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Sustained Inflation in Response to Price Liberalization

Sustained inflation is a predictable response to price liberalization in the countries of the former Soviet Union.

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Summary findings

Conway demonstrates that sustained inflation is a predictable response to price liberalization in the countries of the former Soviet Union.

He models the phenomenon in a dynamic macroeconomic framework, and demonstrates the immediate price jump followed by sustained inflation that has characterized the transitional economies of the former Soviet Union.

He supports the theoretical derivation with a simulation exercise that demonstrates the scope of sustained inflation for specific parameters.

This paper — a product of the Country Operations Division 2, Europe and Central Asia, Country Department IV — is part of a larger effort in the region to study financial sector and macroeconomic policies in transition economies. The study was funded by the Bank's Research Support Budget under the research project "Ruble Shortage Phenomenon in Members of the Ruble Currency Zone" (RPO 678-08). Copies of this paper are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Lenora Suki, room H2-096, extension 33974 (25 pages). October 1994.

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The countries of the former Soviet Union have experienced sustained inflation in the period since independence. Although a burst of inflation was widely anticipated as a response to the "ruble overhang" built up in the final years of the Soviet Union, the subsequent price inflation has been more rapid and sustained than expected.

There are a number of causes for this sustained inflation: continuing budget deficits in these countries financed through the inflation tax, increases in prices of energy and other imported intermediate inputs, and more recently the establishment of inflationary expectations. In this paper I demonstrate that removal of the "ruble overhang" is not an instantaneous outcome in a forward-looking economy, but rather will generate a sustained inflation independent of changes in these other factors. Sustained inflation is thus a predictable market outcome in response to an initial price liberalization. The reason lies in the interaction of private saving responses to inflation and the government's resulting altered reliance upon the inflation tax to finance its expenditures.

In the first section I present the history of the "ruble overhang" and subsequent ruble shortages in the former Soviet economies. I also illustrate the problem of sustained inflation in these economies through examination of historical data for a number of republics. In section II I construct a simple dynamic model of private wealth accumulation and inflation. I demonstrate that the model has a steady state equilibrium, but exhibits saddlepath stability. Adjustment along the saddlepath from a position of "ruble overhang" is characterized by an initial price jump followed by sustained inflation. A numerical example is examined to illustrate the logic of the adjustment process. Section III includes conclusions and possible extensions to the analysis. The logic of the adjustment process is examined as well to consider the possibility of an explosive dynamic.

I. From Ruble Overhang to Ruble Shortage.

The Soviet Union of the late 1980s was characterized by price controls, government budget deficits and an allocation of resources disproportionately to national defense and producer-good output. As Nordhaus (1990) reports, this led to shortages of consumer goods, repressed inflation and an undesired build-up in household holdings of liquid assets. The ratio of household liquid assets to household income rose from about .60 in the 1970s to about .95 in 1989.[1]

McKinnon (1991) provides an alternative view of the build-up of this overhang through the 1980s, and notes the positive correlation with the Soviet budget deficit. His figures are provided in Table 1. Prior to 1986 household saving deposits rose at a roughly one-for-one rate with the government budget deficit -- the Soviet government was simply using the financial sector and the government budget as a means to channel resources into government investment. Subsequent to that time the budget deficit totalled much more than the increase in saving deposits, with the balance being made up through monetization. Despite money creation during the 1987-1989 period that approached six percent of GNP annually (and the forced nature of at least some of the household deposits), price controls ensured that retail inflation rates never exceeded two percent per annum.[2]

Commentators worried about the inflationary impact of price liberalization in this context. Solutions suggested can be organized into "supply-side" and "demand-side" policies. On the demand side, McKinnon (1991) suggested the raising of interest rates on deposits to convert forced saving into desired saving and to encourage the reduction in currency hoarding. On the supply side, proposals included the exchange of government assets and gold holdings for the excess currency and deposits.

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[1] In economies with greater financial development the government will finance budget deficits through issuing bonds. In the Soviet Union the government used the banking system as the intermediary to channel resources to the government, and household deposits in the commercial banks (in addition to hoarding of currency) became claims on the government.

[2] Dornbusch (1992), Table 1.

In January 1991 the Soviet government undertook a draconian supply-side policy by declaring large-denomination bank notes to be no longer legal tender. Holders were allowed to exchange them for smaller bills up to a maximum governed by a worker's monthly salary or a fixed quantity, whichever was less. Household saving accounts were frozen, with individuals allowed to withdraw only 500 rubles per month.[3] The republics softened these regulations somewhat in subsequent actions. The net impact of this reform on inflation is by no means clear: although money broadly defined is lessened, so also is confidence in these stores of value. The velocity of expenditure almost certainly rose in consequence.

In 1991 the aggregate fiscal deficit of the members of the Soviet Union reached 26 percent of GDP.[4] Inflation reached previously unimagined rates: 142 percent on retail goods and 236 percent on wholesale products. This inflation induced the government to provide transfers to wage-earners, pensioners and savers to index partially the value of their incomes and financial assets. However, due to a lack of goods and services the households retained the income in forced saving of deposits or currency holding. The real value of household deposits was reduced somewhat by the inflation, while the ratio of currency in circulation to GDP remained nearly constant.

The former republics of the Soviet Union cooperated nearly unanimously on the liberalization of the majority of wholesale and retail prices on 2 January 1992. Those prices not liberalized were nearly all raised by between 300 and 500 percent. Given the repressed inflation of the ruble overhang, prices jumped rapidly -- in the first three months of 1992 retail prices rose by 600 percent and wholesale prices by over 1000 percent. This rise in prices greatly reduced the value of nominal assets like savings deposits and currency: by the end of January 1992 the ratio of money broadly defined to GDP had fallen to less than 20 percent.

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[3] These details are reported in McKinnon (1991, p. 157).

[4] The information in these two paragraphs is drawn from World Bank (1992).

The ruble overhang was followed by widespread cash shortages during 1992 and 1993 in the ruble zone. However, the inflationary burst was not halted -- these countries have experienced sustained inflation throughout the period to the present. Table 2 presents the inflationary record of a number of these countries and indicates the sustained nature of the inflation. After the inflationary burst associated with price liberalization inflation continued to erode the real wealth of savers.

II. A Macroeconomic Model of Inflation, Wealth and Private Saving.

I consider an economy with government, state enterprises and a private sector. The government is combined with the state-enterprise sector in the analysis, with the amalgam referred to as the public sector. There are a large number of transactions within the public sector -- purchases of goods from state enterprises by the government, payment of taxes by state enterprises -- but only its net position vis à vis the private sector is considered here.[5] The private sector is represented by its net position relative to the banking sector: its real saving decision.[6]

Private saving behavior.

Private real saving behavior summarizes the real resource allocation decision for the private sector. It is income net of consumption and taxes, and can be represented as the behavioral equation

$$s = S(i-\pi^e, Y/P, \Omega/P) \qquad S_1 > 0,\ S_2 > 0,\ S_3 < 0 \qquad (1)$$

[5] As a result, I neglect questions relating to interenterprise arrears. Ickes and Ryterman (1992) provide a detailed discussion of this phenomenon. It has similar characteristics to the "cash shortage" problem and I hope to address it in future work.

[6] I thus ignore other important repositories of private saving in the transitional economies, including foreign exchange holdings and hoarding of goods. I examine the importance of these in more detail in Conway (1994 a,b).

: nominal interest rate (i) and the expected inflation rate (π^e = E(dP/P), with E(.) the expectations :rator) combine to form the real interest rate on saving instruments. The aggregate price index is en by P, while Y/P is real income and Ω/P is the real accumulated wealth of the private sector.[7] ring is rising in the real interest rate, while rising as well with real income and falling with umulated assets.[8]

There is in general a distinction between ex ante and ex post saving behavior. Saving ex ante resents the saving behavior predicated upon last period's price index, while saving ex post is based ›n the value of the price index that yields equilibrium in the current period.

Expectations.

Actors are assumed to have perfect foresight in what follows. The expected inflation rate is s equal to the observed inflation rate.

$$\pi^e = \pi$$

[7] Ω is the stock of nominal assets held by the households, and will include both financial deposits currency holdings.

[8] Saving is rising with the real interest rate in most theoretical derivations: see, for example, nchard and Fischer (1989) and Campbell (1988) for utility-maximizing derivations in a variety of ›retical models and McKinnon (1973) for a more heuristic explication relevant to developing countries.

Public-sector deficits.

The net public-sector position is one of a real budget deficit denoted by (g-t(P)). Public-sector expenditure (g) is thus on private-sector goods and services, with the wage bill a large component; tax revenues (t) include purchases of public goods and services by the private sector. These revenues are assumed to be declining in real terms with the price level (P), with the elasticity of this "buoyancy" effect defined $\epsilon = (t_P P/t) < 0$.[9]

The government finances its deficit through the issuance of accounting credits (CR).

(3) $$g - t(P) = \Delta CR/P$$

The private sector can pay taxes in accounting credits.

The national income and product identity in real terms implies that ex post:

(4) $$g - t(P) \equiv (s-j) - b$$

When private saving is considered net of private investment (j) it is one channel for public deficit finance. The other is a deficit (-b) on the current account. In keeping with the historical record, opportunities for private physical investment and international trade are treated as negligible in what follows. Their introduction does not change the qualitative conclusions of the analysis.

Intermediation by the banking sector.

Private saving is thus the dominant source of finance for public-sector deficits. This occurs in a non-inflationary setting through the intermediation of the banking sector. This sector is defined to

[9] This paper follows the convention that subscripts indicate partial derivatives.

include both the central bank and the commercial banks. Its balance sheet can be represented in stylized form as follows:

$$(5) \qquad CR \equiv H + D$$

The banking sector holds as assets the accounting credits (CR) of the public sector. As liabilities it holds both currency in circulation (H) and deposits by households at commercial banks (D). With an increase in accounting credits, the banking sector will either increase currency in circulation or increase the private sector's holdings of deposits (in accounting credits).

The budget deficit can also represent a cash-flow constraint on the economy. If payments g to the private sector (wages and pensions, for example) must be conducted in currency, then in any period the banking sector must be able to convert $\Delta CR/P$ in accounting credits into cash. The banking sector can provide that amount either through increasing the quantity of currency in circulation (ΔH) or attracting private-sector deposits of currency that are held on the banks' books as accounting credits (ΔD).[10]

The Evolution of Private Wealth and Inflation.

The private sector has accumulated a nominal stock of wealth (Ω). Real private saving and interest earnings on nominal wealth augment the stock of real accumulated wealth.

$$(6) \qquad \Delta\Omega/P = i\Omega/P + s$$

[10] This places an added constraint on the make-up of the budget. If δg is paid out in currency, then by the banking-sector balance sheet and the budget deficit condition it is also true that $(1\text{-}\delta)g \equiv t(P)$: government expenditures in accounting credits are financed through taxes paid in accounting credits. This does not appear to be a restrictive implication of the model.

I model the rate of inflation as a response to a simple tatonnement rule in excess demands for goods and services. The dynamic can be stated for $j = b = 0$.

$$(7) \qquad \pi = \Delta P/P = \phi((g - t(P)) - s) \qquad \phi' > 0$$

When private saving is insufficient to cover the budget deficit for constant P, the government uses its "first-purchaser" advantage to finance expenditure through credit creation. This leads to price increases as the private sector must bid for the consumption of a decreased stock of resources.

Steady-state Equilibrium.

Equations (6) and (7) define the dynamic processes in nominal asset accumulation and prices for a given level of the budget deficit. Nominal income (Y) and the nominal interest rate (i) are held constant for simplicity.

Equilibrium values of P and Ω can be characterized through imposition of appropriate steady-state solutions. First, real wealth is assumed constant in the steady state. Second, price stability is modeled by setting $\Delta P = 0$. These conditions generate loci in Ω and P as represented in Figure 1. AA represents the combinations of Ω and P that assure saving equilibrium; its upward slope represents the steady-state condition that $s = -i\Omega$. GG represents the combinations that ensure price stability; it can take either slope, but will be less steep than the AA curve.[11]

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[11] Introducing unemployment and underproduction, as observed in the former Soviet economies, will lead to the same conclusion.

The mathematics of the curves are presented in the reduced-form equations of the appendix. The AA curve is steeper than the GG curve due to the effect of price increases on real tax revenues. I maintain the assumption for the diagrammatic representation that $-(S_3/S_2) > (Y/\Omega)$, ensuring that both curves are positively sloped.

The appendix also provides a numerical example that illustrates the steady-state equilibrium and the associated saddlepath.

The economy exhibits saddlepoint stability in these two variables. Inflation leads to dissaving, budget deficits and still further inflation: this behavior has a convergent dynamic only along the saddlepath SS. Appendix A provides a mathematical derivation of the saddlepoint properties of this steady state for a linearized version of this model.

In the Soviet economy prior to price liberalization the households were not on their preferred trajectory. The constraints on both price levels and supply of goods led to rationing and forced saving. This forced saving resulted in the "ruble overhang" that could more properly in this context be characterized as an "asset overhang" and illustrated at point A.

Dynamic Adjustment with Price Liberalization.

The dynamic followed from A with price liberalization replicates a number of features of private adjustment in the former Soviet republics. First, households had accumulated excess financial assets, as indicated by the position of A above the AA curve. Second, the accumulated wealth was more than necessary to cause unfinanceable budget deficits as households were unwilling to save: this is evident in A's distance above GG. Third, households nevertheless held these assets because of their claims on future consumption: this is evident in the distance by which A is below SS. When prices were liberalized there was an immediate jump, followed by ongoing inflation. The nominal value of wealth declined during the adjustment as consumers purchased real goods for consumption, while with inflation the real value of wealth (Ω/P) fell still more. The government maintained budget deficits throughout, and ex ante private saving was insufficient to finance these: the inflation tax on nominal assets represents the balance of the budget.

The jump in prices was widely forecast as the means of removing the excess purchasing power represented by the ruble overhang. As the present scenario indicates, the overhang caused ongoing inflation as well: households tempered the upward pressure placed on demand for goods because of the effect of the ensuing price increases on purchasing power in the future. The price jump is represented by the movement from A to B on the saddlepath; the ongoing inflation by the movement along SS from B toward E.

The historical record on saving is complicated by the collapse of production output beginning in 1991. This can be introduced as an exogenous reduction in private income ($\Delta(Y/P)<0$) that reduced both private income and the tax revenue base. These place upward pressure on P; in Figure 2 the effect is illustrated as both AA and GG shift to the right. Each such shock causes an immediate burst of inflation followed by continuing price movements until the new steady state is achieved. One such path is drawn in Figure 2: beginning from equilibrium E, prices jump immediately to B' along the new saddlepath SS', and then decline somewhat as households accumulate assets. The new steady state at E' has a larger nominal stock of assets but a reduced real value. This period would be characterized by excess supply of goods, as prices have overshot the long-run value. Alternatively, the increased fiscal deficit could be recognized while still on the original saddlepath around B -- if so, there would be an additional jump in P followed by still further inflation while moving down the other arm of SS' to E'.

These properties can be demonstrated in a simple numerical example. The appendix presents the parameterization employed to generate the phase dynamics of Figure 3. The steady-state equilibrium is characterized by constant price index ($P^* = 1$) and real wealth ($\Omega^* = 300$). Consider the evolution of an economy beginning with wealth $\Omega_0 = 350$ and artificially suppressed price $P_0 = .1$. The initial response upon liberalization of prices is a jump to the saddlepath at $P_1 = .61$: a 510 percent increase. Subsequent to that the adjustment occurs along the saddlepath, with P rising and Ω falling toward steady-state equilibrium. The accumulated price increase over the entire adjustment path is 900 percent, with 390 percent of the price increase occurring during the gradual adjustment along the saddlepath. Real wealth in the private sector declines by 92 percent; 84 percent of the decline takes place in the initial jump of prices following liberalization, while another 8 percent occurs along the saddlepath.

III. Conclusions and extensions.

Sustained inflation can be the outcome of price liberalization if the economy begins from a situation of "ruble overhang". This accumulated wealth causes low levels of annual saving by the private sector. Price liberalization will lead to a jump in prices, but this jump does not eliminate the ruble overhang. Instead, the jump places the private-sector in position to implement a flow dis-saving that ends with convergence to the steady-state outcome. That dis-saving dynamic coincides with a sustained inflationary episode.

The dynamic of adjustment is due to saddlepath stability of the economic model. This characterization depends upon the non-financed budget deficit being more responsive to price increases than private wealth accumulation. The non-buoyancy of tax revenues in response to price increases is a realistic feature of the transition economies that provides that feature, but other economic characteristics will cause this relation as well. An increase in real expenditures in response to price rises, due for example to the safety net of social expenditures being spread over newly destitute citizens, will also have this effect.[12]

Stability is not assured for all values of the exogenous variables. One feature in particular stands out: sufficiently high nominal interest rates can for low interest-rate elasticity of saving lead in this model to an instability of equilibrium. In that instance, the types of shocks experienced in the

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[12] The sufficient mathematical condition for saddlepath stability of the steady state in this case is that

$$-s < \partial(g-t)/\partial P$$

In the specification used here, private saving (defined net of interest receipts) is zero. Thus, any feature of the budget deficit that makes it susceptible to widening in response to price increases will ensure this result.

ransitional economies lead to accelerating inflation rather than convergence to the steady state. This s due to the budgetary cost of interest payments, and underscores the warning found in Giovannini nd deMelo (1993): financial liberalization policies must be made taking into consideration their udgetary impact. The possibility of instability as described here is an additional danger not onsidered in their work.

Bibliography

Åslund, A.: "Key Dilemmas in the Russian Economic Reform", processed, 1983.

Blanchard, O. and S. Fischer: Lectures on Macroeconomics. Cambridge, MA: MIT Press, 1989.

Bruno, M., G. di Tella, R. Dornbusch and S. Fischer, eds.: Inflation Stabilization: The Experience of Israel, Argentina, Brazil, Bolivia and Mexico. Cambridge, MA: MIT Press, 1988.

Campbell, J.: "Does Saving Anticipate Declining Labor Income? An Alternative Test of the Permanent Income Hypothesis", Econometrica 55, 1987, pp. 1249-1274.

Conway, P.: "Rubles, Rubles Everywhere...Cash Shortages and Financial Disintermediation in the former Soviet Union, processed, 1994a.

Conway, P.: "The Economics of Cash Shortage", processed, 1994b.

Conway, P. and A. Gelb: "Oil Windfalls in a Controlled Economy: A 'Fix-Price' Equilibrium Analysis of Algeria", Journal of Development Economics 28, 1988, pp. 63-81.

Dornbusch, R.: "Lessons from Experiences with High Inflation", World Bank Economic Review 6, 1992, pp. 13-32.

Fry, M.: Money, Interest and Banking in Economic Development. Baltimore, MD: Johns Hopkins Press, 1988.

Giovannini, A.: "Saving and the Real Interest Rate in LDCs", Journal of Development Economics 18, 1985, pp. 197-217.

Giovannini, A. and M. deMelo: "Government Revenue from Financial Repression", American Economic Review 83, 1993, pp. 953-963.

GOSKOMSTAT-USSR: Narodnoe Khoziaistvo SSSR v 1999 g. Moscow: GOSKOMSTAT, 1991.

Hansson, A.: "The Trouble with the Rouble: Monetary Reform in the Former Soviet Union", Stockholm Institute of Soviet and East European Economics Working Paper 57, 1992.

Hardy, D. and A. Lahiri: "Bank Insolvency and Stabilization in Eastern Europe", IMF Staff Papers 39, 1992, pp. 778-800.

Ickes, B. and R. Ryterman: "Inter-Enterprise Arrears and Financial Underdevelopment in Russia", processed, 1992.

International Monetary Fund: International Financial Statistics Supplement 16, 1993.

McKinnon, R.: Money and Capital in Economic Development. Washington, DC: Brookings Institution, 1973.

McKinnon, R.: The Order of Economic Liberalization: Financial Control in the Transition to a Market Economy. Baltimore, MD: Johns Hopkins University Press, 1991.

Nordhaus, W.: "Soviet Economic Reform: The Longest Road", Brookings Papers in Economic Activity 1, 1990, pp. 287-308.

Ostry, J. and C. Reinhart: "Private Saving and Terms of Trade Shocks", IMF Staff Papers 39, 1992, pp. 495-515.

Pleskovic, B.: "Regional Development and Transition in the Former Soviet Union: A Comment", International Regional Science Review 15, 1993, pp. 297-305.

Pleskovic, B. and J. Sachs: "Political Independence and Economic Reform in Slovenia", in O. Blanchard, K. Froot and J. Sachs, eds.: Economic Transition in Eastern Europe. University of Chicago and NBER, 1993, pp. 191-230.

Sachs, J. and D. Lipton: "Remaining Steps to a Market-Based Monetary System in Russia", Working Paper 54, Stockholm Institute of Soviet and East European Economics, 1992.

World Bank: "Russian Economic Reform: Crossing the Threshhold of Structural Change", processed, 1992.

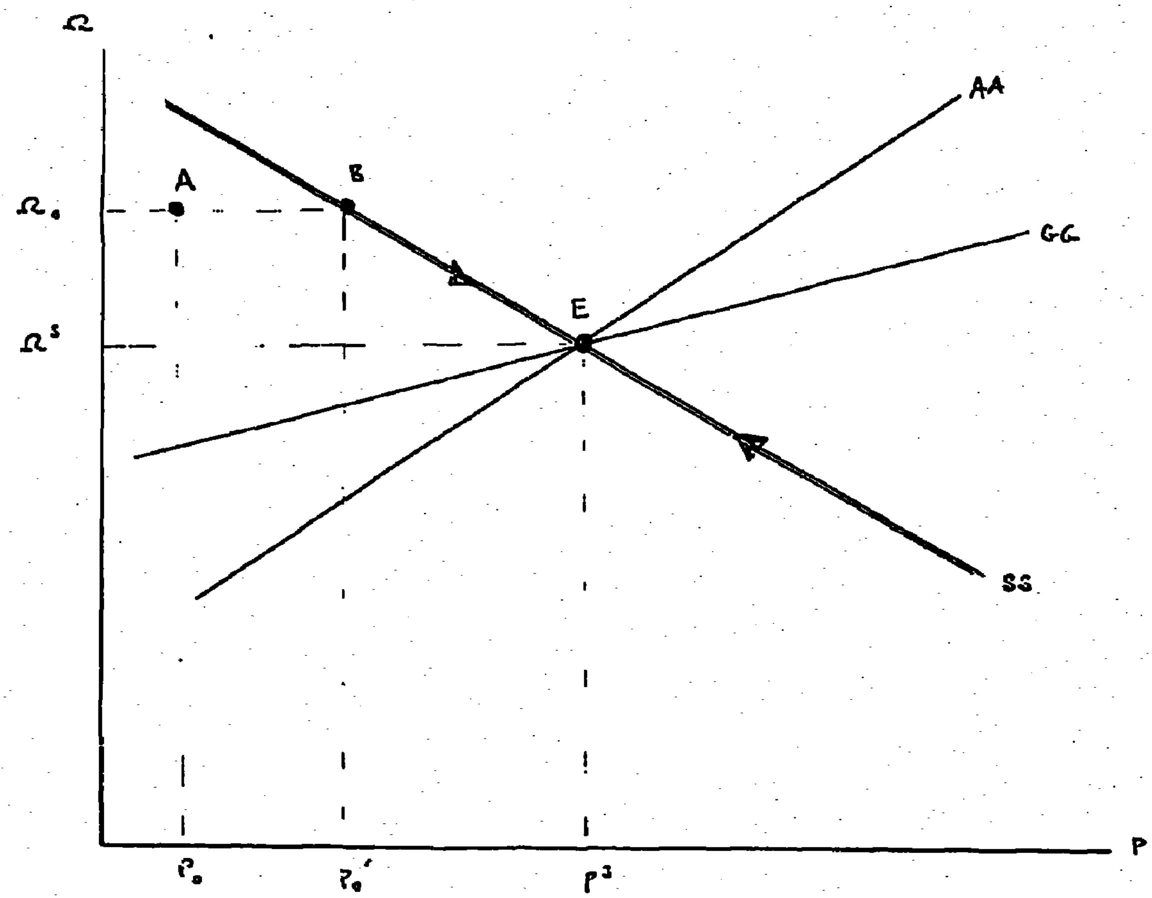

Figure 1

Steady-state Equilibrium in Price and Wealth

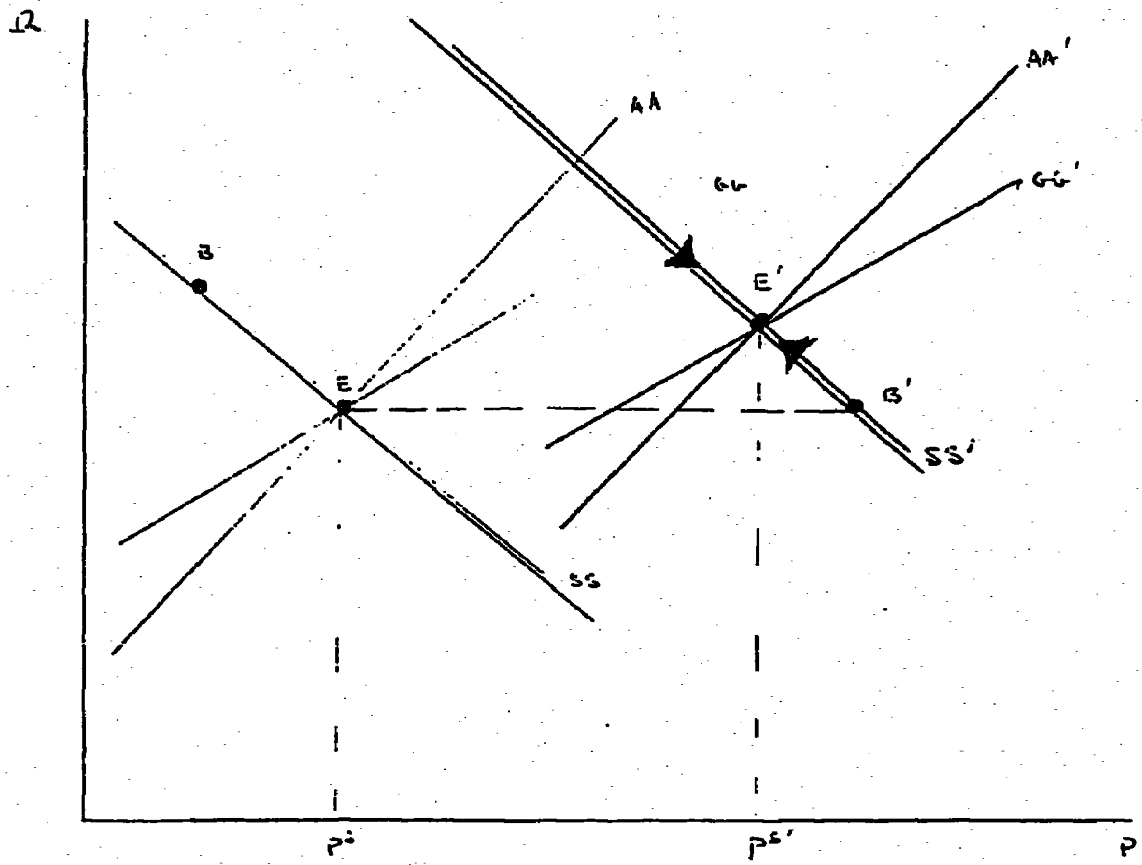

Figure 2

Adjustment to the Steady State

Figure 3

Numerical Simulation of Equilibrium and Saddlepath

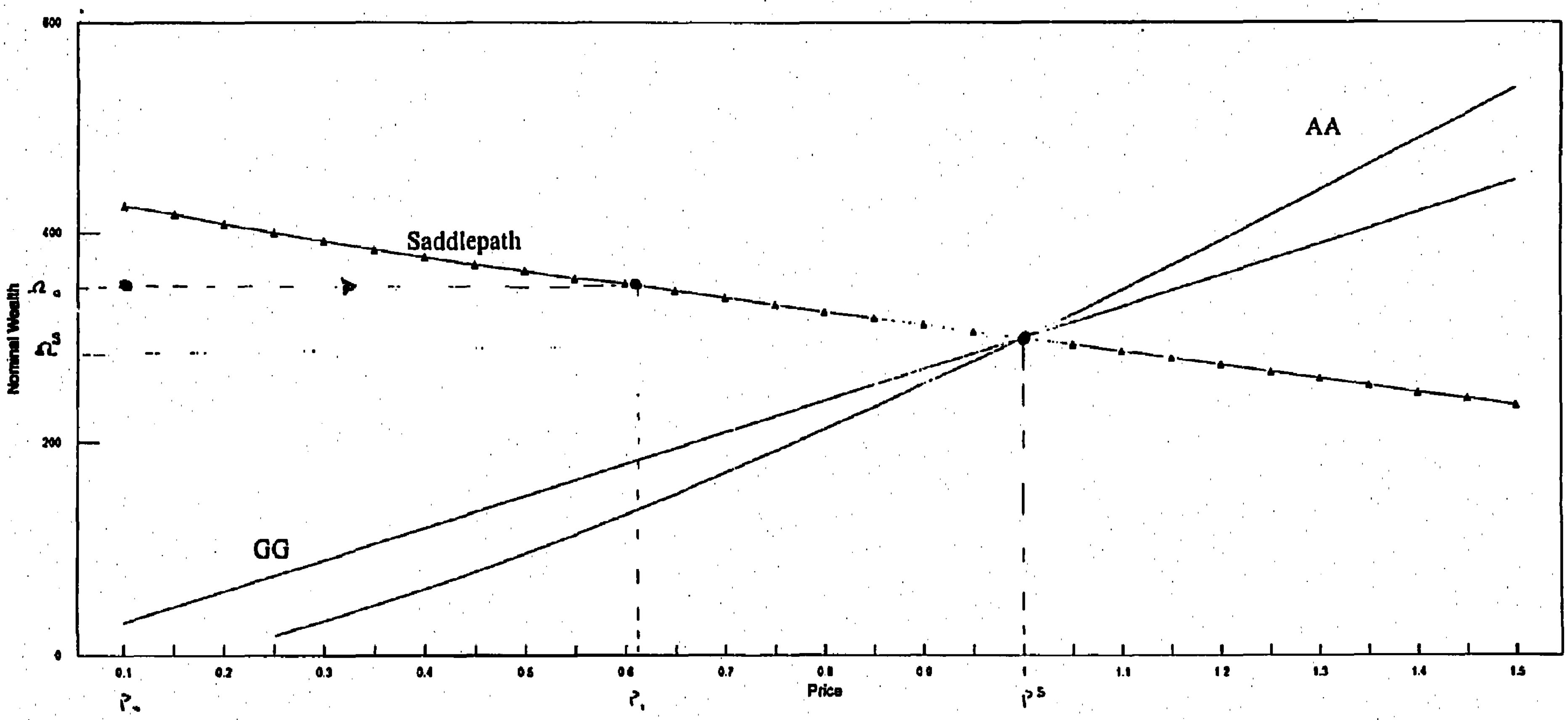

Table 1
Financial Statistics for the Soviet Economy

	Government Budget Deficit		Government Debt		Household Saving Deposits	
	billions of rubles	percent of GNP	billions of rubles	percent of GNP	billions of rubles	percent of retail sales
1979	n.a.	n.a.	64	n.a.	146.2	57.6
1980	12	1.9	76	12.2	156.5	57.9
1981	9	1.4	85	13.1	165.7	57.9
1982	15	2.2	100	14.4	174.3	58.9
1983	10	1.4	110	15.1	186.9	61.1
1984	9	1.2	119	15.7	202.1	63.9
1985	14	1.8	133	17.1	220.8	68.0
1986	46	5.8	179	22.4	242.8	73.1
1987	52	6.3	231	28.0	266.9	78.2
1988	81	9.3	312	35.7	296.7	81.0
1989	92	6.9	404	43.4	337.7	83.7

Source: McKinnon (1991, Table 11.1)

Table 2
Inflationary Histories of Transition Economies of Former Soviet Union

	Quarterly Inflation Rate					
Country	I/92	II/92	III/92	IV/92	I/93	II/93
Belarus	304.5	67.1	38.4	54.4	78.6	90.0
Georgia	339.1	151.6	32.7	52.4		
Kazakhstan	405.5	104.7	57.2	69.8	128.1	
Lithuania	192.0	47.7	69.0	91.1	57.6	61.7
Russia	431.1	81.1	41.9	73.9		
Ukraine	360.3	58.2	75.1	87.4	225.5	111.7

Source: International Monetary Fund, International Financial Statistics, Supplement 16, 1993.

Consumer price indices in all cases; Russia's series is denoted the "Hybrid CPI".

Appendix
The Simulation Model of Dynamic Evolution of Wealth and Aggregate Prices.

The dynamic evolution of prices and nominal wealth in response to market liberalization can be demonstrated in a simple numerical model based upon the theory of section II.

Equations of motion.
The saving equation is linearized:

(A1) $$s_t = a + b\,(i - \pi^e_t) + c\,Y/P_t + (i-k)\Omega_{t-1}/P_t$$

This definition has the pattern of derivatives noted in the text: saving is rising in the real interest rate, while rising as well with real income. It rises with interest paid on accumulated assets and falls with a propensity k to dissave as wealth rises. The nominal interest rate and income are exogenous, while expected inflation and nominal wealth are endogenous.

Real private saving augments the stock of real accumulated wealth.

(A2) $$\Omega_t = \Omega_{t-1} + P_t s_t$$

The expected price level evolves according to a tatonnement dynamic:

(A3) $$P^e_t - P_{t-1} = \phi\,(g - \tau(1/P_{t-1})^q) - s_t\,)$$

There is a lack of buoyancy of tax receipts with price inflation with elasticity q.

The actors are assumed to have perfect foresight:

(A4) $$P^e_t = P_t\,, \qquad \text{implying} \quad \pi^e_t = \pi_t$$

Substitution of (A1) and (A4) into the other two equations yields:

$$\Delta\,\Omega_t = i\,\Omega_{t-1} + P_t\left[a + b\left(i - \frac{\Delta P}{P_t}\right) + c\left(\frac{Y}{P_t}\right) - k\left(\frac{\Omega_{t-1}}{P_t}\right)\right]$$

$$\Delta P_t = \phi\left(g - \tau\left(\frac{1}{P_t}\right)^q - a - b\left(i - \frac{\Delta P}{P}\right) - c\,\frac{Y}{P_t} - (i-k)\frac{\Omega_{t-1}}{P_t}\right)$$

When these are evaluated in the vicinity of $P^e_t = P^* = 1$ and $\Omega_t = \Omega^*$:

$$\begin{bmatrix} 1 & b \\ 0 & 1-b \end{bmatrix} \begin{bmatrix} \Delta\Omega_t \\ \Delta P_t \end{bmatrix} = \begin{bmatrix} i-k & a+bi \\ \phi(k-i) & \phi(q\tau + (i-k)\Omega + cY) \end{bmatrix} \begin{bmatrix} \Omega_t - \Omega^* \\ P_t - 1 \end{bmatrix}$$

Using the value of saving in the steady state, this can be simplified:

$$\begin{bmatrix} \Delta\Omega_t \\ \Delta P_t \end{bmatrix} = \begin{bmatrix} 1 & -\dfrac{b}{1-b} \\ 0 & \dfrac{1}{1-b} \end{bmatrix} \begin{bmatrix} i-k & -cY-(i-k)\Omega \\ \phi(k-i) & \phi(q\tau + (i-k)\Omega + cY) \end{bmatrix} \begin{bmatrix} \Omega_t - \Omega^* \\ P_t - 1 \end{bmatrix}$$

$$= \begin{bmatrix} \left(\dfrac{1-b(1-\phi)}{1-b}\right)(i-k) & -\left(\dfrac{1-b(1-\phi)}{1-b}\right)(cY + (i-k)\Omega) - \dfrac{b\phi}{1-b}(q\tau) \\ -\left(\dfrac{\phi}{1-b}\right)(i-k) & \dfrac{\phi}{1-b}((i-k)\Omega + q\tau + cY) \end{bmatrix} \begin{bmatrix} \Omega_t - \Omega^* \\ P_t - 1 \end{bmatrix}$$

Define $\alpha = \left(\dfrac{1-b(1-\phi)}{1-b}\right)(i-k)$ and $\beta = \left(\dfrac{\phi}{1-b}\right)((i-k)\Omega + q\tau + cY)$

as the dominant diagonal elements of the matrix. Then the system of equations can be rewritten as:

$$\begin{bmatrix} \Delta\Omega_t \\ \Delta P_t \end{bmatrix} = \begin{bmatrix} \alpha & -(b\beta + (i-k)\Omega + cY) \\ -\dfrac{\phi\alpha}{1-b(1-\phi)} & \beta \end{bmatrix} \begin{bmatrix} \Omega_t - \Omega^* \\ P_t - 1 \end{bmatrix}$$

Describing movement out of the steady-state: eigenvalues and eigenvectors.

The eigenvalues and eigenvectors of this system of equations govern the adjustment of Ω_t and P_t in the transition to the steady state. The eigenvalues can be denoted λ, and defined implicitly by:

$$0 = \lambda^2 - [\alpha + \beta]\,\lambda + \left(\frac{q\tau\phi}{1-b}\right)(i-k)$$

Define $\theta = (\alpha + \beta)$. Then the pair of eigenvalues is given by

$$\lambda = \frac{\theta \pm \sqrt{\theta^2 - 4\left(\frac{q\tau\phi}{1-b}\right)(i - k)}}{2}$$

The adjustment path to the steady state is defined as

$$\Omega_t - \Omega^* = c_{11} \exp(\lambda_1 t) + c_{12} \exp(\lambda_2 t)$$

$$P_t - P^* = c_{21} \exp(\lambda_1 t) + c_{22} \exp(\lambda_2 t)$$

with $c_{12} = c_{22} = 0$ along the saddlepath.

The eigenvectors can be defined:

$$\begin{bmatrix} \alpha - \lambda_1 & -(b\beta + (i - k)\Omega + cY) \\ -\left(\frac{\phi}{1-b}\right)(i - k) & \beta - \lambda_1 \end{bmatrix} \begin{bmatrix} c_{11} \\ c_{21} \end{bmatrix} = 0$$

implying two equations:

$$-(\alpha - \lambda_1)\, c_{11} + c_{21}\, (b\beta + (i - k)\Omega + cY) = 0$$

$$\lambda_1 = \beta - \left(\frac{\phi}{1-b}\right)(i - k)\left(\frac{c_{11}}{c_{21}}\right)$$

which can be combined to yield a single equation in c_{21} as a function of c_{11}.

$$-\left(\alpha - \beta + \left(\frac{\phi}{1-b}\right)(i - k)\,\frac{c_{11}}{c_{21}}\right) c_{11} + c_{21}\,(b\beta + (i - k)\Omega + cY) = 0$$

$$c_{21}^2\,(b\beta + (i-k)\Omega + cY) + (\beta - \alpha)\,c_{11}c_{21} - \left(\frac{\phi}{1-b}\right)(i-k)c_{11}^2 = 0$$

with solutions:

$$c_{21} = \frac{(\alpha-\beta)\,c_{11} \pm c_{11}\sqrt{(\alpha-\beta)^2 + \dfrac{4\phi}{(1-b)^2}(i-k)\,((1-b(1-\phi))((i-k)\Omega + cY) + q\tau b\phi)}}{2}$$

The value of c_{11} is defined by the solution to the first equation of this section evaluated at the initial period (t=0):

$$c_{11} = (\Omega_0 - \Omega^*)$$

A simulation exercise.

The exogenous variables are assumed to take constant values throughout the simulation, with $g = \tau = 150$, $i = .10$ and $Y = 100$. The private sector is assumed to begin with nominal wealth $\Omega_o = 350$. Behavioral parameters are: $a = -30$, $b = .03$, $c = .1$, $q = .5$, $k = .12$, $\phi = .13$.

The steady state has as properties that Ω^* and P^* are constant. Introduction of these requirements into these three equations yields the steady-state conditions that:

$$P^* = 1$$
$$\Omega^* = -s^*/i = 299.64$$

This specification of the more general model generates the AA and GG curves of Figure 3. The saddlepath is derived through reference to eigenvalues and eigenvectors of the dynamic system, and is illustrated in Figure 3 as well.

Consider the evolution of an economy beginning with wealth Ω_o and artificially suppressed price $P_o = .1$. The initial response upon liberalization of prices is a jump to the saddlepath at $P_1 = .61$. Subsequent to that the adjustment occurs along the saddlepath, with P rising and Ω falling toward steady-state equilibrium.

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