NBER WORKING PAPERS SERIES

HIGH INFLATION AND THE NOMINAL ANCHORS OF AN OPEN ECONOMY

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Working Paper No. 3518

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 1990

NBER Working Paper #3518
November 1990

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ABSTRACT

A high inflation process is usually due to a real imbalance and cannot be cured without a correction of real fundamentals. Yet it can be characterized as a quasi-stable nominal process which gets divorced from the real system in what Patinkin could call a valid classical dichotomy. This paper extends the existing seignorage model approach to multiple inflationary equilibria by rationalizing a high inflation equilibrium as well as its stability as the outcomes of sub-optimization by a 'soft' government. It considers the advantages as well as the weaknesses of using the exchange rate as the key nominal anchor in the various stages of stabilization to low (or zero) inflation. Finally the rationale for using multiple nominal anchors is also discussed. Applications of the theoretical arguments are illustrated from recent high inflation and stabilization experience.

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HIGH INFLATION AND THE NOMINAL ANCHORS OF AN OPEN ECONOMY*

I. Introduction: Between Garden Variety and Hyperinflation

It has given me great pleasure to be able to commemorate a great economist by giving a talk on a subject that lies close to one of his great contributions — Graham's (1930) pioneering study on hyperinflation in Germany during 1920–23. Much of my talk will relate to a somewhat different, albeit extreme, inflationary process — high (chronic) inflation and its stabilization. This was not known in Graham's days but, I am sure, he would have loved to study, given his interests, were he living 60 years later, in our time and age.

Graham starts the preface to his book by referring to a remark of Cliffe-Leslie's that in social matters the greatest scientific progress is made when economic disorders raise vexing questions as to their causes. He continues by saying:

> In the study of social phenomena, disorder is, it is true, the sole substitute for a controlled experiment in the natural sciences. But it sometimes happens that, in the midst of disorder, events move so rapidly that we are not able properly to absorb them; disorder may be excessive even to the most detached of scientists. The course of inflation in Germany in the first post-war quinquennium had so much of this character that it has seemed to many to be incapable of throwing any light upon monetary problems. This most striking of monetary experiences has in consequence evoked a minimum of scientific curiosity....

There follows a footnote that substantiates this last sentence from the vantage point of the 1920s — in a chapter on the "The Banking System of Germany," which appeared in 1929 in a book titled *Foreign Banking Systems*, it is declared that "it would

be useless to try to connect the development of the German currency from 1919 to 1923 with any theories of money...."

In hindsight this statement does indeed sound even more strange than it did to Graham, as the German hyperinflation has subsequently become one of the most researched episodes in monetary history and theory — vide the endless stream of papers and monographs on the subject which continues to appear to this very day. Frank Graham was undoubtedly a pioneer in this matter.

There are two topics in Graham's study that remain relevant in our present context even though the dynamic process to be discussed will be a different one. One has to do with the circular process of prices, the exchange rate and money chasing each other. The question of causality in the process occupied Graham's mind. Econometric techniques were not known at the time yet he tried in his own way to trace leads and lags in the data. The second issue pertains to the costs and benefits of extreme inflation, to which we shall turn below. Graham maintained the surprising view that inflation benefitted Germany because it helped to erode the real value of the required reparation payments. The motivation for high chronic inflation is somewhat different but the basic notion that one has to look also at the benefits (to the government) of inflation versus its social costs will still apply.

While the German hyperinflation displayed very extreme dimensions (at the height of the crisis, in October 1923, prices increased by almost 30,000 percent!) it was not the only case in its category. Cagan's (1956) definition of hyperinflation (monthly rates over and above 50 percent, amounting to five digit annual inflation of more than 13,000 percent) covers several other European episodes in the 1920s (see Table 1 and Figure 1) and also in the 1940s (not shown here; see Yeager, 1981). Hyperinflations of similar magnitude occurred again in very recent history — Bolivia (1983–85), Argentina and Brazil (after their respective 1985–6 stabilization programs collapsed) as well as in Yugoslavia and Poland (1989) (see Table 2 and Figure 2). The common characteristic of all of these episodes is their relatively short and highly explosive nature. Even if we broaden the definition of the range of the process as

applying to sustained monthly inflation rates above 25 percent (which amounts to more than an annual four-digit rate of 1,455 percent) the German hyperinflation lasted only 20 months while the other three major episodes of the 1920s mentioned here lasted only between 9 and 16 months. This was also the length of the process in Bolivia as well as in Argentina and Brazil (at least until the beginning of 1990 — see Table 2).

The relatively short duration of the hyperinflation phenomenon is closely related to its highly unstable, dynamically explosive nature. It represents in most cases a virtual collapse of the monetary system which can only be cured by a sharp fiscal and monetary reform. It is important to bear these facts in mind when considering another type of relatively extreme, yet somewhat different, inflationary process to which the cumulative experience of the 1970s and 1980s has drawn our attention, that of high (chronic) inflation. This is a much more prolonged and more stable process which could last up to 5 or even 8 years and show monthly rates of inflation between 5 and 25 percent, or annual three digit rates — see Table 2 for the case of Chile before 1979 and that of Argentina, Brazil and Israel before 1985 and Mexico before 1988. While the origin of high inflation, as in the case of its more extreme hyper brother is the existence of a large public sector deficit, the quasi-stability of this dynamic process comes from an inherent inertia which is strongly tied up with a high degree of indexation or accommodation of the key nominal magnitudes — wages, the exchange rate and the monetary aggregates — to the lagged movements of the price level. It is the way an inflation-prone system attempts to protect itself from the evils of inflation, thus giving it a longer lease on life and delaying its more fundamental cure.

Moderate versions of chronic inflation, having some of the same indexation or monetary accommodation characteristics already appeared in Latin America in the 1950s (see Pazos, 1972). However, as long as inflation stayed below a monthly rate of, say, 5–6 percent (which corresponds, roughly, to no more than a two-digit annual rate) its cure could be gradualist, as in the case of the garden variety, more conventional type, of inflation. It is the large external shocks of the 1970s and 1980s (oil

shocks and debt crises) which brought about the new species of galloping, yet for a time quasi-stable, rate of inflation in the three-digit annual range. Its cure is unlikely to be feasible in a gradualist manner while its shock therapy in some sense tends to be more complicated than that of a hyperinflation because there is a persistent inflation memory that has to be broken in addition to the sharp fiscal reform. On the other hand, if it is not terminated in time or if its stabilization attempt fails, the high inflation process is most likely to lead eventually to a 'classic' hyperinflation, as the recent case of Argentina and Brazil illustrates.[1]

The various types or stages of inflation outlined here — roughly corresponding to the number of digits of annual inflation — can, in fact, be sequenced by the existence or absence of some key institutional or behavioral attributes. Failure to stabilize a stage I 'garden variety' inflation plus systematic indexing (and/or monetary accommodation) may lead to chronic inflation (stage II). In the presence of large price shocks this may in turn lead to high (chronic) inflation (stage III). Failure to stabilize the latter will eventually move the system into hyperinflation (stage IV). Countries can, of course, move from stage I (or II) to stage IV directly without going through stage III at all. This was the case for most 'classic' hyperinflations and most probably also applies to the most recent hyperinflations of Eastern Europe like Yugoslavia and Poland where liberalization of a repressed price system could lead to hyperinflation almost at once.

The reason for focusing theoretical and policy-oriented interest on high chronic inflation comes from the fact that it exhibits a case in which, almost independently of the size of the real budget deficit (the 'real anchor') the dynamic nominal process may live a life of its own, the system having lost its 'nominal anchor'. Such type of 'disorder' can be well grounded in the fundamentals of the neoclassical monetary system. A mental experiment that any student of Patinkin's *Money, Interest and Prices* was taught in his youth (at least in Israel) was the following: "double the quantity of money and that of all nominal prices and the real system will stay invariant". This, of course, is nothing but an expression of the basic homogeneity postulate of the

neoclassical model which underlies the absence of money illusion, the neutrality of money as well as the so-called nominal–real dichotomy. Was this particular 'nominal doubling' experiment destined to remain only a mental exercise? As it turned out — twenty years later an almost ideal laboratory experiment offered itself in Patinkin's own country.

In early 1981, in observing the inflationary process in Israel, it occurred to me that we may be in the midst of an *actual* 'experiment' of this kind. For two years Israel had been running a more or less stable inflation rate of 130 percent per annum (7 percent per month),[2] up from an annual 6–7 percent in the 1950s and 1960s, and accelerating two-digit inflations throughout the 1970s. By now a nominal 'annual doubling' process was going on which seemed divorced from the real economy and almost running a life of its own, though it was originally rooted in the real system and eventually almost ruined it. All nominal variables — prices, wages, nominal assets and the exchange rate — were moving in a quasi steady state. Nominal or real shocks could change this steady state rate of inflation (which indeed they did), yet the same real system, including a persistent, reasonably stable, government deficit of the order of 15 percent of GNP, was consistent with several rates of inflation. A similar phenomenon had been observed at the time in Brazil, whose inflation profile before 1985 is almost identical with Israel's as well as in Argentina and more recently in Mexico and a number of other countries, which have likewise 'lost their nominal anchor' (see Figure 2).

It is important to stress that this phenomenon is relatively new. It is different from the much studied short and explosive hyperinflation process, in being much more stable and therefore sustainable for a longer period. It also differs from the 'garden variety' inflations in exhibiting relatively small changes in relative prices compared to the nominal ones. One manifestation of this property is the virtual disappearance of short-term Phillips curve tradeoffs.

This phenomenon could simply not persist for any length of time were it not for the inherent capability of exhibiting a nominal–real dichotomy. At an inflation rate

of 7 percent a month, for example, a nominal wage inflation of less than 6 percent a month, say, would imply a cumulative real wage drop of over 12 percent within a year. This would obviously and eventually be resisted by wage earners and a corrective formal or informal improved indexation mechanism would set in. Similarly for the real erosion of the money stock, which would eventually be accommodated even by a moderately independent central bank, or erosion of the real exchange rate, whose repercussions on the loss of foreign exchange reserves would soon be felt, in the absence of a crawling devaluation at a rate more or less equal to the inflation rate. In other words, once inflation reaches a high rate, unless a short-lived explosive or implosive situation quickly develops institutional and policy mechanisms must set in which in turn perpetuate inertia and a quasi-stability of the kind mentioned.

Given the empirical existence of a high inflation process there are two important sets of questions to be asked. The first is in the area of positive economics. Is a high inflation rate itself a random walk or can it be determined as an equilibrium solution to some rational (real) process? If such equilibrium exists is it unique (the answer usually is 'no') and what are its (or their) stability properties? Considerable literature has developed in this area in recent years, based on a seignorage deficit finance framework (see Liviatan, 1983; Sargent and Wallace, 1987; Bruno and Fischer, 1990) but it is as yet incomplete. We shall here extend the existing discussion somewhat and motivate the existence of high inflation and its relative stability as the outcome of suboptimization by a 'soft' government.

There follows an obvious second set of normative policy questions. An inflationary process of the kind mentioned must have its roots in some fundamental disequilibrium of the real economy, invariably a sustained government and/or current account deficit. Once this gets corrected it in itself is no guarantee that the inflationary process will not persist by force of inertia, sluggish expectations or lack of credibility. Remember — there is nothing in the dichotomous system to make such outcome inconsistent with the real fundamentals unless the institutional arrangements that have perpetuated the dynamic nominal process are also broken. The very nature

of the process described would suggest that there is room for a coordinated 'shock' program that will simultaneously shift the system from high inflation to a new zero (or relatively low) level equilibrium so as to avoid sharp and destabilizing changes in relative prices. This is the conceptual basis for the so-called 'heterodox' stabilization program. What then is the main nominal anchor (or several anchors) and set of rules on which the new equilibrium must be based? Could the choice of anchors change with the stage of disinflation?

The next section (II) takes up a simple open economy extension of the basic macro model and considers alternative price *level* anchors. The subsequent section (III) looks at the case of steady state inflations, and the nature of alternative equilibria. This is followed (section IV) by the issue of the choice of nominal anchors in the context of *rate* stabilization — what are the pros and cons of using the exchange rate rather than a monetary aggregate as the key stabilizer. How is that related to wage stabilization policy and more generally can a case be made for the choice of more than one anchor even though the system could then be overdetermined? We end with some empirical observations based on recent policy experience.

II. The Neo-classical Framework and the Nominal-Real Dichotomy

Absence of money illusion, the neutrality of money as well as the so called valid nominal-real dichotomy (see below) all stem from the basic homogeneity postulate — excess demand functions in each and every market are homogeneous of degree zero in all nominal variables or, in other words, are functions only of real (or *relative* price) variables. General equilibrium will in general determine a unique solution for the real variables (and, with some Samuelsonian assumptions, also their stability). The price level, however, remains indeterminate unless one other nominal variable (e.g., the money stock or the nominal wage or, in an open economy, the nominal exchange rate) is fixed. The latter lies at the heart of the concept of a 'nominal anchor'.

In this context one may invoke Patinkin's (1965) important distinction between the 'invalid' and 'valid' classical dichotomies:

> It is fatal to succumb to the temptation to say that relative prices are determined in the commodity markets and absolute prices in the money market. This does not mean that value theory cannot be distinguished from monetary theory. Obviously, there is a distinction; but it is based on a dichotomization of *effects*, not on a dichotomization of *markets*. (Patinkin, 1965, Ch. VIII, p. 181.)

It is the latter, valid nominal–real dichotomy which is the relevant one for our present context.

Consider first a simplified closed economy model which could conveniently be summarized in two excess demand schedules for the labor and commodity markets respectively:

$$L(W/P;\ A_l) = 0 \qquad (1)$$
$$-$$

$$Y(W/P,\ M/P;\ A_y) = 0\ . \qquad (2)$$
$$+\quad +$$

W, M, P are the nominal wage, aggregate money stock and price level, respectively. A_l and A_y are exogenous shift factors for the labor and commodity market excess demand schedules, respectively (e.g., the capital stock and productivity. A_y also includes demand shift factors like fiscal policy). The absence of the interest rate as a separate variable could be justified in terms of Patinkin's (1965) model (Chapter IX) through the substitution in the commodity market for the interest rate from the market equilibrium condition for either money or for bonds.[3] Equations (1) and (2) determine unique equilibria for the real wage (W/P) and real balances (M/P). Stability of the equilibrium depends,of course, on the conventional adjustment rules for W and P under excess demands L and Y.

Now consider the simplest exercise in monetary expansion (we assume a static economy with no growth). An increase in money supply (M) causes an excess supply for money (not shown here) and an excess demand for goods [i.e., in equation (2), $Y > 0$]. The inflationary gap brings about a dynamic adjustment in the price level (P

moves up) which in turn reduces the real wage (at a given nominal wage W) and causes an excess demand for labor [in equation (1), $L > 0$]. The latter in turn brings about a dynamic upward adjustment in W. Equilibrium will finally be re-established only after P and W have increased at the same rate as the initial increase in M. As long as all markets (commodities as well as labor) are fully flexible W and P levels will move towards a new unique equilibrium whenever M changes (whether upward or downward). On the other hand these nominal magnitudes are bound to stay stable if M is kept stable (as long, of course, as there is no change in the exogenous shift parameters A). It is in this sense that we say that money is the *nominal anchor* of the system.

One could equally envisage an economy in which it is the nominal wage which is the anchor. Suppose we are in a strongly unionized economy in which fear of Keynesian unemployment dictates an accommodating monetary policy. In that case M/P will stay pegged and W becomes the nominal anchor of the system. In the absence of price controls a rise in W will eventually be followed by an equivalent increase in the price level (and the quantity of money), leaving relative prices (i.e., W/P and M/P) the same. Incomes policy (affecting W) will determine the relative stability of the system.

For the sake of completeness one may ask if there is a case in which P itself can be directly controlled as the nominal anchor. The answer to that is a qualified 'yes', providing we consider a command economy in which the prices of all components of the commodity basket (composing the aggregate index P) are fully controlled as was the case in a communist regime of the old (and maybe soon extinct) style. In such a regime which presumably also dictates W across the economy, inflation, even if it potentially exists, will not come into the open. Such argument may explain why during the periods in which there was substantial open inflation in the western industrial world the eastern block countries exhibited prolonged price stability.

An increase in M may cause excess demand for goods [in equation (2)] and the

inflationary gap will not be bridged by a price increase but rather by shortages, rationing, queuing etc. In other words this is the case of *repressed* inflation. In present-day Soviet Russia the problem of the so-called 'monetary overhang' is precisely that. Any price liberalization process is bound to lead to open inflation. P is thus a nominal anchor only in a very formal sense. The cost of recourse to such 'anchoring' is, of course, the distortive effects on the real economy (likewise fixing W at a level that does not clear the labor market, if such a market exists at all, will force the system to disguise the unemployment).

While an extreme form of sustained and widespread price and wage regulation may not seem a realistic possibility in a market economy it should be pointed out that partial price and wage controls (e.g., controlled prices of key commodities and wage controls in the public sector) are rather widespread. In the process of stabilization of an economy the exercise of such controls and even temporary imposition of full controls could serve an important expectation signalling role providing, of course, the real disequilibria are removed and fundamentals are first set in place. We shall come back to that question and the issue of 'multiple' anchoring in Section IV.

Leaving aside the case of direct price or wage fixing, and as long as we are in a closed economy, it is the quantity of money (or some other widely used nominal asset) which is the sole and informationally the most efficient nominal anchor of the system.

Keynes, Patinkin and most of the classical writers set up their macroeconomic frameworks for discussion of monetary theory in the context of a closed economy. Neutrality of money and issues of price inflation were thus naturally centered around the control of the money supply or loss thereof. Most economies of the world, however, are open in one way or another and the price system of one country can be tied to that of the rest of the world through the choice of the exchange rate. It is, in theory at least, a perfectly valid contender to M as the centerpiece of the monetary game in any individual economy (though not, of course, in the global economy, at least as long as there is no active trade with outer space...).

The above macro framework is most easily and realistically extended into an

open economy by allowing the aggregate good to be imperfectly tradable on the export market (with exports positively dependent on exogenous world demand and relative world to domestic prices) while imports consist of a competing input into the aggregate production function. Equations (1) and (2) must now be rewritten with an additional relative price, the real exchange rate (E/P, where E is the nominal exchange rate) appearing inside the respective excess demand functions for labor and goods:[4]

$$\underset{-}{L}(W/P, \underset{-}{E/P}; A_l) = 0 \qquad (1')$$

$$\underset{+}{Y}(W/P, \underset{+}{M/P}, \underset{+}{E/P}; A_y) . \qquad (2')$$

We now add a third market for foreign exchange with a suitable excess demand function (the current account):

$$\underset{-}{F}(E/P, \underset{+}{W/P}; Y_f) = 0 \qquad (3)$$

The set of three equilibrium conditions (1′), (2′) and (3) will fix a unique solution for the three relative magnitudes M/P, W/P and E/P and fixing any one of the four nominal variables will fix the equilibrium level of the remaining three. E is now a legitimate alternative nominal anchor. An exercise, similar to the previous one, can be conducted showing how a change in E will feed into suitable changes in excess demands of other markets and an adjustment will take place in all other nominal variables. The endogeneity of M in this simplified pegged exchange rate system will come from a specie flow mechanism that feeds from changes in exchange reserves (when $F > \text{or} < 0$) into the domestic money supply. The dynamic analysis must be suitably modified if foreign exchange borrowing is allowed and foreign and domestic assets are not perfect substitutes, but the long-run equilibrium solution is the same.

So far price inflation has been represented as an adjustment to an excess demand in the commodity market with parallel excess supply in the money (or foreign

exchange) market. A persistent inflationary process such as high inflation may very well continue to take place even while the commodity market is in continuous balance. It will simplify matters if we make this assumption from now on. Also, since from now on we want to talk about high inflation processes and comparative dynamics thereof we can translate an equilibrium equation such as (2′) into an equation in terms of rates of change of the nominal variables. We leave it to the next section to discuss the rationale for having the system sustain a steady rate of inflation at all.

Log-linearizing (1′) and considering changes over time we get:

$$\pi = a_1\omega + a_2\epsilon + a_3\mu + \nu \tag{4}$$

where $\pi = \dot{P}/P$ — rate of inflation, and a dot represents a discrete $(P_t - P_{t-1})$ or instantaneous (dP/dt) time change; $\omega = \dot{W}/W$ — wage inflation; $\epsilon = \dot{E}/E$ — rate of devaluation; $\mu = \dot{M}/M$ — rate of monetary expansion; ν — supply and demand shocks; $a_1 + a_2 + a_3 = 1$ by homogeneity of (1′).

Equation (4) may be rewritten in the form of an *inflation acceleration equation*

$$\pi - \pi_{-1} = a_1(\omega - \pi_{-1}) + a_2(\epsilon - \pi_{-1}) + a_3(\mu - \pi_{-1}) + \nu \tag{5}$$

π_{-1} is the one-period lagged inflation rate $[(P_{t-1} - P_{t-2})/P_{t-1}]$.

Start from a steady state in which all nominal variables rise at the same rate μ_0. Suppose now that a real shock to the current account (for example A_f in (3) increases due to a permanent fall in world demand) requires a step adjustment in the exchange rate so that there is a one-time increase in E/P, i.e., a one-time blip in $\epsilon - \pi_{-1}$, after which again $\epsilon = \pi$. In the absence of a negative real shift in the commodity market, such as a fiscal cut, this requires a one time drop in M/P or in both (simultaneous labor market equilibrium would require both). If M and W have hitherto grown at the rate μ_0 and cannot be made to grow at a lower rate, only

a one-time additional increase in the price level, causing a temporary blip to the inflation rate, will bring about the required one-time drop in M/P and W/P after which all nominal magnitudes will resume their steady state rate.

Suppose, however, money is always accommodating and wages are formally indexed to past inflation. In that case $\omega = \mu = \pi_{-1}$ always. M and W will now grow at a rate higher than μ_0, after the devaluation. The one-time blip in $\epsilon - \pi_{-1}$ (after which we must preserve $\epsilon = \pi$) by equation (5) must cause a permanent increase in the inflation rate and all nominal variables will rise at a new steady rate that is higher than μ_0. This, of course, is a well-known property of formally indexed systems which exhibit considerable inertia. Under full indexation a one-time change in a relative price (real devaluation, real wage and/or monetary cut) can only be achieved by a jump in the inflation rate itself.

An interesting property of such systems relates to workers' demand to raise the degree of indexation as the inflation rate increases, but at the same time reduce the length of lag in the formal part of indexation. Suppose wage adjustment takes the form $w = \delta\pi_{-1} + (1 - \delta)\pi^e$, where π^e are the expectations of inflation as reflected in the wage contract which also incorporates a partial cost of living adjustment. Accelerating inflation will tend to motivate an increase in δ which will enhance the inertia of the inflationary process. However a shortening of the lag (embodied in the length of time period between which π_{-1} and π are measured) actually reduces inertia. Monthly, weekly, and in the limit perhaps daily indexation would reduce inertia. It also destroys the quasi-stability of the process and enhances the shift from stage III (high inflation) to stage IV (hyperinflation). At the same time reduced inertia also makes it easier to quickly reduce inflation, once there is a will, with relatively less real disruption.

III. Seignorage and the Optimal Inflation Rate

So far we have avoided the question of a rationale for having any positive inflation rate. For that we have to look at the rules governing the supply of and

demand for the depreciable asset money. A natural beneficiary of inflation is the government which reaps an inflation tax to the extent that the public is willing (or forced by law) to hold its depreciable monetary issue. Suppose we denote the part of the deficit financed by seignorage by d, the nominal money base by H and the real base (H/P) by h. In steady state we have $\dot{H}/H = \pi$, the inflation rate, and therefore:[5]

$$d = h\pi \ . \tag{6}$$

As is common in the literature and is also confirmed by empirical work, assume a semi-log (Cagan, 1956) demand function for money, where π^e denotes expected inflation. (The real interest rate is assumed exogenous, and is suppressed here.)

$$h = \exp(-\alpha\pi^e) \ . \tag{7}$$

Figure 3 draws equation (6) for a given d, as a rectangular hyperbola and the money demand schedule h (7) as cutting it, at most, at two points A and B, both of which represent steady-state inflationary equilibria ($\pi = \pi^e$). As is well known there is one value of d at which there is a (single) tangency point between the two curves. This is Friedman's (1971) maximum seignorage (d^0)

$$d^0 = \text{Max}[\pi \exp(-\alpha\pi)] = 1/\alpha e \ ,$$

where the maximizing inflation rate is $\pi^0 = 1/\alpha$.

The elasticity of demand for money ($\alpha\pi$) at that point is unity. If $d > d^0$ there is no steady state equilibrium (this may correspond to the case of explosive hyperinflation), while for $d < d^0$ there will be two intersections A, B as shown in Figure 3.

Rightward shifts of the d curve (an increase in the seignorage-finance deficit) or leftward shifts of the money demand function (a fall in money demand or a rise

in an exogenously given reserve ratio) — will cause an upward shift of the lower equilibrium point A, i.e., an increase in steady state inflation. In a growth context (with rate of growth n) d should be taken as the share in GNP and in that case (6) becomes $d = (\pi + n)h$ and the curve could also shift to the right by an exogenous drop in the rate of growth.

Such framework has been used to rationalize the upward jumps in Israel's inflation profile in the period 1970–85 (see Bruno and Fischer, 1986). Empirical evidence for Israel in the period mentioned (Melnick and Sokoler, 1984) also suggests that the revenue-maximizing rate was 6.5 percent a month (115 percent annual inflation) and that starting somewhere around the early 1980s the elasticity of demand for money exceeded unity and that inflation may have moved toward an upper (B) equilibrium. Note that at B an increase in the deficit actually *reduces* the inflation rate — a 'perverse' result which will be discussed below.

Is there a sense in which the existence of an upper, high-inflation, equilibrium could be rationalized as the outcome of optimal choice?

An argument based on Barro (1983)[6] clearly suggests this possibility, provided we assume discretionary behavior. Suppose we assume that the government benefits from seignorage but trades off that benefit against the social costs of both actual (π) and anticipated (π^e) inflation. Assume that the objective function takes the general form:

$$V = \sigma d - f(\pi) - g(\pi^e) \tag{8}$$

σ — (the marginal benefit from seignorage) is exogenous (but may vary over time) and $f', g' > 0$.

Substituting from (6) and (7) into (8) and maximizing V with respect to π (namely choosing actual money growth for given π^e) we find:

$$V'_{\pi}|_{\pi^e} = \sigma \exp(-\alpha\pi^e) - f'(\pi) = 0 \tag{9}$$

Under rational expectations on part of the private sector we have $\pi = \pi^e$. This gives an equilibrium inflation rate which may very well be at a point like B.

From (9) we have in discretionary equilibrium π_d:

$$\alpha\pi_d = \ell n\sigma - \ell nf'(\pi_d) \tag{10}$$

For sufficiently large σ, $\alpha\pi_d$ will be > 1.[7]

In theory, at least, there is an interesting paradox here — with an economy at a stable high inflation equilibrium (B in Figure 3), a mere budget cut (leftward shift of the d-curve) will shift the new B-equilibrium up — i.e., in the absence of a change in the dynamic adjustment rules the new upper equilibrium inflation rate is even higher. This seeming paradox can be given economic content (see Bruno, 1989) — the fiscal cut involves an instantaneous monetary squeeze and a step increase in the nominal interest rate — with asset markets adjusting instantaneously and the commodity market more slowly. An upward shift in the interest rate signals an equal shift in $(\epsilon_t - \epsilon_{t-1})$ and in inflationary expectations.

The vagaries of discretion stand out even more when we contrast it with the alternative case of a government that can precommit itself and thus control inflationary expectations in a non-discretionary ('rules') way. If one maximizes V under precommitment ($\pi = \pi^e$) we get:

$$V'|_{\pi=\pi^e} = (1 - \alpha\pi)\sigma \exp(-\alpha\pi) - f'(\pi) - g'(\pi) = 0 \tag{11}$$

For this equilibrium rate (denoted by π_R) we have:

$$1 - \alpha\pi_R = \frac{\exp(\alpha\pi_R)}{\sigma(f' + g')} > 0 .$$

Thus *the optimal precommitted rate of inflation will always be less than the revenue-maximizing rate*, i.e., the economy will in that case always be at a low equilibrium point like A.[8]

One weakness of the preceding analysis is the assumption that d itself is chosen in some optimal way. Another question is the stability of the equilibrium inflation rate. In practice governments often find themselves in deficits or in inflationary situations which have occurred as a result of past mistakes and stay there because of an inability to muster the strength or the social consensus needed for a major reform. Suppose now that d is exogenously determined and we ask what determines the stability of an equilibrium point A or B. For that we have to say something about expectation formation or dynamic behavior of the nominal variables out of steady state equilibrium. Several avenues have been studied all of which have in common some friction in the inflationary process whether in price expectations, money, wage or exchange rate adjustment. The speed of adjustment determines the stability or instability of equilibrium at A or B.

The simplest example, for a closed economy, is that of adaptive expectations (see Bruno and Fischer, 1990):

$$\dot{\pi}^e = \beta(\pi - \pi^e) \,. \tag{12}$$

Log time-differentiation of (7) and substitution in (12) gives the equation of motion of π^e out of equilibrium,

$$\dot{\pi}^e = (1 - \alpha\beta)^{-1}\beta[d \exp(\alpha\pi^e) - \pi^e] \,. \tag{13}$$

The familiar Cagan (1956) Condition $\alpha\beta < 1$ or > 1 determines whether A,B are stable or unstable equilibria, respectively. It is important to point out that adaptive adjustment of expectations is only one option by which this result is obtained. Slow adjustment of one of the other nominal magnitudes under rational expectations will give similar results. In another paper (Bruno, 1989) I have applied the same idea to the exchange rate, substituting ϵ (the rate of devaluation) for π^e in equations (7) and (12). Another modification makes the adjustment coefficient (β)

increase with the rate of inflation. This is a rule for a crawling peg which has also been estimated empirically:

$$\dot{\epsilon} = \beta(\pi)(\pi - \epsilon) \,. \tag{14}$$

The variability of β raises the interesting possibility that both A and B may be stable equilibria. Assume $\beta'(\pi) > 0$ and let π^* be the threshold inflation rate at which $\alpha\beta(\pi^*) = 1$. If $\pi_A < \pi^* < \pi_B$, both equilibria are in fact stable.

A discrete time version (non-linear difference equation) was run over 123 monthly observations for the crawling peg period in Israel 1975–1985 in the form:

$$\epsilon_t - \epsilon_{t-1} = \beta_0 - (\beta_1 + \beta_2\pi_{t-1})(\pi_{t-1} - \pi^{US}_{t-1} - \epsilon_{t-1}) + J_t$$

where π^{US} is the U.S. inflation rate and J_t represent dummy (jump) variables for periods of discrete level devaluations that took place in 1975, 1977 and 1983. The threshold inflation rate (π^*) was estimated to be a monthly rate of 4.8 percent (for wholesale prices) or 5.8 (for consumer prices) or 76, 97 percent, respectively in annual terms (see Bruno, 1989). We note that this rate is the one that roughly distinguishes between two-digit (stage II) and three-digit (stage III) high inflations.

Here comes an interesting question — can one motivate an adjustment rule like (14) as the result of some underlying optimization? It turns out that one can,[9] if one takes the existence of inflation as a norm.

Given that a steady process of inflation has already been taking place there are costs of marginally deviating from it, so that some local sub-optimization may still be relevant. Assume the government minimizes a quadratic loss function of the following form:

$$L_t = \alpha_1(\epsilon_t - \epsilon_{t-1})^2 + \alpha_2(\omega_t - \epsilon_t - \alpha_0)^2 \,. \tag{15}$$

The first term represents the cost not of inflation per se but of changes thereof while the second represents the cost of deviations from current account balance (depending on the relative exchange rate). It does not matter whether we replace ω_t by π_{t-1} or by π_t^e as long as it is exogenous to the choice of ϵ_t.

Maximizing L_t with respect to ϵ_t we get:

$$\epsilon_t - \epsilon_{t-1} = \beta(\omega_t - \epsilon_t - \alpha_0) , \tag{16}$$

where $\beta = \alpha_2/\alpha_1$.

This is precisely the discretionary adjustment rule that was introduced above, and observed in the empirical data, except that we have now provided a rationale for it. It also makes sense to assume that the higher the rate of inflation the smaller is the marginal cost of absolute deviations from it relative to those of current account imbalance. Thus β may be assumed to rise with the rate of inflation.[10] A certain weakness of the quadratic loss function (15) is its symmetry with respect to upward and downward deviations.

It is interesting to note that such sub-optimization may 'anchor' the rate of inflation at either a higher or a lower inflation rate depending on initial conditions and external inflationary shocks to the system. However the two alternative equilibria themselves depend on real fundamentals.

Applying this theory the sharp rise in Israel's inflation rate between 1975 and 1980 can be attributed to two major monetary decisions. The one on which many observers agree is the introduction of foreign exchange-linked (Patam) bank accounts in 1977–8. This has shifted the demand for M_1 (an inward shift in the h-schedule in Figure 2) and introduced indexation into a broader measure of money M_3. The other, much less stressed, is the decision taken in 1975 to give up the pegged foreign exchange rate anchor and move to a flexible crawling peg. Gottlieb and Piterman (1985) identified 1975 as a crucial turning point in the expectation formation mechanism. This amounts to a change from $\beta = 0$ in equation (14) to $\beta > 0$ and

gradually rising.

A discrete devaluation in 1977 and again in 1983 caused a jump not only in the price level but, with almost complete indexation of the nominal system, a series of upward jumps in the rate of inflation ('flats' in terms of Figure 2) making the system tend to move towards higher inflation equilibria. After the 1983 shock a new equilibrium was probably never reached, since the 1985 stabilization interrupted the process.

IV. Choice of Anchors During Disinflation

Consider a country that has been running a high inflation and wishes to stabilize while minimizing the initial cost of adjustment. Obviously, first and foremost the real source of fundamental disequilibrium has to be removed. Existence or absence of that necessary 'orthodox' ingredient contributed the major distinction between success and failure in recent stabilization episodes of the 1980s. We therefore take it for granted that the policy package includes a set of measures that corrects the fundamental sources of imbalance in the government budget or in the balance of payments or (usually) in both. This would in general involve a substantial fiscal cut with or without an initial step adjustment in the exchange rate. Our discussion here, however, takes off from the point that correction of fundamentals will in general not suffice to eliminate high inflation. The earlier analysis tells us that the corrected real system could still be consistent with more than one inflation rate and for that reason the self-perpetuating nominal mechanism must be made to switch at once to a stable low (or zero) inflation target. Moreover, minimizing the social cost of adjustment (or even its political feasibility) dictates minimal superfluous changes in *relative* prices during the transition.

There are at least two separate issues here. One is the problem created by formal institutional arrangements such as backward indexation, particularly of wages. Even if inflation starts to drop lagged indexation may cause a very large initial increase in the real wage thus exacerbating unemployment. The nominal system must

be made to forget its memory of the past. But a mere formal de-indexation will in general not suffice either, since sluggish change in government credibility (or lack of price coordination) may cause forward nominal stickiness (in ω and π). A clear signal of a sharp shift in policy is required, by targeting at least one nominal anchor. (The possible need for more than one anchor will be taken up below). Suppose one central anchor has to be pegged during the transition to low inflation — is it the exchange rate or the quantity of money?

The argument in favor of the exchange rate

The cumulative history of sharp disinflations in open economies seems to point to a dominant use of the exchange rate as a key nominal anchor. A general discussion of the role of the exchange rate in stabilization was given in an earlier Frank Graham lecture by Dornbusch (1986). In a survey of past substantial inflations (Yeager, 1981) only the Italian disinflation of 1945 seems to have involved extensive use of a monetary target rather than the exchange rate. In almost all historical hyperinflations as well as in recent attempts at stabilization from high inflation, fixing the exchange was a key element of rapid stabilization (see Dornbusch and Fischer, 1986; Bruno *et al.*, 1988, 1991). In the case of more moderate inflations the experience is more mixed (see Kiguel and Liviatan, 1989).

There are several practical reasons for the choice of the exchange rate quite apart from the intuitive a priori reasoning that if the exchange rate had been a key manifestation of the loss of the nominal anchor it would only make sense that disinflation would also require re-establishing it as an anchor. But is there a more systematic theoretical argument in favor of that choice?

Fischer (1986) has investigated the question in the context of a small open economy of the kind mentioned in Section II with perfect capital mobility and wage contracts set for either one or two-periods, thus explicitly bringing in some nominal stickiness but no backward indexation. The model assumes rational expectations and instantaneous credibility once a policy change takes place (an assumption that is, of

course, highly questionable in practice and will be discussed again below). Exchange rate led stabilization is compared with choice of a money growth target in terms of the resulting sacrifice ratio — the ratio of total loss of output to the fall in the inflation rate, calculated over two periods.

The analysis shows that while examples of exceptions can be produced, in general the case of exchange rate stabilization is less costly. For the same drop in the inflation rate the fall in the quantity of money is smaller under reduced exchange rate adjustment (since endogenous money demand rises as a result of the drop in ϵ, here the interest rate). The required equivalent reduction in the rate of growth of money under the monetary option (with a flexible exchange rate) is thus larger than in the previous case. With a smaller reduction in the quantity of money, given wage stickiness, the output loss is smaller. The extent of the recession depends on wage stickiness and sensitivity of aggregate demand to the real exchange rate (which appreciates) and the real interest rate (which rises), and for this reason the result is not unambiguous. Fischer shows one extreme example in which exchange rate stabilization produces a higher sacrifice ratio than money growth stabilization — when interest elasticity of money demand is zero (i.e., extremely low) and the direct elasticity of the price level to exchange rate changes in the cost function is very high (0.8 is assumed), both of which are empirically unlikely.

A larger recession with monetary stabilization could, in principle, be avoided if the reduction in the *rate of growth* of money is coupled with a one time initial upward adjustment in the *level* of the money stock. Such up-front monetary expansion does create a well-known credibility problem, however, and is therefore inadvisable in practice.

Once uncertainty is introduced into the analysis the specific market location of disturbances matters for the result. If they arise in the goods market, output tends to be less stable under a fixed exchange rate than under fixed money while prices tend to be less stable under a fixed money rule. What is probably practically more relevant is the finding that the fixed exchange rate regime is preferable when disturbances are

primarily in the demand for money, a fact well born out in the practice of stabilization. Wage disturbances are a problem under either procedure and provide the rationale for making wages consistent with the new inflation target through an incomes policy or a 'package deal', a subject to which we shall return below.

Howitt (1987) has analyzed a model similar to Fischer's (1986) in which the optimal disinflation policies of a central bank are discussed under two types of wage stickiness assumptions — backward-looking stickiness under a dynamic Phillips curve and forward-looking stickiness arising from lack of credibility. There is a history of positive inflation and a disinflation program is instituted. The central bank is assumed to maximize an infinite sum of squared output and inflation terms. Under backward stickiness the optimal speed of disinflation becomes an increasing function of the weight attached to inflation in the objective function and of the slope of the Phillips curve. It is found that monotonic reduction of monetary expansion is not generally optimal. Rather E/P should be reduced immediately and then allowed to rise monotonically back to its initial value. A similar general result is obtained under forward stickiness coming from lack of credibility — the government has no tolerance of inflation but private agents do not know this. The speed of disinflation depends on a variance ratio that measures the severity of the central bank's credibility problem.

In practice the problem of credibility pushes relatively 'soft' governments in the direction of attaching themselves to the reputation of a 'stronger' government's conservative central bank through a fixed exchange rate. This argument of 'tying one's hands' lay at the roots of the choice of historically inflation-prone countries, like Italy and France, to join the EMS and tie themselves to a strong D-mark (see Giavazzi and Giovannini, 1989). These can be contrasted with the case of the United Kingdom, which delayed its decision on the EMS and suffered from considerably higher inflation rate, whose reasons were not fiscal. It will be interesting to see how the United Kingdom's final entry into the EMS (in October 1990) will have affected its subsequent relative inflation performance.

In addition to the theoretical arguments discussed so far one may mention a

couple of quasi-practical reasons for the advantage of the exchange rate over the money supply in the process of disinflation. In an open economy tradable goods form a substantial part of the goods basket and thus of the components of the price level. Stabilizing a key price in the economy, which is observable on a daily basis (unlike the price index which is usually published only once a month and with some delay) thus provides an important signal to the rest of the system, much more than the indirect signal embodied in the quantity of money. Also, the exchange rate is a clearer magnitude to set against the wage rate in the stabilization game played with the wage fixers, whether employers or unions in a highly unionized economy (see below). Finally the instability of monetary targets especially during disinflations has already been mentioned. The demand for M_1, for one, tends to rise steeply in the early stages of a quick disinflation as expected inflation is adjusted downward.

A subsidiary issue with which we have not dealt here but may be of considerable practical importance is the basis for exchange rate pegging during transition to lower inflation. Pegging to a major currency which had been the closest substitute to domestic money in the asset market, and thus serves as a unit of account in many transactions, would be preferable from the point of view of establishing initial credibility (the dollar in the case of Israel and the DM in the recent stabilizations of Yugoslavia and Poland). Given the fluctuations of cross rates in world markets, pegging to a trade weighted basket of currencies would be preferable from the point of view of real trade flows. Israel, in fact, moved to a basket approximately one year after its initial stabilization.

Multiple nominal anchors

If the exchange rate seems a more effective instrument what are its defects? The key problem arises from forward wage and price stickiness due to the slow credibility build-up. This invariably leads to real appreciation of the exchange rate, expectations of further adjustment of the exchange rate peg resulting in large cycles of speculative capital flows and substantial monetary and interest rate fluctuations. To avoid regime

collapse larger exchange reserves have to be held than under a flexible exchange rate regime and there is also a tendency to maintain exchange controls which can be distortive or else relatively ineffective.

These arguments work in favor of confining oneself to the use of the exchange rate as a key anchor in the early stages of sharp stabilization but once credibility has been built up the system could be flexened. For example, the median exchange rate can be kept as a longer run signal while greater short-run fluctuations within a fixed band are allowed. This enables a moderation of capital movements and provides a more active role for monetary policy even under less restrictive foreign exchange controls.

Is there a sense in which it pays to coordinate more than one anchor in the process of disinflation? In answer to that question one should distinguish between the two possible stages in the stabilization process, the initial step of a very sharp cut in inflation (from three digit inflation to 20 percent per annum, say) and the subsequent, usually slower and more gradual drop, to the lowest (zero?) inflation target.

Assume as before that the required fiscal and exchange rate adjustments have been made and now the exchange rate, say, is pegged. Even the smallest backward or forward stickiness in any of the other nominal aggregates in a disinflating system with confusing signals, may cause very sharp shifts in *relative* prices which in turn may upset the planned equilibrium of the real system. Wage indexation has to be suspended, at least temporarily, and monetary aggregates had better be set so as to be consistent with the wage and exchange rate freeze. Are temporary price controls — the fourth anchor — also required? Given the uncertainty of signals, especially for goods and services that are not tradable (as well as wages in the government service sector, for example), price controls can help in signalling the sudden shift and absolute commitment of the new policy. In making a deal with the trade unions on a wage freeze, such counterpart freeze of prices may be required as part of the bargain anyway (This has been the experience in the Israeli stabilization of 1985.) Price controls, if they are to be monitored by the public, can only apply to an absolute

level freeze, and not to any positive rate of inflation, which cannot easily be monitored.

Controls, we know, can be very distortionary. But a sharp disinflation, if it persists, may outweigh, in terms of the distortions eliminated, the temporary distortive effects of price controls. What this argument suggests, however, is that price controls may not pay for small disinflations and even under large disinflations, they had better be short-lived and be eliminated rather quickly, as soon as the credibility and signalling objective has been achieved.

Given the underlying macro economic framework of Section II there is a prima facie contradiction in an argument that calls for the fixing of more than one nominal variable at a time. Unless the coordinated choice of nominal targets is exactly 'right' the system must be overdetermined or, alternatively, get into a disequilibrium. This statement, however, rests on an assumption of full certainty. Here we are considering an optimal policy choice under uncertainty. In such case market equilibrium or disequilibrium must be redefined in an expectational sense. Given the potential benefits of success and the high risks of failure of a sharp disinflation, tying one's boat to several anchors rather than one would seem to be a prudent policy as is the portfolio diversification of risk in the optimal menu of risky assets.

The analog of the multiple anchoring of a boat (in which only one of the anchor ropes can be tight and may threaten to break at any point in time), has been the rationale behind the simultaneous intervention in all other nominal variables during the Israeli stabilization of 1985. In addition to a sharp fiscal contraction (including a cut in subsidies) and an up-front devaluation the government announced a credit freeze as well as its intention to keep the exchange rate pegged providing the unions would temporarily suspend the COLA and freeze wages for a few months. Agreement on the latter was, in turn, made conditional on the introduction of price controls. The resulting tripartite agreement between employers, trade unions and government provided the supportive means by which the nominal system was at once shifted from a 500 percent inflation to 25 percent (and subsequently to 15–20 percent) per annum.

It is important to point out that the ex ante freeze of all nominal variables, other than the exchange rate, was rather short-lived ex post and significant changes took place in *relative* prices only a few months after the initial 'shock', primarily a real wage increase and a real appreciation. Yet the lower inflation rate was maintained successfully. This may show that the signalling of serious intentions and precommitment on part of the government constituted the most important role of the synchronized freeze in the early stage of stabilization. A real appreciation (though not a real wage increase) has also accompanied the successful stabilization in Bolivia and Mexico.

Consider now the second stage. Once price controls are lifted and the exchange rate is maintained as the key nominal anchor monetary policy will be geared to protect the exchange rate. The inflation that remains can best be described as the outcome of a repeated game between the government (setting the exchange rate) and the private sector (setting the nominal wage), in which the government attempts to establish its reputation and credibility is gradually built up. In practice the game may be a much more complicated one with each sector also playing an internal game — the central bank and the ministry of finance over the commitment to a pegged exchange rate and the unions versus the employers over the wage rate. However, even the bilateral monopoly case is not an easy one to model realistically. A beginning has been made in a paper by Horn and Persson (1988).

In the Israeli case the exchange rate was adjusted five times during the five years following the July 1985 stabilization (January 1987, December 1988, January 1989, June 1989 and March 1990), almost always coupled with an agreed suspension of the cost of living adjustment. Since March 1990 Israel moved to a more flexible regime in which fluctuations within a 5 percent band above and below the mid-rate are allowed and a greater role is given to the foreign exchange market and to monetary policy in the determination of the exchange rate. An alignment of the mid-rate was made in September 1990.

Table 3 shows the annual rates of change of the nominal exchange rate (trade

weighted basket of currencies), the nominal wage and the per unit real wage cost in the business sector. The figures suggest a gradual learning process that took place in wage behavior over the period 1985–89 with an eventual turnaround in unit wage costs by 1989. 1990 has very likely shown a continuation of this process. This result, however, was bought at the cost of rising unemployment and considerable initial real appreciation. Flexening of the foreign exchange market and the slack in the labor market allow a gradual easing of the burden from the exchange rate as the key nominal anchor. A sequence of exchange-rate realignments with real appreciations as well as painful adjustments of management and labor have also characterized the gradual and very slow disinflations of EMS-linked countries like Italy and France over the 1980s. Because of its much more flexible labor market Mexico could shift from a fixed peg to a crawling devaluation at an earlier stage of its stabilization program albeit at a rate which has kept real appreciation going.

The second phase of a disinflation process, that of gradually pulling a 20–25 percent inflation further down turns out to be the most difficult part of the stabilization effort. In all recent successful stabilizations from high inflation,in addition to Israel's (Bolivia, Chile and Mexico) the inflation rate has still remained close to that range. The stickiness of the inflation rate in all of these cases most probably had to do with some lack of credibility and the weakening of commitment to the stability goal once 'the worst is seemingly over'. In Israel's case a variety of structural factors played an inhibiting role (slow removal of indexation, slow dismantling of protective and monopolistic obstacles, minimum real wage legislation, etc.). Of the four countries mentioned only Chile has in recent years managed to reverse the trend in its real exchange rate.

Finally, in characterizing the end of the high-inflation process we may also return to the issue of the nominal–real dichotomy. We have seen that the system undergoes a fundamental change in this respect as inflation 'lifts off' from a two-digit range into a high-inflation dichotomous regime. Upon 're-entry' — once sharp disinflation has taken place — one may expect a reversal of the dichotomy between the nominal and

the real economy and a closer resemblance to the ordinary 'garden variety' inflations. One would thus expect to see much less nominal accommodation and an enhanced importance of real versus nominal shocks. A related property would be an increase in the tradeoff between inflation and unemployment which under high inflation virtually disappears. A recent study by Leiderman and Liviatan (1989) confirms these findings for a comparison of the nominal and real variable behavior in Israel before and after stabilization. The degree of nominal inertia has substantially fallen while the variability of changes in real output, employment and the trade deficit has not changed. The Phillips curve short-term tradeoff seems to have increased considerably. This is further evidence for a shift back from stage III, high chronic inflation, to a lower stage inflation regime. It remains to be seen if and when the Israeli economy, and similarly Bolivia, Chile and Mexico will finally move to the lower rate of inflation which has characterized the industrial world in recent years.

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Notes

* This paper is based on notes initially prepared for the Frank Graham Memorial Lecture given at Princeton University in March 1989. A draft of the paper was subsequently read at a workshop in honor of Don Patinkin, held in Jerusalem in May 1990. I am grateful to Rudiger Dornbusch for a very useful discussion of the paper at that workshop. Research for this paper was partly conducted during brief stays at the National Bureau of Economic Research, with the support of the National Science Foundation, for which thanks go to both institutions.

1. For a study of recent high-inflation experience, stabilization and its aftermath in the eight countries of Figure 2 see Bruno *et al.* (1991).

2. The 7-percent monthly rate actually lasted four years — until 1983 — when a large jump took place. This shows in Figure 2 as a 'flat' between 1979-83 and a kink in 1983.

3. In the original Patinkin model M/P in the excess demand for goods comes from the real balance effect. In this case the interest rate appears as a separate variable, which could be suppressed by substitution from the equilibrium condition in the bond market. In that case A_y must also incorporate exogenous shift factors from the bond market. An alternative approach, based on an ISLM model tradition and leading to a similar formal result would be the substitution for the interest rate in aggregate commodity demand Y from a money equilibrium condition $H(M/P, i) = 0$, say. (In equilibrium, by Walras's Law, bonds will also be in equilibrium.) Since investment (and consumption) demand depends on the *real* interest rate, one should in any case also include a price expectations variable under the shift variable A_y. I am indebted to Carl Christ for pointing out an ambiguity in my previous version of this argument.

4. Since imports are an input into the production function, labor demand now depends also on its relative price EP_n^*/P (P_n^* is the world price of the import good which will appear as one of the components of the shift factor A_t). For the commodity market a similar modification follows from both the supply and the demand

side. Excess demand can be written as the difference between aggregate demand $Y^d(M/P, EP^*/P; A_d)$ and aggregate supply $Y^s(M/P, EP^*_n/P; A_s)$, where P^* is the world price of exports and the shift factors are suitably extended to include the respective world parameters. The signs of response on E/P assume labor and imports to be gross substitutes in production.

5. Out of a steady state we can write (for a discrete time model)

$$d_t = (H_t - H_{t-1})/P_t = h_t - h_{t-1}(1 - \pi_t)$$

where $h_t = H_t/P_t$ and $\pi_t = (P_t - P_{t-1})/P_t$.

6. I am indebted to Nissan Liviatan for this reference. See also Kiguel and Liviatan (1990).

7. For example, using an exponential form for f (as in Barro, 1983) one gets an explicit analytical solution. Assume $f(\pi) = k/b \exp(b\pi)$; we get $\pi_d = \ell n(\sigma/k)/(b + \alpha)$. Thus $\alpha\pi_d > 1$ providing $\sigma > k \exp(1 + b/\alpha)$.

8. Note that we get zero inflation ($\pi_R = 0$) when $f'(\pi_R) + g'(\pi_R) = 1/\sigma$. Also note that this result does not depend on the inclusion of $g(\pi^e)$ in the objective function V, i.e., one may put $g' \equiv 0$ in (3.6).

9. I am indebted to Nissan Liviatan for this important insight.

10. $\omega - \epsilon$ is the rate of change of W/E, i.e., the rate of real appreciation, which leads to a certain change in foreign exchange reserves. $(\epsilon_t - \epsilon_{t-1})$ is the absolute change in the rate of devaluation (inflation). At a steady rate of inflation of 100 percent per annum a 5 percent deviation is relatively less costly than the same absolute deviation at a 10 percent steady rate.

Table 1

Hyperinflations of the 1920s (1920–1924)

	Average monthly rate	Peak monthly rate (date)	Number of months with inflation > 50% (> 25%)	Number of years with inflation > 100%
Germany	949	29,525 (10/23)	11 (20)	4
Poland	33	275 (10/23)	9 (16)	3
Austria	17	129 (8/22)	4 (10)	3
Hungary	17	98 (7/23)	5 (9)	3

Sources: Cagan (1956) and Sargent (1982).

Table 2
High inflation, Hyperinflation and Stabilization, 1970–1989 (monthly percentages and numbers of months and years)

Country (Year of major stabilization program)	Average monthly rate[a] '70–79 (1)	'80–'85 (2)	'86–'90 (3)	Peak monthly rate (date) (4)	No. of months with rate > 50% (> 25%) (5)	No. of years with annual rate > 100% '70–'79 (6)	'80–'89 (7)
Chile (1975)	7.6	1.7	1.4	88 (10/73)	1 (1)	4	—
Bolivia (1985)	1.4	18.5	2.1	182 (2/85)	9 (16)	—	5
Argentina (1985)	6.8	11.9	19.0	197 (7/89)	3 (16)	5	10
Brazil (1986)	2.4	7.9	19.7	73 (1/90)	3 (16)	—	8
Israel (1985)	2.6	9.1	1.4	28 (7/85)	— (1)	—	6
Mexico (1988)	1.2	3.9	4.8[b]	15 (1/88)	— (—)	—	3
Turkey (1980)	1.9	3.3	3.8	21 (2/80)	— (—)	—	1
Yugoslavia (1990)	1.4	3.4	14.5	60 (12/89)	3 (7)	—	3
Poland[c] (1990)	0.3	9.6	8.6	77 (1/90)	2 (5)	—	2

Source: International Financial Statistics (International Monetary Fund).

[a] Monthly averages refer to periods from January of the first year to December of the last year, except for 1990 for which most data reach only up to January-February 1990.

[b] From April 1988 to April 1990 the average monthly rate was 1.7 percent.

[c] Based on annual data up to 1987 and monthly data for 1988–1990.

Table 3

The Exchange Rate, Nominal Wage, and Unit Real Wage Costs in the Business Sector, Unemployment and Inflation, Israel 1986–1990 (annual rate of change)

	1986	1987	1988	1989	1990
Exchange rate[a]	45	13	2	16	11[b]
Nominal wage	65	33	22	18	14[c]
Unit real wage costs	6	4	0	–4	n.a.
Rate of unemployment (percentage)	7	6	6	9	10[d]
Wholesale prices	45	19	18	21	11[b]
Consumer prices	48	20	16	20	17[b]

Source: 1986–1989 — Bank of Israel, *Annual Report, 1985*. 1990 — Preliminary estimates.

[a] Based on trade-weighted basket of currencies.

[b] Based on first 9 months of the year.

[c] Based on first 7 months of the year.

[d] First half of 1990.

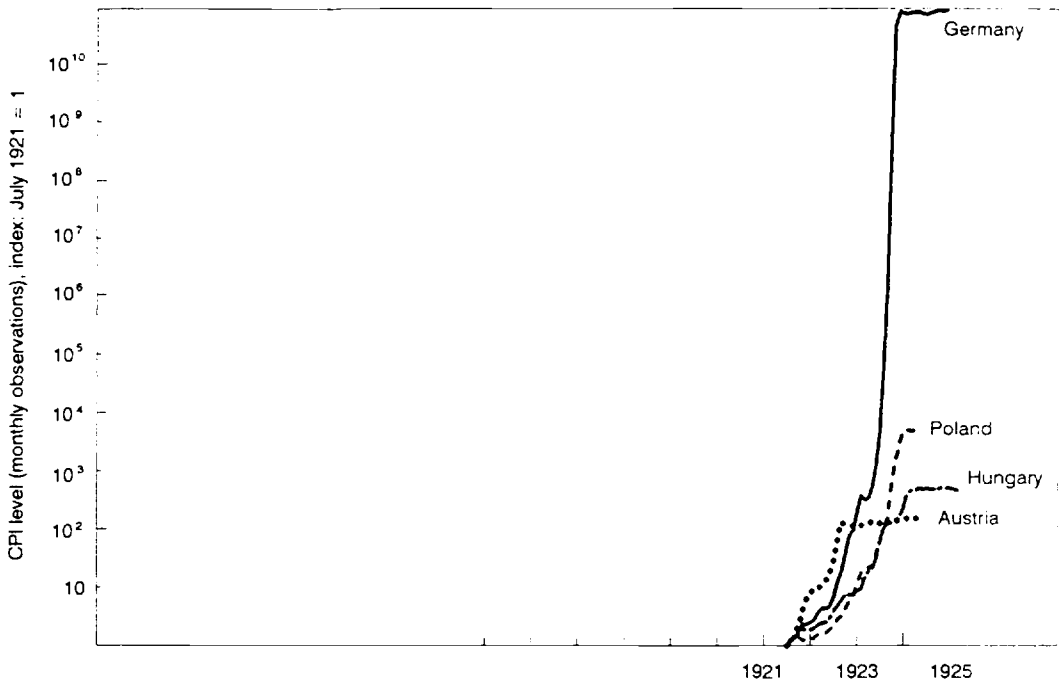

Figure 1

Four Hyperinflations of the 1920s

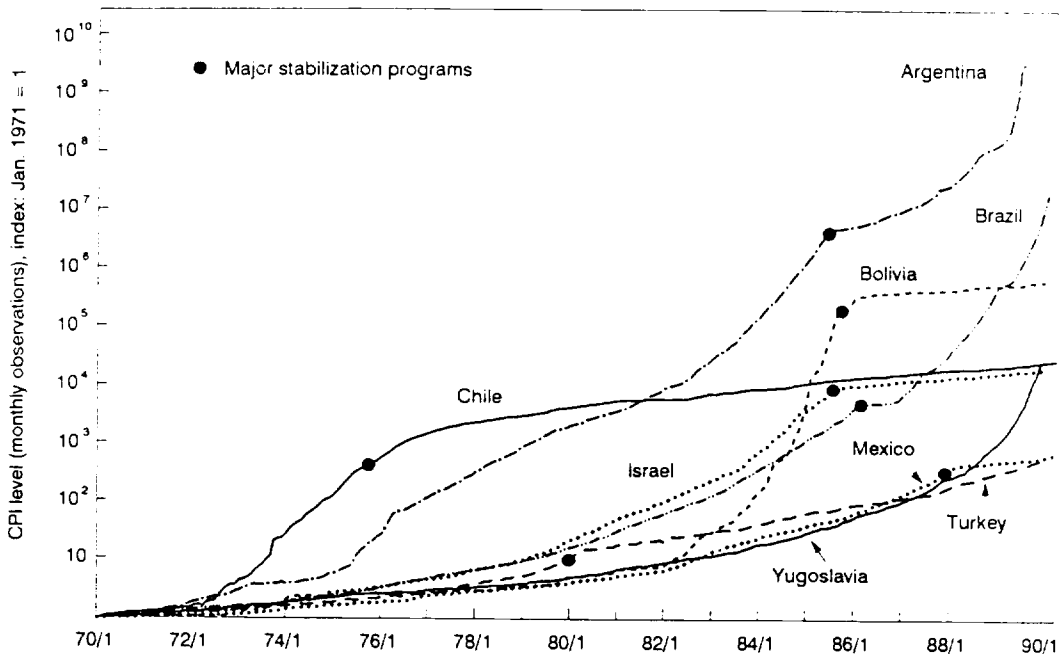

Figure 2

Major Inflations of the 1970s and 1980s

Source: IFS (IMF). The sample of 8 countries is analyzed in terms of recent experience, in Bruno *et al.* (1991).

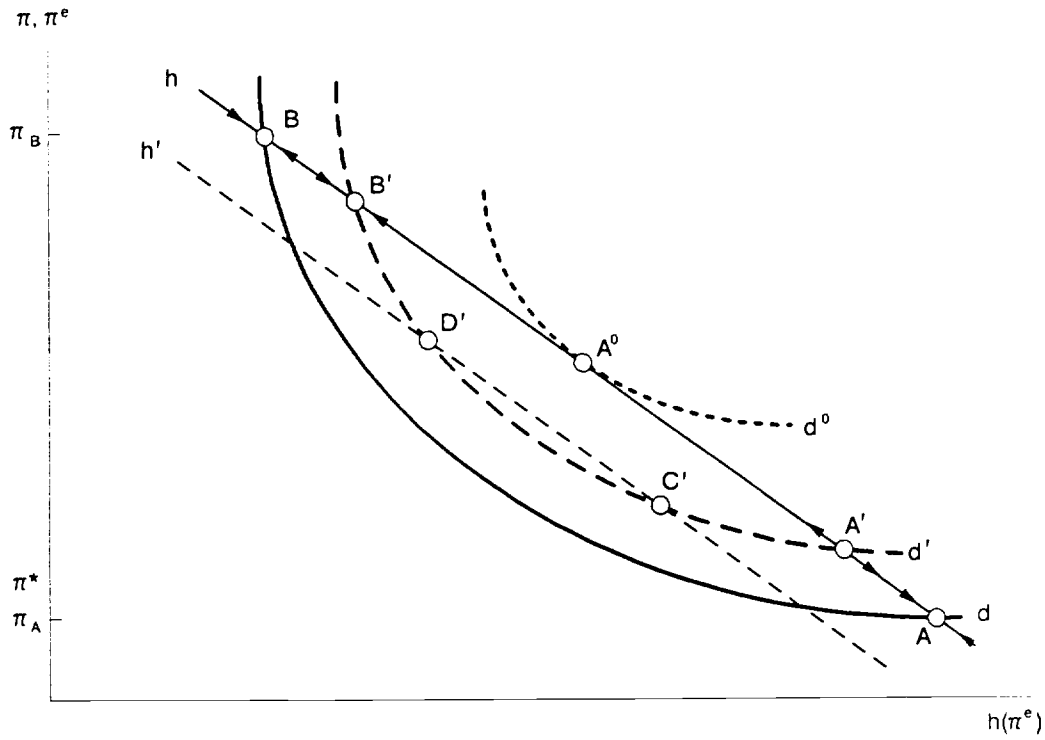

Figure 3

Government Finance, Monetary Base and Equilibrium Inflation