

Economic Review

*Do Interest Rates Help
Predict Inflation?*

Kenneth M. Emery and
Evan F. Koenig

*Trade Policy
and Intellectual
Property Protection:
The North–South Dispute*

William C. Gruben

*Regional Wage
Divergence and National
Wage Inequality*

Keith R. Phillips

Economic Review

Federal Reserve Bank of Dallas

Robert D. McTeer, Jr.

President and Chief Executive Officer

Tony J. Salvaggio

First Vice President and Chief Operating Officer

Harvey Rosenblum

Senior Vice President and Director of Research

W. Michael Cox

Vice President and Economic Advisor

Gerald P. O'Driscoll, Jr.

Vice President and Economic Advisor

Stephen P. A. Brown

Assistant Vice President and Senior Economist

Economists

Zsolt Becsi

Robert T. Clair

John V. Duca

Kenneth M. Emery

Robert W. Gilmer

David M. Gould

William C. Gruben

Joseph H. Haslag

Evan F. Koenig

D'Ann M. Petersen

Keith R. Phillips

Fiona D. Sigalla

Lori L. Taylor

John H. Welch

Mark A. Wynne

Kevin J. Yeats

Mine K. Yücel

Research Associates

Professor Nathan S. Balke

Southern Methodist University

Professor Thomas B. Fomby

Southern Methodist University

Professor Scott Freeman

University of Texas

Professor Gregory W. Huffman

Southern Methodist University

Professor Roy J. Ruffin

University of Houston

Professor Ping Wang

Pennsylvania State University

Editors

Rhonda Harris

Virginia M. Rogers

The *Economic Review* is published by the Federal Reserve Bank of Dallas. The views expressed are those of the authors and do not necessarily reflect the positions of the Federal Reserve Bank of Dallas or the Federal Reserve System.

Subscriptions are available free of charge. Please send requests for single-copy and multiple-copy subscriptions, back issues, and address changes to the Public Affairs Department, Federal Reserve Bank of Dallas, Station K, Dallas, Texas 75222, (214) 922-5257.

Articles may be reprinted on the condition that the source is credited and the Research Department is provided with a copy of the publication containing the reprinted material.

Contents

Page 1

Do Interest Rates Help Predict Inflation?

Kenneth M. Emery and
Evan F. Koenig

Accurate forecasts of inflation are important to policy-makers and to individuals who must make decisions on the basis of expectations about the future purchasing power of the dollar.

Recent research on forecasting inflation has shown that interest rates, *by themselves*, may provide useful information about future inflation. In this article, Kenneth M. Emery and Evan F. Koenig investigate whether interest rates contain information about future inflation beyond that found in traditional inflation-forecasting models. In other words, does adding interest rates to traditional inflation models enhance the models' forecasting ability? Emery and Koenig find that including interest rates does significantly improve the forecasting ability of traditional models. They also find, in contrast to recent research focusing on the forecasting ability of interest rates in isolation, that the information content of interest rates did not diminish in the 1980s.

Emery and Koenig point out that whether the historical forecasting ability of interest rates can be exploited by policy-makers is problematic. Because interest rates reflect expectations of future monetary policy, if the Federal Reserve were to begin relying more on interest rates as a guide to policy, the relationship between interest rates and inflation would likely change.

Page 19

Trade Policy and Intellectual Property Protection: The North–South Dispute

William C. Gruben

News about foreign-made counterfeit products that range from pharmaceuticals to tennis shoes and about processes that have been copied without payment of royalties to patent holders has become commonplace. Many of these appropriations of intellectual property originate in developing countries, where intellectual property laws and enforcement have traditionally been less restrictive than in developed countries. These differences between the North—the developed countries that produce most intellectual property—and the South—the developing countries that consume more than they produce—have generated much international friction.

(Continued on the next page)

Contents

(Continued from the previous page)

Trade Policy and Intellectual Property Protection: The North–South Dispute

William C. Gruben

Recently, however, some developing countries have begun to tighten these laws and their enforcement. A few analysts have been quick to explain why: these countries are simply reacting to increasingly tough U.S. pressure. But are they? Not all countries under the most intense U.S. pressure have reacted to it, and there is a difference between those that have and those that have not. The difference turns out to be these individual countries' own trade policies.

Focusing primarily on the experiences of Latin American countries, William C. Gruben shows how and why a nation's own trade policy influences its intellectual property laws and enforcement and why conventional arguments about U.S. trade pressures may be only part of the story. Gruben shows why developing countries that practice strong trade protectionism are motivated toward weak intellectual property protection, but those that have liberalized trade may find strong intellectual property protection more attractive.

Page 31

Regional Wage Divergence and National Wage Inequality

Keith R. Phillips

Throughout much of the 1980s, wage inequality increased in the United States. Previous research has found that a rise in earnings by educational level and increased wage dispersion across occupations were important factors in the rise in wage inequality. Researchers, however, have noted that much of the rise in wage inequality was left unexplained by the demographic and industry factors that they examined. In this study, Keith R. Phillips extends the analysis by examining the impact on wage inequality of a divergence in regional wages that occurred during the 1980s.

The author finds that regional shocks, such as the recessions in the oil and farm belts, pushed wages lower in these below-average-wage areas, and increased defense spending pushed up wages in many above-average-wage areas. While these regional shocks increased overall wage inequality, Phillips finds that regional wage divergence accounted for only 2.1 percent to 5 percent of the rise in national wage inequality. Other factors, such as increased wage dispersion across educational and occupational groups and a reduction in the male–female wage gap, played larger roles.

Kenneth M. Emery

Senior Economist
Federal Reserve Bank of Dallas

Evan F. Koenig

Senior Economist and Policy Advisor
Federal Reserve Bank of Dallas

Do Interest Rates Help Predict Inflation?

The primary responsibility of a central bank is to preserve the value of its nation's currency. In the United States, the Federal Reserve System attempts to meet this responsibility by pursuing monetary policies that promote economic growth without fueling inflation. Achieving sustained noninflationary growth is complicated by the fact that changes in monetary policy affect the economy with a lag. Thus, the successful conduct of monetary policy requires reliable forecasts of both inflation and economic activity.

A plot of the three-month U.S. Treasury bill rate and subsequent quarterly inflation suggests that interest rates may contain information about future inflation (*Figure 1*). Indeed, recent research indicates that movements in interest rates are helpful in predicting inflation (Bernanke 1990; Fama

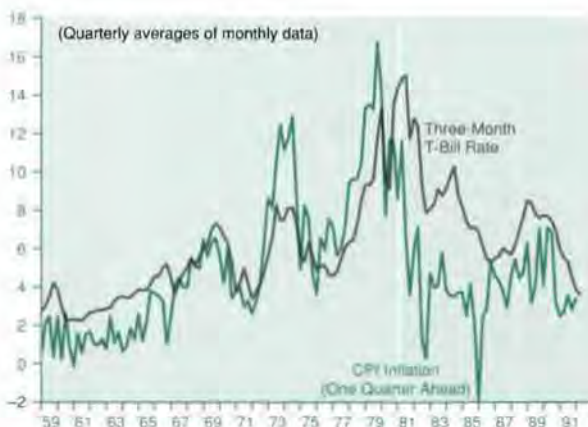
1990; Mishkin 1990a, 1990b; Frankel and Lown 1991). Interest rate movements may, therefore, provide the Federal Reserve with information useful in conducting monetary policy. In fact, some monetary policymakers (Johnson 1988) have advocated a strategy for conducting policy based on monitoring several financial variables, including interest rates.

While the studies cited above have addressed the question of whether interest rates, *by themselves*, help predict inflation, more relevant to policymaking is the question of whether *adding* interest rates to traditional models for forecasting inflation yields any improvement in the models' forecasting ability. This article examines whether interest rates provide information about inflation beyond that contained in traditional models. For two reasons we focus on inflation as measured by the consumer price index (CPI). First, existing studies of the predictive content of interest rates use the consumer price index almost exclusively. Second, because they are not distorted by transitory shifts in the composition of output, fixed-weight indexes like the consumer price index give a more accurate picture of near-term changes in the cost of living than do variable-weight indexes.

The first section of the article reviews the economic intuition underlying the connection between interest rates and inflation. The second section presents evidence of the power of interest rates, by themselves, to predict near-term inflation. Consistent with previous studies, we find that although interest rates are quite helpful in explaining movements in inflation during the 1960s and

Figure 1
Three-Month Treasury Bill Rate and CPI Inflation

Percent



SOURCES OF PRIMARY DATA: Board of Governors, Federal Reserve System; U.S. Bureau of Labor Statistics.

We wish to thank John V. Duca, David M. Gould, and Joseph H. Haslag for helpful comments and Adrienne C. Slack for excellent research assistance.

Table 1

Inflation and Interest Rates

	DV	Marginal Significance Level				Number of Lags				\bar{R}^2
		3M	3MFF	10Y3M	JOINT	DV	3M	3MFF	10Y3M	
A.	π	.000	.034	.012	.000	3	1	6	5	.899
B.	π	.733	.920	.059	.296	3	1	1	1	.618
C.	$\Delta\pi$	.006	.000	.483	.000	8	8	5	1	.493
D.	$\Delta\pi$	.146	.862	.671	.168	2	2	1	1	.265

Sample periods

- A. 1959:1–1979:4
- B. 1980:1–1991:2
- C. 1959:1–1979:4
- D. 1980:1–1991:2

Definitions

DV = dependent variable in the regression.

π = change logarithm of the consumer price index.

$\Delta\pi$ = change in π .

3M = interest rate on three-month Treasury bills.

3MFF = difference between 3M and the federal funds rate.

10Y3M = difference between the interest rate on ten-year Treasury bonds and 3M.

JOINT = marginal significance level from a test of the hypothesis that the coefficients of all interest rate variables are equal to zero.

NOTE: All regressions were carried out using the RATS regression package, Version 3.0.

1970s, the explanatory power of interest rates markedly deteriorates in the 1980s. The third section of the article specifies traditional inflation-forecasting models and examines whether including interest rates in these models results in additional explanatory power. We find that short-term interest rates *do* possess marginal explanatory power in the pre-1980 sample. Furthermore, this increased explanatory power does *not* disappear during the 1980s. Indeed, we find that long-term interest rates also become significant during the 1980s. The fourth section of the article examines the real-time forecasting performance of the most general of our inflation models. Four versions of this general model are considered—versions meant to explain the level of inflation and the change in inflation, both with and without the help of interest rates. We find that better inflation forecasts are obtained from models that explain the change in inflation

than from models that explain the level of inflation. Moreover, we find that interest rates improve our ability to predict near-term changes in inflation. We conclude by interpreting our findings and discussing their implications for policy.

The relationship between interest rates and inflation

In general, the expected real return on a loan equals the nominal return less the expected rate of inflation. Turning this relationship around,

$$(1) \quad \pi_t^e = i_{t-1} - r_{t-1}^e,$$

where i_{t-1} is the market interest rate at time $t-1$, r_{t-1}^e is the expected real interest rate at time $t-1$, and π_t^e is the expected rate of inflation between period $t-1$ and period t . If the expected real

interest rate is constant, then movements in expected inflation will be reflected, one for one, in movements in the market interest rate. More generally, as long as the expected real interest rate is not correlated with the market interest rate, analysts can infer a 1-percentage-point increase in expectations of inflation from a 1-percentage-point increase in the market interest rate. Of course, insofar as analysts are able to find variables that control for movements in the expected real interest rate, they will be able to improve the accuracy of their estimates of expected inflation. However, even exact estimates of expected inflation are of little use unless expected inflation is, in turn, an accurate indicator of *realized* inflation.

Similarly, the expected *change* in inflation is

$$(1') \quad \pi_t - \pi_{t-1} = (i_{t-1} - i_{t-2}) - (r_{t-1} - r_{t-2}),$$

where π_{t-1} represents the realized rate of inflation between period $t-2$ and period $t-1$ and where $(r_{t-2} \equiv i_{t-2} - \pi_{t-1})$ is the *ex post* real rate of return on a loan made in period $t-2$ that matures in period $t-1$. If expected changes in the real interest rate are not correlated with changes in the market interest rate—as will be the case, for example, when the real interest rate follows a random walk—then a 1-percentage-point increase in the market interest rate can be used to infer a 1-percentage-point increase in expectations of the change in inflation. Variables correlated with the expected change in the real interest rate will allow analysts to control for the change in the real rate and thereby improve their forecasts of the market expectation of the change in inflation. This market expectation may or may not be a good predictor of the actual change in inflation.

Before moving on to further analysis of the additional predictive content of nominal interest rates, we briefly review the evidence that movements in nominal interest rates, by themselves, can help predict future inflation or future changes in inflation.

Inflation and interest rates: the existing evidence

A study by Fama (1975) first showed that interest rates might be useful for predicting inflation. For the period from 1953 through 1971, Fama

found that the level of one- to six-month Treasury bill rates provided information about future inflation beyond that contained in lagged values of inflation. Additionally, Fama's results suggested that all the variation in one- to six-month nominal Treasury bill rates during this period was due to variation in expected inflation, rather than variation in expected real interest rates.

Hess and Bicksler (1975) showed that Fama's finding of a constant real rate of interest was specific to the sample period he examined. However, Fama's other result—that market interest rates provide information about future inflation beyond that obtained from lagged values of inflation—has been confirmed by subsequent studies (Fama and Gibbons 1982, 1984).

Table 1 demonstrates the usefulness of interest rates in explaining inflation and changes in inflation. Line A, for example, summarizes results obtained when quarterly CPI-inflation data from the first quarter of 1959 through the fourth quarter of 1979 are regressed on three lagged values of inflation and several interest rate measures.¹ The interest rate measures are the three-month Treasury bill rate, six lags of the difference between the three-month Treasury bill rate and the federal funds rate, and five lags of the difference between the ten-year Treasury bond rate and the three-month Treasury bill rate.² If the expected real interest rate were constant over the 1959–79 period (apart from white noise) and if market

¹ Inflation is measured as the logarithmic difference of the data series CPI-UX (U.S. Bureau of Labor Statistics), which treats housing costs on a rental-equivalence basis. Two dummy variables were included in the regressions to capture the impact of the Nixon Administration wage and price controls. The first dummy variable is unity over the actual period of price controls (1971:3–1972:4), and the second dummy variable is unity over the period immediately following the price controls (1973:1–1974:4).

² All interest rates are quarterly averages. We used Akaike's final prediction error (FPE) criterion to choose the appropriate lag length for each right-hand-side variable. The FPE statistic (Akaike 1969) measures a regression's mean-square prediction error. We used the FPE statistic, along with a methodology outlined by Hsiao (1981), to determine the order in which lag-length selections were made. A maximum of eight lags was allowed.

expectations of inflation differed from realized inflation by only a white-noise error, then equation 1 would imply a coefficient of unity on the three-month Treasury bill rate and zero coefficients on all other right-hand-side variables. In fact, the coefficient on the three-month T-bill rate is estimated precisely and is within one standard error of unity, but lagged inflation and the interest rate spreads also have significant explanatory power for inflation.³ Apparently, *ex post* real returns were correlated with both lagged inflation and lagged interest rate spreads over the 1959–79 period.

A number of studies have suggested that the relationship between interest rates and inflation has broken down or, at least, changed since 1979.⁴ This shift in the interest rate–inflation relationship is illustrated on line B of Table 1, which presents results from a regression of inflation on lagged inflation and several interest rate measures over the period from the first quarter of 1980 through the second quarter of 1991. Note that over this later sample period, none of the interest rate measures help to explain movements in inflation.

Similar results are obtained when one substitutes the *change* in inflation for the *level* of inflation in the regression equations. During the pre-1980 period, both the level of the three-month Treasury bill rate and the spread between the three-month Treasury bill rate and the federal funds rate have significant marginal explanatory power for changes in inflation (line C). After 1979, this explanatory power disappears (line D).

What accounts for the changed relationship between market interest rates and inflation since 1980? Broadly speaking, only two explanations are

possible. Either the relationship between actual inflation and expected inflation or the correlation between movements in nominal interest rates and movements in real interest rates must have been different during the 1980s compared with the 1970s. Evidence exists to support each of these views (which, after all, are not mutually exclusive). Thus, for example, Evans and Lewis (1991) and Raymond and Rich (1992) have presented empirical results suggesting that inflation policy is subject to discrete “regime shifts.”⁵ During the 1970s, according to these two studies, there may have been a systematic tendency for realized inflation to exceed expectations of inflation. This apparent bias in expectations would be rational if, over this period, people had felt that the Federal Reserve might soon adopt a stronger anti-inflationary stance. Beginning in late 1979, according to many observers, the Federal Reserve did indeed launch a campaign to bring down the rate of inflation. Therefore, the seeming bias in inflationary expectations likely was eliminated, or even reversed in sign, after 1979. Thus, a plausible case can be made for a sudden shift in the relationship between expected inflation (the inflation incorporated into market interest rates) and realized inflation (the inflation we are attempting to explain in our regression equations).

The view that the correlation between nominal interest rates and real interest rates may have been altered has received indirect support from empirical studies documenting a shift in the relationship between nominal interest rates and real economic activity—a shift that apparently occurred at about the same time as the shift in the relationship between nominal interest rates and inflation. Bernanke (1990) documents the changed relationship between interest rates and real activity and discusses financial innovations that may have been responsible for the change. Expected real returns, though not directly observable, are thought to be closely related to movements in real economic activity (Chapman 1991).

In summary, existing studies indicate that over some sample periods, interest rates and interest rate spreads have provided information useful in explaining or predicting movements in inflation. However, these studies have only examined whether market interest rates have explanatory or predictive power beyond that evident in the history

³ The estimated coefficient on the three-month Treasury bill rate is 1.115, with a standard error of 0.215.

⁴ See, for example, Clarida and Friedman (1984), Huizinga and Mishkin (1986), Bemanke (1990), Fama (1990), Mishkin (1990a, 1990b), and Jonion and Mishkin (1991). The change in the relationship between interest rates and inflation is also evident in Figure 1.

⁵ Also see Romer and Romer (1989) and Balke and Fomby (1991).

of inflation itself.⁶ In the analysis that follows, we adopt a more stringent test of the usefulness of interest rates in predicting inflation. In particular, we examine whether market interest rates provide information about price movements beyond the information included in variables traditionally used to forecast inflation. Besides interest rates, the variables we consider are measures of money growth, the velocity of money, the relative price of energy, productivity-adjusted wages, and output-market slack. We first estimate empirical models that rely solely on these non-interest-rate variables, then test whether adding interest rates to the models significantly improves their performance.

Specification of traditional inflation models

Most economists would agree that over the long term, inflation is determined by the rate of money growth relative to the rate of potential output growth. There is considerably less consensus about the factors that influence near-term movements in inflation. Two paradigms, the monetarist and Phillips-curve approaches, have dominated the empirical literature on near-term movements in inflation. In the monetarist paradigm, inflation is caused by money-supply growth in excess of money-demand growth—in other words, by “too much money chasing too few goods.” In monetarist models, past money growth is the primary determinant of near-term movements in inflation. The Phillips-curve paradigm, in contrast, attributes near-term movements in inflation to variations in excess demands on the labor or output markets. In Phillips-curve models, variables that proxy for the gap between current output and the full-employment level of output play an important role in determining inflation.

We estimate variants of both monetarist and Phillips-curve models, as well as a general model that draws upon both paradigms. Estimating several inflation models allows us to determine whether our results are robust with respect to model specification. Testing for robustness is important, given the current lack of consensus about which inflation paradigm is superior.

A monetarist model of inflation. A typical monetarist model of inflation takes the form

$$(2) \quad \pi_t = a + \sum_{i=1}^p h_i \pi_{t-i} + \sum_{i=1}^q c_i \hat{M}_{t-i} + \sum_{i=1}^r d_i \hat{E}_{t-i},$$

where π is inflation, M is money growth, E is an energy-shock variable, and the lowercase letters denote parameters to be estimated. We use the logarithmic difference of the M2 monetary aggregate as our measure of money growth and use the growth rate of the producer price index for fuels and energy relative to the overall producer price index as our energy-shock variable.⁷ All data are quarterly, running from 1959 through the second quarter of 1991.

Before equation 2 can be estimated, several technical issues need to be addressed. The first concerns appropriate lag lengths for the right-hand-side variables in the equation. Choosing a model with lags that are too short can result in biased estimates, while choosing lags that are too long can result in inefficiency. We relied upon Akaike's (1969) final prediction error (FPE) criterion to select the appropriate lag length for each right-hand-side variable in our regressions.

A second technical issue is the stationarity of the regressors in equation 2. If any of its right-hand-side variables have nontrivial trends, then misleading conclusions may result from hypothesis testing. For this reason, Dickey–Fuller tests were used to ensure that all right-hand-side variables entered in (2) are stationary.⁸ These tests gave ambiguous results for the stationarity of inflation. Therefore, (2) was estimated twice: once with inflation as the dependent variable and once with the change in inflation as the dependent variable.⁹

⁶ The exception is Bernanke (1990), who also includes a history of the U.S. Commerce Department's index of leading indicators.

⁷ We also examined monetarist models using the St. Louis monetary base, rather than M2, and found no qualitative differences in results. Separately, we examined models in which the energy-shock variable was the growth rate of consumer energy costs relative to overall consumer prices, rather than the growth rate of producer energy costs relative to overall producer prices. Again, we found no qualitative differences in results.

⁸ A time series random variable is said to be stationary if its distribution does not depend on time.

⁹ Differencing a random variable that is nonstationary with a single unit root ensures stationarity.

Table 2

Traditional Inflation Models

A. Monetarist Model

DV	Marginal Significance Level			Number of Lags			
	DV	\dot{E}	\dot{M}	DV	\dot{E}	\dot{M}	\bar{R}^2
π	.000	.000	.003	3	8	1	.833
$\Delta\pi$	.000	.000	.002	2	8	1	.433

B. Phillips-Curve Model

DV	Marginal Significance Level				Number of Lags				
	DV	\dot{E}	GAP	V2	DV	\dot{E}	GAP	V2	\bar{R}^2
π	.000	.000	.013	.303	3	8	1	2	.829
$\Delta\pi$	.000	.000	.001	.006	2	8	6	2	.476

C. General Encompassing Model

DV	Marginal Significance Level						Number of Lags						
	DV	\dot{W}	\dot{E}	GAP	V2	\dot{M}	DV	\dot{W}	\dot{E}	GAP	V2	\dot{M}	\bar{R}^2
π	.000	.018	.000	.093	.194	.001	3	6	8	1	2	1	.856
$\Delta\pi$	.000	.251	.000	.024	.114	.000	2	1	8	1	1	1	.473

Sample period: 1959:1–1991:2

Definitions

 \dot{E} = change in the logarithm of the relative price of energy in the producer price index. \dot{M} = change in the logarithm of the M2 monetary aggregate.

GAP = difference between the logarithm of GNP and the logarithm of potential GNP.

V2 = logarithm of the velocity of M2.

 \dot{W} = change in the logarithm of the ratio of compensation per hour to output per hour in the nonfarm business sector.

NOTE: For further explanations, see Table 1.

Results are presented in Table 2, part A.

The explanatory power of the monetarist models is quite high. Clearly, both lagged money growth and lagged energy prices help explain move-

ments in inflation. In neither regression is serial correlation or heteroskedasticity of the errors a problem. Furthermore, traditional F tests do not provide evidence of a structural break in either model.¹⁰

A Phillips-curve model of inflation. One motivation for the Phillips-curve inflation model is presented by Hallman, Porter, and Small (1991). An attractive feature of their approach is that it makes explicit the importance of money growth for long-term trends in inflation, while allowing excess demand for output to influence move-

¹⁰ Godfrey-Breusch Lagrange-multiplier tests were used to check for serial correlation. We used a version of White's test to examine for heteroskedasticity. The breakpoint for these and other F tests was the first quarter of 1980.

ments in inflation over the near term.

Hallman et al. write inflation as a function of lagged inflation and of the gap between the current price level, P , and the long-run equilibrium price level, P^* .¹¹ The equilibrium price level is defined as the price level consistent with the current outstanding stock of M2, the average velocity of M2 ($V2^*$), and the current value of potential, or full-employment, real output.¹² Formally,

$$(3) \quad P^* \equiv M2 + V2^* - Q^*,$$

where Q^* is potential real output and all variables are in logarithmic form.

According to the equation of exchange, $P = M2 + V2 - Q$, where $V2$ is the current velocity of M2 and Q is the current level of output. Clearly, if the velocity of M2 tends to revert to $V2^*$ and if output tends to revert to Q^* , then the price level will converge to P^* . Hallman, Porter, and Small argue that this convergence is described by the equation

$$(4) \quad \Delta\pi = -b(P - P^*),$$

where $\Delta\pi$ is the change in inflation and b is a fixed, positive parameter. From the equation of exchange, (4) can be rewritten as

$$(5) \quad \Delta\pi = -b[(V2 - V2^*) - (Q - Q^*)]$$

or, more generally, as

$$(6) \quad \Delta\pi = a - bV2 + c(Q - Q^*),$$

where a is defined as $bV2^*$. Equations 5 and 6 are equivalent if c equals b .

We estimated not only a version of the Phillips-curve model with the change in inflation as the dependent variable, as in equation 6, but also a version with the level of inflation as the dependent variable. In both cases, lagged values of the dependent variable were allowed to enter as right-hand-side variables. We used gross national product as our measure of output. Estimates of potential output came from the Board of Governors of the Federal Reserve System. As with the monetarist models, an energy-shock variable and dummy variables for the Nixon wage and price controls were included in the regres-

sions. The Akaike criterion was used to select lag lengths, and Dickey-Fuller tests were applied to ensure stationarity of the right-hand-side variables. Like Hallman, Porter, and Small, we found that both M2 velocity and the output gap are stationary. Heteroskedasticity and serial correlation did not appear to be a problem.¹³ Results are presented in Table 2, part B.

The explanatory power of the inflation-level version of the Phillips-curve model, as measured by its \bar{R}^2 , is similar to that of the corresponding monetarist model. The inflation-change version of the Phillips-curve model, on the other hand, has somewhat greater explanatory power than does the corresponding monetarist model. Each right-hand-side variable in the Phillips-curve model makes a significant contribution to the explanation of the change in inflation. Every right-hand-side variable except the velocity of money makes a significant contribution to the explanation of the level of inflation.

A general encompassing model of inflation.

The final inflation model we estimate includes both monetarist and Phillips-curve variables. The

¹¹ Strictly speaking, the Hallman-Porter-Small derivation goes through only if P is an implicit deflator for some measure of aggregate output. As a practical matter, however, movements in the consumer price index are highly correlated with those in the implicit gross national product deflator and gross domestic product deflator. Consequently, one might reasonably expect that the set of variables that helps explain movements in the implicit deflators would also help explain movements in the CPI.

¹² Mehra (1989) advocates an alternative definition of the long-run equilibrium price level. Mehra's analysis leads to an inflation equation that includes the change in money's opportunity cost as a right-hand-side variable. Because changes in the opportunity cost of holding money are highly correlated with changes in interest rates, Mehra's analysis provides a rationale for including interest rate measures in the inflation equation that is an alternative to the rationale sketched earlier in this article.

¹³ F tests yielded strong evidence against the structural stability of the Phillips-curve model estimated in levels form but no evidence against structural stability of the model estimated in changes form. Accordingly, although we present results for both forms of the model, we place greater emphasis in our analysis on results obtained from the inflation-change regressions.

Table 3
Interest Rates and the Monetarist Model

A. Interest Rate Variables

DV	1959:1–1979:4								1980:1–1991:2							
	Marginal Significance Level				Number of Lags				Marginal Significance Level				Number of Lags			
	3M	3MFF	10Y3M	JOINT	3M	3MFF	10Y3M		3M	3MFF	10Y3M	JOINT	3M	3MFF	10Y3M	
π	.032	.089	.148	.025	1	4	1		.165	.011	.043	.000	4	3	2	
$\Delta\pi$	.122	.032	.468	.034	1	4	1		.978	.016	.000	.000	1	3	2

B. Non-Interest-Rate Variables

DV	1959:1–1991:2							
	Marginal Significance Level			Number of Lags				
	DV	\dot{E}	\dot{M}	DV	\dot{E}	\dot{M}	\bar{R}^2	
π	.000	.000	.001	3	8	1	.876	
$\Delta\pi$	.000	.000	.001	2	8	1	.564

motivation for estimating a general model of this type comes from recent findings that models including both monetarist and Phillips-curve characteristics significantly outperform narrower models (Haslag and Ozment 1991; Mehra 1990).

Besides lagged values of the dependent variable (either the level of inflation or the change in inflation), money growth, and the output gap, we include lagged values of M2 velocity, lagged energy-price shocks, and lagged values of a measure of labor costs as right-hand-side variables.¹⁴ Dummy variables for the Nixon wage and price controls complete the model. There is no evidence of a structural break in the general model, regardless of whether the model is formulated in terms of the level of inflation or the

change in inflation. There is also no evidence of serial correlation or heteroskedasticity. Results are presented in Table 2, part C.

According to the table, the general model explains a somewhat higher proportion of the variation in the level of inflation than do the monetarist and Phillips-curve models. Most of this incremental explanatory power comes from productivity-adjusted wages. The inflation-change version of the general model performs no better than does the corresponding Phillips-curve model. However, money growth helps significantly in explaining variations in both the level of inflation and the change in inflation, and the velocity variable is now insignificant in the changes regression. In the changes regression, unlike the inflation-level regression, wage growth contributes little explanatory power.

Additional information content of the interest rate variables

To examine the marginal information content of interest rates for future inflation, we added

¹⁴ The labor-cost measure is defined as the growth rate of compensation per hour relative to output per hour in the nonfarm business sector. Mehra (1990) and Haslag and Ozment (1991) include similar labor-cost measures in their analyses.

lagged values of three interest rate measures to the right-hand sides of our inflation models. These measures were the level of the three-month Treasury bill rate (*3M*), the spread between the three-month Treasury bill rate and the federal funds rate (*3MFF*), and the spread between the ten-year Treasury bond rate and the three-month Treasury bill rate (*10Y3M*). The three-month rate was included because economic theory suggests that the rate incorporates market expectations of inflation over the coming quarter (compare with equation 1). The spread between the ten-year bond rate and the three-month bill rate was included because previous research indicates that this spread is closely related to future growth in real economic activity and, hence, might control for movements in expected real interest rates (Bernanke 1990; Estrella and Hardouvelis 1991). The spread between the three-month Treasury bill rate and the federal funds rate was included partly for completeness and partly because the federal funds rate is the interest rate that is most nearly under the control of the monetary authority.

In each regression equation, both the constant term and the coefficients on the interest rate variables were allowed to differ between the pre-1980 and post-1979 sample periods.¹⁵ This split was introduced because formal *F* tests indicated that the coefficients on some interest rate variables in the monetarist and Phillips-curve models shifted beginning in 1980. A split was allowed even in the general model, which showed no evidence of a structural shift, because we wanted to examine whether interest rates played a less important role in explaining movements in inflation during the 1980s than during the 1960s and 1970s. (Recall that in regressions involving only interest rates and the lagged level of inflation or change in inflation, we found evidence that the marginal explanatory power of interest rates declines after 1979.) Coefficients on non-interest-rate variables were constrained to be equal across the entire 1959–91 period.

We found that in the pre-1980 period, the short end of the interest rate yield curve has substantial marginal explanatory power for both the level of inflation and the change in inflation, while the long end of the yield curve does not. In the post-1979 period, *both* short-term and long-

term interest rates help to explain movements in inflation. Our general encompassing model with interest rates apparently dominates the interest-rate-augmented monetarist and Phillips-curve models, not only in terms of its structural stability but also in terms of its ability to explain inflation. In the general model, a yield curve that is steep at its long end tends to signal low, and declining, near-term inflation.

Impact of interest rates on the monetarist model. According to Table 3, adding interest rates to the monetarist model of the level of inflation raises the \bar{R}^2 of the regression equation to 0.88. Over the pre-1980 period, the three interest rate measures are jointly significant at well under the 5-percent level. Over the post-1979 period, the joint significance level falls to 0.02 percent, indicating that the marginal explanatory power of interest rates increased during the 1980s. Most of the marginal explanatory power of interest rates over the early sample period is accounted for by the level of the three-month interest rate, though the spread between the three-month rate and the federal funds rate is also significant at the 10-percent level. The spread between the ten-year and three-month interest rates—representing the slope of the long end of the yield curve—does not contribute significant marginal explanatory power until the 1980s.¹⁶

¹⁵ Lags on the non-interest-rate variables were held fixed at lengths determined by Akaike's FPE criterion as applied to the monetarist, Phillips-curve, and general models without interest rates. The Akaike criterion was applied separately to the pre-1980 and post-1979 interest rate variables to determine the optimal number of lags of these variables to be included in the regression equations.

¹⁶ One explanation for this result—and similar results reported later in the article—can be provided within the context of a model (such as that of Mehra 1989, 1990) in which the opportunity cost of holding money is one determinant of inflation. During the 1960s and 1970s, when deposit rate ceilings were generally binding, the opportunity cost of holding money principally varied with short-term interest rates. Once deposit rate ceilings were abolished, banks were free to change deposit rates in response to movements in loan rates—which are relatively long-term—and the opportunity cost of holding money became a function of the spread between long-term and short-term market rates.

Table 4
Interest Rates and the Phillips-Curve Model

A. Interest Rate Variables

DV	1959:1–1979:4								1980:1–1991:2						
	Marginal Significance Level				Number of Lags				Marginal Significance Level				Number of Lags		
	3M	3MFF	10Y3M	JOINT	3M	3MFF	10Y3M		3M	3MFF	10Y3M	JOINT	3M	3MFF	10Y3M
π	.020	.018	.314	.011	3	4	1		.082	.778	.012	.011	1	1	1
$\Delta\pi$	.542	.422	.774	.413	1	2	1		.589	.026	.001	.001	1	3	2

B. Non-Interest-Rate Variables

DV	1959:1–1991:2									
	Marginal Significance Level					Number of Lags				
	DV	\hat{E}	GAP	V2		DV	\hat{E}	GAP	V2	\bar{R}^2
π	.001	.000	.766	.055		3	8	1	2	.856
$\Delta\pi$	.000	.000	.019	.004		2	8	6	2	.567

Table 5
Interest Rates and the General Encompassing Model:
Split-Sample Interest Rate Coefficients

A. Interest Rate Variables

DV	1959:1–1979:4								1980:1–1991:2						
	Marginal Significance Level				Number of Lags				Marginal Significance Level				Number of Lags		
	3M	3MFF	10Y3M	JOINT	3M	3MFF	10Y3M		3M	3MFF	10Y3M	JOINT	3M	3MFF	10Y3M
π	.015	.051	.990	.007	1	3	1		.049	.002	.097	.000	1	3	2
$\Delta\pi$	.596	.037	.700	.093	1	4	1		.877	.013	.001	.001	1	3	2

B. Non-Interest-Rate Variables

DV	1959:1–1991:2												
	Marginal Significance Level						Number of Lags						
	DV	\bar{W}	\hat{E}	GAP	V2	\bar{M}	DV	\bar{W}	\hat{E}	GAP	V2	\bar{M}	\bar{R}^2
π	.586	.012	.000	.628	.022	.003	3	6	8	1	2	1	.895
$\Delta\pi$	.000	.286	.000	.621	.751	.001	2	1	8	1	1	1	.561

When interest rates are added to monetarist variables in an attempt to explain *changes* in inflation, the \bar{R}^2 of the monetarist equation rises from 0.43 to 0.56. Collectively, the interest rate measures help significantly in explaining changes in inflation during both the early and the late sample periods. As in the inflation-level regression, the bulk of interest rates' marginal explanatory power during the early sample period comes from the short end of the yield curve. During the 1980s, the long end of the yield curve also makes a significant contribution.

Impact of interest rates on the Phillips-curve model. Results for the Phillips-curve model (Table 4) are qualitatively similar to those for the monetarist model. Including interest rates in the Phillips-curve equation for the level of inflation raises the equation's \bar{R}^2 from 0.83 to 0.86 and raises the \bar{R}^2 of the Phillips-curve equation for the change in inflation from 0.48 to 0.57. In the levels regression, only short-term interest rates have significant marginal explanatory power in the early sample period, while it is principally the slope of the long end of the yield curve that helps explain movements in inflation during the 1980s. In the regression for the change in inflation, none of the interest rate measures are statistically significant during the early sample period, but the slopes of both the short end and the long end of the yield curve have substantial explanatory power during the 1980s.

Impact of interest rates on the general encompassing model. Including interest rates in the general encompassing model of inflation raises the \bar{R}^2 of the levels regression from 0.86 to 0.89 and raises the \bar{R}^2 of the changes regression from 0.47 to 0.56. (Compare Table 5 with Table 2.) In both the pre-1980 and the post-1979 segments of the 1959–91 sample period, measures of short-term interest rates help substantially in explaining movements in the level of inflation and the change in inflation. In contrast, the slope of the long end of the yield curve is of little help in explaining movements in the level of inflation or the change in inflation until after 1979. Table 6 shows that when the coefficients of the interest rate variables are constrained to be constant over the sample period, all three interest rate measures make a statistically significant contribution to both the level-of-inflation

and the change-in-inflation regressions.

Including interest rates among the right-hand-side variables in the regression equations for the general encompassing model has important effects on the explanatory power of both the output gap and the velocity of money. The explanatory power of the output gap for the level of inflation is weakened by the inclusion of interest rates, while that of velocity is markedly strengthened.¹⁷ (Compare Tables 5 and 6 with Table 2.) In the inflation-change version of the general encompassing model, adding interest rates markedly reduces the explanatory power attributable to the output gap. The velocity variable remains insignificant.

Inflation and the slope of the yield curve. Is a steep yield curve a signal of high inflation or of low inflation? Is a steep yield curve a signal of rising inflation or of falling inflation? One can determine the long-run effect of a change in the steepness of the yield curve on predicted inflation, or on the predicted change in inflation, by using the sum of the coefficients attached to lagged values of the interest rate spread. In our estimate of the *levels* version of the general encompassing model, this sum of coefficients is 0.891 (with standard error 0.346) for the spread between the three-month rate and the federal funds rate and is -0.403 (with standard error 0.175) for the spread between the ten-year rate and the three-month rate. Thus, a three-month interest rate that is high relative to the federal funds rate signals a *high* near-term rate of inflation, while a ten-year interest rate that is high relative to the three-month rate signals a *low* near-term rate of inflation.

One interpretation of these results is that bond market participants expect the Federal Reserve to raise the federal funds rate quickly when near-term inflation threatens to be high. Because the three-month rate is more responsive to expected near-term movements in the federal funds rate than is the ten-year rate, the prospect of an increase in the federal funds rate raises the

¹⁷ This statement also applies to the Phillips-curve model (Compare Table 4, part B, with Table 2, part B.)

Table 6

Interest Rates and the General Encompassing Model: Unified-Sample Interest Rate Coefficients, 1959:1–1991:2

A. Interest Rate Variables

DV	Marginal Significance Level				Number of Lags		
	3M	3MFF	10Y3M	JOINT	3M	3MFF	10Y3M
π	.001	.011	.004	.000	5	3	3
$\Delta\pi$	.017	.011	.002	.001	2	2	2

B. Non-Interest-Rate Variables

DV	Marginal Significance Level						Number of Lags						
	DV	\hat{W}	\hat{E}	GAP	V2	\hat{M}	DV	\hat{W}	\hat{E}	GAP	V2	\hat{M}	\bar{R}^2
π	.021	.000	.000	.289	.002	.000	3	6	8	1	2	1	.891
$\Delta\pi$	.000	.196	.000	.518	.134	.000	2	1	8	1	1	1	.548

three-month rate relative to both the current funds rate and the ten-year rate.¹⁸

In the regression explaining *changes* in inflation, inflation tends to rise more slowly in the future, the steeper is the long end of the yield curve. Thus, the sum of the estimated coefficients attached to lagged values of the spread between ten-year and three-month interest rates is -0.368 , with standard error 0.158. Again, a possible interpretation is that the Federal Reserve is thought to be more likely to drive down near-term interest rates when inflationary pressures are waning than when inflationary pressures are building.

The following section analyzes the forecasting performance of the general encompassing models of the level of inflation and the change in inflation. The analysis compares the forecasting performance of models with interest rates with the forecasting performance of the corresponding models without interest rates. We confine our attention to the general models because they encompass the monetarist and Phillips-curve models and because the coefficients on the interest rate variables in the general models—unlike the other models—are stable across the entire sample.

Out-of-sample forecasts

The out-of-sample forecasting exercises we conduct are one-quarter-ahead static forecasts of inflation as generated by the general encompassing models. The forecasts are real-time in the sense that they are generated using only information available at the time of the forecasts. Furthermore, the parameter estimates of the models are updated each period as new information becomes available. However, the lag structures of the models were selected by using data from the entire sample. (Specifically, the lags used in the forecasting

¹⁸ See McNees (1989, 33). Alternatively, a large spread between long-term and short-term interest rates may signal a low opportunity cost of holding money and, hence, a low velocity of money. A low velocity of money tends to imply a low equilibrium price level for any given money supply, putting downward pressure on near-term inflation. The problem with this explanation is that velocity is already included as a separate right-hand-side variable in the level-of-inflation regression.

Table 7

Forecasting Performance of the General Encompassing Model

	With Interest Rates		Without Interest Rates	
	π	$\Delta\pi$	π	$\Delta\pi$
Mean error	-278	-255	-235	-130
Mean absolute error	1.445	1.175	1.303	1.211
Root-mean-square error	1.836	1.465	1.697	1.574

NOTE: Based on one-period-ahead forecasts from 1980:1 through 1991:2.

All statistics are multiplied by 100; for example, a mean error of -0.255 represents an error of -0.255 percentage point.

models are the same as those in Table 6.)

Table 7 presents forecast results for the level of and the change in inflation obtained from the general encompassing models with and without interest rates. In every case, the forecast period runs from the first quarter of 1980 through the second quarter of 1991. None of the mean errors are statistically different from zero, indicating that the forecasts are unbiased. Root-mean-square errors are lower for forecasts based on regressions in the change in inflation than for forecasts based on regressions in the level of inflation.¹⁹

Table 8 presents the results of formal encompassing tests. (For an explanation of forecast encompassing tests, see the box titled "Forecast Encompassing," page 15.) These tests confirm that the inflation-change versions of the general model yield significantly more accurate forecasts of inflation than do the corresponding inflation-level versions. Thus, forecast errors of the inflation-change models help explain the forecast errors of the inflation-level models but not vice versa (Table 8, lines A and B). Comparing the inflation-change models, the model with interest rates encompasses the model without rates, but the model without rates fails to encompass the model with rates (Table 8, line C). Consequently, the forecasting performance of the model with interest rates is unambiguously superior to that of the model without interest rates. In particular, interest rates contain information useful in predicting near-term movements in inflation.

Discussion

Previous research has shown that the slope of the interest rate yield curve can serve as a useful predictor of long-term changes in inflation. Attempts to extract information about *near-term* movements in inflation from interest rates have proven to be less successful—especially for the 1980s. *A priori*, one might have expected the marginal information content of interest rates to shrink as additional explanatory variables were included on the right-hand side of the inflation regression. Apparently, however, the variables that might have been expected to be most competitive with market interest rates actually help the analyst to control for unobservable movements in expected real interest rates. Thus, supplementing interest rates with traditional inflation-predicting variables makes it easier to extract the information about near-term inflation that is hidden in the yield curve.

¹⁹ By way of comparison, McNees (1992) reports the inflation-forecasting performance of an anonymous "prominent forecaster" for the period from the first quarter of 1980 through the first quarter of 1992. The mean error, mean absolute error, and root-mean-square error for this forecaster were 0.1, 1.2, and 1.7 percentage points, respectively (McNees 1992, Table 2).

Table 8
Encompassing Tests

	Independent Variable	Dependent Variable	t Statistic
A.	$(\pi - \pi^i) - (\Delta\pi - \Delta\pi^i)$	$\pi - \pi^i$	2.710*
		$\Delta\pi - \Delta\pi^i$	.192
B.	$(\pi - \pi^F) - (\Delta\pi - \Delta\pi^F)$	$\pi - \pi^F$	5.146*
		$\Delta\pi - \Delta\pi^F$	.696
C.	$(\Delta\pi - \Delta\pi^i) - (\Delta\pi - \Delta\pi^F)$	$\Delta\pi - \Delta\pi^i$	2.685*
		$\Delta\pi - \Delta\pi^F$	.458

Definitions

- $\pi - \pi^i$ = forecast error from the level-of-inflation model without interest rates.
- $\Delta\pi - \Delta\pi^i$ = forecast error from the change-in-inflation model without interest rates.
- $\pi - \pi^F$ = forecast error from the level-of-inflation model with interest rates.
- $\Delta\pi - \Delta\pi^F$ = forecast error from the change-in-inflation model with interest rates.

* Significant at the 1-percent level.

In the existing literature, a steep yield curve signals rising inflation. Here, however, short-term rates that are low relative to long-term rates are a signal of *falling* inflation over the near term. Bond-market traders possibly believe that policymakers are more inclined to drive down short-term interest rates, steepening the yield curve, when the near-term outlook for inflation is favorable than when the near-term outlook for inflation is unfavorable. This interpretation of our empirical results would imply that a shift in the monetary authority's response to changes in the near-term

inflation outlook would lead to a shift in our parameter estimates. In particular, if the Federal Reserve were to begin to rely more heavily on the slope of the yield curve as a guide for monetary policy, policymakers might find that the estimated relationship between the slope of the yield curve and near-term inflation would change. While interest rates historically have contained information helpful in predicting near-term inflation, this historical relationship is no guarantee that movements in market interest rates can be used successfully to guide policy.

Forecast Encompassing

The idea underlying the Chong and Hendry (1986) forecast encompassing test is not complicated. Let y denote the variable being forecast, and let y_1^f and y_2^f denote forecasts generated by two competing models. Consider the regression equation

$$(B.1) \quad y = \alpha y_1^f + (1 - \alpha) y_2^f + \epsilon,$$

where ϵ is a random error term. If α does not equal zero, then y_1^f contains useful information for forecasting y that is not contained in y_2^f , and model 1 is said to "encompass" model 2. If α does not equal 1, then y_2^f contains useful information for forecasting y that is not contained in y_1^f , and model 2 encompasses model 1. If model 1 encompasses model 2 but model 2 does not encompass model 1 (that is, if α equals 1), then model 1 is clearly superior for forecasting purposes. If model 1 is encompassed but is not encompassing (that is, if α equals zero), then it is model 2 that has clear superiority.

An easy way to test for forecast encompassing is to estimate each of two rearrangements of equation B.1:

$$(B.1') \quad y - y_1^f = (1 - \alpha)[(y - y_1^f) - (y - y_2^f)] + \epsilon$$

and

$$(B.1'') \quad y - y_2^f = \alpha[(y - y_2^f) - (y - y_1^f)] + \epsilon.$$

In equation B.1', if the estimated value of

$(1 - \alpha)$ is significantly different from zero, then α is significantly different from unity, and model 2 encompasses model 1. Similarly, if the estimated value of α in equation B.1'' differs significantly from zero, then model 1 encompasses model 2. If $(1 - \alpha)$ is significantly different from zero but α is not, then model 2 contains information about y beyond that contained in model 1, while model 1 contains no information about y beyond that contained in model 2. In this case, model 2 is clearly superior for forecasting purposes. Similarly, if α is significantly different from zero while $(1 - \alpha)$ is not, then model 1 is clearly superior.

In Table 8, we first test whether forecasts of inflation derived from models of the change in inflation encompass forecasts of inflation obtained from models of the level of inflation. (Implicit in any one-period-ahead forecast of the change in inflation is a one-period-ahead forecast of the level of inflation.) The t statistics reported on lines A and B of Table 8 confirm that forecasts of inflation derived from the change-in-inflation regressions are superior to forecasts obtained from the level-of-inflation regressions. Finally, the t statistics reported on line C of Table 8 indicate that in predicting inflation, forecasts derived from change-in-inflation regressions with interest rates are superior to forecasts derived from change-in-inflation regressions without interest rates.

References

- Akaike, Hirotugu (1969), "Fitting Autoregressive Models for Prediction," *Annals of the Institute of Statistical Mathematics* 21, no. 2: 243–47.
- Balke, Nathan S., and Thomas B. Fomby (1991), "Large Shocks, Small Shocks, and Economic Fluctuations: Outliers in Macroeconomic Time Series," Federal Reserve Bank of Dallas Research Paper no. 9101 (Dallas, February).
- Bernanke, Ben S. (1990), "On the Predictive Power of Interest Rates and Interest Rate Spreads," *New England Economic Review*, Federal Reserve Bank of Boston, November/December, 51–68.
- Chapman, David A. (1991), "Real Bond Yields and Aggregate Activity" (University of Rochester, November, Photocopy).
- Chong, Yock Y., and David F. Hendry (1986), "Econometric Evaluation of Linear Macroeconomic Models," *Review of Economic Studies* 53 (August): 671–90.
- Clarida, R. H., and Benjamin M. Friedman (1984), "The Behavior of U.S. Short-Term Interest Rates Since October 1979," *Journal of Finance* 39 (July): 671–82.
- Estrella, Arturo, and Gikas A. Hardouvelis (1991), "The Term Structure as a Predictor of Real Economic Activity," *Journal of Finance* 46 (June): 555–76.
- Evans, Martin D. D., and Karen K. Lewis (1991), "Do Expected Shifts in Inflation Policy Affect Real Rates?" (New York University, University of Pennsylvania, September, Photocopy).
- Fama, Eugene F. (1990), "Term-Structure Forecasts of Interest Rates, Inflation, and Real Returns," *Journal of Monetary Economics* 25 (January): 59–76.
- (1975), "Short-Term Interest Rates as Predictors of Inflation," *American Economic Review* 65 (June): 269–82.
- Fama, Eugene F., and Michael R. Gibbons (1984), "A Comparison of Inflation Forecasts," *Journal of Monetary Economics* 13 (May): 327–48.
- and ——— (1982), "Inflation, Real Returns, and Capital Investment," *Journal of Monetary Economics* 9 (May): 297–323.
- Frankel, Jeffrey A., and Cara S. Lown (1991), "An Indicator of Future Inflation Extracted from the Steepness of the Interest Rate Yield Curve Along Its Entire Length," NBER Working Paper Series, no. 3751 (Cambridge, Mass.: National Bureau of Economic Research, June).
- Granger, C. W. J., and Paul Newbold (1986), *Forecasting Economic Time Series*, 2d ed. (Orlando, Fla.: Academic Press).
- Hallman, Jeffrey J., Richard D. Porter, and David H. Small (1991), "M2 Per Unit of Potential GNP as an Anchor for the Price Level," *American Economic Review* 81 (September): 841–58.
- Haslag, Joseph H., and D'Ann M. Ozment (1991), "Money Growth, Supply Shocks, and Inflation," Federal Reserve Bank of Dallas *Economic Review*, May, 1–17.
- Hess, Patrick J., and James L. Bicksler (1975), "Capital Asset Prices Versus Time Series Models as Predictors of Inflation: The Expected Real Rate of Interest and Market Efficiency," *Journal of Financial Economics* 2 (December): 341–60.
- Hsiao, Cheng (1981), "Autoregressive Modelling and Money–Income Causality Detection," *Journal of Monetary Economics* 7 (January): 85–106.
- Huizinga, John, and Frederic S. Mishkin (1986), "Monetary Policy Regime Shifts and the Unusual Behavior of Real Interest Rates," *Carnegie–Rochester Conference Series on Public Policy* 24: 231–74.
- Johnson, Manuel H. (1988), "Current Perspectives on Monetary Policy," *Cato Journal* 8 (Fall): 253–60.

- Jorion, Philippe, and Frederic Mishkin (1991), "A Multicountry Comparison of Term-Structure Forecasts at Long Horizons," *Journal of Financial Economics* 29 (March): 59–80.
- McNees, Stephen K. (1992), "How Large Are Economic Forecast Errors?" *New England Economic Review*, Federal Reserve Bank of Boston, July/August, 25–42.
- (1989), "How Well Do Financial Markets Predict the Inflation Rate?" *New England Economic Review*, Federal Reserve Bank of Boston, September/October, 31–46.
- Mehra, Yash P. (1990), "Real Output and Unit Labor Costs as Predictors of Inflation," Federal Reserve Bank of Richmond *Economic Review*, July/August, 31–39.
- (1989), "Cointegration and a Test of the Quantity Theory of Money," Federal Reserve Bank of Richmond Working Paper no. 89-2 (Richmond, April).
- Mishkin, Frederic S. (1990a), "The Information in the Longer Maturity Term Structure About Future Inflation," *Quarterly Journal of Economics* 55 (August): 815–28.
- (1990b), "What Does the Term Structure Tell Us About Future Inflation?" *Journal of Monetary Economics* 25 (January): 77–95.
- Raymond, Jennie, and Robert W. Rich (1992), "Changes in Regime and the Behavior of Inflation" (Auburn University, Vanderbilt University, January, Photocopy).
- Romer, Christina D., and David H. Romer (1989), "Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz," in *NBER Macroeconomics Annual 1989*, ed. Olivier Jean Blanchard and Stanley Fischer (Cambridge, Mass.: MIT Press), 121–70.

Trade Policy and Intellectual Property Protection: The North–South Dispute

Do inventors have a right to profit from their inventions? The implications of this question have evoked controversy in recent years, and much of the dispute has occurred between developing and developed countries. The major producers of intellectual property, the developed nations, typically want strong intellectual property protection. Developing nations, which traditionally consume more intellectual property than they produce, prefer not to pay for it. They often want weaker protection. (See the box titled “What Is Intellectual Property?”)

Recently, however, some developing countries have begun to tighten their protection of intellectual property. This article discusses the motives behind these countries’ recent changes and focuses on the experience of Latin American countries in this process. In large part, the bases for these changes involve trade policy.

I argue that two types of linkages between trade policy and intellectual property exist. First, as has often been noted, weak intellectual property laws in developing countries have led developed countries to retaliate with selective barriers to Third World exports. Some developing countries have begun to respond by tightening their intellectual property laws. But there is much that this standard argument cannot explain. Not all countries under the highest pressure to change their laws have changed them. The difference between countries that have not changed and those that have appears to reflect a second type of linkage.

The second type of linkage involves a specific relationship between a country’s trade policy and what it may perceive as its optimum intellectual property regime. When a country tries to develop a range of home industries by protecting them from foreign competition, a loose intellectual property

regime may seem rational. As I will explain, getting the latest technology in such a country may not be easy. Without foreign competition, however, industries may not need the latest technology; without intellectual property protection to hinder them, they can get older technologies for nothing.

But many developing countries are shifting from strong trade protectionism to more liberal trade and foreign investment policies and to an increasing focus on manufacturing exports. For their products to compete more intensely in both domestic and world markets, developing nations must base their products on the latest technology, which they can acquire more easily when they protect intellectual property. In sum, two of my principal arguments are that trade protectionism rationalizes loose intellectual property laws and that trade liberalism rationalizes tight laws.

Why has Latin America preferred weak protection?

During the first two decades after World War II, Mexico, Brazil, Argentina, and most other countries in Latin America followed trade policies focused on *import substitution*, a policy that entailed the protection of local markets with high barriers to imports. Most of these countries continued their adherence to import substitution policies in the 1960s, but by the 1970s, the distribution of trade

Stephen P.A. Brown and David M. Gould offered many helpful comments as reviewers of this article. I also benefited from discussions with Alison Butler, Edwin F. Einstein, Joe W. Pitts III, and Robert M. Sherwood. Any errors or omissions are my own.

What Is Intellectual Property?

Intellectual property has two attributes. First, it is a tangible product of the intellect—an invention, an idea, a product, or a process. Second, a nation's laws say that intellectual property can be owned; it may not be used by others without the owner's permission.

In the most general sense, laws concerning intellectual property address four types: trade secrets, patents, trademarks, and copyrights.¹ Even though each of these four types is different, the lines separating what they protect are often blurred. In the United States, for example, a computer program may be protected either by copyright or patent. Despite these ambiguities, an understanding of the broad distinctions between such laws is useful.

Among the alternatives in protecting intellectual property, the patent is the most powerful. The *patent* is a temporary right to exclude others from using an invention. Patent laws grant this right for only a certain number of years, and it is not unusual for inventors to complain that a patent's duration is not long enough.

The *copyright* is also a temporary right. It is the right to keep others from selling copies of one's creative expression. Pirating copies of copyrighted material—such as films, books, and computer programs—may be among the

most publicized class of violations of intellectual property rights.

A *trade secret* consists of otherwise legally unprotected confidential information that, in a firm's opinion, gives the firm a competitive edge. The trade secret, although possibly not covered or even subject to coverage by patent or copyright law, has demonstrable value; a firm could legitimately claim damage if a departing employee left with the secret and transmitted it to a competitor.

Last is the trademark. The *trademark* is a word or mark that identifies the source of a good or service. The sale of clothing and athletic shoes that display unauthorized trademarks is another of the more publicized classes of intellectual property rights violations. In the United States, protection of trademarks and trade secrets lies principally with the states, as contrasted with the federal protection that dominates for copyrights and patents.

¹ While these four classes of intellectual property law are the most important, there are others. Sherwood (1990) adds a fifth class: laws that protect computer "mask works," or chip designs. It is possible to protect mask works by patent, copyright, or trade secret law, but increasingly, a separate body of law is developing for them. Lesser (1990) also cites a fifth class: special laws that offer patent-like protection to cover bred plant varieties. Lesser does not include mask works as a separate category.

policies among these countries had begun to widen. A few began efforts to develop some manufacturing for export.¹ But for the most part, even these nations persisted with their import substitution policies. It is no coincidence that, through this entire period and into the 1980s, these countries also offered relatively weak and spotty intellectual property protection.

Import substitution and intellectual property.

Latin American countries commonly based import substitution and intellectual property policies on the arguments of Raul Prebisch (1950 and 1959), who maintained that the terms of trade were turning against nations whose chief exports were raw materials, and in favor of exporters of manufactures.

Prebisch counseled continued exports of raw materials together with the development of domestic manufacturing capacity targeted toward the home market. This strategy would not only foster development, but also save foreign exchange. Following Prebisch, Mexico, Brazil, Argentina, and some smaller countries protected

¹ Among the most noticeable such countries were Brazil and Korea.

manufacturers with high tariffs and other barriers.

The protection of their markets gave most manufacturers in these countries little incentive to buy the latest technology because trade barriers barred many of the foreign producers who had it from competing in the developing countries' markets anyway.² Prebisch and his followers counseled weak intellectual property protection, so that the local developing country producers could avail themselves of technology without the discomfort of paying for it.³ Pressures against strong intellectual property protection were not only high and widespread in these countries, but also effective. Local manufacturers might not have been able to get the very latest technology but, for what they could get, the price was right.

Although Latin American and other developing countries have traditionally offered weak intellectual property protection, they have offered some. The difference between the motivations of consuming countries and the motivations of producing countries has made developing-country protection spotty. A country can vary its degree of intellectual property protection among individual products and processes. Developing countries' protection may have traditionally been spotty in order to encourage innovations the country otherwise could not get; spotty protection enabled the country to avoid paying for innovations that would occur anyway.

For example, where an intellectual-property-consuming country's distribution of demands for innovations differs from the producing country's distribution of demands for innovations, the consuming country is motivated to protect (Diwan and Rodrik 1991). Suppose the consuming country demands innovations that are very different from innovations the producing country demands. The producing country may still innovate products the consuming country wants, but only if the consuming country protects intellectual property. If the consuming country has a polio epidemic and the producing country does not, the producing country may still invent a cure for polio, if the consuming country protects the cure.⁴

Suppose a polio epidemic hits both countries. In this case, the producing country and consuming country have identical preferences, so the consuming country has less incentive to protect. The producing country may still innovate what the

consuming country wants because firms in the producing country can at least benefit from innovating when they sell the product at home.

Other arguments for weak intellectual property protection. The case for weak intellectual property protection does not rely solely on the ability to acquire innovations without paying for them. Strong intellectual property protection may also permit monopolistic abuses. Under some conditions, a monopolist may accumulate patents to preserve the monopoly and then allow the patents to "sleep" so as to deter entry into an industry (Gilbert and Newbery 1982). Chin and Grossman (1990) cite cases in which, for innovation-consuming countries like the developing nations, the cost of monopolization more than offsets the contribution that stronger intellectual property protection can make in stimulating cost-saving innovations.⁵

² This relationship between trade protectionism and the demand for new technology has persisted. Using data from a 1981 survey of more than 3,000 Brazilian firms, Braga and Willmore (1991) found that firms' development of technology through research and development and their likelihood of purchasing foreign technology were both negatively related to the degree to which their industries were protected from foreign competition.

³ For discussions of the early arguments of Prebisch and his followers, see Sherwood (1990, 173-74) and Gadbar and Richards (1988, 21). Sherwood notes that Prebisch, not long before his death in 1986, rejected these earlier arguments. During the period I am discussing, however, the consistency of weak intellectual property laws with import substitution was perceived as high. When Prebisch finally did turn against the notion of weak intellectual property protection, he also turned against the idea of import substitution.

⁴ It is interesting to note that Frischtak, in a paper that offers a plan for tightening Brazil's intellectual property policies, suggests changes that are completely consistent with these arguments: "The introduction of full (product and process) patent protection might lead to market disruption and, possibly, increases in drug prices without clear benefits. A possible transitional step might be the development of a 'positive list' of diseases for which new drugs would be patentable, such as tropical diseases highly prevalent in Brazil (Chagas' disease, schistosomiasis, malaria, etc.)" (Frischtak 1990, 64).

⁵ Here, the degree to which the consuming country is motivated not to protect is, in part, inversely related to the relative size of its market.

From the perspective of net innovation-consuming countries that want to encourage innovation at home, an additional argument against strong intellectual property protection involves the institutional structures in which such property is produced and distributed. Vessuri (1990) notes that transnational computer corporations in Brazil were not interested in developing or absorbing local technological efforts because of the centralized nature of their own research and development. So, instead of protecting this intellectual property strongly, Brazil tried to foster local innovation by reserving a portion of the market for minicomputers, microcomputers, and their peripherals for domestic producers.

For Latin American and other consuming countries, another argument against strong intellectual property laws is that enforcement costs can be very high (Primo Braga 1990b). When the bulk of protection is for foreign innovations, these enforcement costs lead to increased royalty gains for foreigners and greater royalty expenses for nationals.⁶ Foreigners do, in fact, hold the bulk of patents that are registered in developing countries.

Not only might foreigners benefit disproportionately from licensing and royalties, but also from cost advantages. The introduction and enforcement of tougher intellectual property laws would increase production costs for domestic producers who had not been paying for the intellectual property that they were using. These domestic producers might be supplanted by the foreign firms that had originally produced the intellectual property on which the domestic firms' production processes were based. Pirates who continued to sell products of the intellect, or use them in production processes, without paying the producers would in any case be run out of business.

The changing role of the United States in international trade liberalization

In the 1980s, new pressures motivated some developing countries to change both their trade

policies and their intellectual property regimes. Some of the pressures involve events in the United States.

From the end of World War II until the late 1970s, the United States adopted a relatively liberal trade regime based on the idea of *multilateralism*, the idea that trade agreements among many nations at the same time work best. The United States expressed this commitment through its support and use of the *most favored nation* clause of the General Agreement on Tariffs and Trade (GATT). By this clause, any reciprocal tariff reduction negotiated between the United States and any of its trading partners applies to all U.S. trading partners.

However, under the GATT, the United States also offered special trade privileges for developing countries through the Generalized System of Preferences (GSP). Through the GSP, the United States and other developed countries may waive duties on selected imports from selected developing countries. Currently, a number of products of the Mexican in-bond plants (*maquiladoras*) flow back to the United States under the GSP.

By the 1980s, the United States had begun to back well away from trade liberalism and had started to use GSP provisions as weapons. Frustrated with what it viewed as the contamination of multilateralism, the United States markedly increased its use of *countervailing actions*, such as raising trade barriers it had lowered and increasing its filings of dumping charges. Whatever else these actions meant, they signaled a rise in U.S. protectionism. Beginning in 1984, the rate of acceleration became more acute. One route the United States chose for this escalation is particularly relevant to intellectual property protection in developing countries.

The United States provides itself retaliatory remedies for "unfair trade" through Section 301 of the U.S. Trade Act of 1974 and Section 337 of the Tariff Act of 1930. Section 337 protects U.S. firms from "unfair" competition from imports. Section 301 offers more leeway; it allows the United States to act against inadequate protection of its intellectual property in other countries, even if the violations do not involve products imported into the United States.

In 1984, the U.S. Congress passed a Trade and Tariff Act that strengthened options under

⁶ According to the Organization for Economic Cooperation and Development (OECD 1989), nationals of developing countries hold only 1 percent of existing patents in the world.

Section 301. The 1984 act explicitly designates weak intellectual property protection in a country as grounds for withdrawing trade concessions extended to that country under the Generalized System of Preferences. Next, Congress passed the Omnibus Trade and Competitiveness Act of 1988. This act requires the United States Trade Representative to specify timetables for investigation of actions and to identify countries that have inadequate intellectual property regimes.

In sum, these measures expanded options the United States could use to pressure countries to change their intellectual property protection. Congress added provisions to signal to U.S. officials that they had better use these new tools. Mody (1990, 219), commenting on the 1984 Trade and Tariff Act, notes that "four countries, Korea, Mexico, Brazil, and Thailand, have been affected by this legislation." With the 1988 act, the list lengthened considerably.

Foreign debt, trade liberalization, and intellectual property reform

Part, although not all, of the increase in U.S. protectionism constituted retaliation for increases in Third World protectionism during the 1980s.⁷ During the 1970s, several Third World countries had chosen to expand their development programs by resorting to foreign loans. These countries borrowed under the assumption that the prices of their exports, which had been high during much of the 1970s, would remain high enough to allow repayment. When the prices of many developing countries' principal exports fell hard in the early 1980s, a world debt crisis ensued.

To revive their sagging terms of trade and to earn hard currency to pay their external obligations, some developing countries commenced the same beggar-thy-neighbor policies that the developed countries had used during the Great Depression. That is, they increased protectionism.

In the face of massive trade retaliation from the United States, however, some countries changed course and opened their own economies. If Mexico's economy, or Korea's, became more open, how could the United States, with its ongoing declarations of commitment to free trade, remain closed to them? Of ten developing nations in the Western Hemisphere evaluated by Williamson

(1990, 26), "only Peru and Brazil remain locked in the old protectionist mode."

By themselves, these trade liberalizations offered a good deal of motivation for the increased intellectual property protection that occurred in Latin America in the late 1980s and early 1990s. Trade liberalization, after all, means that foreign products incorporating and produced by the latest and most inexpensive technology will now be competing at home with domestically made goods and services.

If developing-country producers wish to replicate this latest technology, they will often have to pay for it. The latest technology is often harder to acquire by subterfuge than are processes that have been longer in the market in some form. Moreover, the policies of a nonprotecting consuming country can affect its businesspersons' ability to purchase such technology, even if they are willing to pay for it. When dealing with firms in such countries, foreign producers of technology are cautious about selling it because the prospective buyers may violate purchasing agreements with impunity. Sherwood (1990) cites anecdotal evidence in which a Brazilian firm's employees have approached companies abroad to gain cost-effective technology. However, the firm's negotiations with the foreign source often came to an abrupt end when the source learned of Brazil's weak protection for many innovations.

Increased competition from foreign technologies may also convince a developing country to seek domestic innovations as well, and there is much evidence to suggest that weak intellectual property protection discourages innovation. In a Brazilian survey, 80 percent of 377 firms said they would invest more in internal research and would improve training for their employees if better legal protection were available (Sherwood 1990). While Brazilian survey evidence suggests that the lack of protection discourages innovation, U.S. survey evidence (Mansfield 1986) suggests that protection stimulates innovation.

Protectionism in the United States had been rising during the 1970s as well, before the developing countries began to raise theirs.

And, at least in the United States, there also appears to be a high social rate of return to innovation, considerably higher than the rate of return to the innovator (Mansfield et al. 1977).

Latin America's widening technological gap in the 1980s

While their trade liberalizations alone might well have motivated Latin American countries to tighten their intellectual property protection, the pressures for such protection increased in the 1980s as the technological gap between Latin America and the developed countries widened.

One reason this technological gap widened so much in the 1980s is because terms of trade shocks and debt problems forced a slump in Latin American investment that lasted much of the decade. New capital goods were not replacing old and, as the average age of Latin American plants and equipment rose, the region's capital stock became increasingly obsolete.

The technological gap widened further because, while investment was plunging in Latin America, the developed countries were entering a period of particularly rapid technological advance (Baer 1993). During this period, spending on research and development was growing much more rapidly than gross national product in all major OECD countries, and product life cycles were becoming shorter. Moreover, while the productivity of knowledge was increasing relative to other inputs, the cost of generating it was also rising. Accordingly, knowledge became increasingly privatized (Mody 1990). In light of these

changes, Frischtak (1990, 62) notes, "The trade-off between encouraging the diffusion of existing technology through unlicensed imitation and stimulating the creation of new technology becomes steeper over time."

This last argument became particularly compelling in a Latin American context during the 1980s. Latin American countries' "severe loss of competitiveness" was worsened by their "inability to carry out the structural modifications of an institutional character that would have enabled them to develop sources from which they could create and disseminate new technologies" (Barbera 1990, 92).

In sum, at the same time that foreign debt problems had led many developing countries to seek new avenues to earn foreign exchange, these countries were suffering from increasing technological backwardness. Moreover, it had become obvious that many of these nations' deteriorating competitiveness resulted, in part, from institutional problems that impeded the development and transfer of technology. In the new atmosphere of falling Latin American trade barriers, with its resulting increases in local competition from imports, the incentives for technologically competitive domestic products and forms of production had risen. In any case, the debt problem and technological backwardness were important factors that affected Latin America's ability to respond to foreign competition, and they may also have been important in changing developing nations' responsiveness to U.S. initiatives concerning Third World intellectual property protection.

Has U.S. policy caused the Latin American move toward stronger intellectual property protection?

Considering that the United States has not only empowered itself to inflict trade retaliations upon countries that do not fully protect intellectual property, but also to impose schedules by which the U.S. Trade Representative is supposed to inflict them, increased Third World compliance might be expected.

Moreover, a preponderance of Third World changes in intellectual property protection has occurred since the passing of the United States' 1984 Trade and Tariff Act and of the Omnibus

⁸ *Gadbaw (1988, 284) notes that "in 1986 and 1987, the Republic of Korea [Korea] enacted into law a series of revisions to its intellectual property regime that provide a dramatic example of U.S. success in promoting intellectual property reform through the combined use of negotiation and the threat of trade retaliation." The U.S. government maintains that enforcement remains a problem, however (East Asian Executive Reports 1990). In 1990, Mexico proposed sweeping reforms of its intellectual property laws that constituted "a virtual laundry list of the present law's major inadequacies" (Einstein 1991, 134). In June of 1991, Mexico passed these reforms into law.*

Trade and Competitiveness Act of 1988. Gadbow and Richards (1988, 21) offer the argument, written under the heading of "Trade Pressure," that "only when the potential loss of other economic benefits is introduced into the equation have governments of the nations studied concluded that it is in their interest to reform their intellectual property protection regimes."

While the potential loss of economic benefits surely motivates countries to strengthen their intellectual property laws, the perception of potential loss appears to be a more complicated phenomenon than Gadbow and Richards' characterization of it. If U.S. trade pressure is the direct and preponderant reason developing countries have strengthened their intellectual property law, what explains the laggards? As an example, consider the four countries Mody notes as affected by the 1984 Trade and Tariff Act. By the end of 1990, Mexico and Korea had both greatly liberalized their trade regimes (see above) and had taken steps to markedly strengthen their intellectual property laws,⁸ while Brazil and Thailand had done neither.⁹

The recalcitrance of Brazil and Thailand¹⁰ does not mean U.S. trade pressures are ineffective any more than the continuation of speeding in the United States means that traffic laws are ineffective. But this recalcitrance does suggest that other factors are involved. Here, a broader definition of "potential loss" than what Gadbow and Richards seem to be using is in order. That is, countries that impose barriers to foreign competition may more fully serve themselves by making backward technology cheap than by allowing the most modern technology to be expensive. But when (as in the case of Mexico) they choose to open their economies to foreign competition, it is the loose intellectual property regime that becomes more expensive.

Thus, while U.S. policy encourages countries to tighten their intellectual property regimes, the policy may be most effective with countries that have chosen to open their economies to trade. After all, these countries have the strongest predisposition to tighten their intellectual property regimes, in any case.

This argument has significant implications for the process by which U.S. policy actually affects other nation's intellectual property laws. This argu-

ment suggests that the direct effect of U.S. trade policies upon Third World intellectual property laws may not be as strong as the indirect effect, in which the U.S. trade policies simply influence other nation's trade policies. That is, to the extent that U.S. trade policy motivates Third World countries to lower their trade barriers, then U.S. policy indirectly motivates Third World countries to tighten their intellectual property regimes. If trade liberal-

⁸ Although Brazil did adopt copyright protection for software in 1987 and enforced it (Sherwood 1990, 196), until very recently there have been few other changes to Brazil's intellectual property regime since the early 1970s. In addition, "the Brazilian judicial system does not appear to provide an effective deterrent to violations of intellectual property rights" (Frischtak 1990, 73). In 1991, the office of the U.S. Trade Representative placed Brazil on its priority watch list of areas "where the U.S. faces 'serious problems' with intellectual property protection or market access" (Truell and Lachica 1991, A16). However, Brazil has very lately begun to liberalize more of its trade policies, including those on some high-technology imports. As of last February, Brazil began to allow the free import of hard and floppy disk drives and digital voice mail equipment. Additional products will be subject to liberalization as of October 29, 1992. Meanwhile, some tightening of related intellectual property protection has also begun to occur. In June 1992, Brazil announced that it would begin to protect "franchise agreements" that may include a combination of trademark usage, technical service assistance, and other types of technology transfer included in the agreements. With regard to Thailand, Schumann (1990, 164) notes that "Infringement of intellectual property rights seems to be an ongoing issue despite efforts by some Asian countries to suppress it. In 1988, the Asia-Pacific Council of American Chambers of Commerce view Thailand as the worst offender." She adds that "the United States Trade Representative (USTR) report on 'Special 301' of May 25, 1989, determined Thailand and India as being leaders of its 'priority watch list'..."

¹⁰ This recalcitrance has had its costs. As a result of noncompliance with U.S. requirements, Thailand lost GSP privileges, resulting in a 5-percent to 10-percent import duty increase on \$165 million of Thai exports. The United States also imposed 100-percent duties on \$39 million of Brazilian exports, even though these exports were not related to products or services on which intellectual property infringement was alleged. Moreover, the United States proposed but did not implement punitive tariffs on \$105 million of Brazilian exports as a sanction against Brazilian computer policy. This last measure was withdrawn with the passage of the Brazilian software copyright law mentioned in the previous footnote. As for the other penalties, "exporters in Thailand and Brazil have said they can live with the increased duties." (Mody 1990, 224)

ism motivates intellectual property conservatism, then pressures for trade liberalism are pressures for tight intellectual property protection.¹¹

In this context, however, it is important to remember that the events of the 1980s in the Third World motivated intellectual property protection in any case. Latin America's increasing technological backwardness—caused by a combination of declining investment there, accelerating technological advances in the First World, and Latin

America's own innovation-discouraging institutional structure—should be a strong motivator when nations in the region must focus on manufactures exports to pay their foreign debts.

It is, of course, difficult to know if these pressures alone would have been sufficient to motivate Third World countries to amend their intellectual property laws. But it is unusual to find countries that have tightened these laws when trade liberalization had not occurred as well.

¹¹ *While the importance of what I claim to be the connection between trade policies and intellectual property regimes seems not to be fully appreciated, it certainly has been recognized. Primo Braga (1990b) notes that "the foreign debt crisis, decreasing private capital flows to developing countries, negative experiences with the regulatory approach, outward-oriented development strategies, and the ongoing 'technological revolution' are some of the possible explanations for the more liberal posture adopted by many developing countries on intellectual property" [emphasis mine]*

References

- Baer, Werner (1993), "U.S.–Latin American Trade Relations: Past, Present, and Future," in *Free Trade in North America: Expanding Trade for Prosperity*, ed. Gerald P. O'Driscoll, Jr. (Boston: Kluwer Academic Publishers), forthcoming.
- Barbera, Mattia (1990), "Latin America's Place in World Trade," *CEPAL Review* 41 (August).
- Beristain, Javier, and Ignacio Trigueros (1990), "Mexico," in *Latin American Adjustment: How Much Has Happened?* ed. John Williamson (Washington, D.C.: Institute for International Economics), 154–68.
- Braga, Helson C., and Larry N. Willmore (1991), "Technological Imports and Technological Effort: An Analysis of Their Determinants in Brazilian Firms," *The Journal of Industrial Economics* 39 (June): 421–33.
- Butler, Alison (1990), "The Trade-Related Aspects of Intellectual Property Rights: What Is at Stake," *Federal Reserve Bank of St. Louis Review* November–December, 34–46.
- Cardoso, Eliana A., and Daniel Dantas (1990), "Brazil," in *Latin American Adjustment: How Much Has Happened?* ed. John Williamson (Washington, D.C.: Institute for International Economics), 129–53.
- Chin, Judith C., and Gene M. Grossman (1990), "Intellectual Property Rights and North–South Trade," in *The Political Economy of International Trade*, ed. Ronald W. Jones and Anne O. Krueger (Cambridge, Mass.: Basil Blackwell), 90–107.
- Collins, Susan M. (1990), "Lessons From Korean Economic Growth," *American Economic Review* 80 (May): 104–07.
- Diwan, Ishac, and Dani Rodrik (1991), "Patents, Appropriate Technology, and North–South Trade," *Journal of International Economics* 30 (February): 27–48.
- East Asian Executive Reports* (1991), "Intellectual Property Rights in Korea: Legal Framework and Enforcement Problems—Part II: Trade-marks, Copyrights, Software," 13 (February): 18–20.
- (1990), "Intellectual Property Rights in Korea: Legal Framework and Enforcement Problems—Part I: Patents," 12 (November): 13–5.
- Einstein, Edwin F. (1991), "Promising Developments in Technology Transfer and Intellectual Property Protection in Mexico," in *North American Free Trade: Proceedings of a Conference* (Dallas: Federal Reserve Bank of Dallas), 123–37.
- Evenson, Robert E. (1990), "Survey of Empirical Studies," in *Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature*, ed. Wolfgang E. Siebeck, World Bank Discussion Papers, no. 112 (Washington D.C.: The World Bank), 33–46.
- Frischtak, Claudio R. (1990), "The Protection of Intellectual Property Rights and Industrial Technology Development in Brazil," in *Intellectual Property Rights in Science, Technology, and Economic Performance: International Comparisons*, eds. Francis W. Rushing and Carole Ganz Brown (Boulder, Col.: Westview Press), 61–98.
- Gadbaw, R. Michael (1988), "Republic of Korea," in *Intellectual Property Rights: Global Consensus, Global Conflict?* eds. R. Michael Gadbaw and Timothy J. Richards (Boulder, Col.: Westview Press), 272–310.
- , and Timothy J. Richards (1988), "Introduction," in *Intellectual Property Rights: Global Consensus, Global Conflict?* eds. R. Michael Gadbaw and Timothy J. Richards (Boulder, Col.: Westview Press), 1–37.
- Gilbert, R.J., and D. Newbery (1982), "Pre-emptive Patenting and the Persistence of Monopoly," *American Economic Review* 72 (June): 514–26.

- Hoay, T.B. (1988), "The 1987 Singapore Copyright Act and Its Economic Consequences," *APLA [Asia-Pacific Lawyers Association] Journal*, December, 111–15.
- Laird, Sam, and Julio Nogues (1989), "Trade Policies and the Highly Indebted Countries," *World Bank Economic Review* 3 (May): 241–61.
- Latin American Monitor* (1991), "The Doors Are Opening," 8 (September): 937.
- Lesser, William (1990), "An Overview of Intellectual Property Systems," in *Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature*, ed. Wolfgang E. Siebeck, World Bank Discussion Papers, no. 112 (Washington, D.C.: The World Bank), 5–15.
- Levin, Richard C., Alvin K. Klevorick, Richard R. Nelson, and Sidney G. Winter (1987), "Appropriating the Returns from Industrial Research and Development," *Brookings Papers on Economic Activity* (3), 783–820.
- MacLaughlin, Janet H., Timothy J. Richards, and Leigh A. Kenny (1988), "The Economic Significance of Piracy," in *Intellectual Property Rights: Global Consensus, Global Conflict?* eds. R. Michael Gadbaw and Timothy J. Richards (Boulder, Col.: Westview Press), 89–108.
- Mansfield, Edwin (1986), "Patents and Innovation: An Empirical Study," *Management Science*, February, 173–81.
- (1985), "How Rapidly Does Industrial Technology Leak Out?" *Journal of Industrial Economics* 34 (December): 217–23.
- , John Rapoport, Anthony Romeo, Samuel Wagner, and George Beardsley (1977), "Social and Private Rates of Return from Industrial Innovations," *Quarterly Journal of Economics* 91 (May): 221–40.
- Mody, Ashoka (1990), "New International Environment for Intellectual Property Rights," in *Intellectual Property Rights in Science, Technology, and Economic Performance: International Comparisons*, eds. Francis W. Rushing and Carole Ganz Brown (Boulder, Col.: Westview Press), 203–39.
- Nunnenkamp, Peter, and Ugo Fasano-Filho (1986), "Manufactured Export Performance of Brazil: Analysis of Determinants and Prospects," Kiel Working Paper, no. 269 (Kiel, Germany: Kiel Institute of World Economics, September).
- Organization for Economic Cooperation and Development (1989), "Economic Arguments for Protecting Intellectual Property Rights Effectively," TC/WP (88)70 (Paris: OECD).
- Prebisch, Raul (1959), *The Economic Development of Latin America and Its Principal Problems* (New York: United Nations).
- (1950), "Commercial Policy in the Underdeveloped Countries," *The American Economic Review*, Papers and Proceedings of the American Economics Association, 49 (May): 251–83.
- Primo Braga, Carlos Alberto (1990a), "Guidance from Economic Theory," in *Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature*, ed. Wolfgang E. Siebeck, World Bank Discussion Papers, no. 112 (Washington, D.C.: The World Bank), 17–32.
- (1990b), "The Developing Country Case For and Against Intellectual Property Protection," in *Strengthening Protection of Intellectual Property in Developing Countries: A Survey of the Literature*, ed. Wolfgang E. Siebeck, World Bank Discussion Papers, no. 112 (Washington, D.C.: The World Bank), 69–87.
- (1989), "The Economics of Intellectual Property Rights and the GATT: A View From the South," *Vanderbilt Journal of Transnational Law* 22, 243–64.
- Schankerman, Mark (1991), "How Valuable is Patent Protection? Estimates by Technology Field Using Patent Renewal Data," NBER

- Working Paper Series, no. 3780 (Cambridge, Mass: National Bureau of Economic Research, July).
- Schumann, Gunda (1990), "Economic Development and Intellectual Property Protection in Southeast Asia: Korea, Taiwan, Singapore, and Thailand," in *Intellectual Property Rights in Science, Technology, and Economic Performance: International Comparisons*, eds. Francis W. Rushing and Carole Ganz Brown (Boulder, Col.: Westview Press), 157–202.
- Sherwood, Robert M. (1990), *Intellectual Property and Economic Development* (Boulder, Col.: Westview Press).
- Truell, Peter, and Eduardo Lachica (1991), "Politics and Policy: Administration Gets Tough on
- Trade as Congress Gets Set to Vote on Extending Negotiating Powers," *Wall Street Journal*, April 29, A16.
- United Nations (1964), *The Role of Patents in the Transfer of Technology to Developing Countries*, Report of the Secretary General (New York: United Nations).
- Vessuri, H.M.C. (1990), "O Inventamos O Erramos: The Power of Science in Latin America," *World Development* 18 (November): 1543–1553.
- Williamson, John (1990), *The Progress of Policy Reform in Latin America* (Washington, D.C.: Institute for International Economics).

Regional Wage Divergence and National Wage Inequality

In recent years, concern about rising wage and income inequality in the United States has been expressed in both the mass media and the academic literature. The media stories have stressed the uneven nature of the gains in wages and incomes during the 1980s, with reports that the gains have been concentrated at the top of the distribution and that most Americans have seen little, if any, increase in either wages or income.¹

The academic literature on the subject has been focused on the possible causes of the rise: labor-supply factors—such as changes in the education, age, and gender of the work force—and labor-demand factors—such as changes in the industry and occupation mix. Although several recent studies have pointed to some possible causes for the rise in inequality, much of the rise remains unexplained.²

In this study, I seek to add to the literature by addressing the question of how much of the rise in U.S. wage inequality during the 1980s can be explained by a divergence in wages across regions. Several studies have shown that after a long period of convergence, regional wages diverged during the 1980s. These studies also indicate that the divergence was likely temporary and that wages are likely to return to convergence. If a strong link exists between the regional divergence and the rise in U.S. wage inequality, then a return to regional convergence in the 1990s could put significant downward pressure on wage inequality.

I find that the regional shocks that occurred during the 1980s produced a pattern of wage divergence that correlated closely with the pattern of national wage inequality. In a mathematical decomposition of national wage inequality, however, I find that the divergence of regional wages

accounted for only 2.1 percent to 5 percent of the rise in national wage inequality. The regional effect is similar in magnitude to factors relating to the industrial structure but is relatively small in comparison with factors relating to education, occupation, gender, and age. Given this result, the regional convergence that will likely take place in the 1990s is unlikely to have a significant impact on overall wage inequality in the United States.

National wage inequality

In a review of the literature on wage inequality, Loveman and Tilly (1988) find that most researchers agree that the inequality of labor earnings has increased since the late 1970s. The causes of the increase, however, are not well understood. According to Loveman and Tilly, factors such as changes in gender composition, age distribution, and industrial and occupational mix explain only a small part of the rise in earnings inequality.

I wish to thank Joseph H. Haslag, Zsolt Becsi, Stephen P.A. Brown, and Lori L. Taylor for helpful comments and James L. Hedges for excellent research assistance.

¹ For example, see Smith (1992) and Stein (1992).

² While studies have found a rise in both income and wage inequality, the two measures are quite different. Income is affected by investment income and transfers. Household income is affected by family size and structure. In this study, I look solely at pretax wages, and, thus, my focus is on the structure of labor income. Labor income does not reflect the total income or the overall welfare of individuals.

In more a more recent study, Grubb and Wilson (1992) find that factors relating to education and occupation played important roles in a rise in wage inequality in the 1980s, while worker age and industry had relatively small impacts. Grubb and Wilson find, however, that much of the rise in inequality in the 1980s was unexplained. They conclude that the spread of wages across education groups is likely to continue to increase in the future, causing further upward pressure on wage inequality. The authors caution that further analysis is needed to find a more complete explanation for the rise in wage inequality.

Bound and Johnson (1992) highlight three major wage structure developments in the 1980s: an increase in wage differentials by education, a decrease in the gender wage gap, and—for workers without a college degree—an increase in the average wage of older workers relative to younger workers. Bound and Johnson conclude that the principal reason for the increase in wage differential by education and the decrease in the gender differential was a skilled-labor-biased technological change. The authors found little to explain the relative-wage decrease of young workers with low educational attainment. The authors indicate that wage differentials by education are likely to continue to increase, putting further upward pressure on wage inequality.

Regional wage divergence

One possible factor in rising national wage inequality that has received relatively little attention is a divergence in wages across regions. Browne (1989) notes that “after three decades of

gentle convergence, regional per capita incomes diverged sharply in the 1980s.” She finds that changes in relative wages were the primary source of changes in regional per capita income.

If regional shocks, such as the recessions in the oil and farm belts, caused wages in low-wage areas of the country to decline relative to the wealthier areas, then this change could cause national wage inequality to increase. And if these shocks were temporary, then a return to regional convergence in the 1990s could put downward pressure on wage inequality.

Eberts (1989) finds that a divergence in regional wages in the 1980s likely was caused by region-specific factors, such as the oil and farm crisis, and was not merely the uneven regional impact of changing national patterns. For example, if there was a regional concentration of highly educated workers, then the national rise in wages resulting from educational attainment could have resulted in regional wage divergence. Eberts shows that the rise in regional wage inequality generally was not caused by differences in regional shares of demographic and industry factors.

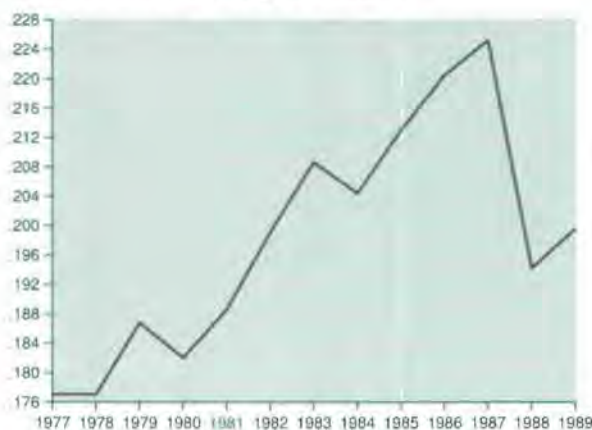
Carlino (1992) uses a time-series approach to determine whether the regional earnings divergence in the 1980s was caused by permanent or temporary shocks. He concludes that the divergence was most likely caused by temporary shocks, such as the energy and agricultural shocks, and that the divergence does not represent a reversal of the long-term trend in regional convergence. Given the results of Eberts’ and Carlino’s studies, the regional wage divergence in the 1980s was likely temporary and independent of national demographic and industry factors. These results indicate that if regional divergence in the 1980s had a strong impact on national wage inequality, then a return to regional wage convergence in the 1990s could put significant downward pressure on wage inequality.

Describing U.S. wage inequality and regional shocks

As shown in Figure 1, wage inequality in the United States increased throughout much of the 1980s.³ The measure of wage inequality shown in Figure 1 is the population-weighted Theil statistic. (For more information about the calculation and

³ In this study, wages are measured as annual wages and salaries of people 16 years of age or older who worked year-round, full-time (YRFT), or, more precisely, people who worked fifty weeks or more during the year and thirty-five or more hours during the week. The data are taken from the March Current Population Surveys (CPS) of the U.S. Bureau of the Census. During the study period, YRFT workers represented 54 percent to 60 percent of all sampled workers, and the sample size of YRFT workers ranged from 41,750 in 1977 to 50,434 in 1989. Although average hourly wages received during the year for all workers are preferred, this information is not available on the CPS tapes.

Figure 1
Theil Measure of Wage Inequality



NOTE: This measure is defined in equation 2 in the box.

SOURCE OF PRIMARY DATA: U.S. Department of Commerce, Bureau of the Census, Current Population Survey, March tapes.

properties of this measure of inequality, see the box titled "Using the Population-Weighted Theil Measure of Inequality.") As shown in Figure 1, wage inequality increased from 1978 to 1987 and then declined. The rise in wage inequality shown here is consistent with other measures of wage inequality.⁴

The rise in wage inequality in the early 1980s is at least partly explained by the two recessions that occurred between 1980 and 1982. Previous work has shown that wage inequality typically increases during cyclical downturns and decreases during expansions.⁵ The increase in inequality during the long expansion from 1983 to 1987 is more difficult to explain. The rise in wage inequality, however, matches closely with the economic decline in the farm and oil states and the corresponding rise in the defense states.

As shown in Figure 2, employment in the farm and oil states generally grew faster than the national average during the 1970s.⁶ But during the 1980s, these regions weakened sharply. High debt levels, combined with rising interest rates and falling farm exports, pushed the farm economy into a recession that persisted until 1987.⁷ The energy states also entered a recession following a peak in oil prices in early 1981. Following some improvement in 1984 and 1985, the energy states suffered a sharp blow in 1986, when oil prices

crashed and real estate markets tumbled.

In contrast with the oil and farm areas of the country, the defense dependent regions grew at a healthy pace during the 1980s (Figure 3).⁸ Between 1980 and 1987, national defense outlays, in constant dollars, increased at an annual rate of 5.3 percent, and total defense employment increased at an annual rate of 4.2 percent. The military buildup was centered in private-sector companies that produce military equipment. Private-sector defense employment grew 7.8 percent annually, while public-sector military personnel grew only 1.4 percent annually.⁹ The strong surge in defense

⁴ Karoly (1992) shows that ten different measures of wage inequality all increased during the 1980s.

⁵ For example, Blank (1985) finds that "the income distribution narrows in times of growth, primarily because of large elasticities of labor market income among poor heads of household for whom both wages and hours increase during economic upturns." Also, Bluestone and Harrison (1988) find that the proportion of year-round full-time workers who earned low wages has a statistically significant negative relationship with cyclical movements in gross national product.

⁶ The farm states are defined as deriving at least 5.2 percent of their gross state product in 1977 from farming (The national average was 2.6 percent.) These states are Arkansas, Idaho, Iowa, Kansas, Minnesota, Mississippi, Montana, Nebraska, North Dakota, South Dakota, and Wisconsin. The energy states are defined as those that would suffer employment losses from a decline in energy prices, as shown in Brown and Hill (1988). The energy states are Alaska, Colorado, Louisiana, New Mexico, Oklahoma, Texas, West Virginia, and Wyoming (Kansas and North Dakota also suffered employment losses from an energy-price decline but were not included here because they were considered primarily agricultural states.)

⁷ For a discussion of the reasons for the farm recession in the early 1980s and its subsequent recovery that began in 1987, see Drabentstolt and Barkema (1990).

⁸ The defense states were defined as states (plus the District of Columbia) that in 1991 had at least 3 percent of their work force employed in the private defense industry. The defense states are Arizona, California, Connecticut, Maryland, Massachusetts, Virginia, and Washington.

⁹ Figures for defense spending and employment were taken from pages 61, 229, and 230 of U.S. Congress, Office of Technology Assessment (1992).

Figure 2
Economic Performance of Energy
and Farm States



NOTE: The lines are equal to the year-over-year percentage growth in employment in the farm and energy states minus the year-over-year percentage of growth in U.S. employment.

SOURCE: Bureau of Labor Statistics, Establishment Survey.

Figure 3
Relative Economic Performance
of Defense States



NOTE: The line is equal to the year-over-year percentage growth in employment in the defense states minus the year-over-year percentage of growth in U.S. employment.

SOURCE: Bureau of Labor Statistics, Establishment Survey.

spending boosted employment and wages in areas of the country where defense companies were located.

The weak performance of the farm and energy regions reduced their relative wages, while the relative wages of the defense states rose. As shown in Figure 4, from 1981 to 1987 relative wages in the energy states declined from 102.8 percent of the national average to 97.7 percent, and relative wages in the farm states declined from 94.3 percent of the national average to 89.3 percent. In contrast, wages in the defense states grew from 105.6 percent of the national average in 1981 to 110.3 percent in 1987.

During the late 1980s, defense spending began to decline. The end of the defense buildup had a detrimental effect on employment growth and relative wages in the defense states, as shown in Figures 3 and 4. During this period, a gradual recovery was occurring in the farm and oil regions of the country, and employment growth improved in these areas. As shown in Figure 5, the dispersion of average wages across regions increased sharply between 1978 and 1987, and subsequently

fell from 1987 to 1989. The divergence in regional wages from 1978 to 1987, and the subsequent convergence, is consistent with first the increase, and then the decline, in national wage inequality in the 1980s.

A decomposition of the rise in wage inequality

While the timing of changes in regional wage dispersion suggests a link to national wage inequality, a decomposition of national wage inequality shows that regional wage divergence had only a small direct impact on the rise in national wage inequality. Although the dispersion in average wages across the four economic regions increased sharply between 1978 and 1987, and from 1982 to 1987 (*Figure 5*), the effect of the increased dispersion on national wage inequality was small in both periods.

The Theil measure of inequality can be decomposed into two main effects: inequality caused by inequality in average wages across groups and inequality caused by wage inequality

within groups. Both of these effects can then be divided into a primary effect and the effect of changing shares. For example, inequality that results from inequality of average wages across groups could increase even if the estimated mean wage of each group remained constant. This increase would occur if the employment shares shift such that the weight given to a high- or low-wage group increases and the weight given to an average-wage group decreases. Similarly, overall inequality could increase if wage inequality was constant within each group but the employment share rose for a high-inequality region and declined for a low-inequality region.

The Theil measure of inequality increased from 0.177 to 0.225 from 1978 to 1987, from 0.199 to 0.225 from 1982 to 1987, and then decreased to 0.199 in 1989. Table 1 shows the decomposition of these changes in the Theil into the two main effects and then, within these main effects, that part that results from changing employment shares. As shown in the top half of Table 1, between 1978 and 1987 the national Theil increased by 0.0481, and the change in the dispersion of average wages across regions only accounted for 0.001 (or 2.1 percent) of the increase. Almost all this change was brought on by wage changes, not by changing employment

Figure 4
Relative Regional Wages
(Regional Wage Divided by U.S. Wage)



SOURCE OF PRIMARY DATA: Bureau of Labor Statistics, Establishment Survey.

Figure 5
Dispersion of Wages Across Economic Regions



NOTE: The measure of dispersion show here is defined in equation 5 in the box.

SOURCE OF PRIMARY DATA: Bureau of Labor Statistics, Establishment Survey.

shares. Excluding the recessionary periods of the late 1970s and early 1980s, increases in the variation of average wages across economic regions still accounts only for 2.7 percent of the increase in national wage dispersion.

Most of the rise in wage inequality is left unexplained by the divergence in average wages across regions. Increased wage dispersion was mostly a result of increased wage dispersion within regions. The increase within regions gives little information about the causes of the rise in wage inequality. As shown in Table 2, wage inequality, as measured by the regional Theil statistic, rose in all four regions from 1978 to 1987 and from 1982 to 1987. During the period from 1982 to 1987, inequality in the farm and oil states increased at a significantly faster pace than in the defense states and at a moderately faster pace than in the remaining states.

While the shocks to the farm, oil, and defense regions likely played a major role in the divergence of regional wages, other factors likely also played a role. To account for other factors, I also look at the effect on national wage inequality of the wage divergence across all fifty states and the District of Columbia. As shown in the bottom half of Table 1, the overall effect does not in-

Table 1

Decomposition of Theil¹ Measure of National Wage Inequality**Decomposition by Economic Regions²**

	1978–87	1982–87	1987–89
Change in Theil (Equals 1 + 2)	.0481	.0260	-.0256
1. Change in inequality of wages across regions (Equals A + B)	.0010	.0007	-.0003
A. Due to change in weight given to each region	.00005	.00003	.00000
B. Due to change in wages	.00098	.00069	-.00030
2. Change in inequality within regions (Equals C + D)	.0471	.0253	-.0254
C. Due to change in weight given to each region	-.00005	-.00040	.00002
D. Due to change in regional inequality measures	.04709	.02572	-.02539

Decomposition by States³

	1978–87	1982–87	1987–89
Change in Theil (Equals 1 + 2)	.0481	.0260	-.0256
1. Change in inequality of wages across states (Equals A + B)	.0016	.0013	-.0004
A. Due to change in weight given to each state	.00005	.00009	.00000
B. Due to change in wages	.00158	.00121	-.00040
2. Change in inequality within states (Equals C + D)	.0464	.0247	-.0252
C. Due to change in weight given to each state	.00122	.00002	-.00008
D. Due to change in state inequality measures	.04522	.02474	-.02513

¹ The Theil statistic increased 27.1 percent from 1978 to 1987, (from 0.177 to 0.225), 13.1 percent from 1982 to 1987 (from 0.199 to 0.225), and declined 11.5 percent from 1987 to 1989 (from 0.225 to 0.199). For more information on the calculation and decomposition of the Theil, see the box.

² The four economic regions are the energy states, the farm states, the defense states, and all other states (including the District of Columbia). For more information on the states included in each region, see footnotes 6 and 7 in the text.

³ Includes the District of Columbia.

Table 2
Average Wages and Wage Inequality¹ Within Regions

Regions	1978			1982			1987		
	Wages	Theil	Weight	Wages	Theil	Weight	Wages	Theil	Weight
Energy	14,287	.198	11.9	20,200	.215	13.2	24,785	.250	12.0
Farm	13,424	.191	9.9	18,962	.208	9.4	22,655	.242	9.3
Defense	15,625	.176	22.4	22,020	.205	23.4	27,993	.221	24.1
Other	14,475	.169	55.7	19,724	.189	54.0	24,807	.215	54.5

¹ Data are for year-round, full-time workers. The Theil measure of inequality is described in the box.

SOURCE OF PRIMARY DATA: U.S. Department of Commerce, Bureau of the Census, Current Population Survey, March tapes.

crease significantly with the larger breakdown. Only 3.3 percent of the net increase in national inequality between 1978 and 1987 can be directly attributed to an increased dispersion in average wages across states. Excluding the recessionary periods of the late 1970s and early 1980s, increases in the variation of wages across states still only accounts for 5 percent of the increase in national wage dispersion. Once again, the increased wage dispersion was mostly a result of increased wage dispersion within states. The rise in wage inequality within states was widespread, with wage inequality rising in forty-four states from 1978 to 1987 and in thirty-seven states from 1982 to 1987.

The divergence of wages across states played a smaller role in national wage inequality than did several other factors, such as a rise in the variance of wages across groups classified by education, occupation, and age. The effect of gender factors was also stronger than the regional factors, but in the opposite direction. A reduction in the wage gap between men and women acted to reduce wage inequality, even while the share of women in the work force grew. The regional effect was similar only to that of the changing industrial structure of the work force.

As shown in Table 3, education and occupational factors seem to have played the largest role in the rise in wage inequality.¹⁰ From 1982 to 1987, an increase in the dispersion of wages across educational groups was responsible for 22.5 percent of the net increase in the Theil; an increase

across occupational groups was responsible for 17.7 percent of the increase; an increase across age groups was responsible for 8.8 percent; and an increase across industries was responsible for 4.6 percent of the increase. A reduction in the dispersion of wages across gender groups reduced the net increase in the Theil by 15.8 percent.¹¹

As shown in the third columns of Tables 1 and 3, wage inequality declined quite sharply from 1987 to 1989. The convergence in wages across states that occurred from 1987 to 1989 accounted for only 1.6 percent of the decline in national wage inequality during that period. The most important factor affecting the decline in wage inequality was a continuing decline in the male-female wage gap. A decline in the relative wages of managerial, professional, technical, and sales workers reduced the occupational wage spread, which also led to less overall wage inequality. The dispersion of wages across educational groups was essentially unchanged from 1987 to 1989.

¹⁰ For definitions of the factor groupings, see the Appendix.

¹¹ The decompositions provided in Tables 1 and 3 simply provide clues as to which economic and demographic factors may have played a role in rising wage inequality. The decomposition ignores important interactions between factors such as occupation and education, and it is thus inappropriate to total the percent explained by all factors.

Table 3

Decomposition of Theil Measure of National Wage Inequality By Demographic and Industry Demand Factors¹

Education	1978-87	1982-87	1987-89
Change in Theil (Equals 1 + 2)	.0481	.0260	-.0256
1. Change in inequality of wages across educational groups (Equals A + B)	.0131	.0058	-.0001
A. Due to change in weight given to each group	-.00018	-.00156	-.00049
B. Due to change in wages	.01331	.00732	.00035
2. Change in inequality within groups (Equals C + D)	.0349	.0203	-.0255
C. Due to change in weight given to each group	-.00016	-.00022	-.00009
D. Due to change in group inequality measures	.03510	.02051	-.02543
Age	1978-87	1982-87	1987-89
Change in Theil (Equals 1 + 2)	.0481	.0260	-.0256
1. Change in inequality of wages across age groups (Equals A + B)	.0034	.0023	-.0023
A. Due to change in weight given to each group	-.00325	-.00085	-.00070
B. Due to change in wages	.00663	.00313	-.00156
2. Change in inequality within age groups (Equals C + D)	.0447	.0238	-.0234
C. Due to change in weight given to each group	-.00056	-.00021	.00075
D. Due to change in group inequality measures	.04525	.02397	-.02413

¹ For definitions of demographic and industry groups, see the Appendix. Data are for year-round, full-time workers.

SOURCE OF PRIMARY DATA: U.S. Department of Commerce, Bureau of the Census, Current Population Survey, March tapes.

(Continued on the next page)

Table 3—Continued

Decomposition of Theil Measure of National Wage Inequality By Demographic and Industry Demand Factors

Gender	1978–87	1982–87	1987–89
Change in Theil (Equals 1 + 2)	.0481	.0260	-.0256
1. Change in inequality of wages across gender (Equals A + B)	-.0077	-.0049	-.0046
A. Due to change in weight given to each group	.00147	.00040	-.00000
B. Due to change in wages	-.00921	-.00528	-.00460
2. Change in inequality within gender groups (Equals C + D)	.0558	.0309	-.0210
C. Due to change in weight given to each group	-.00211	-.00064	-.00001
D. Due to change in group inequality measures	.05792	.03156	-.02102
Occupation			
	1978–87	1982–87	1987–89
Change in Theil (Equals 1 + 2)	.0481	.0260	-.0256
1. Change in inequality of wages across occupations (Equals A + B)	.0078	.0046	-.0033
A. Due to change in weight given to each group	-.00147	-.00033	.00014
B. Due to change in wages	.00926	.00428	-.00340
2. Change in inequality within occupations (Equals C + D)	.0403	.0214	-.0224
C. Due to change in weight given to each group	.00864	.00144	.00154
D. Due to change in group inequality measures	.03164	.02000	-.02393

(Continued on the next page)

Table 3—Continued

Decomposition of Their Measure of National Wage Inequality By Demographic and Industry Demand Factors

Industry	1978–87	1982–87	1987–89
Change in Theil (Equals 1 + 2)	.0481	.0260	-.0256
1. Change in inequality of wages across industries (Equals A + B)	.0020	.0012	-.0022
A. Due to change in weight given to each group	.00064	.00029	.00022
B. Due to change in wages	.00136	.00089	-.00242
2. Change in inequality within industry groups (Equals C + D)	.0461	.0249	-.0234
C. Due to change in weight given to each group	.00539	.00188	.00124
D. Due to change in group inequality measures	.04071	.02298	-.02469

Summary and implications

Throughout much of the 1980s, wage inequality increased in the United States. Previous research has found that a rise in earnings by educational level and increased wage dispersion across occupations were important factors in the rise in wage inequality. Researchers, however, have noted that much of the rise in wage inequality was left unexplained by the demographic and industry factors that they examined. In this study, I have furthered the analysis by examining the impact on wage inequality of a divergence in regional wages that occurred during the 1980s.

I find that regional shocks, such as the recessions in the oil and farm belts, pushed wages lower in these below-average-wage areas, and increased defense spending pushed up wages in above-average-wage areas. While these regional shocks increased overall wage inequality, I find

that regional wage divergence accounted for only 2.1 percent to 5 percent of the rise in national wage inequality. Other factors, such as increased wage dispersion across educational and occupational groups and a reduction in the male–female wage gap, played larger roles.

Although recent studies suggest that regional wages are likely to return to convergence, results of this study suggest that the convergence will likely have only a small impact on national wage inequality. The future direction of wage inequality is unclear. A growing demand for high-skilled workers (without a large increase in the supply of skilled workers) would put upward pressure on wage inequality, while a continued decline in the male–female wage gap would put downward pressure on wage inequality. To get a better idea of the future direction of national wage inequality, further work needs to be done to fully understand the factors affecting wage inequality.

Using the Population-Weighted Theil Measure of Inequality

In this paper, I use a measure of inequality due to Theil (1967, 126–27). As shown in Horrigan (1991), this measure can be written simply as

$$(1) \quad T = \sum_i^P ps_i \ln \left(\frac{ps_i}{is_i} \right),$$

where ps_i is the population share of the i th person, is_i is the income share of the i th person, and P is the number of people in the sample. Thus, the greater is the difference between individual's income share and their population share, the greater is the Theil statistic.

As brought out by Haslag, Russell, and Slottje (1989), no single inequality measure has been proved superior to the others. As described in Shorrocks (1980), however, the population-weighted Theil is one of a limited number of additively decomposable inequality measures that satisfy three important properties:

- A transfer of earnings from a richer to a poorer individual reduces the value of the measure;
- If there are r groups with n individuals and each group has an identical distribution, then aggregating the groups would result in an inequality measure that would be equal to the measure for each of the individual groups; and

- If the wages of each person were multiplied by some positive constant, the degree of inequality would remain the same.

Shorrocks finds that among the limited number of additively decomposable inequality measures that fit these criteria, the population-weighted Theil is the most satisfactory because its decomposition is unambiguous.

In calculating the Theil with CPS data, several problems must be addressed. The first is that each observation is not weighted equally. I address this problem by adjusting the Theil measure to account for unequal weights. As shown in Horrigan (1991), the adjusted Theil is calculated as

$$(2) \quad T = \ln \mu - \frac{\sum_i^P W_i \ln(Z_i)}{N},$$

where

$$(3) \quad \mu = \frac{\sum_i^P W_i * Z_i}{N}, \text{ and}$$

$$(4) \quad N = \sum_i^P W_i.$$

W_i is equal to the CPS sampling weight for individual i , and Z_i is the wage and salary earnings of individual i .

(Continued on the next page)

Using the Population-Weighted Theil Measure of Inequality—Continued

The second problem in using the CPS data is that wages that exceed a set level are not given in the sample. Although the truncated part is usually only between 0.5 percent and 1.5 percent of the sample, it nonetheless can represent an important downward bias in the Theil. To account for these high-wage earners, a Pareto distribution was estimated by state, excluding the lowest-paid 60 percent of the work force.¹ An average top-coded wage for each state was calculated by using the estimated distribution of the top-coded individuals, and each top-coded person was then assigned the average wage.

Once a wage was estimated for each of the top-coded individuals and a national Theil statistic was calculated using the CPS weights, then the Theil was decomposed first into the contribution of wage differences between subgroups:

$$(5) \quad B = \frac{1}{N} \sum_g^G N_g \log \frac{\mu}{\mu_g},$$

where N and μ are defined in equations 3 and 4. The contribution due to inequality within each subgroup $g = 1, \dots, G$ is then defined as

$$(6) \quad C_g = \frac{N_g}{N} T_g,$$

where T_g is the Theil for each group. The aggregate Theil measure is then equal to

$$(7) \quad T = B + \sum_{g=1}^G C_g.$$

¹ Past research on the distributions of wages and income has found that the Pareto distribution fits well at the upper end of the distribution. For example, see Singh and Maddala (1976) and Cramer (1971).

Appendix

Group Definitions

1. Age

- A. 16–19
- B. 20–29
- C. 30–39
- D. 40–64
- E. 65+

2. Education, Years Completed

- A. 0–8 Elementary School or Less
- B. 9–11 Some High School
- C. 12 High School Graduate
- D. 13–15 Some College
- E. 16 College Graduate
- F. 17+ Post-College Graduate

3. Gender

- A. Female
- B. Male

4. Industry

- A. Agriculture, Forestry, and Fisheries
- B. Mining
- C. Construction
- D. Durable Goods Manufacturing
- E. Nondurable Goods Manufacturing
- F. Transportation, Communication, and Public Utilities

G. Trade

- H. Finance, Insurance, and Real Estate
- I. Business and Repair Services
- J. Personal Services
- K. Entertainment and Recreational Services
- L. Professional Services
- M. Public Administration

5. Occupation

- A. Executive, Administrative, and Managerial
- B. Professional
- C. Technicians and Related Support
- D. Sales Occupations
- E. Administrative Support
- F. Private Household
- G. Protective Service
- H. Farming, Forestry, and Fishing
- I. Precision Production, Craft, and Repair
- J. Machine Operators, Assemblers, and Inspectors
- K. Transportation and Material Moving
- L. Handlers, Equipment Cleaners, Helpers, and Laborers

References

- Blank, Rebecca (1985), "Disaggregating the Effects of Economic Growth on the Distribution of Income," Institute of Research on Poverty Discussion Paper no. 780-85 (Princeton, N.J.: Department of Economics and Woodrow Wilson School of Public and International Affairs, Princeton University, September).
- Bluestone, Barry, and Bennett Harrison (1988), "The Growth of Low-Wage Employment: 1963-86," *American Economic Association Papers and Proceedings* 78 (May): 124-28.
- Bound, John, and George Johnson (1992), "Changes in the Structure of Wages in the 1980's: An Evaluation of Alternative Explanations," *American Economic Review* 82 (June): 371-92.
- Brown, S.P.A., and John K. Hill (1988), "Lower Oil Prices and State Employment," *Contemporary Policy Issues* 7 (July): 60-68.
- Browne, Lynn E. (1989), "Shifting Regional Fortunes: The Wheel Turns," Federal Reserve Bank of Boston *New England Economic Review*, May/June, 27-40.
- Carlino, Gerald A. (1992), "Are Regional Per Capita Earnings Diverging?" Federal Reserve Bank of Philadelphia *Business Review*, March/April, 3-12.
- Cramer, J. S. (1971), *Empirical Econometrics* (Amsterdam: North-Holland Publishing Company).
- Drabenstott, Mark, and Alan D. Barkema (1990), "U.S. Agriculture Charts a New Course for the 1990s," Federal Reserve Bank of Kansas City *Economic Review*, January/February, 32-49.
- Eberts, Randall W. (1989), "Accounting for the Recent Divergence in Regional Wage Differentials," Federal Reserve Bank of Cleveland *Economic Review*, Third Quarter, 14-26.
- Grubb, W. Norton, and Robert H. Wilson (1992), "The Effects of Demographic and Labor Market Trends on Wage and Salary Inequality, 1967-1988," *Monthly Labor Review*, forthcoming.
- Haslag, Joseph H., William R. Russell, and Daniel Slottje (1989), *Macroeconomic Activity and Income Inequality in the United States*, vol. 55 in *Contemporary Studies in Economic and Financial Analysis* (Greenwich, Conn.: JAI Press, Inc.).
- Horrigan, Michael (1991), "The Effect of Truncation Bias on Measures of Inequality" (Paper presented at the Western Economic Association meetings, Seattle, Washington, June 29-July 3).
- Karoly, Lynn A. (1992), "Changes in the Distribution of Individual Earnings in the United States: 1967-1986," *Review of Economics and Statistics* 74 (February): 107-15.
- Loveman, Gary W., and Chris Tilly (1988), "Good Jobs or Bad Jobs: What Does the Evidence Say?" Federal Reserve Bank of Boston *New England Economic Review*, January/February, 46-65.
- Shorrocks, A.F. (1980), "The Class of Additively Decomposable Inequality Measures," *Econometrica* 48 (April): 613-25.
- Singh, S. K., and G. S. Maddala (1976), "A Function for Size Distribution of Incomes," *Econometrica* 44 (September): 963-70.
- Smith, Lee (1992), "Are You Better Off?" *Fortune*, February 24, 39-46.
- Stein, Herbert (1992), "Reflections on the Top 1 Percent," *Wall Street Journal*, May 26, A14.
- Theil, Henri (1967), *Economics and Information Theory*, vol. 7 in *Studies in Mathematical and Managerial Economics* (Amsterdam: North-Holland Publishing Company).
- U.S. Congress, Office of Technology Assessment (1992), *After the Cold War: Living With Lower Defense Spending*, OTA-ITE-524 (Washington, D.C.: U.S. Government Printing Office), February.

1992 Index

Economic Review

First Quarter

The Case of the Missing M2

John V. Duca

Monetary Policy in a Small Open Economy: The Case of Singapore

John H. Wood

Regional Effects of Liberalized Agricultural Trade

Fiona D. Sigalla

Second Quarter

The Comparative Growth Performance of the U.S. Economy in the Postwar Period

Mark A. Wynne

Free Trade Agreements and the Credibility of Trade Reforms

David M. Gould

Quantifying Management's Role in Bank Survival

Thomas F. Siems

Third Quarter

Money and Output: Correlation or Causality?

Scott Freeman

Loan Growth and Loan Quality: Some Preliminary Evidence from Texas Banks

Robert T. Clair

When Will the United States Grow Out of Its Foreign Debt?

John K. Hill

Fourth Quarter

Do Interest Rates Help Predict Inflation?

Kenneth M. Emery and Evan F. Koenig

Trade Policy and Intellectual Property Protection: The North-South Dispute

William C. Gruben

Regional Wage Divergence and National Wage Inequality

Keith R. Phillips

Past issues of the *Economic Review* are available free of charge by writing to the Public Affairs Department, Federal Reserve Bank of Dallas, Station K, Dallas, TX 75222, or by calling (214) 922-5257.