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Vol. 40 No. 4 DECEMBER 1993

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International Standard Serial Number: ISSN 0020-8027

The U.S. Library of Congress has cataloged this serial publication as follows:

International Monetary Fund
Staff papers — International Monetary Fund. v. 1– Feb. 1950–
[Washington] International Monetary Fund.

v. tables, diagrs. 23 cm.

Three no. a year, 1950–1977; four no. a year, 1978–
Indexes:
Vols. 1–27, 1950–80, 1 v.
ISSN 0020-8027 = Staff papers — International Monetary Fund.

1. Foreign exchange—Periodicals. 2. Commerce—Periodicals.
3. Currency question—Periodicals.

HG3810.15 332.082 53-35483

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IMF *Staff Papers*
Vol. 40, No. 4 (December 1993)
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Skill Levels and the Cyclical Variability of Employment, Hours, and Wages

MICHAEL KEANE and ESWAR PRASAD*

This paper uses microeconomic panel data to examine differences in the cyclical variability of employment, hours, and real wages for skilled and unskilled workers. Contrary to conventional wisdom, it finds that, at the aggregate level, skilled and unskilled workers are subject to the same degree of cyclical variation in wages. However, the quality of labor input is found to rise in recessions, inducing a countercyclical bias in aggregate measures of the real wage. The paper also finds substantial differences across industries in the cyclical variation of employment, hours, and wage differentials, indicating important interindustry differences in labor contracting. [JEL E32, J31, J41]

WHILE IT HAS long been recognized that skilled workers face substantially lower cyclical variation in employment than unskilled workers, little evidence is available on the relative variation of their real wages over the cycle. Based largely on the work of Reder (1955, 1962), it has come to be widely accepted that wage differentials across skill levels are countercyclical. More precisely, the relative wage differentials between skilled and unskilled workers are believed to widen in recessions and narrow in booms. For instance, Azariadis (1976) brings this stylized

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fact to bear on his discussion of implicit contracts in the labor market, and Kydland (1984) discusses it in the context of his heterogeneous-agent business cycle model.

Most previous studies of wage differentials have used data that are aggregated based on some specific criterion of skill. For example, Reder (1955) divides the work force into skilled, semiskilled, and unskilled categories using job classifications and proceeds to look at average wage measures for each category. The use of such aggregate data may obscure the effect of substantial compositional changes in the work force over the cycle. In particular, systematic cyclical changes in the quality of the employed work force within specific job classifications may bias Reder's aggregate measurement of the cyclicality of wage differentials between skilled and unskilled workers.

Raisian (1983) was among the first to study the cyclicality of wage differentials using micro panel data to control for compositional changes in observed characteristics of workers and some unobserved measures of ability. He finds that workers with more work experience and longer tenure on their current job exhibit significantly greater procyclical variability in wages and weekly hours worked but less variability in annual weeks worked. Contrary to Reder's findings, Raisian concludes that relative wage differentials between skilled and unskilled workers are procyclical.

In this paper, we present new evidence on the cyclicality of wage differentials using micro panel data from the National Longitudinal Survey of Young Men, a panel containing 12 surveys over a period of 16 years. The long panel enables us to obtain efficient estimates of the interaction between skill levels and the cyclical behavior of real wages. Our estimates control for aggregation bias on the basis of observed worker characteristics and also for unobserved individual fixed effects. Another potentially important source of bias, referred to as selection bias, arises from the fact that in any period wages are observed only for workers who are employed in that period. By choosing only those person-year observations for which a wage is observed, estimated coefficients may pick up the effect of some unobserved component of ability that has a systematic effect on employment probabilities as well as on wages. We implement a maximum-likelihood version of Heckman's (1974) selection model to correct for such selection bias. This source of bias has not been dealt with in earlier studies of wage differentials.[1]

By controlling for observed worker characteristics and unobserved

[1] The magnitude of this bias in measuring the cyclicality of the average real wage may be substantial as shown in Keane, Moffitt, and Runkle (1988).

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fixed effects and by correcting for selection bias, we are able to provide consistent estimates of the cyclical properties of offer-wage differentials. The offer wage for workers of a particular skill level is defined as the wage offered to a "representative" worker of that skill level, after controlling for heterogeneity within that skill category. Our results demonstrate that the two quantities discussed above, mean offer wages and average observed wages, have considerably different cyclical properties. This implies that changes in the average wage of employed workers are biased measures of changes in the mean of the offer-wage distribution, both at the aggregate level and within specific skill categories.

In our empirical work, we do not attempt to develop a single measure of skill level but, instead, examine a variety of plausible proxies for human capital. In particular, we focus on education levels, total labor market experience, and tenure on the current job. These variables arguably act as a proxy for different facets of human capital. Since Becker's (1962) seminal paper, it has been recognized that a careful distinction needs to be made between general human capital and firm-specific or industry-specific human capital. This distinction has implications for the effects of skills on employment, hours, and wage variability. Indeed, we find that our proxies for skills differ considerably in their effects on cyclical fluctuations in employment, hours, and wages.

We also provide results broken down by industry, in order to closely examine interindustry differences in the cyclical behavior of the wage premium for skills. In addition, we separately measure the cyclicality of employment and weekly hours worked. This enables us to estimate the relative magnitude of the variation in employment and weekly hours in accounting for cyclical labor input variation in different industries.[2]

A key finding of the paper is that, at the aggregate level, skilled and unskilled workers face almost the same degree of relative cyclical variation in wages. In other words, offer-wage differentials between skilled and unskilled workers are essentially acyclical. However, after controlling for other characteristics, older workers are estimated to have more procyclical wages.

Although their patterns of wage variation are similar, workers with a college degree have little cyclical variation in employment probabilities or weekly hours, while workers without a degree have employment probabilities and hours that are procyclical. The greater procyclical variation in employment and hours for nondegreed workers implies that the

[2] The standard measure of labor input is aggregate hours worked, which is the product of the number of persons employed and the average weekly hours worked (or the appropriate frequency).

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average quality of labor input per manhour rises in a recession. It follows that a substantial countercyclical bias may exist in those measures of the real wage that simply divide aggregate compensation by total manhours. Our finding that the quality of the labor force rises in a recession is similar to that reported by Kydland and Prescott (1988), who use data from the Michigan Panel Study of Income Dynamics.

At the industry level, we find that the wage premium for skills is strongly procyclical in durable and nondurable manufacturing and is countercyclical in retail trade and services. In durable manufacturing, workers with a college degree have much more procyclical variation in wages than other workers. Educated workers in durable manufacturing have relatively less procyclical variation in employment probabilities and are actually found to have countercyclical variation in weekly hours.

Variation in average weekly hours accounts for only about 30 percent of the variation in total hours worked in the economy. However, in certain industries, such as nondurable manufacturing, variation in average weekly hours accounts for a substantial portion of the variation in total hours. These and other industry results indicate substantial intersectoral differences in labor contracting.

It is useful to discuss the relation between skill levels and employment, hours, and wage variability in the context of labor market contracting models. The next section of the paper surveys some theoretical models of labor market contracting and compares their implications. This provides a framework for analyzing and interpreting our empirical results. We follow with a section describing the econometric techniques used in the paper and another section describing the data set used in the estimation. Next, we detail our main results, concluding with a summary of the paper's findings and implications.

I. Conceptual Framework

The concept of a "skilled worker" is rather nebulous since the term "skill level" is often used as a portmanteau to refer to various aspects of human capital. The literature on human capital theory makes an important analytical distinction between general and firm-specific (or industry-specific) human capital (see Becker (1962)).[3] General human capital

[3]Notice that firm-specific and industry-specific capital are not necessarily identical. However, when issues of labor reallocation and wage dispersion are examined in the context of business cycles, the typical unit of analysis is the industry (for example, see Lilien (1982)). This is partly driven by the fact that industry-level data contain less measurement error. Also, the concept of a "firm"

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increases the productivity of a worker in any firm. Such capital is assumed not to depreciate when a worker switches from one firm (or industry) to another. Firm-specific capital is, by definition, not transferable across firms. There is an element of risk to investment in such capital since a separation of the worker from the firm leads to the loss (or significant depreciation) of such capital. The real resource costs of investment in specific capital include training costs and forgone output from time spent training rather than directly producing output.[4] Workers may bear a portion of these costs by accepting a wage below their marginal product when they join the firm. This joint investment provides an incentive for both the firm and the worker to avoid a separation.

Specific human capital is key to many of the models of labor market contracting that have direct implications for the cyclical behavior of employment, hours, and wages for workers of different skill levels. These models may be classified into two broad categories. The implicit contract models of Azariadis (1975, 1976), Baily (1974), and Gordon (1974) imply the existence of wage-smoothing arrangements provided by firms for their workers. The implicit contract models of Hashimoto (1981) and Raisian (1983), on the other hand, imply the existence of labor contracts with more procyclical compensation for workers with higher skill levels. The main differences between these two sets of models arise from their assumptions regarding the rules that determine how the costs of investment in specific capital and the returns from it are shared by firms and workers.

The Azariadis-Baily-Gordon class of models postulates that risk-neutral firms may implicitly offer insurance to risk-averse workers by guaranteeing them relatively stable employment and wages when faced with uncertain demand for the firm's product. In its basic form, this theory suggests that all workers receive some form of employment or wage insurance, reflected in the weak response of employment and wage measures to demand shocks or other real shocks.

By incorporating firm-specific human capital, this theory can be extended to the case of risk-averse firms and heterogeneous workers. Risk-averse firms would, in general, not be willing to take on the risks posed by fluctuations in demand or productivity. However, if firms bear the cost of investment in specific human capital, they might be reluctant

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is much less well defined than that of an industry. Given these facts and the constraints on our data set, we refer to industry-specific and firm-specific capital interchangeably. Alternatively, we could use the notion of a representative firm in each industry as the unit of analysis.

[4] Oi (1962) uses a similar notion of fixed hiring costs to model skilled labor as a quasi-fixed factor input.

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to lose the specific capital embodied in their workers. When faced with adverse demand or productivity shocks that they perceive to be transitory, firms then have an incentive to retain workers with high specific skill levels. Thus, skilled workers may be offered contracts that, at business cycle frequencies, provide them with smoother wages and more stable employment patterns than unskilled workers.[5] Unskilled workers would simply be paid their marginal product in every period, and their employment would depend solely on current-period demand conditions. Hence, their employment and wages would tend to be strongly procyclical.

The Hashimoto-Raisian class of models has markedly different implications. The key underlying notion in these models is that specific capital involves a joint investment by the firm and the worker. Further, the returns from this form of human capital are assumed to be shared by the two parties. This gives both parties, the worker and the firm, an incentive to avoid a separation that would cause specific capital to be lost. Thus, workers with more firm-specific human capital would face a trade-off between employment and wage variability. Since such workers typically have higher incomes than unskilled workers, they are likely to have better access to asset markets where they could insure against income fluctuations. Consequently, skilled workers would be willing to accept more procyclical variation in wages than unskilled workers, in return for a greater degree of employment stability.

It follows from the above argument that the larger their share in the returns from specific capital, the more employment stability the skilled workers would value (or the more variability in wages they would accept in return for not being laid off).[6] However, it is likely that skilled workers face a greater degree of adjustment at the intensive margin (that is, weekly hours worked). In other words, firms may respond to downturns by laying off unskilled workers and reducing the hours worked by skilled workers. This implication follows from the assumption that specific human capital is unaffected by hours variation but depreciates if a firm and a worker are separated for one or more periods.

[5] Further, if a firm received the entire return from a worker's specific capital, it would be even more willing to assure him or her a relatively smooth wage in order to prevent a separation and the consequent loss of such specific capital. The precise extent of wage and employment smoothing would depend on the degree of the firm's risk aversion, the cost of specific capital investment, and the persistence of the shock, among other things.

[6] This argument implicitly assumes that temporary and permanent separations between a firm and a worker are equivalent in that they cause specific capital to depreciate fully. This is the limiting case of a more general argument that would hold if there was a sufficiently large depreciation in specific capital resulting from a temporary separation.

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However, the Hashimoto-Raisian model could also be consistent with countercyclical hours variation for skilled workers. Since highly skilled workers in many industries typically earn salaries rather than hourly wages, working longer hours in a downturn may be a means of taking a temporary cut in hourly wages.

Thus, the Azariadis-Baily-Gordon and Hashimoto-Raisian models have similar predictions about employment variability: skilled workers should face less cyclical variation in employment. Neither set of models has a definitive implication regarding relative cyclical variability of hours for workers of different skill levels, although, in its simplest form, the Hashimoto-Raisian model implies that skilled workers face more procyclical variation at the intensive margin (hours worked).

The predictions regarding differences in wage variability across skilled and unskilled workers are diametrically opposed in these two sets of models. The Azariadis-Baily-Gordon class of models posits the existence of contracts that assure skilled workers of smoother wages and employment, thereby implying a countercyclical wage premium for skilled labor. This is consistent with the findings of Reder (1955, 1962), who uses aggregate data to show that skilled-unskilled wage differentials narrow in booms and widen in recessions. The Hashimoto-Raisian model, on the other hand, implies that workers with more specific capital face more variable wages. That is, skilled workers may have more stable employment but are subject to greater wage variability than unskilled workers. This implies procyclical wage differentials between skilled and unskilled workers. Raisian (1983) provides evidence in support of this view.

We attempt to provide an empirical resolution of this issue using a detailed set of micro survey data to correct for various potential sources of bias. In our empirical work, we use different proxies for skills in order to disentangle the various effects of human capital on wage and employment variability. The primary determinant of general human capital is education. The costs of such human capital investment are usually considered to be borne entirely by the worker, as are the returns accruing from it. It is also likely that measures of general human capital, such as education, are highly positively correlated with levels of specific human capital. For instance, workers with a college degree presumably have attributes that make them more efficient at acquiring specific capital. Thus, education levels are a good measure of general as well as specific human capital.

A more direct proxy for specific human capital is tenure on the current job (see Altonji and Shakotko (1987)). On-the-job training and learning-by-doing are likely to enhance skills that are of particular value to a specific firm or industry. Further, longer tenure arguably indicates the

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existence of specific capital that the firm and the worker are reluctant to lose.[7] Another useful proxy for human capital is total labor market experience, although it is not obvious what aspect of human capital this best measures. We use all three variables as proxies for skills and estimate a series of models that independently analyze their effects on wage and employment variability.

II. Econometric Framework

The basic regression model is as follows:

$$\ln W_{it} = \mathbf{X}_{it}\boldsymbol{\beta} + U_t\alpha + \mu_i + \epsilon_{it} \qquad \forall i = 1,2,\ldots,N;$$
$$t = 1,2,\ldots,T. \tag{1}$$

The real hourly wage rate of individual i at time t is represented by W_{it}. $\mathbf{X}_{it}$ is a vector of observed individual-specific variables that affect this wage rate, with associated coefficient vector $\boldsymbol{\beta}$. In our application, we use the aggregate unemployment rate in the economy, U_t, as an indicator of the cycle.[8] α indicates the relation between the real wage and the business cycle. For instance, a negative estimate of α would imply that the average real wage declines when the aggregate unemployment rate rises (or that the average real wage is procyclical). μ_i stands for a vector of unobserved individual-specific characteristics that are fixed over time. The elements of μ_i may be correlated with $\mathbf{X}_{it}$. The regression error ϵ_{it} is assumed to be independently and identically distributed (i.i.d.).

We are interested in estimating the effects of observed measures of skills on the cyclicality of a worker's real wage. This is accomplished by including an appropriate interaction term as follows:

$$\ln W_{it} = \mathbf{X}_{it}\boldsymbol{\beta} + U_t\alpha + U_iE_{it}\gamma + \mu_i + \epsilon_{it}$$
$$\forall i = 1,2,\ldots,N; \qquad t = 1,2,\ldots,T. \tag{2}$$

The variable E_{it} is a measure of skill level (it should also be included in $\mathbf{X}_{it}$). The coefficient γ on the interaction term U_tE_{it} captures differences in the cyclicality of wages for workers with different skill levels. A positive estimate of γ would indicate a countercyclical wage premium for skills—

[7] Length of tenure is also a good measure of the quality of the match between a worker and a firm. Given the uncertainty inherent in job matching, workers and firms would both be reluctant to terminate a good match when faced with a temporary decline in demand or productivity. For our purposes, the quality of a job match may be considered part of a worker's specific capital.

[8] Our results were not significantly affected by the choice of the business cycle indicator. See the discussion in the next section.

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that is, the skill premium increases when the unemployment rate rises. Conversely, a negative γ would indicate a procyclical skill premium.

Estimating equation (2) by ordinary least squares (OLS), with $\mu_i + \epsilon_{it}$ being the composite error term, would yield biased estimates of β and γ unless the variables in μ_i were uncorrelated with the regressors. In general, this is not likely to be true. Workers with a high (unobserved) value of μ_i are high-ability workers. If high-ability workers were less likely to be laid off in a recession than were low-ability workers, the mean level of μ_i among employed workers would covary positively with the aggregate unemployment rate. The correlation between such unobserved individual fixed effects and the unemployment rate would induce an upward (countercyclical) bias in the estimated coefficient on the unemployment rate. Similarly, if an unobserved component of ability were positively correlated with, say, the observed level of education, the estimated coefficient on the education variable would be biased upward.

The interaction coefficient γ is subject to similar bias. For instance, if an increase in the aggregate unemployment rate caused the average unobserved ability of workers in lower skill categories (those with lower values of E_{it}) to rise relative to the average unobserved ability of workers in higher skill categories, γ would be biased downward. This procyclical bias in the estimated cyclical variation of the skill premium would spuriously indicate a narrowing (or understate the increase) of the skill premium in a recession.

To deal with such unobserved individual fixed effects, we employ a fixed effects estimator by using OLS to estimate the following transformed equation:

$$\ln \tilde{W}_{it} = \tilde{\mathbf{X}}_{it}\beta + \tilde{U}_t\alpha + \tilde{U}_t E_{it}\gamma + \tilde{\epsilon}_{it},$$

where $$\ln \tilde{W}_{it} = \ln W_{it} - \frac{1}{T}\sum_{t=1}^{T} \ln W_{it},$$

$$\tilde{\mathbf{X}}_{it} = \mathbf{X}_{it} - \frac{1}{T}\sum_{t=1}^{T} \mathbf{X}_{it},$$

$$\tilde{U}_t = U_t - \frac{1}{T}\sum_{t=1}^{T} U_t,$$

$$\tilde{U}_t E_{it} = U_t E_{it} - \frac{1}{T}\sum_{t=1}^{T} U_t E_{it},$$

$$\tilde{\epsilon}_{it} = (\epsilon_{it} + \mu_i) - \frac{1}{T}\sum_{t=1}^{T} (\epsilon_{it} + \mu_i)$$

$$= \epsilon_{it} - \frac{1}{T}\sum_{t=1}^{T} \epsilon_{it}. \qquad (3)$$

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This transformation subtracts out individual means over time for each variable, causing the individual fixed effects to drop out. The error term $\bar{\epsilon}_{it}$ is i.i.d. and is uncorrelated with the regressors. Note that to implement the fixed effects model we need to leave out control variables that are constant over time or collinear with the time trend.

To estimate the cyclical behavior of wages and skill premia at the industry level, we could include interactions of U_t and $U_t E_{it}$ with industry dummies. Specifically, the following counterpart to the OLS model in equation (2) may be employed:

$$\ln W_{it} = \mathbf{X}_{it}\boldsymbol{\beta} + \sum_{j=1}^{J} I_{ijt} U_t \alpha_j + \sum_{j=1}^{J} I_{ijt} U_t E_{it} \gamma_j + \boldsymbol{\mu}_i + \epsilon_{it}. \tag{4}$$

I_{ijt} is a binary indicator variable that takes the value one if worker i locates in industry j at time t. Otherwise, I_{ijt} equals zero. The coefficients α and γ are now indexed by industry. For instance, γ_j is an estimate of the cyclical variation in the skill premium in industry j. With appropriate transformations of the variables as described in equation (3), a similar pooled regression could be used to estimate the fixed effects model at the industry level:

$$\ln \tilde{W}_{it} = \tilde{\mathbf{X}}_{it}\boldsymbol{\beta} + \sum_{j=1}^{J} I_{ijt} \tilde{U}_t \alpha_j + \sum_{j=1}^{J} I_{ijt} \tilde{U}_t E_{it} \gamma_j + \tilde{\epsilon}_{it}. \tag{5}$$

A potential problem with specification (5) is that it restricts individual fixed effects to be the same across all industries. This would bias the coefficients of industry-level estimates if there were industry-specific unobserved fixed effects that were correlated with any of the regressors.[9] Further, both equations (4) and (5) restrict the coefficient vector $\boldsymbol{\beta}$ to be the same across industries. This implies the strong assumption that the returns to observed worker characteristics are the same in all industries.

Apart from unobserved individual fixed effects and industry-specific effects, there remains another potential source of bias. All of the above discussion assumes that the mean of $\bar{\epsilon}_{it}$ conditional on individual i being employed in period t is zero. But notice that wages are observed only for those individuals who are employed in a given period. If an unobserved component of ability that affected the wage rate for an individual was correlated with the unobserved component that affected that individual's probability of employment, we would be faced with a typical selection

[9] Industry-specific fixed effects are a potential problem only in the case of workers switching industries over the sample period. Workers who stay in one industry over the entire sample period would have their industry-specific fixed effects eliminated by the transformation described in equation set (3).

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bias problem.[10] For instance, changes in U_t may cause workers with systematically high or low values of the time-varying unobserved productivity component (reflected in high or low values of $\bar{\epsilon}_{it}$) to enter or leave employment in an industry. The effect of changes in average labor force quality resulting from the inflow or outflow of high or low productivity workers would then bias the unemployment rate coefficient. If, in addition, the magnitude of this effect differed by skill level, a fixed effects estimate of γ_j would be a biased estimate of the change in the mean offer-wage differential in industry j.

To eliminate the effect of cyclical changes in the composition of the work force induced by such systematic selection, we estimate the variability of mean industry offer wages for different classes of workers using a maximum-likelihood version of Heckman's (1974) self-selection model. This model estimates a wage equation for each industry jointly with a probit choice equation that determines whether a worker locates in that industry. The model is written as follows:

$$\ln W_{ijt} = \mathbf{X}_{it}\boldsymbol{\beta}_j + U_t\alpha_j + U_t E_{it}\gamma_j + \mu_{ij} + \epsilon_{ijt},$$
$$\textit{observed iff } I_{ijt} = 1,$$

$$\text{where} \quad I^*_{ijt} = \mathbf{Z}_{it}\boldsymbol{\theta}_j + U_t\delta_j + U_t E_{it}\eta_j + \Psi_{ij} + \omega_{ijt},$$

$$I_{ijt} = \begin{cases} 1 \textit{ if } I^*_{ijt} \geq 0 \\ 0 \textit{ if } I^*_{ijt} < 0 \end{cases}. \tag{6}$$

Here I^*_{ijt} is the latent index of a probit employment equation that determines whether worker i is employed in industry j at time t. $\mathbf{Z}_{it}$ is a vector of individual-specific regressors that affect the probability of employment in industry j at time t. The corresponding coefficient vector is denoted by $\boldsymbol{\theta}_j$. Typically, $\mathbf{Z}_{it}$ contains elements that enter into $\mathbf{X}_{it}$ as well as some additional variables that may affect labor supply propensity but not worker productivity. Since our data set does not contain any variables that fall clearly into this category, we include the same set of controls in the wage and employment choice equations. Further, our results were not sensitive to the overidentifying restrictions of omitting variables from $\mathbf{X}_{it}$. Individual fixed effects in the employment choice equation are represented by Ψ_{ij}.

[10] It might appear, from the specification in equation (2), that individual fixed effects could be eliminated by first differencing the data. However, such a procedure may exacerbate this selectivity bias if there are any missing data, except under a set of restrictive conditions. This is because differencing would require selecting only those pairwise adjacent periods for which an individual has an observed wage in both. See Keane, Moffitt, and Runkle (1988, pp. 1238–44) for a detailed discussion.

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We estimate binomial selection models separately for each industry. This allows fixed effects to vary across industries and, thus, obviates the potential bias from restricting the fixed effects for any given individual to be the same across all industries. Further, it allows the coefficient vector $\boldsymbol{\beta}$ to vary across industries.[11]

The error terms ϵ_{ijt} and ω_{ijt} are assumed to have a bivariate normal distribution with correlation ρ_j and respective standard deviations σ_{ϵ_j} and 1. The latter variance is normalized to one for identification of the probit choice equation. The parameter ρ_j, estimated from the cross-equation correlation between wage equation residuals and employment equation residuals, is crucial for correcting the selection bias. The sign of this correlation coefficient is informative. A negative estimate of ρ_j, for instance, would indicate that workers with a high transitory wage component are more likely to be laid off in a downturn. This would, if a selection correction is not employed, bias the estimated effect of the cycle on the real wage and the skill premium.[12]

The source of selection bias can now be demonstrated fairly easily. For instance, consider the coefficient α_j in the above wage equation. Under the distributional assumptions made above (and ignoring fixed effects for the moment), we have

$$\frac{\partial E(\ln W_{ijt} \mid I_{ijt} = 1)}{\partial U_t} = \alpha_j - \rho_j \sigma_{\epsilon_j} m_{ijt} \delta_j,$$

where $m_{ijt} = \lambda_{ijt}(\lambda_{ijt} + \mathbf{Z}_{it}\boldsymbol{\theta}_j + U_t\delta_j)$ and λ_{ijt} is the Mill's ratio. It can be shown that $m_{ijt} > 0$. Hence, the estimate of α_j is biased downward if ρ_j and δ_j have the same sign and is biased upward if they have opposite signs. The other coefficients in the wage equation are also affected by selection bias.

[11] Estimating a single, multinomial model with selection corrections would require sector-specific regressors in order to identify cross-correlations among the error terms in the choice equations. We do not have such regressors in our

[12] In the fixed effects selection model, estimates of the choice equation fixed effects are inconsistent for small T. Monte-Carlo experiments by Heckman (1981) show that this inconsistency is small for $T > 8$. In our data set, T is on average 6 (with a maximum value of 12), indicating that inconsistency is a potential problem. However, the estimated ρ in the model with fixed effects in both the wage and employment equations always went to 1 or -1. Hence, the results we report are from a model with fixed effects in the wage equation alone. This obviates the problem of inconsistency of the estimated fixed effects in the choice equation. Besides, consistent estimation of the choice equation parameters is not important for our main results. Further, in our estimates reported below, we obtain values of ρ close to zero. Hence, any transfer of inconsistency from the choice equation to the wage equation would be negligible.

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The selection-corrected fixed effects estimator in this paper is implemented by full-information maximum likelihood.[13]

III. Data

The data set used in this paper is the National Longitudinal Survey of Young Men (NLS), comprising a nationally representative sample of 5,225 young males. The participants were between 14 and 24 years of age in 1966 and were interviewed in 12 of the 16 years from 1966 to 1981. Data were collected on their employment status, wage rates, and sociodemographic characteristics. We screened the sample to include only those persons who, as of the interview date, were at least 21 years of age, had completed their schooling and military service, and had available data for all variables used in our analysis. The final sample contained 4,439 males and a total of 23,927 person-year observations. This included years when the person being interviewed was unemployed. The employment status dummy is nonzero in 21,203 of these person-year observations. Table A1 in the Appendix reports sample means for the individual specific variables used in the estimation. Workers are classified into 11 broadly defined industries on the basis of the three-digit census industrial classification (CIC) codes. The list of industries, their CIC codes, and the sample size for each industry are reported in the Appendix in Table A2.

The wage measure we use is the hourly straight-time earnings reported by workers for the survey week. This measure is deflated by the consumer price index (CPI) to provide a real wage measure normalized in terms of 1967 dollars. It is important to note that this is a point-in-time wage measure taken at the date of the interview. This obviates the recall bias that may contaminate annual measures that are obtained by dividing annual earnings by annual hours worked. The NLS does not include data on overtime earnings in all of the interview years. Hence, we restrict ourselves to a straight-time wage measure rather than attempt to impute overtime earnings for years in which they were not available. To adjust for nonwage compensation, such as variation in fringe benefits across industries, the hourly wage rate for each worker is multiplied by the ratio of total labor costs to wages in the corresponding industry. Data on total labor costs are obtained from the National Income and Product Accounts. The log of this adjusted real wage measure, denoted by W_{CPI}, is

[13] An alternative two-stage procedure developed by Heckman (1979) yields estimates that are consistent but not efficient. This motivates our use of full-information maximum likelihood.

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used in all of our analysis. This variable has a sample mean of 1.065 in 1967 dollars.

The *HOURS* variable we use in this study is a measure of the weekly hours worked reported by the worker for the survey week. In four of the survey years, this variable was unavailable, and we use the "usual weekly hours worked" instead.[14] The three variables used as proxies for human capital are *DEGREE*, *EXPERIENCE*, and *TENURE*. *DEGREE* is a dummy variable that takes the value one if the worker has a college degree and zero if he or she does not. *EXPERIENCE* is defined as the total number of years of labor market experience; it is calculated as the interview date minus the completion date of a worker's schooling or military service, whichever is later. It is important to note that the *EXPERIENCE* variable is a measure of labor force participation rather than of actual work experience. *TENURE* is defined as the length of uninterrupted tenure (in years) on the current job.

We use the aggregate civilian unemployment rate in the economy as an indicator of the business cycle. The variable *URATE* is defined as the seasonally adjusted monthly unemployment rate for all civilian workers aged 16 years and older. We also experimented with other indicators of the business cycle, such as real GNP. Our main conclusions do not appear very sensitive to the particular choice of the business cycle indicator. We report below only the results using the aggregate unemployment rate.

IV. Empirical Results

This section presents empirical results on employment, hours, and wage variability across skill levels and concludes with an interpretation of the findings.

Employment Variability

Table 1 contains estimates from a set of linear employment probability models. The first two columns report results from regressions with the *URATE* * *DEGREE* interaction term.[15] The second set of columns con-

[14] For the survey years in which both of these hours variables are available, the correlation between them is about 0.6. About 45 percent of the observations for the *HOURS* variable used in this study lie in the range of 37 to 40 hours a week.

[15] In this and all the tables that follow, we run separate regressions for each of the interaction terms. We do this to compare the effects of different proxies for human capital. Further, it is instructive (and much less tedious) to examine and interpret the magnitude of fixed effects and selection corrections for each of the human capital variables separately.

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tains results from a similar regression using the *URATE * EXPERIENCE* term. In this table, the estimated coefficients on the interaction terms measure the differential impact of the cycle on employment probabilities for skilled and unskilled workers.[16] In the top row, the significant positive coefficient on *URATE * DEGREE* for all workers (0.0161, with a standard error of 0.0035) implies that workers with higher levels of education have lower procyclical employment probabilities. In fact, the sum of the coefficients on *URATE* and *URATE * DEGREE* (−0.0164 + 0.0161) is close to zero indicating that workers with a college degree have essentially acyclical employment patterns. *EXPERIENCE*, on the other hand, does not seem to affect employment probabilities over the cycle, as the interaction term *URATE * EXPERIENCE* for all workers has a coefficient (−0.0005, s.e. 0.0003) that is not significantly different from zero.

The remaining rows of the table break down the sample by industry. In our sample, durable manufacturing accounts for the bulk of the aggregate cyclical variation in employment. In this industry, workers with college degrees face little cyclical variation in employment probabilities. The employment probabilities of workers with a degree are procyclical in services and F.I.R.E. (finance, insurance, and real estate) and countercyclical in construction and retail trade. For workers without degrees, employment probabilities are highly procyclical in durable manufacturing and acyclical in all other industries.

Increased experience, by contrast, seems to lead to less procyclical employment in durable manufacturing. However, in retail trade and government, the *URATE * EXPERIENCE* coefficient is significantly negative, indicating that workers with more experience are more likely to be laid off in a recession. Experience does not have a significant effect in the remaining industries, where the weak employment effect may be due to the substitution of younger workers for older workers in a recession. Given the young age of our sample, this may offset the overall negative employment effect in those industries during a recession.

To sum up, Table 1 indicates that having a college degree significantly reduces the cyclical variation in a worker's employment probability. On the other hand, the total labor force experience possessed by a worker does not have a similar effect on the cyclicality of his or her employment probability except in durable manufacturing, where increased experience significantly reduces procyclical variation in employment.

[16] *TENURE* was not used as a regressor in the employment choice equations in Table 1. The estimated equations in that table are essentially reduced-form equations for employment choice, and obviously *TENURE* would be endogenous in the choice equation.

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Table 1. *Estimated Correlations of Business Cycle with Employment Probabilities*

	URATE	*URATE * DEGREE*	*URATE*	*URATE * EXPERIENCE*
All workers	−0.0164*	0.0161**	−0.0099**	−0.0005
	(0.0020)	(0.0035)	(0.0028)	(0.0003)
Durable manufacturing	−0.0137**	0.0109**	−0.0170**	0.0008**
	(0.0025)	(0.0044)	(0.0035)	(0.0004)
Construction	−0.0029	0.0075**	−0.0003	−0.0001
	(0.0018)	(0.0032)	(0.0026)	(0.0003)
Transportation and utilities	−0.0015	0.0046	0.0001	−0.0001
	(0.0017)	(0.0030)	(0.0024)	(0.0003)
Wholesale trade	−0.0006	−0.0028	−0.0012	0.0000
	(0.0013)	(0.0033)	(0.0018)	(0.0002)
Retail trade	0.0022	0.0079**	0.0088**	−0.0007**
	(0.0019)	(0.0033)	(0.0027)	(0.0003)
F.I.R.E.[a]	0.0012	−0.0043**	0.0001	0.0000
	(0.0012)	(0.0020)	(0.0016)	(0.0002)
Services	0.0017	−0.0137**	−0.0026	0.0002
	(0.0020)	(0.0035)	(0.0028)	(0.0003)
Government	−0.0016	0.0046*	0.0029	−0.0005**
	(0.0015)	(0.0026)	(0.0021)	(0.0002)
Agriculture	0.0002	0.0000	0.0005	−0.0001
	(0.0009)	(0.0016)	(0.0013)	(0.0001)
Mining	0.0001	0.0011	0.0007	−0.0001
	(0.0007)	(0.0013)	(0.0010)	(0.0001)

Notes: Standard errors are in parentheses. Double asterisks (**) indicate significance at 5 percent level. A single asterisk (*) indicates the 10 percent level. Sample size = 23,927. Controls are a time trend; education; experience and its square; four dummies for types of college degrees; five dummies for fields of degree; an SMSA dummy; a south dummy; a race dummy; a marriage dummy; number of children; and interac ions of experience with education, a college degree dummy, and a race dummy.

[a] Financial services, insurance, and real estate.

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Variation in Weekly Hours

Table 2 provides estimates of the cyclical variability of weekly hours worked. The estimation framework is identical to that used for real wages, as discussed earlier. As in the case of wages, unobserved individual fixed effects could potentially bias measures of cyclical variation in weekly hours worked. For instance, it is likely that low-ability workers, on average, work fewer hours and are more likely to get laid off in a recession. This compositional change over the cycle might induce an upward bias in the *URATE* coefficient and indicate countercyclicality in weekly hours worked. However, OLS estimates for virtually all of the relevant coefficients were of the same sign and generally close in magnitude to the fixed effects (FE) estimates. Hence, we report only FE estimates in Table 2.

The first two columns of Table 2 contain results from regressions with the *URATE* * *DEGREE* interaction term. In the top row, the coefficient on *URATE* for all workers is −0.0061 (s.e. 0.0014) and the coefficient on *URATE* * *DEGREE* is 0.0082 (s.e. 0.0022).[17] Since the sum of these coefficients is near zero, weekly hours are essentially acyclical for workers with a college degree. On average, however, weekly hours worked are estimated to decline by 0.42 percent for every 1 percentage point increase in the unemployment rate.[18] At the industry level, these results corroborate the aggregate finding that educated workers face little cyclical variation in weekly hours. In fact, weekly hours for educated workers appear to be weakly countercyclical in durable manufacturing, F.I.R.E., and services. On average, hours are procyclical in durable and nondurable manufacturing, transportation and utilities, retail trade, and agriculture.

The fact that, for workers with a degree, weekly hours are much less cyclical at the aggregate level, and are even countercyclical in industries such as durable manufacturing, is an important result. Since educated workers typically earn higher wages than other workers, our findings imply a countercyclical bias in those measures of hourly wages that simply

[17]The *URATE* coefficient is an estimate of the percentage change in weekly hours for workers without a college degree, associated with a 1 percentage point rise in the unemployment rate. For workers with a degree, this is given by the sum of the coefficients on *URATE* and *URATE* * *DEGREE*.

[18]The mean value of the *DEGREE* variable in our sample is 0.23. Multiplying this by the coefficient on *URATE* * *DEGREE* and adding the product to the *URATE* coefficient yields an estimate of the percentage change in average weekly hours associated with a 1 percentage point increase in the unemployment rate [(0.23 * 0.0082) − 0.0061 = −0.0042)].

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Table 2. *Estimated Correlations of Business Cycle with Weekly Hours Worked: Fixed Effects Estimates*

(Dependent variable: Log weekly hours)

	URATE	*URATE * DEGREE*	*URATE*	*URATE * TENURE*	*URATE*	*URATE * EXPERIENCE*
All workers	−0.0061**	0.0082**	−0.0049**	0.0002	0.0006	−0.0007**
	(0.0014)	(0.0022)	(0.0018)	(0.0003)	(0.0023)	(0.0003)
Durable manufacturing	−0.0077**	0.0131**	−0.0057*	0.0003	0.0020	−0.0009**
	(0.0023)	(0.0029)	(0.0029)	(0.0004)	(0.0036)	(0.0003)
Nondurable manufacturing	−0.0098*	0.0088**	−0.0058*	0.0000	−0.0035	−0.0007**
	(0.0029)	(0.0034)	(0.0036)	(0.0004)	(0.0042)	(0.0003)
Construction	−0.0035	0.0019	−0.0063*	0.0004	0.0003	−0.0006*
	(0.0032)	(0.0039)	(0.0036)	(0.0004)	(0.0047)	(0.0003)
Transportation and utilities	−0.0076**	0.0097**	−0.0083	0.0004	−0.0029	−0.0006*
	(0.0035)	(0.0039)	(0.0044)	(0.0004)	(0.0050)	(0.0003)
Wholesale trade	−0.0048	0.0050	−0.0028	−0.0002	0.0027	−0.0009**
	(0.0045)	(0.0035)	(0.0051)	(0.0004)	(0.0057)	(0.0004)
Retail trade	−0.0058*	0.0048	−0.0066*	0.0003	0.0008	−0.0008**
	(0.0030)	(0.0033)	(0.0035)	(0.0004)	(0.0043)	(0.0003)
F.I.R.E.[a]	−0.0032	0.0091**	−0.0020	0.0002	0.0083	−0.0011**
	(0.0056)	(0.0039)	(0.0059)	(0.0005)	(0.0071)	(0.0004)
Services	−0.0047	0.0082**	−0.0036	0.0004	−0.0039	−0.0002
	(0.0031)	(0.0027)	(0.0032)	(0.0004)	(0.0037)	(0.0003)
Government	−0.0037	0.0062*	0.0001	0.0000	0.0090*	−0.0011**
	(0.0044)	(0.0035)	(0.0052)	(0.0004)	(0.0055)	(0.0004)
Agriculture	−0.0127**	0.0082	−0.0146**	0.0005	0.0062	−0.0014**
	(0.0061)	(0.0084)	(0.0072)	(0.0006)	(0.0089)	(0.0004)
Mining	0.0059	0.0137*	−0.0031	0.0006	0.0225**	−0.0013**
	(0.0079)	(0.0083)	(0.0090)	(0.0006)	(0.0106)	(0.0005)

Notes: Standard errors are in parentheses. Double asterisks (**) indicate significance at 5 percent level. A single asterisk (*) indicates the 10 percent level. Sample size = 21,004. For the tenure equations, sample size = 20,309 since the tenure variable is not available for all employed workers. The same set of controls is used as in Table 1, except that tenure is added as an additional control for the second set of equations.

[a] Financial services, insurance, and real estate.

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divide the aggregate wage bill by aggregate hours in an industry.[19] However, the bias induced by differentials in hours variability across skill levels turns out to be rather small, once differentials in employment variability are accounted for.[20] Turning to the second set of columns in Table 2, it is clear that tenure has virtually no effect on weekly hours either at the aggregate level or in any of the industries. In the third set of columns, the coefficient on *URATE * EXPERIENCE* is significantly negative for all workers and in virtually every industry. This indicates that older workers are more likely to work fewer hours in a recession.

While Table 2 shows that average weekly hours worked are clearly procyclical, the magnitude of the variation in weekly hours appears to be much less important than variation in employment in accounting for cyclical fluctuations in aggregate hours.[21] The aggregate results from all three panels indicate that weekly hours decline by about 0.4 percent when the unemployment rate goes up by 1 percent. In other words, variation in average weekly hours accounts for about 30 percent of the total variation in aggregate hours. This echoes the findings of Hansen (1985) and others that a substantial fraction of the variation in aggregate hours in the postwar U.S. economy is explained by employment variation rather than variation in weekly hours.

However, in a few industries that exhibit weak employment responses to the cycle, it appears that procyclical hours variation may account for a relatively larger share of the variation in total labor input. Nondurable manufacturing, transportation and utilities, retail trade, and agriculture fall into this category.

Wage Variability

Table 3 presents results from a series of estimated wage equations that incorporate the *URATE * DEGREE* interaction term. The first two

[19] For the average wage measure from aggregate data to be countercyclically biased, it is sufficient that the interaction coefficient in the hours regression be significantly positive.

[20] Note that 23 percent of the observations in our sample have a college degree. Weekly hours are acyclical for workers without a degree and their hours decline by 0.6 percent when the unemployment rate goes up by 1 percentage point. Thus, when the unemployment rate goes up, for instance, by 5 percent, uneducated workers face a 3 percent decline in hours. Assume that a college degree yields a wage premium of 50 percent (workers with a degree are 50 percent more productive). Then, after controlling for employment variation, an unweighted total hours measure would overstate the decline in quality-corrected hours (and, thereby, lead us to understate the decline in mean offer wages) by less than a quarter of a percent.

[21] When unemployment goes up by 1 percentage point and weekly hours fall by 0.4 percent, the reduction in total hours is roughly 1.4 percent. Hence, it can be inferred that the decline in weekly hours accounts for about 30 percent (0.4/1.4) of the fall in total hours.

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Table 3. *Estimated Correlations of Business Cycle with Real Wages: Degree Interactions*

(Dependent variable: Log real wage)

	OLS estimates		Fixed effects estimates		election-corrected fixed effects	
	URATE	*URATE * DEGREE*	*URATE*	*URATE * DEGREE*	*URATE*	*URATE * DEGREE*
All workers	0.0031	−0.0294**	−0.0062**	0.0013	−0.0057**	0.0012
	(0.0024)	(0.0041)	(0.0017)	(0.0026)	(0.0019)	(0.0013)
Durable manufacturing	0.0073**	−0.0348**	−0.0033	−0.0028	−0.0049*	−0.0059*
	(0.0036)	(0.0048)	(0.0026)	(0.0034)	(0.0030)	(0.0026)
Nondurable manufacturing	0.0082*	−0.0231**	−0.0044	−0.0004	−0.0029	−0.0170**
	(0.0046)	(0.0051)	(0.0034)	(0.0039)	(0.0033)	(0.0030)
Construction	−0.0118**	−0.0468**	−0.0112**	−0.0015	−0.0135**	0.0010
	(0.0049)	(0.0056)	(0.0037)	(0.0046)	(0.0040)	(0.0045)
Transportation and utilities	0.0222**	−0.0393**	0.0060	−0.0057	0.0037	0.0067
	(0.0055)	(0.0053)	(0.0041)	(0.0045)	(0.0043)	(0.0049)
Wholesale trade	−0.0005	−0.0091	0.0007	0.0104**	−0.0020	0.0046
	(0.0007)	(0.0057)	(0.0052)	(0.0041)	(0.0051)	(0.0038)
Retail trade	−0.0079*	−0.0253**	−0.0065*	0.0055	−0.0057	0.0136**
	(0.0047)	(0.0052)	(0.0035)	(0.0038)	(0.0036)	(0.0041)
F.I.R.E.[a]	−0.0070	−0.0181**	−0.0087	0.0113**	−0.0111*	−0.0044
	(0.0086)	(0.0057)	(0.0065)	(0.0046)	(0.0061)	(0.0043)
Services	−0.0039	−0.0245**	−0.0214**	0.0079**	−0.0161**	0.0152**
	(0.0049)	(0.0048)	(0.0036)	(0.0031)	(0.0044)	(0.0030)
Government	0.0176**	−0.0300**	−0.0004	0.0027	0.0028	0.0004
	(0.0067)	(0.0051)	(0.0051)	(0.0041)	(0.0049)	(0.0030)
Agriculture	0.0102	−0.0132	0.0117*	−0.0019	0.0168*	−0.0130
	(0.0092)	(0.0080)	(0.0071)	(0.0097)	(0.0101)	(0.0167)
Mining	−0.0061	−0.0387**	−0.0156	−0.0022	0.0021	−0.0673**
	(0.0118)	(0.0094)	(0.0092)	(0.0096)	(0.0100)	(0.0080)

Note: Standard errors are in parentheses. Double asterisks (**) indicate significance at 5 percent level. A single asterisk (*) indicates the 10 percent level. Sample size = 21,004. Controls are a time trend; education; experience and its square; four dummies for types of college degrees; five dummies for fields of degree; four dummies for occupation; an SMSA dummy; a south dummy; a race dummy; a marriage dummy; number of children; and interactions of experience with education, a college degree dummy, and a race dummy. Estimates for the selection models use the full sample of 23,927 person-year observations. The probit employment choice equation estimates from the selection models are not reported here.

[a] Financial services, insurance, and real estate.

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columns contain results from OLS regressions (specification (4)). The next two columns contain results from a fixed effects estimator (specification (5)). The last two columns report results from a selection-corrected fixed effects model (specification (6)).[22]

In the first set of columns in Table 3, the estimated OLS coefficient on *URATE* * *DEGREE* for all workers is −0.0294 (s.e. 0.0041) indicating that, at the aggregate level, workers with a college degree face relatively more procyclical real wages.[23] A similar pattern holds at the industry level. The coefficients on the interaction terms *URATE* * *DEGREE* are significantly negative in a majority of the industries. Thus, the OLS estimates imply that, in a downturn, skilled workers find their wages falling relative to the wages of unskilled workers. Recall that Tables 1 and 2 showed that workers with college degrees are protected from cyclical variation in employment and hours. In conjunction, these results suggest that skilled workers accept steeper wage cuts in a downturn but have more stable employment and hours than unskilled workers. This accords with the predictions of the Hashimoto-Raisian model.

We turn next to the fixed effects estimates in Table 3. The change in the estimated coefficients relative to the OLS estimates is substantial, with some of the coefficients even reversing signs. Controlling for unobserved individual fixed effects changes the *URATE* coefficient for all workers from 0.0031 (s.e. 0.0024) to −0.0062 (s.e. 0.0017). This indicates that, among workers without a college degree, low-ability workers are more likely to be laid off in a downturn, thereby increasing labor force quality. This induces a positive (countercyclical) bias in the OLS *URATE* coefficient.

[22] Panels containing selection-corrected fixed effects estimates do not report estimates from the probit employment choice equations that were estimated jointly with the wage equations. The full effect of changes in the aggregate unemployment rate on unemployment probabilities must be read off the OLS employment probability models in Table 1.

[23] The coefficient on *URATE* measures the percentage change in the average real wage, for workers without a degree, associated with a 1 percentage point rise in the aggregate unemployment rate. For example, a coefficient of −0.0050 implies that a 1 percentage point increase in the aggregate unemployment rate causes a 0.5 percent decline in the real wage for unskilled workers (in the aggregate or in a particular industry, as the case may be). A positive coefficient on *URATE*, on the other hand, implies a countercyclical unskilled wage—an increase in the unskilled wage when the unemployment rate rises.

The interaction term *URATE* * *DEGREE* indicates how the cyclicality of the real wage faced by workers with a college degree differs from that of workers without one. A coefficient of 0.0100, for instance, indicates that, when the aggregate unemployment rate goes up by 1 percentage point, workers with a degree face a 1 percent increase in their real wage relative to that of unskilled workers (though the absolute real wage may decline for both types of workers). The sum of the coefficients on *URATE* and *URATE* * *DEGREE* measures the full effect of the cycle on the wage of workers with a degree.

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On the other hand, the coefficient on *URATE* * *DEGREE* changes from −0.0294 (s.e. 0.0041) to 0.0013 (s.e. 0.0026), indicating that the OLS estimate of the interaction coefficient is procyclically biased.[24] The FE estimate implies that the skilled wage falls at about the same percentage rate as the unskilled wage. In other words, after the fixed effects correction, the skilled-unskilled relative wage differential appears to be essentially acyclical.[25]

At the industry level, the *URATE* * *DEGREE* coefficient is insignificant for most industries except wholesale trade, F.I.R.E., and services. In these three industries, the interaction coefficient becomes positive and significant, indicating a countercyclical skill differential (that is, the relative wage of skilled workers rises in a downturn). In most industries, however, the fixed effects estimates show that, after controlling for unobserved time-invariant measures of ability, the relative wages of skilled and unskilled workers remain essentially unchanged over the cycle.

The last set of columns in Table 3 contains selection-corrected fixed effects (SCFE) estimates. The estimated parameter p (not reported here) was small and insignificantly different from zero in the aggregate and for all industries. This indicates that the correlation between the transitory components of workers' wages and their employment probabilities is small, once fixed effects are accounted for. It appears that most of the compositional changes over the cycle can be measured by the combination of observed characteristics of workers and unobserved individual fixed effects. Thus, the selection correction has little impact on the estimates. For all workers, the coefficient on *URATE* goes from −0.0062 (s.e. 0.0017) in the FE estimates to −0.0057 (s.e. 0.0019) in the SCFE estimates while the *URATE* * *DEGREE* coefficient remains insignificantly different from zero. This confirms the result that, at the aggregate level, the relative offer-wage differential between skilled and unskilled workers is essentially acyclical.[26]

At the industry level, the coefficients for most industries change from

[24]The biases in the OLS *URATE* and *URATE* * *DEGREE* coefficients offset each other to some extent. At the mean of the data, the OLS estimate of overall wage cyclicality is weakly countercyclically biased.

[25]The variable *URATE* trends upward over our sample period. Hence, workers who take longer to get a degree and who enter near the end of the sample have larger mean *URATE* * *DEGREE* values. Such workers also tend to have lower wages. This leads to a downward bias in the OLS interaction coefficient. The fixed effects estimates obviate this problem by considering only the effects of deviations of variables from their individual means.

[26]This implies that the absolute offer-wage differential is, in fact, procyclical. We focus on relative wage differentials since the emphasis of this paper is on the relative variability of wages across skill levels.

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the FE estimates. Since the estimated p is insignificant for all industries, this change is attributable to the potential bias in the FE estimates resulting from restricting the fixed effects and the returns to observed characteristics (that is, the coefficient vector β) to be the same across all industries.[27] The selection models are estimated separately for each industry, thereby controlling for general as well as industry-specific individual fixed effects. The industry estimates in the selection models also allow the returns to observed worker characteristics to vary across industries.[28]

In durable and nondurable manufacturing and in mining, the coefficient on *URATE* * *DEGREE* turns significantly negative. This means that in a recession degreed workers in those industries face a larger decline in offer wages than nondegreed workers. The difference between the FE and SCFE results may arise because skilled workers who leave manufacturing and mining in a recession have a lower level of industry-specific individual fixed effects than those who remain (in other words, unobserved quality rises). Alternatively, this difference may arise because the returns to observable quality are higher than average in manufacturing and mining, and high–(observed) quality workers move into these industries during a recession. In any case, these three industries provide strong support for the Hashimoto-Raisian hypothesis that skilled workers take larger wage cuts in a downturn than unskilled workers. On the other hand, in retail trade and services, the interaction term is positive and significant. In those industries, workers with a college degree do better, in relative terms, when the aggregate unemployment rate in the economy goes up.

Next, we look at the effect of another human capital variable, *TENURE*. Table 4 contains OLS and fixed effects estimates of wage equations that include the *URATE* * *TENURE* interaction term.[29] The coefficient on *URATE* * *TENURE* for all workers is close to zero in both

[27] Industry-specific individual fixed effects are a potential source of bias only if (i) they are correlated with the regressors in the model and (ii) individuals in the sample switch industries. Employing the same data set as in this paper, Jovanovic and Moffitt (1990) find that gross flows across sectors average as much as 17.2 percent of the sample between two-year survey waves. Moreover, their three-sector classification probably understates the gross flows relative to the finer industry classification used in this paper. Such high mobility is partly attributable to the young age of the sample.

[28] Fixed effects models estimated separately for each industry yield point estimates close to the SCFE industry estimates. Rather than present yet another set of estimates, we chose to report only the SCFE industry estimates since they correct for all the sources of bias that we discussed earlier.

[29] As noted earlier, *TENURE* would be endogenous in the employment choice equation. Hence, we are unable to estimate the selection-corrected fixed effects model using this variable.

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Table 4. *Estimated Correlations of Business Cycle with Real Wages: Tenure Interactions*
(Dependent variable: Log real wage)

	OLS estimates		Fixed effects	
	URATE	*URATE * TENURE*	*URATE*	*URATE * TENURE*
All workers	−0.0036	−0.0001	0.0052**	−0.0004
	(0.0027)	(0.0005)	(0.0021)	(0.0004)
Durable manufacturing	−0.0029	−0.0002	−0.0019	−0.0002
	(0.0041)	(0.0005)	(0.0043)	(0.0005)
Nondurable manufacturing	−0.0030	−0.0003	0.0032	−0.0003
	(0.0051)	(0.0005)	(0.0053)	(0.0006)
Construction	−0.0053	−0.0024**	−0.0042	−0.0025**
	(0.0050)	(0.0006)	(0.0053)	(0.0006)
Transportation and utilities	0.0071	−0.0003	0.0092	−0.0002
	(0.0059)	(0.0005)	(0.0062)	(0.0006)
Wholesale trade	0.0081	−0.0002	0.0054	0.0003
	(0.0072)	(0.0006)	(0.0076)	(0.0006)
Retail trade	−0.0093**	0.0003	−0.0127**	0.0003
	(0.0050)	(0.0005)	(0.0052)	(0.0006)
F.I.R.E.[a]	−0.0159*	0.0008	−0.0171**	0.0008
	(0.0082)	(0.0007)	(0.0086)	(0.0007)
Services	−0.0103**	−0.0004	−0.0125**	−0.0005
	(0.0045)	(0.0005)	(0.0047)	(0.0005)
Government	−0.0039	0.0001	−0.0011	−0.0002
	(0.0069)	(0.0006)	(0.0073)	(0.0006)
Agriculture	0.0367	−0.0040**	0.0355**	−0.0042**
	(0.0096)	(0.0007)	(0.0101)	(0.0008)
Mining	0.0025	−0.0020**	0.0007	−0.0021**
	(0.0121)	(0.0006)	(0.0127)	(0.0009)

Notes: Standard errors are in parentheses. Double asterisks (**) indicate significance at 5 percent level. A single asterisk (*) indicates the 10 percent level. Sample size = 20,309. Same controls as in Table 3 are used, except that tenure is added as an additional control variable.

[a] Financial services, insurance, and real estate.

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the OLS and FE estimates. This seems to indicate that specific human capital levels, as measured by tenure on the current job, have virtually no effect on relative wage variability.

At the industry level, *TENURE* has little effect on the cyclicality of wages in a majority of the industries. In construction, agriculture, and mining, workers with longer tenure have marginally more procyclical wages, since the *URATE* * *TENURE* coefficients are negative but not very large in magnitude in both the OLS and FE estimates. We conclude from Table 4 that workers with different amounts of tenure face essentially the same degree of cyclical variation in real wages. Interpreting specific capital levels as a measure of skill, this bolsters the conclusion drawn from the previous table that, at the aggregate level, the relative wage differential between skilled workers and unskilled workers is acyclical.

Finally, we examine the effect of total labor market experience on the cyclicality of wages. The first set of columns in Table 5 contains OLS estimates of the wage equation with the *URATE* * *EXPERIENCE* interaction term. For all workers, the coefficient on *URATE* * *EXPERIENCE* is −0.0010 (s.e. 0.0004), implying a tenth of a percent increase in the cyclical sensitivity of wages for every added year of experience.

A similar pattern holds at the industry level. The coefficients on the interaction term *URATE* * *EXPERIENCE* are significantly negative in a majority of the industries. In industries where the average real wage is highly procyclical, experience does not have much effect. This includes construction, retail trade, and F.I.R.E. On the other hand, the coefficient on *URATE* is significantly positive in nondurable manufacturing, transportation and utilities, government, and agriculture, indicating a countercyclical average real wage for new entrants in those industries. The *URATE* * *EXPERIENCE* coefficient is negative and significant in each of those four industries, implying that added experience reduces the countercyclicality of a worker's real wage.[30]

The fixed effects estimates in the second set of columns reinforce this picture. The coefficient on *URATE* becomes significantly positive in the aggregate and for most industries. The coefficient on *URATE* * *EXPERIENCE* for all workers goes from −0.0010 (s.e. 0.0004) in the OLS estimates to −0.0026 (s.e. 0.0003) in the fixed effects estimates. The *URATE* * *EXPERIENCE* coefficient is negative and significant in all

[30]The cyclicality of the average real wage is given by the sum of (i) the coefficient on *URATE* and (ii) the *URATE* * *EXPERIENCE* coefficient multiplied by the mean level of *EXPERIENCE* in the sample (7.9 for all workers). In the four industries mentioned here, the *URATE* coefficient is positive and more than 12 times the magnitude of the respective *URATE* * *EXPERIENCE* coefficient (which is negative in all four cases).

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Table 5. *Estimated Correlations of Business Cycle with Real Wages: Experience Interactions*
(Dependent variable: Log real wage)

	OLS estimates		Fixed effects estimates		Selection-corrected fixed effects	
	URATE	*URATE * EXPERIENCE*	*URATE*	*URATE * EXPERIENCE*	*URATE*	*URATE * EXPERIENCE*
All workers	0.0033	−0.0010**	0.0121**	−0.0026**	0.0122**	−0.0026
	(0.0034)	(0.0004)	(0.0017)	(0.0003)	(0.0018)	(0.0002)
Durable manufacturing	0.0067	−0.0009**	0.0145**	−0.0026**	0.0076*	−0.0017**
	(0.0048)	(0.0004)	(0.0041)	(0.0003)	(0.0046)	(0.0004)
Nondurable manufacturing	0.0206**	−0.0017**	0.0194	−0.0030**	0.0056	−0.0015**
	(0.0058)	(0.0005)	(0.0049)	(0.0004)	(0.0045)	(0.0004)
Construction	−0.0174**	−0.0006	−0.0036	−0.0019**	−0.0006	0.0015**
	(0.0064)	(0.0005)	(0.0055)	(0.0004)	(0.0062)	(0.0006)
Transportation and utilities	0.0233**	−0.0012**	0.0195**	−0.0024**	0.0326**	−0.0039**
	(0.0068)	(0.0005)	(0.0058)	(0.0004)	(0.0061)	(0.0006)
Wholesale trade	0.0067	−0.0009*	0.0193**	−0.0024**	0.0056	0.0010
	(0.0084)	(0.0005)	(0.0066)	(0.0004)	(0.0069)	(0.0008)
Retail trade	−0.0136**	−0.0002	0.0119**	−0.0025**	−0.0268**	−0.0042**
	(0.0060)	(0.0004)	(0.0049)	(0.0004)	(0.0048)	(0.0005)
F.I.R.E.[a]	−0.0221**	0.0003	0.0064	−0.0021**	0.0183**	−0.0055**
	(0.0097)	(0.0006)	(0.0082)	(0.0005)	(0.0077)	(0.0010)
Services	−0.0044	−0.0015**	0.0060	−0.0032**	0.0187**	−0.0047**
	(0.0051)	(0.0004)	(0.0043)	(0.0003)	(0.0034)	(0.0005)
Government	0.0198**	−0.0016**	0.0159**	−0.0026**	0.0301**	−0.0047**
	(0.0075)	(0.0005)	(0.0064)	(0.0004)	(0.0056)	(0.0007)
Agriculture	0.0251**	−0.0015**	0.0307**	−0.0026**	0.0032	0.0013
	(0.0014)	(0.0006)	(0.0104)	(0.0005)	(0.0156)	(0.0014)
Mining	0.0074	−0.0019**	0.0111	−0.0031**	0.0284**	−0.0037**
	(0.0140)	(0.0007)	(0.0122)	(0.0006)	(0.0137)	(0.0012)

Notes: Standard errors are in parentheses. Double asterisks (**) indicate significance at 5 percent level. A single asterisk (*) indicates the 10 percent level. Sample size = 21,004. See note for Table 3 for list of controls.
[a] Financial services, insurance, and real estate.

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industries. The estimated interaction coefficients at the industry level cluster around −0.0026. That is, the procyclicality of wages increases by about a quarter of a percent for every added year of labor market experience. Thus, both the OLS and FE estimates show that in a downturn workers with more labor market experience find their wages falling relative to the wages of workers with little or no experience.

The selection-corrected fixed effects estimates in the third set of columns show that the selection correction has virtually no effect on the results for all workers. The coefficients on *URATE* (0.0122, s.e. 0.0018) and *URATE* EXPERIENCE* (−0.0026, s.e. 0.0002) are almost identical to the FE estimates.[31] This is as expected since the parameter ρ was estimated to be close to zero in the aggregate and for all industries. At the industry level, many of the point estimates change from the FE estimates, again indicating the bias in the industry-level FE estimates that results from restricting individual fixed effects and returns to observed ability to be the same across all industries.

Despite the change in the point estimates, most of the interaction coefficients at the industry level remain significantly negative. Thus, workers with higher levels of labor market experience face relatively greater procyclical variation in wages than recent entrants into the labor force. Since the *EXPERIENCE* variable is defined as current age minus age at entry into the labor force, it is possible that the above results are dominated by age effects rather than by any aspect of human capital.

An important point to note about the aggregate and industry-level estimates in Table 5 is that they clearly show that older workers (those with more labor market experience) have more procyclical wages. Since our sample contains only young men, this implies that our estimates of the procyclicality of wages may significantly understate the true degree of procyclical variation in average wages in the U.S. economy.[32]

Interpretation of Findings

The results from the selection models at the aggregate level do not support the notion that skilled workers enter (implicitly or explicitly) into contracts with procyclical wages in order to secure more stable employ-

[31] These estimates indicate that the average offer wage in our sample is weakly procyclical [0.0122 − (0.0026 * 7.9) = −0.0083].

[32] For instance, using data from the Panel Study of Income Dynamics, Kydland and Prescott (1988) estimate average real wages to be strongly procyclical after adjusting for obser ed measures of worker quality.

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ment and thereby protect their investment in specific human capital. Workers with a college degree have much less employment variation at business cycle frequencies. But this is not explained in terms of a trade-off between wage and employment stability since college-educated workers are not subject to a greater degree of procyclical variation in offer wages than is the general work force. Neither is it the case that skilled workers face more procyclical variation in weekly hours worked. In fact, workers with college degrees appear to have very little cyclical variation in hours.

The industry-level estimates reveal that the aggregate results obscure considerable differences among industries in the nature of labor contracting. In durable and nondurable manufacturing, workers with degrees have more procyclical wages than other workers. In durable manufacturing, average employment probabilities are highly procyclical, but workers with degrees are relatively protected from substantial employment variation. In nondurable manufacturing, most of the cyclical variation in labor input comes from variation in weekly hours, but hours are almost acyclical for degreed workers. The employment and hours results together indicate that annual hours worked are essentially acyclical for college-educated workers in both industries. Thus, in the manufacturing sector, as suggested by the Hashimoto-Raisian model, the relative wage premium for skills is procyclical and skilled workers do indeed seem to accept greater wage variation over the cycle in return for employment stability.

Two industries, retail trade and services, are estimated to have countercyclical variation in the wage premium for skills. In retail trade, wages and employment probabilities are marginally countercyclical and weekly hours are acyclical for workers with college degrees. In this industry, skilled workers appear to have labor contracts of the type suggested by Azariadis-Baily-Gordon. In services, average wages are highly procyclical but, for workers with a degree, wages are almost acyclical. However, educated workers in services have strongly procyclical employment probabilities and countercyclical hours.

Workers with longer tenure on the current job face the same degree of wage cyclicality as workers with little or no tenure, both at the aggregate and industry levels. In addition, length of tenure has little effect on employment or hours variability. The fact that we get such strong results with the degree variable but not with the tenure variable is, at first, rather puzzling. We surmise that the degree variable might proxy for the distinction between white-collar and blue-collar workers. These two classes of workers appear to have substantially different labor contracts, and the level of specific capital, as measured by tenure, seems to be less important

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in determining the precise nature of these labor contracts. Workers with more labor market experience seem to have more procyclical variation in wages and hours worked than recent entrants into the labor force, but experience has no effect on employment variation.[33] However, this variable is probably the least reliable of the three proxies for human capital as it is simply a measure of labor force participation (or age) rather than of actual employment patterns. In fact, the age effect appears to dominate the regression results with the *URATE * EXPERIENCE* interaction terms.

While older workers may have more specific capital than younger workers in a given firm, a firm has less incentive to retain older workers since the returns from their specific capital, if they accrue to the firm at all, are available for a much shorter time horizon than for younger workers. Since older workers do not experience more employment variation but have more procyclical wage and hours variation than younger workers, they appear to be protecting their specific capital by taking cuts in wages and hours to avoid job separation.

V. Summary and Conclusion

The results of this paper indicate that, at the aggregate level, offer-wage differentials between skilled and unskilled workers are essentially acyclical. Using education and tenure as proxies for skill levels, we find no evidence to support the view that relative wage differentials between skilled and unskilled workers are countercyclical, a view that has long been accepted as a stylized fact. Our OLS estimates suggest, in fact, that relative wage differentials may actually be procyclical: the difference between skilled and unskilled workers' wages widens in booms and narrows in recessions.

However, the OLS estimates are subject to bias resulting from systematic compositional changes that are not captured by observed worker characteristics. To provide correct measures of the cyclicality of wage differentials, we estimate a series of models that control for unobserved individual fixed effects as well as selectivity bias. The magnitude of selectivity bias turns out to be not very significant in our sample, but

[33] In this context, it would also be of interest to examine the role of noncompetitive factors such as union membership. Unfortunately, except in a couple of years, our data set does not have a variable that would enable us to distinguish between union and nonunion workers.

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unobserved fixed effects are found to bias the OLS coefficients severely. Correcting for observed and unobserved worker heterogeneity, we conclude that, at the aggregate level, correctly measured relative offer-wage differentials do not have any consistent procyclical or countercyclical tendencies. However, after controlling for other characteristics, older workers do appear to have more procyclical wages than younger workers.

Variation in employment appears to be more important quantitatively than variation in weekly hours worked in explaining cyclical fluctuations in total labor input. On average, weekly hours worked are procyclical, with an average decline of about 0.4 percent for every percentage point increase in the aggregate unemployment rate. Variation in weekly hours per worker accounts for about 30 percent of the variation in total hours.

We find that workers with a college degree have acyclical employment probabilities and weekly hours, while uneducated workers have highly procyclical variation in employment and hours. These results imply that the average quality (in terms of skill level) of labor input per manhour rises in recessions and falls in booms. It follows that measures of the real wage that simply divide the total wage bill by total manhours are likely to be substantially countercyclically biased.

Our industry-level estimates reveal striking differences across industries in the cyclical variation of employment, hours, and wages. For example, in our sample, durable manufacturing displays the strongest procyclical employment variation, although workers with a college degree face much less relative variation in employment in that sector. In both durable and nondurable manufacturing, workers with a degree have weakly countercyclical hours, but face much more procyclical variation in wages than other workers. Thus, the results for manufacturing support the Hashimoto-Raisian hypothesis that skilled workers accept more wage variation in return for employment stability, thereby also implying procyclical wage differentials between skilled and unskilled workers.

On the other hand, retail trade and services reveal a different pattern. In retail trade, college-educated workers have countercyclical wages while nondegreed workers have procyclical wages. In services, uneducated workers have strongly procyclical wages while workers with a degree have acyclical wages. Thus, for this measure of skill level, the relative skilled-unskilled wage differential is estimated to be countercyclical in these two industries.

In some industries such as nondurable manufacturing and retail trade, a large fraction of the variation in total hours worked appears to be accounted for by variation in average weekly hours rather than in the number of persons employed. In most other industries, as in the aggre-

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gate, employment variation seems more important than hours variation in accounting for cyclical fluctuations in total hours.

Our disaggregated results indicate that worker heterogeneity and sectoral differences interact in crucial ways over the business cycle. Analyzing this issue is beyond the scope of this paper, but our results suggest that both kinds of heterogeneity and the interactions between them are likely to play an important role in modeling and understanding business cycle fluctuations.

APPENDIX TABLES

Table A1. *Means of Variables in NLS Analysis Sample*

Variable	Mean
Log real wage—W_{CPI}	1.06
Real price of refined petroleum—*OIL*	1.53
Unemployment rate—*URATE*	6.38
Education (years)—*EDUC*	12.57
Experience on current job (years)—*TENURE*	4.00
Labor market experience (years)—*EXPER*	7.90
Experience squared—$EXPER^2$	87.05
White race dummy—*WHITE*	0.74
Wife present dummy—*WIFE*	0.69
SMSA resident dummy—*SMSA*	0.70
South resident dummy—*SOUTH*	0.41
Children in household—*KIDS*	1.30
College degree dummy—*DEGREE*	0.23
Employment dummy	0.89
Occupational dummies	
Professional and technical workers (0–370)	0.31
Craftsmen and foremen (401–545)	0.19
Salesmen (380–395)	0.05
Services (801–890)	0.05
Operatives, laborers, farmers (200–222, 601–775, 901–985)	0.29

Note: Census three-digit occupation codes are used.

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Table A2. *Sample Size by Industry*

Industry	CIC codes	Person-year observations
Durable manufacturing	206–296	4,693
Nondurable manufacturing	306–459	2,580
Construction	196	2,217
Transportation and utilities	506–579	1,852
Wholesale trade	606–629	1,039
Retail trade	636–696	2,343
Finance, insurance, and real estate	706–736	833
Services	806–898	3,252
Government	906–998	1,389
Agriculture	16–18	535
Mining	126–156	327
Unemployed	—	2,724
Employed with nonspecified industry	—	143

Notes: Person-year observations for employed workers total 21,203. For 143 of these, the industry or occupation code was not available. This leaves 21,004 observations for employed workers that were used in the analysis.

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IMF *Staff Papers*
Vol. 40, No. 4 (December 1993)
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Economic Restructuring, Unemployment, and Growth in a Transition Economy

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This paper develops a model of the process of reallocation of labor from the state sector to the private sector. When growth is exogenously determined, we show that in the initial stages of transition unemployment will rise. After a critical stage in the transition process, restructuring is accompanied by a decline in unemployment. When growth is endogenously determined, and human capital is acquired by learning-by-doing, we show that whether or not restructuring eventually occurs is determined by the level of human capital in the private sector and the rate of unemployment. The effects of various shocks and government policies on the costs, speed, and eventual outcome of restructuring are analyzed. [JEL J41, J6, O11, P2]

THE PROCESS OF TRANSITION following the introduction of reforms and liberalization in the previously centrally planned economies (PCPEs) of Central and Eastern Europe has proved costly in terms of unemployment and output.[1] In all of these economies, open unemployment was

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The authors would like to thank Olivier Blanchard, Eduardo Borensztein, Peter Clark, Mohsin Khan, Paul Masson, and seminar participants at the World Bank for useful comments. Any errors and all views expressed here are their own.

[1] We follow Calvo and Frenkel (1991) in referring to these economies as PCPEs. They discuss how a centrally planned economy is likely to spend a significant

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absent prior to the reforms. Figure 1 indicates that the unemployment rate has steadily increased, and so far—except in Czechoslovakia—there are no signs of a reversal in this trend, or even of a leveling off of the unemployment rate. In most PCPEs, increases in the unemployment rate have occurred despite rapid growth of the private sector.[2] Thus, increasing unemployment reflects a gap between the speed at which the state sector is shedding labor and the speed at which the private sector is absorbing it.

This paper develops a simple model of the process of reallocation of labor from the state sector to the private sector and examines several questions relating to the dynamics of the transition process. The model emphasizes important institutional features of economies in transition that affect incentives and behavior in both the state and the private sector. Specifically, the transition economy is characterized by the asymmetric behavior and market power of labor in the two sectors. In the state sector, labor dominates the decision process of enterprises, while in the private sector employment and wage decisions are determined by profit-maximizing firms. It is assumed that firms in the private sector are concerned with worker effort and productivity, but that these considerations play a minor role in the state sector. Worker effort in the private sector is endogenously determined by the differential of wages over the alternative income of workers. In order to boost the productivity of the work force, firms find it optimal to pay a premium over the market-clearing wage, resulting in unemployment. Unemployment acts as a disciplining device so that, at any wage rate, worker effort increases with unemployment. Unemployment thus exerts downward pressure on the equilibrium wage paid in the private sector.[3]

The level and behavior of the unemployment rate over time is determined by the relative speeds of growth in the private sector and of decline in the state sector. The scope for productivity growth is assumed to be greater in the private sector and two alternative processes driving growth and restructuring are considered: a neoclassical exogenous productivity growth model, where transition is inevitable; and an endogenous growth model, where the work force acquires human capital through learning-by-doing, and restructuring is endogenously determined. The exogenous growth version of the model is related to recent work by Blanchard (1991)

period of time as a PCPE before becoming a full-fledged market economy. For a review of the experience with reform and stabilization during 1990-91 in Eastern Europe, see Bruno (1992).

[2]See Bruno (1992).

[3]This is exactly as posited by aggregative rules of disequilibrium price or wage adjustment, such as the well-known Phillips curve relation.

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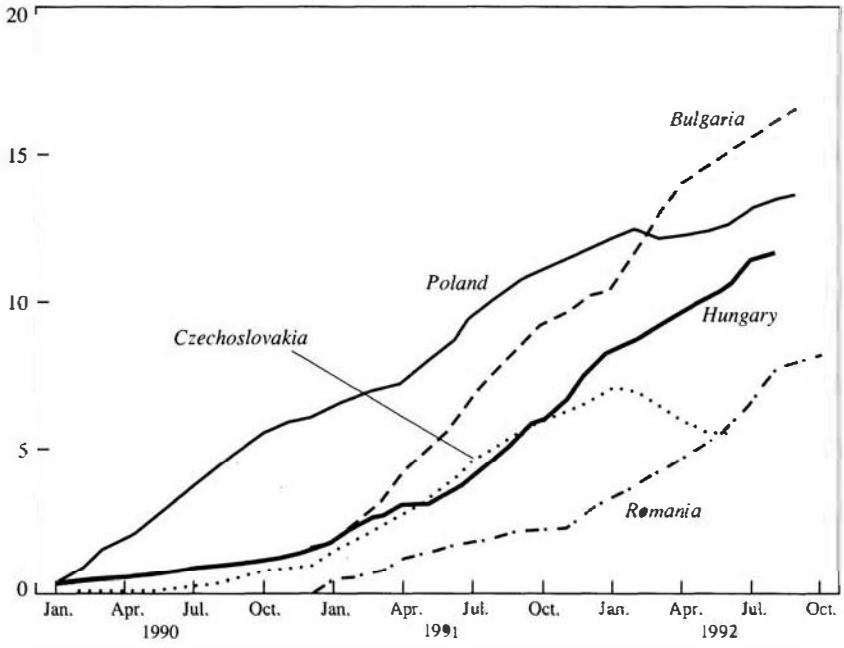
Figure 1. *Unemployment Rate in the PCPEs, 1990–92*
(In percent)



and Atkeson and Kehoe (1992) on the costs and speed of transition following major reform in a two-sector economy.[4] A key difference of our approach is that the relative speeds at which the private sector expands and the state sector contracts are determined endogenously and vary over time.

When growth and restructuring are exogenously determined, we show that the dynamic behavior of unemployment is determined by the initial distribution of the labor force. If the initial level of employment in the state sector is "high" and the level of unemployment is "low"—a stylized

[4] Atkeson and Kehoe (1992) examine the effects of social insurance for risk in search on the speed of the transition process. They show that the presence of social insurance can slow the transition. Blanchard (1991) develops a model in which an initial shock owing to a reform of the state sector creates a pool of unemployed workers. Unemployment then declines over time as the unemployed are absorbed into an expanding private sector, while state sector employment is constant. Once unemployment declines sufficiently, it becomes constant with the private sector expanding and the state sector shrinking at the same rate.

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feature of the initial conditions in most PCPEs—then, in the early stages of the transition process, the unemployment rate will rise. Once private sector activity has expanded beyond a critical level, the private sector begins to absorb labor at a faster pace than it is shed by the state sector, and the unemployment rate falls over time. The framework presents a manifestation of popular notions about the cost of transition from an economy dominated by the state sector to one dominated by the private sector. In the initial stages of transition, as a natural consequence of the reallocation of labor accompanying the restructuring of production, the economy will not only suffer a cost in terms of unemployment but this cost will rise. Only after a critical stage in the transition process is restructuring accompanied by declining unemployment.

When growth is endogenously determined, and the work force acquires human capital through learning-by-doing, we show that there are two potential long-run equilibria. Whether or not the restructuring of production toward the private sector eventually occurs is determined by the level of human capital in the private sector and the prevailing rate of unemployment. With low levels of human capital or of skills specialized in the production of the private sector good, a relatively high rate of unemployment is necessary to place the economy on a self-sustaining path of restructuring toward the private sector. In this framework, the speed of transition, as measured by the share of the labor force employed in the private sector at any point in time, takes on a critical importance. Policies that succeed in allocating labor toward the private sector either by increasing unemployment, thus depressing private sector wages and expanding employment in the sector, or by directly subsidizing employment in that sector will result in the acquisition of comparative advantage in production of the private sector good and could place the economy on a path of restructuring toward the private sector good.

The effects of various shocks—such as changes in relative prices—and government policies on the dynamic path of unemployment are analyzed. The role of government policies differs significantly depending on whether growth is viewed as an exogenous or an endogenous process. When growth is exogenously determined, the speed of transition has no long-run impact, and restructuring is inevitable. Therefore, policies that reduce unemployment in the early stages of transition—for instance, subsidies to the state sector—may reduce short-term costs without affecting the long-run equilibrium. In this framework, the budgetary costs of policies that attempt to lower unemployment need to be compared only against the welfare and budgetary costs of unemployment. In contrast, when growth is endogenous, policies that reduce unemployment will slow down the transition process and can jeopardize the restructuring and

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eventual convergence to long-run specialization in the private sector good.

I. A Model of Growth and Restructuring

We consider an open economy comprising a "state" sector and a "private" sector. Each sector produces a (basket of) traded good(s), the prices of which are determined in the rest of the world. Each sector's good is produced with labor as an input. For simplicity, and so as to focus on forces emanating directly from the employment decisions in each sector and the movement of labor across sectors, we abstract from the presence of physical capital and other factors in the production process. The population, or labor supply, is assumed to be constant and normalized to equal unity.

State Sector

The model used here to characterize the state sector closely follows the model developed in Commander, Coricelli, and Stähr (1992) and is similar in spirit to that presented by Dinopoulos and Lane (1991).[5] The stylized feature of the state sector that these models emphasize is that of a labor-dominated firm: a firm controlled by a worker council, for example, whose interference in management is nontrivial. The implications of active participation of workers in management have been extensively explored in the literature (Ward (1958), Vanek (1970), and Brewer and Browning (1982)). For our purposes, worker control is treated as equivalent to a powerful trade union presence where wages and employment are subject to joint maximization.[6] In contrast to the classical labor-managed firm, the union modeled here also cares about employment and accordingly maximizes the expected utility of a representative worker in the firm or union. We assume further that the selection of workers who remain employed and who are laid off from the state sector is random. A worker who is laid off either remains unemployed and receives an exogenously set level of unemployment benefits from the government or gains employment in the private sector and earns the wage prevailing in that sector. These assumptions allow us to view the labor-dominated firm

[5] See also Lane (1991).

[6] This contrasts with monopoly union models where the wage is either bargained or picked by the union and employment is subsequently set unilaterally by the employer; the outcome will therefore lie on the labor demand curve. See Oswald (1985) for a summary of this literature.

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as a limiting case of an efficient-bargaining model of the type commonly used to describe capitalist firms. The wage bill of the worker-controlled firm will be constrained by the level of output, which is adjusted for any subsidies to (or taxes on) the sector. Since all profits are appropriated by workers, the wage and employment combination picked by the union will not generally correspond to the point on the contract curve picked in bargaining between union and employer in a conventional capitalist firm.

The union maximizes the expected utility of a representative worker over prospects of employment at the contract wage against the expected utility of being laid off from the state sector. The expected utility of a worker who is laid off is a weighted average of unemployment benefits and the private sector wage, where the weights are defined by the probability that a laid-off worker remains unemployed and the probability that he or she obtains employment in the private sector, respectively. All current workers or members of the union (M_t) receive equal treatment. The union's utility function is given by

$$V_t = \left(\frac{L_t^1}{M_t}\right)V(W_t^1) + \left(\frac{M_t - L_t^1}{M_t}\right)V[\delta_t B + (1 - \delta_t)W_t^2], \quad \text{for } M_t \geq L_t, \tag{1}$$

where L_t^1 denotes the share of the labor force employed in the state sector, denoted as sector 1; W_t^1 represents the real wage in the state sector expressed in units of the private sector's good, which is assumed to be the numeraire; δ_t represents the probability that a worker laid off from the state sector remains unemployed, and $(1 - \delta_t)$ represents the probability that the worker obtains employment in the private sector; and B denotes the exogenous level of unemployment benefits paid by the government. The production function in the state sector is assumed to be of the Cobb-Douglas type, with diminishing returns to labor, so that state sector output Q_t^1 can be described as a function of labor input

$$Q_t^1 = F(L_t^1) = H_t^1(L_t^1)^{\beta}, \qquad \text{where } 0 < \beta < 1, \tag{2}$$

where H_t^1 represents the skill level or human capital specialized in the production of the state sector good. The union maximizes its utility function with respect to wages and employment subject to a zero-profit condition.[7] Expressed in units of the numeraire (the private sector good), this condition is

$$\tau P Q_t^1 - W_t^1 L_t^1 = 0, \tag{3}$$

[7] In other words, the hard budget constraint is assumed to be binding. While subsidies to the state sector are allowed for, they are assumed to be prespecified and set exogenously by the government.

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where τ is a parameter determined by the subsidy (or tax) the enterprise receives (pays) from the government. P denotes the ratio of the internationally given price of the state sector good to that of the private sector good. We assume that the union does not care about its size over time per se and that membership evolves according to

$$\dot{M}_t = -\Psi(M_t - L_t^1), \qquad \text{where } M_o > L_o^1 \quad \text{and} \quad 0 < \Psi < 1, \tag{4}$$

so that some proportion, Ψ, of union members who get laid off leave the union.

Again, to keep the analysis simple, and to highlight the effects of certain forces in the labor market on the transition process, we assume that the union is risk neutral and that $V(W_t^1)$ simply equals W_t^1.[8] Then, maximizing the union's expected utility subject to the zero-profit constraint, first-order conditions can be combined to yield the union's employment rule as

$$F'(L_t^1) = H_t^1 \beta (L_t^1)^{\beta - 1} = \frac{1}{\tau P}[\delta_t B + (1 - \delta_t) W_t^2], \tag{5}$$

while the real wage in the sector equals the (subsidy-adjusted) average product of labor. Note that the left-hand side of equation (5), the marginal product of labor, is a decreasing function of employment in the state sector. Equation (5) therefore implies that, for any given value of δ_t (the probability that a worker laid off from the state sector remains unemployed), an increase in the level of unemployment benefits or an increase in the wage rate in the private sector will, by increasing the expected income of a worker laid off from the state sector, lower employment in the state sector. As employment in the state sector falls, the marginal and average product of labor will rise and the wage paid to those remaining employed will rise.[9] Similarly, at a given level of unemployment benefits and private sector wages, a rise in δ_t reduces the expected income of a worker laid off by the union and will tend to maintain employment in the state sector.[10]

[8] The objective function we posit is analogous to that employed by Calvo (1978). He develops a two-sector model in which a trade union in the urban sector maximizes the difference between its members' income and their alternative income in the rural sector. Note that when $V(\ )$ in equation (1) is linear, it can be rewritten as an increasing function of the differential of state sector wages over the expected alternative income of a worker laid off from the state sector.

[9] Under the assumption of a Cobb-Douglas technology, the average product of labor is simply a linear function of the marginal product of labor.

[10] It is shown below that wages in the private sector are always higher than the level of unemployment benefits.

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Private Sector

The private sector is populated by firms whose employment and wage decisions are determined purely by profit-maximization considerations. In particular, firms in the private sector, unlike the union in the state sector, derive no returns from maintaining employment per se and are free to fire workers.[11] Worker effort in the private sector is endogenously determined by an efficiency-wage mechanism, which is elaborated below.[12] Output in the private sector, Q_t^2, is produced by a technology of the Cobb-Douglas type, with diminishing returns to labor measured in efficiency units:

$$Q_t^2 = H_t^2[E(W_t^2 - B, U_t)L_t^2]^\alpha, \quad \text{where } 0 < \alpha < 1$$
$$\text{and } E(0, U_t) < 0 \text{ for all } U_t, \tag{6}$$

where H_t^2 represents the skill level or human capital specialized in the production of the private sector good and U_t represents the aggregate level of unemployment. Labor measured in efficiency units $[E(W_t^2 - B, U_t)L_t^2]$, or the effective labor input, is defined as the product of the effort of an individual worker, $E(W_t^2 - B, U_t)$, and the number of workers employed in the private sector, L_t^2. In the spirit of standard efficiency-wage theory,[13] we posit that an individual worker's effort in the private sector is (i) an increasing concave function of the differential of the real wage W_t^2 over the level of unemployment benefits, B, which the worker would earn if he or she were fired from the private sector (it is assumed that a worker fired from the private sector cannot be immediately hired into the state sector since the worker is not a member of the state sector union, and so the worker's reservation wage is given by the level of unemployment benefits)[14] and (ii) an increasing function of unemployment, U_t.[15] As shown below, this specification implies that

[11] There are no incentives to "hoard" labor.

[12] Dinopoulos and Lane (1991) also employ an efficiency-wage mechanism in the private, or what they term the "nonsocialized," sector. Our specifications differ. While they posit effort to be a function of the wage rate in the private sector, we posit effort to be a function of both the wage rate and the aggregate unemployment rate. The implications differ considerably.

[13] For a recent survey and overview of efficiency-wage models, see Weiss (1990). Among the references cited there and for the motivations of our specification, see Shapiro and Stiglitz (1984) and Calvo (1979).

[14] Since effort is an increasing function of the differential of the wage paid over unemployment benefits, it follows that the wage offered will always be greater than the level of unemployment benefits.

[15] This specification is intended to capture the mechanism put forward, for instance, by Shapiro and Stiglitz (1984), who show that unemployment induces effort because the higher is unemployment, the greater is the punishment to a

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aggregate unemployment acts as a disciplinary device, constraining wages in the private sector. For simplicity, we assume that the effort function is separable in the two arguments.

The representative firm in the private sector maximizes profits with respect to wages and employment, given the skill level in the sector, the level of unemployment benefits, and the aggregate level of unemployment. The firm's first-order conditions for profit maximization can be solved for wages and employment in the sector as functions of the level of unemployment in the economy and the level of human capital in the private sector.[16] Wages are determined by the well-known condition in efficiency-wage models that the elasticity of effort with respect to the real wage is unity:

$$\frac{\partial E(W_t^2 - B, U_t)}{\partial W_t^2} \cdot \frac{W_t^2}{E(W_t^2 - B, U_t)} = 1. \tag{7}$$

Equation (7) can then be used to solve for a unique real wage in the private sector as a function of the unemployment rate for any given level of unemployment benefits:

$$W_t^2 = W^2(\underset{-}{U_t}; \underset{+}{B}), \tag{8}$$

where signs underneath the arguments in the W^2 function indicate signs of the partial derivatives, which can be derived by differentiating equation (7). Equation (8) implies that for any given level of unemployment benefits, an increase in the aggregate unemployment rate leads the firm to offer a lower wage to workers. This effect corresponds to standard models of the Phillips curve. In our model, however, the effect results from the assumption that an increase in the aggregate unemployment rate raises each worker's effort at the existing wage. This allows the firm to lower the wage offered and still obtain the same level of effort from workers.

The optimal level of employment in the private sector can be expressed as a function of the wage:

$$L_t^2 = \frac{(\alpha H_t^2)^{1/(1-\alpha)}[E(W_t^2 - B, U_t)]^{\alpha/(1-\alpha)}}{(W_t^2)^{1/(1-\alpha)}}. \tag{9}$$

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worker who is fired for shirking. The specification we adopt is chosen for analytical tractability. The main results on the dynamic path of unemployment are not affected by the presence of unemployment in the effort function.

[16]The firm treats both of these as exogenous to its actions at any point in time. The specific assumptions on the form and evolution of human capital are discussed below.

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It is straightforward to show that the optimal level of employment in the private sector is a decreasing function of the wage offered by the firm. Employment in the private sector can, therefore, be described by the function

$$L_t^2 = L^2[W_2(U_t; B), U_t, H_t^2; B], \qquad (10)$$
$$\underset{-}{} \quad \underset{-}{} \quad \underset{+}{} \quad \underset{+}{} \quad \underset{+}{} \quad \underset{-}{}$$

where the signs underneath the last three arguments can be obtained directly by examination of equation (9). For later purposes, it is useful to distinguish two separate channels through which an increase in unemployment affects employment in the private sector: through the lowering of wages and more directly through an increase in worker effort at the existing wage, as equation (9) brings out. Equation (10) implies that employment in the private sector can be written simply as

$$L_t^2 = L^2(U_t, H_t^2; B), \qquad (11)$$
$$\underset{+}{} \quad \underset{+}{} \quad \underset{-}{}$$

that is, as an increasing function of the unemployment rate and the level of human capital in the private sector and as a decreasing function of the level of unemployment benefits.

Labor Market Equilibrium

Equilibrium in the economy at any point in time can be defined by the identity

$$L_t^1 + L_t^2 + U_t = 1. \qquad (12)$$

In other words, the labor force is either employed in one of the two sectors or is unemployed. Further, we impose that in general equilibrium the probabilities perceived by union members of a worker laid off from the state sector becoming unemployed or gaining employment in the private sector are equal to their actual values. Assuming that the private sector randomly selects the desired number of workers from the pool of workers who are not employed in the state sector, we define this probability by[17]

$$\delta_t = \frac{U_t}{U_t + L_t^2}. \qquad (13)$$

[17] An alternative approach is to allow for job tenure and define the probability of an unemployed worker obtaining a job in the private sector using the "flows" approach to labor markets as, for example, presented in Blanchard and Diamond (1992). The flows approach defines the probability of an unemployed worker obtaining employment as the ratio of job creation to the pool of unemployed—

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Substituting this definition into the employment rule of the state sector union, equilibrium employment in the state sector can be expressed as a function of the unemployment rate, the level of employment in the private sector, the wage rate in the private sector, and the exogenous variables of the system:

$$L_t^1 = L_t^1[\underset{+}{U_t}, \underset{-}{W_t^2}, \underset{-}{L_t^2}; \underset{+}{\tau P}, \underset{-}{B}], \tag{14}$$

where the signs of the partial derivatives are straightforward from equation (5). Substituting in equations (8) and (11), which define employment and the wage rate in the private sector, equilibrium employment in the state sector can be written as

$$L_t^1 = L_t^1[\underset{+}{U_t}, \underset{-}{W^2(U_t)}, \underset{-}{L^2(U_t, H_t^2; \underset{+}{B})}; \underset{+}{\tau P}, \underset{-}{B}], \tag{15}$$

that is, as a function of the unemployment rate, the level of human capital in the private sector, and the exogenous variables in the system. Substituting both this expression for L_t^1 and the solution for L_t^2 in equation (11) into equation (12) yields an equation that can be solved for equilibrium unemployment as a function of the level of private sector human capital.

To establish the nature of the relation between unemployment and private sector human capital, it is necessary first to determine the response of state sector employment to changes in unemployment and the level of human capital in the private sector. Note from equation (15) that employment in the state sector is a decreasing function of the level of human capital in the private sector. An increase in the level of human capital in the private sector expands employment in the private sector, lowering the probability that a worker laid off from the state sector becomes unemployed. This raises the expected wage of a worker laid off from the state sector, causing the union to lay off workers.

The response of employment in the state sector to an increase in unemployment is more complicated. Three separate effects can be iden-

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that is, in our notation as $\dot{L}^2/U$. The key difference is the flow change in employment in the numerator rather than the level of employment. Private sector employment and job creation are

$$L_t^2 = H_t^{1/(1-\alpha)} \cdot \underset{+}{Z(U_t)}, \qquad \dot{L}_t^2 = \left[\frac{\theta}{1-\alpha} + \frac{\partial Z}{\partial U}\frac{1}{Z}\dot{U}_t\right] L_t^2 = g_t L_t^2.$$

It is shown below that as H increases, private sector job creation is always positive and the level of employment in the sector increases monotonically. The variable g_t in the above expression is, therefore, always positive. Since job creation is thus an increasing function of the level of employment, it follows that our use of the level of employment is consistent with the flows approach and that this assumption does not qualitatively affect any of the results.

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tified. First, an increase in unemployment raises the probability that a worker laid off from the state sector will remain unemployed, thus discouraging the union from laying off workers. Second, an increase in unemployment reduces wages in the private sector, also discouraging the union from laying off workers. Third, an increase in unemployment raises employment in the private sector, lowering the probability that a worker laid off from the state sector will become unemployed, thus encouraging the union to lay off workers. The latter effect works through two channels: through a decline in the real wage and through a direct effect on worker effort in the private sector. The Appendix establishes that, under a condition that places an upper bound on the elasticity of effort in the private sector with respect to unemployment, employment in the state sector is an increasing function of the unemployment rate. This condition is assumed to hold.

While the employment effects of changes in relative prices and in the rate of subsidy to the state sector are straightforward to establish, the effect of a change in unemployment benefits is ambiguous as suggested by equation (15). We postpone a detailed discussion of the effects of unemployment benefits on employment in the state sector to the discussion of policies below, and for now simply leave the partial derivative unsigned. To summarize, we have shown that

$$L_t^1 = L^1(\underset{+}{U_t}, \underset{-}{H_t^2}; \underset{+}{\tau P}, B). \tag{16}$$

General equilibrium in the economy at each point in time is defined by

$$L_t^1(\underset{+}{U_t}, \underset{-}{H_t^2}; \underset{+}{\tau P}, B) + L_t^2(\underset{+}{U_t}, \underset{+}{H_t^2}; \underset{-}{B}) + U_t = 1. \tag{17}$$

The Appendix establishes that the slope of this curve in the unemployment and private sector human capital plane, referred to as the UH curve, eventually becomes negative as the level of private sector human capital increases. However, at small values, the slope can be negative or positive. The latter case implies that the slope of UH switches sign at some level of human capital: unemployment will first rise, even as human capital in the private sector grows and employment opportunities in that sector expand. It is shown that whether or not this curve first slopes upward is determined by the initial distribution of the labor force between employment in the state sector and unemployment. The larger the initial size of the state sector, and hence the smaller the initial unemployment rate, the more likely it is that this curve will slope upward at small levels of H^2. Since high levels of state sector employment and low unemployment are characteristic of initial conditions in most PCPEs—with, in many cases,

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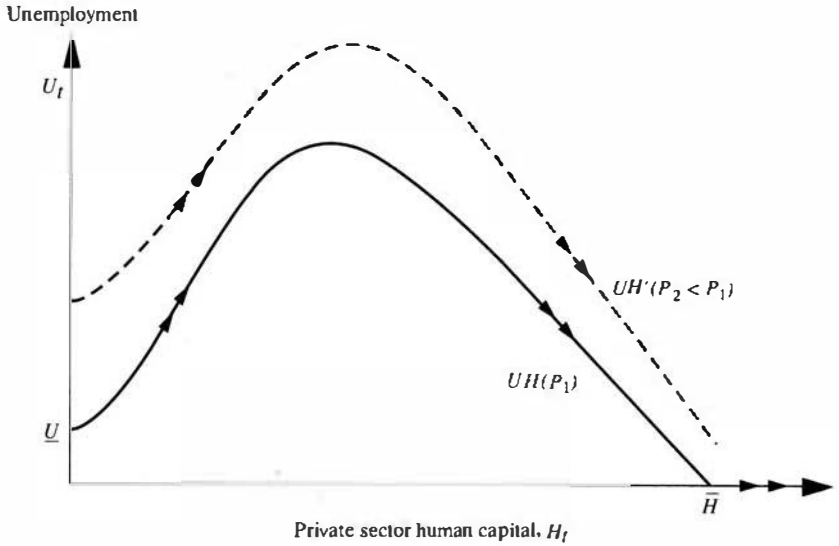
Figure 2. *Dynamic Path of Economy with Exogenous Accumulation of Human Capital*



almost the entire labor force having been employed in the state sector and unemployment nonexistent—this is the case we focus on in the remainder of the paper. Figure 2 plots such a hump-shaped UH curve with the unemployment rate rising as H^2 increases and then eventually declining as H^2 continues to increase.[18]

Growth and Restructuring: Dynamic Path of the Economy

H_t^i in each sector's production function represents the skill level or human capital specialized in the production of each sector's good, or the

[18]The initial distribution of the labor force is determined, as the Appendix shows, by the level of unemployment benefits, the magnitude of the subsidy to the state sector, and the relative prices of the two goods. While a detailed discussion of the effects of policies on the path of unemployment is postponed for later, note that this implies, for example, that unemployment benefits can be increased sufficiently to ensure that the UH curve is downward sloping. This, however, would be accomplished only by increasing the initial level of unemployment so that the potential increase in unemployment that occurs at a later stage in the transition is simply brought forward in time.

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level of total factor productivity. The effect of the skill level or human capital is assumed to be entirely external to any single firm and cannot be captured by it. We analyze two cases: one in which, in the spirit of neoclassical growth models, the growth of human capital or total factor productivity occurs exogenously; and one in which the growth of human capital is endogenous, deriving from a process of learning-by-doing. The potential relevance of exogenous versus endogenous factors in affecting growth cannot be determined on the basis of empirical evidence, as the process of growth in the transition economies is only beginning. In fact, even for market economies, there is no conclusive empirical evidence on the relative applicability of exogenous versus endogenous growth models.[19] It therefore seems worthwhile to consider both cases.

In both cases, we assume that the speed of productivity growth, and thus the potential for technological advance, is faster in the private sector. The assumption of a higher speed of productivity growth in the private sector is the driving force behind restructuring in the model. There are several reasons to expect this to be the case. First, to the extent that private sector activity represents a "new" activity while state sector activity represents an "old" activity, the scope for learning and hence productivity increases should be greater in the new activity. Second, if the private sector good is interpreted as representing goods produced in Western markets, while the state sector good is interpreted as representing goods produced in an insulated market, in the former Eastern trading bloc CMEA, for example, then the higher speed of productivity growth can be interpreted to be a result of the greater potential for productivity increases as the economy "catches up" to Western total factor productivity levels. Third, rather than as a catch-up effect owing to level differences, it could be argued that the underlying speed of innovation was greater in Western markets, so that one would expect a greater potential for technology transfer from the rest of the world to the PCPEs. Finally, it could be argued that the inherent distortions in the state sector—the low quality of inherited physical capital (plants and machinery) and the obsolete technologies embodied in them—present an environment in which productivity increases are likely to be slow.

Exogenous Growth

Skills are acquired according to

$$\frac{\dot{H}_t^1}{H_t^1} = \gamma_1, \qquad \frac{\dot{H}_t^2}{H_t^2} = \gamma_2. \tag{18}$$

[19] See Lucas (1988) for a discussion of the ability of alternative models to explain the growth experience of various countries.

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We posit further that $\gamma_2 > \gamma_1$, so that the skill level, or productivity, grows at a faster rate in the private sector than in the state sector. Equation (18) then implies that the production possibility frontier of the economy will shift out over time in favor of production of the private sector good. Comparative advantage in producing the private sector good will thus grow over time and, at unchanged relative prices, employment and production will be restructured in favor of the private sector good.

The skill accumulation equations can be combined to yield a relative skill accumulation equation:

$$\frac{\dot{H}_t}{H_t} = \gamma_2 - \gamma_1 = \theta_1, \tag{19}$$

where H_t represents the ratio of the skill level or human capital in the private sector to that in the state sector. To keep the analysis tractable, while still allowing for a higher speed of productivity growth in the private sector, we model the limiting case where skills accumulate in the private sector but the skill level in the state sector is constant and normalized to equal unity. H_t is then used to denote the level of human capital in the private sector, and the sectoral subscript on it is dropped.

Dynamic Path of the Economy

With unchanged policies, the UH curve in Figure 2 describes the dynamic path of the economy as the (relative) level of productivity, skills, or human capital in the private sector grows over time. It is possible to show that along this path, employment in the state sector shrinks continuously, while employment in the private sector expands continuously. Eventually, the unemployment rate goes to zero,[20] and subsequently the economy specializes in the production of the private sector good.[21] On the left-hand side of the peak unemployment rate, as the economy traverses up the UH curve, both unemployment and the level of human capital are increasing. Since employment in the private sector is an increasing function of both, it must be expanding. Since private sector employment and unemployment are both expanding, the remainder of

[20] Alternatively, the rate could converge to some positive number representing the natural rate of unemployment. Here, the natural rate has been "normalized" to zero.

[21] In microeconomic models of efficiency wages, for example, Shapiro and Stiglitz (1984), the unemployment rate can never fall to the natural rate in that there is always involuntary unemployment. With our specification of a continuous effort function, however, as H_t continues to rise, unemployment will tend toward the natural rate. Once unemployment declines to the natural rate (zero), strictly speaking there is a discontinuity in behavior in our model, as efficiency considerations cease to play any role and wages arrive at their competitive level.

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the labor force, which is employed in the state sector, must be shrinking. On the right-hand side of the peak unemployment rate, unemployment is falling, while the level of human capital is rising. Employment in the state sector is an increasing function of the level of unemployment and a decreasing function of the level of human capital in the private sector. It follows that employment in the state sector will continue to decline as the economy traverses down the *UH* curve from the peak unemployment rate. Since both state sector employment and unemployment are falling, the remainder of the labor force, which is employed in the private sector, must be rising. The entire restructuring process is characterized by a monotonic decline of employment in the state sector and a monotonic rise of employment in the private sector. However, in the early stages of the transition process, when the level of employment in the state sector is high and the level of employment in the private sector is low, the analysis shows that the speed at which the state sector sheds labor is greater than the speed at which the private sector absorbs labor, leading to a rise in unemployment. In the later stages of transition, the opposite is true. Once the private sector has expanded to a critical stage, it absorbs labor at a faster pace than the state sector sheds it, leading to a decline in unemployment.[22]

Consider the path of wages in each sector during the restructuring process. As employment in the state sector declines, the marginal and average products of labor in the state sector will rise and so the wage paid in that sector will rise. In the private sector, however, in the early stages of the transition process, as the unemployment rate rises, the wage rate will fall until the unemployment rate peaks. Subsequently, the wage in the private sector will begin to rise.

The analysis presents a manifestation of popular notions of the costs of transition from an economy dominated by a state sector to one largely comprising a private sector. The forces in such a system imply that in the initial stages of transition, as a natural consequence of the process of reallocation of labor accompanying the restructuring, the economy will

[22] It is possible to show that δ_t declines monotonically from unity when H_t equals zero, as the economy moves rightward along the *UH* curve. On the left-hand side of the peak unemployment rate, note that

$$(d\underset{-}{L_t^1}) = \left(\frac{\partial \underset{+}{L_t^1}}{\partial \delta}\right) d\delta + \left(\frac{\partial \underset{-}{L_t^1}}{\partial \underset{-}{W_t^2}}\right)(d\underset{-}{W_2}).$$

Therefore, $d\delta$ must be negative. On the right-hand side of the peak unemployment rate, U_t is falling, while $(1 - L_t^1)$ is rising; therefore δ_t, which equals $U_t/(1 - L_t^1)$, must continue to fall.

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not only suffer unemployment but it will rise over time even as the private sector expands. It is worth emphasizing that this is dictated by the intrinsic dynamics of the economy and happens in the absence of any new shocks to the system. It is only after a critical level of development has been attained by the private sector that continued restructuring will be accompanied by a decline in the unemployment rate. There are thus two distinct stages in the transition process: an early difficult stage and a relatively easier later stage. There is clearly a potential role for government policies in affecting the dynamic path of the economy during the restructuring process and thus in reducing the costs of the transition. However, policies that attempt to reduce the costs of the transition by lowering the unemployment rate are also going to affect the speed of the transition. We show in the next section that the speed of transition can play an important role in determining the outcome of the restructuring process when the accumulation of skills in the private sector is endogenously determined.

Endogenous Growth

Following Lucas (1988) and Chadha (1991), suppose now that skills or human capital specialized in the production of each sector are acquired according to

$$\dot{H}_t^1 = H_t^1 \theta_1 L_t^1, \qquad \dot{H}_t^2 = H_t^2 \theta_2 L_t^2, \tag{20}$$

where, as before, skills are assumed to be entirely external to any single firm. The growth of the skill level should now be interpreted as occurring through the learning-by-doing of the work force. The rate of growth of the skill level in equation (20) is a positive function of both a pure speed-of-learning parameter θ_i and the effort or resources devoted to producing good i, which is assumed to be related to the proportion of the labor force employed in the production of good i. It is posited further that the speed of learning or potential for productivity increases is greater in the private sector, so that $\theta_2 > \theta_1$. In terms of the previous discussion of the role for different rates of technology transfer from the rest of the world to the two sectors, imagine that "available" technological progress globally is greater in the production of the private sector good than in the production of the state sector good. The present formulation then implies that the speed at which technologies are adopted, or the actual technology transfer, will also be a function of the resources devoted to producing the private sector good.

The skill accumulation equations can be combined to obtain a relative learning equation and, on substituting in the labor market identity,

$$\frac{\dot{H}_t}{H_t} = \theta_2 L_t^2 - \theta_1 L_t^1 = (\theta_1 + \theta_2) L_t^2 - \theta_1 + \theta_1 U_t, \tag{21}$$

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where H_t denotes the ratio of human capital in the private sector to that in the state sector. Equation (21) brings out that there will exist distributions of the labor force between the two sectors such that the ratio of skill levels remains exactly constant over time: where, for example, the effect of a smaller share of labor in the private sector on the growth of the relative skill level is exactly offset by the higher speed of learning in that activity.

To keep the analysis tractable, we assume, as in the previous subsection, that whereas skills are accumulated in the private sector through learning-by-doing, the skill level in the state sector is constant and normalized to equal unity. Again we use H_t to denote the level of human capital in the private sector and suppress sectoral subscripts. To retain the essence of the effects of differential speeds of learning-by-doing in the two sectors on relative skill accumulation, as in equation (21) above, we assume that

$$\frac{\dot{H}_t}{H_t} = (\theta_1 + \theta_2)L_t^2 - \theta_1, \tag{22}$$

where the θ_i now represents arbitrary constants and the term in the unemployment rate has been dropped for simplicity.[23] Then, substituting in the employment rule in the private sector from equation (11) yields

$$\frac{\dot{H}_t}{H_t} = (\theta_1 + \theta_2)L^2(\underset{+}{U_t}, \underset{+}{H_t}; \underset{-}{B}) - \theta_1. \tag{23}$$

The locus of points where the (relative) skill level in the private sector remains constant can then be plotted as a function of unemployment and human capital, or the downward-sloping $\dot{H} = 0$ curve in Figure 3. The arrows indicate the direction of movement of the (relative) skill level in the private sector when the economy is off the $\dot{H} = 0$ locus. To the right of the locus, human capital increases, while to the left it falls.

The UH curve represents the equilibrium of the economy at each point in time. The direction of movement along the UH curve, however, will be determined by the intersection of the UH curve with the $\dot{H} = 0$ locus. The Appendix establishes that the slope of the UH curve is always greater than the slope of the $\dot{H} = 0$ locus so that there is a unique intersection of the two curves. The intersection can in general occur below, at, or above the peak unemployment rate on the UH curve and will be determined by all the parameters and exogenous variables of the system. Since the economy is always on the UH curve, the double arrows in Figure 3

[23] Since L_t^2 is an increasing function of U_t, and U_t enters equation (21) positively, its presence would have no qualitative impact on the slope of the $\dot{H} = 0$ locus.

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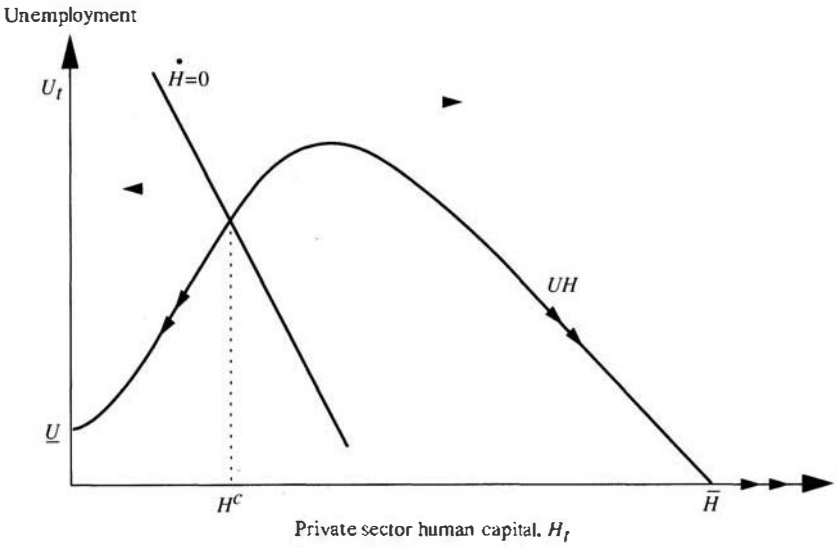
Figure 3. *Dynamic Path of Economy with Endogenous Accumulation of Skills*



are used to denote the actual path of the economy starting from any initial level of human capital given by history. The intersection of the $\dot{H} = 0$ locus with the UH curve defines a critical level of human capital, H_t^c. Unless the economy has an initial human capital ratio of exactly H_t^c, either the economy will, over time, traverse rightward along the UH curve, and eventually specialize in the production of the private sector good, or it will traverse leftward, and eventually specialize in the production of the state sector good.

The production possibility frontier of the economy shifts out, over time, with experience gained by the labor force proportionately in favor of one of the two goods, depending on the speed of learning-by-doing in each sector and the resources devoted to learning in each activity. The implications of the analysis differ markedly from those of the exogenous growth framework in the previous subsection. There are now no forces in the system that would necessarily place the economy on a path converging to eventual specialization in the private sector good. Thus, a clear role for government intervention emerges. In particular, policies that allocate labor toward the private sector would lead to the acquisition of comparative advantage in the production of the private sector good and could

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place the economy on a path to self-sustained restructuring in production, leading eventually to specialization in the private sector good. Under our assumptions, specialization in the private sector good implies a higher long-run growth rate of output.

We turn now to an examination of the effects of policies and exogenous variables on the time path of unemployment during the transition process and on the speed of transition.

II. Effects of Policies and External Shocks

We examine first the effects of changes in exogenous parameters and policy variables in the exogenous growth model.

Case of Exogenous Growth

We focus first on the effects of once-and-for-all changes in these variables and then examine the effects of a policy that attempts to continuously reduce unemployment.

Changes in the Terms of Trade or a Liberalization of Prices

Consider the effect of an exogenous increase in the internationally given relative price of the private sector good. If the private sector good is interpreted as a (basket of) good(s) predominantly produced in Western markets, and the state sector good is thought of as one produced for an insulated market (for trade within the former CMEA, for example), then the process of price liberalization and the opening of markets to competition from the West, which has taken place in the PCPEs of Central and Eastern Europe, can be likened to an exogenous decline in the relative price of the state sector good. Note that P denotes the ratio of the price of the state sector good to that of the private sector good. An increase in the relative price of the private sector good thus corresponds to a decline in P. Then, differentiating equation (17) and noting the sign of the partial derivative of employment in the state sector with respect to an increase in P, we find that at each level of H_t

$$\frac{dU_t}{dP} = \frac{-\dfrac{\partial L_t^1}{\partial P}}{\dfrac{\partial L_t^1}{\partial U_t} + \dfrac{\partial L_t^2}{\partial U_t} + 1} < 0. \tag{24}$$

Since we have established that the denominator is positive, the curve UH unambiguously shifts upward in response to a decline in P as shown in

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Figure 2. Since the private sector good is treated as the numeraire, a change in relative prices has no direct effect on the employment decision of the private sector. For the state sector, however, an increase in the relative price of the private sector good raises the expected income of a laid-off worker, measured in units of the state sector good, leading the union to lay off workers. While there is no direct effect of a change in the relative price on the private sector's employment decision, there is an indirect effect. Since unemployment is now higher at each level of H_t, the wage paid by the private sector will be lower, and employment in the private sector will expand. Since at each level of H_t, and therefore at each point in time during the transition process, unemployment and private sector employment are higher, employment in the state sector is lower. The speed of transition of the economy is thus higher as a result of an increase in the relative price of the private sector good.

Changes in State Sector Subsidies

The effects of once-and-for-all changes in the parameter τ, which is used to represent (one plus) the rate of subsidy (or tax) on output of the state sector in equation (3), are completely analogous to the effects of a change in relative prices. This can be seen by noting that τ and P appear jointly in equation (5), the state sector's employment rule, and do not directly affect the private sector's employment decision. A decline in the rate of subsidy to the state sector, which corresponds to a decline in the value of the parameter τ, would therefore shift the UH curve up, exactly as in Figure 2, increasing unemployment at each point in time, reducing the share of the labor force in the state sector, and increasing the share of the labor force employed in the private sector.

At the level of aggregation employed in the model here, the effects of changes in the parameter τ can also be interpreted as the effects of changes in other policy variables on the state sector: a tariff on the state sector; an employment or wage tax (or subsidy) in the state sector; and the effects of wage-bill ceilings. While these interpretations are not pursued here, it is useful to bear them in mind as alternative instruments for achieving the policy objectives discussed.

Employment or Wage Subsidy in the Private Sector

Since unemployment rises in the early stages of the transition because the state sector sheds labor at a faster rate than the private sector absorbs labor, a natural question is the effect of an employment or wage subsidy in the private sector. If firms in the private sector are granted an exogenous subsidy at the rate μ for each unit of labor they hire, the firm's

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first-order conditions imply

$$\frac{\partial E(W_t^2 - B, U_t)}{\partial W_t^2} \cdot \frac{(W_t^2 - \mu)}{E(W_t^2 - B, U_t)} = 1, \qquad \mu < W_t^2, \tag{25}$$

so that the elasticity of effort with respect to the real wage, adjusted for the rate of subsidy, equals unity. The real wage can then be expressed as a function of the rate of subsidy. It is straightforward to establish that

$$W_t^2 = W^2(\underset{-}{U_t}; \underset{+}{B}, \underset{-}{\mu}), \tag{26}$$

so that the wage paid in the private sector declines with an increase in the rate of the employment subsidy. By lowering the cost of raw labor, the employment subsidy lowers the firm's cost per unit of effective labor. The firm will therefore offer a lower wage rate to achieve the same cost per unit of effective labor and expand employment. Employment in the private sector is now given by

$$L_t^2 = \frac{(\alpha H_t)^{1/(1-\alpha)}[E(W_t^2 - B, U_t)]^{\alpha/(1-\alpha)}}{(W_t^2 - \mu)^{1/(1-\alpha)}}. \tag{27}$$

Therefore,

$$L_t^2 = L^2(\underset{+}{U_t}, \underset{+}{H_t}; \underset{-}{B}, \underset{+}{\mu}). \tag{28}$$

Noting that an employment subsidy to the private sector will also directly affect the state sector's employment decision by changing the expected wage of a worker laid off by the union, the impact on unemployment at any given level of H_t, or the vertical shift of the UH curve, is given by

$$\frac{dU_t}{d\mu} = \frac{-\left[\frac{\partial L_t^1}{\partial \mu} + \frac{\partial L_t^2}{\partial \mu}\right]}{\left[\frac{\partial L_t^1}{\partial U_t} + \frac{\partial L_t^2}{\partial U_t} + 1\right]}. \tag{29}$$

The denominator of equation (29) is positive. It can be shown that the sign of the numerator is determined by the sign of

$$\{[W_t^2 - \tau P F'(L_t^1)] - (1 - L_t^1)\tau P[-F''(L_t^1)]\}\underset{+}{\left(\frac{\partial L_t^2}{\partial \mu}\right)} + L_t^2\underset{-}{\left(\frac{\partial W_t^2}{\partial \mu}\right)}. \tag{30}$$

Whereas the second term in the expression is negative, the sign of the first term is determined by the sign of the term in the curly brackets. This

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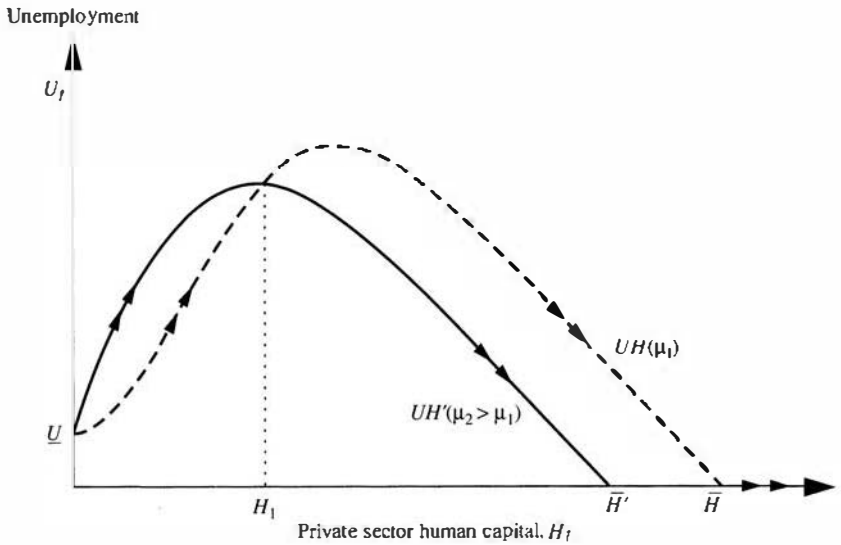
expression in the curly brackets is exactly the expression that determines the slope of the UH curve (see equation (A7) in the Appendix). It follows that when the slope of the UH curve is zero or negative, as it is for large values of H_t, expression (30) must be negative, so that the curve UH shifts down. For small values of H_t, however, when the UH curve is positively sloped, the first term in (30) is positive. Note further that, in the limiting case when H_t equals zero, L_t^2 equals zero, so that the expression will be positive. By continuity, it follows that there exists a range of values of H_t starting with zero such that the UH curve shifts up. Such a shift of the UH curve is plotted in Figure 4, where for small values of H_t the UH curve shifts up and for larger values of H_t it shifts down. The downward shift of the UH curve, or the reduction in unemployment at large values of H_t, is intuitive. The reason for the upward shift at low levels of H_t should also be clear. Essentially, subsidizing employment in the private sector causes employment to expand. However, the size of the sector also affects the extent to which it will expand. At the same time, the expansion of employment opportunities in the private sector causes an outflow of workers from the state sector. What we have established is that at low

Figure 4. *Increase in Private Sector Employment Subsidy with Exogenous Growth*



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levels of H_t the outflow from the state sector will exceed the flow into the private sector.

We now establish that private sector employment is higher at each point during the transition as a result of the increase in the employment subsidy to the sector. In Figure 4, for values of H_t up to H_1, an increase in the employment subsidy in the private sector creates higher private sector employment, since at each level of H_t, in addition to the effects of the subsidy, unemployment is higher. To establish that private sector employment is higher for all levels of H_t, first note that at H_1, where the values of unemployment and human capital in the private sector are the same on both curves, private sector employment is higher on the shifted UH curve since the rate of subsidy to the sector is higher. Then, note that the response of private sector employment to changes in H can be written as

$$\frac{\partial L_t^2}{\partial H_t} = \frac{1}{1-\alpha}\frac{1}{(\alpha H)} L_t^2(\mu), \tag{31}$$

so that the response increases with an increase in the rate of subsidy. It follows that since the level of private sector employment at H_1 is higher after the increase in subsidy and its slope with respect to H_t increases, private sector employment is higher at all subsequent levels of H_t.

Unemployment Benefits

An increase in unemployment benefits, by raising the alternative income of a worker employed in the private sector, that is, his or her reservation wage, causes firms in the private sector to raise offered wages and cut back employment. For workers in the state sector, the expected wage of a laid-off worker increases because of both the increase in unemployment benefits and the increase in private sector wages, creating an incentive for the union to lay off workers. However, the outflow of workers from each sector increases the probability that a worker leaving the state sector will remain unemployed, thus creating an incentive for the union to retain workers. The total impact on unemployment at any level of H_t is given by

$$\frac{dU_t}{dB} = \frac{-\dfrac{\partial L_t^1}{\partial B} - \dfrac{\partial L_t^2}{\partial B}}{\dfrac{\partial L_t^1}{\partial U_t} + \dfrac{\partial L_t^2}{\partial U_t} + 1}, \tag{32}$$

where the denominator is always positive. The sign of the numerator can

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be shown to be determined by the sign of

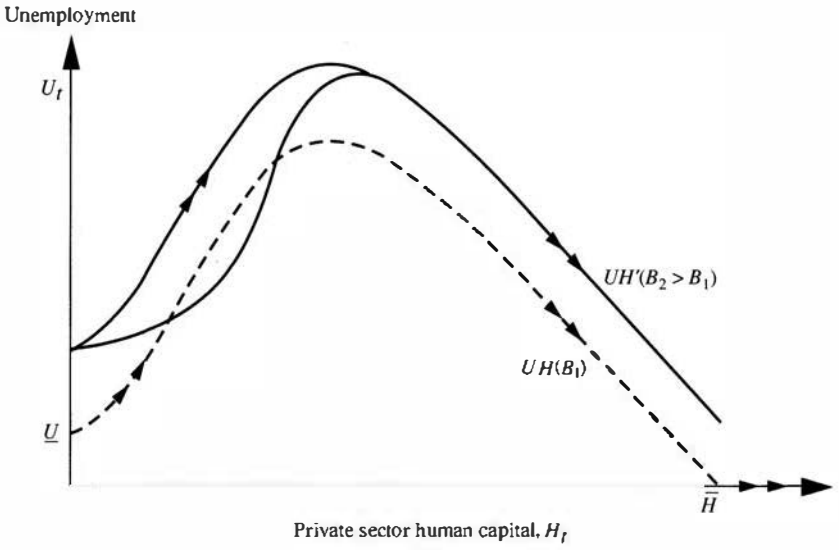
$$U_t + L_t^2\left(\frac{\partial W_t^2}{\partial B}\right) + \{[W_t^2 - \tau PF'(L_1)] - (1 - L_1)\tau P[-F''(L_t^1)]\}\left(\frac{\partial L_t^2}{\partial B}\right). \quad (33)$$

It follows that when the slope of the UH curve is negative or zero (as determined by the term in curly brackets), the expression is positive so that the UH curve shifts up. For values of H_t between zero and that corresponding to the peak unemployment rate, however, the effect is ambiguous. Note that the intercept of the UH curve unambiguously shifts up (see equation (A5) in the Appendix). Figure 5 plots two possible shifts of the UH curve in response to an increase in unemployment benefits.

Policies to Reduce the Unemployment Rate Continuously

There is, of course, no reason why policy variables should be adjusted only in a once-and-for-all manner in the present framework. Since the analysis suggests that with unchanged policies the unemployment rate

Figure 5. *Alternative Effects of an Increase in Unemployment Benefits*



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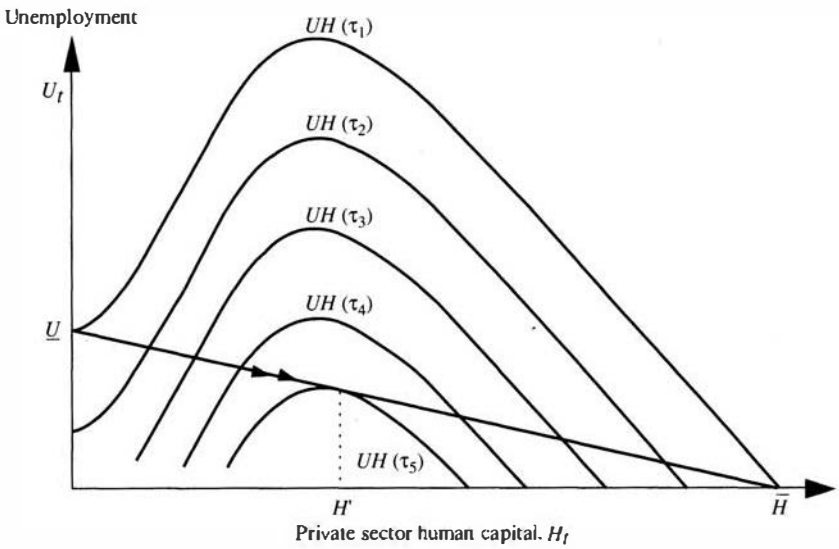
will rise over time in the early stages of the transition, it is natural to consider policies that prevent the unemployment rate from rising or even, since the analysis predicts the unemployment rate will eventually fall to zero, to consider policies that attempt to reduce unemployment monotonically to such a level, and thereby reduce the costs of transition. In the absence of specifying a particular objective function for the government, there are an infinite number of paths for the unemployment rate that would satisfy this objective. To focus ideas, we examine one that seems intuitive. In Figure 6, with unchanged policies, unemployment rises from $\underline{U}$, then subsequently falls, eventually reaching zero at $\bar{H}$. We consider a policy that seeks to take the economy in a linear fashion from $\underline{U}$ to $\bar{H}$, so that the dynamic path is given by the straight line joining $\underline{U}$ and $\bar{H}$. Starting at the initial unemployment rate, therefore, such a policy would succeed not only in lowering the unemployment rate at each point in time, compared with what it would be in the absence of such a policy, but also in lowering the rate of unemployment monotonically over time.

Consider how policies can achieve such a path. An employment subsidy to the private sector was shown to raise unemployment for small values of H without affecting the initial unemployment rate. This suggests

Figure 6. *Time-Varying State Sector Subsidy to Continuously Lower Unemployment with Exogenous Growth*



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that a policy to reduce the unemployment rate at small levels of H would actually need to tax employment in the private sector, and would succeed in lowering unemployment by preventing an outflow of workers from the state sector. A more direct way of doing this would be to subsidize employment or output in the state sector.[24] Moreover, since changes in the rate of subsidy to the private sector are powerless to affect the vertical intercept of the UH curve, and the curve is positively sloped at this point for any rate, it follows that there will exist some range of H_t over which such a policy cannot succeed in lowering the unemployment rate monotonically over time.

Consider instead an output subsidy to the state sector.[25] This was shown to shift the UH curve down for all levels of H. Figure 6 plots several UH curves as the rate of subsidy to the state sector increases. Figure 6 makes clear that for the economy to traverse on a straight line from $\underline{U}$ to $\overline{H}$ the rate of subsidy to the state sector will have to increase over time as H_t increases to H'. That the rate of subsidy needs to increase over time is intuitive since the subsidy will be preventing potentially increasing amounts of unemployment. As H exceeds H' in Figure 6, however, if the rate of subsidy is maintained, then the economy will simply traverse down the right-hand side of the UH curve tangent to the straight line $\underline{U}\overline{H}$ at $H = H'$. Therefore, a more gradual reduction in the unemployment rate, as implied by a movement along the $\underline{U}\overline{H}$ line would imply that the rate of subsidy can be relaxed or reduced over time.

Now compare the implications of a transition path along the straight line $\underline{U}\overline{H}$ to a transition path along the original UH curve on the speed of transition. Since unemployment is lower for each level of H_t and the state sector subsidy does not directly affect the private sector's employment decision, it follows that employment in the private sector will be lower at each point in time. Since private sector employment and unemployment are both lower at each point in time, it follows that state sector employment is higher at each point in time.

By maintaining employment in the state sector at a higher level, the policy succeeds in reducing the costs of the transition but it slows the speed of the transition process. In this framework, where the transition is inevitable because of an exogenously assumed faster rate of skills accumulation in the private sector, the budgetary costs of the subsidies to the state sector need to be compared only against the budgetary and welfare costs of unemployment. The speed of transition has no long-run

[24] There is no reason to use the same policy instrument for the entire transition process.

[25] Recall the earlier discussion that the use of several alternative policy instruments in the state sector would be equivalent in this model to the use of an output subsidy.

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impact. If the process of skill accumulation driving the transition process is endogenously determined, however, as discussed in the next section, the extent of transformation at any point in time, as measured by the relative size of employment in the private sector, takes on a critical importance in whether or not restructuring actually takes place.

Case of Endogenous Restructuring

The $\dot{H} = 0$ locus of combinations of unemployment and human capital separates initial conditions that imply eventual convergence to specialization in either the state sector or the private sector good. If the equilibrium level of unemployment for any given level of human capital is higher than that implied by the $\dot{H} = 0$ locus, the economy will converge to specialization in the private sector good. Note that the curve is negatively sloped in the unemployment–human capital plane. This implies that at low levels of human capital a high rate of unemployment is necessary to place the economy on a path leading to specialization in the private sector good. This characteristic of the present framework creates the fundamental dilemma for policies, in that unemployment, although it represents a cost to the economy, may be necessary for creating downward pressure on wages, such that private sector employment can expand sufficiently. The negative slope also implies, on the other hand, that at high levels of human capital, a (relatively) low level of unemployment may be sufficient for eventual specialization in the private sector good.

Consider now the effects of various policies and exogenous variables on restructuring toward the private sector good. Essentially, policies that succeed in reducing the critical level of human capital necessary for attaining a self-sustained path toward restructuring will increase the set of initial conditions converging to such a path, and can thus potentially alter the long-run equilibrium of the economy. Alternative policies will, however, have alternative implications for the unemployment rate.

An increase in the relative price of the private sector good, or a reduction in the rate of subsidy to the state sector, will shift the UH curve up as in Figure 7. Skill levels between H_t^c and $H_t^{c\prime}$, which are levels of human capital that previously implied convergence to the state sector good, now imply, given the higher rates of unemployment on the new UH curve, UH', convergence to production of the private sector good. Figure 8 shows the effects of an increase in the rate of employment subsidy to the private sector. This will shift the UH curve leftward,[26] implying at low levels of H higher unemployment and at high levels of H lower unemploy-

[26]The vertical intercept would be maintained, however.

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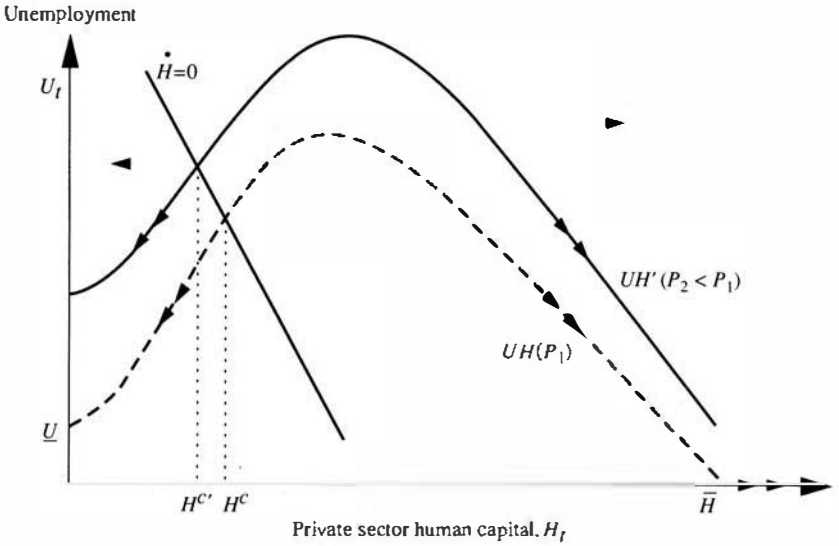
Figure 7. *Decrease in State Sector Subsidy with Endogenous Skill Accumulation*



ment. In addition, the $\dot{H} = 0$ locus shifts to the left, implying a lower level of unemployment necessary, at any given level of human capital, to place the economy on a path to self-sustained restructuring toward the private sector good. Figure 8 depicts two alternative situations: when the $\dot{H} = 0$ locus intersects the UH curve on the upward-sloping portion of the UH curve, and when it intersects it on the downward-sloping portion of the curve. In the former case, the $\dot{H} = 0$ locus is downward sloping while the UH curve is upward sloping. Since both curves shift leftward it follows that the critical level of human capital unambiguously falls. In the latter case, when both curves are downward sloping, it is possible to show—as is done in the Appendix—that the $\dot{H} = 0$ locus shifts down by more than the UH curve so that the critical level of human capital again falls.

In summary, then, policies that affect the state sector alone affect restructuring by shifting the UH curve, with an increase in unemployment increasing the set of initial conditions converging to specialization in the private sector good. Policies that affect the private sector, on the other hand, while affecting the UH curve, have the advantage that by also shifting the $\dot{H} = 0$ locus they reduce the unemployment necessary at any

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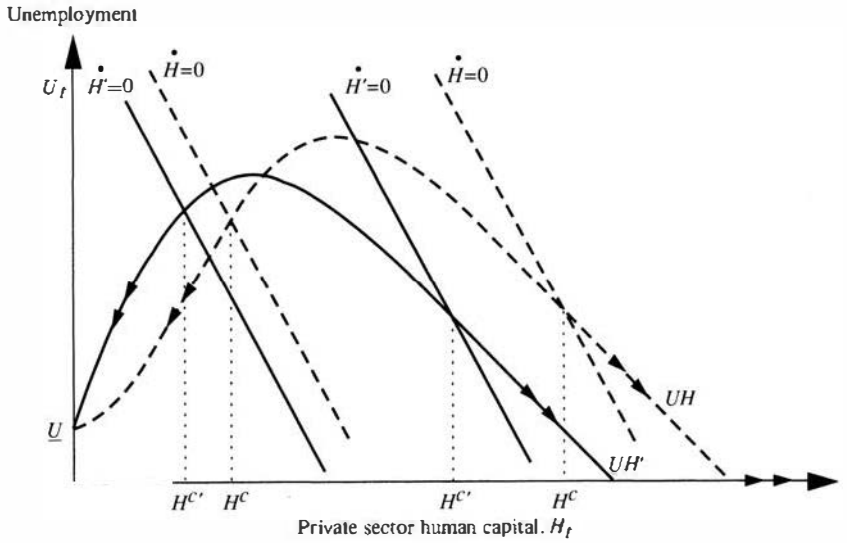
Figure 8. *Increase in Employment Subsidy to Private Sector with Endogenous Skill Accumulation*



level of human capital to bring about restructuring toward the private sector good.

III. Concluding Remarks

This paper has developed a simple model of the process of reallocation of labor from the state to the private sector in PCPEs. When growth and restructuring are viewed as exogenously driven, we showed that unemployment may increase in the transition because of the intrinsic dynamics of the reallocation process and in the absence of any new shocks to the economy. In explaining the actual experience of unemployment in the PCPEs, several factors are likely to have contributed to the rise in unemployment. First, the rise in unemployment can be viewed as resulting from a sequence of unanticipated exogenous shocks that generated and have sustained increases in unemployment.[27] While the initial re-

[27] If there are adjustment costs, each shock changing relative prices would generate transitory unemployment. See Mussa (1978) and Neary (1982) for two-sector models in the trade context that incorporate costs of adjustment.

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forms probably represented the largest shock, they were followed by a series of subsequent reforms, so that there were actually several shocks. Similarly, the collapse of the CMEA, and the subsequent loss of markets, could be viewed as having generated a sequence of shocks. Second, the rise in unemployment could be interpreted as a one-time movement toward an equilibrium rate of unemployment, in an economy characterized initially by "excessive" employment. Our analysis is not intended to diminish the role of these or other such factors in explaining the rise in unemployment in the PCPEs. Rather, it complements their role by highlighting a set of intrinsic dynamics that will tend to exacerbate increases in unemployment triggered by exogenous shocks.

The effects of alternative policies in reducing the unemployment costs of the transition process, and their impact on the speed of transition, were examined when growth was viewed as exogenous and restructuring as inevitable. In that context, several policies could be adopted to reduce or prevent a rise of unemployment during the initial stages of the transition without jeopardizing the final outcome of restructuring. Nevertheless, we showed that these unemployment-reducing policies would slow down the restructuring process. In a framework where growth was endogenous and the eventual outcome of restructuring determined by initial conditions, we showed that unemployment may be necessary to ensure that restructuring occurs. Policies that reduce unemployment, thus alleviating the costs of the transition, may jeopardize the final outcome of the restructuring.

It should be noted that in order to focus on the intrinsic dynamics generated by the transition it was implicitly assumed that any budgetary balance could be financed. The fiscal implications of the transition and the effects of alternative policies on the fiscal balance were ignored. In this sense, the analysis of the paper represents the unconstrained path of the economy. The fiscal dimension of the transition process is, of course, an important one.[28] The interaction of fiscal constraints with the endogenous process of restructuring and the reallocation of resources from the state to the private sector are examined in Chadha and Coricelli (1993). It is shown there that with constant tax rates on the state sector and a fixed real level of unemployment benefits per worker, the path of the budget deficit will mirror the behavior of unemployment. The budgetary balance will deteriorate continuously during the early stages of the transition, recovering only when the savings in unemployment expenditures are sufficient to compensate for the continuing decline in tax revenues from the state sector. Attempts to improve or maintain the budgetary balance

[28] Kornai (1992) and Tanzi (1993), among others, discuss the budgetary implications of restructuring in Eastern Europe.

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during the transition are shown to create pressures to maintain the state sector, slow the transition process, and could jeopardize the eventual outcome of the process of restructuring.

APPENDIX

This Appendix establishes several propositions employed in the text.

State Sector Employment and Unemployment

Differentiating the union's employment rule, the response of employment in the state sector to an increase in unemployment can be written as the sum of the four effects mentioned in the text, with the first two positive and the second two negative:

$$\frac{\partial L_t^1}{\partial U_t} = \frac{(L_t^1)^{2-\beta}}{\beta(1-\beta)\tau P}\frac{(1-\delta_t)(W_t^2 - B)}{(1-L_t^1)} + \frac{(L_t^1)^{2-\beta}}{\beta(1-\beta)\tau P}(1-\delta_t)\cdot\left(-\frac{\partial W_t^2}{\partial U_t}\right)$$
$$- \frac{(L_t^1)^{2-\beta}}{\beta(1-\beta)\tau P}\frac{\delta_t(W_t^2 - B)}{(1-L_t^1)}\frac{L_t^2}{W_t^2}\cdot\left(-\frac{\partial W_t^2}{\partial U_t}\right)$$
$$- \frac{(L_t^1)^{2-\beta}}{\beta(1-\beta)\tau P}\frac{\delta_t(W_t - B)}{(1-L_t^1)}\frac{\alpha}{(1-\alpha)}L_t^2\frac{\partial E}{\partial U_t}\frac{1}{E}. \qquad \text{(A1)}$$

By combining terms,

$$\frac{\partial L_t^1}{\partial U_t} = \frac{(L_t^1)^{2-\beta}}{\beta(1-\beta)\tau P}\left[-\frac{\partial W_t^2}{\partial U_t}\right]\frac{(1-\delta_t)}{W_t^2}[\delta_t B + (1-\delta_t)W_t^2]$$
$$+ \frac{(L_t^1)^{2-\beta}}{\beta(1-\beta)\tau P}\frac{\alpha}{(1-\alpha)}\frac{(1-\delta_t)}{(1-L_t^1)}(W_t^2 - B)\left[\frac{1-\alpha}{\alpha} - \left(\frac{\partial E}{\partial U_t}\right)\left(\frac{U_t}{E_t}\right)\right], \qquad \text{(A2)}$$

where the first term is positive, since the direct effect of a decline in private sector wages on state sector employment dominates the indirect effect by which the decline in private sector wages raises private sector employment and thus tends to reduce state sector employment. The second two terms represent the difference between the direct effect of unemployment on state sector employment and the indirect effect of unemployment, which raises worker effort in the private sector, and the consequent expansion in private sector employment. As equation (A2) shows, as long as the elasticity of effort with respect to unemployment is less than a positive constant, this term will be positive:

$$\frac{\partial E_t}{\partial U_t}\cdot\frac{U_t}{E_t} < \frac{1-\alpha}{\alpha}. \qquad \text{(A3)}$$

We assume that this is the case. It is worth noting that this condition is not necessary for any of our results. It is, however, sufficient.[29]

[29] The necessary condition for the analysis to be entirely unchanged is that the sum of the (i) partial derivative of employment in the state sector with respect to unemployment, (ii) the partial derivative of employment in the private sector

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Shape of the UH *Curve*

Note from equation (9) in the main text that when the level of human capital in the private sector is zero, employment in the private sector will be zero. The probability that a worker laid off from the state sector will remain unemployed is then unity. Therefore, the initial share of employment in the state sector is determined by solving

$$\beta(L_t^1)^{\beta-1} = \frac{B}{\tau P} \tag{A4}$$

for L_t^1. The initial unemployment rate is then

$$\underline{U} = 1 - \left[\frac{\tau P \beta}{B}\right]^{1/(1-\beta)}, \tag{A5}$$

so that the higher are unemployment benefits, the lower is the initial level of employment in the state sector and the higher the initial unemployment rate.

For positive levels of human capital in the private sector, the evolution of the unemployment rate with the accumulation of private sector human capital is determined by differentiating equation (A5):

$$\frac{dU_t}{dH_t} = \frac{-\left[\frac{\partial L_t^1}{\partial H_t} + \frac{\partial L_t^2}{\partial H_t}\right]}{\left[\frac{\partial L_t^1}{\partial U_t} + \frac{\partial L_t^2}{\partial U_t} + 1\right]}. \tag{A6}$$

The denominator is always positive. In the numerator, whereas employment in the state sector is a decreasing function of the level of human capital, employment in the private sector is an increasing function of the level of human capital. Differentiating equation (5) from the main text, and combining terms, the numerator in (A6) can be expressed as

$$\{\delta_t(W_t^2 - B) - \tau P(1 - L_t^1)[-F''(L_t^1)]\}\frac{1}{\tau P}(1 - L_t^1)\frac{1}{[-F''(L_t^1)]}\left(\frac{\partial L_t^2}{\partial H_t}\right). \tag{A7}$$

Since the terms outside the curly brackets are all positive, the sign of this expression will be determined by the sign of the expression in the curly brackets:

$$\text{Sign of } \left(\frac{dU_t}{dH_t}\right) = \text{Sign of } \{\delta_t(W_t^2 - B) - \tau P(1 - L_t^1)[-F''(L_t^1)]\}, \tag{A8}$$

the difference of two positive terms.

---

with respect to unemployment—which is unambiguously positive, and (iii) unity be positive. Alternatively stated, the partial derivative of aggregate employment in the economy with respect to unemployment must be greater than negative unity. From a stability point of view, one would expect the partial derivative of aggregate employment with respect to unemployment to be positive. While we could assume a much weaker condition, our assumption has the advantage of keeping the presentation of the analysis transparent. We note also that in simulations of the model we were unable to find a case where the partial derivative of employment in the state sector with respect to unemployment was negative.

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It is useful to note several features of the expression in equation (A8), which can be rewritten as

$$\left[W^2(U_t) - \frac{\tau P \beta}{(L_t^1)^{1-\beta}}\right] - \frac{\tau P(1 - L_t^1)\beta(1 - \beta)}{(L_t^1)^{2-\beta}}. \tag{A9}$$

First, note that as L_t^1 becomes small the absolute value of the second term increases and the expression must, at some value of L_t^1, become negative. In fact, as L_t^1 approaches zero the expression will approach negative infinity. Since L_t^1 is a decreasing function of H_t, it follows that as H increases, the slope of the UH curve eventually becomes negative. Second, note that when L_t^1 is large the second term is small. In fact, as L_t^1 approaches unity the second term approaches zero. The magnitude of the first term depends also on the level of unemployment. Since the wage in the private sector is a decreasing function of the level of unemployment, the first term, the one in square brackets, will be largest when employment in the state sector is high (so that the marginal product of labor in the state sector is low) *and* when unemployment is low (so that the level of unemployment does not exert much downward pressure on the private sector wage). In such circumstances, the private sector wage will be determined predominantly by considerations of worker efficiency and hence tend to be relatively high. The expression is likely to be positive, therefore, when the initial level of employment in the state sector is high and the level of unemployment low.

UH *and* $\dot{H} = 0$ *Curves*

This section establishes that (i) the slope of the UH curve is always greater than the slope of the $\dot{H} = 0$ locus so that there is a unique intersection of the two curves and that (ii) in response to an increase in the private sector employment subsidy, when both the UH curve and the $\dot{H} = 0$ locus are downward sloping, the $\dot{H} = 0$ locus shifts down by more than the UH curve, and the critical level of human capital falls.

To establish that the two curves have a unique intersection, two observations are necessary. First, note that the $\dot{H} = 0$ locus can be written as $L_t^2 = \theta_2/(\theta_1 + \theta_2) = \phi$, so that along an $\dot{H} = 0$ locus the proportion of the labor force employed in the private sector is constant. Since L_t^2 is a positive function of unemployment and private sector human capital, note that the $\dot{H} = 0$ locus shifts to the right for an increase in ϕ. Along the new $\dot{H} = 0$ locus, L_t^2 is constant at a higher level. Second, recall that L_t^2 increases monotonically as the economy moves rightward along the UH curve. Now, suppose that the UH curve and the $\dot{H} = 0$ locus intersect twice, as in Figure A1. Then, in moving from point X to Y in Figure A1 along the UH curve, L_t^2 increases. However, this contradicts the fact that L_t^2 is higher along the $\dot{H}(\phi_2 > \phi_1) = 0$ curve than along the $\dot{H}(\phi_1) = 0$ curve. Therefore, this can never be.

We have established that an increase in the private sector employment subsidy shifts the UH curve to the left and L_t^2 is higher at each level of H on the new UH curve. Comparing points A and B on the two UH curves drawn in Figure A2, L_t^2 is greater at B than at A. The original $\dot{H} = 0$ locus intersecting the original UH curve at point A implies that L_t^2 equals ϕ at point A. So L_t^2 must be greater than ϕ at B. Recalling that L_t^2 increases monotonically along the UH curve, it follows that L_t^2 is greater than ϕ all along the right-hand side of B on the new UH curve, UH'. Now note that the new, or shifted, $\dot{H} = 0$ locus still represents $L_t^2 = \phi$. Therefore, it must intersect UH' to the left of B.

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Figure A1. *Proof by Contradiction of Unique Intersection of UH and $\dot{H}$=0 Curves*

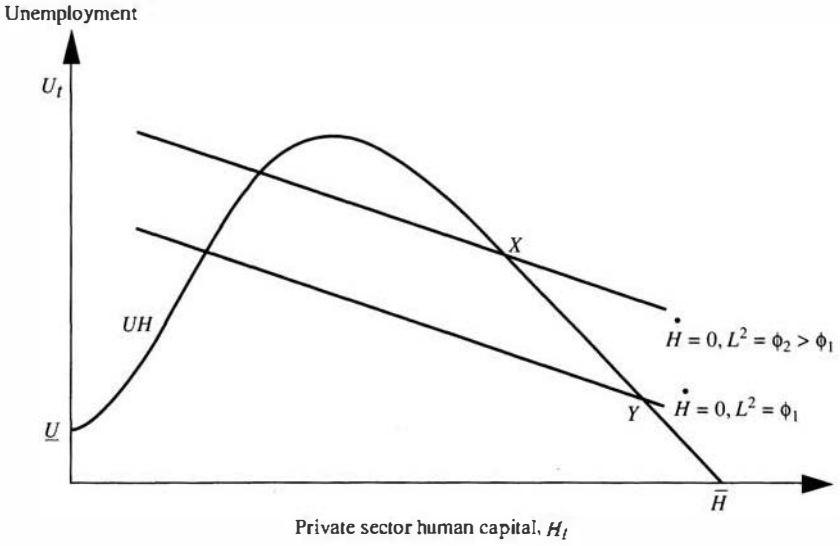
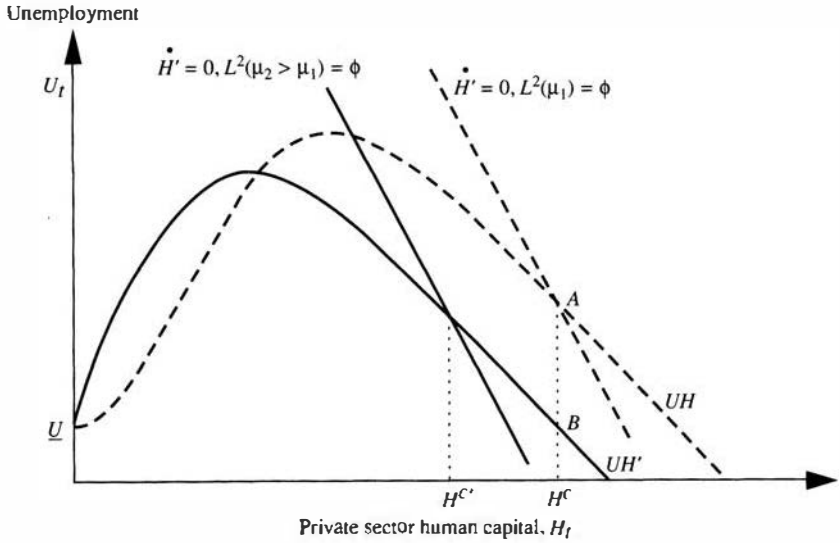


Figure A2. *Increase in Employment Subsidy to Private Sector*



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The Yield Curve and Real Activity

ZULIU HU*

This paper attempts to formalize the link between the yield curve and real economic activity. A closed-form formula for the term structure of interest rates is derived. The paper then documents the use of bond market data for predicting GDP growth in the G-7 industrial countries. The results suggest that a simple measure of the slope of the yield curve, namely the yield spread, serves as a good predictor of future economic growth. The out-of-sample forecasting performance of the yield spread compares favorably with that of the alternative stock price–based model and a univariate time series (ARMA) model. [JEL E32, G12]

THE DAILY FINANCIAL PRESS frequently runs stories suggesting a close association between the term structure of interest rates and future real activity. Banks, bond dealers, and Wall Street pundits often claim that the shape of the yield curve says something about economic prospects. An upwardly sloping yield curve, for example, is interpreted as a sign of a strong economy ahead; a flattening or inverting yield curve is seen as a foreshadowing of recession. The goal of this paper is to formalize the link between the yield curve and real activity and examine the alleged predictive power of yield curve variables.

A number of studies have examined the relationship between short-term and long-term interest rates (see Shiller, Campbell, and Schoenholtz (1983) and Mankiw and Summers (1984)). In particular, Fama (1984, 1990a), Mishkin (1990a, 1990b), and Campbell and Shiller (1991) have found that the term structure predicts future spot rates and inflation. Clearly, economists and policymakers are also concerned with the link between movements in long-term and short-term interest rates and

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macroeconomic fluctuations in real output. Recent work by Stock and Watson (1989), Harvey (1989), Chen (1991), and Estrella and Hardouvelis (1991) has provided evidence that the U.S. term structure can also be used to predict growth in real GNP.

This study documents the forecasting power of the yield curve variables for predicting gross domestic product in the Group of Seven (G-7) industrial countries. The paper sets out a simple model that gives rise to a closed-form solution of the term structure of interest rates. It is shown that the slope of the yield curve has a linear relation with the expected growth in real output. After briefly discussing measurement issues and data sources, the paper then examines empirically whether the main implications of the model are borne out by data from a set of industrial countries. The focus is on investigating the predictive power of a simple measure of the term structure—the yield spread between long-term and short-term government bonds—for subsequent economic growth.

I. The Model

The term structure of interest rates measures the relationship among the yields on default-free bonds of varying maturities. Equilibrium asset pricing theories shed light on how underlying economic variables determine this relationship. The current paper asks the opposite question: whether one can extract from the yield curve information about future real activities.

This paper presents an intertemporal equilibrium model. In the empirical part of the paper, observed interest rate variables are used to predict future output growth. The model is built on the work of Merton (1973), Lucas (1978), Brock (1982), Cox, Ingersoll, and Ross (1985), and especially Breeden (1979, 1986).

Consider an infinite-horizon economy made up of a single agent, a single production technology, and a single physical commodity that can be allocated to either consumption or investment. Let (Ω, F, P) be a filtered probability space for the continuous time set $T = [0, \infty)$, where $F = \{F_t, t \geq 0\}$ is the filtration of a standard Brownian motion B. The consumption set C comprises those positive predictable processes $c = \{c_t, t \geq 0\}$ that satisfy

$$E\left\{\int_0^T e^{-\rho t} u[c(t)]\, dt\right\} < \infty, \tag{1}$$

almost surely for all $T \geq 0$. The agent has preferences over positive

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stochastic consumption processes c given by the lifetime utility functional:

$$U(c) = E\left\{\int_0^\infty e^{-\rho t} u[c(t)]\, dt\right\}, \tag{2}$$

where $c(t)$ is the time t rate of consumption, $E(\cdot)$ is an expectations operator, ρ is the rate of time preference, and $u(\cdot)$ is the instantaneous utility function. To derive an analytic characterization of the term structure, $u(\cdot)$ is restricted to be the logarithmic function: $u[c(t)] = \log[c(t)]$.

Assume that the shocks to the productivity of capital can be described by a single sufficient statistic or state variable, $x(t)$, defined by

$$dX_t = \mu_x(X,t)dt + \sigma_x(X,t)dB_t, \tag{3}$$

where $\mu_x(x,t)$ and $\sigma_x(x,t)$ are predictable processes, and the standard Brownian motion, B_t, is a martingale under the filtered probability measure.

The gross output in this economy is given by the following stochastic integral equation:

$$Y_t = Y_0 + \int_0^t \mu_y(Y,X,s)ds + \int_0^t \sigma_y(Y,X,s)dB_s. \tag{4}$$

Further impose the restrictions that both the drift and diffusion terms in equation (4) are homogeneous of degree one in Y:

$$\mu_y(Y,X,s) = Y\mu_y(X,s),$$

and

$$\sigma_y(Y,X,s) = Y\sigma_y(X,s).$$

These restrictions imply that the production technology has stochastic constant returns to scale.

The consumer can borrow or lend the consumption good at the instantaneously riskless interest rate r. The consumer can also hold a default-free zero-coupon bond that delivers one unit of the consumption good at maturity date T. Without loss of generality, assume that this default-free bond is the only financial security available. The value of the default-free zero-coupon bond, $P(t,T)$, will in general depend on the state variable $X(t)$ as well as the time to maturity. Its dynamics can be written as

$$dP = \mu_p\, dt + \sigma_p\, dB. \tag{5}$$

The consumer's total wealth at time t, $W(t)$, in units of the physical good, is the sum of his or her human and nonhuman wealth. Since labor

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is not used in the production processes, the consumer's entire wealth consists of the nonhuman part only, which is to be allocated among investments in the production processes, default-free bonds, and riskless borrowing and lending. Suppose that the consumer invests an amount of wealth, aW, in the production process and an amount of wealth, bW, in the default-free bond. Then, his or her intertemporal budget constraint takes the form

$$dW = [aW(\mu_y - r) + bW(\mu_p - r) + rW - c]dt + aW\sigma_y dB + bW\sigma_p dB. \tag{6}$$

An equilibrium is defined as a set of stochastic processes (P, r, a, C) such that (i) the agent maximizes his or her expected lifetime utility, equation (2), subject to budget constraint (6) and (ii) the net supply of the default-free bond and riskless lending is zero: $b = 0$.

The market-clearing condition (ii) is intuitive since there is only one agent in this economy. This condition implies that $a = 1$—that is, all the agent's wealth is invested in the physical production processes.

Denote the consumer's value function as $V(W, X, t)$. Applying Bellman's principle to this continuous-time stochastic control problem leads to the following first-order conditions:

$$\frac{1}{c} = V_w, \tag{7}$$

$$WV_w(\mu_y - r) + W^2 V_{ww} a\sigma_y^2 + \frac{1}{2}W^2 V_{ww} b\sigma_y\sigma_p = 0, \tag{8}$$

$$WV_w(\mu_p - r) + \frac{1}{2}W^2 V_{ww} a\sigma_y\sigma_p + W^2 V_{ww} b\sigma_p^2 = 0, \tag{9}$$

where V_w and V_{ww} denote the first-order and second-order partial derivatives of V with respect to W. Substituting the market-clearing conditions into equation (8) gives

$$r = \mu_y + \frac{WV_{ww}}{V_w}\sigma_y^2. \tag{10}$$

It can be shown that given the specific assumption about the utility function, the consumer's value function also takes a simple form: $V(W,t) = (1/\rho)\log(W)$. Therefore, from equation (7) one can write optimal consumption as

$$c = \rho W = \rho Y.$$

This consumption function implies that the agent consumes a fixed proportion of output, with the proportionality factor being his or her rate of

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time preference. Furthermore, since the agent's coefficient of relative risk aversion equals one, equation (10) can be simplified as

$$r = \mu_y - \sigma_y^2. \tag{11}$$

Equation (11) gives a simple, closed-form formula for the equilibrium interest rate. It explicitly links the interest rate to the economy's production processes. Since real output is postulated to follow the Ito process, and the agent has logarithmic preference, the path of the riskless interest rate is completely determined by the first two moments of the production technology. The equilibrium interest rate is higher if the expected growth rate of real output is higher, and is also higher if the risk associated with aggregate production is smaller, all other things equal. This important relationship provides the basis for forecasting economic growth through interest rate variables.

Note that because of the logarithmic utility assumption, the covariance of the production process with the state variable X_t does not enter equation (11). Such a covariance term would appear for more general preference specifications, as, for example, in Breeden (1986).

For empirical implementation, the following discrete-time approximation to equation (11) is used:

$$r(t, T) = \mu_y(t, T) - \sigma_y^2(t, T). \tag{12}$$

The term structure implied by this production-oriented equation has some interesting shapes. It will be upwardsloping if, holding the variance of production constant, the growth rate of real output in the economy is expected to be higher. It will be downward sloping if the economy is expected to enter a phase of recession. Therefore, the term structure, or the yield differential between long-term and short-term interest rates, embodies the market's expectations about the prospects of the economy, and hence contains useful information about aggregate economic fluctuations.

Since

$$\mu_y(t, T) = E_t\left(\frac{\Delta Y_{t,T}}{Y_t}\right), \tag{13}$$

equation (12) can be rearranged to obtain

$$E_t\left(\frac{\Delta Y_{t,t}}{Y_t}\right) = r(t, T) + \sigma_y^2(t, T). \tag{14}$$

Equation (14) makes it clear that investment in the risky production process receives a premium over the riskless interest rate, determined by the conditional variance of production. In the rest of this paper, it

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is assumed that the stochastic process of production has constant variance so that one can concentrate on the relationship between expected economic growth and the term structure of interest rates.

Consider two default-free bonds with maturity dates at T and τ, respectively. Subtracting from equation (14) the corresponding equation for the bond with maturity τ yields

$$E_t\left(\frac{\Delta Y_{\tau,T}}{Y_t}\right) = S^y_{t,T-\tau}, \tag{15}$$

where

$$S^y_{t,T-\tau} = r(t,T) - r(t,\tau) \tag{16}$$

is the interest rate differential, or yield spread, between the two default-free bonds.

To remove the conditional expectations operator, rewrite equation (15) as

$$\frac{\Delta Y_{\tau,T}}{Y_t} = S^y_{t,T-\tau} + \epsilon_t, \tag{17}$$

where ϵ_t is the forecast error. Equation (17) is the basic model for empirical estimation in this paper.

II. Measurement Issues and Data Sources

To examine the relationship between the term structure and real activity, this paper focuses on the yield spread between default-free bonds with different maturities. This spread measures the slope of the yield curve. Economists' interest in this particular variable dates back to Kessel (1965), who first documented the co-movements of the term structure and the business cycle and found that the size of the yield spread is associated with general economic conditions, such as recession and recovery. For simplicity, only a single measure of the slope of the yield curve is constructed: the difference between annualized yields on long-term versus short-term government bonds. This variable is denoted as S^y. A wider spectrum of bond maturities would presumably provide finer information on the forecasting power of the term structure for economic growth. Thus, the regression results below should be carefully interpreted, because poor empirical performance using S^y does not necessarily constitute a strong case against the principle implication of the term structure model in the preceding section—namely, that expected growth

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in real output is positively and linearly related to the slope of the yield curve.

The gross national product and the gross domestic product are the natural candidates for measuring aggregate output. Strictly speaking, the horizon over which one measures real output growth should correspond to the exact maturity structure of the government bonds chosen. What the regressions use, however, are year-to-year growth rates taken from quarterly data. In other words, the dependent variable in the regression equations is

$$dY_t = \log\left(\frac{Y_{t+4}}{Y_t}\right). \tag{18}$$

It is acceptable to focus on the four-quarter growth rates when testing the term structure model, because data over shorter horizons, such as one-quarter changes, likely contain more measurement error. The related evidence on stock returns (see Fama (1990b), for example) suggests that term structure may also have better predictive power for real activity over horizons spanning from one to several years.

The basic model of interest rate term structure is applied to the G-7 countries—Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The paper works with quarterly data. Most of the series used in this study are taken from the International Monetary Fund's *International Financial Statistics*.

For aggregate real output series, the study uses real GNP or real GDP, whichever is contained in the *International Financial Statistics*. The quarterly series are seasonally adjusted at annual rates. In those cases in which both nominal GNP and nominal GDP are available for a country, the two real series have been compared under the assumption of a common deflator. Because only a minor difference between the two series exists, the longest series is picked as the measure of real output.

The quarterly long-term government bond yield and quarterly treasury bill (T-bill) rate are taken from *International Financial Statistics*'s interest rate data. They are period-average annualized rates. The long-term government bonds usually have at least five years to maturity, while the short-term rate used here is the three-month T-bill rate. If the treasury bill series is not available for a country, a typical short-term interest rate is then used as a proxy for the T-bill rate. This series is published in Organisation for Economic Cooperation and Development's (OECD) *Financial Statistics*. The stock price index and consumer price index are taken from *International Financial Statistics*. Quarterly data are period averages.

Table 1 reports summary statistics for three time series: real GDP

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Table 1. *Summary Statistics for Real GDP Growth, Yield Spread, and Real Stock Price Changes Based on Quarterly Data*

	Sample period	Number of observations	Mean	Standard deviation	Autocorrelation ρ1	ρ2	ρ3	ρ4	ρ8	ρ12
Canada										
GDP growth	1957:1–1991:4	140	0.03825	0.02566	0.81	0.59	0.36	0.11	0.08	0.07
Yield spread	1957:1–1991:4	140	0.00942	0.01474	0.85	0.67	0.51	0.40	0.07	−0.04
Stock price changes	1957:1–1991:4	140	0.00349	0.16708	0.79	0.45	0.07	−0.22	−0.07	−0.05
France										
GDP growth	1971:1–1991:3	83	0.02715	0.01946	0.86	0.69	0.48	0.29	0.11	0.11
Yield spread	1971:1–1991:3	83	0.00683	0.01258	0.75	0.42	0.20	−0.02	−0.25	−0.01
Stock price changes	1971:1–1991:3	83	0.00714	0.23665	0.77	0.53	0.25	−0.08	−0.03	0.01
Germany										
GDP growth	1961:1–1991:4	124	0.03046	0.02381	0.78	0.56	0.38	0.16	−0.12	0.01
Yield spread	1961:1–1991:4	124	0.01913	0.01595	0.84	0.67	0.48	0.28	−0.07	0.09
Stock price changes	1961:1–1991:4	124	−0.00961	0.18663	0.80	0.51	0.25	−0.02	−0.25	0.13
Italy										
GDP growth	1972:1–1991:4	80	0.03021	0.02851	0.79	0.48	0.12	−0.17	−0.15	0.16
Yield spread	1972:1–1991:4	80	−0.00356	0.01902	0.78	0.44	0.14	−0.05	0.12	0.09
Stock price changes	1972:1–1991:4	80	−0.04972	0.33407	0.88	0.67	0.41	0.16	−0.01	0.04
Japan										
GDP growth	1967:4–1991:4	97	0.04472	0.03678	0.83	0.73	0.58	0.40	0.07	0.11
Yield spread	1967:4–1991:4	97	0.00234	0.01430	0.85	0.64	0.18	−0.01	−0.32	−0.29
Stock price changes	1967:4–1991:4	97	0.06262	0.20236	0.86	0.63	0.38	0.11	−0.17	0.11
United Kingdom										
GDP growth	1959:1–1991:4	132	0.02413	0.02432	0.65	0.44	0.24	0.03	−0.13	−0.02
Yield spread	1959:1–1991:4	132	0.01188	0.02063	0.90	0.79	0.68	0.58	0.27	0.29
Stock price changes	1959:1–1991:4	132	0.02076	0.21898	0.81	0.54	0.25	−0.02	−0.11	−0.12
United States										
GDP growth	1958:1–1991:4	136	0.02828	0.03302	0.85	0.62	0.35	0.11	−0.09	−0.06
Yield spread	1958:1–1991:4	136	0.01231	0.01155	0.85	0.68	0.55	0.43	0.01	−0.12
Stock price changes	1958:1–1991:4	136	0.01939	0.15618	0.80	0.47	0.11	−0.17	−0.08	0.09

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growth, yield spreads, and stock market price changes. The standard deviations of the yield spreads are typically within one-half of the mean GDP growth rates. The stock market price changes are much more volatile than either GDP growth or the yield spreads. They exhibit fairly similar patterns of autocorrelation.

The time series data are plotted in Figure 1. The series are aligned so that if the GDP growth and financial time series coincide, then the financial variables are a perfect forecast of GDP growth. The individual figures suggest that the yield spread leads real output. This pattern is especially evident for Canada, France, and Germany. It seems that the yield spread tracks real GDP growth more closely than do stock prices. Since stock prices exhibit far more variability than real GDP, stock price changes are likely to be very noisy predictors of GDP growth.

III. Empirical Evidence

Table 2 documents the within-sample forecasting power of the term structure over the whole period for each country. Because of the overlapping data in the regressions for annual growth, the ordinary least squares (OLS) standard errors are inconsistent, although the OLS estimates of the slope coefficients are not. The Hansen (1982) and Newey and West (1987) method is used to correct for autocorrelation and conditional heteroskedasticity.

The estimated slope coefficients are significantly positive for all countries, suggesting that the slope of the yield curve is positively related to the expected growth rate in real output. A simple measure of the term structure—the yield spread between long-term and short-term government bonds—can explain a large fraction of the variation in real output. It is especially striking to note, for example, that the yield spread alone explains more than half of the GDP variation in Canada. The explanatory power of the yield spread is not limited to the full sample period. The subsample results in Table 3 offer further evidence that the yield curve contains a great deal of information about real output growth. It appears, for example, that the relatively small R^2 for the United Kingdom stems from the latter half of the sample. Table 4 presents evidence that the yield spread also helps predict the GDP growth residual, obtained by regressing GDP growth on all its possible lags.

To evaluate the forecasting performance of the term structure, consider an alternative model based on the changes in stock prices. Studies of the business cycle have paid a great deal of attention to the stock market. In the 1920s, the Harvard "ABC" system pioneered the use of

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Figure 1. *GDP Growth, Lagged Yield Spread, and Lagged Stock Price Changes: G-7 Countries*

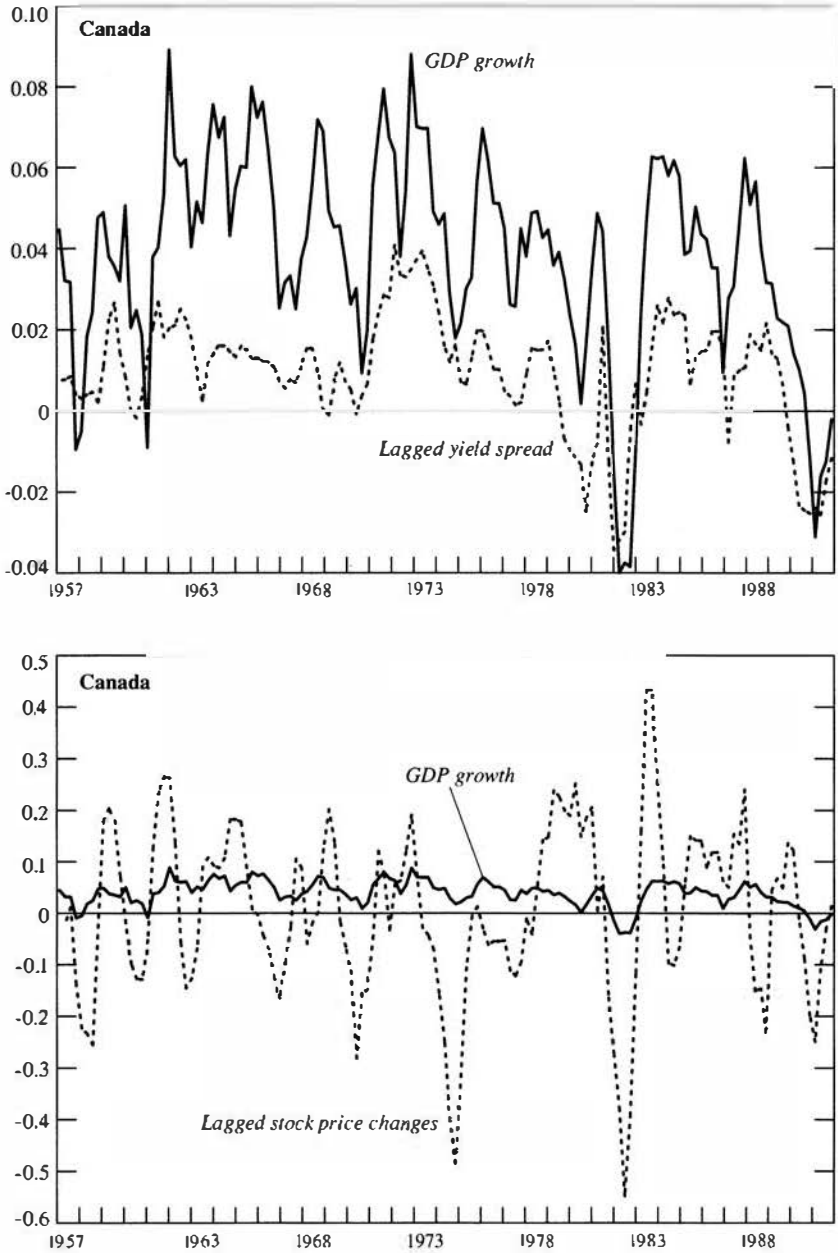

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Figure 1 *(continued)*

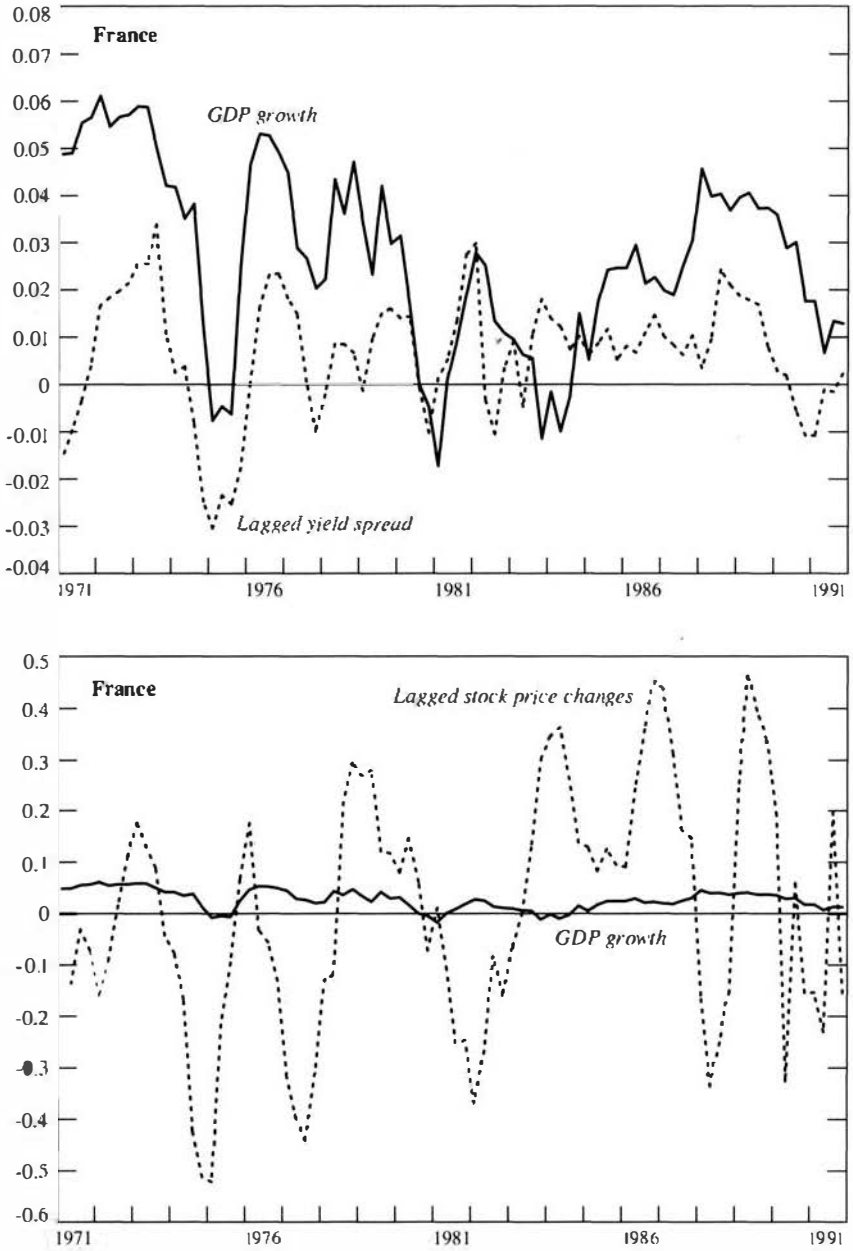

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Figure 1 *(continued)*

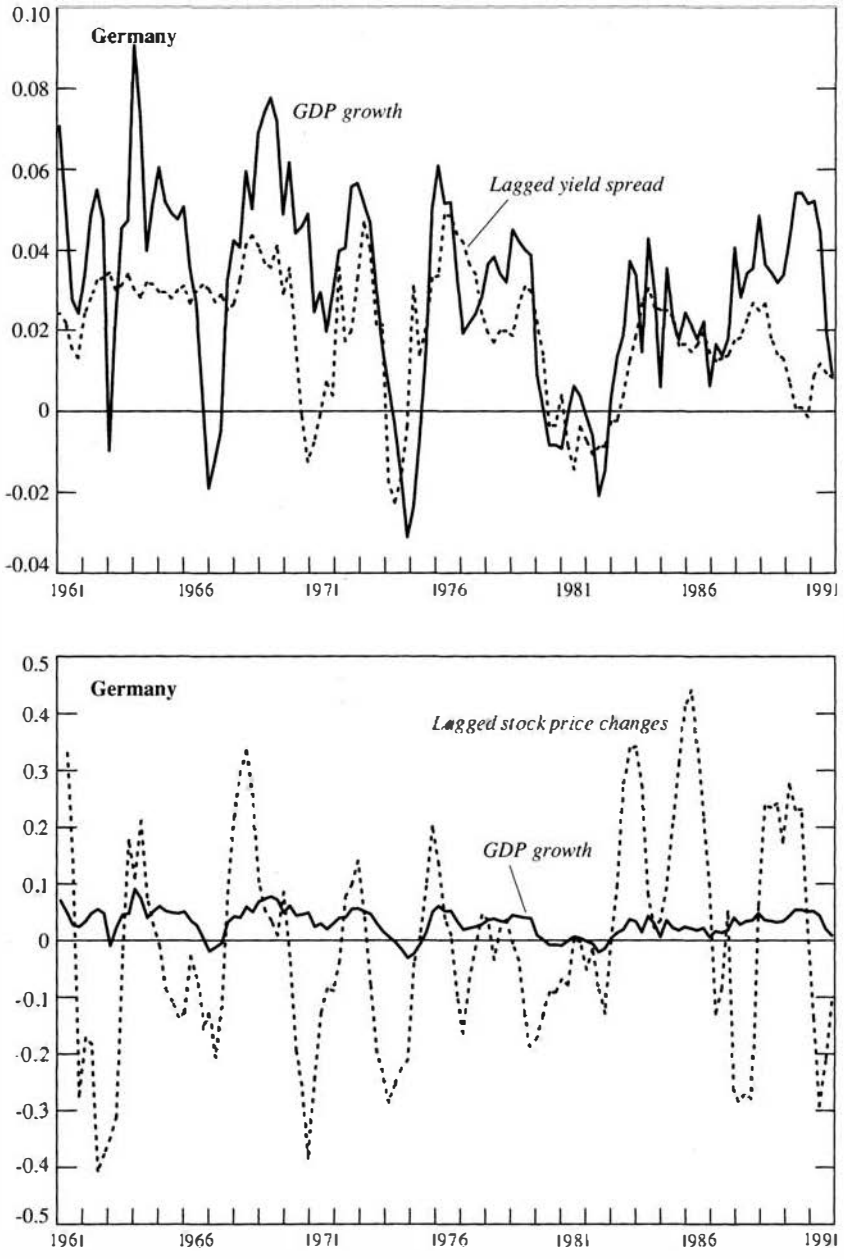

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Figure 1 *(continued)*

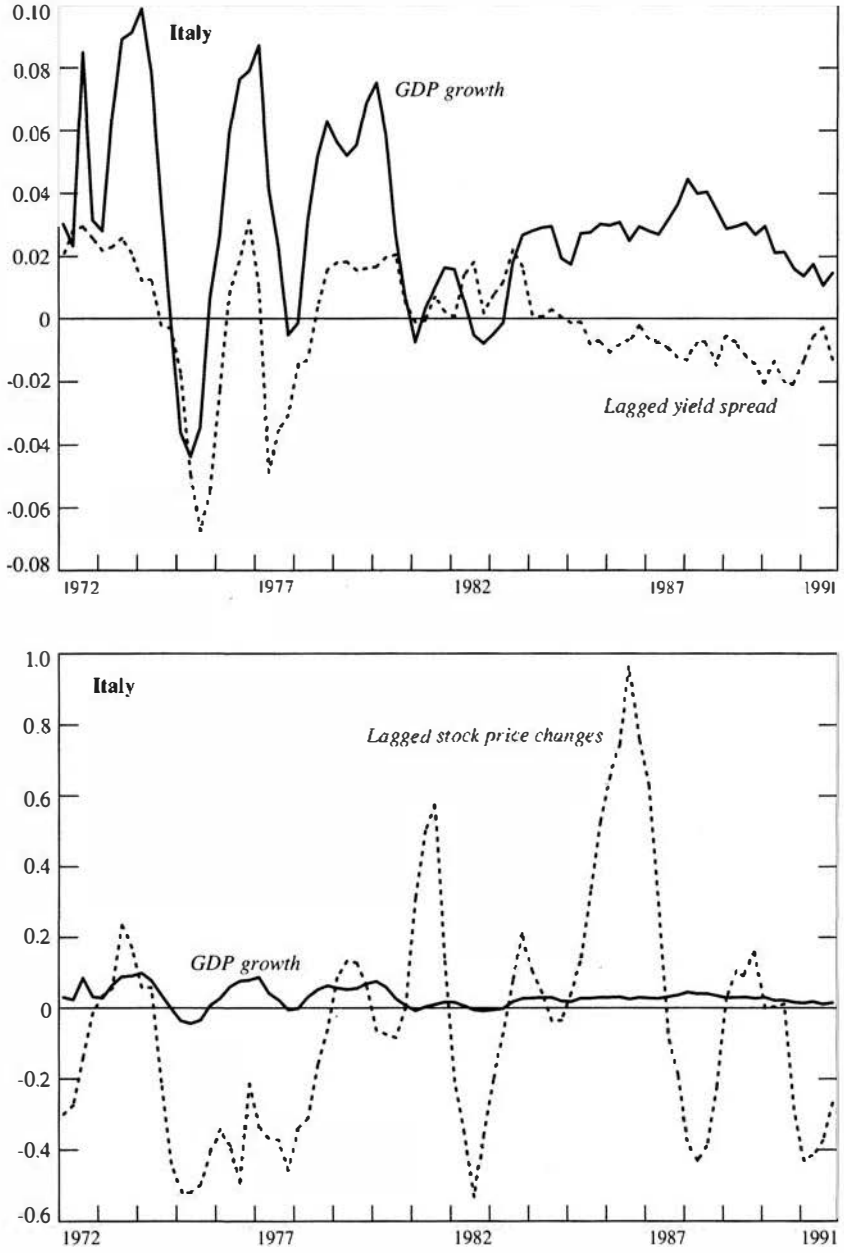

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Figure 1 *(continued)*

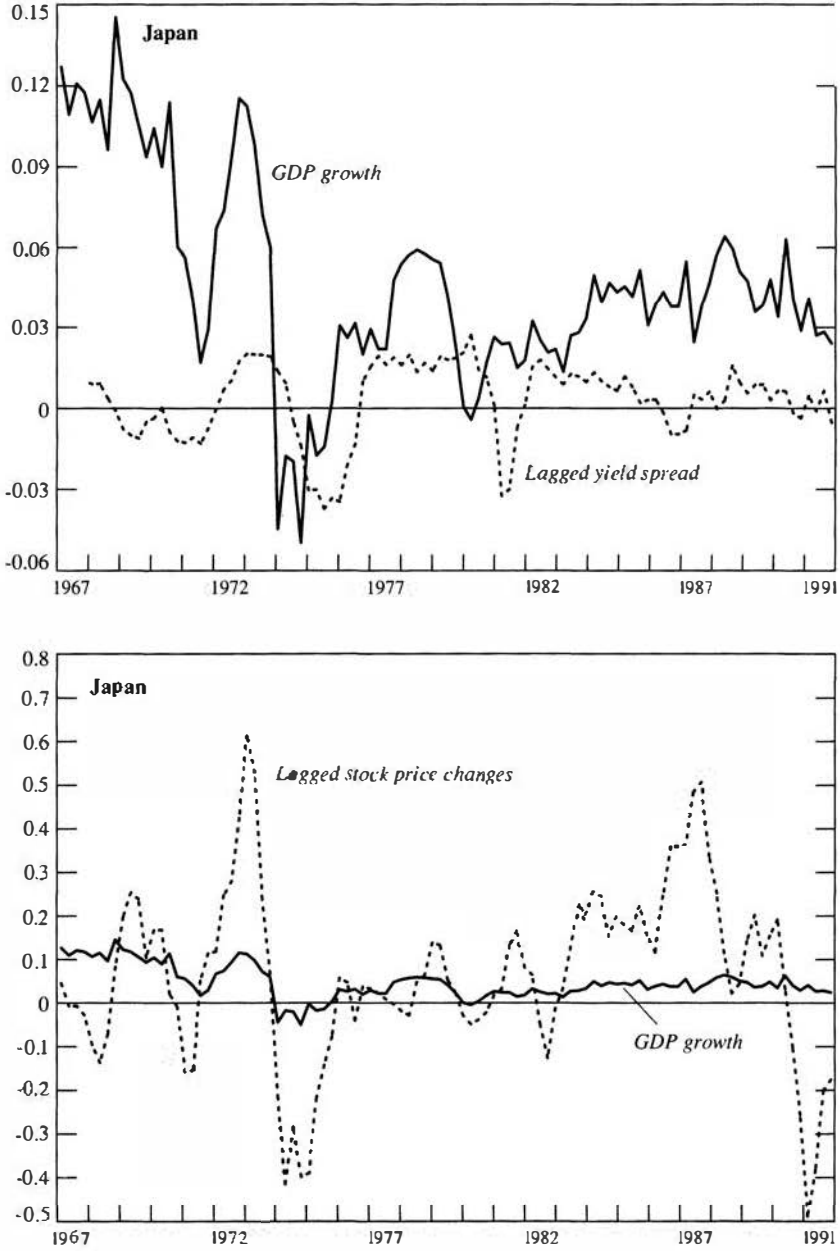

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Figure 1 *(continued)*

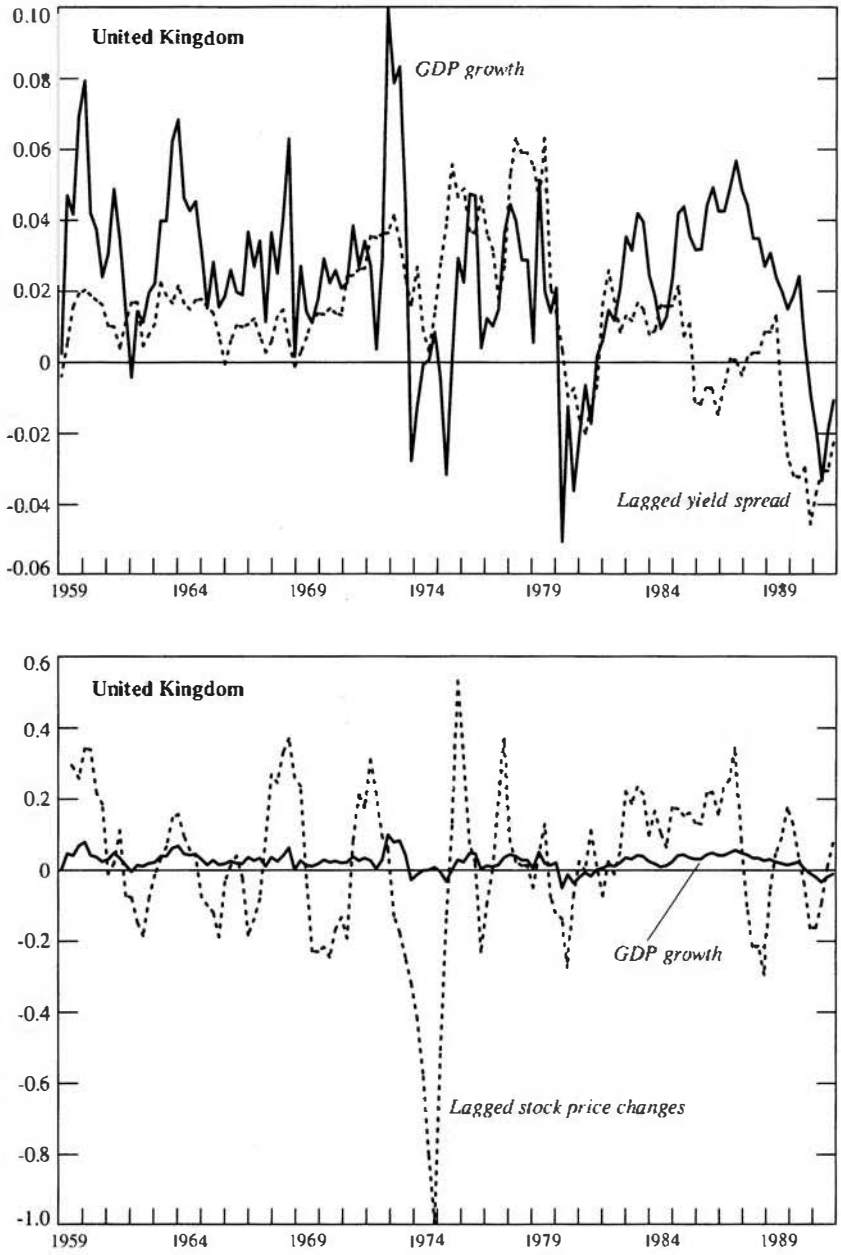

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Figure 1 *(concluded)*

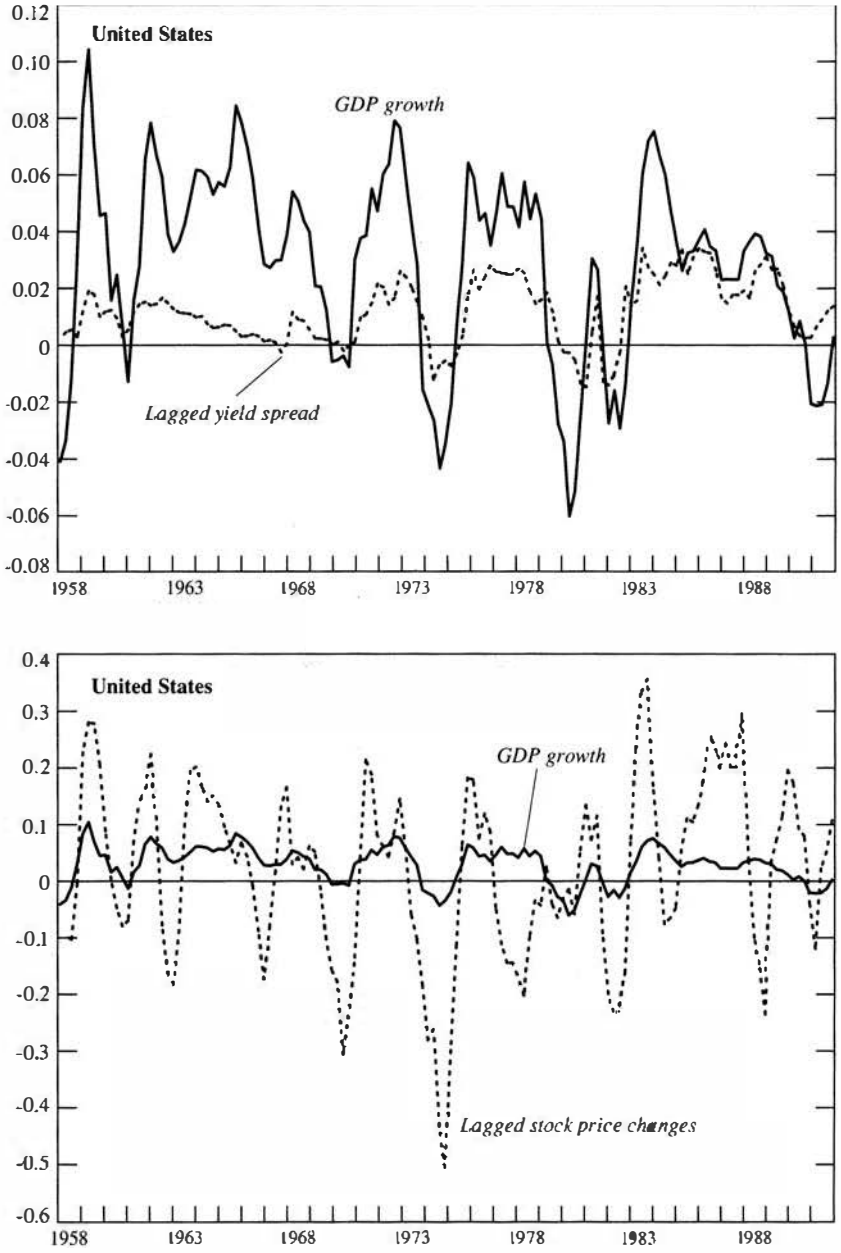

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Table 2. *Forecasting Real Output Growth from the Yield Curve*

Country	Sample period	Number of observations	Coefficient on yield spread (β)	$\chi^2(2)$	$\chi^2(1)$	$\bar{R}^2$
Canada	1957:1–1991:4	140	1.2659 (8.6548)	11.2909 (0.0083)	0.1169 (0.7748)	0.523
France	1971:2–1991:3	83	0.62203 (3.0140)	32.2443 —	0.9762 (0.3510)	0.159
Germany	1961:2–1991:4	123	0.8067 (4.0584)	3.3542 (0.0679)	0.8455 (0.4309)	0.270
Italy	1972:1–1991:4	80	0.7992 (4.4916)	65.0060 —	0.9027 (0.3991)	0.287
Japan	1967:4–1991:4	97	0.7424	46.9170 —	1.2464 (0.2260)	0.168
United Kingdom	1959:1–1991:4	132	0.6595	16.0044 —	1.8736 (0.1752)	0.083
United States	1958:1–1992:1	137	1.5702 (4.4576)	23.1909 —	0.2367 (0.6266)	0.296

Note: The regression equation is $dY_t = \alpha + \beta S^y_{t-1} + \epsilon_t$, where $dY_t = \log(Y_{t+4}/Y_t)$ is the annual growth rate in real GNP or GDP, and S^y is the yield spread between long-term and short-term government bonds.

The table presents (i) the slope coefficient β; (ii) the t-ratios (in parenthesis), computed from standard errors after a Hansen (1982) and Newey and West (1987) correction for autocorrelation and conditional heteroskedasticity; and (iii) regression R^2, adjusted for degrees of freedom.

Also, $\chi^2(2)$ is the joint test for $\alpha = 0$ and $\beta = 1$, and $\chi^2(1)$ is the test for $\beta = 1$ only. The corresponding p-values are in the parenthesis. A dash stands for zero p-value.

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Table 3. *Forecasting Real Output Growth from the Yield Curve: Subsample Results*

Country	Sample period	Number of observations	Coefficient on yield spread (β)	$\bar{R}^2$
Canada	1957:1–1974:4	72	1.0498	0.250
			(4.2984)	
	1975:1–1991:4	68	1.2769	0.613
			(7.4700)	
France	1971:1–1981:4	44	0.7767	0.297
			(4.1944)	
	1982:1–1991:3	39	0.6316	0.185
			(2.9468)	
Germany	1961:1–1974:4	56	0.6869	0.184
			(2.7733)	
	1975:1–1991:4	68	0.7561	0.265
			(3.5066)	
Italy	1972:1–1981:4	40	0.9832	0.429
			(7.1228)	
	1982:1–1991:4	40	0.5959	0.429
			(2.911)	
Japan	1967:4–1981:4	57	0.5662	0.210
			(2.218)	
	1982:1–1991:4	40	0.4342	0.114
			(3.125)	
United Kingdom	1959:1–1974:4	64	0.9561	0.148
			(3.1619)	
	1975:1–1991:4	68	0.2460	0.059
			(1.4185)	
United States	1958:1–1981:4	96	1.2004	0.377
			(4.9555)	
	1982:1–1991:4	40	1.0757	0.582
			(6.4756)	

Note: The regression equation is $dY_t = \alpha + \beta S^y_{t-1} + \epsilon_t$, where $dY_t = \log(Y_{t+4}/Y_t)$ is the annual growth rate in real GNP or GDP, and S^y is the yield spread between long-term and short-term government bonds.

The table presents (i) the slope coefficient β; (ii) the t-ratios (in parenthesis), computed from standard errors robust to conditional heteroskedasticity; and (iii) regression R^2, adjusted for degrees of freedom.

the stock market price as a main component of its "A" curve for tracking the business cycle. Today the Standard & Poor's 500 stock price index is included in the U.S. Department of Commerce's index of leading economic indicators. The OECD regularly publishes a national share price index along with a list of other economic variables in its main economic indicators. The view that stock prices contain information about future economic fluctuations is highly popular among academics and practi-

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Table 4. *Predicting the Residual of GDP Growth from the Yield Curve*

Count y	Sample period	Number of observations	Coefficient on yield spread (β)	$\bar{R}^2$
Canada	1957:1–1991:4	140	0.2699* (3.8715)	0.095
France	1972:3–1991:3	77	0.1776* (2.0966)	0.061
Germany	1962:3–1991:4	118	0.2222* (3.3349)	0.022
Italy	1972:1–1991:4	80	0.1276 (1.5436)	0.022
Japan	1967:4–1991:4	97	0.1472 (1.1063)	0.005
United Kingdom	1959:1–1991:4	97	0.1472 (1.1063)	0.005
United States	1959:3–1991:4	130	0.3221* (3.3936)	0.085

Note: The regression equation is $Res_t = \alpha + \beta S^y_{t-1} + \epsilon_t$, where Res_t is the residual obtained by regressing GDP growth on all its possible lags, and S^y is the yield spread between long-term and short-term government bonds.

The table presents (i) the slope coefficient β; (ii) the *t*-ratios (in parenthesis), computed from standard errors robust to conditional heteroskedasticity; and (iii) regression R^2, adjusted for degrees of freedom.

Also, the sign * indicates that the coefficient is significantly different from zero at the 5 percent level in a two-tailed test.

tioners. Fama (1981, 1990b), Barro (1989), Harvey (1989), and Chen (1991) have found evidence from the U.S. data that stock returns lead changes in real activity.

Since stock prices are the discounted present values of future dividend streams, and corporate dividends and earnings are correlated with GDP, stock prices should contain information about GDP growth. However, because the stock market price is far more volatile than output, as can be seen by Figure 1, it is likely to be a very poor predictor of GDP growth. Table 5 gives regression results for the stock price model using international data. For France, Germany, and Italy, stock prices have little power for predicting real output but do have forecasting power for the other G-7 countries. Comparing Table 5 with Tables 2 and 3, however, shows that the forecasting model based on stock prices underperforms the term structure model for all but two countries within the sample. Most of the yield curve regressions in Table 2 have larger R^2's than the stock price equations in Table 5. The yield spread, for example, is able to explain 27 percent of the variance in real GDP in Germany, while stock price changes explain only about 5 percent of Germany's output varia-

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tion. The lagged stock price changes, however, have more explanatory power for GDP growth in Japan and the United Kingdom than the term structure model does. On balance, it seems that the yield spread variable has more within-sample forecasting power for real GDP growth than stock prices. Therefore, while Fischer and Merton (1984) claim that the stock market price is the single best predictor of the business cycle, the evidence documented here suggests that the bond market more likely outperforms the stock market in predicting future real activity.

Table 6 reports results from multiple regressions. In addition to the yield spread, other information variables, such as stock prices, lagged output growth, and inflation, are added to the regression equation. For most countries, the yield spread has marginal forecasting power over stock prices, lagged output growth, and inflation. Indeed, stock price changes have almost no forecasting power for France, Germany, and Italy, while the yield spread has a strong ability to predict real output growth for all the countries except Japan. It appears that the yield curve and current output growth are the most powerful predictors of future output growth.

To evaluate the forecasting performance of the yield spread, a univariate time series forecasting model is also considered as a third benchmark model. Autoregressive moving-average (ARMA) models for real GDP growth, with up to two autoregressive and two moving-average parameters, are estimated for each country. A "best" ARMA representation is chosen as the univariate time series forecasting model, using Akaike's information criterion.

Table 7 provides out-of-sample forecasting evaluation. The out-of-sample forecasting performance of the yield spread is compared with that of a stock price–based model and a univariate time series forecasting model. The stock price model is that described in Table 5. The forecasting period is from 1982:1 to 1991:4, with a total of 40 forecasts. All three models are initially estimated up to 1981:4 for each country and used to forecast real GDP growth for 1982:1. The models are then reestimated with data up to 1982:1, and new forecasts are generated. This procedure is repeated up to 1991:4.

Table 7 reports two evaluation statistics: the mean absolute error (MAE) and the root mean squared error (RMSE). The results suggest that the yield spread model compares favorably with the alternative forecasting models. The yield spread model outperforms both the stock price model and the ARMA model for Canada, Italy, and Japan. It outperforms the stock price model for France and Germany. For the United States, it appears that the two financial variables have about equal forecasting performance, but none of them can do better than the AR(1)

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Table 5. *Forecasting Real Output Growth from Stock Prices*

Country	Sample period	Number of observations	Coefficient on stock prices (β)	$\bar{R}^2$
Full sample results				
Canada	1957:2–1991:4	139	0.071	0.206
			(2.987)	
France	1971:2–1991:3	82	−0.001	−0.012
			(0.040)	
Germany	1961:2–1991:4	123	0.029	0.047
			(1.697)	
Italy	1972:1–1991:4	80	0.015	0.019
			(1.259)	
Japan	1967:4–1991:4	97	0.084	0.204
			(2.443)	
United Kingdom	1959:2–1991:4	131	0.045	0.156
			(5.603)	
United States	1958:2–1992:1	135	0.111	0.286
			(4.887)	
Subsample results				
Canada	1957:1–1974:4	71	0.072	0.214
			(3.992)	
	1975:1–1991:4	68	0.071	0.250
			(2.573)	
France	1971:1–1981:4	44	0.030	0.062
			(2.002)	
	1982:1–1991:3	39	−0.010	0.003
			(0.634)	
Germany	1961:1–1974:4	56	0.062	0.215
			(3.125)	
	1975:1–1991:4	68	0.022	0.022
			(1.263)	
Italy	1972:1–1981:4	40	0.038	0.057
			(0.746)	
	1982:1–1991:4	40	0.011	0.084
			(1.139)	
Japan	1967:4–1981:4	57	0.151	0.388
			(5.225)	
	1982:1–1991:4	40	0.016	0.048
			(2.697)	
United Kingdom	1959:1–1974:4	64	0.045	0.187
			(5.305)	
	1975:1–1991:4	68	0.050	0.178
			(2.721)	
United States	1958:1–1981:4	96	0.141	0.383
			(6.678)	
	1982:1–1991:4	40	0.080	0.195
			(1.980)	

Note: The regression equation is $dY_t = \alpha + dS^p_{t-1} + \epsilon_t$, where $dY_t = \log(Y_{t+4}/Y_t)$ is the annual growth rate in real GNP or GDP, S^p_t is the national stock price index deflated by the consumer price index, and $dS^p_t = \log(S^p_{t+4}/S^p_t)$ is the annual change in real stock prices.

The table presents (i) the slope coefficient β; (ii) the *t*-ratios (in parenthesis), computed from standard errors after a Hansen (1982) and Newey and West (1987) correction for autocorrelation and conditional heteroskedasticity; and (iii) regression R^2, adjusted for degrees of freedom.

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Table 6. *Regressions with Multiple Information Variables*

Country	Sample period	Number of observations	Coefficients on Yield curve (c_1)	Stock prices (c_2)	Lagged output (c_3)	Inflation (c_4)	$\bar{R}^2$
Canada	1958:2–1991:4	135	0.506*	0.031	0.554	−0.023	0.76
			(7.40)	(5.35)	(13.77)	(−0.54)	
France	1971:2–1991:3	82	0.220*	0.003	0.852	−0.036	0.77
			(2.47)	(0.06)	(23.12)	(−0.86)	
Germany	1961:2–1991:4	123	0.237*	0.015	0.694	−0.039	0.67
			(2.32)	(1.79)	(12.60)	(0.51)	
Italy	1972:1–1991:4	80	0.323*	0.001	0.683	−0.094	0.69
			(3.14)	(0.03)	(10.00)	(−2.68)	
Japan	1968:1–1991:4	96	0.041	0.018	0.792	−0.021	0.74
			(0.26)	(2.12)	(9.69)	(−0.28)	
United Kingdom	1959:2–1991:4	131	0.288*	0.021	0.416	−0.135	0.55
			(3.85)	(2.75)	(7.73)	(−4.37)	
United States	1958:2–1992:1	135	0.342*	0.033	0.732	−0.089	0.81
			(2.29)	(2.80)	(12.43)	(−1.27)	

Note: The regression equation is $dY_t = c_0 + c_1 S^Y_{t-1} + c_2 dS^p_{t-1} + c_3 dY_{t-1} + c_4 \pi_{t-1} + \epsilon_t$, where $dY_t = \log(Y_{t+4}/Y_t)$ is the annual growth rate in real GNP or GDP, S^p_t is the national stock price index deflated by the consumer price index, $dS^p_t = \log(S^p_{t+4}/S^p_t)$ is the annual change in real stock prices, and π_t is the consumer price inflation rate.

This table presents (i) the slope coefficients; (ii) the t-ratios (in parenthesis), computed from standard errors after a Hansen (1982) and Newey and West (1987) correction for autocorrelation and conditional heteroskedasticity; and (iii) regression R^2, adjusted for degrees of freedom.

Also, the * indicates that the coefficient is significantly different from zero at the 5 percent level in a two-tailed test.

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Table 7. *Out-of-Sample Forecasting Performance of the Yield Curve Versus Alternative Forecasting Models: 1982:1–1991:4*

Country	Model	Mean absolute error	Root mean squared error
Canada	Yield spread	0.0156	0.0217
	Stock price changes	0.0258	0.0324
	AR(1)	0.0326	0.0365
France	Yield spread	0.0154	0.0201
	Stock price changes	0.0191	0.0234
	ARMA(1,2)	0.0120	0.0150
Germany	Yield spread	0.0117	0.0155
	Stock price changes	0.0235	0.0268
	ARMA(2,2)	0.0128	0.0152
Italy	Yield spread	0.0143	0.0209
	Stock price changes	0.0222	0.0250
	AR(1)	0.0229	0.0246
Japan	Yield spread	0.0156	0.0187
	Stock price changes	0.0311	0.0369
	ARMA(1,2)	0.0356	0.0384
United Kingdom	Yield spread	0.0173	0.0204
	Stock price changes	0.0144	0.0186
	ARMA(1,2)	0.0287	0.0317
United States	Yield spread	0.0291	0.0309
	Stock price changes	0.0286	0.0317
	AR(1)	0.0206	0.0272

Note: Parameters of each model are reestimated at each point in the time series during 1981:4–1991:3. These parameters are used to forecast real GDP growth for the 1982:1–1991:4 period. AR(·) and ARMA(·) denote autoregressive (AR) moving-average (MA) time series models.

model. The United Kingdom is the only case where the forecasts from the yield spread model are inferior to those from the stock price model. Nevertheless, the yield spread model still outperforms the univariate time series forecasting model for the United Kingdom.

In summary, the empirical evidence seems to support the main implications of the simple model developed in the initial sections of this paper. It appears that the slope of the yield curve is positively related to the expected growth rates of real GDP in the G-7 countries. The term structure contains information about the real sector of the economy and can therefore be used to forecast future economic activity. The yield spread tends to have more within-sample forecasting power than stock prices, and its out-of-sample forecasting performance compares favorably with that of alternative forecasting models. The forecasting ability of the yield curve is quite impressive considering the cost and performance of many large-scale macroeconometric forecasting models that are also used to predict real output. In the case of the United States, for

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example, Harvey (1989) found that forecasts based on the yield curve compare favorably with forecasts from seven leading econometric models, including the Data Resources Incorporated (DRI) model and the Wharton Econometric Forecasting Associates (Wharton) model.

IV. Conclusions

There is a popular belief that the term structure of interest rates contains information about fluctuations in real output. Many equilibrium asset pricing models attempt to explain how underlying variables in the economy determine the term structure. The question asked in this paper is, if the term structure bears any relation at all to changes in economy-wide variables, such as real GDP growth, can this relationship be used to forecast aggregate fluctuations via some easily measured term structure variables? This paper made an attempt to formalize the link between the yield curve and real activity. A simple, closed-form formula of the term structure is derived, expressed in terms of the parameters of the stochastic production processes. It is shown that the term structure of interest rates embodies the market's expectations about changes in the macroeconomic fundamental—the growth in real aggregate output. Applying the model to the G-7 industrial countries, the paper found evidence supporting the model's main implication—that the slope of the yield curve is positively related to the expected growth in real output. The empirical results suggest that the yield spread between long-term and short-term government bonds serves as a good predictor of future economic growth. This easily measured variable has more forecasting power than changes in stock prices, and it retains marginal forecasting power when other commonly used variables, such as lagged GDP growth, stock price changes, and inflation, are added to the regressions. The out-of-sample forecasting performance of the yield spread also compares favorably with those of the stock price model and the univariate time series forecasting model. It seems that even a crude measure of the slope of the yield curve, such as the yield spread used in this study, can provide useful information about the business cycle to both private investors and policymakers. Policy authorities might well consider adding some measure of the term structure to their list of leading economic indicators.

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IMF *Staff Papers*
Vol. 40, No. 4 (December 1993)
© 1993 International Monetary Fund

A Primer on Tax Evasion

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Tax evasion is universal. It depends on the economic and tax structures, types of income, and social attitudes. The theory of tax evasion has limitations since it rests solely on attitudes toward risk, with full information regarding the tax administration's behavior. Methodologies for estimating tax evasion include estimating the underground economy and comparing declared taxes with potential tax revenue calculated from national accounts. Measures to address tax evasion include use of withholding, presumptive and minimum taxes, selective auditing, penalties, and cross checks between taxes. [JEL H26]

TAX EVASION is a universal phenomenon. It takes place in all societies, all social classes, all professions, all industries, and all economic systems. Two thousand five hundred years ago, Plato was writing about it, and the aging Ducal Palace of Venice has a stone with a hole in it, through which people once informed the republic about tax evaders. The only surprise is how little attention this phenomenon has received, especially in the United States, until recent years. For example, there is no reference to it in the index to Richard Goode's (1964) classic *Individual Income Tax*, nor in Richard Musgrave's (1959) *The Theory of Public Finance*, nor in Joseph Pechman's (1966) *Federal Tax Policy*. These authors either did not think that tax evasion was important or opted to ignore it.

In recent years, growing attention has been paid to tax evasion. In the United States, awareness may have started with the political problem of the rising fiscal deficit, which some began to argue could be solved by

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reducing the so-called tax gap, rather than by raising tax rates or cutting public spending.[1] Because of its policy of reducing tax rates and its inability to reduce public spending, the Reagan administration, in particular, promoted the idea that the fiscal deficit could be lowered by reducing or eliminating the tax gap. In other countries, concern over tax evasion was in part prompted by a growing preoccupation with horizontal equity. The realization that people with similar incomes often end up paying very different taxes because of different opportunities for tax evasion has led many governments to worry about the implications of tax evasion. Also, a growing concern about underground economic activities, which are often the other face of tax evasion, and how these activities affect economic policies led in the 1980s to increasing interest in the extent of tax evasion.[2] This is certainly true in Latin America, where the authorities, after introducing major tax policy reforms, have devoted more resources to measuring and reducing the evasion of both income and consumption taxes.[3]

In the paper that follows, we survey some of the sources of tax evasion and recount how economists have attempted to provide a theoretical underpinning to them. The discussion also addresses the limitations of this theoretical literature. Next we review the role of tax administration and sanctions in limiting tax evasion and briefly mention the relation between society at large and tax evasion. An Appendix lists some of the methodologies developed for estimating tax evasion.

I. Theoretical Underpinnings

The theoretical literature on tax evasion has progressed in many directions. An August 1993 conference of the International Institute of Public Finance, held in Berlin, revealed that many of the advances in the related fields of tax evasion, corruption, and the underground economy have been made using the theory of constrained maximization under uncertainty, game theory, probit analysis, catastrophe theory, and the like.

[1]The tax gap emerges from comparing taxable income declared to tax authorities with taxable income calculated from other, presumably more accurate, sources.

[2]Scholars often make a distinction between tax evasion and tax avoidance. In theory, tax evasion implies violation of the law whereas tax avoidance implies taking advantage of ambiguities in the law to reduce the tax burden. This distinction, however, is not always easy and in some countries, such as India, the courts have considered tax avoidance with the intention of evading taxation as tax evasion.

[3]Several Latin American countries have requested IMF technical assistance for measuring tax evasion.

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However, the assumptions and results remain relatively restrictive. This section, after describing some of the sources and implications of tax evasion, attempts to assess the main thrust of the literature.

Sources and Implications of Tax Evasion

Tax evasion is practiced in different forms. Tax evaders may not declare income; may underreport income, sales, or wealth; may overreport deductible expenses; may smuggle goods or assets; or may undertake some other deception. The variety of tax evasion is truly remarkable, and taxpayers are always finding new ways to purposely reduce their tax burden.[4] Many authors have reviewed these matters, including Sisson (1981) and Richupan (1987), and more recently Cowell (1990) and Webley and others (1991). Notably, empirical findings are often confidential in nature, as they result from IMF technical assistance to a country or the work of a ministry of finance.

The opportunity for tax evasion varies across sectors, which may lead to social turmoil. In Italy, for example, salaried workers have publicly demonstrated in large numbers for a reduction in tax evasion by independent professionals and other groups. In general, tax evasion is easier for independent contractors, professionals (such as doctors, lawyers, and architects), and those engaged in agricultural activities. There is increasing evidence that multinational enterprises can also reduce their tax burden through judicious transfer pricing.[5]

Tax evasion has much to do with the structure of an economy. The more atomized is production, the more likely it is that tax evasion will flourish. A country where much of the production takes place in large enterprises is unlikely to have much tax evasion. However, a country where much of the economic activity takes place in small shops and small farms, or is conducted by single individuals, is likely to experience a lot of evasion.

Tax evasion is also strictly connected with the structure of the tax system and is likely to vary with the use of different tax bases. For example, in the case of income taxes, evasion is likely to vary between dependent and nondependent income sources, as well as between large,

[4] In recent years, new developments in industrial organization and in technology have introduced new ways of evading taxes.

[5] During the electoral campaign, now-President Bill Clinton argued that the reduction of tax evasion by multinationals could generate a good deal of revenue. Recent work by the U.S. Internal Revenue Service has given some support to this view (see U.S. Treasury (1992)).

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small, and multinational enterprises. In the case of sales taxes, it is likely to be connected with the underreporting of sales or the overreporting of purchases. In theory, at least, tax evasion is connected with the accounting concepts of tax liabilities. When a country relies on presumptive concepts of taxation, tax evasion is likely to be more limited, unless the assets on which the presumptive estimate of the tax payment is based can be hidden. The number of taxes will also influence tax evasion. At times, governments introduce additional taxes in order to neutralize the losses connected with tax evasion. However, an increase in the number of taxes produces inefficiencies in the tax system and facilitates the search for new ways to avoid paying taxes.

The policy implications of tax evasion are quite different depending on whether evasion is an individual or a social phenomenon. A single tax evader in a country of honest taxpayers typifies the behavior of that individual only. However, a tax evader in a country where tax evasion is a national sport is a different phenomenon, in that tax evasion begins to have implications for both the horizontal and vertical equity of the tax system. It also has implications for the efficiency of the tax system and even for the market framework. For example, it is impossible to have pure competition when some of the sellers can evade taxes and others cannot. In this case, the former will be able to undersell the latter.

Tax evasion also affects the productivity of the tax system by reducing the amount of revenue that can be raised under the statutory system. It affects the attitude of citizens toward their government, often building cynicism about the role of the public sector. Often it affects even the statutory system in the sense that the tax laws begin to anticipate the tax evasion by particular groups and try to penalize it by increasing the tax rates for those groups. This often results in increased horizontal inequity since not all the taxpayers in those groups behave alike.

Theory of Tax Evasion

Since Allingham and Sandmo (1972) wrote their classic theoretical paper on tax evasion, the problem of tax evasion, as seen from the taxpayer's point of view, has been discussed as a kind of game theory.[6] In this framework, the taxpayer is faced with the decision of whether or not to evade taxes. In other words, the decision about whether to pay the tax becomes similar to playing a lottery, in that one is free either to buy or not to buy a lottery ticket. For a rational individual, the choice will be

[6]There is actually a close relationship between Allingham and Sandmo's theory of tax evasion and Becker's (1968) theory of crime.

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based on the expected gains or losses associated with the decision. The objective is to maximize the utility of the taxpayer.[7]

The benefit derived from tax evasion is related to the expected value of the money (and thus to the utility of the money) that the individual does not pay. The cost of tax evasion is connected to the probability of being caught and the consequences of this outcome. These consequences, in the Allingham and Sandmo model, are associated with fines that can considerably exceed the original tax due. Nonetheless, the probability that the individual will pay these fines depends on the probability of being caught, and that probability can be very low.

The Allingham and Sandmo theory has some important implications for tax administration. In fact, the theory implies that tax evasion can be reduced either by increasing the penalties associated with it or by increasing administrative expenses, assuming that this increase raises the probability that the tax evader will get caught.[8] In an extreme interpretation of the Allingham and Sandmo theory, it has been argued that the penalties should become so high that, at the limit, the tax evader who gets caught would be hanged and the cost of administration would approach zero, as would the probability of being caught.

The theoretical and practical limitations to the literature on tax evasion have not received the attention they deserve. But some have been discussed by various writers. A first limitation has to do with risk aversion, which may vary among individuals and may depend on the level of the taxpayer's income or wealth. In more recent theoretical advances, the taxpayer's behavior toward tax compliance turns entirely on his or her attitude toward risk.[9] For example, treating tax evasion in the context of intertemporal choice models, Banerji (1991, p. 98), concludes,

> Is there a more subtle way of enforcing compliance without such elaborate calibration—by simply increasing the risk of detection for the evader, and thereby making him or her switch from the riskier asset to the safer one of declared income? Unfortunately, this plan would work with certainty only if we were willing to assume that all possible evaders in the economy had constant absolute risk aversion, i.e., that their willingness to take risks did not depend upon their level of income or consumption.

A second limitation has to do with the use of penalties applied to those evaders who get caught. In other words, many tax evaders who should

[7] Becker's (1968) theory assumes that individuals evaluate the expected benefits and costs of various activities, including criminal activities, and choose those that provide the highest income, taking account of the associated net costs.

[8] The theory assumes a close positive relationship between the costs of administration and the probability of catching tax evaders. The importance of this assumption should be kept in mind.

[9] See especially Cowell (1990) for a review of this literature.

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be penalized do not get caught and so are not affected by the penalties. This raises the question of whether the judiciary system and the community at large are willing to penalize fully the few unlucky individuals who get caught when many more individuals are committing the same offense but are not being punished. Anecdotal evidence from many countries indicates that the judiciary system is unwilling to apply the penalties fully under these conditions. This means that one basic conclusion of the theoretical literature is unlikely to hold if the penalties actually imposed differ from those on the books.

Third, the theory assumes that the taxpayers know precisely the probability of being caught and the penalties they will endure, so that they make the cost-benefit calculations. However, tax administrations often keep this information highly confidential so that for most, if not all, taxpayers the probability of being caught is an unknown. And the penalties may be highly uncertain.[10]

Fourth, the theory ignores the costs in terms of embarrassment, loss of self-esteem, and social status experienced by those who get caught. These costs vary from society to society and from individual to individual. In a society where tax evasion is condoned because of the unpopularity of the government, tax evaders may be admired and the social costs associated with tax evasion may be low or even negative. In a society where tax evasion is taboo, these costs can be very high.

Finally, many countries rely on means testing, based on declared income, for determining access to many government benefits, such as food stamps, free health care, free education or scholarships, and so forth. Therefore, the advantages from tax evasion may far exceed those measured by the nonpayment of the tax.

Role of Penalties and Amnesties

A few comments on the penalties themselves would be appropriate. Some of these comments have relevance for the theoretical literature on tax evasion. The higher are the penalties, the more probable it is that they will not be applied. If the high penalties lead to a reduction in the cost of administration, this reduces the probability of detection and thus the number of cases requiring the imposition of penalties. Many societies feel uncomfortable about singling out and punishing particular individuals, almost by lottery, when many others have committed the same offenses. Second, for the penalties to be effective, they must be applied quickly.

[10] In some cases, penalties may be so delayed that they lose their deterrence effect.

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A penalty that is delayed for years, because of appeals on the part of the taxpayer, is unlikely to become as effective a deterrent as one that is applied immediately. In some legal systems, for example, the Italian and Tunisian ones, it has been possible to postpone for many years, through appeals, the application of the penalties.[11] Moreover, the impact of penalties on tax compliance may not always be great. For example, using a model of varying attitudes toward risk and applying econometric estimation techniques to Mexican data for 1982–89, Dunn (1992, p. 14) concludes

> . . . large changes in the odds of being detected and the penalty for illegal evasion are required to even modestly alter compliance . . . a doubling of the fines for tax evasion would increase declared taxable income by about 10 percent. Similarly, a large increase in the number of audits would achieve only a modest rise in compliance.

Of course, in the prepenalty period, the appeal may be successful or a tax amnesty may come along.[12] Appeals mechanisms and tax amnesties considerably confuse the theory, which assumes that the probability of the penalty being applied and the penalty itself are known and precisely defined. The theory is also affected by the existence of administrative corruption. If the individual who gets caught can bribe some tax officials, and if the bribe is less than the penalty, then the theory becomes ambiguous. The tax amnesties used in some countries also have important implications for tax evasion because in many ways they encourage tax evasion, at least over the longer run, and by so doing they have an impact on the equity of the tax system, tax revenue, and the tax administration. For example, using a game-theoretic approach to the analysis of tax amnesties, Stella (1989, p. i) concludes

> . . . while in general it may be correct to impose a reduced penalty on individuals who voluntarily disclose tax evasion, short-lived amnesties of the type most frequently observed in practice are unlikely to generate significant revenue when judged against the potential danger of reducing future tax compliance.

Also, analyzing the sustainability of the revenue intake from tax amnesty programs in different countries, including Argentina, Colombia, and India during the 1980s, Uchitelle (1989, p. 53) concludes

> . . . most of the programs have not led to a widening of the overall tax base, and many have failed to produce even very large one-time revenue gains.

[11] Sometimes the taxpayer benefits from the delay owing to the low interest rates charged on the taxes that were due. Some countries require an advance payment of the assessed tax even when the taxpayer contests the assessment.

[12] However, appeals are not costless in terms of time, worry, and legal or other fees.

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II. Tax Administration and Tax Evasion

The tax administration of a country plays an important role in the extent to which tax evasion prevails. To the best of our knowledge, the theory of the firm has not yet been applied to the activities of a tax administration.[13] But, a tax administration is not very different from a firm, though it should be compared to a monopolistic firm. The tax administration has a given budget assigned to it by the state and with this budget its task is to maximize an output—tax revenue—taking into account certain important constraints. The allocation of resources within the tax administration is obviously important for determining this output. Under optimal conditions the tax administration would not be able to increase output by shifting resources across various activities, such as assessment, collection, and auditing.[14]

Size and Targeting of Administrative Resources

Some of the constraints on the tax administration are imposed by tax policy; others are objectives that the tax administration needs to take into account (such as the equitable treatment of taxpayers). How much revenue a country should allocate to the administration of taxes remains a largely unexplored subject. There is a remarkable variance among countries in both the amount of resources allocated to tax administration as a share of national income and the amount as a share of total tax collection by the tax administration.[15] It should not be concluded that in either case a low share is necessarily good. In fact, a country that wants to minimize collection costs can simply go after the taxes that are easiest to collect and collect them from the largest taxpayers. Alternatively, it could focus its activity on the largest city or cities. This behavior would condone a lot of tax evasion and generate tax revenue in a way that would be far from optimal. It would also conflict with other objectives of taxation, such as neutrality and equity.

A tax administration should be careful to minimize not only the explicit costs it bears (its collection costs) but also the costs borne by taxpayers and the economy. These latter costs do not show up in the administration's balance sheet and often tend to be ignored. They are essentially welfare costs, compliance costs, and perhaps "good relations" costs.

[13] But, see Goode (1981).

[14] For a recent important contribution to the literature on tax administration, see Bird and Casanegra (1992).

[15] See Sandford, Godwin, and Hardwick (1989).

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Welfare and Compliance Costs

The welfare cost per dollar collected can be defined as the excess cost to society of collecting $1 of tax revenue. These are the costs that have attracted the attention of economists. These costs have been estimated by various authors for the United States, such as Ballard, Shoven, and Whalley (1985a, 1985b), Hansson and Stuart (1987), and others. They have shown that the marginal dollar raised by the U.S. tax administration may have cost the country more than $1.50. Usher (1986) has discussed the marginal cost of taxation in the presence of tax evasion. Clearly, the above estimates indicate that the tax system is far from optimal. However, attempting to make the system optimal may raise other costs, such as administrative and compliance costs. These latter costs have received much less attention by economists. There is still no literature to deal with the administrative and compliance costs of trying to pursue "optimal" tax policies.[16] However, some recent literature has been trying to assess the implications of tax evasion for optimal taxation (see Cremer and Gahvari (1993)).[17]

The compliance costs are more closely associated with the behavior of the tax administration and more likely to be connected with tax evasion. Compliance costs refer to the cost to the taxpayers—in terms of lost time, added stress, payments to tax accountants and lawyers, trips to the tax office, and so forth—associated with a given tax payment.[18] In some countries, and for some taxes, these compliance costs can be enormous, especially if the taxpayers have to stand in line for hours, sometimes days, perhaps several times a year in order to meet their tax obligations.[19] They are also likely to be extremely high when the tax laws are so complicated that the taxpayer has to rely on an expert's advice or, in the case of enterprises, has to hire experts whose only function is to comply with the tax obligations. There have been reports from Latin America that even relatively small enterprises have sometimes had to establish sizable tax departments simply to find their way through the jungle of fiscal laws and regulations. When this situation prevails, the tendency to evade taxes

[16]However, see Slemrod (1990).

[17]This literature concludes that in the presence of tax evasion some of the standard conclusions regarding optimal taxation do not hold.

[18]Thus, the compliance cost per dollar paid can be defined as the excess cost to the taxpayer in terms of lost time, payments to lawyers and accountants, and so forth of $1 of tax payment.

[19]In some cases, they have to spend considerable time just getting the right forms.

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rises. There is a direct and positive relationship between the size of tax evasion and the cost of compliance. It should also be noted that when firms create tax departments to comply with existing tax obligations, those same departments will be used to scrutinize the laws for any possible loopholes or for any ambiguity that might justify tax avoidance.

Public Relations

Let us now turn briefly to what could be called "good relations" costs, which are essentially the public relations activity of a tax administration. This public relations role is connected with the way in which tax administrations are organized: the number of employees and their use, the level of their salaries, the quality of their working conditions, and the controls that the tax administration has on the behavior of tax inspectors. These controls are necessary to minimize or eliminate the possibility that these inspectors, or other tax administrators, will use their positions for their own benefit.[20]

A tax administration that wants to improve taxpayer compliance and minimize tax evasion must be available to the taxpayer who needs information, forms, specific instructions, and so forth. It must show courtesy toward the taxpayers since resentment is likely to create a lower propensity to pay taxes. It must also show punctuality in sending refunds to those who have overpaid since a taxpayer is likely to underpay if he or she might have to wait years for a refund.

Withholding, Presumptive and Minimum Taxes, and Cross Controls

Collection systems are also important for minimizing tax evasion. There is now overwhelming evidence that evasion is minimized whenever there is withholding at source. In the United States, for example, the difference in tax evasion between independent contractors, for whom there is no withholding at the source, and dependent workers, whose taxes are withheld by their employers, is enormous. The same evidence is available for taxes on interest income and dividends.

Various countries have tried to minimize evasion by resorting to min-

[20] Anecdotal reports have referred to countries where some key posts in the tax administration have been in high demand or even "sold" to the highest bidders. Obviously these posts provide possibilities of high "incomes."

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imum taxes or to presumptive methods of taxation. In these presumptive methods now used in many countries, the government tries to assign a particular income to taxpayers based on their standard of living, the value of the houses in which they live, the value of the cars they drive, and so forth.[21] It also tries to estimate, for example, the value added of a company based on its sales statistics and other criteria (employees and floor space, for example). The minimum income tax of a company or individual can be based on their gross assets, a system that has been introduced in Argentina and Mexico.

Tax administrations may also utilize various instruments to limit tax evasion. For example, cross controls between the information available to the tax administration, the social security institution, and the customs administration can play an important role. The assignment of a taxpayer identification number, to be used in this cross control, is extremely important since it facilitates the use of computers. Other such instruments include (1) the government's ability to access the bank accounts of individuals or companies, (2) detailed audits of taxpayers, and (3) reporting requirements by employers or by those who make payments.

Social Ethics

Before leaving the section dealing with the role of the tax administration, it may be worthwhile to refer to another relationship, that between society at large and tax evasion. Tax evasion prospers when society condones it. In a society that does not condone tax evasion, the phenomenon remains isolated and concerns relatively few individuals. When society condones it, however, the phenomenon becomes much more widespread. Citizens at large should have a responsibility to prevent tax evasion. Since tax evasion is often facilitated by the acquiescence of some citizens in the tax-evading behavior of others, laws should penalize not just the tax evaders but also those who collaborate either passively or actively in tax-evading activities. For example, in many countries, the tax evasion of professionals, such as doctors or independent contractors, is facilitated by their requests that customers pay them in cash or accept invoices that underestimate the payment. In addition, those who govern must obey the tax laws. When a country's leadership engages in tax evasion or similar activities, it sends an unmistakable signal that noncompliance is acceptable.

[21] Italy has perhaps been the most imaginative in the use of presumptive taxes in recent years.

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Penalties

As can be anticipated from the preceding discussion, the severity of the penalties has some impact on the extent of tax evasion. Taxes may be paid in arrears without any intention to evade them, especially if the interest charges are low. Usually, interest charges and pecuniary penalties are applied to any tax in arrears that does not reflect tax-evading motivation. Tax evasion or fraud, however, is a more serious matter and, at least in the tax laws, carries much heavier sanctions.

Penalties for Tax Arrears

Usually, the amount of interest charged on taxes paid in arrears is calculated using either a fixed percentage point above some key central bank rate, or above the average of bank rates, or a specified percentage of the amount due in taxes for each month in arrears, up to a maximum amount. In some countries, additional surcharges are also applied.

Penalties on taxes paid in arrears vary depending on whether the cause is late filing of returns, failure to file returns, or filing incorrect returns. In the case of taxes withheld at source, penalties depend on the type of infraction. For example, penalties differ depending on whether the correct amount has been withheld or whether the amount withheld has been surrendered to the tax authorities. In all cases, repeated offenses or offenses not corrected or admitted within a specified time period are subject to higher penalties. Sanctions often take the form of a percentage of the tax due and range from 25 percent to 100 percent; several countries also charge penalties fixed in nominal terms.

Sanctions for Tax Evasion and Tax Fraud

Sanctions for tax evasion and tax fraud are much more severe (many times the amount of the defrauded amount) and include possible closure of an enterprise for a specified time and jail sentences, ranging from a few months to several years. Giving the tax administration the power to close establishments for a few days, without the possibility of appeal, has been an effective deterrent to tax evasion in Argentina and other Latin American countries.

III. Concluding Remarks

This paper has examined the factors that give rise to tax evasion. Tax evasion varies by sector (agriculture, industry, and commerce), organization of production (small trader or large company), and type of economic

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agent (salaried, self-employed, or capital owner). It is also affected by social ethics and the standards set by those that govern. Given these standards, it is further affected by the potential taxpayer's attitude toward risk.

Tax evasion affects the horizontal and vertical equity of a tax system, as well as the efficiency of the market and the tax system. It certainly affects the revenue productivity of the tax system. Unchecked or poorly controlled tax evasion builds cynicism about the public sector. It tends to complicate the tax structure as legislators try to anticipate tax evasion through tax legislation. The use of effective and quickly applied penalties to counter tax evasion has an impact on its extent and spread. However, their application does not necessarily imply even a second-best solution for the correction of inequities or for the efficiency of the competitive mechanism if many tax evaders do not get caught or remain unaffected by penalties.[22]

The theoretical foundation for modeling tax evasion remains wanting. It is too simple to be of much practical use. The theory relates the taxpayer's behavior toward tax compliance to his or her attitude toward risk, but ignores other factors that influence tax evasion. The theory assumes that taxpayers know precisely the probability of being caught and the consequences of such an event; however, tax administrators often keep this information confidential and the consequences of being caught may not be fully predictable.

Estimates of the evasion of income and consumption taxes have been selectively reported in the published literature for many countries. More information of a confidential nature exists as a result of exercises carried out by tax authorities or by technical assistance experts from international organizations. The methodologies utilized leave much to be desired because of the lack of data and, more important, because of what the data are not able to capture. The data may only partially capture the effects of tax evasion while including the effects of other leakages (such as legitimately used tax incentives or deductions whose total effect may be difficult to remove). Thus, it would not be prudent to base economic policy solely on the results that emerge from these estimations.

Given their limitations, methods of estimation include the matching of information from tax declarations with either national accounts data or survey (or sample) data blown up to population levels. Because of the unreliability of surveys (respondents may not reveal the truth regarding

[22] In fact, the theoretically advocated and practically followed procedure of detecting tax evasion through selected audits raises serious questions of equity when many other tax evaders remain undetected and unpunished.

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tax evasion) and because of their cost, the national accounts approach is more commonly used. If the objective is to estimate evasion of the value-added tax (VAT), however, a national input-output framework has to be used because of the VAT's method of collection at different stages of production, some of which may be exempted from the VAT base (or taxed at different rates). An indirect way of measuring tax evasion has been to estimate the extent of the underground economy and, once that has been done, to estimate the taxes that should have been paid. It appears from the published literature that perhaps a third of potential tax revenue may be lost to evasion in selected Latin American and Mediterranean countries. Some estimates indicate even higher percentages. These estimates, however, must be taken with a grain of salt since they would, at times, imply very high tax burdens in the absence of tax evasion. The Appendix reviews a number of the estimation techniques discussed here.

If tax evasion is high, the role of tax administration becomes doubly important. The size of tax administration resources, the main target groups (large enterprises or all taxpayers), the efficiency with which the resources are utilized (collection costs), the ease with which taxpayers can pay taxes (compliance costs), the relation between the tax administration and the taxpayer (good publicrelations rather than the spreading of fear), and the methods of tax collection (withholding, presumptive taxes, minimum taxes, and cross controls) all play a role in determining the level of tax evasion.

Finally, one interesting aspect of evasion is its counterpart on the expenditure side of the budget, which has not received the attention that tax evasion has.[23] While tax evasion is the nonpayment of taxes duly owed to the government, the equivalent phenomenon on the expenditure side is the abusive receipt of government payments. In a way, one finds a parallel in the comparison between indirect taxes and consumer subsidies, one being the reciprocal of the other. Activities connected with the illegal receipt of government expenditures may involve corruption. For example, the receipt of a percentage of government contracts, the receipt of pensions not deserved (for example, by claiming disability when one is not disabled), the payment of wages to so-called ghost workers (a phenomenon common in several developing countries), the taking of leave on the basis of fictitious illnesses, and so forth. This is the flip side of tax evasion: the government loses when taxes are not paid, but it also loses when it makes payments it should not.

[23] For some discussion of this issue, see chapter 8 of Smith (1986).

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APPENDIX

Estimating Tax Evasion

In recent years, many scholars and governments have attempted to measure the size of tax evasion in particular countries, either for specific taxes or for the whole tax system. The measurement of tax evasion is obviously fraught with difficulties. Many of these difficulties have to do with the fact that the information available is limited and often unreliable. However, a more philosophical difficulty is often not acknowledged—namely, the problem that the *statutory* tax system has been "contaminated" by the existence of tax evasion. In other words, it is not the system that would exist in the absence of tax evasion: statutory rates have often been increased to compensate for the revenue losses associated with tax evasion.[24] But if this is true, then when one uses the current statutory rates to measure tax evasion, one exaggerates the size of the evasion, since the rates would have been lower if the evasion had not been there.

Various methods have been used to measure tax evasion. Some of these try to measure it directly, some indirectly. Among the direct methods one can identify are (1) the use of the national accounts, (2) the use of direct controls, (3) the use of household budget surveys, and (4) the use of direct surveys of taxpayer behavior. The indirect methods are largely related to estimates of the underground economy. Once the size of the underground economy has been measured, the extent to which the existence of the underground economy has implied tax revenue losses to the government must be assessed. In other words, undeclared income or some other unreported tax base must first be measured. Subsequently, an estimation of the unpaid tax must be made.

National Accounts Method

Perhaps the commonest and most often used method for assessing the size of tax evasion is comparing the estimate of a particular tax's base made by the national accounts authorities with the base reported to the tax authorities after making appropriate adjustments. An early study that attempted this technique for several industrial countries was Tanzi (1969). A similar one for Argentine data was Herschel (1978). The Internal Revenue Service of the United States has been following this approach routinely for the income tax; various other authorities have used it for measuring the base of the VAT and other taxes. Given that the VAT is collected at various stages of production, careful use of information based on a sectoral input-output table would be necessary. This was initiated by Aguirre and Shome (1988) for Mexico. They developed a methodology for constructing the VAT base on a sectoral basis while allowing for the differential tax rates of the VAT. It was applied by Serra (1991) for Chile and clarified by Mackenzie (1992) methodologically. It has since been attempted in various unpublished

[24] This point was clearly recognized by Luigi Einaudi, the prominent public finance scholar who became president of Italy. He once remarked that if all the Italian tax laws on the books were fully enforced the Italian level of taxation would be 120 percent of national income.

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technical assistance studies by IMF staff and is being used by technical units in the ministries of finance in many Latin American countries.

The difference between the base as reported to the tax authorities and the base as estimated by the national accounts authorities gives an indication of unreported income. If the tax is a fully proportional one, this unreported income automatically and directly provides an estimation of the unpaid tax. If the tax is progressive, as would be the case with income taxes, then the estimation of the unpaid tax becomes more complex since one would have to make assumptions about the effective tax rate at which the unreported tax base would have been taxed. In other words, the unreported income must be allocated among the tax brackets. It would also be necessary to reinstate, into the information based on income tax declarations, the various exemptions and deductions at the different tax brackets in order to make it comparable to the national accounts data.

Individual Income Tax

In the context of the individual income tax, an actual framework for *nonwage earners* may be described as follows. To declared personal income, adjustments should be made for those components of income that are included in the concept of income in the national accounts but are deductible for tax purposes.[25] These include personal exemptions, deductions, investment allowances, and other deductible direct taxes that have been paid. The adjustments need to be made for individual tax brackets if the tax structure is progressive. The result of the exercise would be a series for gross taxable declared income (by income class). A comparison with gross taxable income from the national accounts would yield an estimate of undeclared nonwage income.

Tax evasion among wage earners is often limited because of withholding at the source and because wages are an important cost to enterprises. To claim this cost, they need to report the wages paid. However, it may also be difficult to estimate tax evasion by *wage earners*. Information on tax withheld by employers may not be readily available, since it is not the form in which wage income is usually declared for tax purposes. It may be even more difficult to obtain this kind of information by bracket or sector. Small and medium-sized firms that do not pay profit taxes would also tend to underreport tax withheld on wage income or may actually withhold less income than required by law. However, the overall revenue loss from this source should not be significant owing to the small firm size. In general, estimates of tax evasion from wage earnings would be attempted through sampling techniques.

Corporate Income Tax

Techniques similar to those used for the individual income tax may also be applied to the *corporate income tax*, adjusted for the kinds of deductions and incentives that apply specifically to the corporate sector. The task is not easy, however, since corporate sector tax incentives would have to be accounted for in addition to those surrounding the individual income tax. These incentives can be used legitimately or otherwise, making the task of adjustment difficult. One

[25]The reverse is also true for capital gains, which may be in the concept of taxable income but not in the national accounts.

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redeeming feature in the case of corporate income tax evasion is that the corporate form in developing countries is primarily confined to large and easily identifiable firms. It is common in developing countries for tax administrations to establish special units to control large taxpayers, mainly big—often foreign—corporations.

VAT

The VAT has emerged as the most important revenue earner in many countries, and attempts to estimate evasion of the VAT have become relatively commonplace over the past few years. The widest VAT base is all purchasable goods in the economy: GDP plus imports minus exports. Thus, the starting point is again the national accounts. However, the estimate can be made either from the expenditure side or from the production side.

The expenditure method can be summarized as follows. To total domestic expenditure (including imports) add net private expenditure from abroad and subtract nontaxed expenditure (typically, government expenditure on wages and salaries, fixed capital formation—except private expenditure on new houses—and changes in inventories) to obtain taxable expenditure. Adjust for taxes on expenditure to obtain adjusted taxable expenditure. Further, subtract exempted expenditures (typically, the financial sector, nonprofit and social organizations, small businesses below a legally defined threshold, and gross rents paid) but add back taxable inputs and the capital purchases of exempt sectors to obtain the potential VAT base.

The VAT base calculation from the production side is similar, except that zero-rated exports have to be subtracted and imports added.[26] It is more convenient to use the production side method when the VAT contains more exemptions by economic sector than by product for final consumption. Sectoral data are more amenable to production side estimates, while exemptions for particular products are more amenable to expenditure side estimates. Further, given the nature of the VAT—that is, collection based on stages of production—sectoral data are again more amenable to base calculations.

Using the above-mentioned methodologies, IMF staff have made some interesting inferences regarding the relationship between the VAT rate and the ratio of VAT revenue to GDP. For example, Table A1 introduces the concept of a "revenue productivity ratio—the amount of revenue raised per point of the VAT rate." The last column of Table A1 indicates that the average amount of revenue per point of the VAT rate is 0.37 percent of GDP for the 22 countries in the sample. A country whose ratio approaches 0.5 percent could be said to be performing at a high VAT effort.

Some economists have sharply criticized the national accounts approach on the grounds that if tax evasion is significant, the national accounts are likely to be underestimated. Therefore, the calculation described above may be meaningless in those cases. However, these economists fail to realize that the information that the national accounting offices receive from the tax authorities often contributes very little to the estimation of the national accounts since the national accounts authorities often rely on other methods for measuring production. For example,

[26]In the expenditure side method, exports are already excluded from the domestic expenditure base.

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Table A1. *Value-Added Tax, 1988*
(Countries with single-rate VATs)

Country	Actual VAT revenue: GDP ratio	VAT rate	Revenue productivity ratio
Bolivia	2.6	10.0	0.26
Chile	8.8	16.0	0.55
Costa Rica	3.8	10.0	0.38
Denmark	9.5	22.0	0.43
Dominican Republic	1.6	6.0	0.27
Ecuador	2.5	10.0	0.25
Finland	8.4	19.1	0.44
Grenada	4.5	6.0	0.75
Guatemala	2.4	7.0	0.34
Guinea	0.6	13.6	0.05
Haiti	1.8	10.0	0.18
Indonesia	4.5	10.0	0.45
Israel	9.8	15.0	0.65
Korea	3.3	10.0	0.33
Madagascar	1.5	15.0	0.10
Mauritius	2.1	5.0	0.41
New Zealand	6.7	12.5	0.54
Norway	9.4	20.0	0.47
Panama	1.1	5.0	0.22
Peru	2.0	13.0	0.15
Taiwan	2.6	5.0	0.52
United Kingdom	6.0	15.0	0.40
Average	4.3	11.6	0.37

Source: Silvani (1992).

the agricultural sector's income is often underreported to the tax authorities because of tax evasion, but the estimations for the national accounts are made on the basis of sampling or surveys of directly observed average productivity per acre and the average prices at which the crops are sold.[27]

Sampling Method

The second method of estimation, the *tax compliance measurement method*, has been used largely by the United States. In this method, a random sample of about 55,000 taxpayers is selected from data available to the Internal Revenue Service and to the social security administration. This sample is closely examined for possible tax evasion by the taxpayers chosen.[28] The average tax evasion for

[27] For a discussion of this point, see the paper by Reuter in Tanzi (1982).

[28] See Internal Revenue Service (1979). This method is different from that outlined in the previous section. The sampling method that is being described here is based on a sample selected for special scrutiny on a continuing basis and is used in lieu of the national accounts method.

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the sample is then used to obtain results for the whole population. The results, called the *gross gap*, or the *tax gap*, represent the unpaid income taxes on legally earned individual and corporate income. For 1987, the last year for which this information was published, the tax gap amounted to $85 billion, of which $63.5 billion was tax evasion by individuals, $21.4 billion was tax evasion by corporations, and $1.1 billion was tax evasion by nonfilers. Those who generate the data have expressed skepticism that this money could actually be collected.

Budget Survey Method

The third direct method relies on *household budget surveys*. These surveys show the relationship between the spending of families and their declared income. A family that earns its declared income and spends much more than that income can be suspected of tax evasion unless other factors, such as accumulated wealth or borrowing against future income, account for these differences. The results from this method are not very reliable and they can only provide a gross order of magnitude. The Italian authorities have used the rationale behind this method in the development of the *redditometro*, an index that establishes a minimum taxable income for taxpayers on the basis of external indices of wealth, such as expensive cars and second houses.

Direct Taxpayer Survey

A few countries, especially Nordic countries such as Sweden and Norway, have used *direct surveys of taxpayers*. A random sample of taxpayers is chosen and they are asked, among other questions, to describe their tax-reporting behavior.[29] This approach has received several criticisms, which range from whether individuals remember their past tax behavior to whether an individual would be willing to convey accurate information about an activity that may be considered antisocial, even when he or she is assured anonymity. The common belief is that tax evasion is often underestimated by these surveys even when they guarantee anonymity for the taxpayers.

Indirect Methods

Indirect methods essentially relate to the quantification of the so-called underground economy, which has been attempted for various countries. The connections between this quantification and the size of the tax evasion are often ambiguous and difficult to establish, especially when taxes are progressive. For example, if those who participate in the underground economy are mostly people with very low incomes, who would have paid very few taxes, then the existence of an underground economy may not imply the existence of significant tax evasion.

There is often a lot of confusion in how people define the underground economy. In some cases, people refer to taxes not paid; in other cases, they refer to the alleged underestimation of the national accounts. Often they do not specify which of these two definitions they have in mind. The problem is that, in many cases, one could have tax evasion with no underestimation of the national ac-

[29] See the paper on Norway by Isachsen, Klovland, and Strom, and the paper on Sweden by Hansson in Tanzi (1982).

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counts or, alternatively, little or no tax evasion with underestimation of the national accounts. A further confusion comes from the fact that the attempt to evade taxes is not the only impetus to an underground economy, since corruption, regulations, and various forms of prohibitions are also important factors. Despite these questions, the underground economy is often taken as a proxy for tax evasion.

Discussion of the various methods used to measure the underground economy requires extensive elaboration. Perhaps it would suffice just to mention the methods used.[30] The first method is the so-called *expenditure and income discrepancy method*, which assumes that the hidden incomes will show up as expenditures, so that the difference between the national accounts measured from income flows and the national accounts measured from consumption flows can indicate the size of the underground economy. This method was first applied to the United Kingdom. A second method is the *employment census method*, which tries to compare measured unemployment with the probable participation rate for the population in certain age classes. This method has been applied to Italy, Spain, and some other countries. Third is the *physical input method*, which is based on the idea that there is a predictable relationship between the use of some inputs, such as electricity, and the value of the output. Finally, there are various versions of the so-called *monetary approach*, an approach that associates evasion with currency or money holding. This monetary approach, developed in various forms by Guttman (1977), Feige (1979), and Tanzi (1980), has been widely used in a large number of countries to estimate the size of the underground economy.[31] All of the above approaches have problems. It would be prudent, therefore, not to base economic policy, or even estimates of tax evasion, solely on the results that emerge from these estimations.

To conclude, there are many methods that have been used to estimate tax evasion. In recent years, IMF technical assistance missions have routinely calculated the potential yield of selected taxes using some variant of the national accounts method. These results cannot be provided because of the confidentiality of the reports, but they appear to be quite useful in calculating the extent of tax evasion and in policymaking undertaken by the authorities.

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[30]These methods are discussed in Tanzi (1982).

[31]Tanzi (1980, 1983) used this method to estimate first the size of the underground economy in the United States and then tax evasion.

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IMF Staff Papers
Vol. 40, No. 4 (December 1993)
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Real Exchange Rate Targeting Under Imperfect Asset Substitutability

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This paper presents a model of an economy that uses nominal exchange rate policy to keep the real exchange rate constant at a certain target level, under an assumption of imperfect asset substitutability. The paper discusses the determinants of inflation under such a policy and examines the effects of exogenous and policy-induced shocks on inflation, the external accounts, and the fiscal accounts. The shocks considered include changes in the real exchange rate target, changes in fiscal policy, changes in foreign interest rates, and open market sales of public sector domestic bonds. [JEL E52, E61, F31, F41]

A NUMBER OF COUNTRIES have adopted active exchange rate policies in order to prevent high domestic inflation from eroding their international competitiveness. In many cases, the domestic currency is continuously depreciated by the difference between domestic and foreign inflations so as to keep the real exchange rate constant at some target level. This policy raises a number of macroeconomic issues that are receiving increased attention in the literature. For example, there is the question of whether any arbitrary real exchange rate target can be attained by this policy. Also, since both the exchange rate and the money supply become endogenous under such regimes, it is unclear how inflation is determined and how it responds to exogenous and policy-induced shocks.

Some of these issues were discussed recently in Lizondo (1991) in the

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The author would like to thank José Fajgenbaum, Peter Montiel, Jonathan Ostry, Brian Stuart, Christopher Towe, and Carlos Végh for useful comments on a previous version of this paper.

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context of a model with domestic and foreign non–interest bearing financial assets, in which domestic inflation and the real exchange rate are associated through the inflation tax.[1] That paper argues that the real exchange rate is a relative price that adjusts to ensure equilibrium in the nontraded goods market and that inflation tax payments affect private sector demand in that market. The higher the inflation tax payments, the lower is the private sector demand for nontraded goods, and thus the higher is the real exchange rate that equilibrates the nontraded goods market.[2] In that model, therefore, the long-run rate of inflation is determined by the condition that inflation tax payments generate a level of private sector demand that is consistent with equilibrium in the nontraded goods market at the targeted real exchange rate. Two significant corollaries follow from this basic result. First, attaining a more depreciated real exchange rate target requires higher inflation tax payments, which implies a higher rate of inflation as long as the elasticity of the demand for money is below unity.[3] Second, the range of sustainable real exchange rate targets is determined by the range of feasible inflation tax payments. The maximum sustainable real exchange rate is the one associated with the maximum inflation tax payment obtainable from the given demand for money.

Discussion of these issues was extended by Montiel and Ostry (1991) in the context of a more complex model that included perfectly substitutable interest-bearing domestic and foreign financial assets under perfect capital mobility. The authors show that the basic results mentioned above hold in their model, and they examine the consequences of various macroeconomic shocks, distinguishing between the initial effect on the price level and the effect on the rate of inflation. Since the price level and the rate of inflation must be consistent with equilibrium in the nontraded goods market, any given shock to the economy affects these variables only to the extent that it disturbs the initial equilibrium in this market. In essence, the price level and the rate of inflation respond so as to offset

[1] Previous papers have discussed related issues using different theoretical frameworks. Dornbusch (1982) examines the effect of nominal exchange rate rules on the trade-off between output stability and price level stability in a model defined by deviations from trends. Adams and Gros (1986) assume an exogenously given long-run real exchange rate and discuss the inflationary consequences of purchasing power parity rules for the nominal exchange rate.

[2] The real exchange rate is defined as the relative price of traded to nontraded goods, so that an increase in the real exchange rate indicates a real depreciation.

[3] Lizondo (1991) allows for a certain range of money demand with elasticity above unity and examines the implications of this assumption. Keeping with the usual practice, however, the discussion here focuses on the inelastic portion of the demand for money.

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the original impact of the shock on the nontraded goods market, thereby maintaining continuous equilibrium in this market at the targeted real exchange rate.

For example, an increase in public sector expenditure on nontraded goods creates an excess demand for these goods and results in an immediate increase in the price level and an increase in the rate of inflation. The immediate increase in the price level reduces private sector wealth, which reduces private sector demand for nontraded goods, thus restoring equilibrium in this market at the targeted real exchange rate instantaneously. The increase in the rate of inflation raises inflation tax payments, which keeps private sector wealth and thus private demand for nontraded goods at their new lower equilibrium levels. The paper also shows that an increase in world real interest rates leads to a fall in the price level and a subsequent increase in the rate of inflation. The effects of changes in the terms of trade and import tariffs depend on whether the authorities target the *importables* or the *exportables* real exchange rate.

Montiel and Ostry (1991) also examines the effectiveness of tight credit policy in reducing inflation. They conclude that under real exchange rate targeting and perfect capital mobility any attempt to control the money supply by tightening domestic credit is immediately offset by additional capital inflows, so that the money supply cannot be used as an anchor for the price level. The authors continue the discussion of this subject in Montiel and Ostry (1992), where they explore whether the use of capital controls can make tight credit policy more effective in reducing inflation. Capital controls are modeled as a dual exchange rate system with an official exchange rate subject to targeting (which applies to noninterest current transactions) and a parallel exchange rate that floats freely (which applies to all other transactions). As long as capital controls are effective in preventing leakages between the markets, the authorities regain control of the money supply, and tight credit policy can be used to contain inflation. However, the spread between the official and the parallel exchange rates would increase continuously. Under these conditions, the effectiveness of capital controls in preventing leakages is likely to erode, thus making it impossible for the authorities simultaneously to target the real exchange rate and control the money supply over a long period of time.

The assumption of perfect asset substitutability coupled with perfect capital mobility, or a dual exchange rate that floats freely, is not well suited for examining some cases of real exchange rate targeting. Some countries have implemented this exchange rate policy under basically unified foreign exchange markets and have been able to influence domestic interest rates by altering domestic credit conditions. In these cases, it

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seems more appropriate to treat domestic and foreign financial assets as imperfect substitutes. This raises the issue of whether the conclusions derived for the case of perfect asset substitutability continue to hold when assets are imperfect substitutes. Furthermore, since imperfect substitutability gives the authorities some control over domestic interest rates, there is the question of whether a policy of high domestic real interest rates could be effective in containing inflation.

This paper presents a model of real exchange rate targeting under the assumptions of a unified foreign exchange market and imperfect asset substitutability. The paper shows that introducing imperfect asset substitutability does not alter the conclusions regarding the basic determinants of inflation and the response of the price level and inflation to various shocks, including changes in the real exchange rate target, changes in public sector expenditure on nontraded goods, and changes in world real interest rates. The paper also examines the effect of an increase in taxes, which results in an immediate fall in the price level and a decline in the rate of inflation, and that of an increase in public sector expenditure on traded goods, which affects neither the price level nor the rate of inflation.[4] In addition, the paper shows that an increase in the domestic real interest rate results in an immediate fall in the price level and an increase in the rate of inflation. The paper also discusses in some detail the determinants of the external accounts under real exchange rate targeting. In particular, it shows that a given fiscal tightening may have different consequences for the external accounts depending on the specific instruments used to implement such tightening.

I. The Model

The model presented below includes a private sector that produces and consumes traded and nontraded goods, pays taxes, and allocates its wealth among domestic money, foreign bonds, and domestic government bonds. There is no investment. The model also includes a government sector that consumes traded and nontraded goods, collects taxes, issues domestic bonds, borrows from a central bank, and borrows abroad. The central bank lends to the government and manages the nominal exchange rate in order to keep the real exchange rate constant at a given target level.

[4] Since the public sector is subject to an intertemporal budget constraint, these policies may need to be accompanied by a future fiscal adjustment that ensures solvency.

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Production

Prices and wages are perfectly flexible so that full employment always prevails.[5] Production takes place along a concave transformation curve with

$$y_t = y_t(e) \qquad y_t' > 0,$$
$$y_n = y_n(e) \qquad y_n' < 0, \tag{1}$$

where y_t is output of traded goods, y_n is output of nontraded goods, and e is the real exchange rate defined as (P_t/P_n), with P_t and P_n denoting the domestic currency price of traded and nontraded goods, respectively.[6]

Consumption

Private sector total consumption is given by

$$c = c(y - t; r; w), \qquad 0 < c_1 < 1, \qquad c_2 < 0, \qquad c_3 > 0, \tag{2}$$

where c denotes total consumption in real terms, y denotes real factor income, t denotes taxes in real terms, r denotes the domestic real interest rate, and w denotes private sector financial wealth in real terms.[7] Private sector preferences are such that a constant share of total private expenditure is devoted to each type of good.[8] Denoting the share devoted to nontraded goods by θ and defining the price level as $P = P_t^{1-\theta} P_n^{\theta}$, one has

$$c_t = (1 - \theta)e^{-\theta} c, \tag{3}$$

$$c_n = \theta e^{1-\theta} c, \tag{4}$$

where c_t denotes consumption of traded goods, c_n consumption of nontraded goods, and $e^{-\theta} = (P/P_t)$ and $e^{1-\theta} = (P/P_n)$.

[5] This formulation of the production structure abstracts from any influence that real exchange rate targeting may have on employment and thus on aggregate supply. Therefore, the model focuses primarily on the effects that operate through the demand side of the economy.

[6] Importables and exportables are aggregated into traded goods by assuming free trade and constant terms of trade.

[7] For simplicity, real factor income y is treated as a constant throughout the paper. If the real exchange rate is kept fixed, y is effectively constant so that no additional assumption is needed. However, if the real exchange rate changes, one needs to assume $(y_t/c_t) = (y_n/c_n)$ at the initial equilibrium.

[8] In the context of an optimizing model, this would be consistent with a Cobb-Douglas utility function.

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Private Sector Portfolio

The private sector allocates its financial wealth among three assets: non–interest bearing domestic money M, foreign bonds F, and domestic government bonds b that are indexed to the price level.[9] Denoting the nominal exchange rate by S, real holdings of domestic money by m, and real holdings of foreign bonds by f,

$$w = (M/P) + F(S/P) + b = m + f + b. \tag{5}$$

Private sector portfolio preferences are given by

$$m = L(r + \pi; y) \qquad L_1 < 0, \qquad L_2 > 0, \tag{6}$$

$$b = b(r; r^*; w) \qquad b_1 > (-L_1) > 0, \qquad b_2 < 0, \qquad 0 < b_3 < 1, \tag{7}$$

where π is the domestic rate of inflation and r^* is the real interest rate on foreign bonds.[10] Thus, the demand for money is assumed to depend negatively on the domestic nominal interest rate and positively on real factor income, while the demand for domestic bonds is assumed to depend positively on their real interest rate and on financial wealth and negatively on the real interest rate on foreign assets. The demand for foreign bonds can be derived from the wealth constraint (5) and the demand for the other two assets given in equations (6) and (7).[11]

The accumulation of private sector financial wealth is equal to the difference between that sector's income (including factor income and interest earnings on holdings of domestic and foreign bonds) and its expenditure on consumption, tax payments, and inflation tax "payments." This can be expressed as

$$\dot{w} = [y - t - c(y - t; r; w)] + r^* w + (r - r^*)b - (r^* + \pi)L(r + \pi; y), \tag{8}$$

which can be rewritten as

$$\dot{w} = h(y; t; r; r^*; w; b; \pi), \qquad h_1 \gtrless 0, \qquad h_2 < 0, \qquad h_3 > 0, \qquad h_4 > 0, \qquad h_5 < 0, \qquad h_6 > 0, \qquad h_7 < 0, \tag{9}$$

[9] Assuming nonindexed bonds would not affect the conclusions.

[10] For a constant real exchange rate, the real interest rate on foreign bonds is equal to the foreign currency interest rate on foreign bonds minus the rate of change of the foreign currency price of traded goods. Assuming that the price of traded goods is constant in terms of foreign currency, r^* can be interpreted as both the real interest rate on foreign bonds and the foreign currency interest rate on foreign bonds.

[11] The assumptions about the partial derivatives in equations (6) and (7) imply that the demand for f depends positively on w, r^*, and π and negatively on r and y.

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where the sign of some of the partial derivatives requires additional assumptions.[12]

Public Sector

In presenting the public sector, the accounts of the central bank are consolidated with those of the government. For simplicity, the model abstracts from the rest of the financial system (so that the entire stock of money is a liability of the central bank) and assumes that the central bank extends credit only to the government.[13] Thus, once the accounts are consolidated, the public sector has the stock of international reserves as an asset and the stock of money as a liability.

Therefore, the public sector collects taxes t, buys g_t units of traded goods and g_n units of nontraded goods, and issues domestic bonds b (paying real interest rate r), foreign currency bonds B^* (net of international reserves and paying real interest rate r^*), and money m. Defining $b^* = B^*(S/P)$ and choosing units so that the foreign currency price of traded goods is unity (thus $P_t = S$), the public sector budget constraint is

$$\dot{m} + \dot{b} + \dot{b}^* = (e^{\theta - 1} g_n + e^{\theta} g_t - t) + rb + r^* b^* - \pi m. \qquad (10)$$

Thus, the public sector operational deficit is financed by issuing domestic debt $\dot{b}$ and foreign debt $\dot{b}^*$, by an increase in the real stock of domestic money $\dot{m}$, and by the inflation tax πm.[14]

Fiscal policy is subject to an intertemporal budget constraint that ensures solvency. Expression (10), which describes the evolution of public sector net liabilities over time, must converge to zero in order to rule

[12] Thus, $h_5 < 0$ means that the higher the level of wealth, the lower is the speed at which consumers would accumulate additional wealth; for this to hold, an increase in wealth must increase consumption by more than the income obtained by investing the extra wealth in foreign assets, that is, $c_3 > r^*$. Second, $h_6 > 0$ means that an increase in the stock of domestic bonds increases the speed at which the private sector accumulates wealth; for this to hold, domestic bonds must pay a higher interest rate than the alternative interest-bearing asset (foreign bonds), that is, $r > r^*$. Third, $h_7 < 0$ necessarily holds under the assumption that the elasticity of the demand for money is below unity.

[13] If the central bank lends to the private sector (and charges a real interest rate r) the analysis below is unaltered, with b denoting public sector domestic bonds *net* of central bank credit to the private sector.

[14] The "operational" deficit includes noninterest payments and receipts and the real interest component of interest payments and receipts. Thus, it is equal to $(e^{\theta - 1} g_n + e^{\theta} g_t - t) + rb + r^* b^*$.

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out the possibility that either the public sector's or the rest of the world's net worth is negative in the long run.

Although the discussion below notes the fiscal consequences of various policies and exogenous shocks, it does not focus on the implications for public sector solvency. Implicitly, the discussion assumes that solvency is ensured by an appropriate *future* adjustment in public sector expenditure on traded goods. Clearly, the adjustment that ensuressolvency could also take place in the present. However, it is preferable to set the problem in terms of a future adjustment so as to separate clearly the effect of a given policy (or exogenous shock) from the effect of the corrective measures that will be needed to ensure solvency. Also, solvency could be achieved by a future adjustment based on policies other than changes in public sector expenditure on traded goods, but this would prevent the derivation of the long-run behavior of inflation while focusing only on current variables. A future adjustment based on policies other than changes in public sector expenditure on traded goods would affect the long-run rate of inflation, as can be appreciated from the discussion below.[15] Notice also that in the absence of an appropriate future fiscal adjustment that ensures solvency real exchange rate targeting becomes unsustainable, since public sector net liabilities would increase (or decline) without bound under existing policies. These caveats should be kept in mind when interpreting the "long run" effect on inflation of the various policies and exogenous shocks examined below.

Nontraded Goods Market

It is assumed that the nontraded goods market is always in equilibrium, which requires that the supply be equal to the sum of private sector plus public sector demand:

$$y_n(e) = \theta e^{1-\theta} c(y - t; r; w) + g_n. \tag{11}$$

Other things constant, a real depreciation, an increase in wealth, or an increase in public sector expenditure on nontraded goods generates an excess demand for nontraded goods, while an increase in taxes or an increase in the real interest rate generates an excess supply of nontraded goods.

[15] In an optimizing intertemporal model, the policy composition and the timing of the fiscal adjustment would have implications not only for the long-run rate of inflation but also for current private sector behavior.

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External Sector

The trade balance, measured in foreign currency terms and denoted by T, is equal to the supply of traded goods minus the demand for traded goods by both the private sector and the public sector:

$$T = y_t(e) - (1 - \theta)e^{-\theta}c(y - t; r; w) - g_t. \tag{12}$$

Thus, other things constant, the trade balance improves with a real depreciation, an increase in taxes, or an increase in the real interest rate and worsens with an increase in wealth or an increase in public sector expenditure on traded goods.

The current account of the balance of payments, denoted by CA, is given by the trade balance, plus interest receipts on private sector net foreign assets and minus interest payments on public sector net foreign debt:

$$CA = y_t(e) - (1 - \theta)e^{-\theta}c(y - t; r; w) - g_t + r^*(F - B^*). \tag{13}$$

Equilibrium

In this model, the steady state is reached immediately. At any point in time, given the exogenous variables (y and r^*) and the policy variables (e, t, g_n, g_t, and b), w and r are determined simultaneously by the condition for equilibrium in the market for domestic bonds in equation (7) and by that for nontraded goods in equation (11).[16] Since equations (7) and (11) contain no additional endogenous variable, the solution thus obtained is the steady-state solution. Since π is the only remaining endogenous variable in equation (9), and w is constant, the rate of inflation is determined by setting $\dot{w} = 0$ in equation (9). Once w, r, and π are known, equation (6) can be used to determine m and then equation (5) can be used to determine f.

When examining the consequences of various shocks in the next section, it is important to distinguish between the *initial impact on the price level* and the *effect on inflation*. The effect on inflation is obtained from equations (7), (11), and (9), as described in the previous paragraph. However, any shock that modifies the equilibrium value of w also produces an immediate jump in the price level, which brings about the

[16]The assumption that b is a policy variable implies that the public sector decides how much domestic debt to place in the market. Since at each point in time total net liabilities of the public sector are given, and since the stock of money is determined by private sector demand, the stock of public sector net foreign debt is an endogenous variable.

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required change in w. From equation (5), since M, F, and b are predetermined, w can change only as a result of changes in P or in (S/P). For any shock other than a change in the real exchange rate target, (S/P) is fixed and P changes to bring about the necessary change in w. In contrast, when the real exchange rate target is modified, both (S/P) and P change; (S/P) changes according to the modification in the target, and P changes to bring about the necessary adjustment in w.

II. Exogenous and Policy-Induced Shocks

This section discusses the effects of various shocks on the price level, inflation, and other endogenous variables. The evolution of some of the variables is depicted in Figures 1–3. The top panel of each figure shows equations (7) and (11) represented by curves *bb* and *nn* respectively, and the bottom panel shows the evolution of the price level over time. A formal derivation of the results is presented in the Appendix.

A More Depreciated Real Exchange Rate Target

Choosing a more depreciated real exchange rate target implies that the authorities implement an initial devaluation large enough to move the real exchange rate to its new target level and then keep continuously depreciating the domestic currency so as to offset the effect of domestic inflation.

A more depreciated real exchange rate, other things constant, generates an excess demand in the market for nontraded goods as supply declines and private sector demand increases. Equilibrium is restored by a drop in wealth and an increase in the domestic interest rate, both of which reduce private sector demand, thus bringing total demand for nontraded goods to a level consistent with supply at the new real exchange rate. In Figure 1, a more depreciated real exchange rate shifts the *nn* curve to the left, thus resulting in a lower w and a higher r. From equation (9), both the increase in r and the decline in w create an incipient accumulation of wealth, which is offset in equilibrium by an increase in the inflation rate (so as to restore $\dot{w} = 0$). On impact, the price level jumps upward and the nominal exchange rate undergoes an even larger devaluation so as to produce the real depreciation sought by the new policy.[17]

[17] Choosing a more depreciated real exchange rate target requires a higher (S/P) and a lower w on impact, which according to equation (5) can only be obtained by an upward jump in the price level and a proportionally higher jump in the exchange rate.

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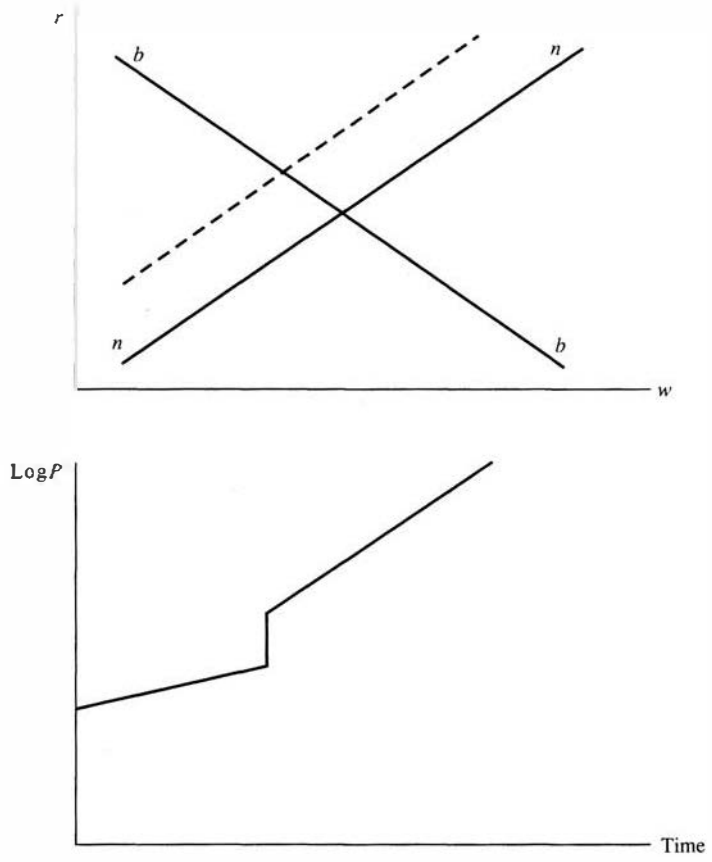
Figure 1. *A More Depreciated Real Exchange Rate Target and an Increase in Public Sector Expenditure on Nontraded Goods*



Although the initial impact takes place simultaneously for all the variables, it is useful to interpret this effect in terms of a "sequential story" so as to gain some intuition about the results. First, to obtain a more depreciated real exchange rate, the central bank devalues the domestic currency. This creates an excess demand in the nontraded goods market, so the price of nontraded goods increases. This increase, together with the devaluation, implies an upward jump in the price level, which reduces real wealth. With lower real wealth, however, the demand for domestic bonds declines, causing an increase in the domestic interest rate, which restores equilibrium in the bond market. Both the reduction

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in wealth and the increase in the domestic interest rate contain the excess demand for nontraded goods. This ensures that the increase in the price of nontraded goods required to restore equilibrium in the nontraded goods market is proportionally lower than the nominal devaluation. Thus, the new equilibrium is consistent with a real depreciation of the domestic currency.

After the initial effects, private wealth tends to increase from its new level.[18] This incipient increase in private sector wealth generates an incipient increase in consumption (including that of nontraded goods), which tends to appreciate the real exchange rate. As the central bank accelerates the rate of nominal devaluation to avoid the real appreciation, inflation increases. In equilibrium, the new rate of inflation has to be high enough to produce the inflation tax necessary to prevent the accumulation of wealth, and thus prevent the real demand for nontraded goods from increasing.

Regarding the external sector, the real depreciation improves the trade balance and the current account because of the increase in supply and the fall in private sector demand for traded goods.[19] The initial impact on private capital flows is ambiguous:[20] private sector demand for foreign assets declines owing to the lower level of wealth and the higher domestic real interest rate but increases owing to the higher inflation rate.[21]

[18]The tendency for wealth to increase from its new (lower) level, before any change in the rate of inflation, can be interpreted in terms of equation (8). It is necessary to look at the effects of changes in r and w on $\dot{w}$, for a constant π. Notice first that private sector consumption declines owing to the increase in r and the fall of w on impact, and that the demand for money declines owing to the increase in r. Thus (for a given rate of inflation), wealth tends to *increase* because of (i) a decline in consumption (the term in square brackets increases), (ii) the higher interest receipts on domestic debt owing to the higher interest rate (the term $[r - r^*]\, b$ increases), and (iii) the gain in income that the private sector obtains by reducing its money holdings and allocating those resources to foreign assets (the term $(r^* + \pi)L(r + \pi; y)$ declines). Wealth tends to *decline* because of the loss of foreign interest receipts that results from the decline in wealth on impact (the term r^*w declines). The net effect on $\dot{w}$ of all these changes is positive, so inflation has to increase to compensate for this (to keep $\dot{w} = 0$), as shown in the Appendix. This type of reasoning can also be applied when discussing the other shocks in order to see whether wealth tends to increase or decrease after impact. However, the explanation for the other shocks is not included in this paper as it would be rather cumbersome and tedious.

[19]Unless there is a change in the foreign interest rate, any given shock has the same effect on the trade balance and the current account.

[20]In the steady state, private capital flows are zero (f is constant). Therefore, policies can have only an instantaneous once-and-for-all impact on those flows.

[21]This can be looked at in terms of the wealth constraint (5). The level of wealth falls, but the demand for money also falls and the stock of domestic bonds is constant. So the effect on foreign asset holdings is undetermined.

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The effect of a more depreciated real exchange rate on the public sector operational deficit is ambiguous. The real value of public sector expenditure can go either way depending on its composition of traded and nontraded goods. Real interest payments on domestic debt increase because of the higher domestic interest rate, while real interest payments on net foreign liabilities may increase or decrease. Interest payments on foreign liabilities are denominated in foreign currency, and thus they increase in real terms, for a given level of net foreign liabilities. However, the level of net foreign liabilities itself may increase or decrease depending on whether there is a private sector capital outflow or inflow on impact.

Increase in Taxes

An increase in taxes, other things constant, reduces private sector demand and thus generates an incipient excess supply of nontraded goods. This is offset by an increase in wealth and a reduction in the domestic real interest rate, which brings private sector demand back to its initial level, thereby restoring equilibrium in the nontraded goods market at the given real exchange rate. In Figure 2, the increase in taxes shifts curve *nn* to the right, resulting in a higher w and a lower r. The price level drops on impact, followed by a decline in the rate of inflation.

The "sequential story" in this case is as follows. On impact, the increase in taxes creates an excess supply of nontraded goods, so the price of nontraded goods declines. To prevent this from resulting in a real depreciation, the central bank revalues the domestic currency by the same percentage, so the price level falls on impact at a constant relative price. The drop in the price level implies a higher level of wealth, which increases the demand for domestic bonds and thus causes a decline in the domestic real interest rate. Both the increase in real wealth and the decline in the domestic real interest rate offset the initial impact of higher taxes on private demand, and thus eliminates the initial excess supply of nontraded goods.

After the initial impact, wealth tends to decline from its new level, producing an incipient reduction in private expenditure, which would depreciate the real exchange rate. The central bank prevents this by slowing down the rate of nominal devaluation, thus generating a lower rate of inflation and lower inflation tax payments.

The trade balance and the current account are not affected by the increase in taxes because, as mentioned above, the increase in wealth and the decline in the domestic real interest rate keep private sector demand

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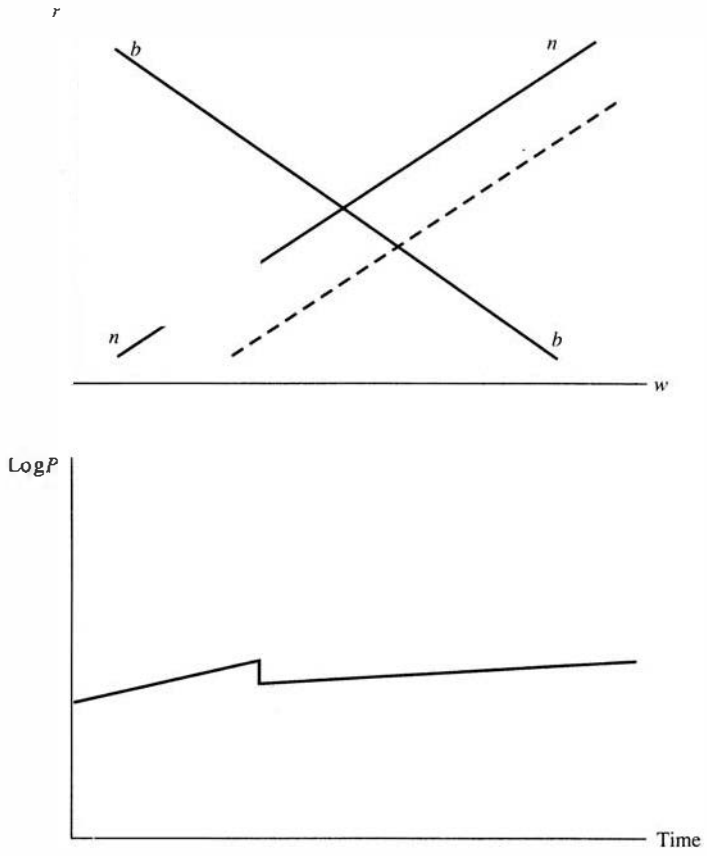
Figure 2. *An Increase in Taxes*



unchanged. The initial impact on private capital flows is ambiguous: private sector demand for foreign assets increases owing to the lower domestic real interest rate and the higher level of wealth but decreases owing to the lower rate of inflation.[22]

The public sector operational deficit declines with the increase in taxes.

[22] In terms of the wealth constraint, the level of wealth increases, but the demand for money also increases and the stock of domestic bonds is constant. So the effect on foreign asset holdings is undetermined.

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The effect of higher taxes and the effect of lower real interest payments on domestic debt more than offset any higher interest payments on public net foreign debt that might originate from a private capital outflow on impact.

Increase in Public Sector Expenditure

The consequences of a given change in public sector expenditure depend on whether it involves traded or nontraded goods. An increase in public sector expenditure on *traded* goods has no effect on either the market for domestic bonds or the market for nontraded goods, and thus has no effect on prices. The only effect of this policy is to worsen the trade balance, the current account, and the public sector operational deficit by the same amount as the increase in expenditure.

In contrast, an increase in public sector expenditure on *nontraded* goods, other things constant, generates an incipient excess demand for nontraded goods. This is offset by a reduction in private sector demand, which is brought about by a fall in wealth and an increase in the domestic real interest rate. The situation is depicted in Figure 1: the *nn* curve shifts to the left, resulting in a lower w and a higher r. The price level increases on impact, followed by an increase in the rate of inflation.

The "sequence" on impact is as follows. The increase in public sector expenditure on nontraded goods creates an excess demand in this market, so the price of nontraded goods rises. To prevent a real appreciation, the central bank devalues the domestic currency, which results in an upward jump in the price level at a constant relative price. The upward jump in the price level reduces real wealth, thereby diminishing the demand for domestic bonds and thus causing an increase in the domestic real interest rate. The decline in real wealth together with the increase in the domestic real interest rate reduces private sector demand for nontraded goods by an amount equal to the increase in public sector demand, and thus restores equilibrium in the nontraded goods market at the original real exchange rate.

After impact, wealth tends to increase, thus inducing an incipient increase in private expenditure, which tends to appreciate the real exchange rate. The central bank prevents this real appreciation by increasing the speed of nominal devaluation, thus generating a higher rate of inflation and higher inflation tax payments.

An increase in public sector expenditure on nontraded goods improves the trade balance and the current account because of the reduction in

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private sector demand for traded goods.[23] The initial impact on private capital flows is ambiguous: private sector demand for foreign assets declines owing to the lower level of wealth and the higher domestic real interest rate but increases owing to the higher inflation rate.[24]

The public sector operational deficit increases with the increase in public sector expenditure on nontraded goods. The direct effect of increased expenditure and the effect of higher interest payments on domestic debt more than offset any reduction in interest payments on public net foreign debt that might be caused by a private capital inflow on impact.[25]

Increase in Foreign Interest Rates

An increase in foreign interest rates, other things constant, reduces the demand for domestic bonds, thus generating an incipient excess supply in this market. This is offset by an increase in wealth and an increase in the domestic real interest rate. In Figure 3, the increase in the foreign interest rate shifts the *bb* curve to the right, resulting in a higher w and a higher r. The price level falls on impact, followed by an increase in the rate of inflation.

The "sequential story" is as follows. On impact, the increase in the foreign interest rate generates an excess supply in the market for domestic bonds, causing an increase in the real domestic interest rate. This induces a reduction in private sector expenditure, which leads to an incipient real depreciation. To prevent the real depreciation from taking place, the central bank revalues the domestic currency, causing a drop

[23]This counterintuitive result can also be explained in terms of a decline in aggregate spending (private sector expenditure declines by more than public sector expenditure increases). Private sector expenditure on nontraded goods must decline by the same amount that public sector expenditure on nontraded goods increases so as to keep equilibrium in this market at an unchanged real exchange rate. However, since the private sector is facing unchanged relative prices, private demand for both types of goods move together. Thus, lower private expenditure on nontraded goods is necessarily accompanied by lower private expenditure on traded goods, thereby resulting in lower aggregate spending for the economy as a whole.

[24]In terms of the wealth constraint, the level of wealth falls but the demand for money also falls and the stock of domestic bonds is constant. So the effect on foreign asset holdings is undetermined.

[25]A sufficient condition for this to hold is $r^* < (b_3 b / b_1)$. If the foreign interest rate is "too high," a private capital inflow (which would reduce public sector net foreign debt by the same amount) could conceivably reduce public sector foreign interest payments by an amount sufficiently large to reduce the operational deficit.

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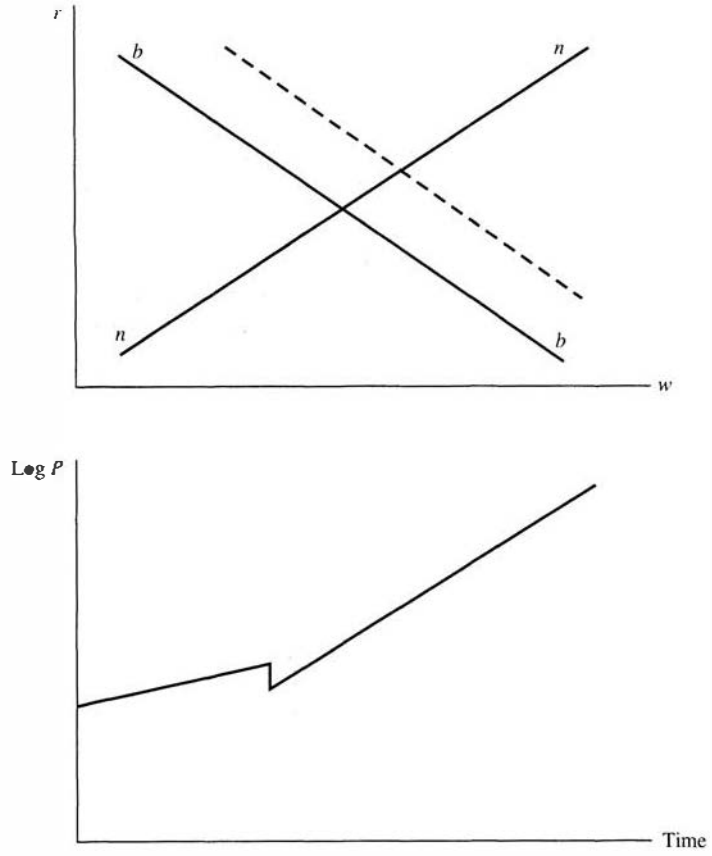
Figure 3. *An Increase in Foreign Interest Rates and an Open Market Sale of Domestic Bonds*



in the price level at a constant relative price, and thus increasing real wealth. The effects of higher real wealth and a higher domestic real interest rate on private sector demand offset each other so that the market for nontraded goods clears at the original real exchange rate. At the same time, the higher real wealth and higher domestic real interest rate restore equilibrium in the market for domestic bonds.

After impact, wealth tends to increase, thus causing an incipient real appreciation. To prevent this, the central bank accelerates the devaluation of the domestic currency, generating a higher rate of inflation and higher inflation tax payments.

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The trade balance is not affected by an increase in the foreign interest rate, as both the demand and the supply of traded goods remain constant. The current account may worsen or improve depending on whether the country is a net foreign debtor or creditor. On impact, there is a private sector capital outflow as the private sector demand for foreign assets increases. The effects of a higher foreign interest rate, higher wealth, and higher inflation more than offset the effect of a higher domestic real interest rate.[26]

The public sector operational deficit increases because of both higher interest payments on domestic debt (brought about by the higher domestic real interest rate) and higher interest payments on foreign debt (brought about by the higher foreign interest rate and the higher level of public net foreign debt, induced by the private sector capital outflow on impact).

Open Market Sale of Domestic Bonds

Imperfect asset substitutability allows the authorities to have some control over domestic interest rates. Since an increase in interest rates leads to a decline in private sector expenditure, this policy could be helpful in containing inflation. This section examines the extent to which this is the case when a country is following a policy of targeting the real exchange rate.

An open market sale of bonds, other things constant, generates an excess supply in the market for domestic bonds. The incipient excess supply is offset by a higher domestic real interest rate and higher level of private sector wealth. As depicted in Figure 3, the sale of domestic bonds shifts the *bb* curve to the right, producing an increase in both w and r. The price level falls on impact, followed by an increase in the rate of inflation.

These results can be interpreted sequentially as follows. The open market sale of bonds creates an excess supply of bonds, leading to an increase in the domestic real interest rate, which tends to reduce private sector expenditure. The incipient decline in private sector demand for nontraded goods produces an incipient real depreciation, which the central bank prevents by a nominal revaluation of the domestic currency. As a result, the prices of all goods fall on impact, causing an increase in

[26]In terms of the wealth constraint, wealth increases while the demand for money falls and the stock of domestic bonds is constant. Thus, holdings of foreign assets necessarily increase.

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real wealth. The effects of a higher domestic real interest rate and higher wealth on the demand for nontraded goods offset each other, thereby keeping equilibrium in the nontraded goods market at the original real exchange rate. The higher real interest rate and the higher wealth also restore equilibrium in the bond market.

After impact, wealth tends to increase, thus inducing an incipient increase in private expenditure, which tends to appreciate the real exchange rate. The central bank prevents this by accelerating the rate of nominal devaluation, thus generating a higher rate of inflation and higher inflation tax payments.

The trade balance and the current account are not affected by an open market sale of domestic bonds, as both the supply and the demand for traded goods remain constant. The initial impact on private capital flows is ambiguous: private demand for foreign assets declines owing to the higher domestic interest rate but increases owing to the increase in wealth and the increase in inflation.[27]

The public sector operational deficit increases. Higher real interest payments on domestic debt (owing to both a higher domestic real interest rate and a higher stock of domestic debt) more than offset any decline in foreign interest payments that might result from a private capital inflow on impact.

III. Concluding Remarks

The discussion above has important implications for countries that follow a nominal exchange rate policy aimed at targeting the real exchange rate. Since the implications are derived from a model based on a number of restrictive assumptions, they must be interpreted in broad terms when applied to specific circumstances. In particular, the assumption of instantaneous price adjustment may be too restrictive for countries with widespread price and wage indexation or other features that introduce significant inertial elements into the determination of prices. In those cases, the instantaneous impact on the price *level* should be interpreted as a short-run effect on the rate of inflation. This suggestion is followed in the remarks below.

In interpreting the various results, it is also important to remember that it has been assumed that public sector solvency is ensured by an appropriate future fiscal adjustment in public sector expenditure on traded goods. Thus, the conclusions regarding the "long run" effect on

[27]In terms of the wealth constraint, the level of wealth increases and the demand for money falls, but the stock of domestic bonds also increases. So the effect on foreign asset holdings is undetermined.

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inflation of the various policies and exogenous shocks are conditional on this type of fiscal adjustment taking place. Otherwise, the references to "long-run" inflation should be interpreted as valid until a different type of fiscal adjustment takes place to ensure solvency or the policy of real exchange rate targeting is abandoned. Subject to these caveats, the main implications of the paper are as follows.

Targeting the real exchange rate may be an effective way of preserving international competitiveness and thus ensuring a satisfactory external trade performance in the presence of high domestic inflation. The rate of domestic inflation, however, is not independent of the external trade objectives of the authorities. Specifically, the more ambitious the external trade objectives, and thus the more depreciated the real exchange rate target, the higher is the resulting rate of inflation in both the short and long run. Thus, other things constant, there seems to be a trade-off between a better external trade performance and a lower rate of inflation.

The effect of fiscal tightening on inflation seems to depend primarily on the instrument that is used to implement this policy. An increase in taxes or a reduction in public sector expenditure on nontraded goods would reduce inflation in both the short run and the long run. In contrast, a reduction in public sector expenditure on traded goods would have no effect on inflation.

The consequences of fiscal tightening for the trade balance are also instrument specific. Although reducing public sector expenditure on traded goods would improve the trade balance by the same amount, increasing taxes would have no effect on the trade balance as private sector expenditure would remain constant owing to reduced inflation tax payments. Furthermore, if the fiscal tightening is implemented through a reduction in public sector expenditure on nontraded goods, the trade balance would actually worsen. Inflation tax payments would decline enough to cause private sector expenditure on nontraded goods to expand sufficiently to offset the reduction in public sector expenditure, thus restoring equilibrium in the nontraded goods market at the initial real exchange rate. Since private sector expenditure on traded goods would also expand as a result of the lower inflation tax payments, the trade balance would worsen.

In the context of this model, the use of high domestic interest rates brought about by open market sales of domestic bonds seems to be effective in containing inflation, but only temporarily.[28] Higher real inter-

[28] While the various results mentioned above would also hold under perfect asset substitutability, the conclusions regarding this policy are specific to the model in this paper, in which domestic and foreign assets are imperfect substitutes.

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est rates would initially contain private expenditure and thus lead to a decline in inflation. After a certain period, however, private sector demand would expand as a result of increased real interest receipts on private sector holdings of domestic bonds. In order to prevent this expansion in private demand from resulting in a real appreciation, the central bank would be forced to accelerate the devaluation of the nominal exchange rate, thus generating higher inflation. Therefore, in the absence of other policy changes, high domestic interest rates do not seem to provide lower inflation on a sustained basis but rather lower inflation in the present in exchange for higher inflation in the future.

This also has implications for designing a response to exogenous changes in world financial markets. For example, a fall in foreign interest rates in the absence of a policy response would induce private capital inflows, a decline in domestic interest rates, and higher inflation in the short run. After a certain period, however, lower real interest receipts by the private sector would lead to lower private expenditure, and thus a lower rate of inflation. If the initial monetary expansion resulting from private capital inflows is sterilized by open market sales of domestic bonds, the authorities would be able to prevent domestic interest rates from falling and thus contain the initial increase in inflation. However, this step would mean forgoing (at least partially) the subsequent fall in inflation that would take place in the absence of sterilization.

The analysis of real exchange rate targeting could advance in various directions. In particular, it would be valuable to examine this exchange rate policy in the context of an optimizing intertemporal model. This would provide an appropriate framework for the explicit consideration of the public sector's intertemporal budget constraint and would permit study of how the private sector's current behavior depends on expectations regarding the type of future fiscal adjustment that would ensure solvency. Also, the analysis could be enriched by the explicit incorporation of uncertainty and by allowing for transitory deviations of the real exchange rate from its target level.

APPENDIX

This appendix derives the effects of various shocks on w, r, π, inflation tax payments πm, the trade account T, and the current account CA. The effects on w and r are obtained from equations (7) and (11).

$$(dw/de) = \Delta\Omega b_1 \theta^{-1} e^{\theta - 1} < 0,$$

$$(dr/de) = -\Delta\Omega b_3 \theta^{-1} e^{\theta - 1} > 0,$$

$$(dw/dt) = \Delta b_1 c_1 > 0,$$

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$$
\begin{aligned}
(dr/dt) &= -\Delta b_3 c_1 < 0,\\
(dw/dg_n) &= -\Delta b_1 \theta^{-1} e^{\theta-1} < 0,\\
(dr/dg_n) &= \Delta b_3 \theta^{-1} e^{\theta-1} > 0,\\
(dw/dr^*) &= \Delta b_2 c_2 > 0,\\
(dr/dr^*) &= -\Delta b_2 c_3 > 0,\\
(dw/db) &= -\Delta c_2 > 0,\\
(dr/db) &= \Delta c_3 > 0,
\end{aligned}
\tag{A1}
$$

where Δ and Ω are defined by

$$\Delta = (b_1 c_3 - b_3 c_2)^{-1} > 0,$$

$$\Omega = [y_n' - \theta(1-\theta)e^{-\theta} c(y-t; r; w)] < 0.$$

The effects on π are obtained by using equation (9) with $\dot{w} = 0$ and the set of equations (A1):

$$
\begin{aligned}
(d\pi/de) &= \Phi\{(r^* - c_3)(dw/de) + [b - c_2 - (r^* + \pi)L_1](dr/de)\} > 0,\\
(d\pi/dt) &= \Phi\{(c_1 - 1) + (r^* - c_3)(dw/dt)\\
&\quad + [b - c_2 - (r^* + \pi)L_1](dr/dt)\} < 0,\\
(d\pi/dg_n) &= \Phi\{(r^* - c_3)(dw/dg_n)\\
&\quad + [b - c_2 - (r^* + \pi)L_1](dr/dg_n)\} > 0,\\
(d\pi/dr^*) &= \Phi\{f + (r^* - c_3)(dw/dr^*) + [b - c_2 - (r^* + \pi)L_1](dr/dr^*)\}\\
&= \Phi\{f - \Delta b_2[bc_3 - (r^* + \pi)L_1 c_3 - r^* c_2]\} > 0,\\
(d\pi/db) &= \Phi\{(r^* - c_3)(dw/db) + [b - c_2 - (r^* + \pi)L_1](dr/db) + (r - r^*)\}\\
&= \Phi\{\Delta[bc_3 - (r^* + \pi)L_1 c_3 - r^* c_2] + (r - r^*)\} > 0,
\end{aligned}
\tag{A2}
$$

where Φ is defined by

$$\Phi = [m + (r^* + \pi)L_1]^{-1} > 0.$$

The effects on inflation tax payments πm are obtained from the set of equations (A2):

$$
\begin{aligned}
(d\pi m/de) &= \Phi\Delta\Omega\theta^{-1} e^{\theta-1}\{\Gamma[(r^* - c_3)b_1 - (b - c_2)b_3] + mr^* L_1 b_3\} > 0,\\
(d\pi m/dt) &= \Phi\{\Gamma[(c_1 - 1) + (r^* - c_3)b_1 c_1 \Delta - (b - c_2)b_3 c_1 \Delta]\\
&\quad + mr^* L_1 b_3 c_1 \Delta\} < 0,\\
(d\pi m/dg_n) &= \Phi\Delta\theta^{-1} e^{\theta-1}\{\Gamma[(c_3 - r^*)b_1 + (b - c_2)b_3] - mr^* L_1 b_3\} > 0,\\
(d\pi m/dr^*) &= \Phi\{\Gamma[f - b_2\Delta(bc_3 - r^* c_2)] + mr^* L_1 b_2 c_3 \Delta\} > 0,\\
(d\pi m/db) &= \Phi\{\Gamma[\Delta(bc_3 - r^* c_2) + (r - r^*)] - mr^* L_1 c_3 \Delta\} > 0,
\end{aligned}
$$

where Γ is defined by

$$\Gamma = (m + \pi L_1) > 0.$$

The effects on the trade balance T and the current account balance CA are obtained from equations (12), (13), and those in (A1):

$$(dT/de) = (dCA/de) = y_t' - \theta^{-1}(1-\theta)e^{-1} y_n' + (1-\theta)e^{-\theta-1} c > 0,$$

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$$(dT/dt) = (dCA/dt) = 0,$$
$$(dT/dg_t) = (dCA/dg_t) = -1,$$
$$(dT/dg_n) = (dCA/dg_n) = \theta^{-1}(1-\theta)e^{-1} > 0,$$
$$(dT/dr^*) = 0,$$
$$(dCA/dr^*) = (F - B^*) \gtrless 0,$$
$$(dT/db) = (dCA/db) = 0.$$

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IMF *Staff Papers*
Vol. 40, No. 4 (December 1993)
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Foreign Exchange Markets in Russia

Understanding the Reforms

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This paper analyzes and interprets the changes that took place in Russia's exchange rate system during 1992. The multiple exchange rate regime that existed in Russia prior to July 3, 1992, created strong incentives for exporters to refrain from repatriating foreign exchange earnings, induced both importers and exporters to participate in unofficial markets for foreign exchange, and encouraged international barter transactions. Efforts to manage the exchange rate through heavy foreign exchange intervention were unsuccessful. The July 3, 1992, unification of the multiple exchange rate system provides important and general lessons for rectifying undesirable conditions caused by poorly implemented exchange rate policy.
[JEL F3, F4, N2, P5]

In 1991, Russian authorities announced their intention to make the ruble convertible. The announcement was made at a time of acute foreign exchange shortages in official markets, which persisted despite a prolonged decline in the value of the ruble. The Russian authorities, along with the international community, hoped that the move toward convertibility would spur economic growth and improve consumption opportunities for Russian residents. Moreover, the currency reforms were to provide greater transparency in the foreign exchange regime, as well

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The views expressed herein are those of the author and not necessarily those of the International Monetary Fund. The author acknowledges numerous helpful comments, especially those of Ernesto Hernandez-Cata, Benedicte Vibe Christensen, Mohsin Khan, Malcolm Knight, and Robert Rennhack.

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as simplified access for Russians to the international currency markets at undistorted prices.

In Russia, the multiple exchange rate system created strong incentives for exporters to avoid repatriation of foreign exchange earnings. The system also resulted in strong incentives for both importers and exporters to avoid participation in legal interbank foreign exchange markets. The structure of foreign exchange surrender requirements in Russia taxed export earnings at a rate of approximately 30 percent. For importers, the cost of obtaining foreign exchange in official (interbank) markets was approximately 25 percent higher than the ruble price of foreign exchange on the black markets.

The exchange rate unification plan—begun on July 3, 1992, to unify the exchange rates applied to foreign exchange surrender by exporting enterprises—was seen as an important first step toward achieving currency convertibility. This new unified exchange rate implied a value for the ruble that was approximately equal to its more depreciated, floating value on the interbank market. A second step toward convertibility took place in mid-August and involved the elimination of several highly appreciated exchange rates that had been applied to centralized imports through mid-1992, although the practice of subsidizing selected imports remained an issue through 1993.

The exchange rate reform implemented by Russia contains many broad and valuable lessons. The unification sharply reduced the effective taxation of export activities, which the preceding system had imposed via unfavorable rates for surrendered foreign exchange. Adjusting for the taxes associated with the exchange rate regime, the resulting "effective" ruble price of foreign currency earned from exports was sharply depreciated and moved to a level close to the black market exchange rate. Incentives for exporters' participation in legal foreign exchange markets increased sharply. For importers, the effective ruble cost of foreign exchange for import transactions rose sharply and also moved close to the black market exchange rate. By sharply reducing the gap between the price of foreign exchange on the black markets and legal markets, the reforms encouraged importers to participate in legal foreign exchange markets. For foreign investors, the unification allowed interbank exchange rates to be applied to capital flows into Russia. Before the first half of 1992, the Central Bank of Russia (CBR) did not clarify which exchange rate was to be applied to foreign direct investment.

Another broad lesson from the reform is that multiple exchange rate regimes should be discussed in terms of their impact on the total effective compensation to an exporter for his or her foreign exchange earnings and on the total effective price that importers pay for foreign exchange.

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Appropriate construction of the relevant official exchange rate (that is, the "effective" exchange rate) must include both the exchange rate relevant to the specific transaction and any additional taxes levied on flows channeled through the legal markets (such as profit taxes and foreign exchange surrender taxes). In Russia, the effective exchange rate for an exporter includes a weighted average of the exchange rate applied to foreign exchange surrender and the exchange rate available to exporters in the interbank foreign exchange market.

The usefulness of this adjustment can be shown in the context of the odd relationship that existed between Russia's official and black market exchange rates before the July 1992 reforms. Usually, countries with balance of payments difficulties and problems of capital flight exhibit *positive* black market premia on foreign exchange. For Russia, the standard computations would suggest that black market premia on foreign exchange were *negative*, since the "free market" value of the ruble at auction and on the interbank markets was more depreciated than the black market exchange rate. When these adjustments are made properly, the apparent discount on the black market price of foreign exchange in Russia disappears.

This paper analyzes the implications of Russia's pre-unification exchange rate regime, the unification itself, and the lessons from Russia's experience. Before preceding with this discussion it is worth noting that the exchange rate unification implemented in Russia differs in several respects from the programs commonly implemented in other countries. In Russia, the unification refers to a merging of the multiple exchange rates that prevailed in official markets, while the parallel market for foreign exchange remained distinct. The closest analogies to the Russian system are dual exchange markets where there are leakages between the legal and black markets.[1]

This paper highlights only those policy developments directly under the rubric of exchange rate policy. Needless to say, monetary policy and other financial policies also strongly influence both the value of the ruble and the level of international transactions. Indeed, the extremely loose monetary and fiscal policies in Russia are important reasons for the capital flight and the sustained depreciation of the ruble in the second half of 1992 and in 1993. While these policies have a bearing on the *value* of the ruble in the foreign exchange markets, this paper focuses almost exclusively on the exchange rate mechanisms that bear on the *functioning* of foreign exchange markets and on related reforms concerning the use of official versus parallel currency markets.

[1] A model of dual exchange rate unification of the type pursued by Russia is provided in Goldberg (1993a).

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I. Foreign Exchange Markets in the Pre-Unification Period

Through the end of 1990, Russia maintained a complicated system of multiple exchange rates. The system involved "differentiated exchange coefficients," which were analogous to multiple exchange rates and consisted of several thousand coefficients that were applied to international transactions. These transactions were broken down by region, currency, and commodity. In January 1991, the structure of "differentiated exchange coefficients" was replaced by a more unified—but still complex—controlled exchange rate regime. This system was inherited by Russia after the break-up of the Soviet Union, and during the first half of 1992 several highly appreciated exchange rates for the ruble still applied to centralized imports (about 60 percent of imports during that period). For an exporting enterprise, the new system entailed a set of fixed exchange rates on foreign exchange surrender requirements and a single "market-determined" exchange rate that was established through the currency auctions or interbank exchanges.[2]

There were three distinct phases in the operation of Russia's currency markets during 1992. The period between January and the end of April 1992 is referred to as the *pre-unification* period. Despite an early sharp swing between 230 and 139 rubles per dollar, the nominal exchange rate during this period remained fairly stable on the interbank market at a rate of approximately 150 rubles per dollar. Between early May and the end of June 1992, referred to as the *interim* period, the ruble posted strong gains in interbank markets after heavy central bank intervention using the sale of foreign currency. Since inflation was high during this period, the ruble was appreciating in real terms. The value of the ruble in the parallel market, while variable during this period, also appreciated in real terms. The period following July 3, 1992, is referred to as the *post-unification* period. Although this paper focuses mainly on the pre- and post-unification periods, a brief description here of the interim period may be useful.

During the interim period, foreign exchange market intervention by the Central Bank of Russia contributed to a temporary 25 percent nominal appreciation of the ruble in official interbank markets. This intervention was quite costly and fulfilled no clear purpose. During May and June 1992, the CBR supplied up to 80 percent of the resources that were sold

[2]This was the dominant system in place, although it must be noted that it was further complicated by all sorts of exemptions from surrender requirements and methods of avoiding use of the official auction and interbank system. IMF (1992a and 1992b) provide information on the exchange rate regime in Russia in 1991 and early 1992.

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in the interbank market, replacing supplies previously sold by exporters. The government's announcements about sustainable exchange rates were not perceived as credible by market participants. The government's loose monetary and fiscal policies continued to undermine the value of the ruble and were not consistent with the objective of ruble appreciation. As the CBR worked to achieve a gradual but steep real appreciation within a two-month period, speculative activity by exporters and importers proved profitable and resulted in direct transfers from the CBR.

The exchange rate objectives and intervention strategy used by the Central Bank of Russia motivated (i) a withdrawal of new exporter activity in official (interbank) foreign exchange markets, (ii) an increase in round-tripping activity, beginning with sales of retained foreign exchange earnings and followed by repurchases of foreign exchange via import demands, and (iii) an increase in import activity channeled through official markets.[3]

Simple numerical examples illustrate the implications of the foreign exchange system in Russia prior to July 3, 1992. These numbers demonstrate how the foreign exchange system created (i) strong incentives for exporters to underreport earnings, (ii) incentives for exporters to engage in barter transactions, and (iii) incentives to retain export earnings in illicit accounts outside of Russia and to avoid the interbank foreign exchange system. This system also fostered underinvoicing of imports in official markets and import smuggling via the black markets. In general, the official internal currency markets simultaneously taxed the transactions of both exporters and importers. To calculate the taxation of exports imposed by the system of foreign exchange surrender, the approximate levels of exchange rates, surrender requirements, and profit tax rates that were in place in Russia in April 1992 are used. These data, along with some explanations, are presented in Table 1.

Table 2 uses the pre-unification exchange rate and tax data to demonstrate the effective taxes on the earnings of a Russian exporting enterprise under alternative scenarios.[4] All computations are based on the returns to the marginal dollar earned by exporters.[5] As presented, the numerical

[3] The reader is referred to Goldberg (1993b) for a more extensive discussion of this interval.

[4] Export taxes, which were often not paid because of exemptions or illegal circumventions, are omitted from the examples.

[5] Since this paper considers the returns to the marginal dollar of earnings, it does not adjust the results for the production costs facing an enterprise. This type of adjustment, which is relevant since profit tax effects are being discussed, would reduce the amount of taxation on earnings.

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Table 1. *Pre-Unification Exchange Rate Regime*

Type of exchange rate	Description	Rate
Commercial exchange rate	Applied to 40 percent foreign exchange surrender requirement (relevant for 80 percent of exports by volume)	55 rubles/dollar
CBR market exchange rate	Applied to 10 percent foreign exchange surrender requirement (relevant for 100 percent of exports by volume)	90 rubles/dollar
Interbank market exchange rate	Applied to sales and purchases of foreign exchange transacted on the interbank foreign exchange market	150 rubles/dollar
Profit tax rate	Marginal (and generally progressive) tax rate on profits of enterprises. Taxes are paid in rubles.	32 percent

comparisons apply most directly to exporters of raw materials and other products subject to the full 50 percent foreign exchange surrender requirement. Analogous comparisons could be provided for those enterprises that were subject only to the 10 percent surrender requirement.

Scenarios A and B in Table 2 were illegal under the pre-unification regime: Scenario A reflects the value of complete nonrepatriation of export earnings, and Scenario B reflects the value of not reporting but repatriating earnings via black markets. The next two scenarios were legal ones. In Scenario C, an exporter repatriated his or her earnings, paid foreign exchange surrender and profit taxes, and kept any residual funds in "retained" foreign exchange earnings accounts. In Scenario D, instead of keeping these residual earnings in foreign currency accounts, the exporter converted his or her foreign currency into rubles using domestic interbank markets. Scenario E presents a fifth possibility for an exporter, one consistent with the letter, but probably not with the spirit, of the law: an enterprise could convert export earnings into "necessary imports for production" before the export earnings actually entered Russia; these imports were then resold in domestic markets.

The estimate of the marginal compensation received by exporters for a transaction channeled through official markets requires some explanation. First, for every dollar of foreign currency earned (and repatriated) by an enterprise, the surrender rules required 50 cents to be converted immediately into rubles. The effective exchange rate on this half of the

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Table 2. *Tax and Revenue Flows Under Alternative Methods of Reporting and Valuing Export Earnings*

Scenario	Ruble receipts under a 50 percent foreign exchange surrender (FXS) requirement	Rubles paid as profit taxes on one dollar of export earnings[a]	Dollars remaining	Ruble earnings
A. One dollar earned, but not repatriated	Rub 0	Rub 0	$1 (cash)	Rub 0
B. One dollar earned, not reported but repatriated via black markets at 125 rubles/dollar	Rub 0	Rub 0	$0	Rub 125
C. One dollar earned, then repatriated and retained in foreign exchange accounts	Rub 31[b]	Rub 24.32	50¢ (noncash)	Rub 31 (pre-tax) Rub 6.68 (after tax)
D. One dollar earned, then repatriated and converted in interbank market at 150 rubles/dollar	Rub 31[b]	Rub 33.92	$0	Rub 106 (pre-tax) Rub 72.08 (after tax)
E. One dollar earned, then converted into imported goods for barter trade	Rub 0	Rub 40	$0	Rub 125 (pre-tax) Rub 85 (after tax)

[a] For Scenarios C, D, and E, rubles paid are calculated as the profit tax rate (32 percent) multiplied by the government-calculated ruble equivalent of foreign exchange earnings. The government calculations of ruble equivalents are as follows: 0.5(62) + 0.5(90) for Scenario C; 0.5(62) + 0.5(150) for Scenario D; and 125 for Scenario E.

[b] Average foreign exchange surrender at 62 rubles per dollar.

earnings was 62 rubles per dollar,[6] which compared with the 150 rubles per dollar on the interbank market and the 125 rubles per dollar on the black markets.[7]

Assume, as in Scenario D, that the enterprise sold the remainder of its export earnings in the interbank market. Then, for every original dollar of export proceeds, the enterprise ultimately received a total of 106 rubles (*prior to profit taxation*).[8] This implies that the surrender

[6] Of the foreign exchange surrendered, 80 percent was compensated at 55 rubles per dollar and 20 percent at 90 rubles per dollar [0.8(55) + 0.2(90) = 62 rubles per dollar].

[7] The ruble appreciated by approximately 27 percent in nominal terms in the interbank market, from approximately 144 rubles per dollar in May 1992 to approximately 113 rubles per dollar in June 1992. In the first half of June 1992, the ruble remained near the latter level, reaching a high of 112.3 rubles per dollar. This appreciation of the ruble, caused by heavy intervention in foreign exchange sales by central banking authorities, served to increase the effective tax on using official markets since it reduced the effective compensation of exporters.

[8] Fifty percent of these proceeds was surrendered at the rate of 62 rubles per dollar and the other 50 percent was converted at the rate of 150 rubles per dollar. Therefore 0.5(62) + 0.5(150) = 106 rubles per dollar.

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system imposed an average export tax rate on foreign exchange earnings of 29.3 percent calculated relative to the interbank market rate[9] and an average export tax rate of 15.2 percent calculated relative to the black market exchange rate. For many producers, the goal of avoiding these taxes may have been sufficient to induce underinvoicing or nonrepatriation of foreign exchange earnings.

The calculations for Scenario D assume that the enterprise sold its postsurrender export earnings in the interbank market in exchange for rubles. However, enterprises had another option for utilizing their foreign exchange earnings. The second option, illustrated in Scenario C, was for enterprises to retain their residual foreign exchange earnings in accounts in Russian commercial banks. This feature of the foreign exchange system in Russia further discouraged the conversion of foreign exchange earnings into "cash" or physical ruble notes via the interbank market. This system led to differential profit tax burdens on firms across the alternative options. The tax burden on firms was much higher when they converted their foreign exchange in the interbank market, as compared with the tax burden when earnings were retained in foreign currency accounts. This feature, termed in Goldberg and Karimov (forthcoming) the "tax haven effect on retained earnings," could also contribute significantly to the avoidance of the interbank foreign exchange markets by exporters.

The numerical relevance of this "tax haven effect" is shown in a comparison of Scenarios C and D in Table 2. Suppose a firm kept its residual foreign exchange earnings in accounts at the central bank without converting them to dollars. Accounting practices in Russia ensured that these earnings would be valued in rubles for profit tax purposes and that taxes would be paid in rubles. To measure the profit tax base, the value of dollar balances in the accounts at the central bank were computed using the CBR market exchange rate. Note that this valuation method assigned a conversion rate of 90 rubles per dollar on retained earnings. Alternatively, if the export revenues were converted into dollars via the interbank market, profit tax liabilities of exporters were computed using a conversion rate of 150 rubles per dollar.

The consequence of this system was that for every dollar of foreign exchange earnings a profit tax of 24.38 rubles was owed if the dollars were not converted into cash rubles, and a profit tax of 33.92 rubles was owed

[9]This rate is calculated as (150 − 106)/150. This computation assumes that the foreign exchange earnings net of surrender were sold at the interbank rate of 150 rubles per dollar.

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if the dollar earnings were converted into cash via the interbank market.[10] This implied that the profit tax burden on exporters could be reduced by almost 30 percent if foreign exchange earnings were not converted into rubles through internal currency markets and instead were maintained in foreign currency accounts at the commercial banks.

Scenario E reflects yet another alternative for exporters, one that was only quasi-legal and provided exporters with the means to evade foreign exchange surrender requirements. In this case, the incentive to avoid the taxes on foreign exchange surrender also provided the exporter with an incentive to become an importer of goods. Instead of repatriating foreign currency earnings, an exporter could purchase foreign currency goods that were nominally necessary as productive inputs for the firm. These imports could later be resold in domestic markets. For the computations in Scenario E, the value of these imports was the black market exchange rate. Assuming that the revenues from these resales were reported, the returns to this activity were between the purely legal and illegal scenarios presented in the first four scenarios.

Thus, avoidance of high taxes on foreign exchange surrender provides one explanation for the cross-border barter transactions with parties outside the ruble zone. By engaging in barter, the exporter was able to avoid foreign exchange surrender taxes, thereby receiving more favorable returns on export transactions channeled through legal markets. By contrast to returns on black market activity, the exporter was still required to pay profit taxes.[11]

Two other international flows also bear mention before leaving this discussion of the pre-unification period: foreign direct investment and import activity. With regard to the former, during the first half of 1992 the CBR did not clarify which exchange rate was to be applied to foreign direct investment in Russia. If foreign capital inflows were converted into rubles using the commercial exchange rate (55 rubles per dollar), the rubles purchased by foreign investors were three times more expensive than rubles purchased at interbank exchange rates.

As for importers, they had considerable freedom to purchase foreign currency in the interbank markets, and two general categories of import activity should be distinguished. Before unification, centralized imports were priced at numerous budgetary exchange rates introduced in Febru-

[10] These calculations are on marginal dollars earned. In practice, profit taxation is levied on revenues net of expenditures on production inputs.

[11] The author appreciates the useful suggestion by Roger Gordon that Scenario E be included in this table.

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ary 1992, which ranged from 1.7 rubles per dollar to 70 rubles per dollar. Altogether, some 25 separate exchange rates were in place.[12] For the remainder of Russia's imports, as previously noted, the interbank rate was approximately 150 rubles per dollar compared with approximately 125 rubles per dollar in black markets. Clearly, this system also created incentives for importers to avoid official markets through underinvoicing imports and smuggling goods across borders.

In summary, the foreign exchange system that was in place in Russia prior to the July 3, 1992, unification created strong disincentives for exporters to repatriate foreign exchange earnings. It also strongly encouraged both exporters and importers to underreport the value of international trade. If foreign exchange earnings were repatriated, the tax haven effect on retained earnings reduced the likelihood that these funds would be sold in the interbank foreign exchange markets. If foreign exchange were earned but not repatriated, the exporting enterprise evaded both foreign exchange surrender requirements and profit taxation. International barter transactions provided one quasi-legal method of avoiding high surrender taxes. Finally, the conversion rates applied to foreign capital inflows implied prohibitive taxation of foreign investments in Russia.

II. Exchange Rate Unification in Russia

The July 3, 1992, move toward convertibility in Russia entailed a unification of the "official" multiple exchange rate system. While there is no single conventional definition of exchange rate unification, Russia's unification differs from those undertaken by some IMF member countries. Often, unification refers to a merging of the official exchange rate market with unofficial parallel markets. Alternatively, unification is used to refer to the integration of a fixed exchange rate regime applied to trade transactions and a flexible exchange rate applied to financial transactions. Russia's unification involved a merging of the many official exchange rates, while the parallel market and the market for capital account transactions remained distinct.

The unification occurred at a floating exchange rate that stood at approximately 135 rubles per dollar in early July. This was the new effective (pre–profit tax) exchange rate on export, import, and capital inflow transactions. Table 3 compares the unified exchange rate with the

[12] IMF staff estimates.

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Table 3. *Comparison of Effective Exchange Rates on Transactions Before and After the July 1992 Reforms (rubles per dollar)*

	Pre-unification		Post-unification	
	Black market	Legal market	Black market	Legal market
Exporters	125	106	140	135
Importers (excludes centralized imports priced at special budgetary exchange rates)	130	150	145	135
Foreign investors (assumes "commercial" exchange rate applied in pre-unification period)	125	55	140	135

rates that previously applied to international transactions.[13] The differences in black market exchange rates relevant for importers and exporters reflect the bid-ask spreads observed in black markets.

Under the assumption that other policy instruments would not be used to offset the impact of the reforms, the exchange rate unification would be expected to yield numerous positive real effects on Russia's currency markets. These real effects include the following:

- The large and distorting tax haven effect of retained earnings was eliminated. It arose because the exchange rates used for computing taxes differed across the uses of foreign exchange earnings. *The removal of the tax-based advantage of retained earnings accounts increased the relative attractiveness of interbank market operations.*
- By equating the exchange rate on foreign exchange surrender with other "market determined" rates, *the foreign exchange surrender tax was sharply reduced.* This should stimulate repatriation of foreign exchange earned by exporters.
- By reducing foreign exchange surrender taxes and the effective black market premia on foreign exchange, *the reforms reduced the incentives to use international barter transactions to avoid taxes.*
- *For exporters, unification implied both a real and nominal effective depreciation of the ruble in interbank markets.* This point, combined with the preceding points, increased the incentives to report export earnings, and consequently could increase the foreign currency sold by exporters in official foreign exchange markets.

[13] "Previously" in this context refers to the period preceding both the heavy CBR intervention in foreign exchange markets and the unification.

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• *For importers, the unification sharply reduced the premium paid on transactions channeled through official foreign exchange markets.* Indeed, importers realized a higher ruble value in interbank markets than in the black markets. This could stimulate total import demand and deepen the demand for foreign exchange in interbank markets.

• *For foreign investors, unification implied an immediate depreciation of the effective cost of rubles.*

In fact, these improvements in the foreign exchange markets did occur in the second half of 1992. One additional implication of the reforms, however, was that the CBR no longer explicitly received the level of revenues that previously arose from its implicit taxation of surrendered foreign exchange. From late 1992 into the first half of 1993, another form of export taxation was implicitly introduced through the foreign exchange surrender regime. Specifically, although exporters were compensated at the current unified market exchange rate for their surrendered foreign exchange earnings, exporters' accounts were not immediately credited with the rubles from this compensation. These delays proved quite costly to exporters in a high-inflation environment. The implicit taxation of exporter earnings through long and variable delays in compensation once again led to some of the onerous implications associated with the pre-unification exchange rate regime.

III. Concluding Remarks

This paper has documented and interpreted some of the developments in Russia's foreign exchange markets during 1992. From these developments we gain important insights into the incentives and disincentives created by the multiple exchange rate regime that existed before July 1992. That system encouraged nonrepatriation of export earnings, international barter activity, and avoidance of legal foreign exchange markets by both exporters and importers.

The exchange rate unification implemented in July 1992 served to reduce the effective taxation of exporters, importers, and foreign investors in Russia. All else equal, the unification was expected to serve a number of very positive functions, including reducing price distortions originating in the official foreign exchange markets and increasing the overall attractiveness of official markets. The gap between effective exchange rates in legal markets and in black markets was nearly eliminated. Foreign exchange surrender taxes were also reduced sharply. These initiatives lessened the attractiveness of international barter activity as a means of avoiding foreign exchange surrender taxes. Other things

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equal, the reforms should tend to increase the reporting of both exports and imports and improve the functioning of interbank foreign exchange markets. These are general lessons that would apply to other countries that have the Russian type of multiple exchange rate regime.

It is clear that a continuance of these positive effects means eschewing repressive taxation of market-based export and import activity. Some export taxation, in addition to explicit taxes, could occur if exporters' accounts are not expeditiously credited for surrendered foreign exchange. Moreover, if the CBR is to target any real or nominal exchange rate levels, it must be recognized that these will be credible targets only to the extent that they are consistent with the economic policies of the government. Without such credibility, the beginnings of a strong foreign exchange system can be undermined by the types of balance of payments crises often observed in developing countries.

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IMF *Staff Papers*
Vol. 40, No. 4 (December 1993)
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Comments

Formulating a Policy Response

Comment on Calvo, Leiderman, and Reinhart

P. NICHOLAS SNOWDEN*

FOLLOWING THEIR examination of the role of external factors in the revival of international capital inflows to Latin America, Calvo, Leiderman, and Reinhart (CLR) review the policy responses available to governments.[1] While acknowledging the contribution of improved economic performance, their focus on exogenous influences leads them to concentrate on the dangers of "excessive" influxes of short-term funds. With market failures quite able to generate the excess, the dangers of real exchange rate appreciation, poor intermediation of large-scale flows, and the threat of rapid reversal are clear. From this perspective, CLR examine different policy options for their effectiveness either in limiting the inflows or in neutralizing their effects.

This note argues that the policies discussed are misleadingly treated as alternatives when, owing to substantial differences in principle, their appropriate application would be to very different policy objectives. It is suggested here that if recipient economies are to benefit from the inflows, while managing the risks that preoccupy CLR, a sequence or combination of policies may need to be applied.

Beginning with the problem of "excessive" inflows induced by market failure, those failures associated with variable government credibility in the context of counterinflationary policy may be usefully singled out. Lack of confidence in the durability of contractionary monetary policies may prevent rapid downward adjustment in domestic wages and prices. The resulting high short-term interest rates, however, may attract speculative inflows based on the judgment that, at least temporarily, the exchange rate will be maintained. Whatever their detailed merits, two of the policies discussed by CLR would be relevant in helping to sustain

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[1] *Staff Papers*, International Monetary Fund, Vol. 40 (March 1993), pp. 108–51.

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domestic monetary targets under these circumstances: a tax on short-term capital inflows and sterilized intervention. While also helping to defend monetary targets, a rise in marginal bank reserve requirements against short-term foreign deposits would probably better address prudential concerns in view of the likely disintermediation noted by CLR.

With counterinflationary credibility at issue, the employment of "trade" policies and nonsterilized intervention would clearly be inappropriate. Time-limited simultaneous export subsidies and import duties amount to a "temporary" devaluation relying on confidence that prices will fall (when the policy is reversed) to attenuate the more usual inflationary impulse. Nonsterilized intervention would, as CLR also note, directly undermine domestic monetary policy targets. The possible relevance of these options must therefore arise when domestic counterinflationary policy (high short-term interest rates) is not thought to be the primary stimulus to the inflows.

In contrast with the taxation of short-term inflows and sterilization, a characteristic of trade measures and nonsterilized intervention is that they do not seek to limit the flows or to prevent them from influencing the domestic money supply. They reflect instead a prior concern with exchange rates—real in the context of trade taxes and nominal in the case of nonsterilization. While these approaches would not be the natural choice to support domestic counterinflationary policy, when might an exchange rate objective be appropriate in the context of resurgent capital inflows?

If a significant part of the inflows reflect a rational response to improving regional prospects, the interpretation of, and response to, real exchange rate developments becomes a central issue. With large-scale investment opportunities in the production of tradables being unleashed by policy reform, it is still likely that nontradables will be involved in the investment expenditures. The rising relative price of the latter will reflect limited absorptive capacity (acting to slow the appropriate *pace* of tradables investment, despite the underlying opportunities) and provide the incentive for some further investment in nontradable capacity. By this interpretation, an attempt to prevent real appreciation would be damaging to long-term development. In the context of fixed exchange rates, nonsterilized intervention would be consistent with this pattern whereas trade measures would not.

The real appreciation that may be justified on these grounds will be difficult in practice to distinguish from that induced by excessive inflows. Nevertheless, the discussion provides some pointers. Although "justified" real appreciation would give rise to an increased share of investment in nontradables, the level of investment spending in tradables (such as

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manufacturing) would be expected to remain strong on the basis of long-term prospects. Collapsing profitability in the sector together with declining investment intentions would not be anticipated.

These observations suggest that a degree of explicit exchange rate policy *conditionality* may be usefully developed by capital-importing countries. The development and publication of indicators related to manufacturing profitability and investment trends could be applied to this end. An announcement that the indicators would be used to guide exchange rate policy, while encouraging fundamentals-based inflows, would tend to discourage speculation arising from a fixed nominal rate. In the context of a floating regime, the proposal would amount to making monetary policy sensitive to overappreciation of the real exchange rate. Since some real appreciation would still be anticipated in connection with the capital inflow, a key advantage of floating rates over (fixed-rate) nonsterilized intervention, as noted by CLR, would be the reduced risk of rekindling domestic inflation. It would also permit a more flexible response to unwelcome appreciation than the occasional application of trade taxes in a fixed-rate context.

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IMF Staff Papers
Vol. 40, No. 4 (December 1993)
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Formulating a Policy Response

Reply to Snowden

GUILLERMO A. CALVO, LEONARDO LEIDERMAN, and CARMEN M. REINHART*

THE CENTRAL POINT of Professor Snowden's note is that, in general, the capital inflows problem should be tackled by a combination of different policies. We fully agree with his assessment and, in fact, made it explicit in our IMF *Staff Papers* article: "... there are grounds to support a mix of policy intervention based on the imposition of a tax on short-term capital imports, on enhancing the flexibility of exchange rates, and on raising marginal reserve requirements on short-term bank deposits" (Calvo, Leiderman, and Reinhart, p. 149).[1] However, Professor Snowden's objection to our paper is perhaps that we discuss the pros and cons of each separate policy without taking into account their mutual interaction. We think this is a valid criticism although, to keep the record straight, it should be said that the paper did not intend to provide a complete discussion of the optimal policy response to capital inflows. In this reply we will offer some thoughts on this latter issue with the caveat that they represent just a first step into largely unexplored territory.

As emphasized in our paper, no policy option is free of potential costs. Therefore, it is to be expected that an optimal policy package will involve more than one measure. The nature of such a policy package is, however, much more difficult to determine. Laissez faire is not optimal because, as a general rule, countries exhibit static or dynamic distortions. Therefore, optimal policy should take explicit account of the relevant distortions characterizing a given economy. The statement above from

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[1] In effect, the advisability of relying on a *mix* of complementary policy measures is also stressed in the concluding remarks to Calvo, Leiderman, and Reinhart (1993).

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our paper is, for instance, strongly conditioned by our feeling that government intervention should aim at preventing financial crises and overvaluation of the real exchange rate.

The desirability of a policy mix does not imply that the policymaker should feel totally free to vary the mix. Ideally, policies should be designed to be responsive to exogenous factors—like terms of trade changes, earthquakes, and even wars—but the type and size of response should be well understood in advance. Otherwise, policy, by becoming "discretionary," constitutes an independent source of uncertainty, which only in rare circumstances could be expected to raise social welfare. Actually, if policymakers attempt to utilize their freedom to choose the policy mix to their (or even social) advantage on a regular basis, the public will learn to anticipate such behavior, and the resulting solution will be decidedly inferior to a (flexible but well understood and credible) rule set in advance.

In practice, policy transparency is much harder to achieve. This is so for several reasons. Policy feasibility depends on political considerations that are hard to predict—if not, hard to verbalize. Flexible policies could be complex—and, hence, expensive to articulate and difficult to understand by the general public—and such policies may induce a loss of credibility. This last point is important and deserves further elaboration.

There exists a subtle line between flexible rules (set in advance) and "discretion." In both cases, the policymaker changes the policy mix in view of circumstances. Thus, the public may find it hard to distinguish between the two. In particular, when rules are mistaken for "discretion," it would be incorrect to apply the policy rule that would be optimal *if the public believed that the policymaker will never resort to discretion*. This is the reason why the choice of optimal rules should take into account the *credibility* of the rules themselves.

For example, we suggest that it may be desirable, among other things, to increase exchange rate flexibility. However, this policy may not be optimal if the public interprets greater flexibility as a signal that policymakers have loosened their monetary discipline and are likely to resort to *surprise* exchange rate devaluations or appreciations. Actually, the more important are credibility-type considerations, the less flexible the policy mix is likely to be. Similarly, the levying of a tax on short-term capital inflows (a form of capital control) may not be advisable if a relatively young stabilization plan, which stresses liberalization and openness, is in effect. Such a measure could endanger the plan's credibility.

Consequently, while fully agreeing with Professor Snowden that optimal policy will likely entail a combination of complementary measures, we believe that the characteristics of optimal policy will be heavily deter-

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mined by country-specific considerations. Approximating such an optimum—especially when a country has experienced an episode of high inflation or high indebtedness—requires the cool mind of an analyst, combined with the refined nose, keen eye, and sharp ears of a champion policymaker.

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IMF *Staff Papers*
Vol. 40, No. 4 (December 1993)
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Output Fluctuations and Monetary Shocks in Colombia

Comment on Reinhart and Reinhart

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IN A RECENT PAPER, Reinhart and Reinhart (RR) provide an interesting perspective on the macroeconomic fluctuations in Colombia: a test of two opposing theories—the neoclassical synthesis versus a "real" technological or preference shock as the source of output changes. The empirical analysis was done using annual data over 1960-87. Following a battery of unit-root tests, variables (except the interest rate) were differenced to achieve stationarity. After experimentation with a wide combination of variables, a six-variable vector autoregressive (VAR) system was finally chosen involving money, real GDP, prices, wages, interest rates, and exchange rates. By imposing restrictions on the system, a neoclassical and a real business cycle structure were obtained. The results show that in the case of Colombia the neoclassical-Keynesian framework better describes output dynamics.

In view of the important monetary policy implications that could follow from these results, the purpose of this note is to reexamine the main findings in RR by using the Bayesian vector autoregression (BVAR) estimation technique (Litterman (1986)) to explain the dynamic between money, output, and prices using quarterly data for Colombia over 1976:1–1993:1. Mamingi (1992) has shown that causality results based on VAR can be misleading under temporal aggregation. Also, the use of BVAR allows the use of level data. It is well known that in the process of first differencing, one may lose important long- and medium-run information (Lutkepohl (1991), Maddala (1992)). Unfortunately, the

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causality relations found using the current methodology are quite different from the "three" dynamic properties of the Colombian economy reported by RR. However, responses of the variables to monetary shocks are similar.

I. BVAR Model Estimation

Quarterly data from Colombia were used for real GDP, money, consumer price index (CPI), exchange rate, nominal interest rate on three-month time deposits, and rural wages as measured by cost per hour (1975 = 100).[1] GDP, money, CPI, and wages were seasonally adjusted. Except for the interest rate, logarithms of variables were used. Data prior to 1976:1 were used as initial observations that contain lags.

Results of univariate analysis of these seven series are shown in Table 1. All variables are characterized as I(1) processes with positive drift. The interest rate is the only exception, characterized as I(1) process without drift.

Six variables consisting of the logarithms of real GDP, money, CPI, exchange rate, rural wages, and the real interest rate were included in the final analysis. Using RATS and following the suggestion of Doan (1990), four lags were included and the relative values of the Theil U statistic for one to four steps ahead were used to choose among the alternative specifications of the model. The prior variances were adjusted until no more improvement in Theil U could be found (Doan (1990), Litterman (1986)). Figure 1 shows the causality relations between variables based on the *F* statistics (10 percent significance). Using the impulse command in RATS, the responses of the system of equations to a first-period standard error shock in money were obtained for eight quarters ahead of the final BVAR model. The results are depicted in Figure 2.

II. Main Findings

Present results contradict the dynamic properties of the Colombian economy found in RR:

[1] Real GDP was obtained from the "Departamento Nacional de Planeacion." Money (M1), the consumer price index, the wholesale price index (WPI), the coffee price, and exchange rate were obtained from the *International Financial Statistics*; oil prices from the Energy Information Administration; rural wages from the "Departamento Administrativo Nacional de Estadistica DANE"; nominal interest rate for time deposits (90 days) from the "Banco de la Republica"; and the real interest rate was computed as the nominal rate minus the inflation rate.

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Table 1. *Time Series Properties of the Macroeconomic Variables*

	Test for one-unit root		Test for two-unit root	
	ADF with drift	10 percent crit. val.	ADF with drift	10 percent crit. val.
Seasonally adjusted variables				
Log money (*LSMONEY*)	1.8585	−2.5892	−4.4277	−2.5896
Log real GDP (*LSGDP*)	−0.9175	−2.5903	−2.6812	−2.5907
Log price index (*LSICPI*)	0.6037	−2.5892	−4.1137	−2.5896
Log rural wages (*LSGANF*)	−0.0931	−2.5892	−3.2414	−2.5896
Exchange rate (*LDEV*)	−1.5568	−2.5896	−4.3125	−2.5899
Nominal interest rate (*DTF*)	−0.1426	−1.6183	−4.4969	−1.6183
Real interest rate (*RINT*)	−1.1913	−1.6183	−5.6551	−1.6183

Note: ADF denotes the augmented Dickey-Fuller test. Critical values correspond to Mackinnon tables. A large negative *t*-statistic allows rejection of the hypothesis of a unit root.

—Money exogeneity in the Granger sense is not observed. Exchange rates influence changes in money. Variations in the exchange rate reflect the international reserve level and show a strong correlation between it and monetary expansions (see Carrasquilla (1992)).

—As in RR, feedback among nominal magnitudes produces complicated dynamics in the entire price sector. In addition, complex movements are observed in the real sector since prices appear to influence real GDP.

—In contrast with RR findings, real GDP induces changes in exchange rates affecting the real interest rate. Again the external sector appears to be a very important factor not only in affecting monetary variables but

Figure 1. *Causal Relationships Among the Variables*

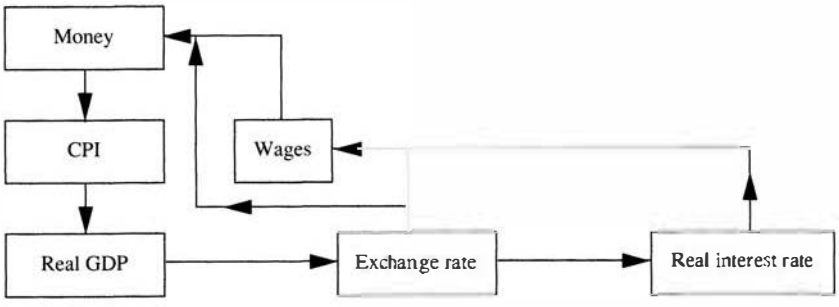

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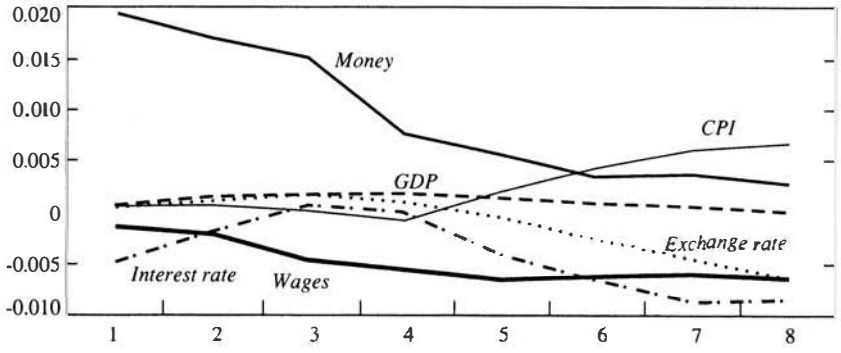
Figure 2. *Responses to Change in One Standard Deviation in Money*



also in touching the real sector. In this model co-movements between income and money could arise from past changes in income and money.

The impulse response analysis for money confirms the approximate long-run monetary neutrality and the tendency of the domestic price level to increase. However, as compared with RR, a smaller increase in real GDP is seen during the first three quarters followed by a slight decrease in GDP and a simultaneous increase in CPI. During the first four quarters, the nominal exchange rate depreciates by twice the increase in the CPI; in the second year, the CPI surpasses the nominal exchange rate two times over, suggesting a real exchange rate appreciation.

III. Conclusions

Although the causality relations among the macroeconomic variables are found to differ from the three dynamic properties of the Colombian economy reported by RR, responses of the variables to monetary shocks are similar in both cases.

The difference in the results could indicate structural changes in the Colombian economy owing to the liberalization of the economy and the elimination of exchange rate controls in Colombia during recent years. Loss of valuable information because of temporal aggregation and first differencing may also explain the anomaly.

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IMF Staff Papers
Vol. 40, No. 4 (December 1993)
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Output Fluctuations and Monetary Shocks in Colombia

Reply to García

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In her note, Maria García revisited our work on macroeconomic linkages in Colombia. Employing recently available quarterly data and a more recent sample, she estimated a vector autoregression (VAR) using levels rather than first differences of the data and a Bayesian statistical technique (BVAR) rather than our structural VARs. Her investigation found that the time series properties of the major macroeconomic variables were similar to what we reported and, while the pattern of causation apparently shifted, the macroeconomic multipliers were mostly unchanged. While we are encouraged by the similarities in results, our sense is that the reported differences in causal patterns do not owe to the choice of technique, which García emphasized, but rather to her application of those techniques to a later time period.

As to the econometrics, most Colombian macroeconomic variables that are stated in nominal terms exhibit a high degree of persistence. This shows up in findings that show they have unit roots, which were reported in both papers. Since statistical inference becomes more complicated when variables that have unit roots appear on both sides of the equation to be estimated, we dealt with that problem by differencing the data. García correctly noted that those macroeconomic relationships could be estimated in levels if some combination of the data forms cointegrating vectors. She did not, however, explicitly impose such structure on the levels relationships, by estimating, for example, the equations in an error-correction form or using Johansen's maximum-likelihood tech-

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nique (both of which are explained in Campbell and Perron (1991)). As a result, the statistical tests on individual or blocks of coefficients (these are the basis of the reported causality tests) from her levels equations do not have standard properties.

As to the choice of time period, García worked with data from 1976 to 1993, whereas we estimated our equations with an earlier sample, from 1960 to 1987. Our results indicated that money was "exogenous" in the Granger sense, as causality ran from money to the other variables and not the other way around. This result is not entirely surprising. During the early part of our sample, a variety of controls impeded the free flow of international capital, giving the Colombian monetary authorities a greater measure of independence in determining the nominal money stock. This greater control was then properly reflected in our finding that money appeared at the top of a causal ordering. However, the substantial pace of financial innovation and explicit measures to liberalize the capital account over the past few years have moved Colombia closer to the paradigm of a small, open economy. In that circumstance, a central bank attempting to manage the float of its currency surrenders its control of the domestic money stock. That is, we would expect to find that money can be explained by earlier movements of other macroeconomic variables—it is not exogenous in the Granger sense. García found just that result.

Since other macroeconomic properties, such as the neutrality of money, are less sensitive to the degree of capital mobility, it is not surprising that García arrived at similar conclusions to our own on the nature of dynamic multipliers. Monetary shocks have real consequences in the short run but these real effects diminish as prices and other nominal magnitudes adjust.

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VOLUME 40, 1993

WASHINGTON, D.C.

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