_H^2}{\pi} + p_H} I.$$

Maximizing with respect to p_H we obtain, after some manipulation:

$$p_H^* = \theta_H + \sqrt{\theta_H^2 + \pi\theta_H}. \tag{15}$$

For low cost-firms, using (12), (14) and $p_y = 1$, we obtain the profit function

$$B_L(p_L) = \begin{cases} \frac{(p_L - \theta_L)p_H}{\pi(\pi + p_H)} I & \text{for } p_L \leq 1 \\ 0 & \text{for } p_L > 1 \end{cases},$$

which (assuming $\theta_L < 1$) is maximized at $p_L = 1$, as stated.

Using (13), (14) and (15) it is easy to verify that, in equilibrium:
(i) X_L is decreasing in π.
(ii) X_H is first increasing and later decreasing in π.
(iii) X_L/X_H is monotonically decreasing in π.

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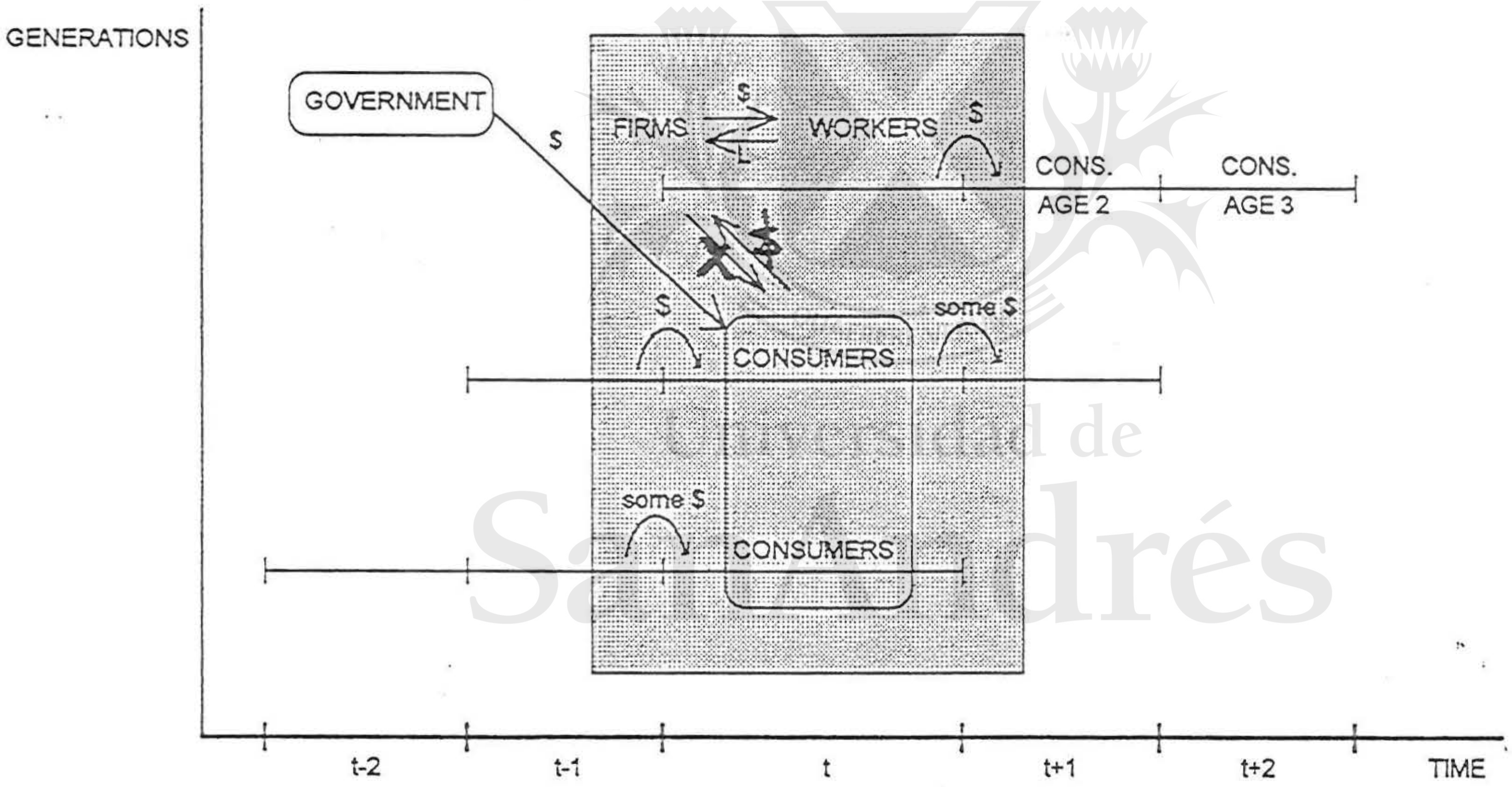


FIGURE 1

TEMPORAL ARRANGEMENT OF AGENTS AND TRANSACTIONS

ANEXO

1. THE ECONOMIC ENVIRONMENT

- overlapping generations, each lives 3 periods
- Each generation: $[0,1]$ entrepreneurs (x)

  $[0,1]$ "workers"

PREFERENCES: $$\left[X_1^{\rho}+Y_1^{\rho}\right]^{1/\rho}+\left[X_2^{\rho}+Y_2^{\rho}\right]^{1/\rho} \qquad (1)$$

ENDOWMENTS: ("workers"): 1 unit of L

TECHNOLOGY: (everybody) $\cdot\ Y = L$

(entrep) $\cdot\ X(i) = L(i)/\theta(i)$

$$\theta(i)=\begin{cases}\theta_L & [1/2]\\ \theta_H & [1/2]\end{cases}$$

· figure 1 (1 match per cons. period)

2. THE CONSUMPTION DECISION

$I(i)$

y IS THE NUMERAIRE $p_y = 1$

max (1) s.t.

- $I \geq p_1 x_1 + y_1 + \pi m$
- $m \geq p_2 x_2 + y_2$

$$p_t = \begin{cases} p_L & [1/2] \\ p_H & [1/2] \end{cases}$$

Intraperiod utility function CES $\Rightarrow$ IUF is linear in expenditure. (Varian 1984)

Easy to show: (let $g(p) = \dfrac{p^{r-1}}{1+p^r}$ where $r = \rho/(1-\rho)$)

· If $p_1 = p_L \Rightarrow$

$$(i) \begin{cases} m = x_2 = y_2 = 0 \\ x_1 = g(p_L)\, I(i) \\ y_1 = \dfrac{1}{1+p_L^r}\, I(i) \end{cases}$$

· For $p_1 = p_H$:

Let $f(p) = (1+p^r)^{-1/r}$

If $\quad f(p_L) + f(p_H) > 2\pi f(p_H) \qquad$ (Case A)

then

$$
(ii)\begin{cases} x_1 = y_1 = 0 \\ x_2 = g(p_2)\, I(i)/\pi \\ y_2 = \dfrac{1}{1+p_2^r}\, I/\pi \end{cases}
$$

If $\quad f(p_L) + f(p_H) \leq 2\pi f(p_H) \qquad$ (case B)

then (i)

3. FIRMS AND EQUILIBRIUM IN THE MARKET FOR X

Assume $\{p_L, p_H\}$ $\qquad I = I_w + \frac{1}{2} I_L + \frac{1}{2}$

Case A:

$$x_L = g(p_L)\, I\left(1 + \frac{1}{2\pi}\right) \equiv x_L^A(p_L)$$

$$x_H = g(p_H)\, I\,(1/2\pi) \equiv x_H^A(p_H)$$

$$\max_{p_i} \; (p_i - \theta_i)\, x_i(p_i)$$

F.O.C. $\Rightarrow$

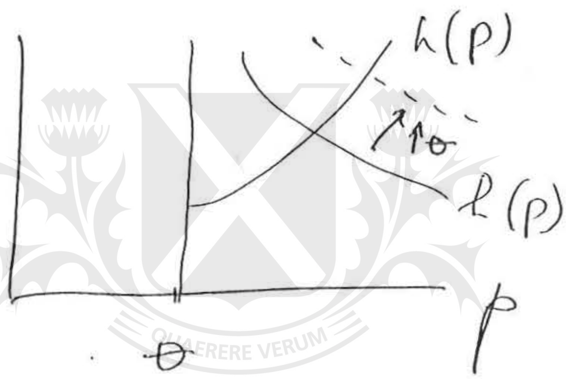
$$\boxed{r \frac{p^r}{1+p^r} + (1-r) = \frac{p}{p-\theta}} \quad (3)$$

(FOR $r<0$)

$\exists!\, p < \infty$

$\frac{\partial p}{\partial \theta} > 0$

$$h(p) = \ell(p)$$



$\Rightarrow p^*(\theta)$

example : $r = -1 \; (\rho = 1/2) \Rightarrow p^* = \theta + \sqrt{\theta(\theta+1)}$

Case B:

$$x_L = g(p_L)\, I \equiv x_L^B(p_L)$$

$$x_H = g(p_H)\, I \equiv x_H^B(p_H)$$

It is easy to see that profit maximizing prices are $p^*(\theta)$ in (3)

PROPOSITION: (Equil in market x)

we characterize [illegible] of π, precisely because it is, at the end, the "param" of interest

for $\pi < \tilde{\pi}$: $\left\{ p_L^*, p_H^*, x_L^A(p_L^*), x_H^A(p_H^*) \right\}$

for $\pi \in [\tilde{\pi}, \pi^B]$: $\left\{ p_L^*, \tilde{p}_H, x_L^B(p_L^*), x_H^B(\tilde{p}_H) \right\}$

for $\pi > \pi^B$: $\left\{ p_L^*, p_H^*, x_L^B(p_L^*), x_H^B(p_H^*) \right\}$

where:

- $\tilde{\pi}$ solves $\left\{ (p_H^* - \theta_H)\, x_H^A(p_H^*) \gtrless (\tilde{p}_H - \theta_H)\, x_H^B(\tilde{p}_H) \text{ as } \pi \lessgtr \tilde{\pi} \right\}$

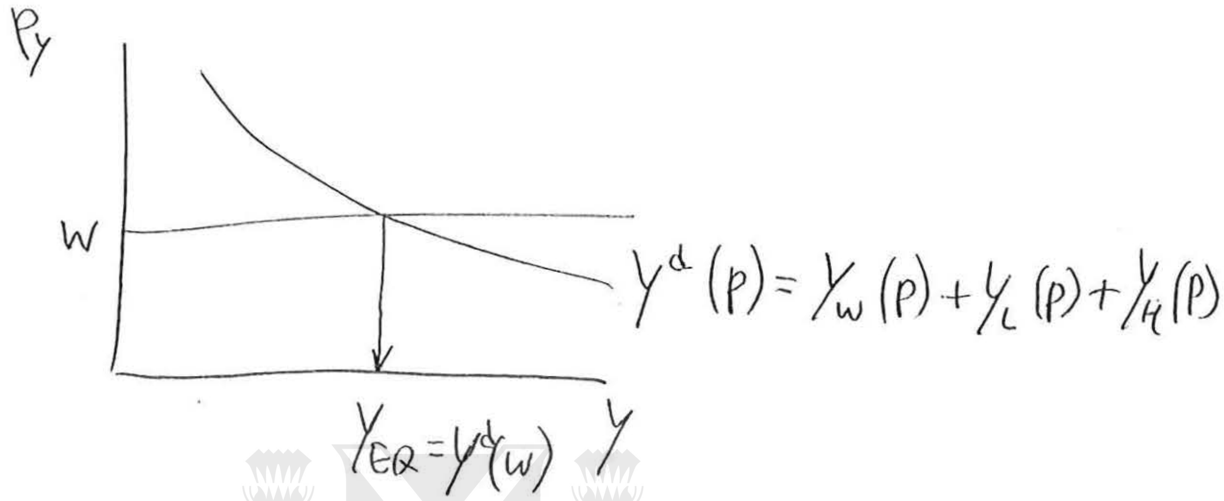
- $\tilde{p}_H = \left[\dfrac{(1 + p_L^{*r})}{2\pi - 1} - 1 \right]^{1/r}$ → (just induces consumers to purchase at $p_1 = \tilde{p}_H$)

- $\pi^B = \dfrac{f(p_L^*) + f(p_H^*)}{2 f(p_H^*)}$

$f_L + f_H = 2\pi f_H$

4. General Equilibrium

4.1. Market for Y: $(Y = L_Y)$ (walrasian)



Since $Y_j(p)$ is decreasing & continuous for $j = W, L, H$

$$\Rightarrow \exists! \quad \boxed{Y_{EQ} = Y^d(w)}$$

$$\& \quad \boxed{P_Y = W}$$

(NUMERAIRE $P_Y = W = 1$)

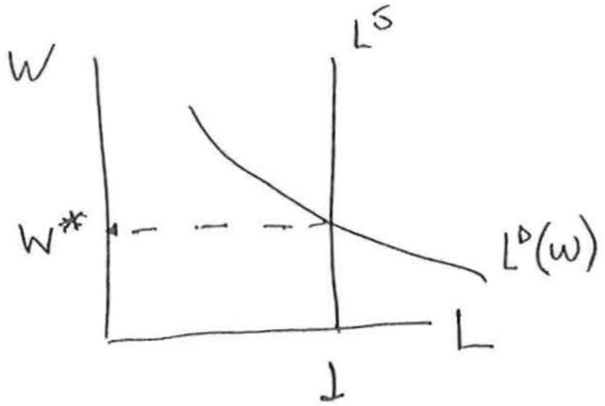
4.2. "Labor Market":

$$L^S = 1$$

$$L^D = L_Y^D + L_L^D + L_H^D$$

$$L^D = Y(w) + X_L\left(p^*(\theta_L w)\right)\cdot\theta_L + X_H\left(p^*(\theta_H w)\right)\cdot\theta_H \quad (4)$$

each piece is $\left|\begin{array}{l}\text{decreasing}\\\text{continuous}\end{array}\right. \Rightarrow \exists!\ W^*$



4.3. Transfers and Income

$$I = I_W + I_L/2 + I_H/2$$

$$I_W = \frac{1}{\pi} + T$$

$$I_L = \frac{Prof(L)}{\pi} + T$$

EQ. A

$$Prof(L) = b_L \left(1 + \frac{1}{2\pi}\right) I_A(\pi)$$

$$Prof_H = b_H \frac{1}{2\pi} I_A(\pi)$$

EQ. B

$$Prof(L) = b_L \, I_B(\pi)$$

$$Prof_H = b_H \, I_B(\pi)$$

$$b_L = (p_L - \theta_L)\, g(p_L)$$ ("profit per customer")

$W(I, \pi) = 1 \implies I(\pi)$

(from labor market equil (4))

EQ. A

EQ. B

$$Y_A(w) = \left[g(w, p_L^*)\left(1 + \frac{1}{2\pi}\right) + g(w, p_H^*)\left(\frac{1}{2\pi}\right)\right] \frac{I_A(\pi)}{2}$$

where $g(a, b) = \dfrac{a^{r-1}}{a^r + b^r}$

$$Y_B(w) = \left[g(w, p_L^*) + g(w, p_H^*)\right] \frac{I_B(\pi)}{2}$$

$X_L^A = g(p_L, w) \dfrac{I_A}{2}\left(1 + \dfrac{1}{2\pi}\right)$ $\qquad X_L^B = g(p_L, w) \dfrac{I_B}{2}$

$X_H^A = g(p_H, w) \dfrac{I_A}{2} \dfrac{1}{2\pi}$ $\qquad X_H^B = g(p_H, w) \dfrac{I_B}{2}$

from $\begin{cases} \cdot L^D = L^S = 1 \\ \cdot w = 1 \\ \cdot (4) \end{cases} \implies$

$$I_A(\pi) = \frac{2}{\left(1+\frac{1}{2\pi}\right) e_L + \left(\frac{1}{2\pi}\right) e_H}$$

$$I_B = \frac{2}{e_L + e_H}$$

where $(j = L, H)$

$$e_j = \frac{1 + \theta_j p_j^{r-1}}{1 + p_j^{r}} < 1$$

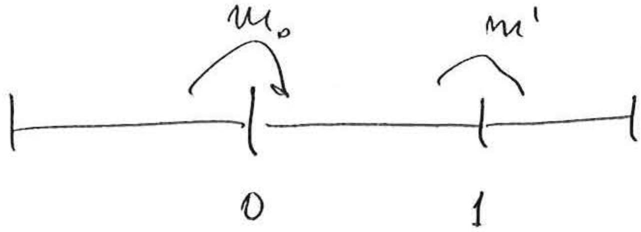
$(e_L > e_H)$

$$T \equiv \frac{\Delta M_t}{P_t} = \frac{M^t - M^{t-1}}{P_t} = (\pi - 1)\, m$$

(stationary equil : $\pi = \mu$)

$$m = \frac{M^{t-1}}{P_t}$$

$$m = m_w^0 + \frac{1}{2} m_L^0 + \frac{1}{2} m_H^0 + m_w^1 + \frac{1}{2} m_L^1 + \frac{1}{2} m_H^1$$



$$I_j = \frac{i_j}{\pi} + T$$

$j = L, H, W$

$$m_j^0 = i_j^{EQ}$$

$i_W = 1$ $i_L = PROF_L$

$i_H = PROF_H$

$$m_j^1 = \begin{cases} 0 & p_1 = p_L \\ I_j & p_1 = p_H \end{cases}$$ for equil A

$$m_j^1 = 0$$ for equil B

$$m^B = 1 + \frac{1}{2} b_L I_B + \frac{1}{2} b_H I_B$$

$$m^A = \left[1 + \frac{1}{2} b_L I_A(\pi) + \frac{1}{2} b_H I_A(\pi)\right]\left(1 + \frac{1}{2\pi}\right) + \frac{T}{2} \quad (5)$$

EQ. B:

$$I_W = \frac{1}{\pi} + (\pi - 1)\left[1 + (b_L + b_H)\frac{I_B}{2}\right]$$

$$I_j = \frac{b_j I_B}{\pi} + (\pi - 1)\left[1 + (b_L + b_H)\frac{I_B}{2}\right]$$

$j = L, H$

EQ. A:

$$T_A = (\pi - 1)\, m^A$$

using (5) =>

$$T_A = \frac{(\pi - 1)\left(1 + \frac{1}{2\pi}\right)}{\left[1 - \left(\frac{\pi - 1}{2}\right)\right]}\left[1 + (b_L + b_H)\frac{I_A(\pi)}{2}\right]$$