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The Macroeconomics of Price Reform in Socialist Countries

A Dynamic Framework

Simon Commander
and
Fabrizio Coricelli

The macroeconomic consequences of adopting different price rules for adjusting controlled prices in systems where controlled and market prices coexist and the implications of varying the proportions of controlled and market prices.

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This paper — a joint product of the National Economic Management Division, Economic Development Institute, and the Macroeconomic Adjustment and Growth Division, Country Economics Department — is part of a larger effort in PRE to analyze the sources and dynamics of inflation in transitional socialist economies. Copies are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Olga del Cid, room M7-047, extension 39050 (45 pages).

Commander and Coricelli analyze the macroeconomics of a system in which controlled and market prices coexist — as happens in socialist countries carrying out gradual price reform. They refer in particular to recent experience in Hungary and Poland with price reform.

They analyze the macroeconomic implications of adopting different price rules for adjusting controlled prices — and discuss the implications of varying the proportions of controlled and market prices. They find that:

- When expectations play an important role, the slow adjustment of controlled prices can serve as an "anchor" for the rate of inflation. But since price controls generally have negative effects on the budget, when money is passive and hence accommodates budget deficits, gradually adjusting controlled prices may fuel inflation through the fiscal/monetary channel. Consequently, expectations and budget adjustments may exert conflicting pressures on inflation, thereby complicating the management of a mixed system of controlled and market prices.

- In adjusting controlled prices, being too responsive to macroeconomic imbalances can destabilize the system; giving heavy weight to reducing the wedge between controlled and free prices stabilizes the system.

- Forward-looking behavior on the part of price-setters is conducive to stability; forward-looking behavior on the part of consumers is destabilizing.

- Complete price liberalization is superior to a mixed system in terms of stability but is likely to be associated with substantial overshooting of the equilibrium inflation rate. Rapid price liberalization tends to produce an inflation rate that is initially higher, but less persistent, than gradual price liberalization would produce.

The Macroeconomics of Price Reform in Socialist Countries: A Dynamic Framework

by
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and
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1. Introduction

The relaxation of price controls has been a consistent feature of reform in socialist economies. At the same time, there appears to have been a strong positive association between such price reforms and increases in the rate of inflation. It is widely held that this association merely reflects the translation of hidden or repressed into open inflation. However, as Table 1 clearly indicates, those countries - Hungary, Poland and Yugoslavia - that have undertaken significant price reforms have maintained such higher levels of inflation. Indeed, price reforms appear to be linked to progressively more powerful inflationary outcomes that can culminate in hyperinflation, as has happened in Poland and Yugoslavia.

Table 1

Inflation in Eastern Europe, Industrial Countries and Developing Countries, 1971-89

	Average 1971-80	1981	1982	1983	1984	1985	1986	1987	1988	1989
Bulgaria	2.0	0.4	0.3	1.4	0.7	1.7	3.5	0.0	-0.1	n.a.
Czechoslovakia	1.1	0.9	4.7	1.1	0.9	1.3	0.4	0.1	0.2	n.a.
GDR	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	n.a.
Romania	0.9	2.0	16.9	5.2	1.1	0.4	-0.1	n.a.	n.a.	n.a.
Soviet Union	0.3	1.0	3.0	1.0	-1.0	1.0	2.0	1.9	n.a.	n.a.
Hungary	4.5	4.6	6.9	7.3	8.3	7.0	5.3	8.6	15.7	16.0(*)
Poland	4.6	24.4	101.5	23.0	15.7	14.4	18.0	25.2	60.0	244.0
Industrial countries	8.6	10.1	7.5	5.0	4.9	4.1	2.4	3.0	3.3	4.5
Developing countries	20.6	25.8	25.4	32.7	38.5	40.6	31.4	41.6	70.8	85.5

Source: UN, Economic Survey of Europe 1988-89; IMF, World Economic Outlook, October 1989
(*) First three quarters for 1989

One emerging judgement is that partial price reforms can promote price disturbances which when linked to volatile expectations can result in a price spiral. The underlying argument can be derived from the nature and scale of the absolute and relative price distortions present in a typical socialist economy. This argument can be taken in a number of directions. On the one hand, the additive nature of the disturbances induced by each bout of price adjustments can be an argument for a once-and-for-all price liberalization of the type undertaken in Poland in January 1990. In this light, and assuming the fundamentals are in order, one transmission path for inflation would be eliminated as both the price level and relative prices would be established by importing international prices (Lipton and Sachs,1990). This ignores, however, non-tradables prices as well as the fact that price inertia and stickiness also characterize market systems. Further, the institutional and behavioural rules operating in the economy may continue to prejudice a rapid or efficient settling down of prices. Among other factors, as long as state-owned enterprises continue to account for the largest share of industrial sector output, even a full price liberalization will not eradicate administrative interference in price setting. The question of political feasibility is also central. Accordingly, more gradualistic approaches to price reform are likely to remain important. Further, as this paper indicates, a gradualistic approach need not yield a price explosion but can, under certain conditions, be used to dampen price volatility and the tendency to rapid inflation.

The gradual approach to a full market-based system of prices implies the continuing coexistence of categories of prices with differing procedures for determination. Generally speaking, this involves two main sets of prices; one administratively set by the government or planner; the other set, in

principle, in the market place. In reality, the distinction is less strict. Indeed, cost-plus pricing, market-clearing and fully arbitrary administrative pricing rules can all be simultaneously present in a partially reformed socialist economy (Kornai,1980). In this paper, for the sake of simplicity, we work with a dual pricing system where one set of prices is determined by markets, the other administratively. It should be noted that we do not identify market prices with fully flexible prices and hence assume the presence of inertial features. Our aim is to set up a relatively simple model capable of handling the particular price-price dynamics that are associated with a dual pricing system where disturbances can be introduced on both sides but primarily by changes to administered prices and, hence, where the discrete choices of the planner are critical. The objective is to clarify analytically the conditions under which this system can be stabilized and which would therefore be relevant when the general approach to price reform is gradualistic. Moreover, because our concerns are macroeconomic, the implications of price changes and relative price movements are traced in relation to effective demand and the budgetary position. Nothing is said about the allocative consequences of such price movements. However, it is worth noting that high inflation on the aggregate level generally undermines the possibility of efficient changes in relative prices.

To pursue this line of enquiry, a number of underlying rules have to be spelt out. One would wish to know the rules by which controlled and market prices were respectively set prior to determining the interactive effects between controlled and market prices. An underlying rule would also include the relative role attributed to the adjustment of controlled prices by the government or planner, as against other instruments, in achieving

macroeconomic targets, such as the planned supply function [2]. It is clearly reasonable to assume that the planner can use controlled prices as a major macroeconomic policy instrument even if the economy is increasingly marked by the presence of non-administered, market-set prices. With respect to the latter, one must obviously assume similar features to market economies - inertia in price adjustment, staggered price setting rules not to speak of the consequences of relatively thin markets, speculative pressures and constrained trades.

The paper emphasizes the fiscal underpinnings of the inflationary process and those particular dynamics when a dual price system is present. In particular, we explore the links between price controls and decontrols and the government budget, mainly through the flow of subsidies to either consumers or producers. A clear conclusion is that without consistency in macroeconomic policy, price liberalization may simply exacerbate imbalances and ultimately provide a mechanism for sustaining inflation, hence compromising a basic objective of macroeconomic policy.

With regard to the underlying rule for the adjustment of controlled prices, we assume that this occurs in response to macro-imbalances, particularly as partial corrections to disequilibria in consumer goods markets. Likewise, we can assume that over time planners do not remain indifferent to the size of the wedge between border and domestic prices for strategic tradables, such as energy, particularly because of the fiscal implications of such a wedge. At a certain point, adjustment of controlled

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[2] Available work has concentrated primarily on quantity adjustments where prices are fixed. The gap between planned and actual consumption by households is fed back into supply equation; hence plan formation is endogenous. See, for example, Portes, Quandt, Winter and Yeo (1983).

prices may occur to close the wedge.

This points not only to one of the basic choices of the planner -- either to adjust those set of prices which are controlled or else rely on fiscal-monetary instruments -- but also to the way in which these instruments interact and to the ambiguous outcomes that can be derived within the constraints of the socialist economy. Thus, reducing a price wedge for energy, say, may result in lower levels of subsidy passed through the budget. If, however, changes to the input costs of enterprises occur but output prices remain controlled and no strong productivity effect is present, this may simply increase the losses of enterprises and ultimately the fiscal or quasi-fiscal deficit. This appears to have occurred in both Poland and Yugoslavia in recent years. Alternatively, if changes to input prices are transmitted immediately via normal cost pricing rules through to final prices, an inflationary outcome is inevitable. These mechanisms are confirmed by the experience of Poland after 1990, whereby controlled input prices -- mainly energy -- were sharply raised in a context where final prices were almost fully liberalized. This led to an improvement in the budget deficit, via a reduction in subsidies, but also provoked an initial boost to inflation.

The interactive effects of price changes to controlled and market prices further depends on the character of the dual system with which we are working. One such system assumes a process of horizontal price liberalization. Under such a mixed system, two sets of prices exist for the same commodity. Alternatively, a vertical liberalization would result in some sets of prices, such as for final goods, being controlled and others, such as intermediates, being set in markets. The nature of the mixed system can be further modified to incorporate official and black market sectors but the real issue is not the

status of the sector but the pricing rule that is imposed [3]. However, the nature of the price liberalization pursued has implications for the manner in which the planner can use prices as a macroeconomic instrument [4].

The model that we set up below does not explicitly discriminate between types of mixed system other than in working with two distinct pricing rules. The price level and inflation rate are derived as a weighted average. The two pricing regimes - that established by the planner and that by the market - are, however, characterized by non-synchronization and by different underlying rules and constraints. Our principal interest is in demonstrating the ways in which changes in the rules for price adjustments of controlled prices by the planner can affect the overall inflation rate. To do this, we make a number of key assumptions.

In the first instance, the planner's rule for controlled price changes remains influenced, if not determined, by the constraints present prior to any price reform. Adjustment to controlled prices to act on demand can be considered an explicit policy choice. Alternatively, the planners can decide to adjust controlled prices in line with changes in market prices. This behavior tends to stabilize the economy. However, for many products there are no domestic market prices to imitate. In these cases foreign prices of similar products may be assumed as reference price for adjusting controlled

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[3] See, for example, Alexeev (1987). Gronicki's (1989) disequilibrium model employs a mixed system but assumes controlled prices to be fixed and free prices to be fully flexible. The latter assumption is obviously inappropriate in the context of a transitional socialist economy as it overstates the equilibrating power of market based prices.

[4] Horizontal systems can either have controlled and market prices for the same good -- as in China -- or else no coexistence for similar or substitutable goods, as in much of Eastern Europe.

prices.[5] A less efficient rule, but perhaps still stabilizing at the macro level, could assume the average price index in the economy as reference point.

Second, market prices are not assumed to be fully flexible prices, having rather some of the properties of the price system that actually prevails in market economies, including inertia and stickiness, but in a more exaggerated form. This would be expected in a transitional regime where competitive conditions are either absent or restricted. Our treatment of this environment -- a standard feature of the reforming socialist economy -- draws on some of the characteristics of price setting that can be derived under monopolistic competition (Chamberlin, 1933). This in turn may actually exaggerate the degree of similarity between such economies and a market system. This is because monopolistic competition assumes free entry of firms and products [6]. We impose long-run equilibrium conditions on the system, while prices cannot instantaneously eliminate macro-disequilibria. The main results that we derive can be summarized as follows;

(i) if the planner becomes too responsive to macro-imbalances in adjusting controlled prices, this can destabilize the system,

(ii) if the planner gives a large weight to reducing the wedge between controlled and free prices, this stabilizes the system,

(iii) while the overshooting on impact of the equilibrium inflation rate

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[5]Interestingly, Kornai(1990) has recently suggested similar rules for adjusting prices of public enterprises during the transition to a market economy.

[6] It might be more appropriate to think in terms of overlapping oligopolies, in the spirit of Kaldor(1935). This has obvious implications for establishing whether Cournot-Nash conditions hold. In this context, we are not interested in the efficiency or optimality conditions but in establishing a pricing rule that does not require market clearing but has broadly flexible properties.

is a general outcome, the overshooting is larger the more frequent are the adjustments to controlled prices by the planner,

(iv) raising the share of market prices in total prices has a stabilizing effect in the long run with, however, a larger overshooting in the short run,

(v) forward-looking behaviour on the part of price-setters is conducive to stability whereas similar behaviour on the part of consumers may be destabilizing,

(vi) the more sensitive aggregate demand is to expected inflation, the larger will be the initial overshooting, while the greater will be the risk of overall instability,

(vii) a complete price liberalization is clearly superior to a mixed system in terms of stability but is likely to be associated with a very substantial initial overshooting of the equilibrium inflation rate.

The structure of the paper is as follows. In the following section we provide a summary discussion of the main features of the mixed price economy. In section 3 we lay out the main features of the formal model (the Appendix contains a full specification) and in section 4 we derive the main conclusions.

2. Some stylized features of the dual price economy

To provide an empirical framework against which to set the workings of the model that we develop in Section 3, we draw on information for two economies -- Hungary and Poland. Analogous considerations would, however, apply to most reforming socialist economies. In the case of Hungary and Poland, both economies have undergone a sustained period of relaxation of controls but this process has been associated with very differing inflationary outcomes (see Table 1). Further, since 1990, the Polish stabilization

strategy has marked a radical break with past practice. To that extent, the Polish experience encompasses both a period in which a mixed pricing system operated and one in which this distinction was dissolved as part of a fuller price liberalization that left barely 5% of retail prices subject to any form of control. For both countries, a mixed pricing system did not generally imply polar cases, in so far as market prices were generally subject to some lesser measure of intervention through establishment of ceilings on price changes and control over the frequency of price adjustment. While rather more binding than in industrial market economies, such interventions bear similarity to periods when prices and incomes policies have been deployed, such as in the United Kingdom in the 1960s and the United States in the early 1970s. The difference, of course, remains the extent of intervention, the rules for enforcing that intervention and the presence of fully controlled prices as a commonly dominant component of the overall system.

The Hungarian experience with a gradual liberalization of prices reflects the relatively early recognition of the need to provide adequate incentives to producers in markets where official controls were weak, such as agriculture, as well as the intention to relate more closely domestic to border prices. Since 1968, when the price liberalization commenced [7], emphasis has shifted from acting on producer prices to direct adjustment of consumer prices. However, the response to external price shocks has been inconsistent; the first oil price shock of 1973 was offset by subsidies, controls and exchange

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[7] Through those reforms a three-tier system was established consisting of fixed prices, flexible prices - with fluctuations permitted between a designated ceiling and floor - and free prices that enterprises were allowed to set within a set of established guidelines and were in reality also strongly regulated. There were in addition prices set in non-official markets but these accounted for a very small share of total transactions.

rate appreciation; a reflection of the planner's preoccupation with stability of official prices. Subsequent policy has generally enabled a more direct translation of external price changes through to domestic producer prices [8]. After 1980 producer prices were more explicitly related to world prices through energy and raw materials prices. The effect on consumer prices has in turn depended on the degree to which enterprises have been allowed to pass on such price increases. The competitive pricing system that was established and operated up to 1987 linked domestic price adjustments and profit margins to export prices and profit margins. Later modifications to the pricing rules, particularly after 1985, have progressively reduced the share of prices subject to controls. Price controls have been maintained on housing.

Table 2 indicates the sharp increase in the share of free prices for both producer and consumer goods over the last decade. By 1989 77% of producer and 83% of consumer prices were classified as free. For consumer prices, explicit price controls, with prices constrained to a maximum, were almost entirely concentrated on domestic energy, medicine and transportation. These controls are in theory to be further scaled down over the coming five years. In the case of the free prices, however, roughly 20% remained subject to either an obligation to report in advance price changes or else to the price consultation process. These mechanisms have attempted to correct for any inherent tendency to exploit market power in highly concentrated markets.

[8] This has not been that consistent- the effects of the 1986 devaluation on domestic prices were restrained by administrative actions.

Table 2: Hungary

Distribution of Producer and Consumer Prices by Pricing Category, 1979-1989

Category	1979	1980	1982	1984	1985	1987	1988	1989
Producer:								
Fixed	43	33	na	30	32	28	25	23
Free	57	67	na	70	68	72	75	77
Consumer:								
Fixed	na	na	15	15	6	6	0	0
Flexible	na	na	29	28	38	32	20	17
Free	na	na	56	57	56	62	80	83

Source: IMF
1/Producer fixed prices include fixed prices, prices fluctuating between fixed upper and lower limits and those subject to a maximum. Consumer flexible prices include prices subject to a maximum.

The principal features of the Hungarian experience can be summarized in the following way. The price system has been mixed with up to four sets of pricing rules coexisting at any one time, being differentiated by the extent of administrative control over their determination. The relative price structure has not been as frozen as in a number of other Eastern European economies due to explicit changes to relative prices by the planner, by the linking of foreign to domestic energy and raw materials prices and some measure of decentralization in price setting by enterprises. The share of prices that can be set by market forces has grown significantly over the 1980s but the degree of implicit controls on the rate of price increase has remained significant.

The Hungarian price setting system in the 1980's has thus been characterized by the maintenance of strong centralized mechanisms, including implicit and explicit guidelines. These have been complemented by loose association of domestic tradables prices to border prices. Thus, shocks to

the price level have come primarily from discrete changes to controlled prices by the planner. Such shocks have,in turn, been a response, commonly lagged, to external price movements as well as explicit realignments of relative prices. While the commitment of the planner to price stability has been progressively relaxed, it is important to understand that a consistent mechanism for dampening price growth has been to offset input cost increases by means of direct or indirect subsidies to enterprises. The financing mechanism has either been through the budget or, more commonly, through the banking system.

Table 3 shows the high level of current subsidies attracted by enterprises. A breakdown of the components of the total subsidy bill indicates that nearly 16% of total current subsidies and financial support to enterprises between 1986-1988 took the form of producer price subsidies. Such subsidy covers the difference between actual costs and administered producer prices and, together with similar import subsidies, amounted to around 3% of GDP.[9] This in turn engendered a pattern of periodic adjustment to producer and consumer prices as a means for reducing the fiscal costs of that gap. Nevertheless, subsidies to enterprises and consumers appear to have been a major element in a rising fiscal and quasi-fiscal deficit and hence a factor in sustaining the shifts in the price level caused by the actions of the planner. Equally significant has been the fact that gradualistic price reforms and a rising share of partially controlled and market-based prices have not been associated with a sharp price spiral, even if inflation has remained at higher levels than in the 1970s.

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[9] The subsidy is determined independently of the general profitability of the producer on the basis of the discrepancy between the administered price and the cost of a given commodity.

Table 3: Hungary

Prices and Subsidies, 1982-1989

Year	Consumer Prices	Producer Prices	----% of GDP---------- General Govt Subsidies	Subsidies to Enterprises	Ratio Enterprise Subsidy to Gross Operating Surplus
1982	6.9	4.7	34.7	18.8	44.4
1983	7.3	5.5	36.4	19.5	46.7
1984	8.3	4.2	34.1	18.4	39.1
1985	7.0	5.3	35.1	20.0	39.0
1986	5.3	2.1	37.0	20.8	38.3
1987	8.6	3.5	34.7	20.8	37.0
1988	15.7	4.6	35.8	17.4	38.0
1989*	17.0	14.2	31.4	n.a.	n.a.

*=estimates
Source: World Bank

Table 4: Poland

Distribution of Prices by Category, 1982-1990 (in percent of the total value of sales for the products covered by each category of prices)

	Administrative Prices	Regulated Prices	Contract Prices
Prices of consumer goods and services			
1982	35	15	50
1983	45	15	40
1984	47	3	50
1985	47	3	50
1986	46	2	52
1987	45	0	53
1988	45	0	55
1989	45	0	55
1990	5	0	95

Source: IMF

Table 5: Poland

a. **Consumer subsidies in percent of GDP and inflation.**

Subsidies		CPI Growth		
In Percent of GDP		Total	Controlled	Free
1980	27.8	9.4	--	--
1981	30.3	24.4	--	--
1982	17.2	101.5	110.7	89.5
1983	14.8	23.0	23.9	19.9
1984	15.8	15.7	14.9	15.5
1985	15.0	14.4	11.3	17.4
1986	15.6	18.0	14.6	19.6
1987	15.1	25.2	21.1	27.4
1988	14.9	60.0	58.4	60.9
1989	12.0	249.0	--	--

b. **Fiscal deficit and seignorage.**

Fiscal deficit/GDP		DM1/GDP[10]
1980	1.15	3.4
1981	10.43	7.1
1982	2.47	8.4
1983	0.82	2.5
1984	0.67	3.0
1985	0.21	4.3
1986	0.45	4.2
1987	1.70	4.6
1988	0.22	6.6
1989	7.50	13.5

Source: World Bank

[10]/ DM1=M1-M1(-1)

The Polish experience with price reform in the 1980's shares many of the features described in the case of Hungary. As shown in Table 4, the major price reform of 1982 created different categories of prices, while increasing over time the share of those prices set, at least in principle, independently of administrative controls.

In general, as in Hungary, price controls in Poland have been maintained through a sizable flow of subsidies to the sectors subject to price controls. Table 5 reports the evolution of consumer subsidies, defined as the difference between production costs and controlled prices, during the 1980's.

Two main observations can be made. First, the price reform of 1982, by both liberalizing prices for a significant share of goods and by increasing prices of controlled goods, involved a sharp contraction of subsidies, from a level which was clearly unsustainable. In other words, the price reform should be interpreted as a clear attempt at reducing macroeconomic imbalance and changing relative prices. Second, there is no simple short-run, negative correlation between the overall inflation rate and the subsidy bill. Rather, one can infer that even at high rates of average inflation a reduction in subsidies will not necessarily occur if controlled prices lag behind market prices. Indeed, it appears that subsidies have been negatively correlated with the relative price of controlled with respect to market prices. This occurs because market prices enter into the production costs of sectors subject to price controls, both directly though the price of inputs or indirectly through the effect on wages. Clearly, in a system in which wages are indexed to a basket of goods which comprises both controlled and uncontrolled goods, an increase in market prices promotes an increase in wages thus ratcheting up wage costs for enterprises, including for those subject to

price controls. Through this channel, increases in market prices, relative to controlled prices, can yield expansion in the level of subsidies and hence of the consolidated fiscal deficit. This outcome appears at various times to have emerged in both Hungarian and Polish cases.

Despite some analogies with the Hungarian experience, however, in Poland there seems to be a clear correlation between price reform and a rapidly accelerating inflation rate. The impulse can be variously traced to controlled and market goods prices. Thus, adjustments to controlled prices invariably led to episodes of accelerating inflation as in 1982, 1988 and 1989. But between 1983 and 1988 the pattern was reversed, with market prices growing faster than controlled prices. In 1989 and in January 1990, administrative prices 'led' the inflationary process. Input prices, in particular energy, were subject to the most significant changes. In three rounds, in October and November 1989, and in January 1990, prices of main energy products were raised sharply, at rates of between 500-600 percent in some cases. This contrasts with the 1982 price reform in which energy and input prices were subject to mild correction.

The different inflationary paths followed in Hungary and Poland during sustained periods of price reform suggests that the effects of the latter depend critically on the way in which they are enacted and on the macroeconomic context, including the bargaining process for wages and prices, in which they operate.

In principle, wages were determined in both economies in reference to a centralized wage norm with some further adjustment for plant-level productivity growth. In Hungary, control of wage changes through progressive taxes was fairly successful until recently. Wage drift over the 1980s was

relatively slight. However, the underlying rule related wages to planned or expected inflation and was to some degree independent of the productivity relationship meant to underpin the wage contract. In the Polish case, by contrast, the ability to enforce a centralized norm was eroded. The 1982 reforms aimed to address macroeconomic imbalances by imposing a real wage reduction. By 1989 real wages had gradually moved back to pre-1982 levels and centralized norms became increasingly irrelevant in the wage determination. Inflationary pressure on costs was consequently more profound than in Hungary. With ex ante indexation of wages to prices, changes to the price level were simply validated. As the planner relied on price adjustments as the main mechanism for correcting macroeconomic imbalances this generated an underlying instability in the system. The high inflation of 1989 can be ascribed to the impact of accelerated domestic price liberalization and exchange rate policy on costs via the indexation scheme and through the cumulative impact on expectations, including the uncertainty imparted to the system by the lack of apparent rules in the determination of price changes by the planner.

3. The formal model

We now construct a simple macroeconomic framework which explicitly accounts for the coexistence of controlled and market determined prices. The model, with the help of some illustrative numerical simulations, aims to explore more rigorously some of the dynamics associated with the mixed price economy as outlined in the previous section.

One of the main problems in analyzing a mixed price system is that of ascertaining the pricing rules followed by the planners for controlled goods. A natural initial assumption would be to associate the motivations underlying price changes of controlled goods with those prevailing in the earlier period

when all prices were set administratively. However, to the extent that this would assume a fix-price economy, this would say little regarding the appropriate rule for adjusting controlled prices. In that respect, it clearly requires that the planner's pricing rule be affected by macroeconomic policy objectives, such as reducing excess demand or the deviations of actual from planned output [11].

In this paper, we explicitly postulate an adjustment rule for controlled prices which accounts not only for excess demand effects but also accommodates relative controlled and market price considerations. Specifically, the planner is assumed to adopt the following rule for price adjustment:

$$\dot{P}^q=\Gamma(Y-Y^*)+c(P^f-P^q)$$

The first term, $(Y-Y^*)$, captures the concern with macro-disequilibria or excess demand and the second term, (P^f-P^q), the concern for relative prices. The latter may arise, for example, because of budgetary considerations, or with free prices following closely world prices --assuming for instance that free prices apply to tradable goods-- this can also reflect the attempt of bringing the whole price system closer to world market prices. Thus, if free prices enter as inputs in the production of controlled goods, relative prices will affect the profitability of enterprises in the controlled sector.

To simplify the exposition we analyze two polar cases in which the planner cares either about excess demand or relative prices. The properties of the general model are a linear combination of the two submodels. For market prices we assume the same setting for the two models. Such prices are

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[11] Charemza and Quandt (1982) introduce price dynamics in a standard disequilibrium model with the assumption that the planner adjusts prices to eliminate macro- disequilibria. See also Peebles (1986).

characterized by some stickiness at the aggregate level, due to the fact that prices are changed only at certain intervals. The price setting embodies a forward-looking component, related both to the price of competitors and to the state of the market for the period in which the "price-tag" will be in place. Moreover, the timing of price changes is assumed to be staggered over individual enterprises. The full specification of the models is contained in the Appendix.

3.1. The planner as 'leader'

Controlled prices move over time according to the following adjustment rule:

$$\dot{P}_t^g = \Gamma(Y_t - Y^*) \qquad [12] \qquad (1)$$

where Y is the demand determined output, and Y^* potential output, assumed constant. We will denote the deviation of output from its potential level as D. Here we assume that the planner sets controlled prices looking at aggregate imbalances and not just at disequilibria in the controlled sector. This assumption simplifies the analysis and seems to reflect the actual concern of planners in socialist economies (Peebles (1986), Charemza and Quandt (1982), Quandt (1989)).

For market prices we assume a framework which accounts for three main features: a) firms are not price takers; they have some monopoly power which they exploit through the price setting; b) at the aggregate level, prices do not adjust instantaneously to equilibrium; c) the price setting is not

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[12] A more rigorous model would add a term reflecting the long-run inflation rate to equation (1). In the present specification, indeed, in the long-run controlled prices do not change, while free prices increase at the constant rate of money growth. Since our concern is on the dynamics and not on long-run positions, we use the simpler version of price adjustment. Considerations of relative prices between controlled and free goods are examined in section 3.3..

synchronized across individual enterprises. This asynchronization increases the inertia in the adjustment of market prices. In order to emphasize the differences between the price setting of market prices with respect to the price setting of controlled prices, we will assume a price system for the former which reflects a fairly developed market system. We assume a monopolistically competitive setting with price setters forming rationally expectations on prices of their competitors and on future states of excess demand [13]. Consequently, market forces play a fundamental role in price adjustment; there is a sufficiently high degree of competition among firms and actors behave rationally, given the market structure in which they operate.

The dynamics of market prices are represented by the following equations:

$$\dot{V}_t = \delta(V_t - P_t - \beta D_t) \qquad (2)$$

describes the dynamics of "new" prices V, set at each point in time by an individual firm, while

$$\dot{P}_t = \delta(V_t - P_t) \qquad (3)$$

describes the dynamics of average prices.

The system of equations (1), (2) and (3) describes a two-track economy, with the controlled sector more sluggish than the market sector. Moreover, the planner is "backward-looking" and takes into account only aggregate variables in the price adjustment rule, whereas the market sector is forward looking and comprises an interaction among individual price setters, through their concern with competitors' prices.

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[13] The price setting for market prices is based on Calvo (1983).

Despite its simplicity, the model captures some of the features of transitional socialist economies. The random arrival of price change signals is consistent where the government pursues uncertain price policies within its implicit constraint of the tolerability of price changes. The role of relative prices is institutionally imposed by rules which state that prices of individual products cannot deviate too much from those of similar products.

To close the model we need to specify the deviation of output from its potential level, D, and the monetary sector. We assume aggregate demand depends on real monetary balances and on the real rate of interest. Output is demand determined, and Y^* is a constant "natural", or non-inflationary, level of output. [14]

$$D_t = \epsilon(M_t - P_t) + \Theta(\pi_t - i_t) \qquad (4)$$

where π is the inflation rate; a weighted average of the rate of inflation in controlled and market prices:

$$\pi_t = \alpha \dot{P}_t + (1-\alpha)\dot{P}^q_t \qquad \text{with} \qquad 0<\alpha<1 \qquad (5)$$

We first analyze a model in which money supply is exogenous and its rate of growth constant over time.

3.2. Exogenous Money Supply

With an exogenous rate of growth of money supply we are assuming that price policies are subordinate to active monetary policy. The price policy pursued by the planner essentially determines the speed at which controlled prices adjust to changed monetary conditions. During the adjustment, this

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[14] Real interest rates have been found irrelevant in empirical analyses of savings functions for classical CPEs (see Portes and Winter 1978). It is plausible to assume that interest rates have gained relevance in affecting consumer behavior in reforming socialist economies.

price policy affects the extent of disequilibria in goods market, as it affects the proportion of increase in the money stock which translates into an increase in real monetary balances and thus, aggregate demand. As shown in the Appendix, when money supply grows at the constant rate μ, there are two possible dynamic configurations: the first, complete instability of the system, the second, a unique convergent path. [15]

The unique convergent solution arises when

$-\Gamma\alpha\delta^2\beta/\Sigma<0$, or $\Sigma>0$.

Recalling the definition of Σ (see Appendix), we can restate the condition above as

$1-(1-\alpha)\Gamma\Theta>0$, or, in a more convenient form,

$$\Gamma\Theta<1/(1-\alpha) \qquad (*)$$

Condition (*) states that for a given value of the elasticity of aggregate demand with respect to expected inflation (the parameter Θ), the speed of adjustment of controlled prices has to be sufficiently slow to ensure a unique convergent path.[16]

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[15] The unique convergent path is associated with a saddle-path type solution. As is standard in the rational expectations literature, we will concentrate on the latter as the stable solution of the system.

[16] Note that the above condition closely resembles both the condition for stability in a standard IS-LM model and the well-known condition for stability of the inflationary process obtained in Cagan(1956), in a purely monetary model, with backward-looking expectations. This is hardly surprising, as our model shares properties of both models. In the short-run it behaves as a standard IS-LM type of model, while in the long-run it has the standard characteristics of a monetary model. In the context of an IS-LM model, the above condition guarantees that the IS curve is downward sloping, and that an exogenous increase in demand increases output. In our model, output is fixed and the decision on price changes of the planner is exogenous. Therefore, a priori we cannot rule out the possibility of instability. As shown in Tobin (1975), the fact that increasing flexibility (the speed of adjustment of prices) of price changes can be destabilizing is a property that extends to a range of models. As in Tobin, we simply show the conflicting effects of price level changes versus expected changes in inflation rates. If the latter effect

According to the condition (*), the following factors stabilize the system:

(a) a low value for $(1-\alpha)$. Thus, the larger is the share of free prices the higher is the probability of stability.

(b) a low value of Γ: the price adjustment in the controlled sector should not be "too fast".

(c) a low value of Θ: a low elasticity of aggregate demand with respect to the real interest rate.

Points (a) and (c) highlight the conflicting impact on the dynamics of the system of forward-looking behavior on the part of price setters and forward-looking behavior on the part of consumers. The larger is the share of market prices, and forward-looking price setters, the more likely is the system to be stable. The intuition behind this result is the following. Forward-looking price-setters reduce the "rigidity" of the system and the inertial movement of prices and hence accelerate the tendency toward long-run equilibrium. By contrast, forward-looking behavior on the part of consumers can destabilize the system, as inflationary expectations reinforce tendencies in demand and prices. Specifically, if demand is increasing and there is upward pressure on inflation, the expectation of rising inflation, by reducing the real interest rate, enhances demand and thus inflationary pressures.

Despite its simplicity the model gives rise to interesting and fairly complicated dynamic configurations. A first inference on the stability properties of the model can now be drawn. In the presence of sticky prices and different speeds of adjustment in the two sectors, a higher flexibility in

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dominates, the system can demonstrate instability. Furthermore, we could have specified Θ not as a constant but as a function --conceivably an increasing function-- of the rate of inflation; this would have caused the perverse result of lowering the value of Γ compatible with stability in conditions of higher inflation.

setting prices in the controlled sector can destabilize the economy. The relatively sluggish behavior of controlled prices may serve as an anchor for the whole system. A solution to this problem would obviously be to change the price setting rule in the controlled sector. If the planner adopts a pricing rule analogous to that of the market goods, there would be no risk of instability, even with a high frequency of price adjustments for controlled prices. Without changing the existing rule, however, an increased flexibility in the controlled sector can be destabilizing, placing the system on a potentially explosive inflation path.

We now turn to the analysis of the unique convergent path and to the dynamics of inflation following policy changes. We will concentrate on a very simple policy change, namely an unanticipated change in the rate of growth of money supply. The dynamics of the system is depicted in Figure 1.

The slope of the unique convergent path is positive. The increase in the rate of growth of money supply yields a shift of the steady-state inflation rate from μ to μ'. It also induces an upward parallel shift of the saddle-path. To determine where the system will settle on impact we know from equation (6) that $(d\pi/dD)=1/(\theta)$. This is the slope of the CC line in Figure 1. From this we can see that the system has to be on line CC and on the new saddle path immediately after the policy change. Therefore, the system will be at the intersection between CC and the new saddle path (point C in Figure 1) [17]. It is clear that there is overshooting on impact. The inflation rate increases initially above its new long run level. Aggregate demand declines but both inflation and aggregate demand move thereafter towards the long-run equilibrium. From Figure 1 we can see that the magnitude of the overshooting

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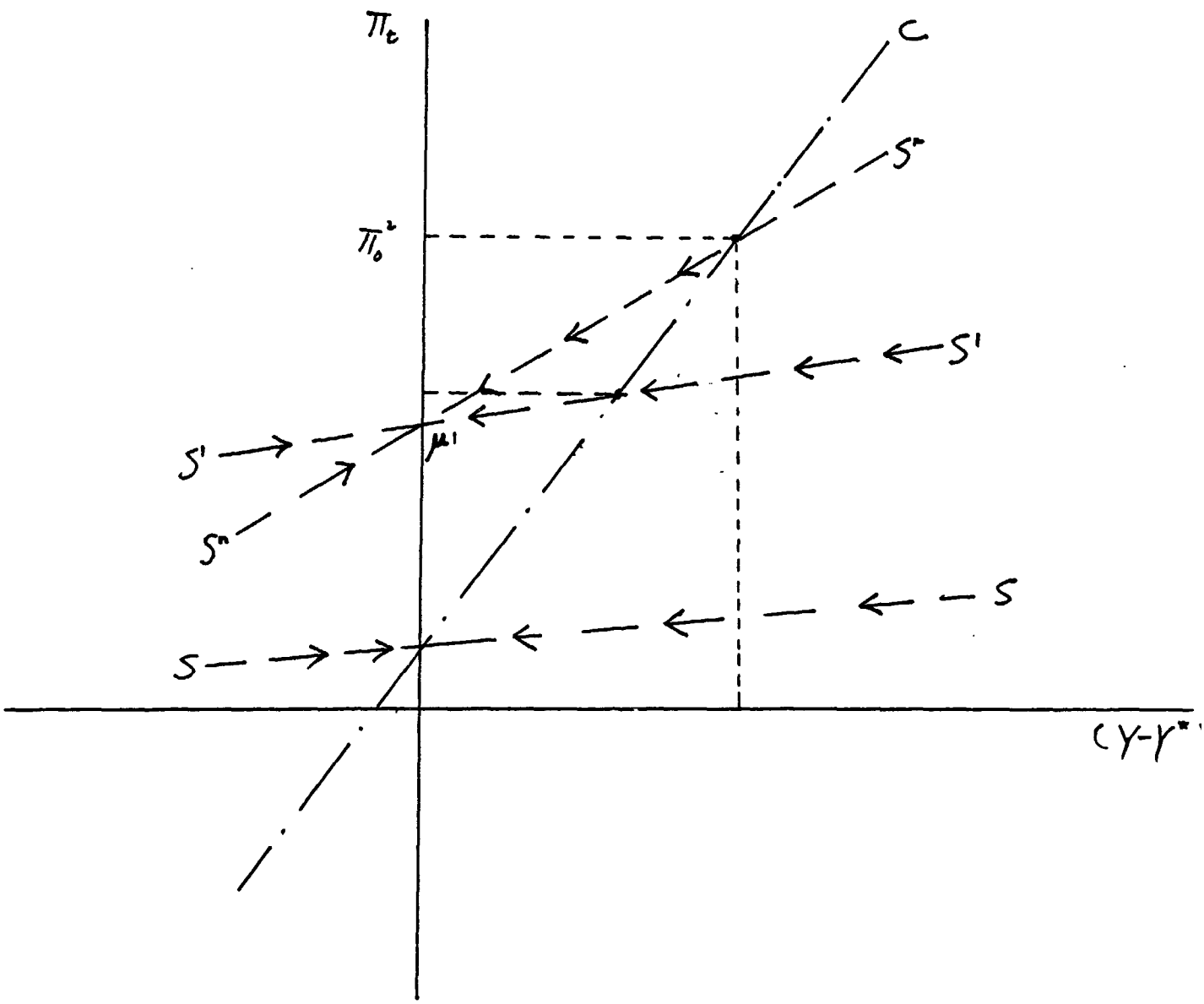
[17] See Blanchard and Fischer (1989) for an analogous derivation.

FIGURE 1

EFFECTS OF A MONETARY EXPANSION[1]



[1] SS = old saddle-path
S'S' = new saddle-path
S^nS^n = new saddle-path with an increased share of free prices

and of the initial output decline depends on the slope of the saddle-path and on the slope of the line CC. In this regard, we can identify the main factors determining these slopes and thus the magnitude of the overshooting.

(a) The higher the sensitivity of aggregate demand with respect to the real interest rate, the larger is the overshooting (this indeed yields a flatter CC line).

(b) The larger is the relative share of market goods, the larger is the overshooting (the SS line becomes steeper; see $S''S''$ line in Figure 1).

(c) Finally, the higher is the flexibility of price adjustments (higher Γ and/or higher δ), the larger is the overshooting.

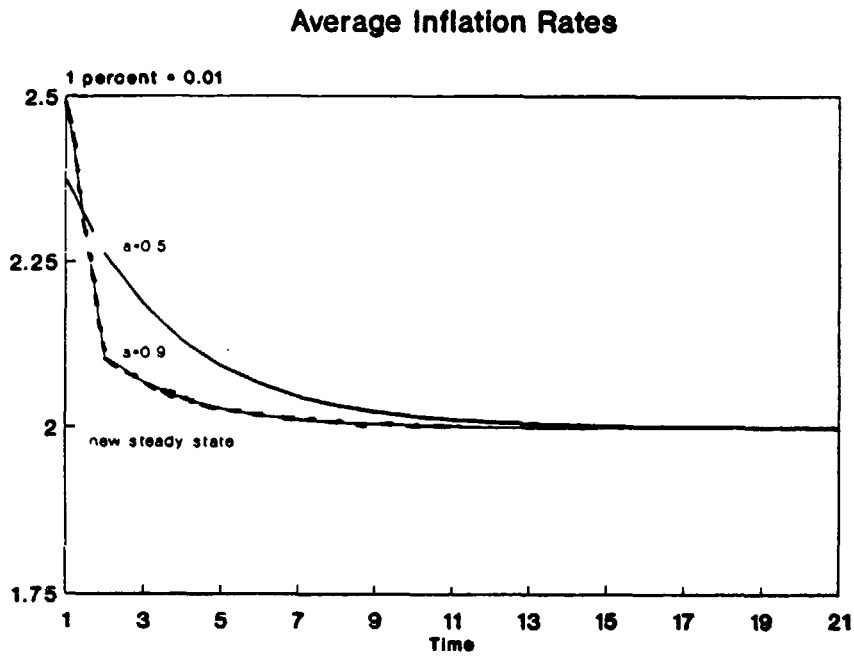
These features point to the difficulties inherent in a price liberalization manoeuvre in the presence of exogenous sources of inflation, such as an increase in the rate of growth of money supply. The resulting overshooting of prices has to be set against the fact that the very same features also accelerate the adjustment to the steady state. The economy faces a trade-off between a sharp, short-lived adjustment versus a more moderate and more protracted adjustment.

We now report the results of a numerical simulation (see appendix for details) of the effects on the inflation rate of different shares of market prices in the total price index.

Figure 2 clearly shows the different response of the system to an exogenous, unanticipated, increase in the rate of growth of money supply. Two cases are outlined, one which is characterized by a low share of market prices (low alpha) and the second by a large share of market prices (high alpha) in total prices. The magnitude of the initial overshooting, and the time span necessary to complete most of the adjustment (a complete adjustment is

Figure 2a

Simulation of the effects of an increased share of Free Prices



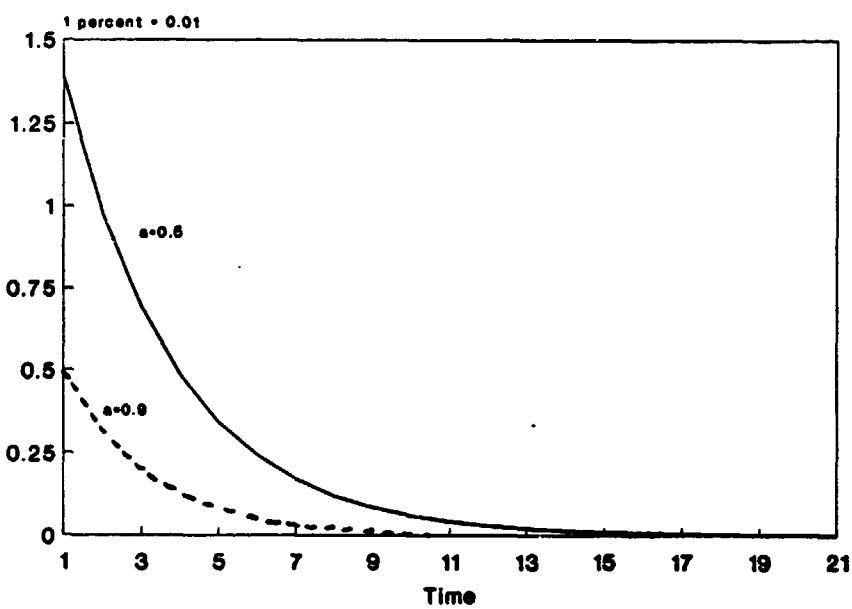
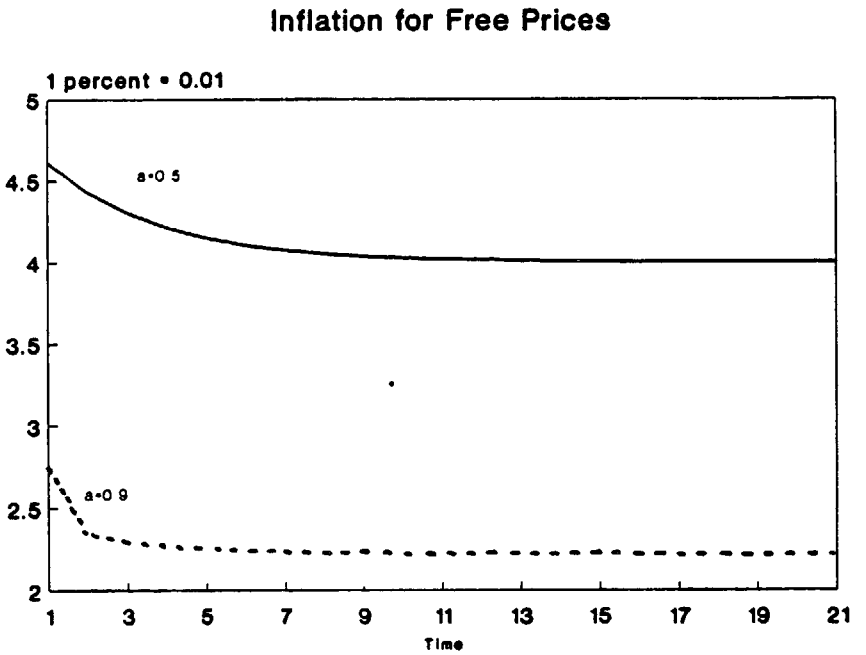
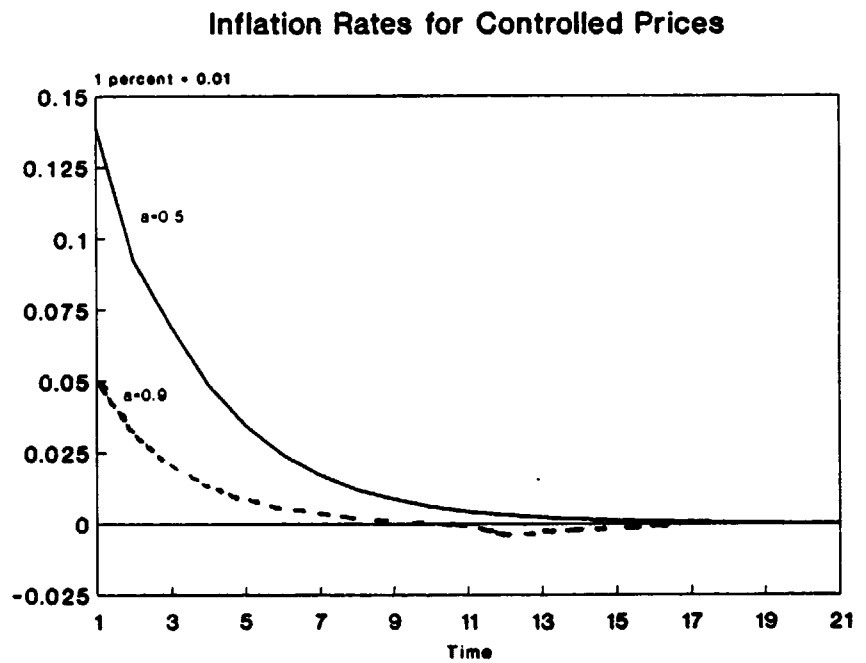


Figure 2b

Simulation of the effects of an increased share of Free Prices





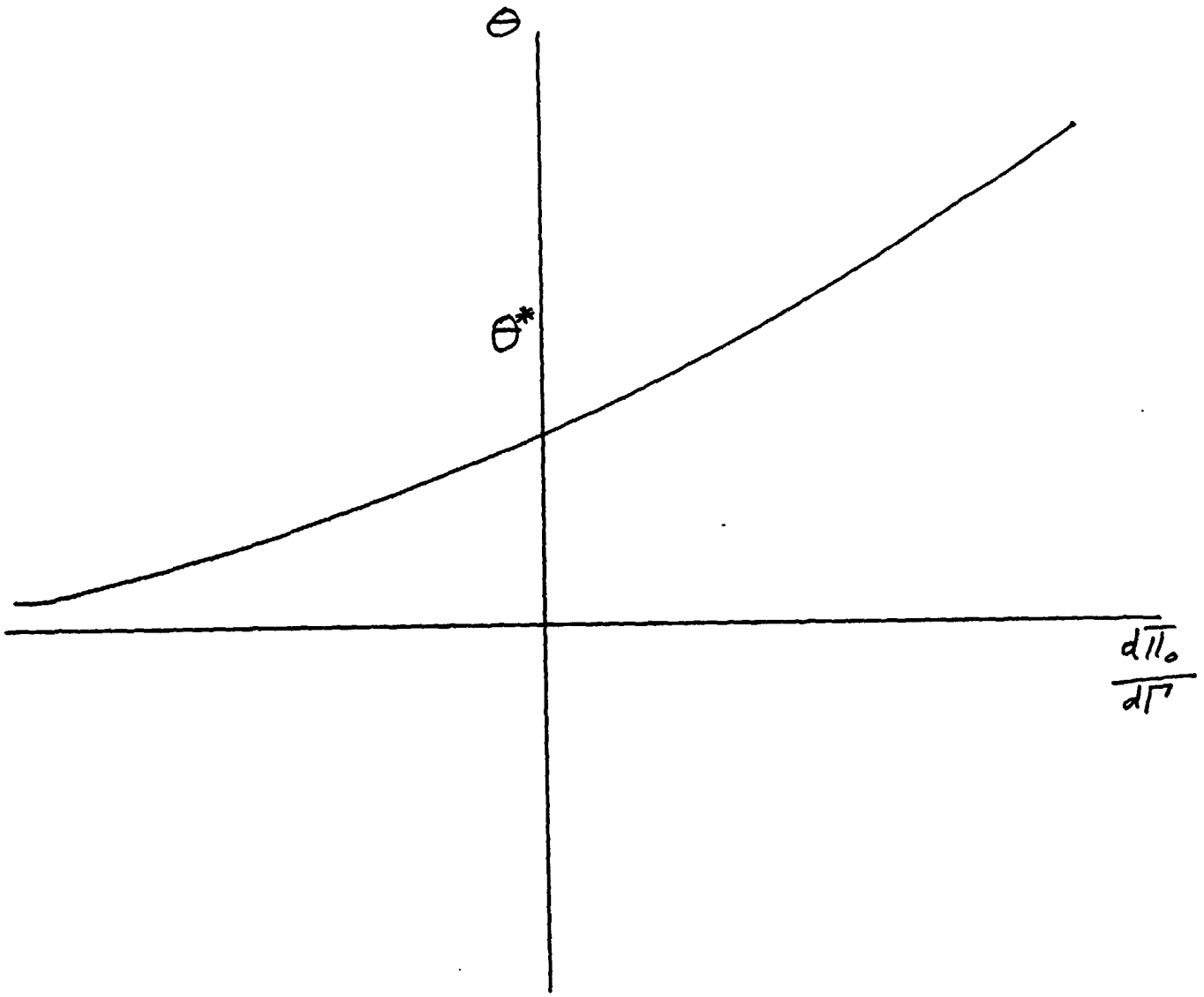
asymptotic) to the new steady state differs significantly in the two cases. It can be seen that an increase in the share of market prices from 50 to 90 percent yields a significantly larger overshooting on impact (about 15 percent of the long-run increase). It can also be noted that the inflation rate declines faster in the more liberalized system and after one period the inflation rate of the system with α=0.9 is below that of the system where 50% of prices are market based. Excess demand, defined as deviation of output from its noninflationary level is much larger and persistent when controlled prices account for 50 percent of the price index. It is also worth noting that in this setting inflation for market prices is an increasing function of inflation for controlled prices. This results because the relative price of controlled and market goods has no macroeconomic impact in this model. This property will disappear in the next two specifications of the model.

Assuming the system is stable, it is interesting to analyze the effect on the path of inflation of varying the speed of adjustment of controlled prices. The numerical simulations indicate that those effects crucially depend on the sensitivity of aggregate demand to expected inflation. Specifically, when this sensitivity is quantitatively significant, a faster speed of adjustment of controlled prices tends to induce a larger overshooting of the rate of inflation on impact. This relation is however reversed for low values of the elasticity of aggregate demand with respect to expected inflation. As shown in Fig.3, for a value of the elasticity below a critical level θ^*, a faster speed of adjustment of controlled prices reduces the overshooting in the overall inflation rate.

Thus, the more relevant are expectations of future inflation in affecting the behavior of consumers, the more "inflationary" on impact will be an increase

FIGURE 3

OVERSHOOTING AND SPEED OF ADJUSTMENT OF CONTROLLED PRICES[1]



[1] Horizontal axis depicts effect on the rate of change of the inflation rate induced by an increase in the speed of adjustment of controlled prices. On the vertical axis is the elasticity of aggregate demand with respect to expected inflation.

in the "activism" of the government in changing controlled prices.

In the next section we modify the model by assuming that the process of money creation is endogenous and, in particular, linked to changes in the relative prices of controlled and market goods.

3.3. Endogenous Money Supply

Disregarding relative prices may have macroeconomic effects through a fiscal-monetary channel that is particularly relevant when producers may be seen to face a "soft budget constraint" (Kornai, 1980). We noted above the importance of this channel particularly in the case of Poland. Assuming that market goods enter as inputs in the production of controlled goods, relative prices of controlled and market prices affect the profitability of enterprises in the controlled sector. Assuming further that the losses of enterprises in the controlled sector are fully monetized by the central bank, we can describe the process of money creation as follows:

$$\dot{M}_t = \tau(P^f - P^g)$$

The stability properties of this model are significantly modified (see Appendix for a full dynamic analysis). The two possible dynamic regimes, depending on parameter values, are still a saddle path equilibrium and a fully unstable solution. The endogeneity of money creation carries a self-correcting mechanism into the inflationary process. The increase in money supply exerts an upward pressure on the prices of controlled goods - through a demand effect - which in turn improves the profitability of enterprises in the controlled sector and thus reduces money creation. Consequently, the model indicates a possible stabilizing effect of changes in controlled prices when the spread between controlled and market prices translates into government subsidies

which are financed through money creation. The speed of adjustment of controlled prices has to be sufficiently fast and, moreover, faster than that of market prices if the latter constitute a large share of total prices.

The interesting conclusion arising from this model is that a mixed system with a large share of controlled goods is intrinsically unstable when the adjustment of controlled goods is slower than that of market prices. "One shot" adjustments of controlled prices may help temporarily in reducing the subsidies induced by a gap between controlled and market prices. However, over time inflationary pressures will re-surface [18] .

This process highlights the fiscal properties of the inflationary pressures associated with a mixed price system. To achieve a sustainable reduction of inflation requires either a full-fledged liberalization of prices or, with maintenance of a dual pricing systems, a fiscal correction on the revenue side sufficient to offset the subsidies engendered by the discrepancy between controlled and market prices.

From a numerical simulation we also obtained that the adjustment to the steady state is generally cyclical. Accordingly, the relative price of controlled with respect to market goods oscillates during the adjustment, with controlled prices growing faster and then slower than market prices in a cycling movement. Interestingly, this type of behavior can be noticed for Poland during the 1980's (see Chart 1). The relation between controlled prices and market prices varies during the adjustment. There are periods in which an increase in market prices leads to a decline in controlled prices, and periods in which the opposite holds (see Figure 4).

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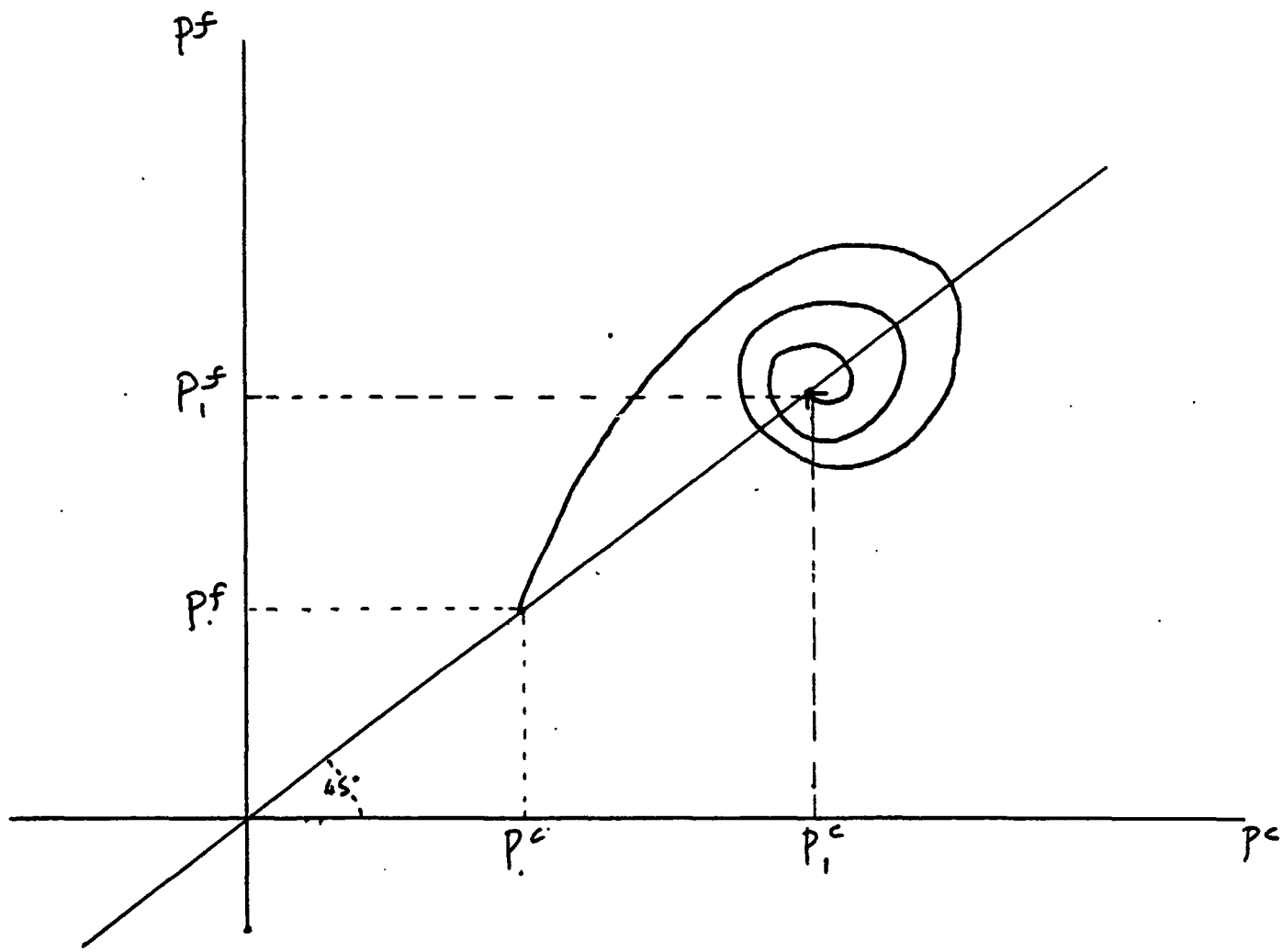
[18] Although we do not explicitly incorporate an indexation rule in the model, it is obvious that when indexation is present the adjustment of controlled prices and the closing of the subsidy gap can be rapidly eroded.

FIGURE 4

FREE AND CONTROLLED PRICES WITH PASSIVE MONEY



The numerical simulations yield some additional results relating to the stability properties of the model. In contrast to the model in which money was exogenous the speed of adjustment of controlled prices has to be larger than the critical value determined by the share of controlled goods in total prices and by the elasticity of aggregate demand with respect to expected inflation. In addition, the speed of adjustment of controlled prices has to be larger than that of market prices, when the share of market prices is larger than a critical value. For structural parameters identical to those of the previous model, it follows that the critical value for the share of market prices is fairly small. We found that when the share of market prices was larger than twenty percent of total prices the model was unstable, even when the speed of adjustment of controlled prices was ten times larger than that of market prices!

Evidently, price controls in a system with endogenous money can act as a nominal anchor and the greater the share of controlled prices in total prices the more effective can this role be. However, this is at the obvious cost of higher repressed inflation. Once some measure of price liberalization is countenanced and market prices are fed back into average prices by means of their impact on input prices or through the loop back into output prices via some indexation rule in the economy, the impact on the fiscal side becomes critical. This indicates some intrinsic difficulties in controlling inflation in a mixed system when money is passive and price controls affect the size of the fiscal deficit and hence of money creation. In contrast to the model with exogenous money, a partial price liberalization can not only lead to an initial overshooting of the long-run rate of inflation but it can push inflation onto an explosive, self-generating path.

On the assumption that the appropriate offsetting fiscal measures are taken, our model with endogenous money helps highlight a fundamental issue facing transitional socialist economies. Without consistent macroeconomic policies, a partial liberalization may prove excessively inflationary while only addressing the underlying fiscal imbalance in the very short run. In the next section, we indicate how the planner can reestablish a unique convergent path by abandoning an accommodating money supply policy for bridging the gap between controlled and market prices, opting instead for a rule aimed at closing the gap in relative prices. Borrowing the definition used by Honohan (1988), we denote this as the behavior of a 'follower'. In situations in which a rapid liberalization may induce a sharp acceleration in the short run of the inflation rate (for reasons discussed in the context of the first model presented in section 3.1. and in particular when expectations of future inflation play a fundamental role), the rule discussed in the next section may be relevant as an alternative to a full-fledged price liberalization.

3.3. The planner as 'follower'

In this section we modify the assumption regarding the planner's rule for price adjustment. Accordingly, we assume that the planner adjusts controlled prices in order to eliminate, although sluggishly, deviations of controlled prices from market prices (for instance for the budgetary reasons discussed above; this can provide a rationale for this rule also when, as it is usually the case, controlled prices relate to different products than market prices). The price adjustment rule for controlled prices is as follows:

$$\dot{p}^c = \tau(p^f - p^c)$$

Market goods are still set in a staggered manner. In this case, however,

demand for market goods also depends on the relative price of market with respect to controlled prices. This can be rationalized by assuming that relative price considerations directly affect the planner's adjustment rule as controlled and market prices are substitutes. Accordingly, relative price considerations also enter into the specification of demand for the two types of goods. This setting may be particularly relevant in those cases where controlled and market prices coexist for the same product. The dynamics of market goods are thus represented by the following dynamic equations:

$$\dot{V}^f = \delta(V^f_t - P^f_t - \beta y^f_t)$$

$$\dot{P}^f = \delta(V^f_t - P^f_t)$$

Excess demand for market goods (y^f) is a function of real monetary balances, the real interest rate and the relative price of market and controlled goods:

$$y^f = \epsilon(M_t - P_t) - \Theta(i_t - \dot{P}_t) - \mu(P^f - P^c)$$

where P is the average price level, defined as a weighted average of market and controlled prices;

$$P = \alpha P^c + (1-\alpha) P^f$$

The details of the dynamics associated with this model are reported in the Appendix. The main result is that this adjustment mechanism for controlled prices rules out instability.

The result is quite intuitive, as market prices do not show any intrinsic tendency to instability. If the planner follows the adjustment of those prices, thus chasing a rate of inflation converging to an equilibrium level, this cannot destabilize the system. However, the presence of controlled prices following market prices obviously slows down the speed of adjustment to the

long-run equilibrium which would prevail in a fully liberalized system [19].

4. Concluding remarks

The liberalization of prices is key to the reform of socialist economies. One polar model involves convergence of domestic to international prices through a 'big bang' stabilization of the Polish variety. Aside from questions regarding the efficacy of such an approach in curbing inflation and providing the parameters for structural change, political and economic arguments for a more gradualistic approach to price reform are likely to prove powerful in shaping the design of other countries reform programmes. In this light, the Hungarian experience with phased price liberalization provides a possible alternative framework.

In this paper we started from the assumption that no jump from an administered price system to a perfectly flexible one could occur. Among other consequences, this implies the introduction of distinct inertial features associated with the liberalization of prices. This may arise as a result of an inability of price setters to coordinate their price fixing rules in a decentralized setting (Dornbusch and Simonsen, 1977). This is particularly pertinent for an economy in which the underlying behavioural rules are being changed and where price setters have in effect to absorb and learn those new rules. To the extent that price liberalization is accompanied by systematic movement to decentralized price and wage setting rules, the emergence of overlapping wage contracts would also be expected to introduce inertia, the degree of which would depend in part on the type of wage

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[19] It is also worth noting that despite the planner behaving like a 'follower' with respect to market goods, during the adjustment controlled prices may rise above market prices. When this occurs, the adjustment becomes oscillatory, yielding cycles around the steady state.

indexation arrangement that existed (Fischer, 1977). Empirical work indicates, for example, that wage indexation has been a feature of both Hungary and Poland, our two illustrative cases (Commander and Coricelli, 1990). Under the cost-plus pricing rules characteristic of these economies, introduction of any backward-looking component in the indexation would have particularly strong inertial consequences. Moreover, the synchronization in price fixing particular to systems where prices are determined by the planner would be lost once pricing is decentralized and price revisions are staggered.

This highlights the point that making the adjustment of controlled prices more flexible can generate instability and large price oscillations if the rules followed by the planner for the adjustment remain unchanged. We show that the risk of instability being imparted to the system depends on whether the planner's adjustment rule targets macroeconomic imbalances or the relative price of controlled and market goods. To the extent that the concern is with the latter and forward looking behaviour characterizes price setters but not consumers, it is shown that the planner's price adjustment rule can serve as an anchor to the overall inflation rate, when money creation is 'passive'. In contrast, an 'activist' rule, based on the use of controlled prices for curtailing excess demand, can destabilize the system even when monetary policy is not accommodating. This occurs when the revision of controlled prices is very fast and is linked to the destabilizing effects imparted by expectations. In this context, price controls can provide an additional anchor that can be combined with a monetary anchor.

The introduction of a greater inertial component in inflation clearly complicates the initial stage of price reform where the objective is to establish a new price level with a different set of relative prices that can

eliminate macroeconomic imbalances. This is because inertia translates changes in price levels into movements of the inflation rate. By affecting expectations inflation may induce undesirable effects on aggregate demand, that problem being magnified by changes in the financial sector that make aggregate demand more sensitive to interest rates. At the same time, it is important to appreciate that if the planner's price adjustment rule incorporates relative price considerations, the fiscal implications may be critical in determining the inflationary path. If controlled prices on either input or output sides call forth an associated subsidy financed from the general budget, the monetary accommodation that could result would validate and potentially accelerate the inflation rate.

The model presented in this paper indicates some of the complex dynamics and sources of instability associated with the liberalization of prices. A number of features of the model have strong assumptions that in future work might usefully be modified. These include dropping the monopolistic competition setting for the market sector and working with a more constrained competitive framework. For controlled prices, rules associated with the optimization of certain objective functions of the government, including a fiscal target, might be introduced. In addition, more consideration could be given to the micro-foundations of pricing rules, incorporating the effect of rule changes and learning on the part of price setters (Day and Eliasson, 1986). At an empirical level we plan, as data becomes available, to estimate econometrically features of the model. Having discretely identified the factors determining price movements for controlled and market prices, simultaneous estimation of the system could pin down their interactive effects in the generation of the overall inflation path.

APPENDIX

1. The price setting for market goods

Price changes for market goods are assumed to be are not synchronized across enterprises and are characterized by a degree of stickiness as "price tags" last for a certain interval. This interval is random at the enterprise level, but is constant at the macro-level on the assumption of an exponential distribution for the price change signals and a large number of enterprises (Calvo 1983).

$$V_t = \delta \int_t^{\infty} (P_s + \beta y_s) e^{-\delta(s-t)} ds \qquad A1$$

$$P_t = \delta \int_{-\infty}^{t} V e^{-\delta(t-s)} ds \qquad A2$$

where P is the average price level, V is the new price set at time t, and y=D-S. From the above, we note two main features. First, (A1) entails a forward-looking component, as new prices depend on the expected price of competitors and on the state of the economy for the period in which the price tag will be in force (which on average is $1/\delta$). Second, despite the "flexibility" of individual new prices V (which can be set at any value at time t and thus are "jump" variables), the price level P is a predetermined variable at time t (the integral in (3) is taken over past realizations of individual prices). The model thus combines inertial and forward-looking elements, creating interesting distinct, although intertwined, dynamics of individual and aggregate prices.

Differentiating (A1) and (A2) with respect to time we obtain (taking the right-hand-side derivative for V, which is a forward-looking jump variable) we obtain (2) and (3) in the text.

2.1. Model 1

Money supply grows at the constant rate μ

$$\dot{M}_t = \mu \qquad (A3)$$

and the interest rate is set equal to zero.

From the definition of the overall rate of inflation we get

$$\dot{\pi}_t = \alpha \dot{P}_t + (1-\alpha) \dot{P}^g_t \qquad (A4)$$

Using (1), and noting from (2) and (3) that

$$\dot{P}_t = \delta (V_t - P_t) = -\delta^2 \beta D_t \qquad (A5)$$

(5) now reads

$$\dot{\pi}_t = -\alpha\delta^2\beta D_t + (1-\alpha)\Gamma\dot{D}_t \qquad \text{(A6)}$$

Differentiating (4) with respect to time we obtain

$$\dot{D}_t = \epsilon(\dot{M}_t - \dot{\pi}_t) + \Theta\dot{\pi}_t = \epsilon(\mu - \dot{\pi}_t) + \Theta\dot{\pi}_t \qquad \text{(A7)}$$

Substituting (A7) into (A6) we obtain the final expression for the dynamics of the inflation rate:

$$\dot{\pi}_t = (1/\Sigma)(-\alpha\delta^2\beta D_t + (1-\alpha)\Gamma\epsilon(\mu - \pi_t)) \qquad \text{(A8)}$$

with $\Sigma = 1-(1-\alpha)\Gamma\Theta$.

Plugging (A8) into (A7) we obtain the final expression for the dynamics of aggregate demand:

$$\dot{D}_t = -(\epsilon + \Theta(1-\alpha)/\Sigma)(\pi_t - \mu) - (\Theta\alpha\delta^2\beta/\Sigma)D_t \qquad \text{(A9)}$$

Combining equation (A8) and (A9) we obtain the dynamic system in (D_t, π_t). In matrix form:

$$\begin{pmatrix} \dot{\pi}_t \\ \dot{D}_t \end{pmatrix} = \begin{pmatrix} -(1-\alpha)\Gamma\epsilon/\Sigma & -\alpha\delta^2\beta/\Sigma \\ -\epsilon/\Sigma & -\Theta\alpha\delta^2\beta/\Sigma \end{pmatrix} \begin{pmatrix} \pi_t \\ D_t \end{pmatrix} + \begin{pmatrix} (1-\alpha)\Gamma\epsilon/\Sigma \\ \epsilon+\Theta(1-\alpha)/\Sigma \end{pmatrix} \mu$$

In the steady state, $\dot{D}_t = \dot{\pi}_t = 0$ and, thus $\pi_t = \mu$ and $D_t = 0$ $(Y = Y^*)$.

The dynamic properties of the system can be ascertained from the sign of the Trace and the Determinant of the transition matrix (recalling that the Trace equals the sum while the Determinant the product of the characteristic roots of the system):

Trace$= (-1/\Sigma)((1-\alpha)\Gamma\epsilon + \Theta\alpha\delta^2\beta)$ and

Determinant$= -(1/\Sigma)\epsilon\alpha\delta^2\beta$.

As all original parameters were assumed positive, the sign of the above expressions depends on the sign of Σ. Note that the system is never fully stable: the existence of two negative roots implies that Det>0, which in turn implies $\Sigma<0$ and thus Trace>0, which contradicts the assumption of two negative roots. The two possible dynamic configurations are the complete instability of the system and the saddle-path instability, which implies the presence of a unique convergent path. A necessary and sufficient condition for a saddle-path solution is that Det<0 (so the two roots have opposite sign). We can then establish that the unique convergent solution arises when

$-\epsilon\alpha\delta^2\beta/\Sigma<0$, or $\Sigma>0$.

Recalling the value of Σ, we can restate the condition above as $1-(1-\alpha)\Gamma\theta>0$, or, in a more convenient form,

$$\epsilon\theta b<1/(1-\alpha) \qquad (*)$$

which is the condition stated in the text. If condition (*) is not satisfied the system is unstable, as both roots of the system have positive real values.

2.2 Endogenous Money Supply

In this section we establish the results of the dynamic properties of the model in which:

$$\dot{M}_t=\tau(P^f-P^g) \qquad (A10)$$

The analysis of the model is simplified by applying the following transformation of variables, which permits reduction in the number of dynamic equations to three:

$Z=V-P^f$, $m=M-P$ and $P^d=P^g-P^f$.

The homogeneous part of the system associated with the above variables is:

$$\begin{pmatrix} \dot{Z} \\ \dot{m} \\ \dot{P}^d \end{pmatrix} = \begin{pmatrix} -\alpha\beta\theta\delta^2/\Sigma; & -\delta\beta\epsilon/\Sigma & ; & 0 \\ -\alpha\delta/\Sigma & ; & -(1-\alpha)\Gamma\epsilon/\Sigma & ; & -\tau \\ \delta(\Gamma\theta-1)/\Sigma; & \Gamma\epsilon/\Sigma & ; & 0 \end{pmatrix}$$

We can again ascertain the dynamic properties of the system by analyzing the trace and the determinant of the transition matrix, which we call A. Since the system comprises two predetermined variables, m and P^d, and one jump variable, Z, the saddle path solution requires one root with a positive real part and two with negative real parts. Therefore a necessary condition for a saddle path solution is that $\text{Det}(A)>0$.

$$\text{Trace}(A)= -\alpha\beta\theta\delta^2/\Sigma-(1-\alpha)\Gamma\epsilon/\Sigma$$

$$\text{Det}(A)= (\tau/\Sigma^2)(\delta^2\beta\epsilon)((1-\alpha)\Gamma\theta-1)=-\tau\delta^2\beta\epsilon/\Sigma$$

A necessary condition for a saddle path solution is that $\Sigma<0$. Interestingly, the condition for a saddle path solution is completely reversed with respect to the model of exogenous money considered before. $\Sigma<0$ implies

$$\Gamma>1/(1-\alpha)\theta.$$

Thus the speed of adjustment of controlled prices has to be fast enough in order to obtain a saddle path solution. However, the above condition is not

sufficient for a unique convergent solution. Indeed, additonal restrictions on parameter values have to be imposed. Namely, the relative speed of adjustment of controlled prices (the parameter Γ) with respect to the adjustment of free prices (the parameter δ) becomes crucial. If the speed of adjustment of controlled prices is slower than that of free prices, then the saddle path solution requires a small value for the share of free prices in the total basket of goods. Alternatively, if the speed of adjustment of controlled prices is faster than that of market prices, then the saddle path solution arises even when the share of market prices approaches unity. Interestingly, from the numerical simulation we obtained that when the saddle path solution arises the adjustment to the steady state is cyclical, as the roots with negative real parts are two complex conjugates.

3. Dynamics of Model 2

Using the definition of average prices, the equation for new prices, V, becomes:

$$\dot{V}^f=\delta\{V^f_t(1-\beta\Theta\delta(1-\alpha))-P^f_t(1-\beta\epsilon(1-\alpha)-\beta\mu+\beta\alpha\Theta\tau-\beta\mu(1-\alpha)\delta)-P^c_t\beta(\mu-\mu\alpha\tau-\epsilon\alpha)-\beta\epsilon M_t\}$$

Combining this equation with that for average market and controlled prices we obtain the following homogeneous part of the dynamic system in matrix form :

$$\begin{pmatrix} \dot{P}^g \\ \dot{P}^f \\ \dot{V} \end{pmatrix} = \begin{pmatrix} -\tau & \tau & 0 \\ 0 & -\delta & \delta \\ -\delta\beta(\mu-\Theta\alpha\tau-\epsilon\alpha); & -\delta(1-\beta\epsilon(1-\alpha)-\beta\mu+\alpha\beta\Theta\tau-\beta\Theta(1-\alpha)\delta); & \delta(1-\beta\Theta(1-\alpha)\delta) \end{pmatrix}$$

Denoting by A the transition matrix, the following holds:

Trace A= $-\tau-\delta^2\beta\Theta(1-\alpha) <0$
Det A = $\tau\delta^2\beta\epsilon >0$.

This configuration of signs implies that two roots have negative real parts and one a positive real part, which is indeed the necessary and sufficient condition for the existence of a saddle path solution.

4. Numerical simulation

The following values were used for the structural parameters in the simulations: $\beta=1$, $\epsilon=0.9$. The rate of growth of money supply is assumed to increase permanently by 100 percent. In the simulation of model 3.1. $\delta=0.4$, $\Gamma=0.1$ and $\Theta=1$. In model 3.2. several combinations of δ, Γ and Θ were tried. Under stability conditions there were consistently 2 complex conjugates, implying a cyclical adjustment. For $\alpha>0.2$, the system was unstable even for $\Gamma=25$ and $\delta=0.4$ (note that average "quotation" length of free prices is $(1/\delta)$, thus for $\delta=0.4$, average quotation length is 2.5 periods. Controlled prices have a speed of adjustment 10 times as large as that of market prices.

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