Essays On Dynamic Economics

by

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Abstract

The first chapter reexamines the issue of growth rate convergence across economies. The substantial empirical literature to date remains inconclusive: Within groups of countries of comparable development status, convergence appears to be taking place while across groups studies detect no convergence trend. Indeed, richer countries apparently grow faster than poorer countries, widening the income gulf. The finding, if correct, would suggest that endogeneous growth models predicting persistence in growth rate differentials are promising conceptualizations of the real world experience.

Correctly so? I argue that the two stylized findings of within but not across group convergence arise mainly from a simple mistake in defining the growth rate regression, specifically, from the common practice of using per capita income rather than the theoretically correct variable, labor productivity. To move from one to the other entails correcting for labor force participation rates and human capital per worker. If the growth rates of either of these two variables are systematically correlated with initial income per capita, the standard income per capita regression suffers from an ommitted variable bias. I demonstrate that such a bias indeed exists for the heterogenous but not for the homogeneous country groups. Correcting for the bias, I show that convergence is a sturdy fact both within and across country groups, suggesting that models with mean reversals in growth rate differentials -catching up, forging ahead, falling behind- are more appropriate descriptions of reality.

The second chapter, dealing with privatization in Eastern Europe, continues the focus on growth. A widespread perception held that the socialist economies underutilized their resources, providing the economic motivation for the transition to markets. Privatization of enterprises is widely regarded as a major prerequisite for attaining a more efficient allocation of resources and thus to generate a growth burst. Yet privatization remains sluggish. Why? Part of the answer is to be found in a range of institutional and legal obstacles. Yet a continued perception that east Europe remains a "goldmine" awaiting the adventurous investors suggests that "wrong" fundamentals are not at the core of the problem.

We suggest that the underlying reason for sluggish privatization may rather be searched for on the political front: while east European governments have adopted

fairly pro-capitalist policies, their ability to continue these policies will depend on their perceived success, and thereby ultimately on their ability to attract investment. The dependence between the probability of policy continuation and the aggregate amount of investment taking place generates the possibility of a pessimistic zero investment trap: if the typical investor expects too few of her fellow capitalists to go in, her perceived probability of policy reversal -lowering her expected rate of return below a safe alternative- will be to high to make entry profitable in expected terms, locking the economy in a zero privatization outcome. Meanwhile, widespread optimism about the investment willingness of her fellow capitalists could have led her to invest, insuring the continuation of the program.

We show the existence of two subgame perfect Nash equilibria in a simple game. We then turn to the policy side: what can be done to coordinate on the optimistic equilibrium? We demonstrate that the traditional policy: investment subsidies, may fail if financed domestically: the necessary tax on workers to finance the subsidy lowers the perceived probability of policy continuation, the latter effect may well dominate the first round effect in politically sensitive environments. The reverse policy of transfers to workers financed by a tax on capital reverses the tradeoff, rendering a populist upheaval less likely at the cost of a lower return on capital, again creating an ambiguity. The secondary effects on income distribution during the transition phase can be avoided by a foreign loan/grant financed social security system during the initial transition period. We furthermore show that foreign threats/promises conditional on policy continuation and the introduction of foreign direct investment insurance schemes provide effective and -fairly- cheap means of rendering the full privatization outcome more likely.

The third paper, dealing with the role of the exchange rate in hyperinflations, continues the focus on multiple equilibria outcomes. I demonstrate that (1) exchange rate innovations are prior to budget, price and money innovations and (2) the correlation between the inflation and the depreciation rate experiences a sudden rapid increase just before the final frantic moments of the hyperinflation. While the first stylized fact is consistent with the traditional balance of payments view, the second fact is not. I propose a second link operating via the role of the exchange rate as a signal about the aggregate price level: as inflation progresses, the weight on current information increases, the exchange rate forms a natural signal as it proxies for the tradeables component of the aggregate goods basket. Increased weight on the exchange rate in price-setting rules of sellers of both tradeables and non-tradeables increases the signal value of the exchange rate, creating a potential critical mass effect leading to widespread pricing on the exchange rate. Such a shift in pricing behavior is well documented in the interwar literature. Furthermore, I demonstrate that the variability of inflation rates for specific goods within and across cities significantly decreases in the final phases of the hyperinflation after experiencing the typical intial increase as inflation rose.

The fourth paper, dealing with tax evasion, continues the emphasis on coordinated behavioral changes responding to dramatic changes in the external environment. Tra-

ditional analysis of tax cheating behavior focuses on the choice oif a representative agent facing a tradeoff between a certain income under tax honesty relative to a stochastic income under cheating, treating the perceived probability of detection as given. I suggest that for a given monitoring rule, the probability of detection, although taken as given by the individual, depends on the aggregate number of tax cheaters in the same income bracket. As a result of the externality of individual cheating decisions on the aggregate detection probability, I show the potential existence of two subgame perfect Nash equilibria: where the individual believing all her fellow tax payers to be honest perceives a sufficiently high detection probability to render cheating suboptimal, the same individual, believing her fellow tax payers to be dishonest, perceives a sufficiently low detection probability to render cheating optimal.

In stable social systems, honesty/dishonesty choices tend to be stable over time. In periods of social upheaval, a shift from one to the other equilibrium may however occur. As a case in point, I consider hyperinflations. The emergence of rapid inflation may result in widespread dissatisfaction with the governments policies and thereby create a "tax revolt". Alternatively, lacking indexation of tax liabilities may lower the perceived costs of detection sufficiently to make non-payment individually optimal. In both cases, a return to price stability may not imply a return to the status ex ante: tax honesty may display hysteresis. The sunspot nature of the two equilibria implies that, once stuck in a low honesty outcome, the use of "symbolic prosecution" -as practiced in Mexico-, may suffice to generate a shift towards tax honesty, a feature not obtainable with traditional models of tax evasion.

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Chapter 1

The Convergence Puzzle Reconsidered

"Exogenous" growth models with decreasing returns to the accumulating factor hold out a simple message of patience for poorer countries: in the absence of impediments to technology flows productivity growth rates across countries converge over time, leaving no role for economic policy to affect steady state growth rates. The convergence is fairly rapid: under standard parameter values, half of the distance to the steady state level of per capita income will be covered in less than thirteen years[1] In contrast, "endogenous" growth models with constant returns to the accumulating factor allow for different growth rates in steady state. Government policies successful in raising the rate of capital accumulation can permanently alter growth rates[2].

The convergence properties of growth rates provide a natural test of the two approaches. During the last half decade a veritable mini-industry in convergence testing has sprung into life. The conclusion of this literature remains however ambiguous. Studies focusing on per capita income or using heterogenous samples frequently reject convergence while papers examining productivity growth rates or focusing on relatively homogeneous groups of countries tend to conclude in favor of convergence.

[1] King and Rebelo (1988), Sala i Martin (1990). For related estimates see Mankiw et al. (1990).

[2] See Rebelo (1986), Dasgupta and Stiglitz(1988), Arrau (1989), Barro (1988), Krueger (1990), Easterly and Wetzel (1989) for a representative sample of the policy-growth debate.

We show that the apparent puzzle can be resolved by taking account of the measurement error introduced by the practice of using per capita income instead of the variable indicated by the theoretical model, labor productivity. Because of a dependence between per capita income, labor force participation rates and labor quality, convergence tests based on per capita income produce biased results, possibly leading to a spurious rejection of convergence. Turning to empirical analysis, the conjecture is born out: growth rates of labor productivity exhibit strong convergence across a large sample of heterogeneous countries.

The economywide results may however reflect spurious convergence: a leading sector with constant returns to the accumulating factor, generating asymptotic divergence may, in any finite dataset, be dominated by convergent traditional sectors. Reexamining the convergence properties of labor productivity growth rates by sectors however yields no evidence in favor of a divergent leading sector.

In sum the available data strongly support the convergence of productivity growth rates, casting doubt on the empirical relevance of endogenous growth models based on *globally* constant returns to the accumulating factor.[3] The paper is set out in four parts. We begin with a brief review of the convergence hypothesis before turning to an equally brief survey of the existing literature. The third section suggests a resolution to the puzzle of conflicting empirical findings. Section four reports the empirical results.

1.1 The Convergence Hypothesis

The convergence hypothesis follows from suitably restricted variants of the neoclassical growth model developed by Ramsey (1928), Solow (1956), Cass (1965) and Koopmans (1965). A generic representation (eg. Sala i Martin (1989)) is given by

$$Max \int_0^\infty e^{(n-\rho)t} U(c_t) dt \tag{1.1}$$

[3]We do not consider the alternative testing strategy focusing on the time series behavior of real interest rates.

$$c_t \equiv \frac{C}{L}$$

$$Y_t = F(K, Le^{gt}) = K^{\alpha}(Le^{gt})^{1-\alpha} \tag{1.2}$$

$$k_t \equiv \frac{K}{Le^{gt}}$$

$$y_t \equiv \frac{Y}{Le^{gt}} = f(k)$$

$$\dot{k}_t = f(k_t) - c_t - (n + \delta + g)k_t \tag{1.3}$$

$$\frac{\partial f}{\partial k} > 0, \quad \frac{\partial^2 f}{\partial k^2} < 0, \quad \frac{\partial f(0)}{\partial k} = \infty, \quad \frac{\partial f(\infty)}{\partial k} = 0$$

with the familiar first order condition:

$$\frac{\dot{c}}{c} = \frac{U''}{U'c}[\frac{\partial f}{\partial k} - \delta - \rho] \tag{1.4}$$

where n, g, δ and ρ denote the growth rate of the (physical) labor force, the growth rate of (exogenous) labor augmenting technological progress, the depreciation rate and the discount rate respectively.

Equations [3] and [4] define the dynamics of c and k along the transition path. By the transversality condition, k approaches the steady state monotonically from below, thus the rate of capital accumulation declines around the steady state. If the income effect dominates the sub[13 stitution effect in some region, the growth rate may however locally increase in output in that interval. To ensure that growth rates monotonically decline the income effect must be bounded. King and Rebelo (1988) show that for a standard specification monotonicity holds for the empirically supported range of parameters. We therefore abstract from monotonicity issues in the econometric work reported below.

Solving out yields the typical (generalized) convergence equation[4]:

$$ln(\frac{y_t^i}{y_{t-1}^i}) = \beta_0 + \beta_1 ln(y_{t-1}^i) \tag{1.5}$$

[4]Note that [5] is compatible with multiple steady states and chaos. Asymptotic convergence to a single steady state requires suitably restricted functional specifications. See Day (1983) and Day and Walter (1989).

$$(A)\ \beta_0 = g > 0$$
$$(B)\ \beta_1 = \beta_1(\alpha, \delta, \theta, \rho, g, n) \leq 0$$
$$(C)\ \beta_1 = 0\ if\ \alpha = 1$$

A variant of [5] underlies most empirical studies of convergence and will be used for the empirical results reported below[5]. The derivation of [5] implicitly imposed restrictions on the international mobility of capital. If capital is perfectly and costlessly mobile, real returns are equalized across countries at all points in time. In consequence, not only steady state productivity growth rates but also steady state *levels* of productivity (though not real incomes) are equalized across countries. In this case, costless adjustment would imply the *instantaneous* convergence of productivity levels. In the (likely) presence of adjustment costs or home produced complementary inputs (infrastructure, social security systems) convergence would be non-instantaneous even in the presence of perfect international capital mobility.[6]

The equation implies that (monotonic) convergence to the exogenous growth rate g takes place if and only if the accumulating factor exhibits diminishing returns to scale. Of course, by virtue of its *deus ex machina* nature, no *ex ante* argument that the rate of technological progress is identical across economies can be made[7]. The convergence prediction is thus based on the *joint* hypothesis of decreasing returns to the accumulating factor *and* unrestricted flows of technology. Rejection of growth rate convergence is thus *not* sufficient to reject "exogenous" growth models.

Endogenous growth has frequently been identified with constant returns to *all* (aggregated) accumulating factors. Constant returns can be achieved either by externalities[8] or by abandoning the assumption of fixed production factors[9]. Strictly speak-

[5]The β convergence implied by [5] is by no means the unique measure of convergence. Alternative concepts include the history independence of asymptotic ranks, the symmetry of transition matrixes between arbitrary growth rate decompositions and the decline of the sample cross sectional variance of growth rates to a multiple of the variance of exogenous shocks. While we will mention a number of these statistics below, we concentrate in the main on the β convergence concept.

[6]See Reynolds (1983,1985), Weede(1983), Barro (1989a,1989b), World Bank (1988,1989), Scully (1988), Buiter and Kletzer (1991).

[7]For example, reverse engineering might require a minimum level of human capital, implicitly excluding a subgroup of countries from the learning process. See Baumol (1986).

[8]Romer (1986,1989) *inter alia.*

[9]Lucas(1988)

ing however, all that is required for endogenous growth in the presence of some fixed factor is that the return to the accumulating factor is strictly bounded above the discount rate as the ratio of the flexible to the fixed factor approaches infinity.[10]

We now present a brief overview of the empirical work on convergence as a background to the discussion of the econometric issues arising in implementing [5] as a regression equation.

1.2 Convergence Testing: A Survey

The emergence of endogeneous growth models in the 1980s as a competing paradigm to the classical approach has provided a motivation for empirical tests judging the relative merits of the two models. The (non)-convergence prediction of the exogenous (endogenous) approach provided a natural point of departure, spawning a veritable mini-industry in convergence testing over the last decade. The following section provides a brief survey of this literature[11].

Exogenous growth models predict the *asymptotic* convergence of growth rates. The early empirical work on growth consequently focused on the convergence properties of the longest available output series. Baumol (1986) finds convergence in productivity growth rates for a small sample of countries spanning a century. Abramovitz (1985), examining a similiar sample, argues against "mechanical" convergence, reporting periods of strong convergence (1870-1938, 1950-1973) interspersed with periods of divergence (1939-1949) and standstill (1973-79). Romer(1986) and DeLong (1988) point out that the long term studies, by concentrating on the *ex post* industrialized economies, bias the results in favor of the convergence hypothesis. Expanding the data set, DeLong(1988) finds evidence against convergence.

[10]Jones and Manuelli (1990) present a model in which the returns to capital are decreasing but are bounded from below above the discount rate, generating persistent growth even in an "exogenous" model without technology growth. See also Rebelo(1988) and Raut and Srinivasan (1991) on this point.

[11]We only survey the literature on *growth rate* convergence. Convergence in *levels* requires further restrictions on the neoclassical model which, as we will see below, are unambigously rejected by the data.

The sample selection problems of long term studies motivated the shift towards more comprehensive studies - at the cost of a shorter time period and thus an increased importance of transitory events. The move towards comprehensive studies was furthered by the publication of the Summers and Heston dataset, providing PPP adjusted real income levels for some 120+ market economies. A sizable number of studies has examined the convergence properties of the new dataset, revealing a number of fairly robust findings:

No Unconditional Convergence The raw growth rates exhibit little if any correlation with the initial per capita levels of income (Romer(1987), Barro(1989a,b), Sala i Martin (1989)).

Conditional Convergence Once controls for different steady states are included, strong evidence in favor of conditional convergence emerges (Kormendi and Meguire (1985), Baumol (1986), Baumol and Wolff (1988), Baumol, Blackman and Wolff (1989) Barro (1989a,1989b), Grier and Tullock (1989), Jones(1990), Mankiw et al. (1990))[12].

Geographic Differences The inclusion of continental dummy variables reveals significant negative coefficients for Sub-Saharan Africa and Latin America (Barro (1989a, 1989b), Jones (1990)). Grier and Tullock (1989) likewise find different convergence parameters across continents, suggesting the presence of additional excluded explanatory variables.

Development Differences A separation of convergence regression by development stage reveals differences between groups. Baumol finds strong convergence *within* the groups of developed, less developed and socialist economies but less evidence for convergence *across* groups. Mankiw et al. (1990) report convergence parameters for different development groups which are increasing in the mean level of output per adult.

[12]Mankiw et al. (1990) use output per adult rather than output per capita.

Temporal Differences A number of studies detected differences in the convergence pattern across time, with convergence most strongly present in the immediate postwar period and divergence becoming prominent in the mid 1970s (Baumol and Wolff (1988), Abramovitz (1975), Barro and Sala i Martin (1989)).

Apart from the comprehensive studies, a number of recent studies has focused on narrower datasets. Dowrick and Nguyen (1989) consider the convergence properties for the postwar OECD, based on the initial level of income per capita relative to that of the United States and conclude in favor of convergence. Barro and Sala-i-Martin (1989) examine the convergence hypothesis for the individual states within the United States. While they find strong evidence in favor of long term convergence, they also detect periods of divergence in the 1920s and again the 1970s, consistent with the findings of Abramovitz and Baumol.

More recently, a number of authors have shifted towards time series econometrics in testing for convergence. Quah (1989) examines whether, given that per capita income series are integrated, bivariate vectors are co-integrated with vector (1,-1). While he rejects cointegration for the entire Summers and Heston sample, implying integrated per capita income differentials across countries, he finds moderate evidence in favor of convergence for the subgroup of developed economies. Bernard and Durlauf (1991) follow a related approach. For 15 OECD economies, they examine whether the persistent components of per capita income changes are identical across countries. While they find some common factors, the persistence in per capita output deviations across countries is sufficient to allow the rejection of the null of no convergence. Quah(1990b) examines the transition probabilities between low and high growth rates. In the presence of persistence and big push effects, the transition matrices are subject to aymmetric restrictions. While Quah finds weak evidence in favor of the implied restrictions, these specifications do not significantly improve upon unrestricted specifications consistent with a simple Solowian model, suggesting that the latter forms an acceptable representation of the data structure.

Table 1 summarizes the empirical literature. The table is subdivided according to the dependent variable used (productivity or per capita income growth), according to

whether controls for different steady states were included (no controls/controls) and according to whether the test was performed on a homogeneous or a heterogeneous group of countries. Findings against (for) the convergence hypothesis are denoted by N (Y). Insignificant parameter estimates are enclosed in brackets.

Table 1.1: Convergence Studies: A Classification

	Productivity		Income Per Capita	
	No Controls	Controls	No Controls	Controls
Homogenous Sample	Baumol Y i Martin Y Helliwell Y	i Martin Y Dowrick Y	Barro Y Mankiw Y Quah Y Rauch Y Streissler Y	Mankiw Y Grier Y
Heterogenous Sample			Barro N Mankiw N Quah (Y) Grier N DeLong N Rauch N Streissler N	Barro Y Mankiw Y Kormendi Y Romer Y Grier N DeLong+ Y Koester Y Landau Y Londregan Y Murphy Y Romer (N) Jones Y Levine Y Fischer Y

The surveyed studies suggest three regularities:

1. Studies imposing the restriction of common steady states across economies tend to reject convergence relative to studies allowing for different steady states.

2. Studies using per capita income tend to reject convergence relative to studies using labor productivity.

3. Studies using homogeneous samples tend to favor convergence relative to studies based on heterogenous samples.

1.3 The Convergence Puzzle

Are these regularities a mere artifact of the available data? In the following section, we provide a consistent explanation for all three findings, based on a misspecification of the equation commonly employed for regression analysis. We then turn to a re-examination of the data to determine whether the correction of the misspecification suffices to resolve the convergence puzzle.

1.3.1 Spurious Divergence I : Steady State Controls

A straightforward regression of productivity growth rates on initial levels can yield misleading results if steady state levels differ across countries[13].

Take the case of two economies, A and B. While country B converges to a higher steady state *level* of productivity, both economies are characterized by decreasing returns to the accumulating factor and thus identical (zero) steady state *growth* rates. If country A reaches the steady state before country B, the latter will exhibit a higher *transitional growth rate* even after surpassing country A in levels, while growth rate convergence holds in steady state. A convergence regression not allowing for differential steady states would thus yield a *positive* estimate of β_1.

If, in a sample, initial levels of income are negatively correlated with temporal discount rates, rich countries may experience faster *transitional* growth than their poorer brethren, leading an unsuspecting econometrician to inappropriately reject *asymptotic* growth rate convergence. Under the plausible assumption that the factors determining steady state productivity levels are fairly similar for homogeneous groups of countries, the problem does not arise in studies focusing on the convergence pattern across similar countries, providing a possible explanation for the third stylized fact.

In the regressions reported below, we control for the possibility of spurious divergence arising from this source by including a set of controls for differing steady states; specifically the average savings rate[14], the average growth rate of the labor force, the

[13] As mentioned above, differential steady states may either reflect differences in fundamentals or multiple equilibria.

[14] Alternatively, under the null, the investment ratio.

mortality rate above age five, the number of revolutions and coups (intended to capture the threat to property rights[15]) and continental dummies (to capture additional location specific determinants).

1.3.2 Spurious Divergence II : Measurement Error

Theoretical growth models consider the convergence properties of labor productivity growth rates. The majority of empirical studies has instead employed the growth rate of per capita income as dependent variable. We now show that this substitution is however far from innocuous.

The two measures are related via two multiplicative factors, the labor force participation rate and the human capital endowment of the average worker. If *either* of these indices is systematically related to initial income per capita, the estimated convergence coefficient β_1 is biased. Under the null of convergence, the true model is given by a variant of equation [5]:

$$ln(\frac{Y_1}{L_1 H_1}) - ln(\frac{Y_0}{L_0 H_0}) = \beta_0 + \beta_1 \, ln(\frac{Y_0}{L_0 H_0}) + \varepsilon \qquad (1.6)$$

where Y, L and H denote real output, labor quantity and a labor quality index, 0 and 1 denote the starting and end point of the sample. Studies examining the convergence of per capita income growth instead estimate:

$$ln(\frac{Y_1}{N_1}) - ln(\frac{Y_0}{N_0}) = b_0 + b_1 \, ln(\frac{Y_0}{N_0}) + \nu \qquad (1.7)$$

where N denotes population. Adding $(-ln(N_1) + ln(N_0))$ to both sides of [6] and rearranging, we obtain the theoretically correct convergence equation in terms of per capita income growth:

$$ln(\frac{Y_1}{N_1}) - ln(\frac{Y_0}{N_0}) = \beta_0 + \beta_1 ln(\frac{Y_0}{N_0}) - [ln(\frac{N_1}{L_1 H_1}) - (1 + \beta_1) ln(\frac{N_0}{L_0 H_0})] + \varepsilon \qquad (1.8)$$

[15] Barro(1989).

Comparing [7] and [8] the estimate of b_1 in equation [7] suffers from omitted variable bias if the term in square brackets is correlated with initial income per capita. Specifically, we obtain:

$$b_1 = \beta_1 + (1+\beta_1)\delta - \gamma - (1+\beta_1)\eta + \psi + Noise \tag{1.9}$$

where δ, γ, η and ψ are the OLS coefficients corresponding to regressions of $ln(\frac{N_0}{L_0})$, $ln(\frac{N_1}{L_1})$, $ln(H_0)$ and $ln(H_1)$ separately on $ln(\frac{Y_0}{N_0})$. If fertility and labor force participation decisions were uncorrelated with initial income per capita, the replacement of productivity by income per capita, while introducing additional noise into the equation, would not affect the unbiasedness property of the estimated coefficients. This special case is of some relevance for the group of developed countries having completed their demographic transition and may thus explain why studies employing income per capita but restricting attention to developed countries (Dowrick and Nguyen (1989), Baumol(1986)) have generally found in favor of convergence.

The convergence parameter β_1 obtained from estimating (7) rather than (6) will however be biased if either labor quality or labor force participation rates are systematically related to initial per capita income. We now consider the potential sources of bias in more detail.

Fertility

The first potential bias arises from the link between fertility and per capita income. An extensive body of literature documents the existence of a (logistic) demographic transition from high to low fertility rates associated with the industrialization process[16]. Figure 1 documents the strong negative link between fertility and income per capita. Table 2 reports the results of a regression of fertility on per capita income and per capita years of primary and secondary education, revealing a negative partial

[16]Kusnets(1965) provides evidence, Barro and Becker (1988,1989), Becker(1981), Becker et al. (1989),Azariades and Drazen (1990,1991), discuss the link between fertility, income and human capital accumulation

correlation between income and fertility[17].

Table 1.2: Fertility And Income

Variable	Coefficient	T-Statistic
Constant	6.60	19.91
Income p.c.	-0.69	3.06
Years of Education	-0.0002	3.53
R^2	.65	

In consequence, the ratio of the (economically inactive) population aged less than 14 years to the total population decreases with GDP per capita, as illustrated in Figure 2.

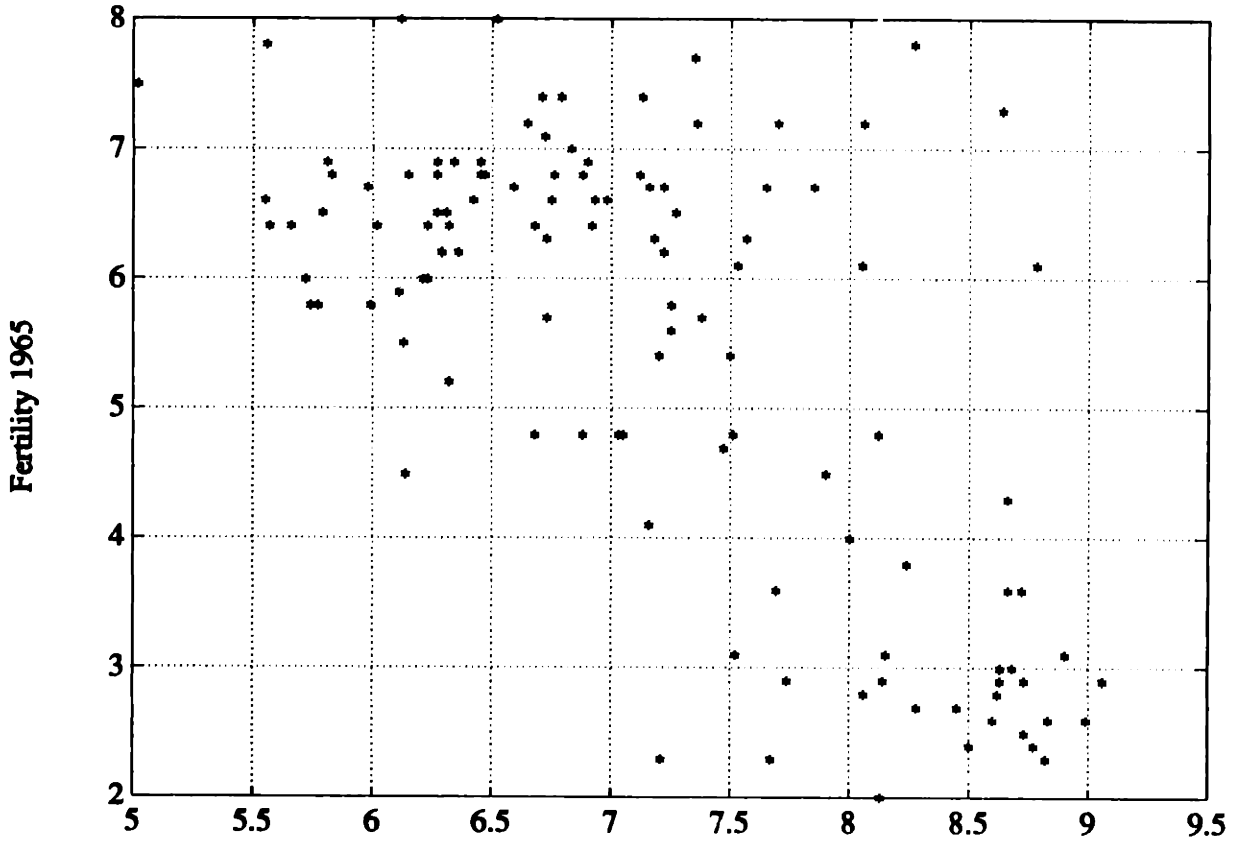
Thus for identical participation rates out of the working age population the initial values of per capita income measured relative to the entire population systematically understate the relative output per worker levels of poorer economies. Appendix 2 reports the participation rates against the entire and against the working age population for 1960 and 1985, illustrating the sizeable differences between the two measures.

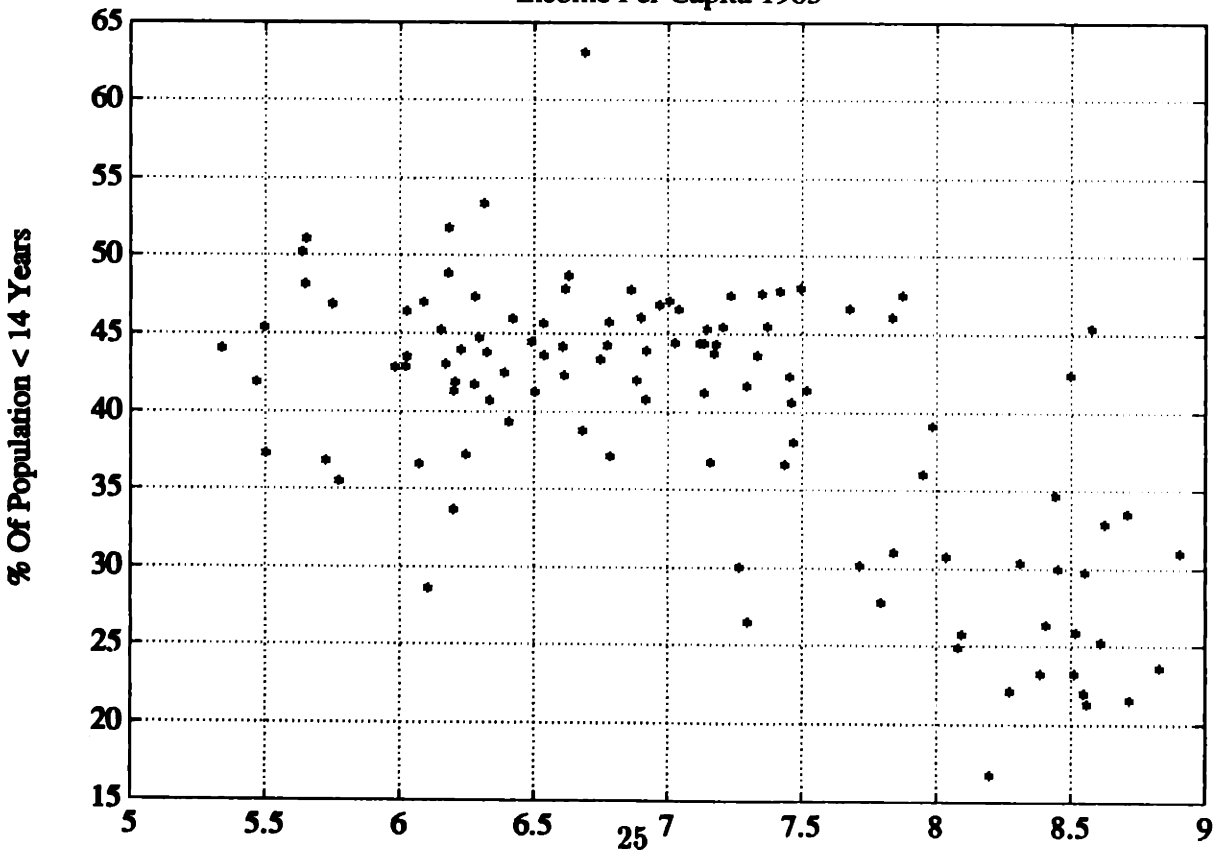
The measurement problem is however not limited to the initial level of output per worker: the negative correlation between fertility and per capita income furthermore implies a mismeasurement of productivity *growth* rates. Developed countries had predominantly completed their demographic transition by 1960. With a fairly constant labor force participation rate out of the adult population, the growth rate of per capita income thus approximately equalled the rate of output per worker growth, rendering the substitution innocous in growth rates as well as in levels. In contrast, initially poor countries passed through their demographic transition during the sample period, implying a declining labor force participation rate measured relative to the total population[18]. Thus per capita growth rates *systematically understate* the productivity growth rates of poorer countries.

[17]All regressions are based on an extended version of the Barro-Wolf (1989) dataset.

[18]A regression of the ratio of the final to the initial participation rate on initial per capita income yields a significant coefficient estimate of .06 (t=3.62).

Figure 1-1: Fertility and Age Structure Versus Income Per Capita





Labor Force Participation Choice

The second link arises from a dependence of the labor force participation rate measured relative to the working age population on income per capita. A regression of the participation rate on initial income reveals a strong and surprisingly time invariant quadratic pattern (Table 3), illustrated in Figures 3 and 4.

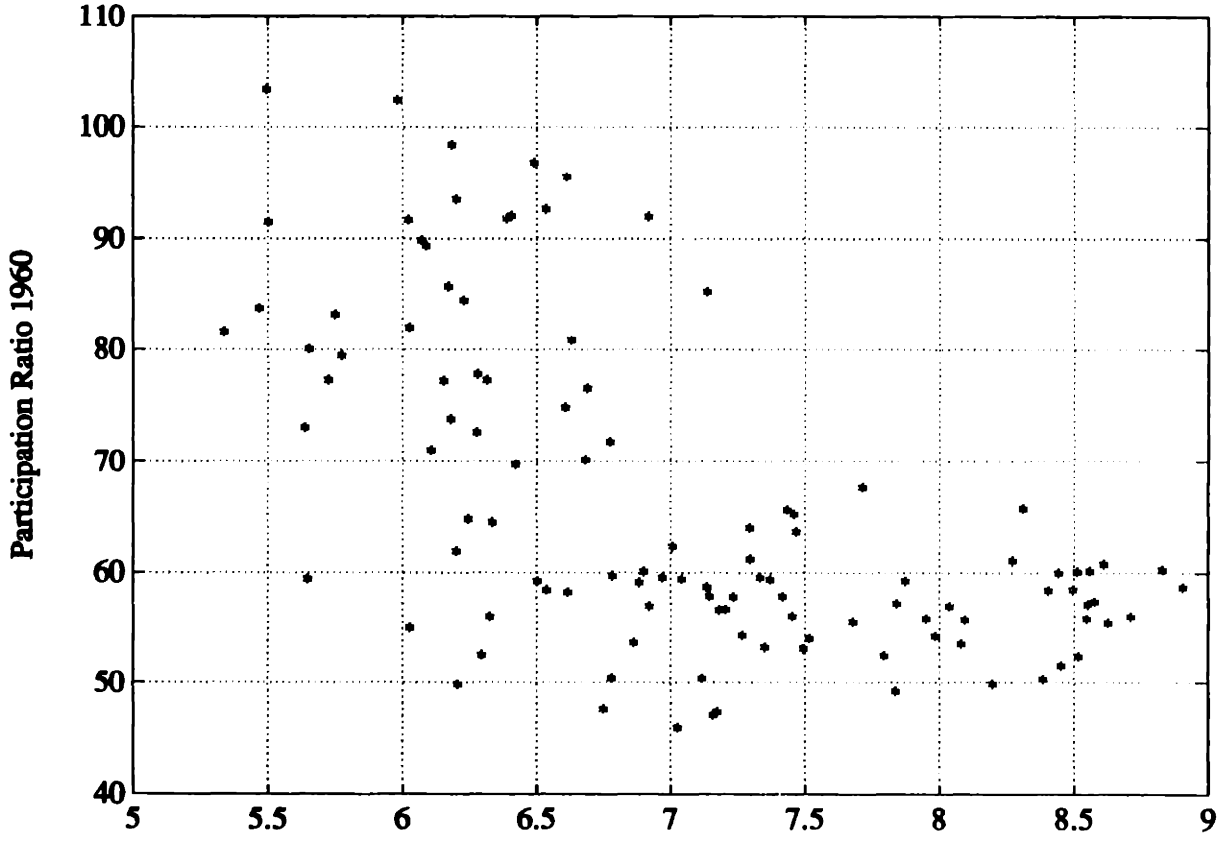
Table 1.3: Labor Force Participation Ratios

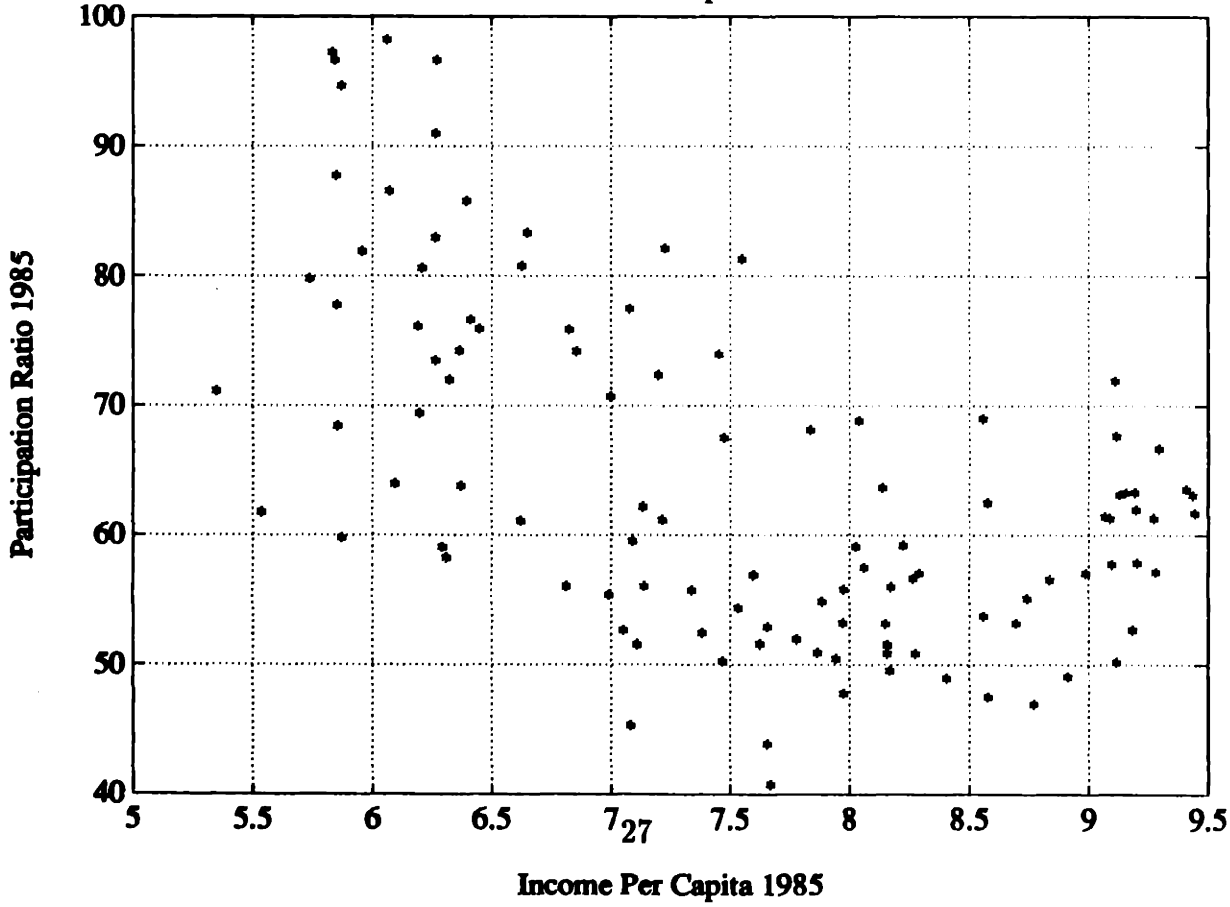
Year	Constant	GDP	GDP^2	R^2
1960	0.643	-0.115	0.040	0.42
	(44.4)	(8.84)	(3.30)	
1985	0.646	-0.118	0.041	0.45
	(49.5)	(9.01)	(5.15)	

The income per capita variable thus underestimates the level of output per worker of medium income countries relative to *both* poor and rich economies. The income-fertility link, taken in conjunction with the income per capita - labor force participation nexus, implies that the ranking of initial income per capita *levels* does not replicate the ranking of the theoretically more appropriate output per worker measure.

The substitution of income per capita for production per capita is thus revealed to be a far from innocuous "approximation": both the relative underestimation of the initial output per worker levels of poorer countries and the relative overestimation of the productivity growth rates of initially rich countries bias the estimated (absolute) convergence parameter downwards, raising the possibility of a spurious rejection of convergence. For the sample underlying our study, the danger of spurious rejection is real: for standard parameter values, the (annualized) convergence coefficient a takes values between -0.01 and -0.05 (King, Plosser and Rebelo (1988) and Sala i Martin (1989)). Substituting the point estimates for k and g obtained from the data set yields a bias from fertility and labor force participation decisions ranging between .0227 for $\beta_1 = -0.01$ and .0174 for $\beta_1 = -0.05$. For $\eta = \psi = 0$ any true convergence parameter for labor productivity larger than -0.02 thus pushes the estimated coefficient into the positive range.

Figure 1-2: Participation Choice Versus Income Per Capita 1960 and 1985





Human Capital

The third measurement problem arises from the failure to take labor quality into account. The theoretical model provides a prediction about the time series behavior of labor productivity, i.e. the value of output per unit of labor input. In practice, the variable most commonly used even in the few convergence studies focusing on labor productivity has been output per member of the labor force. The shortcut of equating raw labor with labor input is only appropriate if human capital per worker is identical across countries as well as constant over time. The assumption may be acceptable for homogeneous samples, it is inappropriate for studies comparing heterogeneous economies. An assessment of the importance of a human capital correction is rendered difficult by the lack of an acceptable measure covering the comprehensive group of countries underlying the convergence regressions. Previous empirical research has made use of two proxies for the stock of human capital, the adult literacy rate and enrollment ratios. Both measures are unsatisfactory. Figures 5 and 6 plot the percentage *increase* in primary and secondary enrollment ratios against initial output per worker, revealing a strong negative correlation. At a given point in time, the enrollment ratio, as a *flow* measure, thus overstates the *stock* of human capital held by developing relative to developed economies.

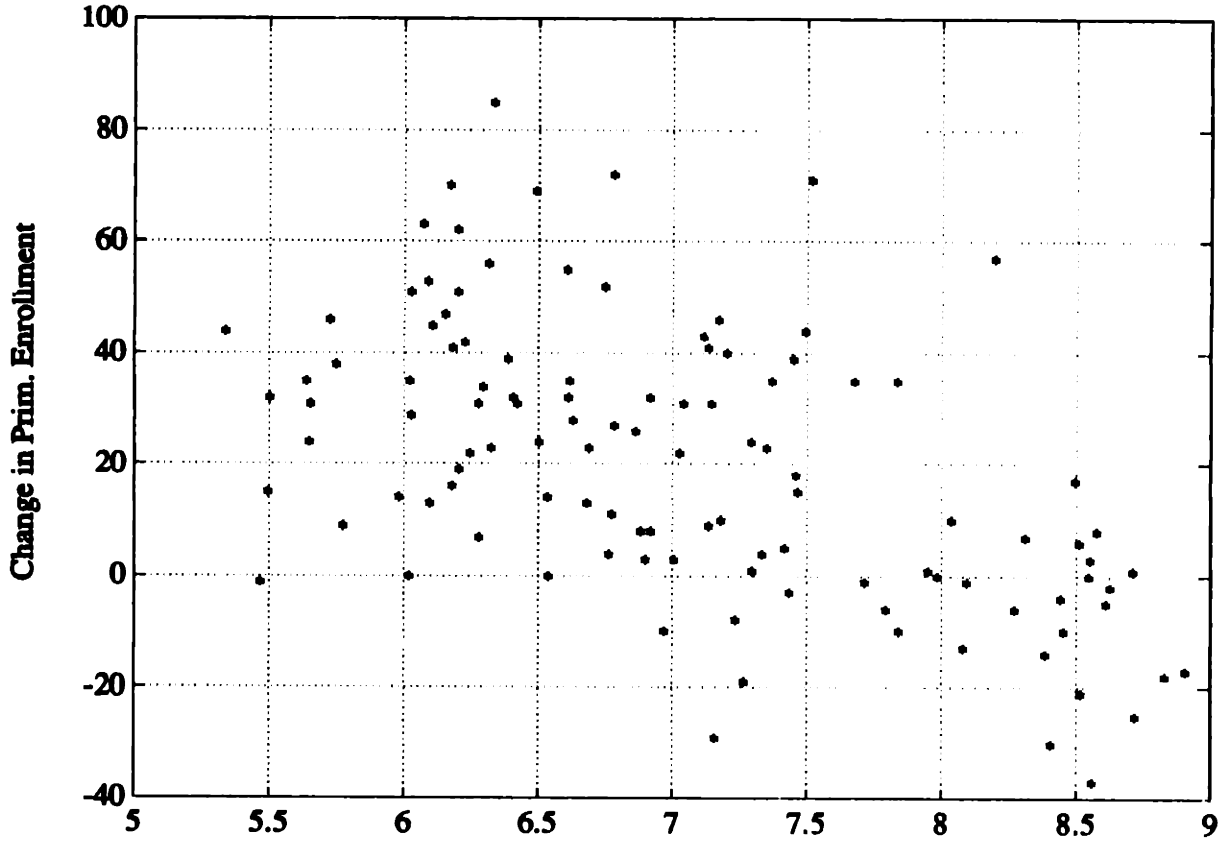
While the adult literacy rate, as a stock variable, avoids this problem, it focuses on to narrow a measure of human capital and is thus unable to discriminate sufficiently between economies surpassing minimal education standards.

To overcome these problems, we have calculated an alternative measure of human capital, the total number of years of primary and secondary education held by individuals not currently enrolled in educational institutions[19]. Figures 7 and 7 plots years of primary and secondary education per adult versus output per worker for 1960, revealing a strong positive correlation.

The positive correlation is confirmed by the regression reported in Table 4: controlling for political variables and location effects levels of human capital per capita

[19]The construction of the variable is described in Appendix 1.

Figure 1-3: Change In Primary and Secondary Enrollment Ratios Versus Income



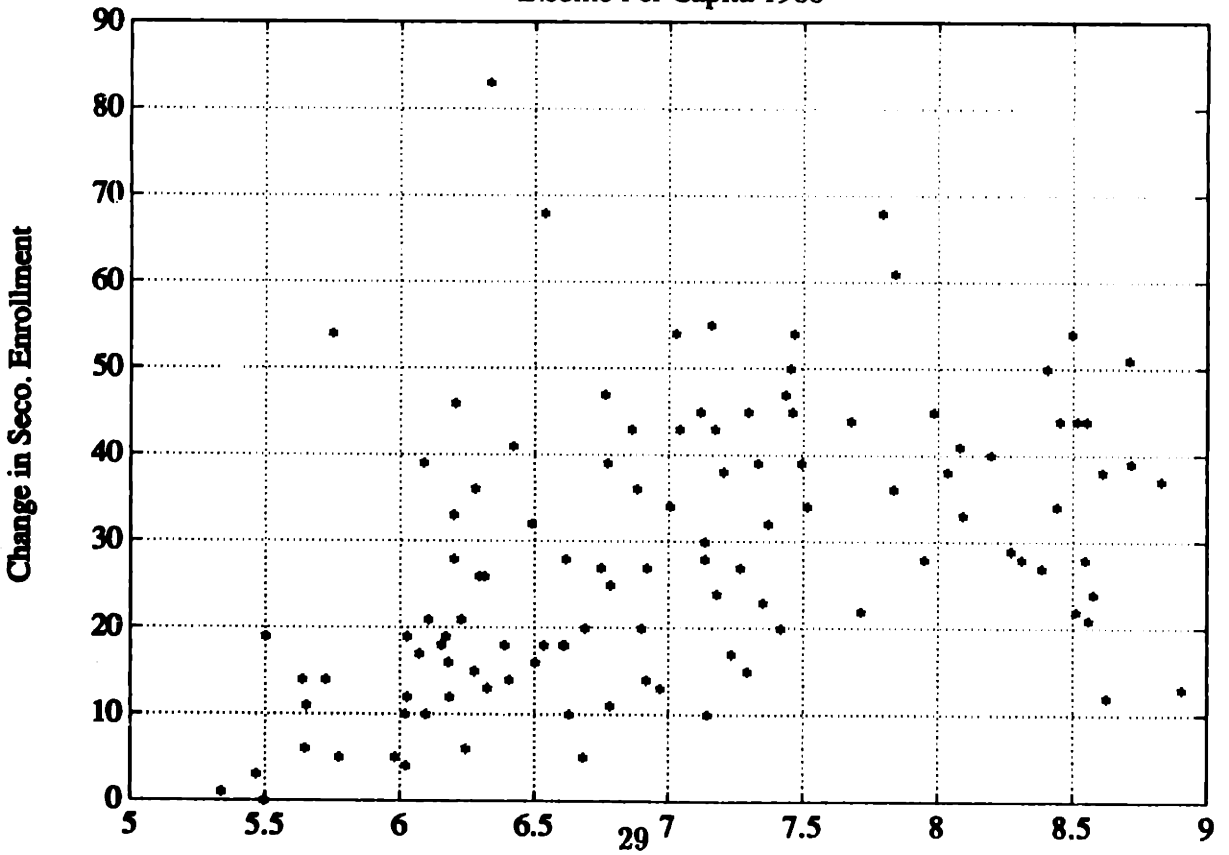
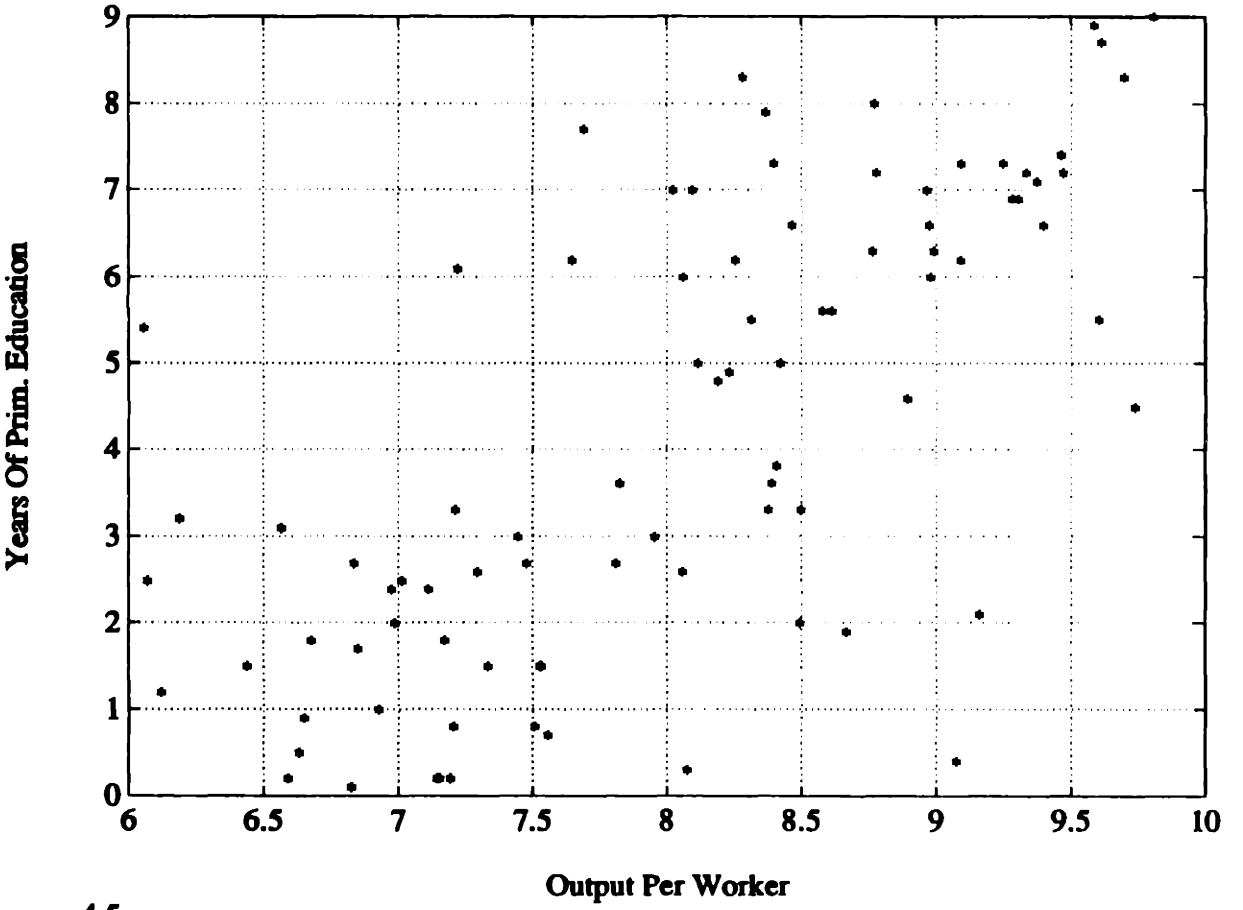


Figure 1-4: Years of Primary and Secondary Education Versus Output Per Worker



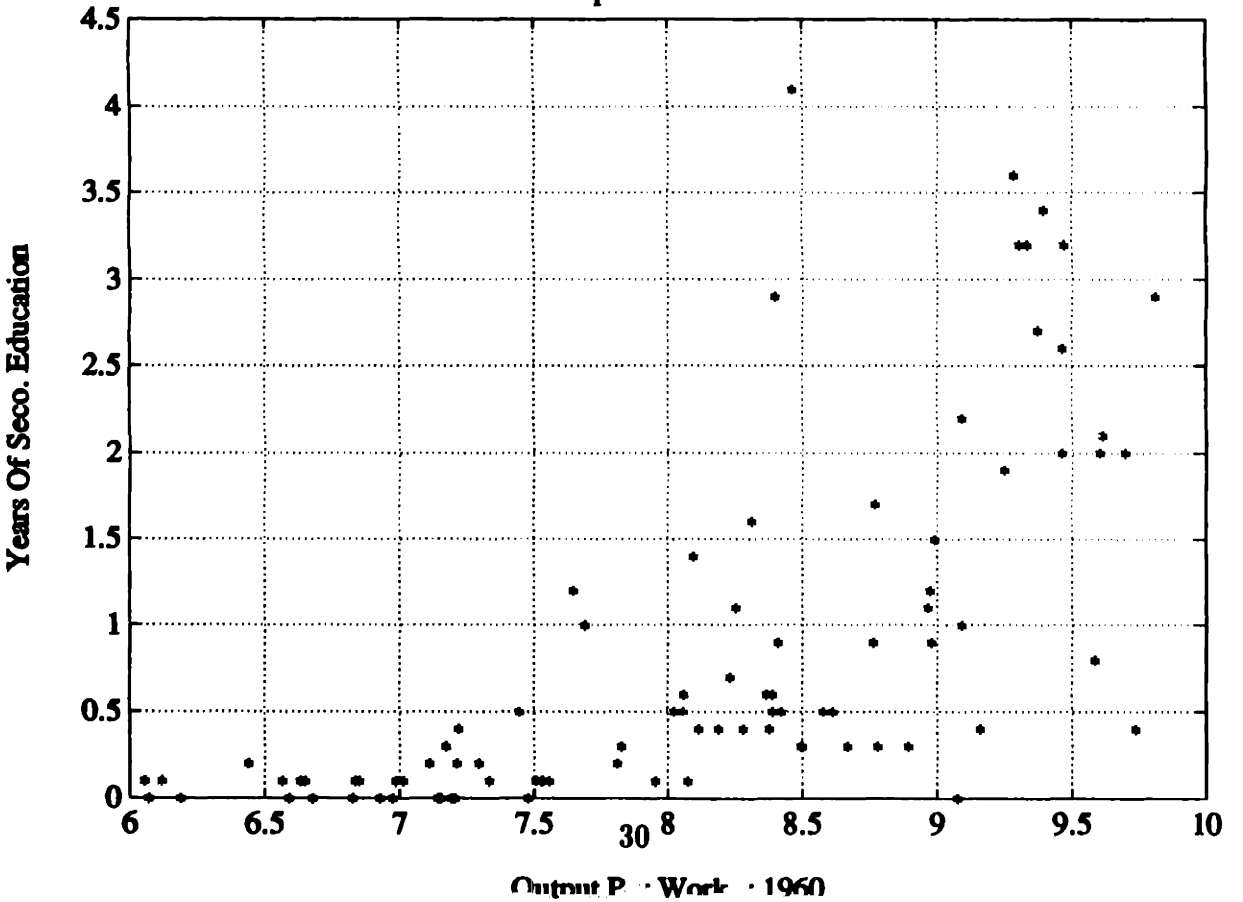


exhibit significant unconditional correlation with output per worker.

Table 1.4: Human Capital Stock Determinants

	Primary		Secondary	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	5259.4	6.13	1214.8	3.35
Output per worker	1022.0	3.21	446.5	3.96
Revolutions + Coups	-1099.1	1.66	18.6	0.09
Political Rights	-361.0	2.84	-163.9	2.62
Africa	-1198	1.95	-240.0	1.29
Latin America	150.9	0.31	-560.6	2.43
R^2	.69		.64	

The positive association of educational achievement with income implies that regressions based on output per worker *systematically* underestimate the initial productivity *level* of poorer economies. The negative correlation between initial income and the *accumulation* of education provides an offset by generating a *systematic* overestimation of the *growth rate* of initially poorer countries.

The net effect is ambiguous and, lacking an observable counterpart to "human capital", difficult to assess. In the convergence regressions, we control for the potential bias deriving from differential growth rates of human capital by including the initial level and growth rate of the two human capital proxies as additional explanatory variables: manipulating equation [7] we obtain:

$$ln(\frac{Y_1}{L_1}) - ln(\frac{Y_0}{L_0}) = \beta_0 + \beta_1 ln(\frac{Y_0}{L_0}) + ln(\frac{H_1}{H_0}) - \beta_1 ln(H_0) + \varepsilon \qquad (1.10)$$

If the proportionality of the proxy with the unobservable "human capital" variable remained (reasonably) constant both for every individual country over time and at any point in time across countries, both the initial level and the growth rate of the proxy are acceptable substitutes for the true but unobservable variable.

Conclusion

The evidence presented above suggests that the substitution of output per worker for labor productivity constitutes a second far from innocuous "approximation". Before we turn to the empirical issue whether the potential errors in fact introduce significant bias into the standard convergence regression, we consider one further problematic assumption underlying most empirical studies, which potentially produces an offsetting bias.

1.3.3 Spurious Convergence: Leading Sectors

We have demonstrated in the previous two subsections that a *positive* reported convergence coefficient β_1 may reflect measurement and specification error rather than providing evidence in favor of divergence. In this section we consider the opposite possibility of spurious convergence deriving from aggregation error.

The majority of convergence studies operates within the confines of a single good economy. If the restriction is dropped in favor of a multi-good economy with different sectoral growth rates, the possibility of spurious convergence arises: a small "leading sector" with constant returns to the accumulating sector can in any *finite* sample be dominated by larger "traditional sectors" exhibiting decreasing returns[20], leading the unsuspecting econometrician examining a non steady-state dataset to spuriously conclude in favor of asymptotic convergence.

We attempt to circumvent the problem by performing the convergence test separately for manufacturing, agriculture and services. The sectoral disaggregation also provides a partial control for the measurement problems introduced by the potential presence of a "surplus labor pool" in agriculture[21]. The existence of a pool of de facto unemployed labor included in official "economically active population" statistics and gradually being absorbed by the expanding sectors during the development process implies a systematic *under*estimation of the productivity levels and an *over*estimation

[20]See Chenery et al. (1986), Rauch(1989) and Matsuyama(1988) for detailed treatments of multisectoral growth patterns.

[21]See Lewis(1954) and Ranis and Fei (1961).

of the productivity growth rates of less developed economies[22].

1.4 Empirical Results

In the previous section, we identified several problems with convergence regressions based on per capita input or output per worker rather than on the theoretically correct variable, labor productivity. Are these problems sufficient to resolve the empirical puzzle of conflicting findings? In the following section we reexamine the evidence.

1.4.1 The Regression Equation

Controlling for the problems discussed above yields a revised regression equation:

$$ln(\frac{Y_1}{L_1}) - ln(\frac{Y_0}{L_0}) = \beta_0 + \beta_1 ln(\frac{Y_0}{L_0}) + \pi_0 ln(H_0) + \pi_1 ln(\frac{H_1}{H_0}) + \pi_2 + \xi_i D_i + \varepsilon \quad (1.11)$$

where $\pi_2 = \lambda_1 SAV + \lambda_2 \triangle LF + \lambda_3 MOR + \lambda_4 RC$ and SAV, $\triangle LF$, MOR and RC denote the savings rate, labor force growth rate, mortality rate and the average number of revolutions and coups, and the D_i denote continental dummies included to capture additional location specific steady state determinants.

King et al. (1988) provide simulations of the linearized solution to a fairly general neoclassical growth model. Their results permit the retrieval of the convergence parameter β_1[23] as a function of the capital share and thence the calculation of the time period required to cover half of the distance between the present and the steady state level of per capita income. For the traditional range of capital shares the predicted convergence parameter, reported in Table 5, lies between 0.03 and 0.04, with associated half- lives between 10 and twenty years. The time required before 95% of the distance between current and steady states is covered lies between 50 and 85

[22]See Asariadis and Drasen (1990) on the issue of population dynamics and the transition from family farming to manufacturing.

[23]See Sala i Martin (1989). The reported parameters have been transformed into 25 year equivalents to conform with the empirical estimates reported below.

years[24]. As the share of output attributable to the accumulating factor increases, growth differentials are characterized by increasing persistence. In the extreme case of the Rebelo AK model, the capital share reaches unity and the endogenous growth prediction of asymptotic persistence maintains.

Table 1.5: Implied Convergence Parameters and Half-Lifes

Capital Share	β_1	Half-Life (Years)	95% Life (Years)
0.3	-.049	6.2	26.9
0.4	-.041	11.5	49.5
0.5	-.031	19.6	84.8
0.6	-.024	28.5	123.3
0.7	-.017	45.6	196.9
0.8	-.012	68.3	295.1
0.9	-.005	160.9	695.2
1.0	-.000	∞	∞

[24]The implied half-lives are sensitive to the parameterization of the model. See Fischer and Frenkel (1974) for considerably longer 95 % intervals.

Under the null hypothesis, we thus have the following testable implications:

1. $\beta_0 \in [0.015, 0.03]$

2. $-0.05 \leq \beta_1 \leq -0.01$

3. $\pi_0 > 0$

4. $\pi_1 = 1$

5. $\lambda_1 > 0$

6. $\lambda_2, \lambda_3, \lambda_4 < 0$

1.4.2 Data

Labor productivity in sector i is obtained by dividing the constant price value added in the sector by the sectoral labor force. Data on real value added are taken from the World Bank World Tables, the labor force statistics are taken from the ILO, the FOA and the World Bank. The estimate of economy-wide labor productivity is obtained by dividing the Summers and Heston (1987) GDP per capita figures by the labor force participation rate. The human capital variables were constructed by integrating over the flow addition, taking account of mortality. A precise definition of the variables is provided in Appendix 1. The steady state controls are taken from Barro and Wolf (1989).

Growth models refer to current value added per unit of labor input. We therefore exclude the oil producing countries for which income per capita reflects predominantly the value of extracted resources rather than value added from the regression equations.

Finally, the selection of the steady state controls requires a brief discussion. It is by now a well known if rarely stated fact that the empirical growth literature suffers from an embarassment of riches: most macroeconomic variables exhibit significant unconditional correlation with economic growth, raising the problem of spurious proxy effects. Thus Scholing and Timmermann (1988) were unable to reject significant correlations for some 118 different social and economic variables. Renelt (1990) likewise

documents that out of the 34 "explanatory" variables in the Barro-Wolf dataset, 22 are significantly related to growth.

Faced with this embarassment of riches, any claim that a new variable provides a significant contribution to the understanding of growth must thus be regarded with some scepticism[25]. While no cleancut solution to the problem exists, an informal modus operandus gaining acceptance in the profession judges the explanatory power of new explanatory variables on their ability to improve, if included, the fit of the "Barro equation" containing a set of fairly robust controls for political, social and economic characteristics of the country. We follow this approach by examining convergence using the Barro framework, replacing per capita income by production per worker.

1.4.3 Economywide β Convergence

The regression results for the aggregate convergence equation are reported in Table 6[26]. Column 1 contains the "naive" convergence regression in terms of income per capita without steady state controls. The explanatory power of the regression is virtually zero, although the estimated parameter is significantly positive. Column 2 reports the corresponding regression for output per worker. The convergence parameters declines by 62 percent and becomes insignificant. The replacement of income per capita by output per worker thus has the expected sign effect on the estimated convergence parameter but does not reverse the divergence finding. Column 3 adds the steady state determinants, improving the fit of the equation significantly and reducing the convergence coefficient into the significant negative range. All steady state controls are correctly signed, although, reflecting the high degree of multicollinearity in the dataset, not individually significant. Column 4 includes the human capital variables. The estimated convergence parameter now further declines into the theo-

[25]Indeed, as any researcher delving into the standard datasets soon discovers, virtually any conjecture can be empirically "supported" or "rejected" for some selection of controls. Contrast, for illustration, the results of Barro(1990) and Fischer (1991) on the link between inflation and growth.

[26]All regressions have been coorected for heteroscedasticity.

Table 1.6: Economywide β Convergence

	[1]	[2]	[3]	[4]
Constant	.019	.017	0.019	0.02
	(10.45)	(5.68)	(1.71)	(1.16)
Output per worker 1960		.002	-0.009	-0.012
		(1.33)	(3.50)	(3.04)
Income per capita 1960	.0058			
	(3.89)			
Savings Rate			0.001	0.002
			(4.31)	(5.70)
Labor Force Growth			-0.217	-0.27
			(1.33)	(1.51)
Mortality			-0.023	0.017
			(0.37)	(0.23)
Revolutions + Coups			-0.011	-0.20
			(1.58)	(2.00)
Africa Dummy			-0.014	-0.019
			(2.59)	(2.65)
Latin America Dummy			-0.001	0.001
			(0.16)	(0.47)
Primary Educ. 1960				0.027
				(0.06)
Secondary Educ. 1960				-0.03
				(0.20)
Growth of Prim. Edu.				-0.00
				(0.13)
Growth of Seco. Edu.				0.00
				(0.21)
Growth of Aggr. Edu				
$\bar{R}^2$	.08	.03	.50	.62

retically suggested range. As familiar from earlier empirical work[27] the human capital variables do not enter significantly if a measure of aggregate investment (or saving) is included as right hand side variable[28].

Table 7 reports a range of subdivisions of the growth regression. The continental decomposition suggest that convergence patterns differ substantially across regions, with a negative association between development levels and convergence speed. Interestingly, the importance of human capital declines with development, lending some credence to threshold models of development[29].

1.4.4 Economywide σ Convergence

Taking the variance of the (deterministic) convergence equation [5] an alternative convergence prediction in terms of the variance of growth rates can be obtained:

$$\sigma_t^2 = (1-\beta)^2 \sigma_{t-1}^2 \tag{1.12}$$

In a deterministic environment, β convergence thus implies σ convergence and vice versa. In a stochastic setting, the cross sectional distribution of growth rates carries additional information about the convergence property of the underlying data set. Table 8 reports the semi-decadal cross sectional variance of income per capita and labor productivity.

While the coefficient of variation for the productivity *levels* remain constant across the sample, *growth rate* dispersion appears to have increased substantially, reflecting the combination of unchanged variation but declining mean growth rates.

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[27] Romer (1989).

[28] A regression of investment on human capital variables reveals a strong correlation.

[29] See Reynolds (1975), Murphy, Shleifer and Vishny (1990), Azariadis and Drazen (1989,1990), Backus et al. (1990) and Becker et al. (1989) for recent treatments of the time honoured threshold models.

Table 1.7: Economywide β Convergence: Continents

	Africa	Latin Am.	Europe
Constant	-.28	-.01	0.04
	(5.36)	(0.98)	(2.01)
Output per worker 1960	-.05	-0.03	-0.02
	(12.59)	(14.8)	(4.08)
Savings Rate	-.00	0.0003	0.0006
	(0.51)	(0.90)	(1.11)
Labor Force Growth	.53	0.13	-0.72
	(1.12)	(0.99)	(1.89)
Mortality	.44	-0.12	-0.10
	(3.52)	(2.15)	(1.24)
Revolutions + Coups	-0.11	0.007	-0.01
	(11.71)	(1.46)	(0.50)
Primary Educ. 1960	0.00	0.00	0.00
	(3.01)	(4.19)	(0.53)
Secondary Educ. 1960	0.0003	0.00	0.00
	(11.19)	(2.15)	(0.58)
Growth of Prim. Edu.	2.40	2.20	0.44
	(9.87)	(5.21)	(0.51)
Growth of Seco. Edu.	1.58	0.20	0.28
	(8.61)	(1.55)	(1.22)
R^2	.96	.96	.89

Table 1.8: Economywide σ Convergence

	PRODUCTIVITY LEVEL			INCOME PER C. LEVEL		
	Levels					
	STD	MEAN	COV	STD	MEAN	COV
1960	4.38	4.69	0.93	1.74	1.79	0.97
1965	5.34	5.68	0.94	2.12	2.14	0.99
1970	6.19	6.75	0.92	2.48	2.53	0.98
1975	7.03	7.62	0.92	2.84	2.88	0.98
1980	8.03	8.7	0.92	3.26	3.33	0.98
1985	7.38	8.27	0.89	3.50	3.44	1.02
	Growth Rates					
	STD	MEAN	COV	STD	MEAN	COV
60-65	0.03	0.03	0.97	0.03	0.03	1.09
65-70	0.03	0.03	0.77	0.03	0.03	0.85
70-75	0.03	0.02	1.52	0.03	0.02	1.44
75-80	0.03	0.02	1.47	0.03	0.02	1.48
80-85	0.04	-0.01	-3.86	0.03	-0.00	-28.83

1.4.5 Sectoral β Convergence

Table 9 reports the results for the sectoral decomposition. The results reveal very pronounced convergence in the two "traditional" sectors, with β coefficients towards the upper end of the supported range. In contrast, the potential candidate for endogeous growth, the manufacturing sector, displays only a weak and insignificant tendency towards convergence, however, the estimated coefficient remains negative, supporting convergence, albeit with a very long half life.

1.5 Conclusion

The coincidence of theoretical innovation and easy data availability has spawned a veritable mini industry in convergence testing over the last half decade. The evidence has undergone a pendulum motion, swinging from early acceptance to intermediate rejection and more recently back towards acceptance of growth rate convergence. We argue that a large part of the apparent contradiction can be resolved by taking

Table 1.9: Economywide β Convergence: Sectors

	Agriculture	Manufacturing	Services
Constant	1.00	.015	0.92
	(7.83)	(0.46)	(5.53)
Output per worker 1960	-0.05	-0.0001	-0.05
	(9.56)	(0.11)	(7.15)
Income per capita 1960			
Savings Rate	-.002	-0.002	0.001
	(2.00)	(5.24)	(0.82)
Labor Force Growth	2.17	-1.09	1.34
	(3.30)	(3.20)	(1.48)
Mortality	-1.05	-0.04	-.44
	(2.91)	(0.56)	(1.35)
Revolutions + Coups	-0.13	-0.009	-0.15
	(2.26)	(0.69)	(2.63)
Primary Educ. 1960	-0.00	0.00	-0.00
	(2.47)	(1.01)	(0.64)
Secondary Educ. 1960	0.00	0.00	0.00
	(2.44)	(1.93)	(2.25)
Growth of Prim. Edu.	-1.22	-0.49	1.41
	(0.43)	(0.63)	(0.49)
Growth of Seco. Edu.	-1.02	0.10	-0.55
	(1.64)	(0.52)	(1.20)
R^2	0.92	0.78	0.93

account of a few simple and (at least to development economists) well known stylized facts on the relation between growth, fertility, labor force participation and human capital accumulation. Turning to the evidence, we indeed find that convergence forms a sturdy and robust fact of life.

We do not interpret the results as evidence against the new class of endogenous growth models: any theory based on "deus ex machina" growth is too much of a confession of ignorance about a crucial determinant of long run performance to be of appeal except as a benchmark case. The evidence does however suggest that "divergence" is a transitory phenomenon, that models based on *asymptotic* differences in growth rates do not provide a satisfactory analysis of real world dynamics. Rather, models of repeated leapfrogging, of catching up, forging ahead and falling behind[30] appear to provide a more realistic descriptions of the real world experience. This is not to belittle the importance of traditional endogenous growth explanations: with half-lives of around a half century, the dominant effect of policies on the present dicounted welfare level takes place at the divergent front end rather than the convergent tail section.

[30]See Ames and Rosenberg(1963) and Abramovitz (1985). Aghion and Howitt (1989) provide a model along these lines.

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Appendix 1: Construction Of Human Capital Variables

We use the total number of years of primary and secondary education as proxy for the stock of human capital. The measure is constructed analogously to the calculation of the physical capital stock as the summation over time of the flow addition, corrected for depreciation. We assume that the number of students in a particular level of education is uniformly distributed across grades, e.g. if education of type i requires Z^i years of schooling, a proportion $\frac{1}{Z}$ of currently enrolled students graduates each year. The increase in the total years of education due to school leavers in a particular year is then given by

$$I_t^i = [(\frac{1}{Z^i})N_t^i]Z^i = N_t^i \tag{1.2}$$

where N_t^i gives the number of students enrolled in year t in schools of type i. Data on N are available from UNESCO for 1950,1955 and 1959-1984. Data for 1951-54 and 1956-58 were approximated by logarithmic interpolation. The total number of years of education of type i in year x is given by:

$$Y^i(x) = Y^i(1950)\beta^{(x-1950)} + \sum_{t=1951}^{x} N_t^i \beta^{x-t} \tag{1.3}$$

where $Y^i(x)$ denotes the total years of education of type i received in or before year x and β is one minus the annual adult mortality rate, constructed from Barro and Wolf (1989). The initial estimate for the 1950 stock of primary education was obtained by multiplying the 1950 population above primary school-leaving age by the corresponding 1950 enrollment ratio and the typical duration of primary education. Analogous calculations were performed for secondary and tertiary education. We thus implicitly assumed that enrollment ratios were constant before 1950. Since enrollment ratios in developed countries had stabilized early in the century and did not experience a second expansion until the 1960s and since developing countries, with some exceptions, also did not experience major movements in the enrollment percentages until the mid 1950s, the assumption appears justifiable. The quality of the school-year index of human capital rests on the importance of three restrictive

assumptions imposed in the calculation. While we account for mortality, we do not allow for depreciation of the stock of human capital over time. To the extent that such depreciation takes place, the index overestimates the human capital stock of the developed countries with older populations (the "vintage" effect). Similiarly, we do not allow for increasing *quality* in education, again favoring the devloped vis a vis the less developed economies. Finally, the measure treats the marginal contribution of education to the accumulation of human capital as constant and does not allow for positive externalities associated with the total existing stock of human capital[31]. If spill-over effects are present, the proxy will underestimate the human capital of the developed countries with higher absolute education levels.

[31]See Barro and Becker (1988,1989), Lucas (1988), Becker , Murphy and Tamura (1989); *inter alia*.

Table 1.10: Appendix 2: Labor Force Participation Rates 1960 and 1985

Country	Total Popu.	Adult Popu.	Total Popu.	Adult Popu.	Bias	Income p.c. 1960
TANZANIA	45.7	81.6	49.1	94.8	108.0	208
MALAWI	48.7	83.8	43.1	82.0	110.5	237
RWANDA	56.4	103.4	50.8	97.3	104.6	244
LESOTHO	57.4	91.6	47.9	83.3	109.1	245
SIERRA LEONE	36.4	73.1	37.0	64.0	86.1	281
NIGER	30.8	59.5	49.9	98.3	102.1	284
ETHOPIA	39.2	80.1	45.4	79.8	86.0	285
BURMA	48.8	77.3	45.3	72.0	100.3	306
ZAIRE	44.1	83.2	34.8	71.1	108.4	314
UGANDA	51.3	79.5	48.0	87.8	117.9	322
MALI	58.5	102.4	34.4	59.8	99.2	396
BURUNDI	52.4	91.7	53.6	96.7	103.0	412
MAURITANIA	31.1	55.1	34.8	58.3	94.6	414
TOGO	43.9	82.0	41.0	76.1	99.5	415
GAMBIA	57.0	89.9	40.3	83.0	130.5	433
SWAZILAND	47.3	89.4	36.1	77.6	113.9	441
LIBERIA	50.7	71.1	36.6	69.4	135.3	449
KENYA	42.3	77.2	41.1	85.8	114.3	470
NEPAL	48.8	85.7	41.6	73.5	100.6	478
SOMALIA	37.8	73.9	37.4	77.8	106.5	483
CAR/FEA	47.5	98.4	49.6	86.6	84.2	485
BOTSWANA	62.0	93.6	35.5	67.6	126.0	493
INDONESIA	36.3	61.9	39.1	62.2	93.4	493
EGYPT	29.0	49.9	26.6	45.3	98.9	496
CAMEROON	47.4	84.5	38.8	70.7	102.0	507
CHAD/FEA	40.7	64.8	35.7	61.8	108.8	515
INDIA	42.3	72.7	38.4	61.1	92.9	533
GHANA	41.0	77.8	36.7	68.5	98.1	534
MOROCCO	29.0	52.5	30.6	51.6	93.0	542
NIGERIA	36.1	77.3	36.7	74.2	94.5	552
PAKISTAN	31.5	56.1	31.2	52.6	94.8	558
CONGO	38.2	64.5	37.8	72.4	113.5	563
BENIN	52.8	91.9	48.6	91.1	107.7	595
HAITI	55.8	92.1	51.4	75.9	89.5	605
ZIMBABWE	37.7	69.7	40.6	74.2	98.7	615
MADAGASCAR	53.8	96.8	44.4	80.7	100.9	659
SUDAN	34.8	59.3	32.1	59.1	108.1	667
THAILAND	50.4	92.7	51.7	81.3	85.4	688
KOREA	32.9	58.5	40.9	59.2	81.6	690
ZAMBIA	41.8	74.9	33.4	63.9	106.6	740
IVORY COAST	55.1	95.6	40.1	75.9	109.2	743

Table 1.2: Labor Force Participation rates

Country	Total Popu.	Adult Popu.	Total Popu.	Adult Popu.	Bias	Income p.c. 1960
HONDURAS	30.4	58.3	29.7	56.1	98.4	748
SENEGAL	41.5	80.9	44.2	80.8	93.7	756
MOZAMBIQUE	42.9	70.1	54.5	96.7	108.6	798
GABON	28.3	76.6	39.7	68.9	64.0	804
TUNISIA	27.0	47.7	31.0	51.6	94.2	852
PHILIPPINES	40.0	71.8	36.3	61.2	94.0	874
ANGOLA	27.4	50.5	43.2	76.7	96.2	880
BOLIVIA	37.6	59.8	31.1	55.4	112.0	882
DOMIN. REP.	28.0	53.7	29.8	50.3	88.1	956
SRI LANKA	34.3	59.2	37.4	55.8	86.5	974
PARAGUAY	32.5	60.2	35.2	57.0	87.3	991
PAPUA N.G.	54.5	92.0	49.7	82.1	97.8	1008
MAURITIUS	32.0	57.0	38.2	54.4	79.8	1012
EL SALVADOR	31.7	59.6	35.6	59.6	88.9	1062
MALAYSIA	33.0	62.4	39.4	63.7	85.6	1103
JORDAN	25.5	46.0	22.9	43.9	106.6	1124
ECUADOR	31.8	59.5	32.5	52.0	85.5	1143
SYRIA	28.0	50.4	25.0	47.8	106.3	1234
PANAMA	32.7	58.8	37.1	55.8	83.6	1255
TURKEY	50.1	85.3	42.7	68.2	93.8	1255
GUATEMALA	31.7	57.9	27.0	52.5	106.3	1268
MALTA	29.8	47.1	38.8	47.6	77.5	1282
ALGERIA	26.7	47.4	22.0	40.8	104.1	1302
BRAZIL	31.5	56.7	36.6	57.6	87.5	1313
COLOMBIA	30.9	56.7	32.3	51.0	86.0	1344
GUYANA	30.4	57.9	41.1	56.1	71.7	1386
PORTUGAL	38.0	54.3	44.6	59.3	92.9	1429
JAMAICA	37.3	64.0	46.5	74.0	92.7	1472
GREECE	45.0	61.2	38.3	49.0	94.2	1474
SINGAPORE	33.6	59.6	47.9	63.4	74.6	1528
SURINAM	27.9	53.3	29.8	49.6	87.3	1558
NICARAGUA	32.4	59.4	31.3	57.0	99.3	1588
COSTA RICA	30.2	57.9	35.9	54.9	80.0	1663
CYPRUS	41.5	65.6	46.9	62.5	84.4	1692
PERU	32.4	56.1	33.3	52.9	91.8	1721
HONG KONG	38.7	65.2	52.8	67.7	76.0	1737
BARBADOS	39.4	63.6	50.0	69.0	85.5	1747
FIJI	27.7	53.2	33.2	53.2	83.4	1799
IRAN	31.7	54.0	28.3	50.9	105.4	1839

Table 1.2: Labor Force Participation rates

Country	Total Popu.	Adult Popu.	Total Popu.	Adult Popu.	Bias	Income p.c. 1960
MEXICO	29.6	55.6	33.0	57.1	92.2	2157
JAPAN	47.2	67.7	49.5	63.3	89.2	2239
SPAIN	37.9	52.5	35.6	47.0	95.5	2425
SOUTH AFRICA	31.1	59.3	33.4	56.7	89.1	2627
IRAQ	26.5	49.3	27.0	50.5	100.8	2527
IRELAND	39.5	57.3	38.5	53.8	96.4	2545
SOUTH AFRICA	31.1	59.3	33.4	56.7	89.1	2627
ISRAEL	35.8	55.9	37.9	55.2	93.2	2838
CHILE	33.0	54.3	35.4	50.9	87.5	2932
ARGENTINA	39.5	57.0	35.6	51.6	100.2	3091
ITALY	40.3	53.6	39.7	49.1	92.9	3233
URUGUAY	41.4	55.8	38.9	53.2	101.6	3271
SAUDI ARABIA	41.6	49.9	30.0	53.2	147.5	3635
AUSTRIA	47.6	61.1	46.7	57.8	96.3	3908
FINLAND	45.8	65.7	50.8	63.1	86.5	4073
BELGIUM	38.6	50.4	42.9	52.7	94.2	4379
FRANCE	43.0	58.5	45.1	57.9	94.5	4473
ICELAND	39.2	60.0	53.1	71.9	88.5	4644
NETHERLANDS	36.1	51.6	40.4	50.2	87.0	4690
TRIN.+TOBA.	33.7	58.5	38.5	56.6	84.7	4904
UNI. KINGDOM	46.2	60.2	49.1	61.5	96.0	4970
NORWAY	38.9	52.4	49.2	61.8	93.0	5001
SWEDEN	43.6	55.9	50.7	62.0	95.4	5149
AUSTRALIA	40.1	57.2	46.7	61.4	92.2	5182
GERMANY	47.4	60.2	48.3	57.2	93.2	5217
VENEZUELA	31.4	57.5	32.5	56.0	94.1	5308
DENMARK	45.4	60.8	54.4	66.7	91.8	5490
NEW ZEALAND	37.2	55.5	44.2	57.1	86.8	5571
CANADA	37.3	56.1	50.0	63.6	84.5	6069
SWITZERLAND	46.1	60.3	49.9	61.4	93.9	6834
UNITED STATES	40.5	58.7	49.1	63.2	88.6	7380

Chapter 2

Large-Scale Privatization in Transition Economies

Worldly wisdom teaches that it is better for reputation

to fail conventionally than to succeed unconventionally.

J.M. Keynes (1936, Chpt.12)

Recipes for East European recovery increasingly place rapid privatization at the center of transformation strategies[1], a suggestion embraced by the radical reformers of Eastern Europe, notably Poland, Russia and the former GDR. Yet despite the apparent advantages provided by an ample supply of skilled low-wage labor close to the West European market, privatization in the transition economies to date falls short of initial predictions: only the Treuhand has succeeded in selling a sizeable fraction of the existing enterprises to investors.[2] Part of the explanation can be found in a range of institutional and informational obstacles: ill-defined property rights, lacking communications and transportation infrastructure, hostility towards foreign investors and uncertainty about environmental and financial liabilities sidelined many potential investors in the early months following the autumn revolutions.[3]

[1] Allison and Yavlinsky (1991), Blanchard et al (1990), Borensztein and Kumar (1990) , Hinds (1990).

[2] Cf. Dornbusch and Wolf (1991) and Sinn(1991) for assessments of the German privatisation process. We will return to the East German case throughout the paper as an illustration.

[3] For a discussion of these issues, cf. Blachard et al. (1991), Kornai (1991) and Tirole (1991),

These explanations however begin to wear thin as the newly capitalist economies move determinedly to overcome the institutional remnants of their socialist past. Where, then, is the culprit to be found? We argue that the delays in privatization derive to a large extent from the particular problems raised by the required *wholesale* transfer of ownership from the public to the private sector.[4] Specifically, we argue that for a number of reasons the value of an individual industrial enterprise offered for sale in Eastern Europe depends positively on the *overall* success of the privatization program. Given a required additional -and irreversible- investment to make the acquired enterprise operational and given certain boundary conditions, a sufficiently large *aggregate* expected volume of privatization may then be required to render the acquisition of enterprises attractive to the *individual* investor. This *critical mass* effect distinguishes the task facing the East European economies from the privatization drives enacted in the OECD over the last decade and brings about the possibility of a self fulfilling expectational *low privatization trap.*

We first discuss the rationale underlying our approach before presenting a formal non-cooperative game between non-communicating investors exhibiting multiple solutions. Based on the model we then evaluate a number of the more prominent policy options put forward over the last two years and propose an alternative (first best) solution.

2.1 Critical Mass Effects

"Welcome to this cruel, competitive world."

The Economist (11.August.1990)

We begin with a brief discussion of our view on three crucial issues underlying the transition process; the privatization decision itself, the link between individual investment returns and aggregate privatization and finally the choice between alternative

inter alia.

[4]Table 1 illustrates the magnitude of the problem. The largest privatization drive hitherto implemented, Chile 1973-90, transferred a comparatively paltry 25% of production to the private sector.

transition strategies.

2.1.1 Privatization: Rationale and Requirements

Table 2.1: State Share in Production

	% of Production
Czechoslovakia	97.0
East Germany	96.5
Soviet Union	96.0
Poland	81.7
Hungary	65.2
France	16.5
Italy	14.0
Germany	10.7
United States	1.3

Various dates 1982-86.
Source: Milanovic (1989).

The average productivity in East European countries lags substantially behind the levels attained in otherwise comparable economies.[5] The productivity shortfall reflects lower total factor productivity rather than differences in the capital/labor ratio.[6] A more efficient allocation of existing factors and the adoption of modern technology and management techniques thus promises significant efficiency gains.[7]

For a variety of reasons these gains are more likely to be realized if the ownership of resources is transferred to the (foreign) private sector.[8] Three aspects are of particular importance in the present context.[9] The survival of many enterprises requires comprehensive updating of antediluvian technologies. While technology can to

[5]Cf. Inotai(1988).

[6]Starting out at a slightly higher productivity levels than West Germany in 1936 (Abelshauser (1983)), East Germany by 1990 had suffered a relative decline to one third of the West German level, despite comparable gross investment per capita (Schmieding (1990), Siebert (1990)).

[7]New investment will be of lesser importance in the medium run: with an initial capital income ratio of 3, a depreciation rate of 10%, a net private (public) investment rate of 20% (0%) of GDP and an (optimistic) annual growth rate of 10% almost a decade will pass before the cumulative new investment equals the existing capital stock.

[8]Table 3 provides an overview of the recent FDI regulations adopted in the transition economies.

[9]More comprehensive overviews and detailed models of the link between form of ownership and efficiency are provided in Bös(1990), Laffont and Tirole (1990), Schmidt (1991) and Tirole(1991).

Table 2.2: Privatization: Current Rules

	Poland	Hungary	Yugoslavia	Germany
Legal Framework Type of Privatization	All	External	Internal	External
Initiator	Workers Ministry	State Agency Management	Management	State Agency
Valuation	External	Auction	Accounting Value	Bids
Shares to Workers	20%	5-15%	Variable	None
Discount for Workers	50%	–	Up to 70%	–
Shares Transferable?	Yes	Yes	Yes	–
Current State				
Corporatization	Advanced	Advanced	Stopped	Completed
Stock Exchange	Yes	Yes	Yes	Yes
Estimated Value of State Owned Assets	\$58bn	\$32bn	\$54bn	\$150bn
Number of Enterprises	7.800	2.000	26.000	8.000

Source: Djelic (1990), Sinn(1991).

Table 2.3: Foreign Direct Investment: Current Rules

Country	Ownership Limits	Repatriation Restrictions	Incentives
Bulgaria	No. No approval.	No.	No excise duty on imports to be used for the investment. Selected tax holidays.
Czechoslovakia	No. Prior approval.	Hard currency profits can be fully repatriated. Restrictions on domestic currency profit repatriation.	Selected tax holidays Selective exclusion from antitrust suits.
Hungary	No. No approval.	No.	Selective tax incentives.
Poland	No. No approval	Hard currency profits can be fully repatriated. Restrictions on zloty profits.	Investment may be set off against taxable profits. Tax holiday. No excise tax on capital goods imports.
Romania	No. Prior approval.	Yes.	Selective tax holidays.

Sources: Institute of International Finance (1990), U.S. Department of Commerce
Klynvelud Peat Marwick Goedeler (1990), BNA International Trade Reporter
East-West Joint Ventures; USITC.

some extent be rented or bought, the open market for process knowhow is notoriously underdeveloped: knowhow is frequently embodied and will not come except in the company of (foreign) investors.[10] In a similiar vein, the scale of the required infusion of management skills realistically precludes a solution by the open labor market and requires a reliance on temporary secondments of skilled personnel by (foreign) investors. The need for technological updating and restructuring implies that the decision to privatize implies a decision to commit additional resources.[11] We consequently view "privatization" as the *joint* process of transferring the ownership of the "shell" of an existing firm, including the operational capital stock *and* a new investment required to make the enterprise viable. In principle, local entrepreneur could perform the investment. In practice, local capital markets are as yet underdeveloped[12] and foreign capital markets are largely closed to highly leveraged individuals from the transition economies.[13]

The requirement for new and irreversible investment carries the important implication that "lowering the price" will not resolve the problem: even at a zero price, the privatization project may not be worthwhile.[14]

2.1.2 Individual Returns and Aggregate Privatization

The need to transfer the dominant part of existing assets to the private sector introduces an important distinction between the transition processes of eastern Europe and the privatization drives in the OECD during the last decade: whereas public sector firms in the OECD could be reliably valued within an existing market structure, the value of an enterprise in the transitional economies depends, for a number

[10]Deutsche Bundesbank (1988), Welfens (1990).

[11]The Treuhand to date has received binding investment commitment totalling DM 13.864 bn, or DM 14.57 m per privatised enterprise.

[12]*" [T]he capital needs required to bring about this transition [...] will be very substantial for some time, and no doubt in excess of the saving that can be mobilized domestically."* (IMF(1991b),p.61).

[13]The reluctance of foreign lenders may -similiar to the model proposed below- reflect the impossibility of valuing the prospects of individual firms independently from the success of the aggregate program, giving rise to a potentially large downside risk resulting in credit market failure.

[14]Of course, a *negative price* does resolve the problem. The Treuhand has frequently sold enterprises for - in effect- negative prices once tax incentives and investment subsidies were accounte for.

of reasons, on the *aggregate* level of privatization. We identify three major linkages:

Politics The transition to markets involves substantial -and ex ante unknown- front end costs as inefficient enterprises are closed, subsidies are removed and a new social infrastructure is build up. The gains to the transition in contrast accrue only over time. The reforming countries retain the option to switch to a less pro-capitalist regime if the initial costs are revealed to be higher than expected. The shift from "big bang" to "gradualism" permits a reduction in the front end welfare costs at the cost of a longer transition process. A higher aggregate amount of privatization in the initial periods raises real income, thereby lowers the likelihood of a policy reversal and thus raises the *expected* return to privatization.

Market Size In the presence of fixed setup costs and local sales orientation, profitable entry necessitates a minimum size of the domestic market. If privatization brings about productivity gains, aggregate real income, and hence demand, increases in the aggregate volume of privatization.

Diffusion Behavioral changes are triggered by exposure to new realities. The presence of other enterprises operating under "capitalistic" rules ensures the gradual creation of a "market-trained" labor force facilitating future expansion. A similiar argument arises with respect to the attitudes and capabilities of local administrations. Likewise, the creation of a comprehensive private enterprise sector generates a system of behavioral rules of conduct reducing negotiation and management costs.

The above arguments[15] share the common implication of *strategic complementarity*: an individual's decision to acquire a state owned enterprise raises the profitability

[15]Quality of local inputs and political power of (foreign) investors provide further positive linkages between individual profitability and aggregate privatization. A partial offset may arise from increased social tension as the income equality worsens, from increased unemployment as privatized firms shed labor and from higher real wages reflecting the increased capial labor ratio.

of acquiring a firm for other potential investors.[16] If the effect is sufficiently pronounced *critical mass* effects can arise: an irreversible investment becomes profitable (in expected terms) for an individual if and only if a critical number of other agents also commits. In the absence of credible precommitment, a *coordination failure* may then bring about a pessimistic under-privatization trap.

While all of these linkages play some role, we believe the first factor to be the crucial immediate mechanism linking individual expected profitability to aggregate investment. The political risk associated with the popular "big-bang" approach has recently attracted increased attention: *"[T]he popular support needed to push ahead with reform is likely to whither, especially given already large declines in real wages and rapidly growing unemployment".*[17] The currently popular response favours an even more determined front end action to create irreversible facts before the political backlash sets in. In contrast, "gradualism" is rejected, reflecting the fear of the transition becoming bogged down in the marshes of old guard retrenchment. In our view, the notion of "irreversible" systemic change is ill defined, an unbuffered "big bang" in our interpretation *raises* the probability of the transition process becoming unglued by rendering a move towards reestablishment of the status ex ante more tempting.[18]

2.1.3 The Transition: Choices

The transition from socialism to markets is now widely recognized to entail a significant (initially widely underestimated) -and *ex ante* unknown- front end decline in the average standard of living.[19] One part of the fall reflects the initial expenses of setting up a market economy, including, *inter alia*, the creation of social security

[16]The arguments implicitly assume that the other entrants are not in direct competition with the enterprise. Even in the latter case training, network and diffusion effects exert a positive influence on profitability.

[17]IMF(1991b), p. 60.

[18]The recent strikes in Poland and Russia demanding a return to old prices are suggestive in this respect.

[19] *"[I]t is clear that the adjustment costs associated with economic transformation may be considerably larger -and sustained for longer- than first expected."* (IMF(1991b, p.60)).

systems, geographical adjustment to the new external environment, reorientation of the transportation[20] and communications[21] infrastructure and institutional reforms.[22] Tables 4 and 5 illustrate that these costs are very substantial.[23] On top of these additional government outlays, the productive side of the economy suffers a one time reduction in the capital stock and hence the capital to labor ratio as technologically obsolete and environmentally unsound factories are forced to close. The obsolete fraction of the capital stock is again likely to be substantial: In the case of the former GDR, the measured capital stock amounted to 1.750 trillion DM. Valued according to West German standards and eliminating the obsolete fraction, the value of the capital stock amounts to 577 billion DM, a front end loss of 67% or 1.172 trillion DM.[24]

Table 2.4: Transition Cost For East Germany (Bn $)

Social Security System	27.3
Infrastructure Investment	35.8
Other	5.4
Total	68.5
% of GDP	67.7

Source: Sinn (1991)

As the transition economies lack both well developed domestic capital markets and access to foreign commercial lenders at the necessary scale, the transition cost has to be financed by taxing either labor or capital income.[25] Taxing capital reduces

[20]UNECE (1990) p. 157-82.

[21]U.S. Department of State (1990).

[22]IMF(1991a,1991b), Murrell(1990), Sachverstandigenbericht (1991), UNECE (1990).

[23]The figures need to be taken with more than a grain of salt. Part of the outlays would have occured even if no systemic change had taken place, furthermore, part of the decline in production is made up by an increase in quality.

[24]Institut für angewandte Wirtschaftsforschung (1990). The proportional split of the loss between technical obsolesence at new prices and accounting changes remains unsettled. Siebert (1990) puts the obsolete fraction at 50%.

[25]We return to the issue of external borrowing in the last section of the paper. The cause of foreign lender restraint may bear strong similiarity to the argument underlying the present paper: if the privatisation process fails, (partial) debt default may be a strictly dominating strategy. Thus supply (demand) of foreign credits will be zero at or below the riskfree rate r^* (above the expected

Figure 2-1: Worker's Choice

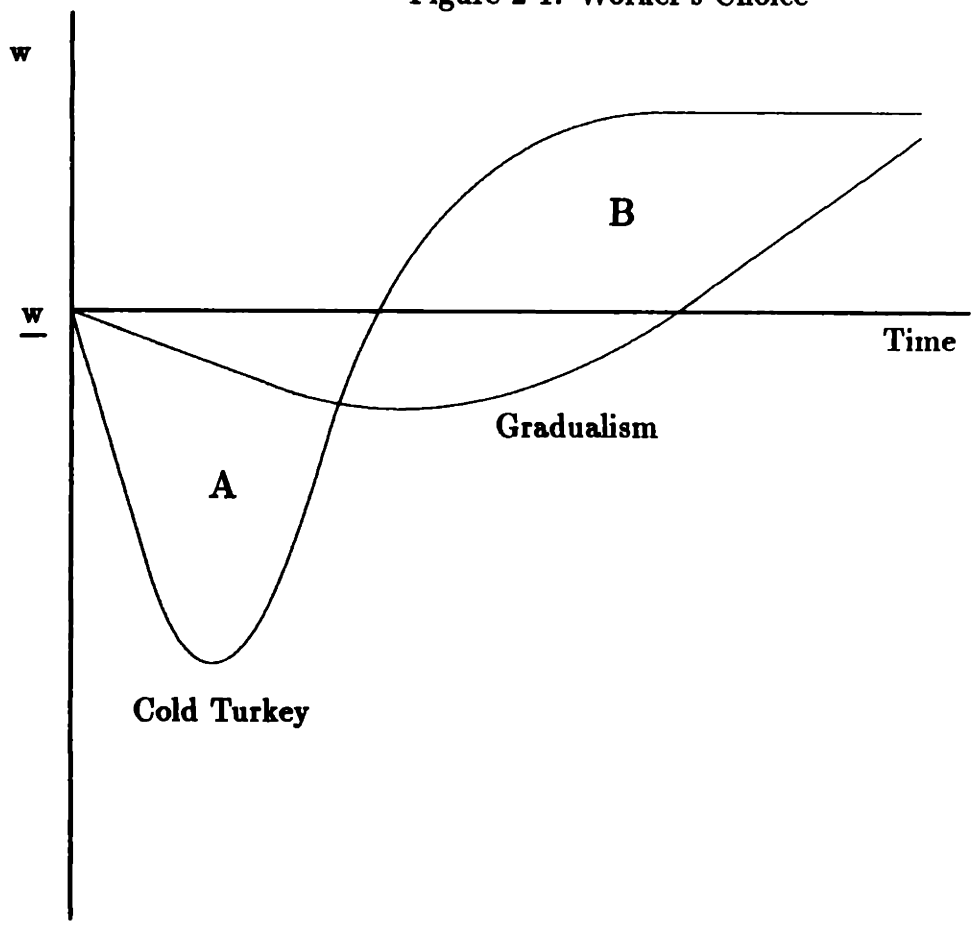


Table 2.5: Industrial Production Decline 1989-91.

Country	IP Decline
East Germany	60 %
Albania	50 %
Bulgaria	35 %
Poland	20 %
Romania	20 %
x-SU	15 %
Czechoslovakia	10 %
Hungary	10 %
EE & x-SU	19 %

Sources: IMF(1991), Bundesbank.

the front end decline in after-tax real wages but renders the acquisition of enterprises less attractive to potential investors and hence lengthens the transition period. The two policy options, referred to below as "big bang" and "gradualism", are depicted in figure 1. The big bang options entails an initial cost of A counterbalanced by a medium term gain B relative to the gradualist option.[26] Crucially, while the initial real wage decline under the gradualist regime can be kept constant regardless of the total cost by shifting the allocation of the cost between capital and labor, the initial fall under the "big bang" approach is uncertain. We assume that voters-workers initially prefer the big bang option, conditional on the *expected* cost of transition. If utility functions obey the Inada conditions, there however exists a lower *threshold* wage level $\underline{w}$ for which voters will prefer to shift from the big bang to the gradualist policy option. After the move to markets, the actual cost is revealed: If the cost is sufficiently larger than expected, the short run utility gain obtainable by shifting some of the transition costs to investors outweighs the present discounted value of the future utility losses due to a lower capital stock, in consequence, voters will opt for a shift to gradualism, modelled as the imposition of a tax on the return to capital.[27]

2.1.4 Spillover Effects From Investment

Individual investment increases the aggregate capital to labor ratio and thereby the economywide real wage for a given transition cost. It thereby reduces the likelihood that the transitional after tax wage falls below the threshold and thus raises the ex-

---

return to privatisation $\bar{r}$). If banks are risk neutral and expect default with probability q (negatively depending on the aggregate amount of privatization taking place) the lending rate equals $r = \frac{1+r^*-q}{q}$. As q tends towards zero, the lending rate increases towards infinity. For a sufficiently small q and a given $\bar{r}$ no equilibrium with positive lending may exist.

[26]There appears to be a widespread consensus that the *undiscounted* utility loss B exceeds A, see e.g. IMF(1991a): *"Although the gradual introduction of financial and market-determined prices may limit the cost of adjustment in the short run, it is likely to involve considerably higher cost in the long run as the persistence of rigidities and price distortions would prevent significant efficiency gains, while the lack of financial would jeopardize macroeconomic stability."* See however Kornai(1990). We do not take up this issue here, concentrating instead on the tradeoff between *discounted* utilities perceived by today's voter.

[27]A popular strand of argument stresses the perceived possibility of a populist backlash as obstacle for investment, e.g. *"[A] fragile democratic opening combined with a deep economic crises is a fertile brew for populist policies"* (Lipton and Sachs (1990).) The model presented here in contrast has no populist connotations: voters decisions are based on welfare maximization.

pected return to other potential investors.[28] If certain boundary conditions on the profitability of privatization are fulfilled, the combination of the positive spillover and the strategic complementarity gives rise to a multiple equilibrium scenario. For a sufficiently large expected volume of *aggregate* privatization, the likelihood of capital income taxation falls to a point rendering the early acquisition of a state owned enterprise individually optimal, bringing forth full privatization. Likewise, a sufficiently low expected aggregate volume of privatization depresses the expected rate of return below the level rendering individual entry non-optimal and thus brings about a zero privatization outcome. The lack of a coordination mechanism between investors may thus derail the privatization process *even in the presence of favorable fundamentals.*

We now turn to a formalization of these ideas before turning to a discussion of the policy alternatives.

2.2 A Model Of Wholesale Privatization

We now derive a three-period non-cooperative game between investors based on the interdependence between uncoordinated individual investment decisions and the likelihood of a policy shift towards capital income taxation. A diagrammatic exposition of the game is provided in Table 6.

2.2.1 Setup

We consider a small open economy producing a unique good Y according to a production function

$$Y_i = A_i F(K, L) \qquad with \quad F_{LK}(K) > 0 \tag{2.1}$$

where A_i is an efficiency parameter with $i = c$ in the centralized and $i = m$ in the market economy with $1 = A_m > A_c$: At constant factor endowments, the move from

[28] In a sticky wage/price environment, a similiar argument can be made in terms of a critical threshold of unemployment. Cf. Roland and Verdier (1991).

Table 2.6: The Game

Period	Workers	Investors	Shocks
Zero	Decision for transition. Firms offered for sale.		One time decline of capital stock.
One	Decision on tax regime in period two.	Decision whether to invest or wait.	Transition cost revealed.
Two		Decision whether to invest of investors holding the safe asset.	
Three		Investment becomes reversible.	

planning to markets brings forth a productivity gain, motivating the decision for a market economy. The exportable is sold at the world price, normalized to unity.

The economy is populated by a representative worker lacking access to capital markets, inelastically supplying one unit of labor and consuming her entire income each period. The workers faces a tradeoff between a lower after tax wage today and a higher real wage in the future. If the transition program succeeds in the first period, the worker's utility function unambigously increases:

$$U(A_c F_L(\bar{K}, L))(1+\beta) > U(\underline{w})(1+\beta) \tag{2.2}$$

Utility functions are assumed to obey the Inada conditions. There hence exists a lower wage level $\underline{w}$ below which a policy reversal (the imposition of a tax on investors) utility dominates the pro-investment policy even if full privatization in period two would be guaranteed.

Since we are interested in the effect of the government's unknown *ability* to sustain the pro-capital policies on the game between *investors*, we concentrate on the *commitment* equilibrium, treating workers as automata implementing their preannounced

rule. While this game between investors and workers is not subgame perfect[29] the game between investors remains subgame perfect *conditional* on the precommitment assumption.

If the worker bears the entire transition cost, she receives the value marginal product of labor net of the *per-capita* transition cost ϵ, drawn independently from a cumulative distribution function $H(\epsilon)$ with support on $[0,\overline{\epsilon}]$: $w_m(K) = F_L(K) - \epsilon$. If capital income taxation is implemented, she receives $w_m = \underline{w}$.[30]

There exists a sufficiently large number of identical, risk neutral foreign investors maximizing the expected present discounted value (EPDV) of their initial wealth. No single investor commands sufficient resources to acquire the critical amount of capital. The investor chooses between a riskfree foreign liquid asset yielding r^* per period and a risky domestic irreversible investment available in both the first and the second period and yielding $r(K)$ if workers bear the entire transition cost and $r(K)(1-t)$ if capital income taxation is imposed. t is composed of a fixed component used to build "monuments" and a stochastic component set to compensate workers for the difference between the actual and the threshold wage $\underline{w}$. Acquiring a state owned asset is profitable if and only if no capital income tax is levied:[31]

$$0 \leq r(K) - t < r^* \leq r(K) \quad for\ all\ K \leq T \tag{2.3}$$

2.2.2 Timing

At the start of the game workers decide to move from central planning to competitive markets and offer the state owned capital stock for sale. The decision entails a one

[29]Formally, time consistency could be ensured by augmenting irreversible real investment with a reversible, productivity enhancing investment of "expertise". An illustration of this possibility arose in the nationalisation of the Anglo-Iranian Oil company in 1951. The complete withdrawal of foreign technicians resulted in a 97% drop in oil sales. Cd=f. Cottam(1964).

[30]The excess of total tax revenues over the required wage subsidy is used to build monuments.

[31]Throughout the paper we assume returns to be sufficiently small to permit linear approximations. For simplicity the fixed component of t is set equal to zero below.

time reduction in the capital stock from $\bar{K}$ to K_0 and results in a transition cost ϵ revealed at the end of period one. Workers credibly announce their intention to bear the entire (as yet unknown) transition cost *iff* the real takehome wage does not decline below a prenounced threshold $\underline{w}$. Investors, without knowledge of either the level or the *ex post* incidence of the cost of transition, then decide whether to purchase the offered enterprises. If no privatization occurs in the first period, the capital stock is operated by the government under market conditions. As a consequence of the borrowing constraint, new investment does not take place and technology remains unchanged at A_c.The front end decline in the capital stock is irreversible. Workers receive $\underline{w}$, the remainder $A_cF(K_0, L) - \underline{w}L$ is again used to build "monuments". The maximum amount of privatization restores the pre-reform capital labor ratio at $\bar{K}/L$.

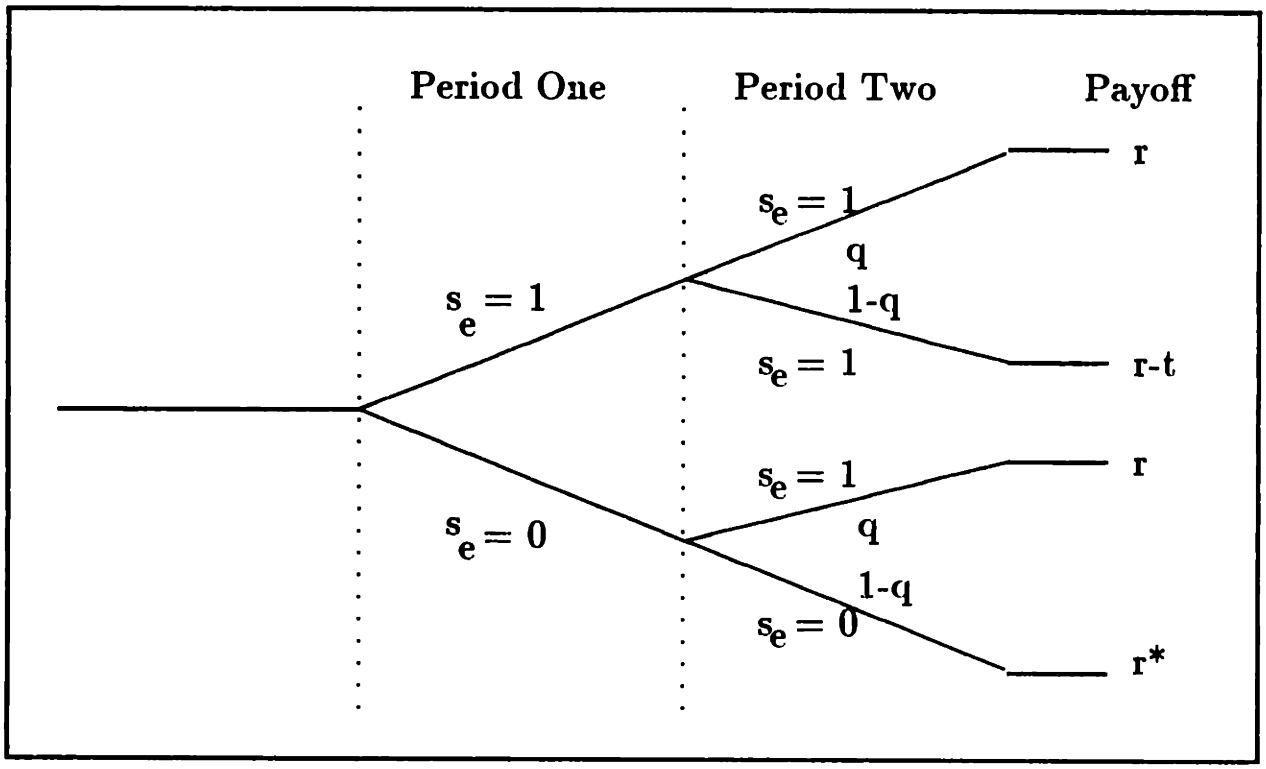
At the end of the first period uncertainty is completely resolved (the transition cost ϵ is revealed) and workers implement the preannounced decision rule. Investors then decide again whether to aquire an enterprise. At the beginning of period three, all prior investment becomes reversible.[32] The investor strategy set is depicted in figure [2]. In period 1 the investor has the choice between the two actions $s_e = 1$: holding a state owned enterprise and $s_e = 2$: remaining liquid. The worker response function is defined by

$$s_w : [0, \bar{\epsilon}]x[s_e = 0, s_e = 1] -> [tax = 0, tax = 1] \tag{2.4}$$

The strategy set in period two depends on the strategy selected in period one: if the investor chooses $s_e = 1$ her strategy set is reduced to e_1, if she choose $s_e = 0$ the strategy set encompasses both $s_e = 0$ and $s_e = 1$. The second period payoff takes three values: if investors aquire a state owned enterprise and the pro-capital policies are sustained (reversed) the return to the risky asset equals r $(r - t)$. If the investor chooses to remain liquid, she receives the safe rate r^*.

[32]The irreversibility assumption for the initial two periods reflects both technological constraints and commonly applied legal minimum periods before principal and interest of investments can be repatriated.

Figure 2-2: The Game In Extended Form



2.2.3 Probability Of Capital Income Taxation

Investors believe that with probability q $(1-q)$ a tax will (will not) be imposed on capital. Both the decline in the capital stock and the cost of transition reduce the real takehome wage and hence influence the probability of the imposition of a capital income tax. The probability $1-q$ of a tax on the return to capital, while treated as exogenous by investors, is thus determined endogeneously: since the real wage increases in the level of aggregate privatization, the probability of *ex post* capital income taxation depends negatively on the aggregate privatized capital stock during period one, K_1:

$$q(K_1) = Prob[\epsilon \leq w(K_1) - \underline{w}] = \int_0^{w(K_1)-\underline{w}} h(\epsilon)\, d\epsilon = H(w(K_1) - \underline{w}) \qquad (2.5)$$

where $h(\epsilon)$ denotes the density function of ϵ. q is assumed to be twice continously differentiable, strictly increasing and concave. Under these assumptions we have that

$$\frac{\partial q}{\partial K_1} = h(w(K_1) - \underline{w})F_{LK}(K_1) \; > \; 0 \tag{2.6}$$

2.2.4 Optimal Investment Decision In Period Two

If the government succeeds in sustaining the pro-investment policies once uncertainty is resolved, the economy is assumed to converge to the full-privatization equilibrium regardless of the level of privatization achieved in the noisy period: $r(\bar{K}) \geq r^*$. If a tax on capital income is imposed, no further investment takes place: $r^* > r(K_2) - t(K_2)$ with $K_2 = K_1$.

2.2.5 Optimal Investment Decision In Period One

We define V_P as the expected present discounted value (EPDV) of purchasing one unit of physical capital at the beginning of period one. Analogously, V_L is defined as the EPDV of holding the liquid asset in period one and thus deferring commitment until the uncertainty is resolved. Defining $1 > \beta > 0$ as the discount factor and ignoring salvage value, we obtain:

$$V_P(K_1) = r(K_1) + \beta \left[q(K_1)r(\bar{K}) + (1 - q(K_1))(r(K_1) - t(K_1))\right] \tag{2.7}$$

$$V_L(K_1) = r^* + \beta \left[q(K_1)(r(\bar{K})) + (1 - q(K_1))\, r^*\right] \tag{2.8}$$

Investors allocate their wealth to maximize the expected value:

$$V^*(K_1) = \max \left[V_P(K_1), V_L(K_1)\right] \tag{2.9}$$

Equation (2.9) implicitly defines the minimum expected aggregate privatization level K_1^* required if investors are to switch from the liquid to the irreversible asset before the revelation of ϵ. Given equations (2.7) and (2.8) K_1^* is obtained by setting the valuation difference conditional on a first period privatization level K_1^* and the

possibility of deferment for holders of the liquid asset equal to zero:

$$0 = G(K_1^*) = V_P(K_1^*) - V_L(K_1^*) = [r(K_1^*) - r^*] - \beta\,[(1 - q(K_1^*))[r^* - (r(K_1^*) - t(K_1^*))]] \tag{2.10}$$

The first term measures the loss incurred by holding the liquid asset in the first period, the second term equals the expected second period loss associated with the decision to commit in the first period.

2.2.6 Properties

Proposition 4.1 *If* $\beta[\frac{\partial q}{\partial K_1}(r^* - (r-t)) - \frac{\partial t}{\partial K_1}(1-q)] > |\frac{\partial r}{\partial K_1}(1 + \beta(1-q))|\ \ \forall K_1$, *this (noncooperative) game exhibits strategic complementarity.*

Proof

The model exhibits strategic complementarity if for any individual investor the marginal utility of entering in period one increases in the amount of privatization undertaken by other investors, i.e. if $\frac{\partial G(K_1)}{\partial K_1} = \frac{\partial V_P(K_1)}{\partial K_1} - \frac{\partial V_L(K_1)}{\partial K_1} > 0$. Thus strategic complementarity requires that

$$\beta[\frac{\partial q}{\partial K_1}(r^* - (r-t)) - \frac{\partial t}{\partial K_1}(1-q)] + \frac{\partial r}{\partial K_1}(1 + \beta(1-q)) > 0 \tag{2.11}$$

The term $(r^* - (r-t))$ represents the (positive) excess return on the foreign asset in the bad state. The partial derivative $\frac{\partial q}{\partial K_1}$ is positive from equation (2.6). The required tax rate on capital income decreases in the level of privatization provided a reasonable restriction on the sensitivity of the return to capital to the aggregate level of privatization holds.[33] Finally, $\frac{\partial r}{\partial K_1}$ is negative under the maintained assumption of decreasing returns. If the model is to exhibit strategic complementarity it must thus be the case that

$$\beta[\frac{\partial q}{\partial K_1}(r^* - (r-t)) - \frac{\partial t}{\partial K_1}(1-q)] > |\frac{\partial r}{\partial K_1}(1 + \beta(1-q))| \tag{2.12}$$

[33] Formally, $\frac{\partial t}{\partial K_1} = \frac{(r + r'K_1)(w(K_1) - \underline{w}) - \frac{\partial \underline{w}}{\partial K_1} rK_1}{(rK_1)^2} \leq 0$ if $r > |\frac{\partial r}{\partial K}|K_1$, which we assume.

Strategic complementarity hence requires the negative effect of an increase in the stock of capital on the probability of capital income taxation and the negative effect on the *per investor* tax to dominate the classical negative effect on the marginal product of capital. In the remainder of the paper we assume the condition to be justified. In order to focus attention on the main transmission channel we further assume that the spillover working through t exactly offsets the effect on r.

Proposition 4.2 *If the condition for strategic complementarity and the boundary conditions [i]* $G(K_0) < 0$ *and [ii]* $G(\bar{K}) > 0$ *are satisfied, the noncooperative game has two (corner) sub-game perfect expectational equilibria.*

Proof

Recall that K_1^* is defined by $G(K_1^*) = 0$. The boundary conditions, combined with the strict monotonicity of $q(K)$ imply that $K_0 < K_1^* \leq \bar{K}$. If expected aggregate privatization in period one falls short of the threshold level ($K_1 < K_1^*$), then $G(K_1) < 0$ and the economy attains the zero-privatization trap ($K_1 = 0$). If ($K_1 \geq K_1^*$), then $G(K_1) \geq 0$ and hence $K_1 = \bar{K}$.[34]

Proposition 4.3 *The equilibrium with full-privatization in the noisy period Pareto-dominates the zero-privatization trap and is efficient.*

Proof

Pareto-Ranking:

Workers. Since $F_{LK}(K) > 0 \ \forall K$, worker's real wage, consumption and hence welfare increases.

[34]The differentiability and continuity assumptions allow easier exposition of the policy implications derived below. The multiple equilibrium structure of the model itself is quite robust to more general specifications, requiring only the positive spillover from individual privatization decisions on the probability of no capital income taxation, the strategic complementarity and the two boundary conditions. Cf. Milgrom and Roberts (1990).

Investors. Individual deviation from the zero- to the full-privatization equilibrium conditional on simultaneous deviation of all other investors is optimal if and only if $V_P(\bar{K}) \geq V_L(0)$. Since $V_P(\bar{K}) - V_L(\bar{K}) > 0$ and $V_L(\bar{K}) > V_L(0)$, it follows directly that $V_P(\bar{K}) - V_L(0) > V_P(\bar{K}) - V_L(\bar{K}) > 0$.

Efficiency: Given the assumption on returns, a central planner internalizing the externality purchases all assets at the beginning of the first period, replicating the optimistic equilibrium.

Under the conditions specified, co-ordination failure thus leads to multiple self fulfilling expectational equilibria, pareto rankable by increasing levels of first period privatization. As the decentralized market frequently fails to solve the coordination problem, *fundamentals* may thus be insufficient to ensure privatization: the economy requires an *expectational big push.* We will show below that certain government interventions potentially facilitate the coordination on the optimistic equilibrium.

Proposition 4.4 *If investment opportunities remain available in the second period and investment in physical capital is irreversible, then uncertainty about the ex-post tax regime confers a non negative (call) option value to the liquid asset even if investors are risk neutral.*[35]

Proof

The option value conferred to foreign assets can be computed by comparing $V^*(K_1)$ with the maximum value $V_c^*(K_1)$ attainable *without* the possibility of deferring precommitment, i.e. if the investor remaining liquid in period one must decide whether to invest in period two *before* uncertainty is resolved. Ignoring salvage, the value of this program (common to all agents) is given by

$$V_{0c}(K_1) = r^* + \beta \max\left[(q(K_1)r(\bar{K}) + (1 - q(K_1))\,(r(K_1) - t(K_1))), r^*\right] \qquad (2.13)$$

[35] In our specification, uncertainty is strictly exogenous. Endogenous uncertainty about future social systems, political outcomes, legal reforms etcetera provides an additional reason for postponing investment (Tirole (1991)).

The investor optimization problem is now

$$V_c^*(K_1) = \max\left[V_P(K_1), V_{0c}(K_1)\right] \tag{2.14}$$

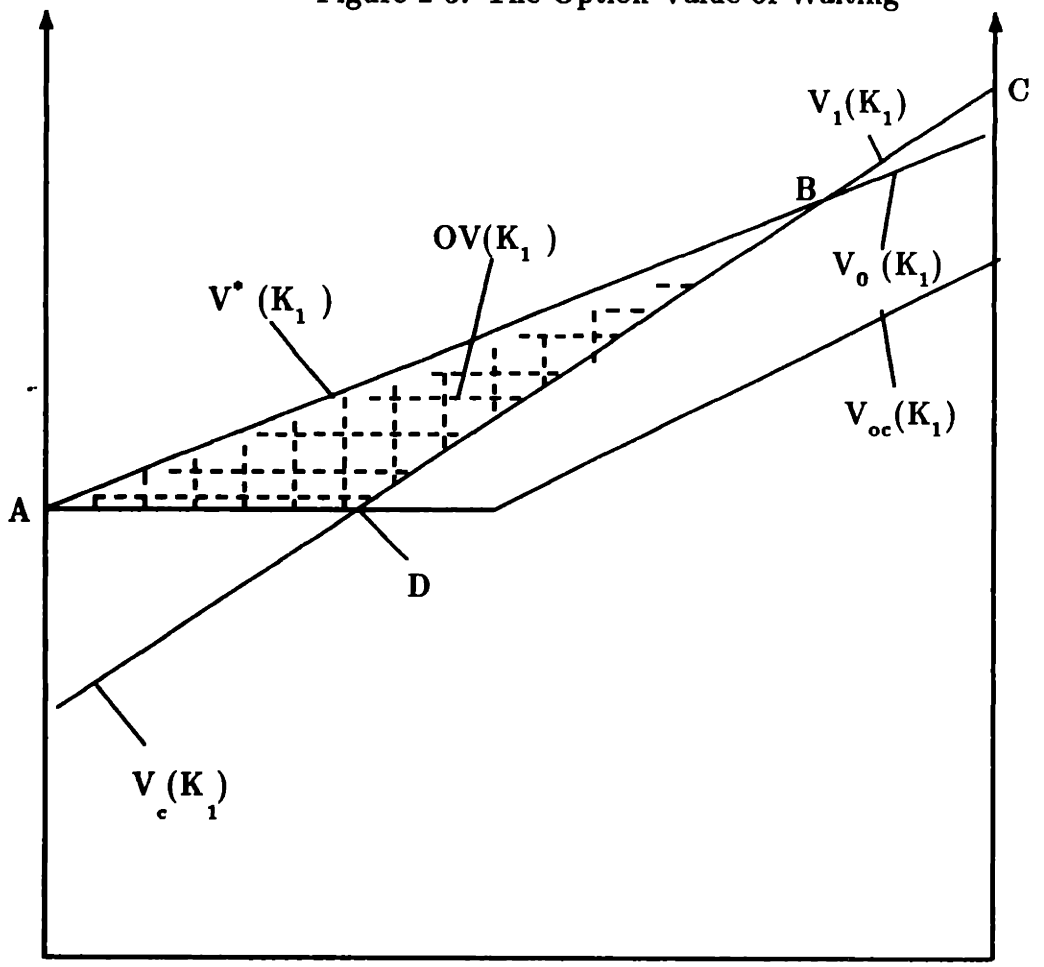
Solving $V_c^*(K_{1c}^*) = V_P(K_{1c}^*) = V_{0c}(K_{1c}^*)$ yields the level of capital required for the economy to converge to the optimistic equilibrium without the deferment option. In order to sign $[K_1^* - K_{1c}^*]$ we compare $V_L(K_1)$ with $V_{0c}(K_1)$, which is equivalent to comparing $A = [q(K_1)r + (1 - q(K_1)r^*]$ with the argmax $[(q(K_1)r + (1 - q(K_1))(r - t)), r^*]$, for any given aggregate capital stock. $A > r^*$ and $A > (q(K_1)r + (1 - q)(r - t))$ since by assumption entry (non entry) is optimal if the program is maintained (reversed). Thus $V_L(K_1) > V_{0c}(K_1)$ for all K_1, implying that $K_1^* > K_{1c}^*$: if waiting were possible at K_{1c}^* it would be optimal to do so. Without deferment the range on which only optimistic forecasts are self-sustainable is thus increased: investors are willing to commit at a lower expected level of privatization.

The option value conferred to the liquid asset is illustrated in Figure 2. The lines ABC and ADC represent $V^*(K_1)$ and $V_c^*(K_1)$, respectively. We thus have that

$$OV(K_1) = V^*(K_1) - V_c^*(K_1) = \begin{cases} V_L(K_1) - V_{0c}(K_1) & \text{if } 0 < K_1 < K_{1c}^* \\ V_L(K_1) - V_P(K_1) & \text{if } K_{1c}^* \leq K_1 < K_1^* \\ 0 & \text{if } K_1^* \leq K_1 \leq T \end{cases} \tag{2.15}$$

Hence $OV(K_1)$, corresponding to the area ABD, is non-negative for all K_1. In the range $(0, K_{1c}^*)$ remaining liquid is optimal both with and without deferment possibility. The value of the option increases monotonically from $K_1 = 0$ to $K_1 = K_{1c}^*$ where it attains its maximum value. In the range $[K_{1c}^*, K_1^*)$ investment in the noisy period is non-optimal if deferment is possible, but is optimal without deferment. In the range $[K_1^*, T]$ the option is worthless since investors will optimally invest regardless of the deferment possibility.

Figure 2-3: The Option Value of Waiting



2.2.7 Evidence

Before turning to the policy prescriptions, we may ask whether the waiting game postulated above really constitutes the crucial obstacle preventing a successful and rapid privatization program. Undoubtedly the answer differs across countries: the more determinedly property right uncertainties, legal obstacles and the issue of environmental liabilities are being addressed, the higher the importance of psychological factors. Given the wrenching shift in institutions, including the statistical offices, hard data are difficult to come by. We focus on two suggestive facts. Table [7] reports the total number of registered and of active joint ventures. The fairly large total number and the sizeable commitment suggests that fundamentals are not perceived as major obstacle. The low fraction of joint ventures which are active on the other hand can be interpreted as evidence that investors are hesitant to commit.

Table 2.7: Joint Ventures

Country	Registrations	Of which active	Foreign Outlay (Million US $)
Hungary	6900	75 %	1410
Poland	3750	40 %	480
Czechoslovakia	2850	20 %	420
X-SU	2000	2.5 %	N.A.
Romania	1250	1 %	290
Bulgaria	350	N.A.	320

Source: Un Economic Commission for Europe.
Business Eastern Europe. Date: Spring 1991

A second indirect suggestive fact is given by the distribution of joint ventures across countries. Among the reforming economies, Hungary and East Germany are arguably the politically most stable as well as the most sucessful in attracting direct investment.

"Hope is a good breakfast, but it is a bad supper"

Francis Bacon

2.3 Economic Policy During the Transition

The possibility of a zero-privatization trap resulting from coordination failure provides a prima facie case for government intervention aimed at reducing the likelihood of the zero privatization outcome.

The return to capital is the probability weighted average of the returns in the pareto superior and inferior outcome. Two policy strategies are hence available: policies can directly increase the *payoffs* in one or both states or alternatively can reduce the *likelihood* of the inferior equilibrium. The former strategy relies on direct subsidies to investors. The latter strategy operates by stabilizing labor income during the transition period, thus reducing the likelihood of a political shift derailing the privatization process. In assessing the relative effectiveness of the two strategies, the finan[12 cing implications of alternative policy programs have to be explicitly

taken into account. We now turn to a detailed consideration of the alternative policy options.

2.3.1 Privatization Subsidies to Early Bidders

We first assume that the government provides a subsidy at a rate s per unit of capital privatized in the noisy period. The subsidy is fully financed by a lump-sum tax levied on workers at a rate t'. For any initial amount of privatized assets K_1 the subsidy reduces the disposable income of labor. The probability of policy continuation $q_s(K_1, t')$ and the threshold level of expected capital ensuring full privatization K_{1s}^* are now given by:

$$q_s(K_1, t') = H(w(K_1)(1 - t') - \underline{w}) < q(K_1, 0) \quad \forall K_1 \quad and \quad t' > 0 \tag{2.16}$$

with

$$\frac{\partial q_s}{\partial t'} = -h(\ )w(K_1) < 0 \tag{2.17}$$

and

$$0 = G(K_{1s}^*) = [r(K_{1s}^*) + s - r^*] - \beta[(1 - q_{K_{1s}^*})(r^* - (r(K_{1s}^*) - t(K_{1s}^*)))] \tag{2.18}$$

The effect of the subsidy on the threshold level of expected aggregate privatization bringing about the optimistic equilibrium is ambiguous. From the investor's point of view, two partially offsetting effects arise. The subsidy itself increases the return to acquiring a state owned asset. The financing of the subsidy via a tax on workers however entails an *income redistribution effect* increasing the likelihood that wages will decline below the threshold level and hence that a tax on capital income will be imposed.

If the *direct* effect dominates, the critical level of aggregate privatization declines,

increasing the range on which only optimistic expectations are self-fulfilling. In the extreme, subsidies may rule out the zero-privatization trap altogether. The subsidy eliminating the pessimistic equilibrium is implicitly defined by the front-end premium required for investors not to exercise the option to wait at a zero expected aggregate privatization level $G(K_0, s^*) = 0$.

Conversely, if the *indirect* effect on the probability of a policy shift against investors dominates, the threshold level increases and hence the range on which optimistic expectations dominate decreases. If popular support for the privatization program is highly sensitive to the real wage, the introduction of subsidies financed by wage taxation may thus perversely achieve the exact opposite of the initial objective suggesting caution regarding a reflex reliance on investment subsidies in politically vulnerable economies.

The short term adverse effects can be avoided by specifying payoffs in future periods conditional on investment in the first period,e.g. a second period subsidy s paid solely to first period investors. The difference between the two value functions in this case increases by $dG(K) = \beta q(K_1)s$. Since the actual payout of the subsidy is now uncertain, the payoff in the good state required to ensure convergence to full privatization increases.

2.3.2 Income Policies

Investment subsidies aim to rule out the pessimistic equilibrium by increasing the return to privatization in a given state. The alternative set of policies leaves the second period returns in the two states unaltered but reduces the likelihood of the introduction of capital income taxation by means of a subsidy to workers during the transition. Again, the financing requirement introduces a potential offset: subsidies to workers must be financed by taxes on capital income. If the direct effect dominates, it will however be in the best (collective) interest of investors to finance the subsidy.

We consider the mirror image of the investment subsidy, a transfer s_w to workers financed by a lump-sum tax on capital income at a rate t_w. For any K_1 the probability of wage taxation changes to:

$$q_{s_w}(K_1, s_w) = H(w(K_1)(1+s_w)-\underline{w}) > q(K_1) \quad \forall s_w > 0, \quad \frac{\partial q_{s_w}(K_1, s_w)}{s_w} > 0 \quad (2.19)$$

The *direct* effect thus decreases the likelihood of capital income taxation for any first period level of privatization. The *indirect* effect, lowering the return to capital, again provides a potential offset. The new threshold capital stock is determined by:

$$0 = G(K_{1s_w}) = [r - t_w - r^*] - \beta[(1 - q_{s_w})(r^* - (r - t))] \quad (2.20)$$

with

$$\frac{\partial G(K_{1s_w})}{\partial s_w} = \beta[h(\ )w(K_1)(r^* - (r - t))] - \frac{\partial t_w}{\partial s_w} \quad (2.21)$$

The net effect is again ambiguous. If the direct effect dominates, the introduction of the subsidy increases the range on which only optimistic expectations are self-fulfilling. Given the world rate of return and given a utility function for workers, there thus exists a positive capital income tax that *increases* the expected return to capital. The optimal subsidy ruling out the pessimistic equilibrium is defined by $G(K_0, s_w^*) = 0$:

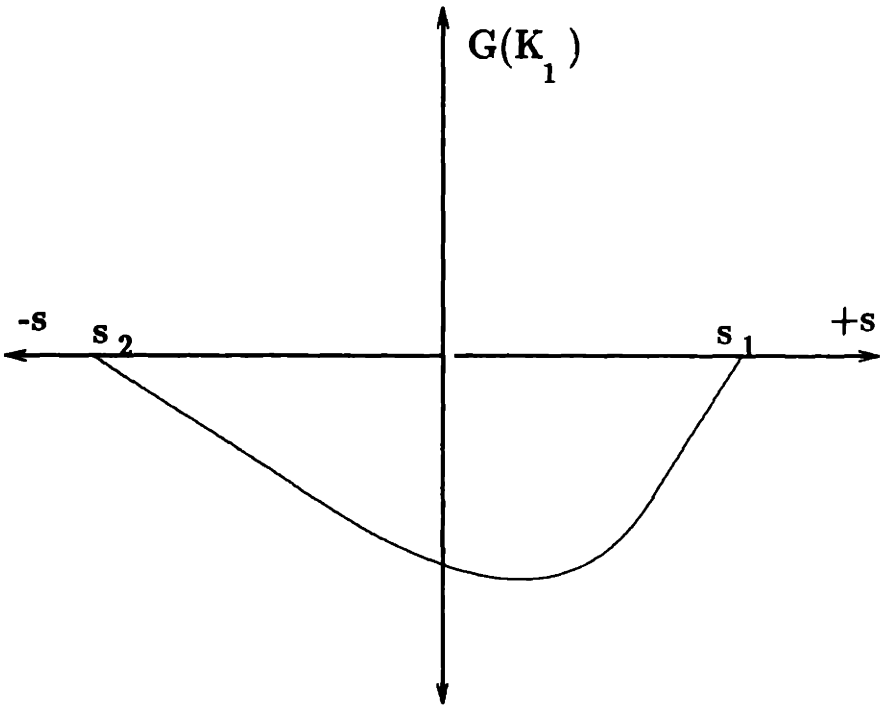
$$\beta q_{s_w}(K_0, s_w^*)[r^* - (r - t)] - t_w^* = r^* - r + \beta(r^* - (r - t)) \quad (2.22)$$

Conditional on $H(\epsilon)$, (18) can be solved explicitly for s_w^* . Alternatively, assuming s_w^* to be small, $h(\ )$ to be linear, $q(K_{0,}, 0)$ to equal zero and imposing the normalization $t_w = s_w$, an approximation can be obtained by taking a Taylor series expansion of $q_{s_w}(K_0, s_w^*)$ around $q(K_0, 0)$:

$$s_w^* \approx \frac{r^* - r + \beta(r^* - (r - t))}{\beta h(K_0, 0)w(K_1)[r^* - (r - t)] - 1} > 0 \quad (2.23)$$

Intuitively, for a given difference in the valuation of the two assets in the pessimistic equilibrium, a higher responsiveness of the probability of policy continuation

Figure 2-4: Multiple Policy Equilibria



with respect to s_w reduces the optimal subsidy to workers.

2.3.3 Multiple Policy Equilibria

The tradeoff between the return and the likelihood of the good state gives rise to a potential *multiple equilibrium in policy*:

Proposition 5.1 *At the margin, investors are indifferent between receiving a compensation s^* from workers for bearing the risk of a policy shift towards capital income taxation and paying a subsidy s_w^* to workers to reduce the probability of of a capial income tax.*

Proof

A comparision of the optimal subsidy to early bidders with the optimal subsidy to workers immediately reveals that $s^* = s_w^* \frac{\partial G(K_0,0)}{\partial s_w}$.

For a given expected capital stock $K_1 < K_1^*$, the case is illustrated in Figure 3. With a zero subsidy, the expected rate of return on the risky asset falls short of the safe return. A subsidy paid by investors to workers initially lowers the expected

rate of return as the increased likelihood of policy continuation is not sufficient to compensate for the lower rate of return in the good state. Beyond a certain level, the latter effect begins to dominate the former, yielding an equilibrium positive subsidy of s_1^*. Again starting from a zero subsidy, a transfer from workers to investors initially does not lower the probability of policy reversal sufficiently to outweigh the increased return in the good state, yielding a second optimal subsidy of s_2^*.

2.3.4 Profit Sharing

A number of recent privatization proposals include some variant of profit sharing (Lipton and Sachs (1990), Blanchard et al. (1991), *inter alia*). We now examine whether profit sharing forms an alternative means of attaining coordination on the optimistic equilibrium.

With a labor specific cost shock, profit sharing provides workers with an additional non-stochastic income, lowering the probability of capital income taxation. If the cost shock also affects the return to capital (a case we do not explicitly consider since workers are assumed to initially bear the entire transition cost) profit sharing remains effective by increasing expected disposable income.

We assume that a percentage α of the non-obsolete capital stock is distributed free of charge to domestic workers in the form of a (costlessly administered) fund receiving the return on its capital portfolio but holding no management authority. The probability of policy continuation is now given by

$$q_\alpha(K_1, \alpha) = H(w(K_1) + r(K_1)\alpha K_0 - \underline{w}) > q(K_1) \quad \forall K_1 \tag{2.24}$$

with $\frac{\partial q_\alpha}{\partial \alpha} = h(\ )[r(K_1)\alpha K_0] > 0$. For any given level of aggregate privatization in period one the probability of policy continuation thus increases in the share of capital distributed to workers. The threshold level of privatization required for the *sharing* economy to converge to the optimistic equilibrium is implicitly defined by:

$$0 = G(K^*_{1\alpha}) = [r(1-\alpha) - r^*] - \beta[(1-q_\alpha)(r^* - (r-t))] \qquad (2.25)$$

Again a tradeoff arises between the return in the good state and the likelihood of the good state occuring arises. Since workers lack access to capital markets, the initial outlay for replenishing the capital stock remains with the investor. Profit sharing thus becomes a de facto subsidy to workers financed by a tax on capital income. If the indirect effect on the probability of policy continuation dominates, profit sharing raises the expected rate of return and thus becomes optimal from the investors viewpoint. If the political support for pro-capital policies is less wage sensitive, profit sharing may however lower the expected return and thus raise the likelihood of the zero privatization trap.

The present inability of workers to contribute to financing may however be overcome by a respecification of the labor contract allowing the firm to subtract a fraction of the difference between the marginal product and the threshold wage *after* the transition. Under such a contract, the firm would effectively function as a financial intermediary lending to workers their share in the initial investment. Of course, such policies would need to be centrally enforced to preempt labor reallocation in the post transition period.

2.3.5 The Role of Foreign Financing

> *"Private financiny is likely to continue to be practically non-existent until confidence is established in the ability of Europe to achieve political and economic stability and to maintain a sustained trend in this direction".*
>
> Hopkinson (1947)

The domestic financing of policies out of current income entails potentially offsetting effects on the distribution of income. Lacking domestic capital markets, a role for foreign financing as a means to smooth the transition cost over a longer time period emerges. Both foreign aid and long term loans enable the financing of coordination devices - targetting either investors or workers- without first order implications for

the *current* distribution of income, removing the ambiguity.[36]

2.3.6 External Enticement

Any measure which increases the cost of a policy shift serves to lower the critical capital mass required to ensure full privatization for a given realization of the transition cost. Under the assumption that external agency have a sufficiently strong interest in ensuring the sucess of the East European transition, second period payoffs conditional on policy continuation reduce the critical mass of privatization. Conditional entry into the EEC and, to a lesser degree, conditional debt reduction schemes might serve this function.[37]

2.3.7 Missing Markets: Insurance

> *"The British Government has considered that the losses of imprudent men who have placed mistaken confidence in the good faith of foreign Governments would prove a salutary warning to others"*
>
> Palmerston (1848)

If the critical mass of investors could be insured against the pessimistic equilibrium, coordination on the optimistic outcome would be automatic given the assumptions on returns and hence the contingency insured against would be ruled out, rendering the policy costless. An insurance scheme - operating as a *coordination device* rather than as an insurance proper - thus appears to be a cost-effective means of eliminating the zero privatization equilibrium.

While theoretically appealing, the insurance scheme encounters significant obstacles. A *domestically* funded policy -whether private or governmental- trivially does

[36]Since the equilibrium of the game is fundamentally indeterminate, the *signalling* role of visible external confidence in the sustainability of the program, the "Kemmerer Seal of Approval", provides an additional benefit.

[37]An externally imposed cost conditional on policy reversal can attain the same outcome. The preferred pre-WWII response of military reprisals following nationalizations provides one example. Cf. Platt(1968). Conditional punishment also motivated the Hickenlooper amendment to OPIC, requiring the suspension of foreign aid following a "discriminatory treatment" of FDI by the host country.

not command the funds to cover liabilities in the pessimistic state and is hence non-credible. Privately run externally funded insurance schemes will be discontinously priced as the required premium declines discretely as soon as the total insured fund exceeds the critical mass. Denoting the total amount of new investment insured (not insured) by the representative risk-neutral insurance company by K^I (K^O) the expected payout per unit of capital insured on a contract promising to reimburse the tax in the pessimistic case is given by

$$C(K^I) = \frac{C}{K^I} = (1 - q(K^I + K^O))t(K^I + K^O) \tag{2.26}$$

Table 2.8: FDI Insurance Programmes

Country	Risk Insured			Maximum	Insured	Years
	Exprop.	War	Transfer			
Australia	Yes	Yes	Yes	200 %	90 %	5-15
Canada	Yes	Yes	Yes	100+ %	N.A.	1-15
Denmark	Yes	Yes	Yes	100+ %	85 %	1-15
Germany	Yes	Yes	Yes	150 %	95 %	1-15
Netherlands	Yes	Yes	Yes	150 %	90 %	1-25
Norway	Yes	Yes	Yes	100+ %	90 %	1-20
Sweden	Yes	Yes	Yes	100+ %	90 %	1-15
Switzerland	Yes	Yes	Yes	100+ %	70 %	N.A.
U.K.	Yes	Yes	Yes	200 %	90 %	1-15
U.S.	Yes	Yes	Yes	200 %	100 %	1-20

Source: Detter De Lupis(1987). Maximum refers to initial outlay.

If $G(\bar{K}) - C(K^I) < 0 < G(\bar{K}) - C(\bar{K})$ no interior equilibrium exists in the private insurance market although a pooling of contracts accross insurers would bring about full privatization. The latter option could in principle be implemented by governmental organizations, along the lines of the Overseas Private Investment Corporation programs. Empirically, the credibility of programs with a bad state outpayment of several percent of GDP of the transition economy appears however doubtful.

2.3.8 Heterogeneity

Extending the model to allow for some source of heterogeneity in entry costs among investors or projects, while not affecting the main results, introduces the possibility of additional equilibria with intermediate levels of privatization during the transition. In this case, while the equilibrium with the highest level of first period privatization continues to pareto dominate the other equilibria, it will in general no longer be efficient since individual investors do not internalize the effect of their decision on the likelihood of a policy shift towards caopital income taxation (Laban (1991)). This inefficiency gives rise to a second role for active government intervention: even if the economy is initially at the optimistic equilibrium welfare can be increased by inducing small deviations from equilibrium position to overcome the *under-privatization trap*. A targetting of subsidies to the lowest cost investors can succeed in generating a critical mass at fairly low cost to the tax payer.

2.4 Conclusions

Privatization in Eastern Europe continues to proceed at a slow pace. Observable fundamentals provide at best a partial answer. What then, is the culprit, and what, if any, policies could be used to accelerate the privatization process? We have shown that uncertainty about the sustainability of pro-investment policies may be a central factor sidelining investors. The combination of uncertainty about future policies with the irreversible nature of investment confers an option value to liquid assets: postponing the investment decision may become the optimal strategy. Waiting deprives the reforming economy of the much needed inflow of capital, worsening the decline in real wages during the transition period. The fall in living standards in turn erodes the political support for the continuation of pro-privatization policies and coming full circle, may bring about the reversal of pro-capital policies initially feared. However, alongside this *zero investment trap* there may exist an equally self-fulfilling *optimistic* equilibrium: investor confidence in the sustainability of the program leads to comprehensive privatization, the additional physical capital flowing into the reforming

economy raises the living standards and thus reduces the likelihood of a policy shift, justifying the initial optimism.

The possibility of a zero privatization trap provides a role for government intervention during the transition period. We have shown that *both* investment subsidies and transfers to workers *can* bring about a shift to the full privatization equilibrium. However, while subsidies and transfers financed by foreign transfers and long term loans *unambiguously* reduce the likelihood of a policy shift towards capital income taxation, *domestically* financed policies have to take account of a hidden offset operating via changes in the income distribution that might reverse the original policy objective. The choice of policy thus requires a careful assessment of the responsiveness of investment to changes in the rate of return vis a vis the sensitivity of the regime with respect to reductions in the real wage.

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Chapter 3

Exchange Rate Pricing In Hyperinflations

The exchange market and the Reichsbank are like
a runaway horse with an incompetent rider -
each aggravates the folly of the other.

Viscount D'Abernon (1926)

3.1 Introduction

The role ascribed to the exchange rate in the initiation and propagation of the German hyperinflation has experienced a curious reversal over time: while the majority of contemporary observers viewed the exchange rate as an independent and often crucial factor in the inflation process, the postwar theoretical literature following Cagan's seminal work is conspicuous in its almost complete neglect of the exchange quotation.

We examine the empirical support for the reversal of opinion. The paper begins with a characterization of contemporary and modern views on hyperinflation initiation and propagation, focusing on the testable implications distinguishing the fiscal view dominating post war thinking from the balance of payments (BoP) approach popular with contemporary observers. We then turn to both casual and formal econometric

evidence on the role of the exchange rate in the initiation and propagation of the German hyperinflation. The evidence argues against the characterization of the German hyperinflation as an essentially domestic event. Yet not all is well for the BoP view: in place of the inflation invariant link suggested by the open economy approach we detect a discrete increase in the correlation between inflation and depreciation rates just before the final, frantic months of the hyperinflation.

In the fourth section of the paper, we suggest an alternative depreciation-inflation nexus based on the potential role of the exchange rate as an expectational anchor for price setters. Initially, sellers employ price forecasting rules based on fairly precise price statistics published with a lag. As inflation accelerates, the unknown price movements in the period *since* the last publication increasingly dominate the information contained in the lagged index, price setters consequently place increasing weight on contemporaneously available indicators of the current price level. The exchange rate as the only widely observable signal provides a natural basis for revised pricing strategies. While the imperfect correlation between domestic and imported prices limits the informational value of the exchange rate in periods of stable prices, the increasing weight placed on the exchange rate in setting nominal prices in periods of high inflation improves the correlation and thus increases the predictive power of the exchange rate. The feedback effect gives rise to a *critical mass* effect beyond which a rapid coordination on the exchange rate takes place, depriving the economy of one of the last nominal anchors and introducing the last frantic period of hyperinflation.

The information nexus, suggesting a one time sharp increase in the elasticity of the inflation rate with respect to the depreciation rate, potentially explains the observed shift in the inflation-depreciation nexus. In the last part of the paper we turn to econometric tests of the information model. The results suggest that in the later part of the hyperinflation process, the signaling role of the exchange rate indeed constituted an important element in the initiation and propagation of rapid price movements.

The valorization is partly motivated by a desire to reduce the costly variability of relative prices typically observed in periods of accelerating inflation. The move to-

wards exchange rate pricing, sharply reducing price dispersion, suggests that the cost of inflation - at least in this respect- declines in the later parts of the hyperinflation.

3.2 The Paradigm Views: A Brief Exposition

Joseph Schumpeter once remarked that views on money are as hard to describe as shifting clouds. The attempt to characterize the "mainstream" contemporary view on the German hyperinflation encounters this obstacle in aggravated form: The contemporary academic literature comprises several hundred works of such widely differing quality that the reader is sometimes tempted to agree with Kautsky's assessment that *"the war appears to have [..] emptied the minds of economic thinking and comprehension"*. To avoid getting entangled in this *"excess production on the field of monetary theory"*[1] we restrict the focus to the main proponents on both sides of the debate.[2]

3.2.1 The Common Ground

In the last resort, hyperinflations cannot persist without monetary accommodation of sustained budget deficits by selling bonds to the central bank:[3]

$$G_t(\varepsilon) - T_t = \frac{dM_t}{dt}\frac{1}{P} = L_t\frac{\frac{dM_t}{dt}}{M_t} \tag{3.1}$$

$$L_t = L_t(\frac{dP_t}{dt}) \tag{3.2}$$

where G, ε and T denote real government expenditures, a fiscal shift parameter and real government revenues. M and L denote the levels of the nominal money supply and the demand for real balances. While government expenditures are taken to be invariant with respect to inflation π, real tax receipts decline with inflation, reflecting both the real erosion between the tax assessment and collection date and

[1] Kerschagl (1921a).

[2] Here as below we will draw on the Austrian as well as the German literature.

[3] We abstract here from the possibility of non-stationary price level processes imposed on stationary money processes. See e.g. Flood and Garber (1980).

increased incentives for tax evasion:[4]

$$T_t = T(\pi) \quad T' < 0 \tag{3.3}$$

Denoting the real deficit by D and imposing the steady state condition $\frac{\frac{dM_t}{dt}}{M} = \pi$ the equilibrium condition is given by

$$D(\pi, \epsilon) = L(\pi)\pi \tag{3.4}$$

3.2.2 The Fiscal View

Under the fiscal view the impulse for price movements derives from an exogenous fiscal shift ϵ. A persistent increase in expenditures raises the future seignorage requirement. Rational anticipation of higher future money growth[5] results in an instantaneous jump in prices, reducing real money.[6] Exchange depreciation follows almost as an afterthought as international arbitrage in goods enforces price equality in common currency: *"[D]espite all apparent exceptions, if and how much the prices of foreign bills have risen is finally decided solely by the fact and extent of the money increase at home."*[7]

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[4]See Keynes(1923), Olivera(1967) and Tanzi(1977,1978) on the first, Wolf (1991) on the second effect.While certain components of expenditures, in particular real interest payments on long term nominal debt and non-indexed public sector wages decline, the effect on taxes tends to dominate. During the German hyperinflation, the real interest payments declined from RM 159 million in 1920 to RM 2 million in 1923. Real spending in the first nine months of 1923 was 21.8 % below the 1921 figures while real revenues had declined by 65.2 % and real tax revenues dropped by 75.3%. (Webb(1989)).

[5]It is assumed that the (absolute) inflation elasticity of money demand falls short of unity.

[6]The "expectations" mechanism recently re-emphasized by Sargent and Wallace(1973), Sargent(1977) and Salemi and Sargent (1977) *inter alia* was well appreciated by contemporaneous observers. Thus Palyi(1925) stresses the importance of "*the quantity of money to be expected as probable within the discernible future*" in explaining current prices. Mises(1925) likewise argues for a link between current inflation and anticipated increases in the circulating media. Von Bortkiewicz(1925,p.267) states that *"the real value of money depends not only on the actual value of money but also on the likely volume of future emissions"* See also Robertson(1922), Gaertner(1922), and Phillipovich(1923) for views stressing the expected quantity of money as major determinant of current prices.

[7]Hahn(1922), p.765. See Pohle (1919) for an alternative interwar exposition of the fiscal view, Cagan(1956), Sargent and Wallace (1973), Sargent (1979) and Salemi and Sargent(1979) for more recent reformulations.

3.2.3 The Balance of Payments View

In contrast to the fiscal view, the Balance of Payments (BoP) school allows for independent impulse effects from the exchange rate along two routes.[8] A "shock" depreciation immediately finds its expression in a rise in the prices of importables and import competing goods. The increase in the cost of living finds its reflection in higher wage demands.[9] Wage push in turn leads to price increases in the non-traded sector. The acceleration of inflation reduces both the real value of tax receipts and real money demand, necessitating an increased rate of monetary growth to obtain the same seignorage revenue. The indirect effect of depreciation on the deficit via real tax revenue erosion is augmented by the direct effect operating through foreign currency denominated government expenditures, notably reparation payments.[10]

Karl Helfferich provides a clear exposition of the balance of payments view: "*The chain of causes and effects is thus as follows: Depreciation of the German money consequent upon reparation payments and French policy; arising from the depreciation increase in the prices of importables, from there general increase in all prices and wages; in consequence demand of industry for liquidity and increased liquidity demand by the fiscal administration; and from there finally increased claims on the Reichsbank by industry and the fiscal authorities and increased note issue*".[11] In a similar tone, Bonn(1922) argues that depreciation "*results immediately in an increase of all imports. The movement of increase of prices in Germany is from the boundaries toward the interior, the whole economic life of the country is affected gradually, the estimates for the governmental budget become worthless, a deficit is created and to make good the deficit more paper money is printed*". Von Bortkiewicz(1925) maintains that "*the true causal chain is thus distrust, resulting in a jump depreciation, leading to domes-*

[8]The two views coincide if the exchange rate movement reflects "news" about the fiscal stance.

[9]Joan Robinson (1938), reviewing Bresciani-Turroni (1937), stresses the (de facto) indexation of wages as the crucial mechanism in bringing about price level instability. For a more recent view along the same line, see Laursen and Pedersen (1964). Stitzler (1924) provides a description of wage indexation arrangements during the German hyperinflation. Indexation on a substantial scale began in January 1922 in Austria, in the fall of 1922 in Germany.

[10]Bonn (1922), Eucken (1923).

[11]Helfferich (1923), p.648.

tic prices and wages bearing no relation to the actual increase in money and thus - a further link in the causal chain- to money scarcity leading in some fashion to a acceleration of velocity". Rathenau(1922) argues that "*[t]he process of money depreciation is the following: passive balance of payments, implying the need to sell our means of payment abroad, thereby depreciation of the offered commodity, the money; thereby damage of the monetary value abroad, damage of the money. Further consequences: increases of all domestic prices, increases of the cost of materials and of wage costs. Further consequence: worsening of the budget.*"

While the mechanism leading to increased money issue appears to be widely agreed upon, authors differ as to the precise causes of the initial depreciation. One group of scholars focuses on current account effects including (1) pent up demand for luxury goods, (2) punitive tariffs, (3) seizure of ships, foreign assets and colonies, (4) "excessive interference" by the German government and the Allies, (5) economic depression in traditional trading partners and , most importantly (6) transfer payments.[12]

On the capital account side, observers stressed the "bubbly" nature of assets markets: "*one has ..to recognize the importance of confidence .... Such apparently 'ideological' causes can be of the very greatest importance.*"[13] In a similar vein, Young argues that speculative depreciation becomes "*the indispensable key to an understanding of the vagaries of behavior of the depreciated currencies of Europe*".[14] The possibility of "*self-inflammatory*"[15] speculative bubbles was well understood by contemporary observers. In his survey of German monetary theory Ellis notes that "*[t]he only limit to the rise of prices and rates seems to be the mood of buyers of commodities or foreign exchange, because soaring price quotations are converted into realized transaction prices through further note issues, by as fatal a linking of cause and effect as would anywhere be encountered in mechanical equilibrium theory. If the Reichsbank*

[12]See Pohle(1920), Bonn(1922), Terhalle (1922) and Eucken(1924), inter alia. Eucken (1923) provides an overview of the literature.

[13]Palyi(1925,p.254-55).

[14]Young(1925, p.403.) See also Angell (1926) , Dulles (1929) , Graham (1930), deBordes (1924), Gaertner (1922) and Philippovich (1923) for views stressing the importance of speculation in exchange rate determination.

[15]Graham(1930).

temporarily did not satisfy the demand for more paper marks, they were simply printed by municipalities and even by private employers. In the final phases of inflation the concept of quantitative equilibria must be dropped in favor of the cumulative action of mass psychology."[16]

3.2.4 Summary

In these stark formulations, the BoP view sees causality flowing from the exchange rate to the deficit and money issue, either indirectly via the prices of tradeables, or directly via the foreign currency denominated components of fiscal expenditures. Ellis, summarizing the contemporary German view, concludes that *"in place of a mutual adjustment of exchange rates and prices, we find in Germany a tendency, remarked upon by many writers, for the foreign exchange quotations to dominate internal prices."*[17] Likewise, DeBordes concludes for Austria that *"it was not the price level which determined the rate of exchange, but the rate of exchange which determined the price level.* The strict fiscal view, in contrast, views causality as running from a -predominantly internal- fiscal shock via (anticipated) money issue to prices and thence to exchange rates adjusting passively to maintain PPP: *"domestic monetary factors alone explain hyperinflations."*

3.3 Fiscal versus BoP Explanations: Evidence

Has the postwar literature been justified in eliminating the exchange quotation as an independent causal factor? We next examine the evidence on the exchange rate-inflation link during the German hyperinflation.

[16]Ellis (1934,p.295). The issue of small denomination "Notgeld" (Emergency Money) by local authorities and firms constituted a significant and - in the spring of 1922 and the autumn of 1923- an equal or greater share than the state money. Cf. Schacht (1926).

[17]Ellis (1933,p.291).

Table 3.1: Bivariate Causality Tests: Exchange Rates on Prices

Caused Variable	Time Period	Significance Value
WPI	7.1918-11.1923	.027
WPI	7.1918-12.1920	.555
WPI	1.1921-11.1923	.044
P(Food)	7.1920-11.1923	.002
P(Food)	7.1920-12.1921	.505
P(Food)	1.1923-11.1923	.040
P(Heat)	7.1920-11.1923	.000
P(Heat)	7.1920-12.1921	.314
P(Heat)	1.1923-11.1923	.009
P(Rent)	7.1920-11.1923	.001
P(Rent)	7.1920-12.1921	.202
P(Rent)	1.1923-11.1923	.027
P(Clothes)	7.1920-11.1923	.000
P(Clothes)	7.1920-12.1921	.101
P(Clothes)	1.1923-11.1923	.014

Significance level refers to the F-Statistic for the exclusion restriction.

3.3.1 Granger Causality

While a number of authors have tested for Granger causality in the context of the German hyperinflation, the analysis to date has been mostly restricted to bi-variate regressions relating money and prices. The basic result is due to Sargent and Wallace (1973) who found strong Granger-causality[18] running from prices to money, with more limited evidence for reverse causation. Their findings have been confirmed in a number of later studies.

While the bivariate results are informative in establishing the endogeneity of the money supply process, they are insufficient to discriminate between the fiscal and the *BoP view, both of which regard money as endogenous. By expanding the analysis to* the causality structure between prices and the exchange rate, the evidence in favor of the two approaches can however be assessed. Under the fiscal view, "shocks" to the

[18]To avoid cumbersome notation, we drop the qualifier below. The terms causality, endogeneity and exogeneity are used in the limited sense.

budget cause prices and money. Prices in turn cause exchange rates by international goods arbitrage. No distinction between the prices of tradeables and non-tradeables is made. In contrast, the BoP view sees causation running from the exchange rate to the prices of tradeables and thence to wages and prices of non-tradeables. Higher prices in turn lead to increased budget deficits and increased monetary growth. The direction of causation between prices, the exchange rate and deficits thus provides a natural test of the two alternative hypotheses.

The results are reported in Tables 1-3. Table 1 gives the bivariate Granger statistics. The tests are performed both for the entire hyperinflation period and separately for the early and late subperiod. The exchange rate is seen to be strongly temporally prior to both the aggregate wholesale price index and to several subgroups of the cost of living index. The disaggregation by time period reveals a significant differences: while the temporal link between the exchange rate and prices was tenuous in the early phase of the hyperinflation, a strong causality pattern emerges for the latter period.

Table 2 reports the results of multivariate causality tests[19] examining the contributory role of the exchange rate to a trivariate system including money, prices and the deficit. Again, the exclusion of the exchange rate is not supported by the data.

Table 3 extends the analysis to further linkages. The exchange rate is seen to be temporally prior to import, domestic and raw materials prices. However, import prices themselves are not temporally prior to domestic prices, suggesting a simultaneous effect of exchange rate innovations on traded and non-traded prices. The link between the exchange rate and wages is also somewhat tenuous at the 15% significance level, possibly a reflection of the more gradual and stepwise introduction of indexation arrangements.[20] Prices are however unambiguously preceded by wage in-

[19]The test is based on the significance values of exclusion restrictions imposed on a trivariate VAR system:

$$x_i(t) = a_i(L)x_1(t) + b_i(L)x_2(t) + c_i(L)x_3(t) + d_i y(t) + u_i \quad i \in (1,2,3,) \tag{3.5}$$

Variable y is said to "granger-cause" the system composed of x_1, x_2 and x_3 if the joint restriction

$$H_0 \; : \; d_1 = d_2 = d_3 = 0 \tag{3.6}$$

is rejected at the chosen significance level.

[20]Cf. Stitzler (1924).

Table 3.2: Trivariate Causality Tests

System Variables	Excluded Variable	Lags	Significance Value
Money, WPI, Deficit	Exchange Rate	1	0.002 %
Money, WPI, Deficit	Exchange Rate	2	0.016 %
Money, WPI, Deficit	Exchange Rate	6	0.070 %

Significance value of Chi-Square statistic.

novations, lending credence to the cost push hypothesis. In correspondence with the results presented above, both money and deficit innovations are preceded by exchange rate innovations, again rejecting the simple closed economy fiscal view. Money is endogenous with respect to both the exchange rate and prices, in accordance with most empirical studies.

3.3.2 Inflation Dependence

The temporal shift in the causality structure in table 1 suggests the presence of a marked change in the exchange rate-price nexus. Table 4 reports the correlation of the inflation and depreciation rate. A clear bunching around the contemporaneous correlation is observable over time. Figure 1 plots the contemporaneous correlation over time, exhibiting a marked increase before the final, hectic phase of the hyperinflation.

The structural shift in the exchange rate-pricing nexus was well appreciated by contemporary observers stressing the evolution of the hyperinflation episode through two different phases. Until the spring of 1921 a partial recovery of the exchange quotation if not a return to the pre-war parity was widely expected[21], partly offsetting the depreciation pressure: following a 88 % real depreciation from January 1919 to

[21] *"To practical men a German Mark meant 23.82 cents. If for the time being the market quoted it at 6 or 4 or 3 cents, they attributed the fall to an adverse balance of trade. Once Germany's urgent needs for imports were satisfied, surely, they argued, the mark would recover, perhaps not to its old parity [...] but at least to the 12 or 15 cents quoted after defeat had occurred ..."* (Hawtrey (1923)). See also Bonn(1922), Hahn(1924), Keynes(1923), von Mises(1923).

Table 3.3: Bivariate Causality Tests

Causing Variable	Caused Variable	Significance Value
Exchange Rate	Domestic Prices	0.015
Exchange Rate	Raw Material Prices	0.084
Exchange Rate	Import Prices	0.067
Exchange Rate	Skilled Wages	0.140
Exchange Rate	Unskilled Wages	0.142
Import Prices	Domestic Prices	0.209
Skilled Wages	Wholesale Prices	0.000
Skilled Wages	Cost of Living	0.001
Unskilled Wages	Wholesale Prices	0.000
Unskilled Wages	Cost of Living	0.001
Exchange Rate	Money	0.038
Wholesale Prices	Money	0.002
Cost of Living	Money	0.000
Exchange Rate	Deficit	0.014

Significance Value of F-Statistic on Exclusion Restriction

Table 3.4: Correlation Between Inflation and Depreciation Rate

Time Period	Lags						
	-3	-2	-1	0	1	2	3
Wholesale Prices							
1920:03 to 1921:03	-.19	.09	.35	.71	.54	.24	-.14
1921:03 to 1922:03	.15	-.04	-.02	.71	.21	-.07	-.36
1922:03 to 1923:03	.18	-.03	-.03	.93	.28	-.09	.40
1922:10 to 1923:10	.08	.32	.52	.99	.53	.32	.07
Cost of Living							
1920:03 to 1921:03	-.32	-.66	-.78	-.48	.03	.40	.35
1921:03 to 1922:03	.06	-.17	-.00	.47	.23	-.24	.04
1922:03 to 1923:03	-.08	.09	-.08	.62	.57	-.01	.47
1922:10 to 1923:10	.09	.36	.55	.98	.53	.31	.06

February 1920, the real exchange rate appreciated by 19 % until May 1922.[22] During the spring of 1921, foreign confidence in the Mark waned, the ensuing collapse of the exchange rate signifies the beginning of the second stage of hyperinflationary dynamics.[23] Bresciani-Turroni, otherwise placing more emphasis on the fiscal view, likewise stresses the apparent regime shift: "*[t]he characteristic of those last phases was the very close connection between the exchange rate and domestic prices [...] A rise in the exchange rate spread almost immediately to all prices*".[24]

3.3.3 Summary

While contemporary observers of the German hyperinflation attributed a primary role to the exchange rate in the initiation and propagation of the inflation process, the postwar literature focused has predominantly on domestic fiscal shocks as driving force, allowing the exchange rate only a side role.

Is the reductionist approach justified by the evidence? The results presented in this section strongly suggest a negative answer. The exchange rate Granger-caused prices, a feature predicted by the Balance of Payments view but at odds with the strict closed economy fiscal view. Not all is well for the BoP view however: both the indication of a structural break within the hyperinflation period and the presence of a simultaneous link between the exchange rate and the price of both tradeables *and* non-tradeables casts doubt on the *cost push* explanation underlying the BoP view as sole causal mechanism linking exchange rates and prices.

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[22] During this period, the current account deficit was substantially financed by the accumulation of speculative Mark holdings by non-residents expecting a recovery of the exchange quotation. Cf. Laursen and Pedersen (1964).

[23] See Bonn(1922), Keynes(1923), Mises (1925), von Bortkiewicz (1925) inter alia. Hahn (1924) distinguishes three phases: " *One believes in the Mark .. one doubts the Mark .. one despairs about the Mark.*".

[24] Bresciani-Turroni (1937, p.401).

3.4 Exchange Rate Pricing

Both empirical findings can be explained by taking account of the *information role* assumed by the exchange rate in high inflation periods. In the following section we first delve into the historical records to characterize price setting behavior during hyperinflations. We then turn to econometric evidence to assess the importance of the informational link.

3.4.1 Pricing In The Contemporary View

While movements in the exchange rate provide some information about price changes of tradeable goods, they constitute a fairly unsatisfactory guide to movements in the aggregate price level in low infiation periods. Price setters for non-tradeables base pricing decisions on published price indices and rules of thumb on underlying cost trends.

The positive link between inflation rate and inflation variability renders these traditional forecasting rules however increasingly unsatisfactory as inflation accelerates: *"This calculation will, however, prove extremely difficult if the rise of prices continues. ... How is it possible to make an accurate forecast of the costs of reproduction when the manufacturing process occupies several months ; and who can say, in such a period, what will be the price level a few months hence?"*[25]

The increased variability implies that the value of the information contained in the lagged published price level becomes increasingly dominated by the value of knowledge about price level movements since the last day of coverage. In setting prices, sellers thus place increasing weight on the most recently available information.[26] The

[25]DeBordes (1924, p.176). In like vein, Bonn(1948) asserts that *"Shopkeepers were never sure of covering the cost."* From the consumer's point of view, Erna von Pustau remarked that *"confusion belongs to inflation, is inseparably connected with it, and was one of the reasons why the people gave up thinking things out. It all seemed just madness...* (cited in Buck(1947)).

[26]Responding to public pressure, the Statistical Reichsamt eventually moved from lagged monthly to biweekly and then weekly publication of a price index as well as a "flash index" based on a representative subset of cities. The improvement in the actuality of the price level however lagged rather than led the demand for ever more up to date information.

exchange rate as the most widely available and easily observable indicator[27] of nominal movements increasingly assumes a central role: *"As regards a considerable part of the costs a basis* [for forecasting] *existed in the rates of foreign exchange, for the wholesale prices of imported raw materials and coal moved up and down in unison with the rates of exchange."*[28] Exchange rate indexation was initially most pronounced among producers of goods with high import content and sellers of imported goods.[29] In the second stage, sellers of goods with high resale value and thus high price elasticities followed suit.[30]

The increased reliance placed on the exchange rate by the early innovators[31] raised the correlation between the aggregate price level and the exchange rate and thereby improved the signaling quality of the exchange quotation for *other* price setters while at the same time reducing the predictive value of the lagged price level. This *spillover*, combined with the positive trend growth rate of inflation resulted in a fairly sudden and widespread shift from traditional to exchange rate pricing as soon as a "critical mass" of prices was effectively indexed on the exchange rate. Price indexation was soon joined by wage indexation, removing the nominal anchors that had previously provided some resistance to explosive inflation.[32] The final phase of the hyperinflation was thus characterized by near universal "valorization":

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[27]The use of foreign currency as a store of value generated a thick street market in foreign exchange dealings and thus reduced the cost of obtaining the current quotation. Bonn(1949) recalls that *"in these faraway mountain villages, every well-to-do peasant followed eagerly the quotation of dollars, of Dutch florins and of Czech crowns"* suggesting that the process was by no means limited to the urban areas.

[28]DeBordes(1924).

[29]Cf. Wagemann (1923).

[30]The real prices of leather and gold articles as well as jewelry increased significantly even during the runup to the hyperinflation (See eg. Lotz (1920)).

[31]The spread of the new pricing strategy was accelerated by a Darwinian selection process during which established merchants following traditional backward looking pricing rules were gradually replaced by newcomers adjusting to the changed environment, not always meeting public approval: *"Individual who were previously bereft of any merchant's honor suddenly commanded riches while the conscientious merchant went bankrupt."* (Zorn(1925)).

[32]The development of cost of living price indices in Austria and Germany were significantly motivated by the very desire to have a measure against which to gauge likely wage demands and thereby to reduce cost uncertainty. Wage indexation was thus widely welcomed: *"The individual entrepreneur grasped this pendant [the cost of living index] to the exchange quotation, since he could hope to finally possess a reliable index for the judgment of wage demands".* (Camuzzi(1925).)

"The next step was therefore to estimate the cost of reproduction in some stable currency and to add a certain margin of profit. ... By converting the resulting figures into Austrian crowns at the rate of exchange of the day, it was easy to say what selling price ought to be asked."[33]

"[A] Grundzahl (basic figure) is fixed of so many marks, and a multiplicator varying every day according to the dollar exchange is placed in the shop windows."[34]

"[A]ll prices have been placed on a gold basis. Generally speaking a 'ground price' is fixed on gold marks at double the pre-war figure, and this is multiplied by a multiplicator fixed by the retailers themselves, according to their own free will, and which increases not only day by day but frequently even hour by hour in an effort to keep pace with the Gadarene downward rush of the paper mark."[35]

" When the flight from a depreciating currency sets in, an early phase is the abandonment of the domestic pricing unit in favor of a stable .. standard. These prices are reinterpreted for the local users of paper by means of a "multiplier", i.e. the current exchange quotation".[36]

"[T]he shop ... closed for two hours or so at midday while the new multiplier was decided upon. The price tickets on the goods were not changed. [...] But in the middle of the window was the multiplier."[37]

"Twice a day we are all forced to await the quotation of the Zurich bourse. Every fresh drop in its value is followed by a wave of rising prices".[38]

The feedback between prices and exchange rates rendered self-fulfilling specula-

[33] DeBordes(1924).
[34] Harold Fraser, cited in Guttmann and Meehan(1975).
[35] Elphick, cited in Ferguson (19??), p.189.
[36] Ellis (1934, p.205).
[37] Edith West, cited in Guttmann and Meehan(1975).
[38] Eisenmenger(1932).

tive movements possible. An "exogenous" depreciation mapped into an instantaneous equiproportinate rise in domestic prices. Increased inflation, in turn, worsened the budget deficit by reducing the real value of tax receipts and thus enforced higher monetary growth, validating the initial depreciation.[39] In the end, the indeterminacy of prices led to an accelerating desertion of the depreciating currency in favor of a stable alternative, the economy became "frankized", eliminating the scope for seignorage and enforcing stabilization: *"The flight from the currency assumed the form initially of reckoning in a relatively stable foreign money, but as the inflation proceeded, it meant the displacement of the depreciated marks through the use of foreign currency and exchange bills as media of transfer and accumulation. When this stage was reached, it was only a matter of theoretical speculation as to how long it would be until the mark was utterly worthless..."*.[40]

3.4.2 The Shift In Pricing Rules: Obstacles

The historical path from the backward looking pricing rules adopted during the years of stable prices to full indexation was all but smooth. A phalanx of institutional obstacles, legal restrictions and simple money illusion hampered the transition process: *"A merchant could have maintained an orderly business if he .. had daily sold his wares according to the Zurich quotation. [...] Most individuals did not pursue this course, partly because they did not fully oversee the situation, partly because they were restrained by the laws and partly under the impression of an inborn sluggishness"*.[41]

DeBordes stresses the importance of widespread uncertainty and gradual learning about the new inflationary environment: *"A time comes, however, when certain groups - in the first place producers whose manufacturing processes take much time - discover that, if they follow their ordinary method of price calculation and increase their cost prices by the usual margin for profit, they are really losing [...]. In such*

[39]The loss of control over the money supply was of sufficient concern to the Government to prohibit the quotation of retail prices in foreign currency. Cf. Schacht (1926), p.52.

[40]Ellis (1934,p. 285). Sturzenegger (1991) provides an account of the dollarization process. The move towards currency substitution was slowed down by legal restrictions on the use of foreign currency in domestic transactions. Cf. Schacht (1926), p.52. and p.66

[41]Patzauer(1925).

circumstances the cost price is no longer a trustworthy basis for the calculation of selling prices. [...] Naturally, some time had to elapse before this new method of calculation could come into general use, and even more before it was really applied in every detail".[42] Max Sokal, director of the Vienna Giro and Kassenverein, in like vein cautions not to assume perfect foresight: *" When studying the effects of inflation .. one has to keep one important, fundamental point in mind. The inflation was a factor which was only gradually and in the full course of the process appreciated by the participants."*[43]

Uncertainty about the true state of affairs found its reflection in court decisions restricting the use of indexation: In 1917 the Austrian supreme court, in a widely noted decision concerning a merchant who had increased his selling price in line with the rising replacement cost, de facto prohibited indexation, decreeing that *"the current, very high prices are not real [!] market prices, but exaggerated and unjustified and that therefore persons who have acquired stocks cheaply cannot be permitted to sell at these obviously excessive prices."*[44] The German anti-speculation laws were likewise based on the principle of "mark equals mark": a nominal sales price exceeding the nominal purchasing price by more than the common prewar margin constituted "speculation" regardless of the replacement price. The "Gestehungskostenprinzip" (original cost principle) postulated by the court *"form[ed] part of the ethical codex of a large part of the consuming population".*[45] Money illusion was widespread, two representative quotations are Grunkel(1923), who notes that *"The flood of banknotes ... sufficed to create a feeling of prosperity in the farmer and the city dweller."* and Terhalle (1922), who comments on balance sheets *"in which paper and gold mark values are used next to each other".*[46]

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[42]DeBordes (1924).

[43]Sokal(1925). A similar, if more sarcastic view is found in Melchior Palyi's (1925) assessment of the Reichsbank policies: *"He who has followed the course of the German currency will find that the only responsibility of the theory has been the absence of any theory among the persons responsible for the events until the middle of 1923."*

[44]Decision of 16.March.1915. See Löffler (1925) for an extended account of the evolution of legal thought on inflation.

[45]Karl Pribram, cited in Löffler(1925).

[46]On the prevalence of money illusion on both sides of the market see also Arlt(1925), Bonn(1948), Buck (1947) and Guttmann and Meehan(1975).

3.4.3 Exchange Rate Pricing: Summary

In setting her price, the individual seller must take account of both the change in the aggregate price level and idiosyncratic shocks. The aggregate price level is a weighted average of the prices of traded and of non-traded goods. The inflation rate of tradeables is well approximated by the nominal depreciation rate. In contrast, the inflation rate of non-tradeables in the early hyperinflation phase depends on a bevy of domestic factors. The exchange rate thus forms only a very imperfect predictor of the non-tradeables inflation rate: satisfying forecasting rules for the rate of non-tradeables inflation in this period continue to rely on information about past pricing decisions which becomes available with a lag. As inflation accelerates, reliance on lagged information becomes increasingly risky: the (unknown) movement in the non-traded index since the last publication assumes increasing importance relative to the information entailed in the last publication itself. Traditional pricing rules break down: *"Inflation thus created a host of problems whose solution could not be left to the individual entrepreneur if he was not to be forced to create a vast apparatus for the solution of this problem."*[47]

Price setters react by placing increasing weight on currently available information about the aggregate price level. The exchange rate, already proxying for the inflation rate in an important subgroup of the overall index, constitutes an obvious choice. As the depreciation rate is increasingly used as a proxy for the non-traded inflation rate since the last publication of the index, its correlation with the non-traded and thus the aggregate inflation rate increases, improving its predictive ability and providing an incentive for further sellers to place a higher weight on the exchange quotation. The feedback gives rise to a *critical mass* effect mirrored by a marked sudden increase in the inflation-depreciation rate correlation. In the final stages of the hyperinflation, valorization is complete: traders translate a stable currency relative price structure into domestic currency prices via the nominal exchange rate. By this mechanism, the rate of depreciation becomes the perfect index for the aggregate inflation rate,

[47]Camuzzi (1925).

locking in the expectations mechanism.

3.5 Evidence

How important was valorization during the German hyperinflation? In the following section we present a number of suggestive tests to assess the role of pricing rules.

3.5.1 Temporal Ordering

Implicit support for the exchange rate pricing hypothesis derives from the causality tests reported above, indicating that while the exchange rate is causally prior to both domestic and import prices, the latter do not cause domestic prices, suggesting a *simultaneous* effect of the exchange rate on all prices: *"[t]he characteristic of those last phases was the very close connection between the exchange rate and domestic prices... A rise in the exchange rate spread almost immediately to all prices; not only to those of imported articles but also to purely domestic goods"*.[48]

3.5.2 Convergence

In the movement from low to hyper inflation, idiosyncratic demand shocks lose significance in price setting relative to movements of the aggregate price level. If the depreciation rate is indeed increasingly used as estimator of the inflation rate, the dispersion of inflation rates across sectors and goods should decline.

We test the convergence hypothesis on a dataset comprising monthly quotations on twelve goods[49] and 15 cities.[50] The data are taken from the Statistical Yearbook of the German Reich.[51] Figures 2 to 6 depict the coefficient of variation across cities and goods.[52] The graphs reveal a fairly uniform initial increase in the coefficient of

[48] Bresciani-Turroni (1937).

[49] Bread, peas, beans, potatoes, milk, sugar, eggs, pork, venison, butter, margarine and lard.

[50] Aachen, Berlin, Bremen, Breslau, Chemnitz, Cologne, Dresden, Dësseldorf, Frankfurt, Hamburg, Kiel, Konstanz, Magdeburg, Nürnberg and Stuttgart.

[51] Appendix 2 contains some further details on data selection and missing observations.

[52] The measure fails if the mean inflation rate is close to zero. The gaps in some of the graphs reflects occurrences of this outcome. The apparent increase in variability in March 1923 likewise

Table 3.5: Regression of CoV on Average Inflation Rate

	Full Sample		2.21-3.22		4.22-6.23	
City	β	t(β)	β	t(β)	β	t(β)
Aachen	-1.41	2.36	-1.46	0.36	-1.72	2.51
Berlin	-1.77	3.19	-1.20	0.61	-2.24	2.48
Bremen					-1.20	2.92
Breslau			-6.34	1.45		
Dresden	-2.50	2.25	-11.23	1.28	-1.08	4.12
Düsseldorf	-2.06	3.32	-8.59	1.85	-1.55	2.51
Frankfurt	-1.35	2.88	-2.66	0.85	-0.94	3.19
Hamburg	-2.13	2.29	-10.68	1.50	-0.78	3.14
Kiel	-1.78	2.37	-4.79	0.92	-1.03	2.63
Köln	-3.16	2.38	-9.35	1.03	-3.24	2.13
Konstanz	-3.58	2.40	-11.31	1.10	-3.08	2.88
Nürnberg	-1.60	2.13	-5.85	0.97	-1.24	2.29
Stuttgart	-2.80	1.29	-18.01	0.93	-0.59	2.11

variation followed by a substantial decline in the later hyperinflation period. The link is born out by a regression of the coefficient of variation on the average inflation rate.[53] The regression coefficient is negative throughout. Again a marked shift between the early and the late period emerges: the significance level of the regression increases substantial in the second half of the hyperinflation experience.

3.5.3 Spatial Causality

Under one interpretation of the strict cost push view, the geographical spread of prices proceeds from the borders to the center, following the movement of imported goods: *"depreciation results immediately in an increase of all imports. The movement of increase of prices in Germany is from the boundaries toward the interior, the whole economic life of the country is affected gradually, the estimates for the governmental budget become worthless, a deficit is created and to make good the deficit more paper*

reflects a near zero inflation rate for several goods.

[53]Again, an average inflation rate close to zero produces an outlier dominating the regression results. The affected regressions for Bremen and Breslau are not reported.

Table 3.6: Spatial Granger Causality

City	Granger causes x of the remaining cities
Berlin	11
Frankfurt	11
Hamburg	11
Dortmund	7
Cologne	7
Mannheim	5
Duisburg	3
Bremen	2
Erfurt	2
Aachen	1
Konstanz	1
Krefeld	1
Leipzig	1
Stuttgart	1
Hannover	0
Munich	0

money is printed".[54]

In contrast, under dollar pricing any movement in the exchange rate leads to simultaneous price increases in all cities. A natural test of the two theories is thus given by the causality pattern between cities. Table 6 reports the bivariate causality statistics between cities, using the consumer price index by city.

The results fairly conclusively reject the geographical spread hypothesis. While one of the main trading cities (Hamburg) is among the three price leaders, the other three border cities (Aachen, Bremen, Munich) are not causally prior to the remaining cities. Interestingly, each of the three price leaders, Berlin, Frankfurt and Hamburg, is a traditional financial center, suggesting a spread of indexation from the financially most sophisticated commercial centers to the remainder of the country.

[54]Bonn (1922).

3.5.4 Predictive Ability

Under the BoP view, the significance of the depreciation rate in predicting the inflation rate remains approximately constant throughout the hyperinflation process. In contrast, the valorization view suggests a sharp increase in the importance of the exchange rate as an information carrier at some point in time as the economy shifts collectively from paper to gold mark pricing.

To operationalize this distinction, consider the ex post forecasting errors associated with predicting the price level using either its own history, the current exchange rate or both:

$$\epsilon_1 = P_t - E(P_t|P_{t-i},\ i \in (1,2)) \tag{3.7}$$

$$\epsilon_2 = P_t - E(P_t|e_t) \tag{3.8}$$

$$\epsilon_3 = P_t - E(P_t|e_t, P_{t-i},\ i \in (1,2)) \tag{3.9}$$

Under the exchange rate pricing hypothesis, we expect that the importance of the exchange rate increases significantly as the inflation progresses. Tables 7 and 8 provide the maximum and minimum one period ahead error as well as the mean squared error both for the entire period and for the two halves. Table 7 is based on forecasting using the entire history of the series while table 8 only uses the information of the last year. Taken separately, the current exchange rate provides a better predictor of the current price level than the past price history. The introduction of the price history in addition to the current exchange rate provides a further but minor improvement for the full information sample but results in a deterioration of the predictive power for the limited sample.

Figures 7 and 8 plot respectively the weight placed on the exchange rate in the joint forecasting equation and the F-statistic of the exclusion restriction on the exchange rate in that regression. The implied optimal linear weight on the exchange rate

Table 3.7: Forecasting Performance: Full Base

	WPI(t-i,i=1,2,3)	Exchange Rate (t)	Both
Full Sample			
Minimum	-0.77	-0.14	-0.31
Maximum	1.17	0.59	0.45
MSE	0.197	0.044	0.042
First Half			
Minimum	-0.26	-0.01	-0.19
Maximum	0.43	0.33	0.33
MSE	0.0500	0.0001	0.00004
Second Half			
Minimum	-0.77	-0.14	-0.31
Maximum	1.17	0.59	0.45
MSE	0.345	0.072	0.059

increases from .2 -roughly the share of tradeables- to .65 during the hyperinflation episode. The exclusion restriction on the exchange rate is rejected from January 1922 onward. An alternative glimpse can be obtained by regressing the price level on the two one step ahead forecasts. Figure 9 plots the t-statistics on the two forecasts. The exchange rate based forecast dominates the forecast based on lagged prices for the entire episode.

While the above evidence is *consistent* with the exchange rate pricing model, it does not by itself provide conclusive evidence in its favor: *if*, as a response to increased inflation, shopkeepers turn to sampling competitors' prices at shorter intervals, the lag on inflation shrinks. The resulting overlap in the information set on which the inflation estimate and the depreciation rate are based may then in principle generate a situation in which although retailers do *not* adopt exchange rate pricing, the regressions reported above will nevertheless yield estimates supporting an apparently higher weight on the depreciation rate as inflation progresses. Taken in conjunction with the evidence on price setting behavior reported above, the latter possibility however cannot be attributed a more than marginal weight.

Table 3.8: Forecasting Performance: 13 Month Rolling Base

	WPI(t-i,i=1,2,3)	Exchange Rate (t)	Both
Full Sample			
Minimum	-0.76	-0.21	-0.37
Maximum	1.09	0.53	0.44
MSE	0.234	0.040	0.057
First Half			
Minimum	-0.31	-0.05	-0.23
Maximum	0.48	0.32	0.39
MSE	0.063	0.014	0.038
Second Half			
Minimum	-0.76	-0.21	-0.37
Maximum	1.09	0.53	0.44
MSE	0.405	0.066	0.076

3.6 Conclusion

The interwar literature stressed the exchange rate as crucial element in the initiation and propagation of the German hyperinflation process. The postwar literature in contrast typically banishes the exchange rate to a supporting role in the hyperinflation drama.

We examined the empirical evidence for an independent role of the exchange rate. Granger temporal ordering tests suggested that exchange rate innovations were indeed prior to deficit- price- wage- and money innovations, casting doubt on the validity of closed economy views of the hyperinflation process. Yet not all is well for the traditional view operating via the price of tradeables either: neither the sudden increase in the correlation between the inflation and the depreciation rate nor the apparent simultaneous effect of exchange rate depreciation on the prices of tradeables and non-tradeables is consistent with the cost push hypothesis.

We document the existence of a second relationship between depreciation and inflation rates based on the role of the exchange rate as a conveyor of information about the aggregate price level. As inflation accelerates, individual price setters coordinate on using the rate of depreciation as estimator of the aggregate inflation rate and

thereby in turn improve the quality of the depreciation rate as signal. The feedback effect results in a sudden shift towards complete valorization once a "critical mass" of price setters has coordinated, substantially reducing the costly "noice" induced variability in relative prices.

The emergence of the second link eradicates one of the few remaining backward looking anchors and introduces the last frantic period of hyperinflation. At the same time, the expectational coordination on the depreciation rate facilitates the stabilization by substantially raising the effect of the introduction of a fixed exchange rate on the inflation rate. While waiting for collapse in this sense renders stabilization less costly, the learning effect associated with living through the hyperinflation also renders the system more sensitive to repeat performances: once added to the behavioral armory, valorization will proceed more rapidly the second time round: *"A return to monetizing deficits would immediately cause a reaction of economic agents which before would not have taken place. ... [I]f all individuals react immediately to the note issue, the government can no longer rely on the printing press for long term financial support"* [55]. The short run stabilization gains thus come at the cost of a permanent increase in the vulnerability of the economy to monetary shocks.

[55] von Mises(1925).

Appendix 1 : Time Series Properties Of Aggregate Variables

The application of Granger causality tests requires stationary variables. As the level series are highly non-stationary, all series were transformed into stationary form by differencing and detrending as appropriate. Tests for the order of integration were performed using the Schmidt-Phillips methodology allowing a discrimination between an exponential time trend and a unit root. The implied transformations are reported in table 1.[56]

Table 3.1: Time Series Properties Of Variables

Variable	Abbre.	Differenced	Detrended
Exchange Rate	EXC	Twice	No
Money Supply	M	Twice	No
Cost of Living (COL)	COL	Twice	No
Wholesale Prices (WPI)	WPI	Once	Yes
Domestic Prices P(DOM)	P(DOM)	Twice	No
Import Prices P(IMP)	P(IMP)	Once	Yes
Food Prices P(Food)	P(FOOD)	Thrice	No
Heating Costs P(Heat)	P(HEAT)	Twice	No
Rent P(Rent)	P(RENT)	Twice	No
Clothing P(Clo.)	P(CLOTH)	Twice	No
Private Sector Wages	W(PRIV)	Once	No
Public Sector Wages	W(PUBL)	Once	No
Deficit	DEF	Thrice	No

[56] All variables are in logs.

Appendix 2: Availability Of City Data

Not all price series are available for the entire time period. To avoid spurious effects, only complete series were used in the calculations. Table [2] lists the available data.

Table 3.2: Price Data By City

	Variable												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Aachen		x	x		x	x	x	x			x		7
Berlin	x	x	x	x	x	x		x	x	x	x		10
Bremen	x	x	x	x	x	x		x	x	x	x		10
Breslau	x	x	x	x	x	x	x	x		x	x	x	11
Chemnitz	x	x	x	x	x	x	x	x	x	x	x		11
Cologne	x	x	x	x	x	x	x	x		x	x		10
Dresden	x	x	x	x	x	x	x	x	x	x	x	x	12
Düsseldorf	x	x	x	x	x	x		x			x		8
Frankfurt	x	x	x	x	x	x		x			x		8
Hamburg		x	x		x	x	x	x	x		x	x	9
Kiel	x	x	x	x	x	x	x	x	x	x	x		11
Konstanz	x	x	x	x	x	x	x	x	x		x		10
Magdeburg	x	x	x	x	x	x	x	x	x	x	x	x	12
Nürnberg		x			x	x	x	x			x	x	7
Stuttgart	x			x	x	x	x	x	x	x	x		9
Total	12	14	13	12	15	15	11	15	9	9	15	5	145

Source: Statistisches Amt des Deutschen Reiches.

Variable codes: (1) bread, (2) peas, (3) beans, (4) potatoes, (5) veal, (6) pork, (7) butter, (8) margerine, (9) eggs, (10) venison, (11) sugar, (12) milk.

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Chapter 4

Sunspots In Tax Compliance Decisions

While the individual tax payer's compliance choice has received extensive attention, the *aggregate* manifestation of tax evasion, the "anti-tax revolution" characterized by a fairly sudden shift of a significant fraction of the tax paying citizenry from compliance to tax evasion has attracted little analytical attention. Below we argue that the whole may well be more than the sum of its parts. Specifically, we model tax revolutions as manifestations of an underlying multiple equilibria structure of tax compliance decisions. In this setting, aggregate shifts towards non-compliance can be optimal responses even in circumstances where individual utility maximization suggests compliance.

An individual's decision whether to cheat on taxes depends, *ceteris paribus*, on her perceived detection probability. For a given monitoring outlay and a non-random audit policy, this perceived probability in turn depends negatively on the *expected* number of tax cheaters in the remainder of the population. The combination of the negative dependence of the probability of detection on the number of tax cheaters with the negative dependence of the return to non-compliance on the probability of detection brings forth a situation of *strategic complementarity*: the attractiveness of cheating for any individual increases in the number of other cheaters. If strong enough, the strategic complementarity can generate multiple rational expectations

equilibria indexed on prior beliefs about the number of cheaters in the tay paying population: the belief that *other* tax payers will cheat can be sufficient to induce the individual to cheat and *vice versa*. In a homogenous agent economy, "sunspot" expectations about other tax payers cheating decisions can hence be self-justifying.

We present a formalization of the tax compliance problem with endogenous detection probabilities in section two. The likelihood of sudden shifts of large fractions of the tax-owing population from compliance to cheating is low in politically and economically stable systems. It however constitutes a quite feasible occurence in times of political and economic turmoil. In section three we turn to inflation as an example of such a setting. Informal evidence suggests a sharp decline in tax honesty during several Latin American mega inflations. The worsening compliance record seems moreover to have persisted into the post-stabilization period. We provide a rationalization both for the initial decline and for the persistence of low tax compliance in the context of the model. In section four we turn to policy analysis. In contrast to the state independent optimal auditing strategies implied by models not taking into account the externality effects, the model presented below suggests a role for the bunching of the monitoring effort in a single period. The aim of coordinating expectations on the high-compliance equilibrium can alternatively be achieved by an effort to create a favorable "sunspot" shifting taypayer's perception. A strategy of highly publized prosecution of public figures, as implemented in Mexico, provides an illustrative example of a policy which, while although not affecting the actual cost-benefit calculus of the *typical* tax payer and hence being completely ineffective under the standard analysis, has the potential of drastically increasing compliance if it succeeds in shifting popular perception. The success of Mexico's measure suggests the potential benefits to be harvested from 'symbolic prosecution'.

4.1 Multiple Equilibria In Compliance Choices

The game between taypayers and the collection agency has attracated substantial attention. The traditional approach, pioneered by Allingham and Sandmo(1972)

and Srinivasan(1973), models the individual choice as a problem in expected utility maximization: the complying tax payer receives a certain post-tax income, the tax cheater faces an uncertain income depending on whether or not she is audited. Given her risk aversion, the individual maximizes her expected utility treating the auditing probability as a parameter.[1] The collection agency in turn selects the optimal auditing strategy (defined over the number of audits and the fine imposed on tax cheaters) maximizing total revenues net of auditing costs.[2]

We maintain the assumption that any individual regards the probability of detection as independent of her own decision but determine the rational expectations equilibrium probability endogenously as a function of the number of tax payers deciding to cheat and the aggregate resources spent on monitoring. Under this extension, the probability of detection decreases *ceteris paribus* in the total number of cheaters. The externality linking the aggregate detection probability, and hence the expected return on tax evasion to individual compliance choices can generate multiple rational expectations equilibria indexed on the rate of compliance. In particular, a representative tax payer believing all other citizens to be honest can be faced by an expected detection probability rendering her own compliance optimal while the same tax payer, believing all other workers to be cheaters, and hence expecting a lower detection probability, may prefer to cheat herself.

The one period economy is populated by N risk-neutral workers of two types with VNM utility functions. Type 1 (2) workers make up a fraction p (1-p) of the population and receive a real income of k_1 ($k_2, k_2 < k_1$) per period, with associated tax liability of t_1 ($t_2, t_2 < t_1$). While her type is revealed to the worker at the beginning of the period, the government must pay an audit cost (normalized to unity) to learn the type of a particular worker. Workers announce a type and pay the corresponding tax. They receive no utility from government expenditure. To deter tax cheating, the government allocates a fixed real expenditure T to random audits of individuals reporting an income of k_2 and levies a penalty $(t_1 - t_2) + W$ on tax cheaters.

[1] See *inter alia* Reinganum and Wilde(1985) and Greenberg(1984) for recent formulations. Cowell (1990) provides an excellent survey of the literature.

[2] See, *inter alia* Kemp and Ng (1979) and Polinsky and Shavell (1979).

The *ex-ante* probability of detection is given by

$$r(Q) = \frac{T}{[(1-p)N + Q]} \tag{4.1}$$

i.e. the ratio of audits to the *expected* number of individuals reporting to be of type 2. The latter group is composed of the $(1-p)N$ individuals reporting truthfully and of some number $Q \leq pN$ of type 1 individuals misreporting their type. The *ex ante* probability of detection is thus conditional on the prior concerning Q, with range $r(Q) \in [\frac{T}{N}, \frac{T}{((1-p)N)}]$ and $\frac{dr(Q)}{dQ} < 0$. Type 1 individuals choose among reporting truthfully (T) and cheating (C). The stochastic income of a tax cheater is thus given by

$$U_C(Q) = r(Q)U(k_1 - t_2 - W) + (1 - r(Q))U(k_1 - t_2) \tag{4.2}$$

with $\frac{\partial U_C(Q)}{\partial Q} > 0$: an increase in the total number of cheaters increases the expected individual return to cheating. The maximimization problem, conditional on Q, is given by

$$Max(E[U_T, U_C]) = Max[r(Q)U(k_1 - t_2 - W) + (1 - r(Q))U(k_1 - t_2)\,, U(k_1 - t_1)] \tag{4.3}$$

Three cases arise:

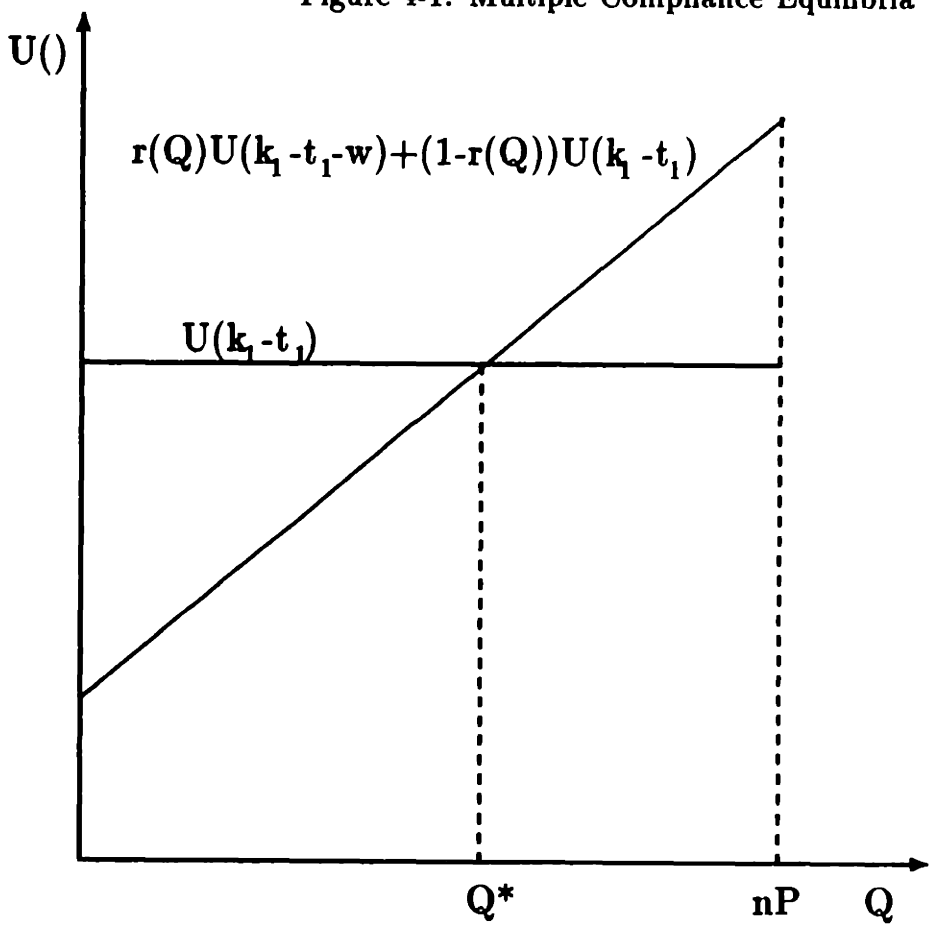
A: $[U_T < U_C(0)]$ **B:** $[U_T > U_C(pN)]$ **C:** $[U_C(0) < U_T < U_C(pN)]$

Cases A and B correspond to the familiar analysis of compliance choice: tax evasion is individually optimal (non-optimal) regardless of the prior concerning other tax payers' decisions.

The interesting case is C: conditionally on no other (all other) high income workers evading taxes, tax evasion is individually non-optimal (optimal). Thus both the honest and the cheating outcome are subgame perfect rational expectations Nash equilibria.

The equality of the two utility schedules defines a critical value Q^* satisfying

Figure 4-1: Multiple Compliance Equilibria



$$r(Q^*)U(k_1 - t_2 - W) + (1 - r(Q^*))U(k_1 - t_2) = U(k_1 - t_1) \qquad (4.4)$$

below (above) which honesty (cheating) is the optimal strategy. Figure 1, relating the expected utility under honesty and cheating to the prior on Q, provides a diagramatic exposition of case C. The choice of equilibrium is fundamentally indeterminate: any "sunspot" capable of shifting expectations to the other side of Q^* alters the equilibrium. While the model does not imply the stability of equilibria, empirical observation suggests that expectational equilibria tend to exhibit substantial hysteresis. Sah(1991) provides an intriguing explanation in terms of "social osmosis": individuals update expectations based on the observed behavior of "neighbours". In the present paper, we take the shortcut of assuming that Q will not be updated if no new information becomes available.

While the likelihood of a sudden equilibrium shift from widespread honesty to

equally widespread cheating appears small in stable economic and political systems, economic, social and political upheaval tend to radically alter accustomed behavioral patterns. We now turn to inflation as an application of the general model to a specific case of politico-economic turmoil.[3].

4.2 An Application: Tax Compliance And Inflation

In 1619, Duke Maximilian of Bavaria aggressively supported the debasement inflation ravaging Germany as a promising source of finance for the catholic counterattack. Three years and a tenfold increased price level later, Bavarian real tax revenues had declined by 60.9 % and Archduke Maximilian led the stabilization effort.[4] The negative link between inflation and real tax revenues has since become a familiar feature in high inflation episodes. The traditional explanation attributes the erosion of the real value of nominal tax liabilities to the lag between the assessment and the payment date.[5] The erosion effect is reinforced by behavioral responses of tax payers. In the absence of indexation, inflation reduces the real value of the outstanding tax liability, encouraging the postponement of tax payment until the last permissable date: the actual payment lag approaches the legal maximum, further reducing the real revenues received by the tax agency.[6]

Reduced tax compliance forms a third link between inflation and revenues. Anec-

[3]While we focus on the effect of inflation, the expectational multiple equilibrium property of the model implies that any event on which expectations are sufficiently co-ordinated may shift the economy from high to low compliance, without an observable change in fundamentals. Historical examples include dissatisfaction with spending plans (Anti-crusade-tithe uprising in France 1188 (Möhring), resentment against occupation forces (Israelite revolt of 66 A.D. (Farmer(1957)), perceived injustice of tax distribution (Peasant wars (Beloff(1963), Schulze(1982), Neveux(1984)) and desire for political participation (Boston Tea party).

[4]Altmann(1976, Addendum III).

[5]See Keynes(1923), Bresciani-Turroni (1937), Graham (1928), Harberger (1964), Olivera (1967) and Tanzi (1977,1978).

[6]Cf. eg. Patzauer (1925,page 276), describing the Austrian hyperinflation: "the taxpayer could save substantially by postponing his tax payment. This was used widely since the only disadvantage to the tax payer was an increase in the liability by a couple of percentage points. The problem was reduced if not solved by the system of pre-payment and the increase of tax liabilities by a multiple in case of non-payment on time".

dotal evidence suggests a widespread worsening in tax honesty during several Latin American mega inflations, a worsening which furthermore has apparently not been significanctly reversed after stabilization. Both the emergence and the persistence of widespread tax cheating can be rationalized in the context of the model developed above.

Part of the explanation can be sought in psychological motives: governments perceived to be failing in their duties command less loyalty by their citizens. Our model implies that a -sufficiently general- anti-government mood shift typical of the later phase of hyperinflation suffices to shift the economy to the low compliance equilibrium with subsequent lock-in.

A second channel linking tax honesty to inflation even in the absence of anti government mood swings can arise from lacking indexation of nominal tax liabilities and fines. Inflation, by reducing the utility cost of detection, can render tax evasion *individually* optimal at the new inflation rate and thus shift the economy to the low compliance equilibrium. If the externality effects are strong enough both equilibria are stable; thus a move towards full indexation or stabilization need not shift the economy back to the full compliance equilibrium.

Let t_i denote the real taxes under full indexation (or zero inflation). Actual taxes are given by $t_i I(q,\pi)$ where the function $I(q,\pi)$ captures the Keynes-Olivera-Tanzi effect. q and π denote the degree of indexation, defined between 0 (no indexation) and 1 (full indexation) and the inflation rate. Analogously, we define a discount function $J(s,\pi)$ for the fine imposed on tax shirkers. The discount functions obey:

$$I(1,\pi) = I(q,0) = J(1,\pi) = J(s,0) = 1 \; \forall s,q,\pi \quad \frac{\partial I(q,\pi)}{\partial q} > 0 \quad \frac{\partial J(s,\pi)}{\partial q} > 0 \quad (4.5)$$

To simplify notation, denote the utility difference between the expected income under honesty and cheating as

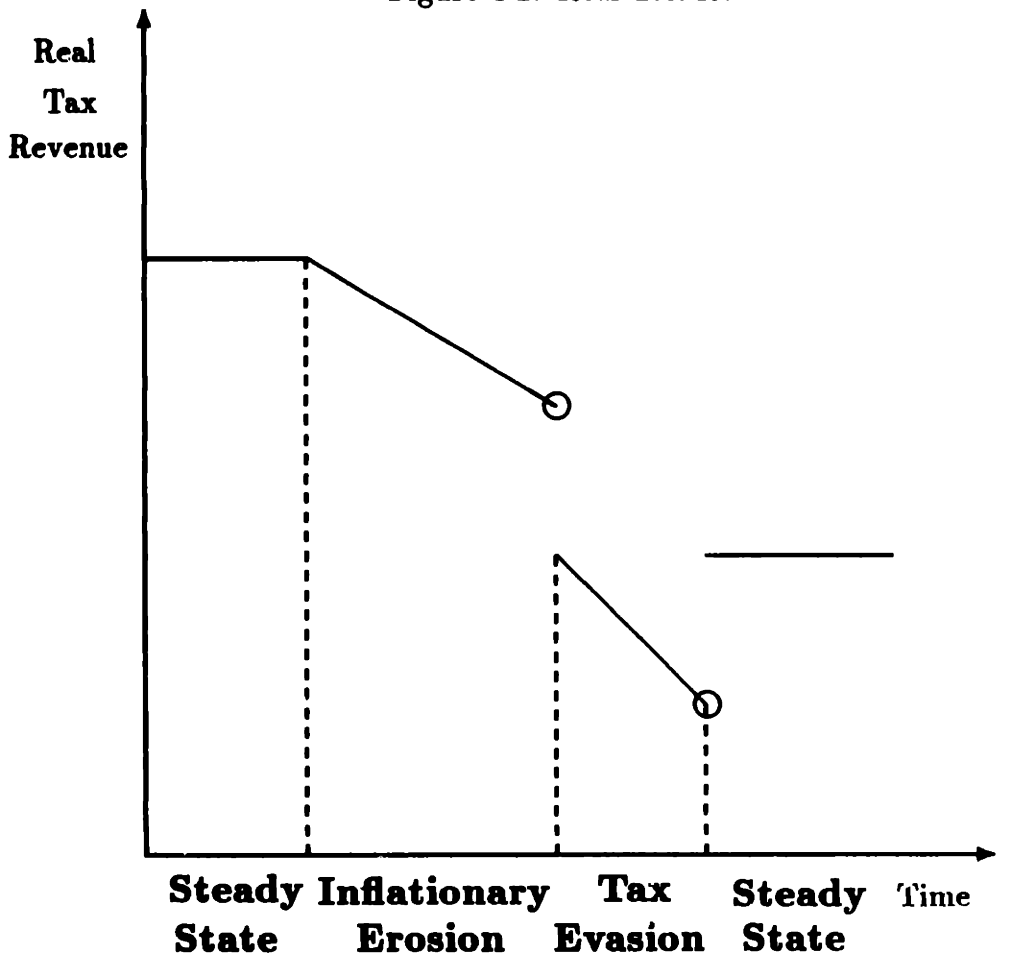
$$Y(Q,q,s,\pi) = U(k_1 - t_1 I) - rU(k_2 - t_1 I - WJ) - (1-r)U(k_1 - t_2 I) \qquad (4.6)$$

We first consider the case $q = 1$ and $s < 1$. Even if full compliance is unconditionally optimal at zero inflation ($Y(pN,1,s,0) > 0$) there now exists an inflation rate π^* defined by $Y(0,1,s,\pi^*) = 0$ at which cheating becomes unconditionally optimal. Thus a sufficiently large *temporary* increase in the inflation rate leads to a *temporary* decline in tax compliance, reinforcing the Keynes-Olivera-Tanzi (KOT) effect but vanishing after stabilization. In terms of Figure 1, inflation shifts the U_C schedule upward, reducing the threshold value of Q^* above which cheating becomes the optimal strategy. In contrast, if the economy exhibits multiple equilibria at zero inflation ($Y(0,1,s,0) < 0 < Y(pN,1,s,0)$) a temporary inflation blip sufficient to make non-compliance unconditionally optimal for one period shifts the system -in the absence of further shocks- *permanently* to the low compliance equilibrium. Inflation in this case generates *hysteresis* effects on the degree of tax compliance, providing an explanation for persistently low real revenues in the aftermath of stabilization.

A typical time path for real tax revenues under hyperinflation is pictured in Figure 2: starting from zero inflation and full compliance, the Keynes-Olivera-Tanzi effect gradually reduces real revenues. Upon reaching the critical inflation rate π^* at which non-compliance becomes the optimal choice real revenues experience a sharp drop from $[pt_1 + (1-p)t_2]NI(q,\pi)$ to $t_2 NI(q,\pi)$ and continue to decline at $\frac{\partial I(q,\pi)}{\partial \pi}$. Upon stabilization, real revenues recover to Nt_2 (the reverse Keynes-Olivera-Tanzi effect), remaining below the initial level.

We next turn to the reverse case of q=0 and s=1. An increase in the rate of inflation now *lowers* the expected benefit from tax evasion: while the real fine remains constant, the real value of the tax saved by undereporting declines with inflation. Commencing from a situation of widespread tax evasion, inflation under this scenario may *improve* tax honesty. The latter case, while an interesting curiosum, however carries little historical significance as some form of tax indexation is typically adopted

Figure 4-2: Real Tax Revenues



by countries undergoing hyperinflation.

While tax compliance may thus be systematically influenced by inflation. The reverse direction of causation also holds. We consider a government with given real expenditures g exceeding maximum steady state seignorage. Taxes are completely indexed (no Keynes-Olivera-Tanzi effect) but may decrease due to tax evasion. The deficit is fully monetized, in steady state we thus have

$$g = TR(Q)I(q,\pi) + \pi L(\pi) \tag{4.7}$$

where $L(\pi)$ denotes the real money demand and $TR(Q) = [((1-p)N+Q)t_2+(pN-Q)t_1+r(Q)[t_1-t_2+w]Q]I(1,\pi)-T$ denotes real tax revenues. For a variety of money demand specifications (4) exhibits multiple steady state inflation rates. We consider the case in which (4) admits zero inflation as a solution: $tI(q,0) = tI(1,\pi) = g$. If the economy exhibits multiple tax compliance equilibria at zero inflation a *temporary* increase in government expenditure, financed by seignorage, may suffice to shift the equilibrium *permanently* from full to low compliance: the budget will not return to balance once the temporary expenditure has ended, requiring a higher *steady state* inflation rate.

4.3 Policy

The individual incentive to evade taxes forces the collection agency to devise auditing rules and penalties for cheaters. In doing so, the agency faces a tradeoff: an increase in audits raises both compliance and outlays. An agency maximizing tax revenues *net* of auditing costs will thus perform checks on tax payers up to the point at which the marginal return from increased compliance equals the marginal cost of auditing.[7]

In models without externality effects, the optimal strategy is *ceteris paribus* state

[7]On the margin, an increase in fines for detected cheaters is less costly than an additional audit. If the Inada conditions hold, the theoretical revenue maximizing strategy thus combines a single audit with a fine equal to the wealth of the cheater. While these "optimal" maximum fine strategies historically enjoyed wide circulation, twentieth century societies have generally opted for bounded maximum penalties, requiring an offset in increased auditing.

independent: the optimal number of audits remains unchanged[8]. The existence of multiple hysteretic equilibria in tax compliance alters the cost-benefit calculus facing the collection agency: starting from a situation of widespread cheating, a *one time* coordination of expectations on the compliance equilibrium carries *permanent* dividends. The attempt to coordinate may take the form of a *temporary* sharp increase in audits beyond the point justified by *within* period net revenue maximization. Once the shift in compliance behavior has been achieved, the optimal auditing strategy is given by the traditional state independent rule. Alternatively, the government may attempt to create a "sunspot" in its favor: the highly publicized imprisonment of a few public figures in Mexico, Sweden and Italy constituted an -apparently successful- strategy to induce a shift in psychology without significantly altering the objective cost-benefit calculus facing the average tax payer and hence without effect in traditional models of optimal auditing.

4.4 Conclusion

Individual decisions regarding tax compliance depend on the perceived probability of detection, which in turn depends upon the number of *other* tax payers deciding to cheat. The negative externality running from individual compliance choices to the probability of detection, together with the negative dependence of the expected return to cheating on the probability of detection gives rise to the possibility of multiple rational expectation "sunspot" equilibria indexed on the prior about other tax payer's compliance choices. In particular, we may observe self-justifying anti tax revolutions occuring in settings in which *individual* tax avoidance would be utility reducing.

The possibility of low compliance traps carries implications for optimal auditing policy. In contrast to the familiar state invariant auditing strategies, the opportunity to achieve a shift of equilibrium from low to high compliance and thus a permanent

[8]In case A above, full compliance can alternatively be ensured by increasing W or T to the point where $Y(pN, q, s, \pi) > 0$ for $\forall \pi$.

dividend of curent period audits justifies a bunching of auditing effort in a single period even if current audit costs exceed current returns in terms of higher compliance. A second route for policy focuses on the generation of a favorable "sunspot" coordinating expecations on the high compliance equilibrium.

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