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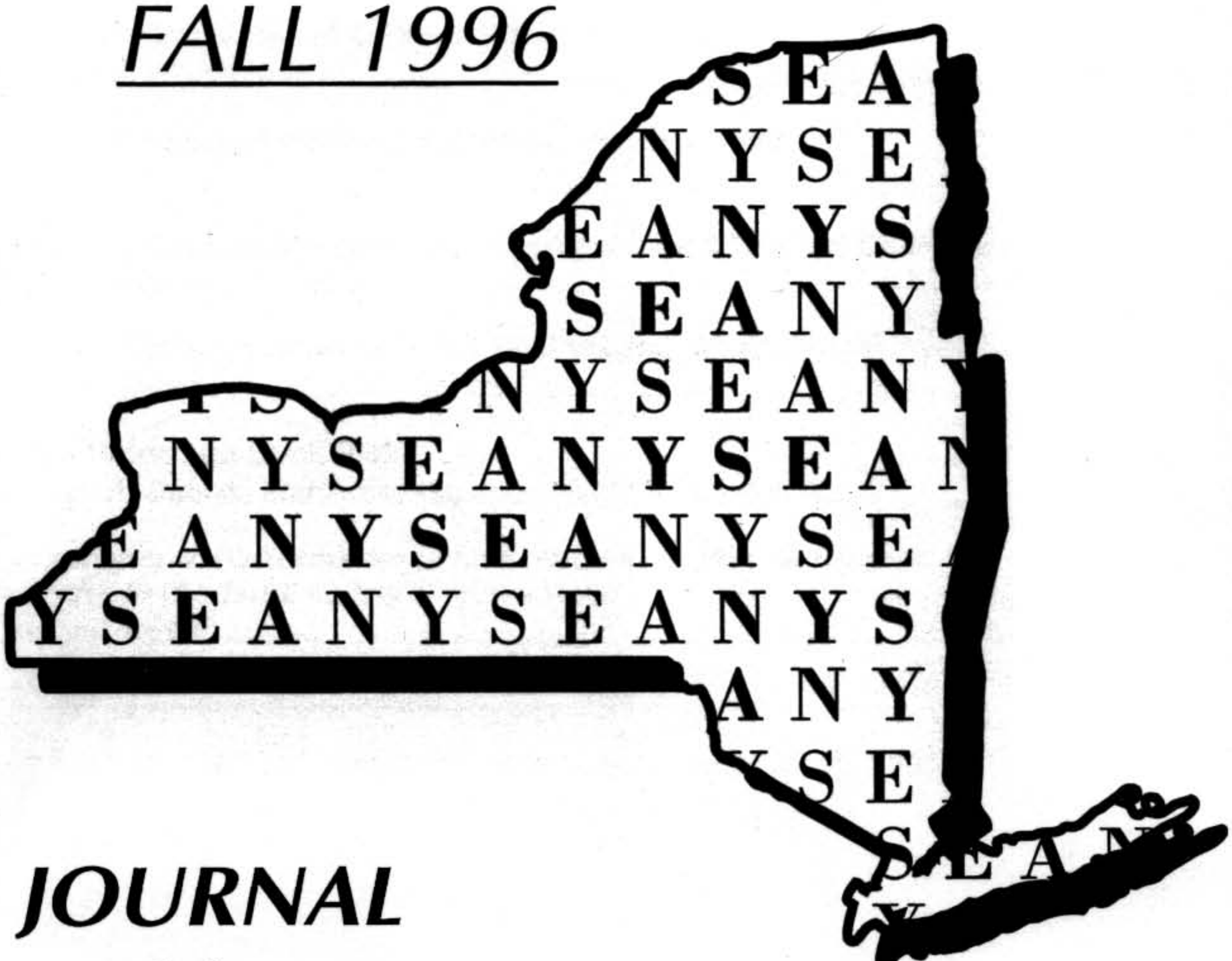
FALL 1996



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CONTENTS

EDITORIAL

The *New York Economic Review* is an annual journal, published in the Fall. The *Review* publishes theoretical and empirical articles, and also interpretive reviews of the literature. We also encourage short articles. The *Review's* policy is to have less than a three month turnaround time for reviewing articles for publication.

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TIME-SERIES ESTIMATES OF OSHA'S EFFECT ON SAFETY

Joseph G. Eisenhauer*

The Occupational Safety and Health Administration (OSHA) was created by Congress in 1970 for the purpose of reducing industrial injuries and illnesses. Specifically, OSHA is charged with (1) establishing health and safety standards, (2) improving data collection, (3) monitoring compliance through inspections, and (4) enforcing the standards by imposing fines and imprisonment on violators. At the time of its enactment, the act was hailed as "the most significant piece of legislation dealing with the work environment of the American wage earner ever passed" (Guenther, 1972, p. 59). Yet since its inception, OSHA has been controversial. A number of studies undertaken in the late 1970s and early 1980s found that OSHA had had little or no effect on safety.

The present paper examines occupational injury and death rates before and after the creation of OSHA. The analysis suggests that, in its first decade, OSHA indeed had no statistically significant effect on observable injury or death rates, a finding which supports earlier studies. Over the longer run, however, a significant improvement in safety is observed.

The first section reviews the previous research. The second and third sections describe the data, methodology, and results of the present study. The paper ends with a brief conclusion.

PREVIOUS RESEARCH

The earliest studies of OSHA almost unanimously found the program to be ineffective. In one of the first studies, Smith (1976) extrapolated injury rates in manufacturing industries from 1968-70 into the 1972-73 period. Comparing his forecasts with actual injury rates in the latter period, he found a statistically insignificant reduction in injury rates. Later, using plant-level data, Smith (1979, p. 169) reported, "...the average 1973-74 impact...suggests an overall reduction of only 1 percent in the aggregate injury rate" and moreover, "the effectiveness of OSHA inspections declined from 1973 to 1974." Utilizing aggregate data, Northrup *et al* (1978, p. 4) reported, "National Safety Council data on injury rates indicate that such rates continued to increase between 1970 and 1974, but do show a marked decline in injury seriousness and particularly in deaths over that period...[however] we lack the theoretical and empirical framework to determine what the trend in measured incidence rates would have been without regulation." Mendeloff (1979) compared projected changes in injury rates with actual rate changes through 1974-75, and found no significant effects on lost-workday injuries nationally, and a reduction of less than three percent in California. In a widely reported study of pooled time-series and cross-section data, Viscusi (1979) found no significant reduction in injury rates for the 1972-75 period. In a more limited analysis, Cooke and Gautschi (1981) found that over 1970-76, OSHA inspections did reduce lost workday cases, but only for large manufacturing firms (those with 200 or more employees) in the state of Maine; and Viscusi (1986) later cast doubt on the validity of the Cooke and Gautschi findings.

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Summarizing the first decade of research on OSHA, Nichols and Zeckhauser (1981, p. 202) reported, "None of a number of studies of the agency's effectiveness has detected an appreciable (harsher critics would say noticeable) reduction in workplace accidents in America." They contend (p. 217) that "Although the studies are by no means conclusive, they tend to reinforce the impression gained from the raw data: OSHA has not affected injury rates significantly in either a statistical or a practical sense."

Two explanations have generally been offered for these findings (Bartel and Thomas, 1985). One is that the OSHA mandates emphasize equipment standards, but fail to address human error. The other explanation has been that OSHA enforcement is ineffective, both because the probability of catching violators is low, and because the financial penalties are relatively inexpensive (Barnum and Gleason, 1976). Thus, it is argued that there exists an insufficient incentive for firms to comply with the relatively expensive risk control standards.

An alternative explanation, however, is that the effects of OSHA were merely unobservable in earlier studies. Because of the time frame involved, the early studies were only able to make a comparatively short run analysis of OSHA's effects. In contrast, the findings of more recent studies have been mixed. In a study similar to Viscusi's, Marlow (1982) performed a cross-section analysis of 1977 data, and found that neither inspections nor reinspections significantly altered firms' allocation of resources toward safety. McCaffrey (1983) examined nearly 40,000 manufacturing firms over the 1976-78 period, and using a procedure similar to that of Smith (1979) found that inspections had no significant effects on safety, either in the year of the inspection, or the following year. But in a study of injury rates in 22 states over the 1974-78 period, Bartel and Thomas (1985, p. 20) found a small positive effect on safety, and concluded that "if all firms moved into complete compliance [with OSHA standards] then injury rates would fall by 9.8 percent." Robertson and Keeve (1983) obtained positive results in 20 states for the 1975-76 period, and in three plants for the 1973-80 period. Updating his earlier study, Viscusi (1986) found small positive effects on safety, and estimated a reduction in injury rates in the range of 1.5 to 3.6 percent over the 1973-83 period. At about the same time, Noble (1986, p. 205) summarized the literature as follows: "The evidence is ambiguous, but, taken together the available studies suggest that, at best, OSHA had a small positive impact on worker health and safety" between 1971 and 1984.

Most recently, Gray and Scholz examined panel data on 6,842 large manufacturing plants between 1979 and 1985. They found statistically significant effects of OSHA inspections on accidents (Gray and Scholz, 1989) and on injuries (Gray and Scholz, 1991). In an analysis of the same period, however, Ruser and Smith (1991, p. 234) found "little evidence to suggest that OSHA inspections in the early 1980s were effective in reducing the lost-workday injury rate."

The studies reviewed above are summarized in Table 1. In general, it is not until data from the late 1970s and 1980s are included that the research reveals any effects of OSHA on safety. Gradually, however, evidence of a significant effect appears to be emerging as more recent data become available. It is therefore of interest to examine the data over the long run.

INJURY RATE DATA

In contrast to the previous research, the present study utilizes a time series consisting of 44 annual observations of occupational injury rates before and after the creation of OSHA. The periods under consideration are 1948-1970 (pre-OSHA) and 1971-1991 (post-OSHA). As in most previous studies, illnesses are excluded from consideration, for several reasons. First, the vast majority - roughly 95 percent _ of all lost workdays are attributed to injuries (see, for example, Bureau of National Affairs, 1990); second, the data on illesses are less reliable than the data on injuries due to problems of isolating causation; and third, OSHA has traditionally emphasized safety over health, so that any effects of OSHA standards are more likely to be evident in injury figures.

Table 1. Previous Studies of OSHA's Effect on Safety

Period	Author(s), Date	Level of Analysis	Data Measurement*	Findings
1972-73	Smith (1976)	industry	frequency	no significant effects
1970-74	Northrup et al (1978)	aggregate	frequency & severity	injury rates rose, severity fell
1973-74	Smith (1979)	plant	frequency & severity	no significant effects
1971-74	Mendeloff (1979)	state & aggregate	frequency	no significant effects
1972-75	Viscusi (1979)	industry & aggregate	frequency	no significant effects
1970-76	Cooke/Gautschi (1981)	plant	severity	positive effects in Maine
1977	Marlow (1982)	aggregate	violations	no significant effects
1976-78	McCaffrey (1983)	plant	frequency	no significant effects
1973-80	Robertson/Keeve (1983)	plant	frequency & severity	positive effects in 3 plants
1974-78	Bartel/Thomas (1985)	industry	frequency	small positive effects
1973-83	Viscusi (1986)	industry	frequency	small positive effects
1979-85	Gray/Scholz (1989)	plant	frequency	significant effects on accidents
1979-85	Gray/Scholz (1991)	plant	frequency	significant effects on injuries
1979-85	Ruser/Smith (1991)	plant	severity	no significant effects

*Frequency generally refers to the number of injuries involving lost workdays per hundred workers; severity generally refers to the number of lost workdays per hundred workers.

One difficulty with intertemporal comparisons of injury rates is the incommensurability of pre-OSHA and post-OSHA data collected by the Bureau of Labor Statistics (BLS). At the time of OSHA's creation, the BLS changed the definitions, coverage, and reporting methods used in its survey of occupational injuries, and in so doing made the new data series incompatible with the old series (Schauer and Ryder, 1972; Inzana, 1973). Thus, as Robertson and Keeve (1983) note, a time series analysis using the BLS data is problematic. In particular, the BLS abandoned its measurement of disabling work injuries after the creation of OSHA (Inzana, 1973). The National Safety Council (NSC) however, retained its measurement of this category into the post-OSHA period. The NSC (1991, p. 105) defines a disabling injury as "an injury causing death, permanent disability, or any degree of temporary total disability beyond the day of the accident." This is equivalent to the definition traditionally employed by the BLS; a more detailed comparison of BLS and NSC definitions and survey methods is contained in NSC (1992). Because of its consistent measurement over time, the NSC series is suitable for intertemporal comparisons. The data were compiled from Williams (1973) and the annual *Accident Facts* reports published by NSC.

Because disaggregated data suffer from occasional changes in standard industrial classification codes, the aggregate number of injuries was used to ensure consistency. The number of injuries was corrected for the number of exposure units by calculating the injury rate per 100 full-time equivalent workers as follows.

$$\text{Injury Rate} = (N/EH) \times 200{,}000$$

where N is the number of injuries, EH is the total number of employee hours actually worked during the year, and a full-time employee is assumed to work 40 hours per week, 50 weeks per year. This is the conversion method currently applied by the BLS to its own data series. The data on employment and hours were taken from the Council of Economic Advisors (1994).

ANALYSIS

The trend in disabling injuries is illustrated by the solid line in Figure 1. Between 1948 and 1958, the injury rate declined by roughly 13 percent, from 3.462 to 3.000 injuries per hundred full-time workers. However, from 1958 to 1970, the rate leveled off and remained essentially unchanged, ending at 3.021 in 1970. The structural break in the time series between the pre- and post-OSHA periods as reported in Eisenhauer (1994) is visually evident in Figure 1. Immediately following the creation of OSHA, the observed injury rate climbed to 3.141 in 1971, 3.158 in 1972, and 3.186 in 1973. This increase is consistent with the findings of earlier studies such as Northrup *et al* (1978), but it is strictly a short run phenomenon. Beginning in 1974, the rate fell rather consistently throughout the post-OSHA period. By 1989, the rate of disabling injuries had reached a low of 1.675 per hundred workers, and in 1991 the rate stood at 1.696, a reduction of nearly 47 percent from the 1973 rate.

To explain the behavior of injury rates in the absence of OSHA, a multiple linear regression model was fit to the data for the pre-OSHA period. In addition to the annual trend, the two explanatory variables included in the model were the percentage of nonagricultural workers in goods-producing industries, and the union density among nonagricultural employees. Data on the former were obtained from the Council of Economic Advisors (1994), and data on the latter were taken from the Bureau of Labor Statistics (1980). *A priori*, the trend in injury rates is expected to be negative, simply because of improving knowledge of safety procedures over time. Because the production of goods is generally more dangerous than the provision of services, injury rates are expected to be positively correlated with the proportion of workers producing goods. And because a primary concern of unions is the safety of the workplace, unionization is expected to have a negative effect on injuries.

Figure 1. Actual and Forecast Occupational Injury Rates

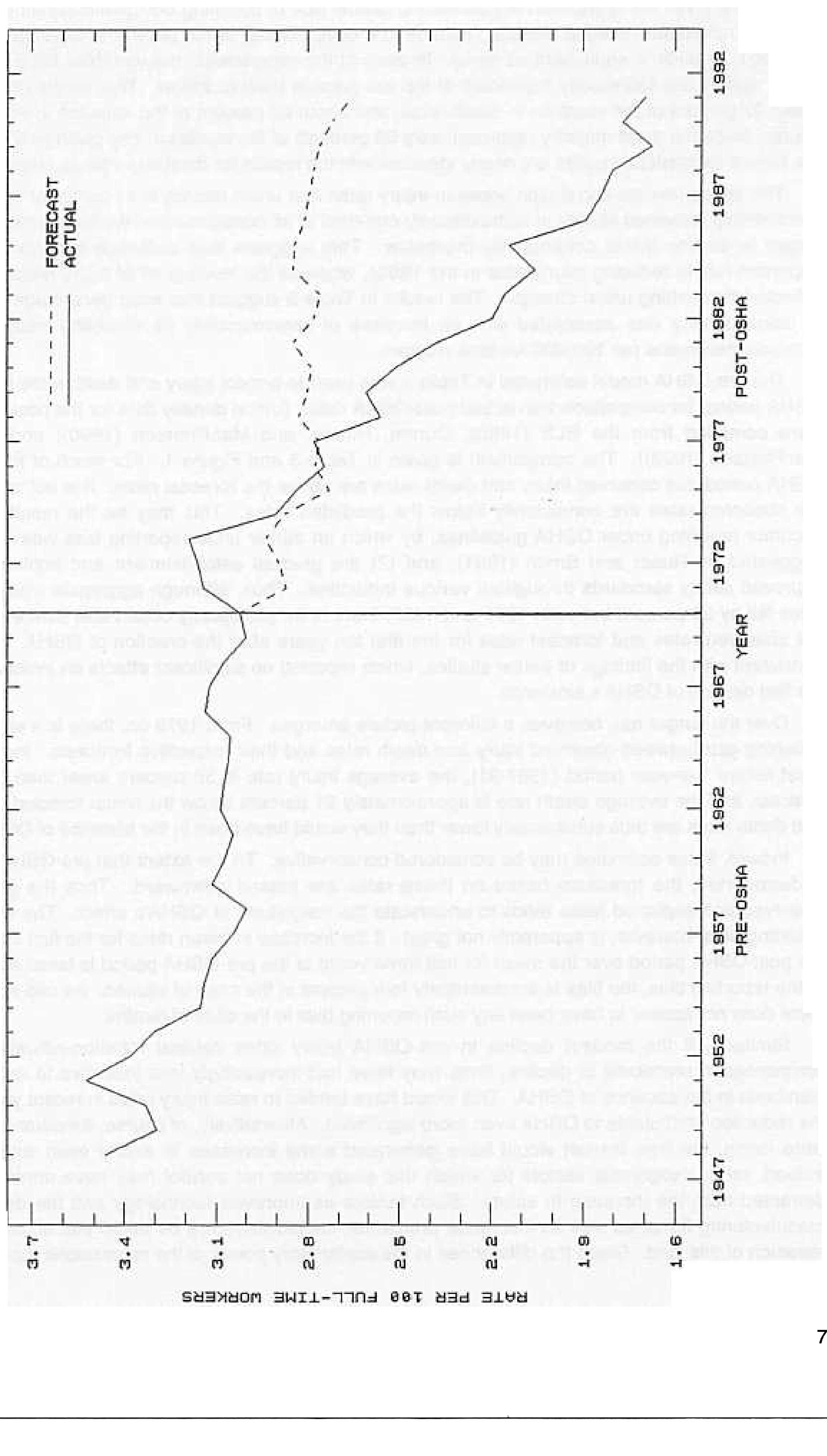

Table 2 gives the regression results for the overall rate of disabling occupational injuries, as well as separate results for nonfatal disabling injuries and occupational death rates (the latter were calculated per 100,000 full-time equivalent workers). In each of the regressions, the variables have the expected signs, and all are statistically significant at the ten percent level or below. This simple model explains about 97 percent of the variation in death rates, and about 80 percent of the variation in injury rates. Of course, since the great majority (approximately 99 percent) of the injuries in any given year are nonfatal, the results for nonfatal injuries are nearly identical with the results for disabling injuries overall.

The strong inverse correlation between injury rates and union density is of particular interest. Union membership remained steady at approximately one-third of all nonagricultural workers through 1958, and began to decline rather continuously thereafter. This suggests that collective bargaining played an important role in reducing injury rates in the 1950s, whereas the leveling off of injury rates in the 1960s reflected diminishing union strength. The results in Table 2 suggest that each percentage point decline in union density was associated with an increase of approximately 65 disabling injuries and 0.45 occupational deaths per 100,000 full-time workers.

The pre-OSHA model estimated in Table 2 was used to project injury and death rates into the post-OSHA period, for comparison with actual post-OSHA data. (Union density data for the post-OSHA years were compiled from the BLS (1980); Curme, Hirsch, and MacPherson (1990); and Hirsch and MacPherson (1993)). The comparison is given in Table 3 and Figure 1. For much of the early post-OSHA period, the observed injury and death rates are above the forecast rates. It is not until 1978 that the observed rates are consistently below the predicted rates. This may be the result of (1) more accurate reporting under OSHA guidelines, by which an earlier underreporting bias was corrected, as suggested by Ruser and Smith (1991), and (2) the gradual establishment and implementation of improved safety standards throughout various industries. Thus, although aggregate injury and death rates fell by 20 percent between 1971 and 1980, there is no statistically observable difference between the observed rates and forecast rates for the first ten years after the creation of OSHA. This result is consistent with the findings of earlier studies, which reported no significant effects on incidence rates in the first decade of OSHA's existence.

Over the longer run, however, a different picture emerges. From 1978 on, there is a significant and widening gap between observed injury and death rates and their respective forecasts. Indeed, for the most recent five-year period (1987-91), the average injury rate is 36 percent lower than the average forecast, and the average death rate is approximately 21 percent below the mean forecast. Both injury and death rates are thus substantially lower than they would have been in the absence of OSHA.

Indeed, these estimates may be considered conservative. To the extent that pre-OSHA rates were underreported, the forecasts based on these rates are biased downward. Thus the gap between observed and expected rates tends to understate the magnitude of OSHA's effect. The extent of this reporting bias, however, is apparently not great. If the increase in mean rates for the first three years of the post-OSHA period over the mean for last three years of the pre-OSHA period is taken as a measure of the reporting bias, the bias is approximately four percent in the case of injuries. As one would expect, there does not appear to have been any such reporting bias in the case of deaths.

Similarly, if the modest decline in pre-OSHA injury rates caused inflation-adjusted workers' compensation premiums to decline, firms may have had increasingly less incentive to enforce safety standards in the absence of OSHA. This would have tended to raise injury rates in recent years, making the reduction attributable to OSHA even more significant. Alternatively, of course, if insurance premiums were rising, the free market would have generated some increases in safety even without OSHA. Indeed, other exogenous factors for which this study does not control may have contributed to or detracted from the increase in safety. Such factors as improved technology and the downsizing of manufacturing firms, as well as insurance premiums, should therefore be taken into account in future research of this kind. Given the differences in the explanatory power of the regressions reported above,

Table 2. Regression Results

VARIABLE[a]	DISABLING INJURIES[b]	DEATHS[b]	NONFATAL INJURIES[b]
Constant (+)	26.77 (1.64)*	833.03 (8.47)**	(1.60)*
Trend (-)	-0.012306 (-1.55)*	-0.4108 (-8.58)**	-0.011895 (-1.50)*
Union Density (-)	-0.06516 (-4.86)**	-0.45092 (-5.57)**	-0.06471 (-4.85)**
Goods Production (+)	0.06561 (2.87)**	0.2157 (1.56)*	0.0654 (2.87)**
R^2	.822	.976	.818
Adjusted R^2	.793	.973	.789
Durbin-Watson	1.93	2.41	1.93

[a]Expected signs given in parentheses below independent variables.
[b]Student's t statistics given in parentheses below coefficients.

*Significant at the ten percent level.
**Significant at the one percent level.

TABLE 3. Forecasts of Injury and Death Rates[a]

	DISABLING INJURY		DEATH		NONFATAL INJURY	
YEAR	ACTUAL	FORECAST	ACTUAL	FORECAST	ACTUAL	FORECAST
1971	3.14139	2.86852	18.7117	18.1150	3.12268	2.84399
1972	3.15825	2.89000	18.4231	17.9573	3.13982	2.86563
1973	3.18587	2.93595	18.2232	17.8800	3.16764	2.91165
1974	2.90406	2.87535	17.0456	17.3105	2.88701	2.85162
1975	2.83959	2.73110	16.7794	16.5369	2.82281	2.70813
1976	2.74661	2.77394	15.6058	16.4967	2.73101	2.75101
1977	2.77726	2.76194	15.5768	16.0633	2.76169	2.73945
1978	2.55924	2.82711	15.2391	16.1912	2.54400	2.80449
1979	2.60770	2.79842	14.7392	15.6792	2.59296	2.77632
1980	2.51042	2.78706	15.0625	15.5319	2.49535	2.76510
1981	2.37693	2.84560	14.1484	15.7091	2.36278	2.82346
1982	2.19431	2.78191	13.7433	15.2713	2.18057	2.76020
1983	2.15347	2.75730	13.2608	14.9456	2.14021	2.73591
1984	2.05618	2.84704	12.4453	15.1685	2.04373	2.82543
1985	2.13930	2.84459	12.3010	14.9865	2.12700	2.82316
1986	1.88779	2.80885	11.6414	14.6076	1.87615	2.78780
1987	1.84006	2.79607	11.5515	14.3112	1.82851	2.77530
1988	1.80479	2.77977	11.0293	13.9488	1.79376	2.75937
1989	1.67486	2.76106	10.7388	13.6069	1.66412	2.74100
1990	1.76990	2.72468	10.4227	13.1833	1.75947	2.70504
1991	1.69623	2.65747	9.8781	12.5895	1.68636	2.63841

[a]Injury rates per 100 workers; death rates per 100,000 workers.

the inclusion of such additional factors will presumably contribute more to the injuries model than the occupational death model.

CONCLUSION

The time series analysis above suggests that by the early 1990s, OSHA had accounted for a significant reduction in both occupational injury and death rates. For the years 1987-91, the reductions are estimated to be on the order of 36 to 40 percent in the rate of disabling work injuries, and 21 percent in the rate of occupational deaths.

The results do not necessarily imply, of course, that the increase in safety is utility maximizing. To the extent that workers receive a risk premium for dangerous work, the reduction in hazards may be accompanied by slower growth in real wages. Indeed, data from the Council of Economic Advisors (1994) show that average real hourly earnings rose 20 percent between 1959 and 1970, a period in which injury rates were essentially stable; but real hourly earnings *fell* by 13 percent between 1973 and 1991 as injury rates declined. This may or may not be a tradeoff which workers would voluntarily elect. However, the relationship between unionization and safety does provide some evidence that, at least collectively, wage-earners have sought safer workplaces.

Nor do the results imply that direct regulation is necessarily the most efficient or cost-effective means of achieving increased safety. Indeed, Lanoie (1994) and others have argued for an accident tax/safety subsidy system that would rely more on economic incentives and less on direct regulation. Nevertheless, the results obtained here do indicate that occupational injuries and deaths would have been significantly higher in recent years in the absence of government regulation.

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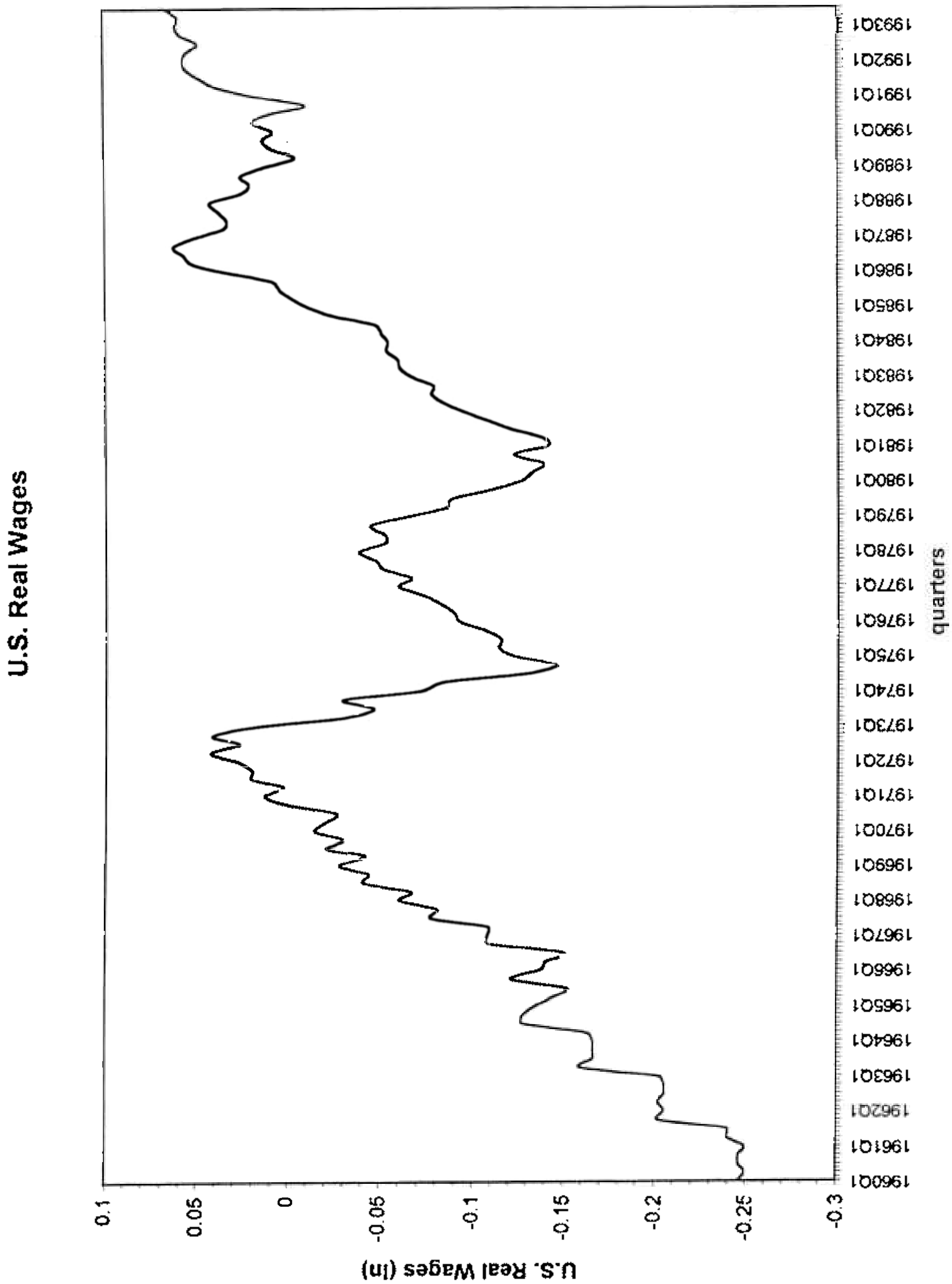
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U.S. Real Wages (ln)
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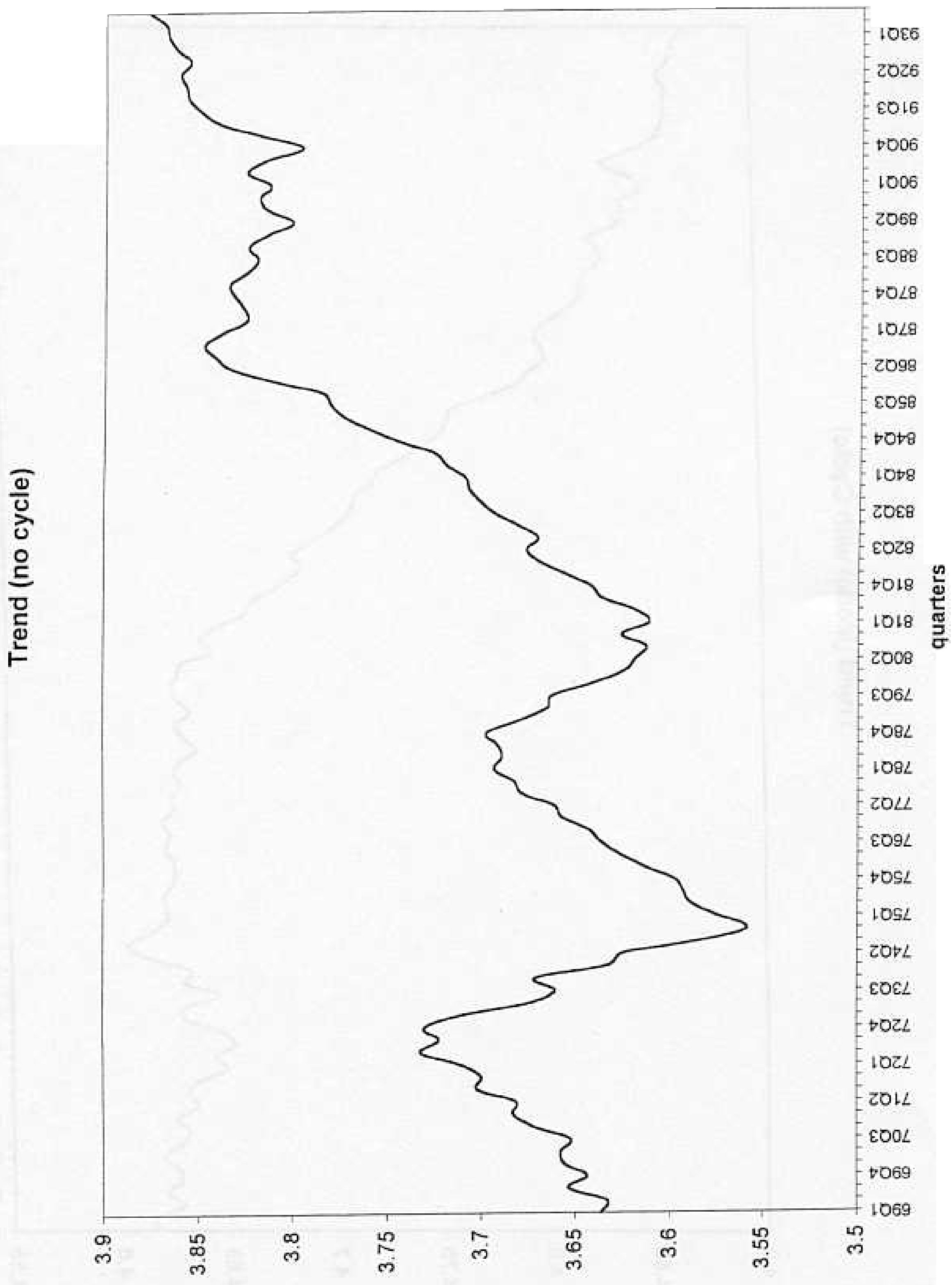
Figure 1

Figure 2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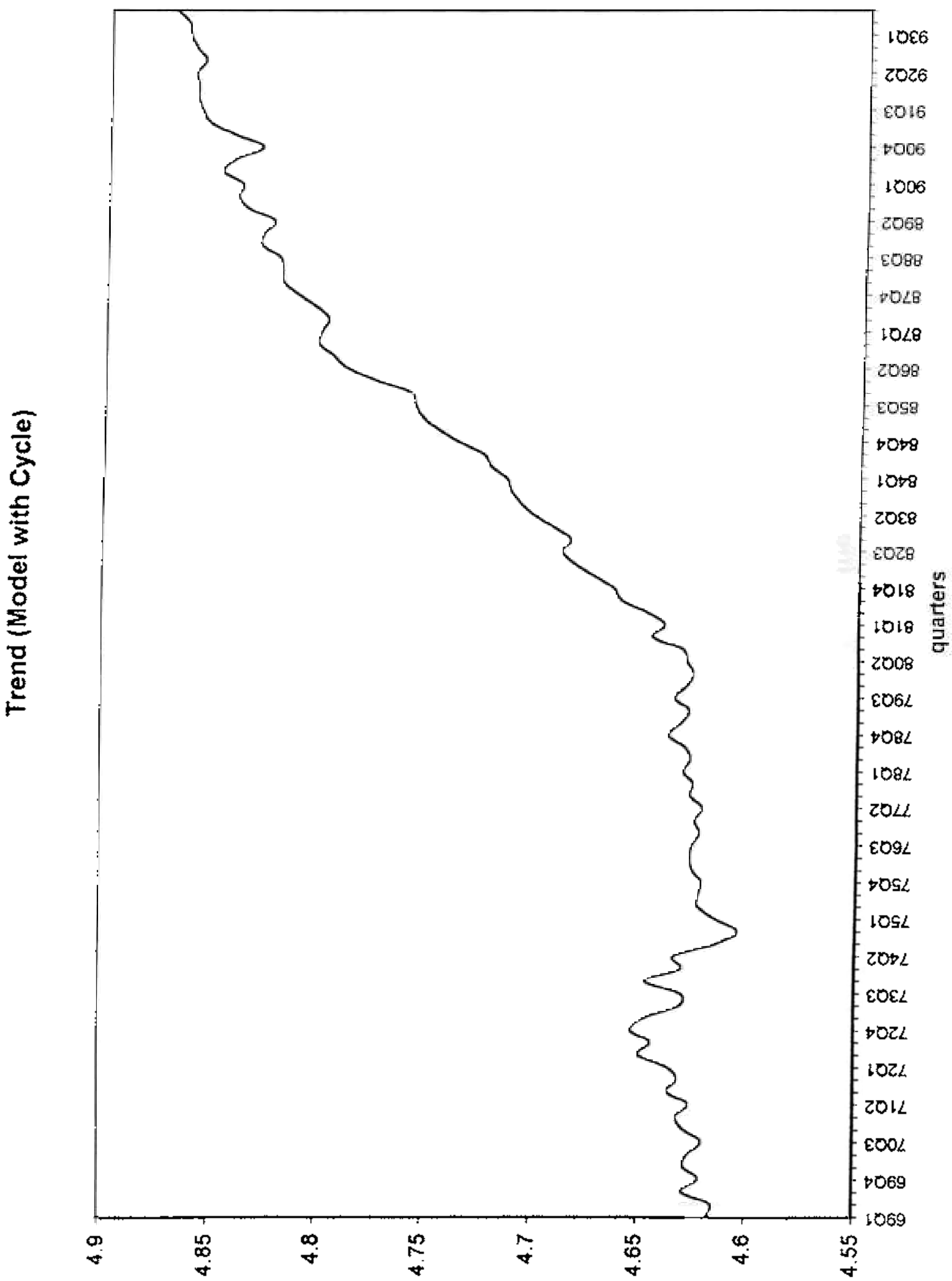
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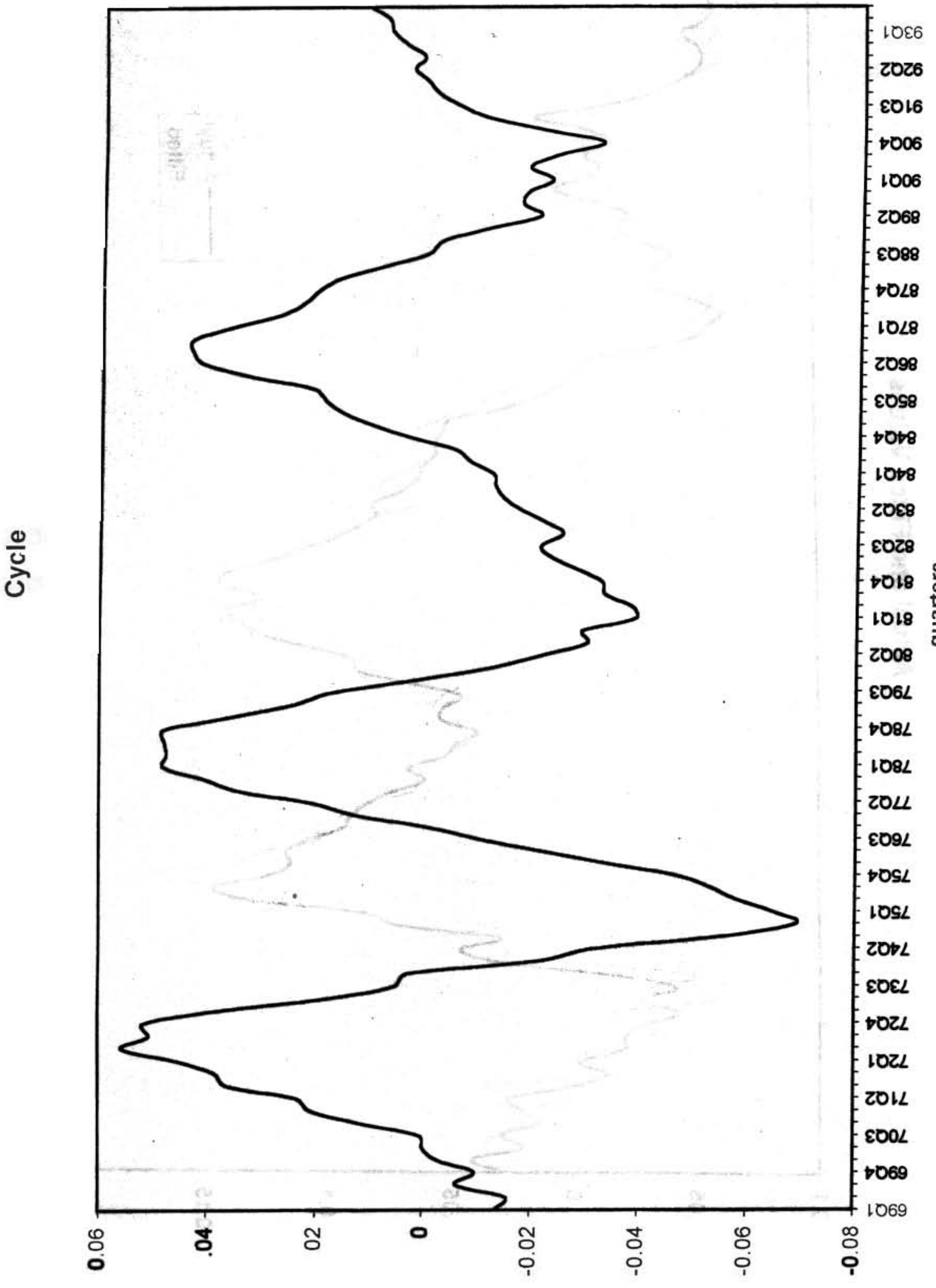
quarters

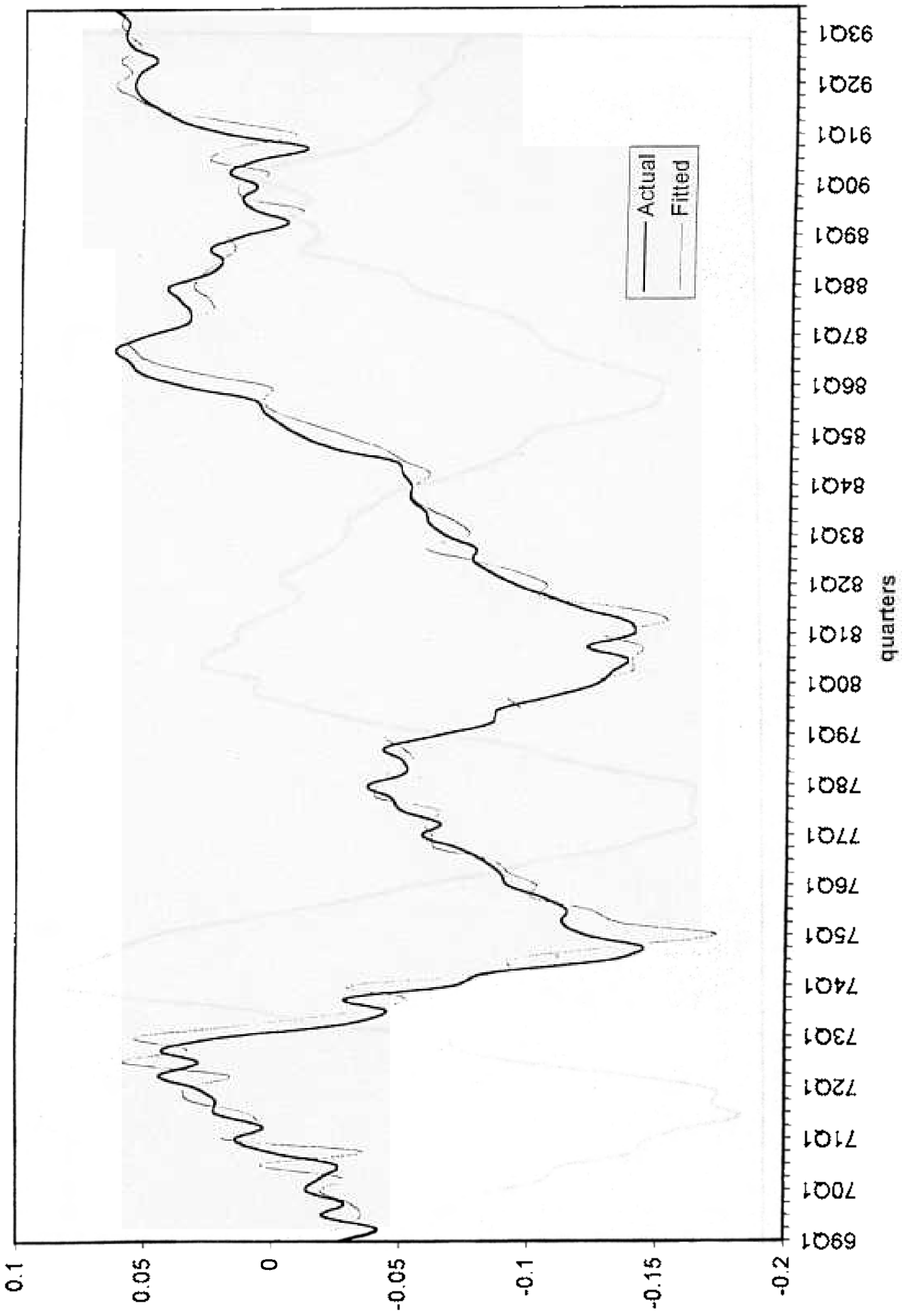
Figure 3


Cycle
0.06
.04
.02
0
-0.02
-0.04
-0.06
-0.08
69Q1
69Q4
70Q3
71Q2
72Q1
72Q4
73Q3
74Q2
75Q1
75Q4
76Q3
77Q2
78Q1
78Q4
79Q3
80Q2
81Q1
81Q4
82Q3
83Q2
84Q1
84Q4
85Q3
86Q2
87Q1
87Q4
88Q3
89Q2
90Q1
90Q4
91Q3
92Q2
93Q1
quarters

Figure

Figure 5

Actual and Fitted Values



ENDNOTES

1. Consider the time series Y_t which is generated by the following stochastic process

   (1) $Y_t = a + \beta t + U_t$

   (2) $U_t = \gamma U_{t-1} + \varepsilon_t$

   where ε_t is a covariance stationary process with mean zero, t is a time trend, and α, β, and γ are the parameters. If $\gamma > 1$ the model depicted in (1) and (2) represents an asmptotically stationary AR(1) process with a linear time trend. If $\gamma = 1$, the model is a random walk around a linear trend. Substituting (2) into (1) and rearranging yields the reduced form

   (3) $Y_t = \delta_0 + \delta_1 t + \gamma y_{t-1} + \varepsilon_t$

   where $\delta_0 = [\alpha(1-\gamma) + \gamma\beta]$ and $\delta_1 = \beta(1-\gamma)$.
   Equation (3) is said to have a unit root if $\gamma = 1$.

2. Estimations throughout the paper are performed using the software **STAMP** (**S**tructural **T**ime series **A**nalyser **M**odeller and **P**redictor) of London School of Economics and ESCR Centre in Economic Computing, written by Simon Peters, Bahram Pasaran, and Andrew Harvey.

3. All series used in this study are obtained from TSM Global Economic Data Base (as of June 1994). DSC Data Services Inc.

4. Box-Ljung Q Statistic: $Q = T^*(T^* + 2)\sum_{t=1}^{p}(T^* - \tau)^{-1} r^2(\tau)$

   where $T^* = T - d$ (d:number of differencing) and

$$r(\tau) = \left[\left(\sum_{t=d+1+\tau}^{T}(u_t - u^*)(u_{t-\tau} - u^*)\right)\sum_{t=d+1}^{T}(u_t - u^*)^2\right], \qquad \tau = 1,2,3,........$$

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INTEREST RATES AND BANK RISK

Steven A. Dennis [*], Mahendra Raj [**], David C. Thurston [***]

INTRODUCTION

The level of risk in the banking sector is an extremely important component of the stability of the financial system as a whole. Maintaining the safety and soundness of the banking system is one of the main goals of the regulatory policy of financial institutions. The attention given to banking risk has increased with the recent debacle in the banking industry (including S&Ls), which resulted in the bankruptcy of the FSLIC and massive bailouts financed by taxpayer dollars. The cost of these bank failures is estimated to exceed $300 billion.

Research concerning bank risk has increased dramatically since 1980. Studies have focused on interest rate risk and credit risk problems associated with the collapse of many banks and S&Ls. Most studies of interest rate risk in banking focus on the degree of exposure to interest rate changes through "gaps" in the duration (or maturity) profiles of assets and liabilities. We present here a relationship between interest rates and bank risk which may arise through borrower-induced volatility increases.

THE BORROWER'S CALL OPTION

Merton (1973) and Black and Scholes (1973) demonstrate that when a firm issues debt, the firm holds a valuable option. If the project's returns fall short of the promised return to debtholders, the borrower defaults and turns the assets over to debtholders. The limited liability of equity holders limits the loss of the borrower to the equity stake of the borrower. Conversely, if the project's returns are above the promised return to debtholders, the borrower repays the debtholders and retains the residual. Therefore, we can view the firm as holding a call option, written by the debtholders, with a strike price equal to the promised repayment on the debt. The promised repayment on the loan, in real terms, is the amount borrowed, D, plus any interest that accrues. The value of the equity stake using the Black-Scholes option pricing formula is:

$$E = SN(d_1) - \left[De^{RT}\right]e^{-r_f T}N(d_2)$$

where,

$$d_1 = \frac{\ln\left(S/De^{RT}\right) + \left(r_f + \sigma^2/2\right)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}.$$

R is the nominal rate on the loan, which is composed of the risk-free rate, r_f, and a risk premium, p. Assuming the bank has a well-diversified portfolio, the risk premium component of R should reflect the contribution of this project to the total risk of the portfolio.

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This option is different from a regular option because the risk-free rate is a component of the nominal rate on the loan. Consequently, the exercise price of the option is both compounded and discounted by the risk-free rate. These two effects cancel and the exercise price is then a function of only the risk premium component of the nominal rate. Therefore, we can rewrite the call option value as:

$$\begin{aligned} E &= SN(d_1) - De^{(R-r_f)T}N(d_2) \\ &= SN(d_1) - De^{pT}N(d_2), \end{aligned}$$

where,

$$d_1 = \frac{\ln(S/D) + \left(-p + \sigma^2/2\right)T}{\sigma\sqrt{T}},$$

and

$$d_2 = d_1 - \sigma\sqrt{T}.$$

As the borrower's call option does not depend upon the risk-free rate, we have:

$$\frac{\partial E}{\partial r_f} = 0.$$

The borrower has no reaction to changes in the risk-free component of the nominal interest rate. Taking the derivative of the call value with respect to the risk premium, we get:

$$\frac{\partial E}{\partial p} = SN'(d_1) - TDe^{pT}N(d_2) - De^{pT}N'(d_2).$$

Stoll and Whaley (1993, p. 45) demonstrate that:

$$N'(d_1) = N'(d_2)\frac{D}{Se^{-pT}}.$$

Therefore,

$$\frac{\partial E}{\partial p} = -TDe^{pT}N(d_2) < 0.$$

Interest rate changes caused by changes in the risk-premium component of the nominal interest rate decrease the value of the call. Recall that the option value, in this context, is the value of the equity in the project. If an increase in the nominal interest rate is caused by a higher risk premium, the value to the firm of investing in the project is reduced.

To maintain the value of equity in the project, the firm can increase the volatility of the project. As the project becomes more volatile, the value of the call option held by the firm increases. Because the bank prices the risk premium on the project according to the systematic risk of the project, the firm can increase the total risk of the project with a less than one-for-one penalty. That is, as the firm increases total risk, some of that risk will be diversifiable. The bank will only price the undiversifiable risk. Therefore, the strike price of the firm's call option only reflects the systematic risk, but the volatility of the call option reflects total risk and the firm can increase the value of the call option (the equity value of the project) by increasing the total risk of the project.

To the extent that deposit insurance is not risk-sensitive or is priced according to the systematic risk of banks, banks incur no penalty for the increased unsystematic risk. Additionally, to the extent that capital is allocated in the banking industry according to the risk of assets, some adverse consequences may arise from the increased unsystematic risk. However, current banking guidelines do not distinguish between risks of commercial and industrial loans. All C&I loans carry a 100% risk-weighting, and therefore increased (unsystematic) risk would not adversely affect the individual bank.

Certainly, the effects of increased risk would be reflected in the bank's cost of funds for non-FDIC guaranteed debt, such as purchased funds and subordinated debt. Unfortunately, this suggests that the analysis presented above is more pervasive for banks which utilise small amounts of these types of debts, such as small banks.

CONCLUSION

We have demonstrated that firms can maintain the equity value of a project when interest rates increase by increasing the volatility of the project. If, as finance theory suggests, banks hold a diversified loan portfolio, increases in project volatility by firms result in higher equity values of the project. Movements in the risk-free component of the nominal rate are neutral to the equity value of the project. However, changes in the risk-premium component of the nominal rate may induce volatility increases by the borrower. This is a potential link between interest rates and bank risk.

In this paper, we do not argue that the interest sensitivity of banks is unrelated to duration gaps, or the management of duration gaps through interest rate changes. This paper examines a more basic linkage between interest rates and bank risk. This relationship holds even if the bank has perfectly matched the duration of its assets and liabilities, maintaining a zero duration gap.

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SURVEY ESTIMATES OF WEALTH CONCENTRATION: 1953–1983

Ted P. Schmidt*

I. INTRODUCTION

Recent evidence suggests that wealth inequality in the U.S. has increased significantly during the 1980s. Estimates from the *Survey of Consumer Finances* reported by Kennickell and Woodburn (1992) indicate that the richest 1.0 percent of households increased their share of wealth from 31.3 percent in 1983 to 37.0 percent in 1989.[1]

While the *Survey of Consumer Finances* has provided relatively accurate evidence about recent movements in wealth inequality, how has wealth inequality behaved in the past? Wolff and Marley (1989), using estate tax data, found two significant declines in measured wealth inequality between 1920 and 1980: the first occurred during the 1940s, and the second occurred during the 1970s. However, the estate tax methodology used in their study, and therefore wealth estimates from these data, has been criticized on several grounds.[2]

Has wealth inequality been rising since the mid 1970s as their study and recent evidence suggest? Or is the rise in inequality a recent phenomenon associated with the decade of the 1980s only? In this paper a trend estimate of wealth concentration is constructed using survey data for the period between 1953 and 1983. The survey estimates of wealth inequality are then compared to the estate estimates over this same period. The results from the survey data support Wolff and Marley's evidence that there was indeed a significant decline in measured wealth inequality during the 1970s.

The remainder of this paper is divided into five parts. In section II the estate data estimates are presented and the methodological criticisms are discussed. Section III discusses the available survey data and their limitations. The survey estimates of wealth concentration are presented and compared with the estate trend in section IV. In section V the methodological differences are discussed, and the paper concludes with a summary of the findings.

II. ESTATE ESTIMATES OF WEALTH CONCENTRATION.

Estate data estimates of wealth concentration have been performed periodically since 1922.[3] The wealth of the living population is estimated using the Estate Tax Multiplier (ETM) method.[4] Wolff and Marley (1989) constructed a consistent trend of wealth concentration using all available estate data between 1922 and 1981 (Figure 1).[5] As their data show, there have been two significant declines in the concentration of individual wealth: the first decline occurred around 1940 and the second occurred in the early 1970s. For the post-war period, their data indicate that wealth inequality was relatively stable until 1972 (a steady rising trend between 1958 and 1965, then reverting to the 1958 level in 1972), declined sharply from 1972 to 1976, but has been increasing since the 1976 trough.

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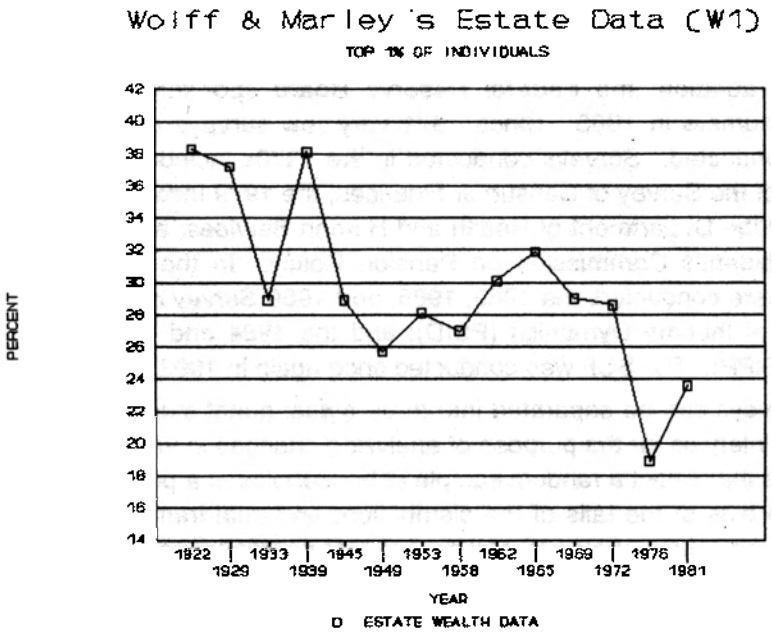
FIGURE 1. ESTATE TAX ESTIMATES OF WEALTH



However, the reliability of estate estimates of wealth concentration has been questioned for several reasons, of which the most significant is the construction of the multipliers.[6] The multipliers are constructed by taking the inverse of mortality rates for various age, sex, and social cohorts. One can estimate the wealth of any cohort by the product of the multiplier and the amount of wealth filed by estates within each specific group. The assumption underlying the construction of the multipliers is that death is a random event within and across the various social characteristics – age, sex, and social class. While death may randomly select individuals from age and sex cohorts, most researchers accept that social class is biased – the rich live longer. Mortality rates are readily available for age and sex cohorts but not for social class. Some of the variables used as an index of social class include income, occupation, educational attainment, housing, and the holding of life insurance assets. Most researchers use the size of one's life insurance holdings as an index of social class because the information necessary to derive mortality rates is readily available from insurance companies.

Atkinson (1975) tested the relative reliability of the ETM method by comparing multipliers from two different researchers, both of whom used the same data. In some cases he found the multipliers differed by as much as twenty percent, which calls into question the reliability of wealth concentration estimates using the ETM method.

Another criticism of the ETM concerns the use of the individual as the unit of observation. As Atkinson (1975) argued, it would probably be more appropriate to use the family or household unit, especially if welfare comparisons are made. More importantly, he argued that individual measures of wealth inequality have a downward bias relative to survey estimates which use the household. The bias is created as more women move into the ranks of the wealthy over time, increasing the number of wealthy individuals, but – assuming the wealthy tend to marry within their class – this also increases household wealth at the top without increasing the number of households. So, even as we observe a decline in individual wealth inequality, it is quite possible that household wealth inequality may be rising. Therefore, it is suggested that the two declines in inequality captured by the estate data may be misleading. This issue will be analyzed further in section IV through a comparison of survey and estate estimates of wealth concentration.

III. AVAILABLE SURVEY DATA

Survey data on assets and liabilities have been available since 1946, when, under the auspices of the Federal Reserve Board, the University of Michigan's Survey Research Center first began its *Survey of Consumer Finances*. The *Survey of Consumer Finances* was performed annually until 1971 when funding ceased.[7] In addition, the Federal Reserve Board sponsored the Survey of Financial Characteristics of Consumers in 1963. Since 1971 very few surveys designed to measure wealth variables have been conducted. Surveys conducted in the 1970s include the 1977 Consumer Credit Survey, a continuation of the Survey of Consumer Finances; the 1979 Income Survey and Development Program, sponsored by the Department of Health and Human Services; and the 1979 pension survey, sponsored by the President's Commission on Pension Policy. In the 1980s six national surveys collecting wealth data were conducted: the 1983, 1986, and 1989 *Survey of Consumer Finances* (SCF); the 1984 Panel Study of Income Dynamics (PSID); and the 1984 and 1988 Survey of Income and Program Participation (SIPP). The SCF was conducted once again in 1992.[8]

Cross-sectional surveys can be separated into three types: panel studies designed to re-interview respondents at specific intervals for the purpose of analyzing changes in variables over a period of time; area-probability samples that select a random sample of households at a point in time, but are subject to significant nonresponse bias at the tails of the distribution; and dual-frame samples which include an additional list of high-income households to compensate for nonresponse bias among the wealthy. In general, these three types of surveys are noncomparable.[9]

Of the available survey data, the *Survey of Consumer Finances* provides the only consistent source available to construct a trend measure of wealth concentration over time, but there are problems with using these data to construct a time trend. Foremost is the nonresponse bias. Both the poorest and the richest households tend to have high nonresponse rates. While it may be justifiable to compensate for nonrespondents by using a weighting scheme for the lower and middle of the distribution, adjustments at the top are more dubious since the distribution of wealth is highly skewed.[10] The dual-frame sample surveys were designed to overcome the bias at the upper end by including a supplemental sample of mostly high-income households produced from IRS files. A new sample is constructed by taking the high-income list and adding it to the original area-probability sample, then each observation is weighted so that the sample reflects the true population of households. The 1963 SFCC, and the 1983, 1989 and 1992 SCFs are all dual-frame samples. While these three surveys are the most accurate and detailed to date, they still do not give us any information for the period between 1963 and 1983, which experienced the most recent decline in measured wealth inequality.

The only possible source of data that could be used to construct a wealth trend over this period is the area-probability sample SCF. However, these surveys typically provide inefficient estimators of general financial characteristics, especially with respect to estimates of mean values. But, as Katona, Lininger, and Kosobud (1963) suggested:

> When distributions and medians are presented, rather than aggregates and means, the errors and omissions are less damaging. When the relation of the distribution of net worth to income or age is studied, the errors are likewise less important. <u>The most valuable data about net worth are comparisons of distributions and relations obtained at two different points of time, because biases and errors probably remain constant</u>. Such data give useful indications of financial trends (p. 117 – my italics).

Evidence from Avery, Elliehausen, and Kennickell (1989) support this contention. They compared the 1983 SCF area-probability sample with the dual-frame sample and found virtually no significant differences between estimates of median asset and debt holdings. It appears that it would be acceptable to construct a wealth trend using the area-probability surveys, and that distribution estimates from these data should accurately reflect movements in the underlying population parameters over time.

There are, however, two other problems to address. First, only a limited number of these surveys contain adequate information on assets and liabilities. The surveys with adequate data include the 1953, 1962, 1970, 1977 Consumer Credit Surveys, and the 1983 SCFs, which give us an adequate number of data points between 1963 and 1983. The second problem is the extent of the assets and liabilities covered in the surveys: the asset list in these surveys is not as broad as the asset list used in the estate data. The weaknesses of the survey data and the underlying methodological differences with the estate data will be discussed in section V.

IV. SURVEY ESTIMATES OF WEALTH CONCENTRATION

In this section area-probability sample estimates of U.S. household wealth concentration are constructed for the years 1953, 1962, 1970, 1977, and 1983. The "cleaned" versions, after imputations, of these data sets are used to estimate household net worth. A complete discussion of the construction and quality of these estimates can be found in Schmidt (1991).

Due to a lack of available asset information in some of the surveys, three estimates of net worth are presented: NW1, NW2, and NW3. NW1 is defined as liquid assets (demand deposits, time and savings deposits, and U.S. savings bonds), plus bonds, plus publicly held corporate equities (including mutual funds and investment clubs), plus housing and other real estate, less all liabilities (mortgage debt, installment and non-installment debt, and revolving credit). NW2 is defined as NW1 plus net private business equity, and NW3 adds the present value of automobiles to NW2.[11]

Comparison of Survey and Estate Data

The most significant differences between the two sources of data are the unit of observation, the percentage of the population covered, and the definition of net worth. Wolff and Marley's (W&M) estate estimates presented here use the individual as the unit of observation, measure the top 1.0 percent of individuals, and define wealth as NW3 plus the cash surrender value of life insurance and pensions, plus net equity in personal trusts, plus household durables. The area-probability sample survey estimates use the household as the unit of observation, under-represent the wealthiest households, and use the wealth measure NW1.

Given these differences, and barring any serious flaws in the data sources themselves, can we expect the two estimates of wealth concentration to display the same relative movements in inequality over time? Table 1 compares W&M's estate data trend estimate of the share of wealth held by the top 1.0 percent of individuals to the area-probability survey trend estimate of the share of wealth held by the top 1.0 percent of households. The estate data and the survey data show the same movements over this period. Measured wealth inequality increased slightly from 1953 to 1962, remained fairly stable until the 1970s, fell significantly in the mid-1970s, then increased again in the early 1980s. In addition, the Gini coefficient was calculated from the survey data estimates and displays virtually the same trend.[12]

Figure 2 graphically compares W&M's estate estimates with the Gini coefficient for NW1 from the survey data. As shown, the movements in the two sources of data are very closely matched. Any change in the share of wealth going to the wealthiest 1.0 percent of individuals is also displayed by similar movements in the Gini coefficients from the survey data.[13] It appears that both sources of data support the same conclusion: there was a small increase in measured wealth inequality in the U.S. from 1953 to 1962; a slight decline from 1962 to 1970; a significant decline from 1970 to 1977; but there has been a rise in measured wealth inequality, moving back towards its earlier levels, in the 1980s.

Table 1. Estate and Survey Estimates of Wealth for Top 1 Percent of Population

Top 1.0%	1953	1962	1969	1970	1976	1977	1981	1983
Estate Data (W1)	26.6	29.1	28.2	—	17.3	22.0	—	
Survey Data **Base Sample**[a]								
NW1	15.9	19.4	—	21.6	—	11.0	—	19.8
NW2	18.4	20.9	—	21.2	—	—	—	26.6
Full Sample[b] (NW1)	—	3.16[c]	—	—	—	—	—	30.4
Gini[d] (NW1)	.74	.761	—	.74	—	.657	—	.738

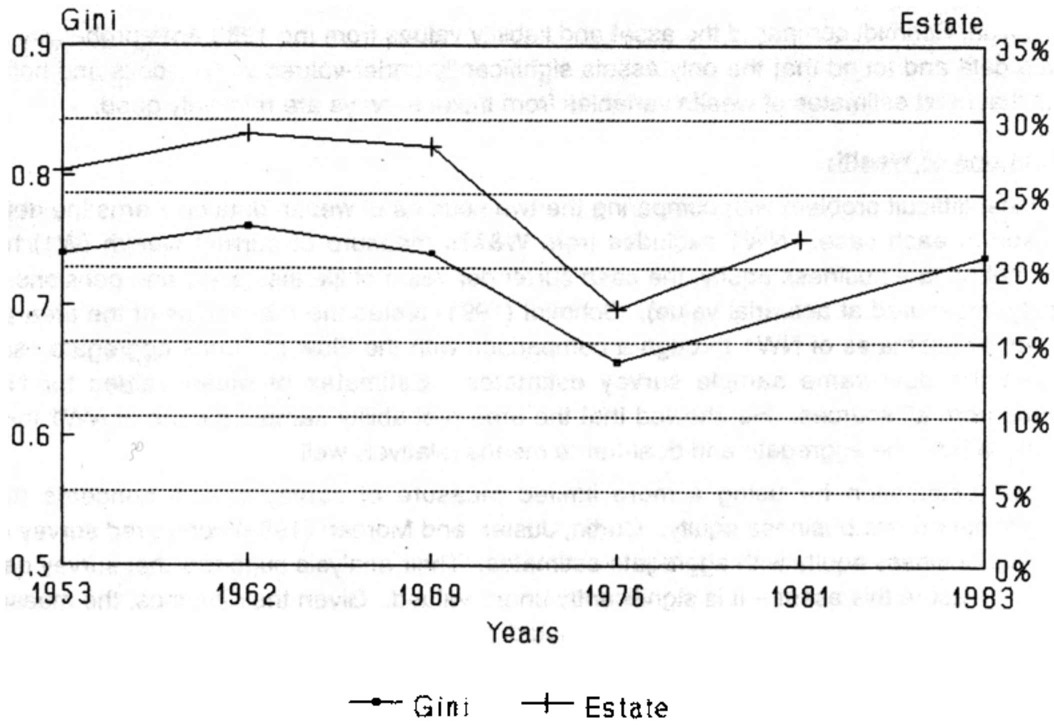
a Base sample estimates refer to the area-probability samples.

b. Full sample estimates refer to the dual-frame samples.

c. 1963 Survey of Financial Characteristics of Consumers.

d. The Gini ratios were estimated using the area-probability sample surveys.

FIGURE 2. ESTATE DATA & GINI COEFFICIENTS



The important result is that two very different sources of data display the same movements over the period between 1953 and 1983, thus supporting the contention that the U.S. experienced a period of decline in measured wealth inequality during the mid 1970s.

V. METHODOLOGICAL DIFFERENCES

In this section I discuss the three main methodological differences between the estate and survey data and suggest explanations for why they lead to similar results.

Unit of Measure

It was argued by Atkinson (1975) and Shorrocks (1987) that a declining trend in individual measures of inequality might conceal a rising trend in household measures of inequality. This criticism is not substantiated. Movements in the estate data which measure individual wealth concentration parallel movements in the area-probability survey data which measure household wealth concentration. In fact, the survey data support the use of estate data as a relatively reliable measure of changes in wealth inequality over time.

An explanation why the unit of measure did not affect the survey wealth inequality trend was suggested by Wolff (1991). Using the estate data, he found that the percentage of married women among the wealthy remained relatively constant from 1958 to 1976, which implies that individual and household measures of concentration should move consistently over this time period.[14]

Population Covered

The estate data estimates of W&M measure the wealth of the top 1.0 percent of individuals, whereas the area-probability sample survey data miss a significant portion of the wealthier households due to non-response bias. Schmidt (1991) compared the area-probability and dual-frame samples of the 1963 SFCC and 1983 SCF and found that the area-probability sample missed (roughly) the top 1.5 percent of the wealthiest households, which suggests that these two sources of wealth data may actually complement each other.[15]

In addition, Schmidt compared the asset and liability values from the 1983 area-probability sample to aggregate data and found that the only assets significantly under-valued were stocks and bonds, which suggests that most estimates of wealth variables from these surveys are relatively good.

Definitions of Wealth

The most difficult problem with comparing the two sources of wealth data concerns the definitions of wealth used in each case. NW1 excludes from W&M's measure of current wealth (W1) household durables, net private business equity, the cash surrender value of life insurance and pensions, and trust fund equity (measured at actuarial value). Schmidt (1991) tested the robustness of the area-probability sample survey estimates of NW1 through a comparison with the Flow of Funds aggregate estimates of wealth and the dual-frame sample survey estimates. Estimates of mean values for NW1 were constructed from all sources. He showed that the area-probability sample means of NW1 followed the movements in both the aggregate and dual-frame means relatively well.

Another justification for using a more limited measure of survey wealth concerns the survey estimates of net private business equity. Curtin, Juster, and Morgan (1989) compared survey estimates of net private business equity with aggregate estimates. Their analysis suggests that survey data do not adequately measure this asset – it is significantly under-valued. Given their findings, the measure NW1, which excludes net private business equity, should provide a more consistent measure of inequality movements over time than measures which include this asset.

VII. CONCLUSION

The survey data presented in this paper support the conclusion from estate tax data estimates that measured wealth inequality fell to a post-war low in the 1970s but has continued to rise since the 1976-77 trough. In addition, the analysis implies that estate tax measures of wealth do provide adequate estimates of trend movements in the concentration of personal wealth.

Given the significant movements in wealth inequality in the post-war period, the more important issue to address is the cause of these movements. While an analysis of the causes behind the changes in measured wealth inequality is beyond the scope of this paper, it has been suggested by Wolff (1992) and Schmidt (1991) that the most important factors affecting wealth inequality over time are changes in income inequality, changes in equity values, changes in housing prices, and changes in the rate of homeownership.

NOTES

Evidence on wealth inequality for 1992 was reported by Kennickell and Starr-McCluer (1994), but no estimate was given for the top 1.0 percent of households. They did present data on mean and median values for 1989 and 1992, and the changes indicated that inequality increased over this period, as the mean-median ratio increased from 3.83 in 1989 to 4.22 in 1992.

2. See Atkinson (1975).
3. See Goldsmith (1956), Lampman (1962), Smith and Franklin (1974), Smith (1984), Schwartz (1983 and 1985), and Schwartz and Johnson (1990).
4. A complete description of the Estate Tax Multiplier method can be found in Bentz (1984).
5. These figures show the amount of wealth held by the richest 1.0 percent of individuals, since only those estates above minimum threshold of wealth are taxed.
6. See Atkinson (1975) and Shorrocks (1987).
7. The primary funding came from grants from the Ford Foundation, the National Science Foundation, and contributions from Ford Motor Company and General Motors Company.
8. The Federal Reserve continues to support the Survey of Consumer Finances, and they have conducted it triannually since 1983.
9. For a complete discussion of survey sampling design and technique see Kish (1965) and Kalton (1983).
10. In statistical terms, the standard deviations of wealth for the lower and middle classes are significantly lower than for the rich. Therefore, if we compensate for nonresponse among the middle class by increasing the significance (or weight) of each respondent in that class, then we will not significantly bias the aggregate measure of wealth; however, if we try to make the same correction for the rich, we might severely bias our aggregate measure of wealth. For example, if the nonrespondents are predominantly "billionaires, " and we compensate by increasing the weights of the respondents, who are predominantly "millionaires," then we will significantly understate the overall level of wealth.

With the exception of 1970 and 1977, each survey has the necessary data to calculate NW1-3. For 1970 there is no value given for autos, so NW3 is excluded. For 1977 both autos and net business equity are missing, so NW1 is the only wealth estimate presented.

12. From 1962 to 1970 the share of wealth held by the top 1.0 percent of households increases slightly, yet the Gini ratio declines. This may occur because the Gini ratio is less sensitive in measuring changes at the tails of highly skewed distributions. See Champernowne (1974) for a detailed discussion of measuring inequality.
13. The Gini ratio is a convenient measure of inequality derived from Lorenz Curves. A Gini of 0 indicates perfect equality, whereas a Gini of 1 indicates the most extreme case of inequality.
14. In addition, Wolff and Marley (1989) adjusted their estate estimates from individual units to household units and found that the individual estimates of concentration declined much more significantly than the household estimates between 1922 and 1953, as the percentage of women among the wealthy increased from 8.5 percent to 18.0 percent; but they found no significant difference in individual and household estimates between 1958 and 1976, because the percentage of women among the wealthy remained relatively unchanged over this period.
15. That is, the estate data indicates what occurs at the top of the distribution and the survey data indicates what has happened to the remaining population.

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DEVELOPING COUNTRIES, ECONOMIC INTERACTIONS AND TROPICAL DEFORESTATION

Dal O. Didia*

I. INTRODUCTION

The alarming disappearance of tropical forests has been recognized as one of the most serious environmental problems facing the world (Myers 1976, Eckholm 1975, 1976). Repetto (1988) and the World Resources Institute (1985) state that over eleven (11) million hectares (114,000 sq. km. or 44,000 sq. miles) of tropical forests are converted[1] to other uses every year – an area larger than Austria.

Because tropical forests play such unique roles in our environment, their destruction will usher in a multitude of environmental problems with real economic and social costs. Such issues as extinction of plant and animal species, extensive wind and soil erosion, decline in soil fertility, and global warming have all been linked to tropical deforestation (Natural History 1985, Mahar 1989). Myers (1984) notes that while tropical forests occupy only 7 percent of the earth's land surface, they support between 2 and 4 million of the earth's 5 to 10 million species. As the World Resources Institute states, less than one percent of the tropical forests have been studied for their medicinal values.

Many researchers assert that the single most important factor driving deforestation in tropical countries is the demand for agricultural land (Mahar 1989; Postel and Heise 1988; World Resources Institute 1985). The pressure from increasing population and lack of industrial sector employment imply that the demand for agricultural land will continue to increase. Other factors in tropical deforestation include the absence of well defined property rights, commercial logging, firewood and charcoal consumption by households and industries, government policies, and natural forces such as drought and fire (Sommer 1976, Kelley 1980, Hassan and Hertzler 1987, Mendelsohn 1994, Deacon 1995).

Tropical deforestation is not entirely due to internal factors. External or international forces also contribute to the destruction of tropical forests. Konrad von Moltke (1990) notes that social transformations induced significantly by international economic relations result in the conversion of tropical forests to other uses. For instance, the huge external debt of these tropical countries places pressure on their governments to allow an unsustainable level of commercial logging in order to earn foreign exchange for debt service and other immediate problems. Hence investments in conservation efforts which yield long-term benefits are ignored.

Von Moltke has suggested that tropical deforestation can be explained by the "tripartite economy" which operates simultaneously in these developing countries. The tripartite economy according to Von Moltke, consists of three parallel economies: subsistence economy, the national economy, and the international or shadow hard currency economy. In the subsistence economy, land and labor are the major inputs, and tropical forests are a crucial part of the land resources. A large proportion of the population in developing countries still depends on the subsistence economy. The national economy is

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where the policy makers can manipulate output through the use of macroeconomic policy instruments such as taxes and the money supply. Policy makers focus mainly on this economy, because it is the economy they can directly manipulate. In the international economy, factors beyond the control of domestic policy-makers are at play. For instance, the dollar and the pound control the prices of exports and imports of developing countries, yet these countries have no control over the dollar or pound. Konrad von Moltke observes that the factors driving deforestation in the tropics are in the interaction of these three parallel economies.

In spite of these observations, no formal analysis has been carried out to investigate the nature of the interactions. On the contrary, the few studies that have looked into this issue have tended to concentrate on a single variable such as debt (Kahn and McDonald 1995) or property rights (Mendelsohn 1994). Huge external debts or lack of well-defined property rights do not occur in a vacuum. Certain economic and sociological factors give rise to huge external debts and the absence of well-defined property rights. Therefore, to understand or isolate the factors responsible for the unprecedented depletion of tropical forests, an attempt must be made to understand how the tripartite economy operates.

Forests are a vital natural resource in developing economies, and their exploitation is inevitable. Deforestation therefore occurs as individuals, households, or nations attempt to maximize their welfare subject to some constraints. Consequently, deforestation is a by-product of production and consumption activities, just as air pollution is. This study does not investigate how a single factor such as debt or lack of well-defined property rights causes deforestation. Rather, we present a more balanced analysis as the process of deforestation is examined in the context of consumers and producers maximizing their welfare. An economic model which incorporates many of the interactions in the three parallel economies is developed. Based on this model, specific economic variables which highlight the impact of the tripartite economy on tropical deforestation are derived. Finally, data from fifty-five tropical countries are employed in an econometric analysis to validate the model, and policy recommendations on how to deal with this issue are outlined.

This paper is organized in the following manner. Section II presents the basic model while section III discusses the data employed in the study. Our empirical analysis is presented in section IV, and section V takes up our summary and conclusions.

II. THE BASIC MODEL

The objective of the model employed here is the maximization of the discounted stream of consumption. This model includes activities in the three parallel economies. We shall change Von Moltke's terminology slightly at this juncture to eliminate a potential source of confusion. In developing countries, it is not very easy to clearly distinguish the subsistence sector from the national sector. For instance, a subsistence farmer may also hold a job in industry, or sell cocoa for export. It is however easier to distinguish activities that result in total forest destruction (non-sustainable activities) from those (sustainable activities) that do not. The unprecedented levels of deforestation occuring now may be partly linked to the growth of the cash crop economy or monocultures (non-sustainable agriculture) motivated by the desire of national governments to earn foreign exchange.

Tropical soils, by their nature, are not suitable for monocultures because monocultures deplete soil nutrients so rapidly that the soil quickly becomes very unproductive. The use of heavy machinery like tractors also helps to destroy the soil (De Wilde 1967). Consequently, a piece of land is cultivated for only a few years and then abandoned. New forests are cut down, and the cycle continues. On the other hand, the mixed cropping technique, and in particular, shifting cultivation practiced by subsistence economies before the introduction of monocultures preserved soil fertility. Hence, the terms sustainable sector, and non-sustainable sector will therefore be used in this study in place of Von Moltke's "subsistence sector" and "national sector" respectively.

Assumptions underlying the basic model are: (i) Countries maximize the discounted stream of consumption; (ii) National governments have no control over prices received for exports; (iii) Available arable land in the country is allocated between forestry and agricultural use.; (iv) Agricultural land use for monocultures or cash crops leads to deforestation and land degradation (non-sustainable) whereas sustainable farming and forestry do not destroy the land. (v) Following Ehui et al (1990), we assume a quadratic functional form for the outputs in both the sustainable and non-sustainable sectors. Both production functions exhibit positive but diminishing marginal returns.

II.1 Sustainable sector

The production function or output (Qs) of the sustainable sector is given in equation (1):

$$Qs = f(SL, FL, Ls, Ks)$$

(1) $Qs = a0 + a1SL + a2FL + a3Ls + a4Ks + a5SLFL + a6SL^2 + a7FL^2$

$a0,\ a1,\ a2, a3, a4, a5 > 0; a6, a7, < 0$

$\delta Qs/\delta SL = a1 + \alpha 5\Phi\Lambda + 2\alpha 6\Sigma\Lambda > 0,\qquad \delta 2\Theta\sigma/\delta\Sigma\Lambda 2 = 2\alpha 6 < 0$

$\delta\Theta\sigma/\delta\Phi\Lambda = \alpha 2 + \alpha 5\Sigma\Lambda + 2a7FL > 0,\qquad \delta^2 Qs/\delta FL^2 = 2a7 < 0$

The inputs here include forestland, FL (a stock), and sustainable cropland, SL (a stock). These inputs reflect the fact that activities in this sector do not result in total forest destruction. Ls and Ks are respectively labor and capital. Sustainable agriculture may result in some clearing of the forest, but the clearing is done in such a way that the soil is protected. The farmers in this sector, who use a shifting cultivation system, depend on their cropland and whatever they can extract from the forestland. Products that can be extracted from the forestland include wild fruits, wild game, nuts, firewood, and wild rubber. Again, the point is that these activities do not result in total forest destruction.

II.2 Non-sustainable sector

The production function or output (QN) of the non-sustainable sector is given in equation (2):

$$QN = f(NL, S, LN, KN)$$

(2) $QN = b0 + b1NL + b2S + b3LN + b4KN + b5NLS + b6NL^2 + b7S^2$

$b0,\ b1, b3, b4, b5 > 0;\ b6,\ b7, < 0;\ b7 < b6;\ b2 < b1; b2 >=< 0$

$\delta QN/\delta NL = b1 + b5S + 2b6NL > 0 \qquad \delta^2 QN/\delta NL^2 = 2b6 < 0$

$\delta QN/\delta S = b2 + b5NL + 2b7S > 0 \qquad \delta^2 QN/\delta S^2 = 2b7 < 0$

The inputs in this sector include non-sustainable farmland, NL (a flow). The conversion of forestland to sustainable agriculture may yield timber for exports, S (a flow). After deforestation, the land is then converted to sustainable cropland (i.e. the clearing to extract timber makes it easier for subsistence farmers to move in and colonize the area). These inputs reflect the fact that activities in this sector result in total forest destruction (i.e. non-sustainable). KN and LN are respectively capital and labor. NL is a flow, and we make the simplifying assumption that NL is productive for only one period or year, after which the land is abandoned and new NL is cleared. Normally, the process of decay of NL may take up to seven or eight years or even longer. However, the point is that this piece of land is ultimately abandoned once the soil nutrients are depleted and productivity declines.

II.3 International sector

Although, the international sector is not explicitly modelled here, we intend to capture its impact through two avenues: (1) the prices (PN) developing countries receive for their exports, and (2) their external debt positions.

II.4 Maximizing the discounted stream of consumption

The gross national product (GNP) is the total value of all goods produced in both the sustainable and non-sustainable sectors;

(3) **GNP = PsQs + PNQN**

Qs, output of the sustainable sector is mainly for internal consumption, and it consists of several agricultural products. It is therefore a composite commodity. We set Ps, the price of Qs, equal to one (1), as we take Qs to be the numeraire. QN is the output of the non-sustainable sector which is mainly for export, and PN is the price of exports. Substituting for **Qs** and **QN** in equation (3);

(4) $$\textbf{GNP} = a0 + a1SL + a2FL + a3Ls + a4Ks + a5SLFL + a6SL^2 + a7FL^2 + PN(b0 + b1NL + b2S + b3LN + b4KN + b5NLS + b6NL^2 + b7S^2)$$

The consumption equation is given as;

(5) $$\mathbf{C(t) = GNP(t) - I(t) - iD(t\text{-}1) + \Delta D(t)}$$

Total debt service iD, (interest on debt i times debt owed D), and investment, I, are expenditures which reduce the amount available for consumption in the economy. New borrowings, ΔD, increase the amount available for consumption. Substituting for GNP in the consumption equation;

(6) $$\mathbf{C} = a0 + a1SL + a2FL + a3Ls + a4Ks + a5SLFL + a6SL^2 + a7FL^2 + PN(b0 + b1NL + b2S + b3LN + b4KN + b5NLS + b6NL^2 + b7S^2) + \Delta D(t) - iD(t\text{-}1) - I(t)$$

Maximizing the discounted stream of consumption, **C**;

(7) $$\mathbf{Max.\int_0^{\infty} C(t)\, e^{-rt} dt}$$

Subject to:	dSL/dt = S	dFL/dt = -(S + NL)	dD/dt = ΔD	dKs/dt = Is
	dKN/dt = IN	FL(0) = Flo	SL(0) = Slo	D(0) = Do
	KN(0) = Kno	Ks(0) = Kso	C(t) >= 0	

where Is and IN are respectively investments in the sustainable and non-sustainable sectors and r is the social discount rate.

The general form of the Hamiltonian equation associated with this maximization problem is given as:

$$\mathbf{H(t) = H[FL(t), SL(t), D(t), K(t); NL(t), S(t), \Delta D(t), I(t), \lambda(t), t]}$$

where FL(t), SL(t), D(t), K(t) are state variables; NL(t), ΔD(t), I(t) are control variables; λ(t) is the adjoint or costate variable and t is the set of time periods of relevance for the dynamic allocation problem. Choice of the control variables determines the rate of forest depletion and the value of the objective function. Specifically, our Hamiltonian equation is:

(8) $$\mathbf{H = [a0 + a1SL + a2FL + a3Ls + a4Ks + a5SLFL + a6SL^2 + a7FL^2 + PN(b0 + b1NL + b2S + b3LN + b4KN + b5NLS + b6NL^2 + b7S^2) + \Delta D - iD - Is - IN]e^{-rt} + \lambda 1S + \lambda 2(-S - NL) + \lambda 3\Delta D + \lambda 4Is + \lambda 5IN.}$$

Time subcsripts are dropped to simplify notation. The constraints, λ1 and λ2 represent the state equations for the stock of sustainable land and forestland respectively, while λ3 represents the state equation for the stock of debt. λ4 and λ5 represent the state equations for the stock of capital in the sustainable and non-sustainable sectors respectively.

The necessary conditions for a constrained optimization are given in equations (9) - (18).

(9) $\delta H/\delta S = PN(b2 + b5NL + 2b7S)e^{-rt} + \lambda 1 - \lambda 2 = 0$

(10) $\delta H/\delta NL = PN(b1 + b5S + 2b6NL)e^{-rt} - \lambda 2 = 0$

(11) $\delta H/\delta \Delta D = e^{-rt} + \lambda 3 = 0$

(12) $\delta H/\delta Is = -e^{-rt} + \lambda 4 = 0$

(13) $\delta H/\delta IN = -e^{-rt} + \lambda 5 = 0$

(14) $d\lambda 1/dt = -\delta H/\delta SL = -(a1 + a5FL + 2a6SL)e^{-rt} = 0$

(15) $d\lambda 2/dt = -\delta H/\delta FL = -(a2 + a5SL + 2a7FL)e^{-rt} = 0$

(16) $d\lambda 3/dt = -\delta H/\delta D = ie^{-rt} = 0$

(17) $d\lambda 4/dt = -\delta H/\delta Ks = -a4e^{-rt} = 0$

(18) $d\lambda 5/dt = -\delta H/\delta KN = -PNb4(e^{-rt}) = 0$

Equations (9) – (13) represent the optimality conditions, while equations (14) – (18) represent the co-state equations.

II.5 Important or Relevant Results

Result 1: The social discount rate, r, adjusts to the rate of interest, i.

To show that r will adjust to i, we differentiate equation (11) with respect to t, and substitute from equation (16);

$$-re^{-rt} + d\lambda 3/dt = 0$$

$$-re^{-rt} + ie^{-rt} = 0$$

(19) $r = i$

Equation (19) is an optimality condition which states that, the social rate of time preference (social discount rate) will equal the rate of interest tropical countries are paying on their debt. This implies that over time, the rate of time preference will adjust to the rate at which a country can borrow. (Note that, at any particular point in time, r may be fixed for each country, but it varies across countries). This result is plausible because the pressure created by a high level of public debt leads to myopic policies aimed at meeting the next payments of principal and interest. The end result of this pressure is to exploit more forest resources. The problem facing policy makers then translates to one of balancing today's consumption of forest resources against future needs. The interest rate on debt, **i** serves as a kind of price in the market, that determines how tropical forests are exploited. An increase in **i** therefore leads to a corresponding increase in r. As Tietenberg (1988) states, a high **r** favors the allocation of more resources to the present, as it gives "the future less weight in balancing the relative value of present and future resource use". A high discount rate therefore leads to over-exploitation or inefficient utilization of forest resources.

Result 2: Deforestation will be carried on up to the point where the income from the marginal product of one more unit of NL equals the discounted income from one more unit of FL.

To prove this result, we differentiate equation (10) with respect to t, and substitute from (15);

$$-rPN(b1 + b5S + 2b6NL)e^{-rt} - d\lambda 2/dt = 0$$

$$-rPN(b1 + b5S + 2b6NL)e^{-rt} + (a2 + a5SL + 2a7FL)e^{-rt} = 0$$

$$rPN(b1 + b5S + 2b6NL) = (a2 + a5SL + 2a7FL)$$

$$r(PNMP_{NL}) = MP_{FL}$$

(20) $\mathbf{PNMP_{NL} = (MP_{FL})/r}$

Equation (20) states that the income ($PNMP_{NL}$) from the marginal product of another unit of non-sustainable land, equals the discounted stream of revenues $\{(MP_{FL})/r\}$, from another unit of forestland. If the returns from keeping a unit of forestland intact exceeds the returns from converting that unit of forestland to non-sustainable land, then more forestland will be preserved. On the other hand, if the returns from a unit of non-sustainable cropand, NL is greater, then more NL will be desired, leading to more deforestation. This condition implies then, that deforestation will be carried on up to the point where the income from the marginal product of one more unit of NL equals the discounted income from one more unit of FL. At this point the incentive for faster or slower deforestation vanishes.

Let us examine how each of the variables in equation (20) affects tropical deforestation.

Evaluation of the social discount rate, r

From equation (19), r = **i**, we observed that an increase in **i** leads to a corresponding increase in **r** to maintain the equilibrium condition. Now, let us examine how changes in the social discount rate, **r**, effect the exploitation of forest resources over time. Equation (20) states that $PNMP_{NL} = (MP_{FL})/r$. Suppose an increase in debt obligations leads to an increase in **i**. This will lead to a corresponding increase in **r**, holding everything else constant. As r increases, the discounted stream of income $\{(MP_{FL})/r\}$ will decline. To maintain the equilibrium implied by equation (20), the left-hand-side (LHS) or $PNMP_{NL}$ must decline. For the LHS to decline, the marginal product of NL, (MP_{NL}) must decline since PN is exogenous to our model. For MP_{NL} to decline, we have to increase the amount of NL under cultivation, because in equilibrium, the MP_{NL} is declining. Increasing the amount of NL under cultivation leads to more deforestation. Deforestation is therefore exacerbated by an increase in **r** resulting from an increase in debt service obligations.

Evaluation of export prices, PN

Changes in the prices of export crops will affect the supply of export crops and the rate of tropical deforestation as we shall observe below. From equation (20), $\mathbf{PNMP_{NL} = (MPFL)/r}$. Suppose that poor harvests or some other factors lead to an increase in **PN**, holding other variables constant. This means that the value of the left-hand-side (LHS) of equation (20) will go up, thereby resulting in a situation of disequilibrium. To maintain the equilibrium condition, the value of the right-hand-side (RHS) must equally go up. For the value of the RHS to go up, we must either increase MP_{FL} or decrease **r**. Since individual countries have no control over r (the value of r is driven by the value of **i**, which is in turn determined by the foreign lenders), decreasing **r** is not an option here. We must therefore increase the MP_{FL}. For the MP_{FL} to go up, the amount of FL must be reduced, because in equilibrium, the MP_{FL} is declining. An increase in **PN** therefore, leads to an increase in deforestation as more NL is cleared for the cultivation of more export crops. This result clearly conforms to rational producer behavior. Economic theory states that, as prices go up, ceteris paribus, producers will supply more.

It is also very conceivable that an increase in **PN**, ceteris paribus, could indirectly lead to a reduction in the rate of deforestation. This is because an increase in **PN** means more foreign exchange earnings for tropical countries, without necessarily increasing output. With an increase in export earnings, the ability to meet debt and development obligations is enhanced. This could lead to a reduction in interest rate, **i** paid on debt, and a lowering of the social discount rate, r over time via equation (19) as increased earnings pay off debt. Consequently, the pressure to deforest may be reduced. Hence the relationship between **PN** and the rate of deforestation could be negative, as opposed to the positive relationship predicted by the model.

Evaluation of the MP_{NL} **and** MP_{FL}

Factors that influence MP_{NL} and MP_{FL} include socio-economic variables such as the number, skills, and training of the labor force. Population growth may cause farmers to move to very unproductive marginal lands. MP_{NL} in these new lands will most likely be less than MP_{NL} in more fertile soils. Marginal lands are easily stripped of the minimal nutrients they contain and are soon abandoned. Growing populations in developing countries, which are increasingly employed in agriculture, add to the pressure to clear forestland for fuelwood, habitat and food production.

Result 3: Deforestation will continue until the income (or loss) from creating another unit of sustainable land plus the discounted stream of revenue from one more unit of cultivated SL equal the discounted stream of revenues from an additional unit of forestland, FL.

To prove this result, we differentiate equation (9) with respect to t, and substitute from (14) and (15);

$$-rPN(b2 + b5NL + 2b7S)e^{-rt} + d\lambda 1/dt - d\lambda 2/dt = 0$$

$$-rPN(b2 + b5NL + 2b7S)e^{-rt} - (a1 + a5FL + 2a6SL)e^{-rt} + (a2 + a5SL + 2a7FL)e^{-rt} = 0$$

$$rPN(b2 + b5NL + 2b7S) + (a1 + a5FL + 2a6SL) = (a2 + a5SL + 2a7FL)$$

$$r(PNMPS) + MPSL = MP_{FL}$$

$$(21) \quad \mathbf{PNMP_S + (MP_{SL})/r = (MP_{FL})/r}$$

Equation (21) states that the income ($PNMP_S$) from the process of converting another unit of forestland to sustainable agriculture plus the discounted stream of revenues {$(MP_{SL})/r$} from another unit of cultivated sustainable cropland is equal to the discounted stream of revenues {$(MP_{FL})/r$} from one more unit of forestland. The trade-off between keeping land in its original form (i.e. forestland), and converting it to other uses such as agricultural land depends on the relative returns of each method of utilization measured in terms of the value of marginal product. If the returns from conversion to cropland, SL, exceed the returns from leaving the land in its original form, then we can expect more conversions. Conversely, if the returns from forestland exceed the returns from conversions, then we can equally expect fewer conversions and more forestland.

As in result 2 above, this condition implies that deforestation will continue until the income (or loss) from creating another unit of sustainable land plus the discounted stream of revenue from one more unit of cultivated SL is equal to the discounted stream of revenues from an additional unit of forestland, FL. When this condition is realized, the incentive for faster or slower deforestation vanishes.

Result 3 similarly reveals that the variables **r, PN, $\mathbf{MP_S}$**, and **$\mathbf{MP_{SL}}$** influence tropical deforestation in the same manner as described in Result 2 above. Therefore, further elaboration is unecessary.

The preceeding analysis reveals that debt service obligations, the price of exports, and the size of the labor force engaged in agriculture are the major forces driving tropical deforestation. Our model predicts a positive relationship between tropical deforestation and debt obligations, the size of labor force, and the price of exports. These predictions are tested in the econometric analysis discussed in section four.

III. DATA

The data largely come from Food and Agricultural Organization (FAO) and World Bank sources. The term "tropical countries" refers to countries located between the tropics of cancer and capricorn, therefore, countries such as Argentina and South Africa are excluded. The countries included in this study, average deforestation levels, and average public debt levels calculated between 1981 - 1985 are listed in the appendix. The sample is limited to those countries with available data on deforestation, debt and other socio-economic variables.

The FAO defines deforestation as a situation where a formerly forested piece of land is cleared and the land is permanently devoted to other uses. Deforestation data is available as averages between 1975-1980 and 1981-1985, measured in thousands of hectares (ha). This limits the time dimension of this study. Total forested area variables are also measured in thousands of hectares. As Kahn and McDonald (1995) point out, "the need for lagged variables as instruments to explain right hand side endogenous variables prevents regression analysis of the 1975-1980 data" The right hand side endogenous variables (i.e. variables that are jointly determined with the left hand side endogenous variable, deforestation) are debt obligations (iD & ΔD), available forestland FL, government expenditures, G and investments, I. The values of these variables for the 1975-1980 period will be used as instruments in the "Two Stage Least Squares" (2SLS) estimation technique employed for the regression analysis.

Total debt service, iD, is the primary debt variable used in this study. It represents the actual payments of interest and principal on public external debt. Public external debt here comprises only public/publicly guaranteed external debt. We do not include private external debt in the debt figure, because there are "too many gaps in the private external debt measure to make this possible". However, this does not constitute a major limitation, since the correlation between private external debt and public/publicly guaranteed external debt is 0.899 for the countries covered in this study (Kahn and McDonald). Another reason for excluding private external debt from the public debt figure is that, it accounts for a small fraction of the total debt owed by developing countries and therefore should not pose a severe limitation. For most of the countries in our sample, public external debt accounts for about seventy to ninety percent of total external debt. It is worth noting at this juncture that the variation in public external debt between the countries covered in this study is quite substantial. The World Bank (1989) debt tables were the source of our debt data. Total debt is measured in current U.S. dollars.

The labor force variable was obtained by multiplying the percentage of the total population represented by the work force times the total population. This figure was taken from the *World Development Report*. We could have used other measures such as working age population, but such measures would result in a reduction of our already limited sample size.

The export price variable was taken from the World Tables of Economic and Social Indicators, 1950 - 1988 (ICPSR 9300) compiled by the World Bank's International Economics Department. The values used in our regression were calculated as a percentage change in Non-fuel Primary Products Export Price Index, from 1981-1985. Calculating the export price variable as a percentage change gives us a better indication of the movement or fluctuations of this variable for developing countries over time, and also allows a meaningful comparison of inter-country differential impacts.

IV. EMPIRICAL ANALYSIS

The first order optimality conditions derived in section (II.4) {equations 19, 20 and 21} and the discussion in section (II.5) form the basis for the empirical estimations discussed in this section. Our analysis covers 1981-1985, as this was the period for which appropriate data were available. The simultaneous relationship between our dependent variable (average annual deforestation) and some of the independent variables means that Ordinary Least Squares (OLS) would not be appropriate for this estimation. If OLS were used, simultaneity bias would result in the over-estimation of the coefficients of the endogenous variables which appear as right-hand-side variables in the model. This would lead to higher t-values and could lead to a type one error, i.e. to reject a true null hypothesis (Studenmund and Cassidy 1992). We therefore use the 2SLS method of estimation.[2]

Wide size disparities in our sample countries require adjusting all relevant variables to avoid observing a relationship based on size. Without adjusting for size, it would be difficult to isolate or understand the nature and implication of the economic forces driving tropical deforestation. As Kahn and McDonald correctly point out "– an unscaled regression could establish a relationship between debt and deforestation that is completely driven by country size and has nothing to do with economic relationships." This point equally applies to all the other right-hand-side variables in our model. Adjusting for size also makes heteroskedasticity less likely in a cross-sectional study where it is always a theoretical possibility (Studenmund and Cassidy 1992). However, all regressions are tested and corrected for heteroskedasticity.

The size of a country can be measured by population or by the amount of the gross national product (GNP) among other measures. Hence, we can adjust for size by dividing all relevant variables by population or by GNP. This study utilizes both methods. To test whether significant regional impacts exist with regard to tropical deforestation, dummy variables were created for the African region (Dum1), Central American & the Caribbean region (Dum2), South American region (Dum3) and the Asian region (Dum4).

The results of our regression explaining total deforestation scaled by population are presented in table 1. Even though the adjusted R^2 of 0.26 looks good for a cross-sectional data, none of the major explanatory variables is statistically significant. The dummy regional variables (Dum1, Dum2 and Dum4) are all statistically significant, implying that there is a differential effect between South America (the excluded regional dummy variable) and the included regional dummies (Africa, Central America & the Caribbean, and Asia). The interaction variables, VEG7PCD4 (Asian region) and VEG7PCD2 (Central American & the Caribbean region) are significantly different from the interaction in the South American region, the excluded interaction term. The interaction variable in the African region is not significantly different from the interaction in the South American region.

Table 2 displays the results of the regression explaining total deforestation scaled by GNP. With R^2 and adjusted R^2 of 0.37 and 0.17 respectively, the fit is considered good for a cross-sectional data. One major difference between table 2 and table 1 is that, while the t-statistic in table 1 shows that significant differences exist between South America and the other regional dummies, the t-statistic in table 2 indicate that no differences exist among the regions. So, while scaling by population leads to significant differences among the regions, scaling by GNP eliminates these regional differences.

Another major difference between table 1 and table 2, is that when scaled by population, none of the major independent variables was statistically significant, whereas scaling by GNP results in three of the major independent variables being statistically significant. This could be attributed to measurement errors in population which we used to scale our regression in table 1. Potential problems of using population figures from developing countries are highlighted by Bauer (1972). Since population figures are a big factor in determining the amount of foreign aid and other grants to developing countries, these countries have an incentive to inflate their population figures. It is therefore quite possible that when we divided our deforestation figures by population, we may have unknowingly biased downwards our per capita average annual deforestation.

GNP figures on the other hand, are much more difficult to misrepresent because international lending agencies have an incentive to monitor and audit the figures reported, as the ability of a country to repay its loans can be approximated by the national output. In many developing countries where government expenditures account for a very significant portion of the GNP, these expenditures which occur in the open market can be tracked. GNP figures reported by developing countries are therefore much more likely to be accurate than population figures. It is particularly striking to note that when scaled by either population, or GNP, the endowment of forestland has no significant influence on the amount of deforestation.

With a t-statistic of 2.37 (see table 2), the labor force variable is statistically significant, and has the expected sign. This implies that, as the labor force increases, more land will be deforested to absorb the increasing number of people who earn their living from the land. As was stated earlier, about sixty to seventy percent of the people in developing countries are engaged in agriculture. It is worth noting that when population is directly used as a regressor (regression results not reported here to conserve space), it is not statistically significant.

The regression results show that debt and deforestation are significantly positively related. Our results are in line with the study by Kahn and McDonald which also confirm that debt and deforestation are significantly positively related. Notice that the debt variable was not scaled by GNP. Following Kahn and McDonald, "another way of measuring the burden of the debt is to measure debt relative to the

Table 1. Two-Stage-Least Squares Regressions Explaining Total Deforestation (1981-1985).

Dependent Variable: Total Deforestation (1000s ha) per million people.

Independent Variable	Coefficient	T-Statistic
Intercept (South America)	38.36	4.70
Africa Dummy (Dum1)	-19.82	-2.42
Central America & Caribbean Dummy (Dum2)	-26.83	-3.64
Asia Dummy (Dum4)	-31.05	-4.20
Forested Land Area (10^3 ha/10^6 people)	-0.00054	-0.46
Labor Force (% of population)	-0.21	-0.99
Total Debt Service (Real US$/$10^6$ people)	$-0.24 * 10^{-8}$	-0.03
Gov't Spending (Real US$/$10^6$ people)	$-0.26 * 10^{-8}$	-0.18
Investment (Real US$/$10^6$ people)	$-0.47 * 10^{-8}$	-0.30
Export Price (% Δ index 1981-1985)	-0.04	-0.38
VEG7PCD1^	-0.001	-0.83
VEG7PCD2~	0.015	2.11
VEG7PCD4`	0.014	5.31
R^2	0.42	
Adjusted R^2	0.26	
Number of observations	55	

Interaction between the African region and total forested land area.
Interaction between the Central American & Caribbean region and total forested land area.
Interaction between the Asian region and total forested land area.

Table 2. Two-Stage-Least Squares Regressions Explaining Total Deforestation (1981-1985).

Dependent Variable: Total Deforestation (1000s ha) per million of real US$ GNP.

Independent Variable	Coefficient	T-Statistic
Intercept (South America)	-0.049	-1.69
Africa Dummy (Dum1)	0.013	1.12
Central America & Caribbean Dummy (Dum2)	-0.011	-0.85
Asia Dummy (Dum4)	-0.011	-0.73
Forested Land Area (10^3 ha/10^6 of US$ real GNP)	0.0051	1.20
Labor Force (per 10^6 of US$ real GNP)	0.000015	2.37
Relative Debt Service {Total debt service/experts (in real US$)}	$-0.28 * 10^{-6}$	2.02
Gov't Spending (Real US$/$10^6$ of US$ real GNP)	$-0.71 * 10^{-7}$	-0.78
Investment (Real US$/$10^6$ of US$ real GNP)	$-0.31 * 10^{-8}$	0.04
Export Price (% Δ index 1981-1985)	-0.00072	-2.08
VEG7D1^	-0.004	-0.94
VEG7D2~	0.018	1.15
VEG7D4`	0.011	0.77
R^2	0.36	
Adjusted R^2	0.17	
Number of observations	55	

^ Interaction between the African region and total forested land area.

~ Interaction between the Central American & Caribbean region and total forested land area.

` Interaction between the Asian region and total forested land area.

ability to repay it, which would be related to foreign exchange earnings."[3] Consequently, our debt variable was constructed to incorporate this effect, by dividing total debt service by total exports which yields relative debt service as our debt variable. Both the government expenditure and investment variables were not statistically significant. Measurement errors may be responsible for this surprising result.

The export price variable (PN) is statistically significant, but the negative sign of the coefficient, which means that less forestland would be cleared for export crop production as export prices rise, is contrary to the positive relationship predicted by our model. However, this result is not entirely surprising. As we alluded to earlier, certain conditions may influence producer behavior to the extent that less is supplied as prices rise. So, what we have here is a situation of both substitution and income effects working together. As export prices rise, the substitution effect leads to more deforestation, as farmers substitute (cultivate) more non-sustainable land (NL) for export crops in place of forestry (FL) and sustainable land (SL). As this substitution takes place, deforestation increases, thereby linking higher export prices to higher deforestation as the model predicted.

The income effect on the other hand, leads to less deforestation. This occurs because an increase in export prices means more foreign exchange earnings for tropical countries, without necessarily increasing output. With this increase in export earnings, the ability to meet debt and development obligations is enhanced. Consequently, much of the pressure that leads to myopic policies that are detrimental to tropical forest conservation is eliminated. Hence, these countries may conserve their forests in a period of rising export prices, thereby linking higher export prices to less deforestation. Therefore, ensuring that developing countries receive competitive prices for their exports may constitute a solution to the predicament of tropical forests.

The most interesting result of our regression analysis is that the endowment of forestland has no significant impact on the amount of deforestation. This is to say that the inhabitants of tropical countries do not cut down their forests just because the forests exist. The robustness of this result is confirmed as the available forestland is interacted with each of the regional dummy variables (VEG7D1, VEG7D2, VED7D4, and VEG7D3 being the excluded regional interaction term). The aim of these interactions being to examine if this result holds across the four regions of the tropical world. The results in table 2, as evidenced by the t-statistic, indicate that across regions, the effect of the endowment of forestland on tropical deforestation does not vary.

V. SUMMARY AND CONCLUSIONS

Tropical deforestation is by and large an economic issue. It occurs as individuals, households or countries attempt to maximize their welfare subject to some constraints. This study develops a behavioral model which incorporates many of the intra-country and inter-country (international) interactions which are thought to be responsible for the depletion of tropical forests. The preceeding analysis show that pressures from servicing huge external debts, declining export prices, and the huge number of people employed in agriculture, lead to myopic behaviors that are detrimental to tropical forest conservation. To devise effective policies aimed at stanching tropical deforestation, these variables must be properly evaluated.

In economic terms, when tropical forests are preserved, they provide external economies to the rest of the world, while the cost of preservation is borne entirely by the country that undertakes to preserve its forests. Similarly, when tropical forests are destroyed, they impose external diseconomies on the whole world, whereas the benefits of deforestation accrue largely to the country that exploits its forests. Given the "global public good" nature of tropical forests, what we have here is a classic case of market failure, and something very similar to Hardin's (1968) "tragedy of the commons", in that the host country in deciding to deforest, does not take into account the costs imposed on the rest of the world. On the other hand, when the host country conserves its forests, the rest of the world does not compensate that country for foregoing some consumption. Therefore, any attempts to devise effective policies for checking tropical deforestation must find a way to compensate developing countries that preserve their forests. This is where the international community must come together to work out equitable arrangements.

On the debt service issue, there is a very good opportunity now for the world community to realistically evaluate the ability of developing countries to repay these debts. As of 1994, the total debt of the developing countries stood at $1.6 trillion. It is projected to hit about $2 trillion by 1996. The interest obligations are so high that developing countries are now paying more money to the West than they are receiving in aid (Barbara Bramble 1987, World Resources Institute 1992). The pressure to service these debts leads developing countries to export more timber and/or increase the cultivation of cash crops, thereby increasing the rate of tropical forest depletion. Our regression analysis (table 2) reveal that a billion dollar reduction in debt can result in a reduction in average annual deforestation of 280,000 hectares. Compare these results to the situation in Ecuador (see appendix) where average annual deforestation is 340,000 hectares, and $5.965 billion is owed in public external debts.

One frequently proposed approach to the debt crisis is the utilization of "Debt-for-Nature"[4] swaps. Although, debt-for-nature swaps are still not widely used, they hold great potential for the future of tropical forests. Debt-for-nature swaps are not a panacea for tropical deforestation, as they can be criticised on a number of counts such as the enforceability of the contracts and the quality of the land being swapped. However, in the short-run, they offer a welcome and implementable solution to the plight of tropical forests. It is therefore suggested that debt-for-nature swaps be explored in greater detail as a tropical forest preservation tool.

On the role of export prices, table 2 suggests that if export prices go up, tropical deforestation will go down. Ensuring that developing countries get competitive market prices for their exports will thus encourage tropical forest conservation. With the exception of a few countries that produce metals and minerals, agricultural commodities account for about sixty-seven percent of export earnings in developing countries. The prices of exports of developing countries are subject to wild fluctuations in international markets and, as export composition is rigid, these countries cannot protect themselves against such fluctuations. During the past three decades, world prices of agricultural commodities relative to world prices of manufactured goods have tended to fall (Singh 1983, Pearce and Warford 1993). As export revenues decline, while the pressure of debt and development obligations mounts, these countries turn to their forests.

An effective means of reducing tropical deforestation would therefore be to stabilize export prices. One way to achieve this may be to enter into long-term contracts with suppliers in developing countries. Another viable option would be to index the prices of exports of developing countries to the prices of their major imports from the industrialized countries. The World Trade Organization may have a role to play in this regard. As Singh noted, in 1981, measured in current dollars, agricultural commodity prices in world markets fell by 19 percent. In 1982, they fell by another 10 percent. Expressed in real terms, the prices were the lowest since the "great depression" of the 1930s. Projections for the quantities and prices of exports for the 1990s are not very favorable. Vaughan (1995) notes that low commodity prices constitute one of the serious impediments to economic development in tropical Africa.

Tropical forest depletion can also be reduced if we take steps to encourage more activities in the sustainable sector, while discouraging activities in the non-sustainable sector. This can be achieved by developing profitable markets for the products of the sustainable sector. Goods that can be produced in the sustainable sector include several varieties of vegetables and fruits, wild nuts, wild rubber, and selective harvesting of some exotic trees among others. If consumers in developed countries are willing to pay higher prices for these products just as they are willing to pay higher prices for "organic" or "designer" fruits and vegetables, then many countries in the tropics may now have the incentive to invest more in the activities of the sustainable sector.

The regression analysis confirm that population per se, does not necessarily lead to increased deforestation. Rather, what matters is the percentage of the labor force that is employed in agriculture. For developing countries, the proportion of the population engaged in agriculture ranges from fifty to eighty percent, which clearly puts much pressure on the land. According to the coefficient of the Labor Force variable (table 2), a reduction in the number of people employed in agriculture by two million people, would result in the decline of average annual deforestation by 30,000 hectares. The governments of developing countries must pursue policies that can create employment opportunities outside the agricultural sector. The multi-national corporations can play a big role in this regard.

This study demonstrates that reducing the debt burden, stabilizing export prices and creating employment opportunities outside the agricultural sector can help reduce tropical deforestation. More analysis needs to be carried out on a technique such as debt-for-nature swaps that promises to reduce the amount of debt, and enhance environmental quality. There may be cases where outright write-offs or repudiation of these debts may be the only solution (Tideman and Lockwood 1993).

The limitations of our model, hence the results, must be acknowledged. Clearly, data problems in measuring deforestation figures abound. More accurate and sophisticated measuring techniques are becoming available, and the FAO is completing a new study on deforestation levels in the tropics. Future studies using more reliable data, other explanatory variables and functional forms would enhance our understanding of the variables driving deforestation. Particularly, the impact of internal factors such as political stability (or the lack thereof) on the exploitation of tropical forests must be explored. One word of caution about the general recommendations given above, is that we must explore the inter-regional and perphaps inter-country differences before implementing any solutions.

Appendix. Sample Countries, Average Annual Deforestation and Public Debt Levels, 1981-1985.

Country (Code)	**Deforestation** (1000s of hectares)	**Public Debt** (billions of $)
Bangladesh (13)*	8.0	5.264
Belize (16)	8.5	0.077
Benin (17)*	67.2	0.610
Bolivia (20)*	117.2	3.306
Botswana (21)*	20.0	0.266
Brazil (22)*	2530.0	63.856
Burundi (27)*	1.1	0.321
Cameroon (29)*	110.0	1.998
Central African Rep. (32)*	55.0	0.255
Chad (34)	80.0	0.165
Colombia (38)*	890.0	7.905
Comoros Islands (39)	0.5	0.099
Congo (40)*	22.0	2.062
Costa Rica (41)*	65.0	2.991
Dominican Republic (47)*	4.0	2.165
Ecuador (48)*	340.0	5.965
El Salvador (50)*	4.5	1.253
Ethiopia (52)*	88.0	1.403
Fiji (53)	1.7	0.281
Gabon (58)*	15.0	0.860
Gambia (59)	5.2	0.169
Ghana (62)*	72.0	1.274
Guatemala (69)*	90.0	1.614
Guinea-Bissau (71)	57.0	0.194
Guyana (72)	2.5	0.706
Haiti (73)*	1.8	0.473
Honduras (74)*	90.0	1.782
India (78)*	147.0	23.647
Indonesia (79)*	620.0	23.017
Ivory Coast (85)*	510.0	5.353
Jamaica (86)*	2.0	2.459
Kenya (89)*	39.0	2.730
Liberia (96)*	46.0	0.793
Madagascar (100)*	156.0	1.938
Malawi (101)*	150.0	0.759
Malaysia (102)*	255.0	11.863
Mali (104)*	36.0	1.096
Mauritania (107)*	13.3	1.201
Mauritius (108)*	-0.1	0.367
Mexico (109)*	615.0	63.354
Nepal (114)	84.0	0.436
Nicaragua (120)*	121.0	3.624
Niger (121)*	67.1	0.729
Nigeria (122)*	400.0	12.135

Appendix (Continued).

Country (Code)	Deforestation (1000s of hectares)	Public Debt (billions of $)
Pakistan (125)*	9.0	10.154
Panama (126)*	36.0	3.098
Papua-New Guinea (127)	23.0	0.952
Paraguay (128)*	212.0	1.236
Peru (129)*	270.0	8.706
Phiippines (130)*	92.0	12.092
Rwanda (138)*	5.2	0.266
Senegal (141)*	50.0	1.616
Sierra Leone (143)*	6.0	0.388
Solomon Islands (23)	0.8	0.038
Somalia (146)	13.5	1.455
Samoa (516)	1.6	0.061
	58.2	2.441
	504.0	5.842
	130.0	2.796
	379.0	7.847
	12.1	0.813
	0.8	1.112
	50.0	0.706
	80.0	0.430
	245.0	16.417
	370.0	4.610
	70.0	2.811
	80.0	1.369

* indicates that the country is included in the 1981-1985 sample
Source: World Bank data obtained from Kahn and McDonald (1995).

ENDNOTES

Conversion is used here in the context in which Myers (1986) defines conversion. "...... a catch-all term that stands for all types of forest depletion, ranging from marked modification to fundamental transformation to outright destruction."

2. The regression estimations were done with the personal computer version 5.1 of the Limdep econometric software (Green 1989).
3. Developing countries service their debts only in convertible (hard) currencies such as the dollar or the British pound. Exports constitute the major source of hard currencies for these countries. Therefore, the ability to meet debt obligations has nothing to do with how much that is produced within the country, but how much is exported to the developed countries like USA or Britain, which earns foreign exchange.
4. Debt-for-Nature swaps represent arrangements where for instance, an environmental organization in the USA buys the debt of a developing country at a discounted value from the lender. The developing country's debt is then written off in exchange for the country undertaking to set aside a tract of forestland for preservation.

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IS THERE A CYCLE COMPONENT IN US REAL WAGES: AN EMPIRICAL INVESTIGATION

Kudret Topyan*

I. INTRODUCTION

It is important to investigate how real wages behave over the business cycle in order to provide evidence for or against the plausibility of competing macro models. Recent empirical work on real wage behavior is inconsistent. Neftçi (1978, Sargent (1978), Otani (1978), and Chirinko (1980) reported countercyclical behavior of real wages, while Bils (1985), Keane, Muffit, and Runkle (1989) demonstrated procyclicality.

Three recent papers add a new dimension to the debate (Sumner and Silver 1989, Mocan and Baytas 1991, and Mocan and Topyan 1993). Their results show that the cyclicality of real wages depends upon whether business cycles are driven by demand or supply shocks.

The present study builds on the work of Mocan and Topyan (1993) in a number of ways. In Mocan and Topyan (1993) the underlying model is a structural time series model where the trend of the real wage is estimated through a Kalman filter. This method enables one to capture the stochastic nature of a time series more accurately, permitting the estimation of more reliable coefficients than can be obtained using traditional methods. More precisely, traditional methods, until recently, have usually treated trends as deterministic functions of time. This assumption yields a time series Y_t in the following form:

(1) $Y_t = f(t) + U_t$

where f(t) is taken to be a deterministic function of time with no stochastic disturbance. On the other hand as Harvey argues (Harvey 1985) most economic trends need not be deterministic. They generally have a stochastic component such as stochastic technical progress in the employment-output relation.

In the same vein, it has been widely recognized that regressions based on inappropriately detrended series can result in highly misleading conclusions (Chan, Hayya, and Ord, 1977; Nelson and Kang, 1988; Stock and Watson, 1988). Since the seminal paper of Nelson and Plosser (1982), much attention has been devoted to examining whether the observed secular growth in most macro economic time series can be characterized by a stochastic or a deterministic trend. At this stage a Dickey-Fuller test for unit root[1] is necessary for determining the proper method of detrending. According to the test, if the hypothesis of a unit root is rejected, the series should be regressed on some polynomial of time for trend removal, otherwise trend elimination should be done by taking the first differences of the series in which a stochastic trend is evidenced by unit root test statistics.

As mentioned by Mocan and Topyan (1993), however, the power of the unit root tests has been questioned recently. Evidence has been provided indicating that the unit root tests are not resilient against the trend-stationary alternatives; and the classical unit root asymptotic is asserted to be of little practical value (e.g. Dejong, Nankervis, Savin, and Whiteman, 1992a,b; Sims and Uhlig, 1991; Sims,

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1988). On the other side, the structural model employed by Mocan and Topyan (1993), which is the one used here, eliminates the need to specify whether the trends are deterministic or stochastic prior to the analysis and enables us to capture the dynamics of the underlying trend more accurately than any other method. In fact, taking the first differences or regressing on a deterministic time trend are special cases of the flexible trend model used in this study.

As mentioned above, this study builds on the work of Mocan and Topyan (1993). However, the basic contribution of this study is to analyze the inclusion of a cycle component in regressions dealing with the behavior of US real wages over the business cycle to examine possible improvements in model specification and estimation results. This application enables us to make more rigorous statements about the behavior of real wages as it rules out biases generated by technical inefficiencies resulting from imperfect model specification. It is explained in this study that the exclusion of a cycle component may lead to a biased stochastic trend that fails to explain dynamic characteristics of the time series and therefore produces misleading estimation results. As a result, the statistically significant relationship between US. real wages and employment may not be captured due to poor modeling and yields a wrong macro conclusion of "there is no statistically significant relationship between the US. real wages and employment." It should also be noted, once again, that the series may have a stochastic trend component as in the recent works cited above, however incorporating a cyclical component, in addition to the stochastic trend component, will play an important role for not only distinguishing betwen the trend movements and cyclical movements, but also providing a description of the series. In other words, a model with no cyclical component will only have a stochastic trend component and cyclical fluctuations are included in this trend component. This is a characteristic that enables the researcher to distinguish between stochastic trend and cyclical components.

II. METHODOLOGY

Real wages can be formulated as

(2) $$w_t = u_t + \psi_t + \varepsilon_t$$

where w_t is the real wage at time t, and u_t, ψ_t and ε_t are the trend, seasonal, and irregular components, respectively. Within this framework, one can specify a local linear trend where the level and the slope of the series are governed as follows:

(3) $$u_t = u_{t-1} + \beta_{t-1} + \eta_t$$

$$\beta_t = \beta_{t-1} + \xi_t$$

where η_t and ε_t are white noise disturbance terms that are serially uncorrelated with variances $\sigma^2_{\eta_t}$ and $\sigma^2_{\xi_t}$ respectively. Following Harvey and Durbin (1986) and Harvey (1989)[pages:26-34] seasonality is assumed to be generated by the following stochastic trigonometric process, which is allowed to evolve over time:

(4) $$\psi_t = \sum_{j=1}^{s/2} \psi_{jt}$$

$$\psi_{jt} = \psi j, t-1 \cos\lambda_j + \psi^*_{j,t-1}\sin\lambda_j + w_{jt}$$

$$\psi^*_{jt} = -\psi_{j,t-1}\sin\lambda_j + \psi^*_{j,t-1}\cos\lambda_j + w^*_{jt}$$

where j=1,2,...[s/2],w_{jt} and w^*_{jt} are zero mean white noise disturbances which are uncorrelated with each other, and w^*_{jt}appears by construction (see Hannan, Terrel, and Tuckwell, 1970; Harvey, 1989, pp. 40-49).

The trend in (3) is equivalent to an ARIMA(0,2,1) process. If $\sigma^2_{\xi_t} = 0$, the trend reduces to a random walk with a drift; i.e. w_t is stationary in first differences (integrated of order one). If $\sigma^2_{\eta_t} = 0$, but $\sigma^2_{\xi_t} > 0$, the trend is still integrated of order two as the original case. If $\sigma_{\eta_t} = \sigma_{\xi_t} = 0$, the model collapses to a standard regression model with a deterministic trend; i.e. $u_t = u_0 + \beta_t$.

The structural model depicted in (2) can be extended by adding an exogenous explanatory variable X_t to the right hand side, which gives

(5) $\quad w_t = u_t + \psi_t + \gamma X_t + \varepsilon_t.$

In (5), X_t represents employment. This is, basically, the model used in most recent studies (such as Mocan and Topyan, 1993; Mocan and Topyan, (1995a), and Mocan and Topyan, (1995b)). The model described above does not have a cyclical component. Including a cyclical component entails adding the term Φ_t to the model (5) which gives

(6a) $\quad w_t = u_t + \psi_t + \gamma X_t + \Phi_t + \varepsilon_t$

where the cycle Φ_t is generated by

(6b) $\quad \Phi_t = \rho \cos \lambda_c \Phi_{t-1} + \rho \sin \lambda_c \Phi^*_{t-1} + \tau_t$

$\Phi^*_t = \rho \sin \lambda_c \Phi_{t-1} + \rho \cos \lambda_c \Phi^*_{t-1} + \tau^*_t$

ρ is a damping factor with $0 \le \rho \le 1$, λ_c is the frequency of the cycle in radians, and τ_t and τ^* are *iid* disturbances with 0 mean and variance σ^2_τ.

The model described above can be put into state space form which consist of the following equations.

(7a) $\quad w_t = Z_t \alpha_t + \varepsilon_t \qquad t = 1, 2, \ldots\ldots, T$

(7b) $\quad \alpha_t = A_t \alpha_t + V_t \qquad t = 1, 2, \ldots\ldots, T.$

Equation (7a) and (7b) are the observation and transition equations, respectively. α_t is an (m x n) unobservable state vector, Z_t is an (m x 1) fixed vector, A_t is a non-stochastic (m x m) matrix, ε_t is a serially independent, normally distributed irregular component with mean zero and variance σ^2_ε. Equation (7b) demonstrates that the state vector is updated each period but is also subject to some serially uncorrelated random distortions with zero mean and covariance matrix Ω_t, represented by (m x 1) vector V_t.

It is worth noting that the state space form is an enormously powerful tool which opens the way to handling a wide range of time series models. Once a model has been put in state space form, the Kalman filter may be applied and this in turn leads to algorithms for estimation, prediction, and smoothing.

After expressing the model in terms of state space representation [equations (7a) and (7b)], maximum likelihood estimates of the parameters of the structural model are obtained in the frequency domain and the Kalman filter is used to update the unobserved components. If a_{t-1} is an estimate of a_{t-1}, and P_{t-1} is its covariance matrix, then the optimal (minimum mean square error) linear projections of a_t and P_t at time t-1 are

(8) $\quad \alpha_{t\backslash t-1} = A\alpha_{t-1}$

(9) $\quad P_{t\backslash t-1} = AP_{t-1}A + \Omega_t.$

The Kalman filter updates the already available optimal predictor $\alpha_{t\backslash t-1}$ with the new information contained in w_t as follows:

(10) $\alpha_t = \alpha_{t\backslash t-1} + P_{t\backslash t-1}Z_t(w_t - Z_t'P_{t\backslash t-1})/f_t$

(11) $P_t = P_{t\backslash t-1} - P_{t\backslash t-1}Z_tZ_t'\alpha_{t\backslash t-1})/f_t$

where $f_t = Z_t'P_{t\backslash t-1}Z_t + \sigma_\varepsilon^2$.

Note that the term in parenthesis in equation (10) is the prediction error. Thus, equation (10) demonstrates that the predictor $\alpha_{t\backslash t-1}$ is updated by incorporating the prediction error, weighted by $P_{t\backslash t-1}Z_t / f_t$, which is the Kalman gain. Similarly, the new covariance matrix P_t in equation (11) is equal to the prior covariance matrix minus $Z_t'P_{t\backslash t-1}$ weighted by the Kalman gain.

III. ESTIMATION RESULTS AND DATA:[2]

The models are estimated for the United States using as the real wage measure average hourly earnings of production workers on the payrolls of manufacturing establishments deflated by the producer price index (Figure 1). For employment, the number of production workers in manufacturing is used. Both variables are in natural logarithms.[3] Estimations are performed in the frequency domain, with numerical optimization carried out using a quasi-Newton algorithm (see Harvey (1989, Ch.4) or Harvey and Peters (1984)).The first model uses equation (5) and the second model uses equation (6a). The estimation period is 1969Q1 to 1993Q3 for both regressions. As part of the diagnostics, normality, heteroscedasticity, and serial correlation tests are performed. The normality statistic (Bowman-Shenton test; Bowman,K.O. and Shenton,L.R (1975)) is tested against a chi-square distribution with two degrees of freedom. An F distribution with the degrees of freedom indicated is used for the heteroscedasticity test. The Box-Ljung statistic is a modified version of Box-Pierce Q test (also known as "portmanteau statistic") and is used for diagnostic checking of model specification. For the Box-Ljung Q-statistic[4], the appropriate distribution is chi-square, with $P-p-q$ degrees of freedom. (p and q are degrees of AR and MA, respectively, and P is $\sqrt{N}$, where N is the number of observations) [Ljung and Box (1978); McLeod (1978); Pierce and Newbold (1987)].

Estimation of the traditional "no cycle" model (5) for the period 69:1 through 93:3 yields coefficient of employment (γ) -.3259 with a t value of -1.3086, implying countercyclical behavior of real wages. However, it is not statistically significant at the 5 percent level or higher. The heteroscedasticity test (H(31,31)=.4377) confirms that the model is not heteroscedastic. The Box-Ljung (Q-statistic) test for model specification yields Q(9) = 14.93 (and Q(20) = 25.25 and Q(26) = 29.95) indicating that there is serial correlation in the errors. The normality test is satisfactory with (N(1) = .1546. R^2 is .8979 with R_d^2 = -.0569. The use of R^2 is conventional, while R_d^2, a better measure for time series data, is obtained by replacing the observations by their first differences. R_d^2 compares the prediction error variance with the sum of squares of the first differences about the mean. This yardstick is adopted in the random walk plus drift model. Therefore, R_d^2 = .15 means, there is a 15 percent improvement in the goodness of fit over a random walk plus drift. In summary, the first model fails to obtain a statistically significant employment coefficient (at the 5 percent level or better) and the Box-Ljung test fails to approve the model specification at the 10 percent level or better, finally R_d^2 is negative implying an efficiency loss (relative to random walk plus drift model) due to an incorrectly specified model. The trend component of this model can be observed in Figure 2.

Estimation of the model "with a cyclical component" (6a) for the same period yields a coefficient of employment (γ) -.4118 with a t value of -2.0031. All test statistics give no indication of model inadequacy:, H(31,31) = .5046, N(1) = 4.67, Q(9) = 11.22 and Q(20) = 16.22 and Q(26) = 18.88. R^2 = .9667, and R_d^2 = .0928. In short, there exists no possibility of model inadequacy. We now have statistically significant counter cyclical real wages with complete support from all test statistics for model selection and specification. Trend and cycle components of this model can be observed in Figures 3 and 4. Since all the other things are identical, this difference must be attributed solely to the inclusion of a cyclical component in the estimation equation. As shown in Figure 5, this model yields an excellent fit and, can be used with complete confidence for forecasts.

DETERMINANTS OF PERFORMANCE IN AN ECONOMIC STATISTICS COURSE: ARE TRANSFER STUDENTS AT ANY DISADVANTAGE?

Baban Hasnat* and Dal Didia*

I. INTRODUCTION

Community colleges are an integral part of higher education. In 1992, community college students accounted for 53 percent of all undergraduates in public colleges, and more first-time freshmen enrolled in public community colleges than in public four-year colleges (Phillippe 1995). In the State University of New York system - one of the largest systems in the world - 37 percent of all entrants into the system first enroll at community colleges (Johnstone 1990). Four-year colleges are now actively recruiting an increasing number of community college students by signing articulation agreements that facilitate transfer of credits. In addition, many state-funded colleges are required to provide community college graduates access to baccalaureate degrees.

However, when transfer students from community colleges (hereafter transfers) do not perform as expected, there is a general and unfounded tendency (albeit hidden) to think that community colleges may not be adequately preparing their students. Several studies have looked into whether transfers perform poorly relative to students who go directly to four-year colleges (hereafter natives). Diaz (1992) provides a good survey of many of these studies. Among others, Laband and Piette (1995), Holahan, Green, and Kelly (1983), Menke (1980), Borg, Mason, and Shapiro (1989), and Anderson (1977) find that transfers in general do not perform as well as natives in four-year college courses. In contrast, Best and Gehring (1993), Leiber et al. (1993), Johnson (1992), and Johnson, Taylor, and Kohler (1991) find no significant difference in performance.

Available evidence therefore indicates that there is no consensus on whether transfers perform as well as natives. The reason these studies have conflicting findings is that they compare the aggregate performance (GPA) of transfers versus natives rather than individual student performance in particular courses (Graham and Hughes 1994). This approach does not address the question of which transfers succeed and under what circumstances. It is quite possible that, in some situations, transfers may outperform natives and vice versa. Examining performance in individual courses rather than aggregate performance may provide an alternative insight into the question of relative performance. Relative to natives, for example, are transfers weak in quantitative or writing courses?

Further, it may not be particularly useful to find out who performs better without providing specific feedback on how to improve performance. From a policy point of view, therefore, the focus of research should be diagnostic -- to find areas of strengths and weaknesses of each group of students. With this information, colleges may be in a better position to advise each other on how to strengthen their programs. We hope that comparing performance in individual courses will provide this feedback. As a

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small step towards examining this issue further, this paper plans to compare the performance of transfers and natives in a quantitative and analytical course - economic statistics.

The rest of the paper is structured as follows. Section II discusses why we focus on economic statistics. Section III introduces our data and section IV presents the empirical model. The results are discussed in section V. Some concluding comments are in section VI.

II. WHY FOCUS ON ECONOMIC STATISTICS

We focus on economic statistics for two reasons. First, in a modern society like the United States, citizens are constantly bombarded with numerical information. The ability to sort through this stream of information and pick out what is relevant will eventually become a prerequisite for success in business. It is therefore imperative that schools equip their graduates with this skill.

Second, economic statistics is one of those courses that many students dread but are required to take. There are, of course, other courses in economics and business departments that students find equally difficult or challenging. Among them are Fundamentals of Accounting (I & II) and Principles of Economics (micro & macro). More repetitions occur in these courses than in other courses. Furthermore, in economics and business departments, a combination of these courses serve as a screening device to determine which students get admitted into the program. Consequently, any student who plans to major in economics or business must first cross this hurdle. It is therefore incumbent on educators to ensure that the use of economic statistics as a screening device does not deny access to students who would otherwise make good leaders.

Given this background, this paper provides an empirical investigation of whether transfers are at a disadvantage when they enroll in an economic statistics course. We do this by examining the key factors that determine performance. The results of the study should aid faculty members in their capacity as advisors to students during registration and course planning/scheduling sessions and help identify critical factors that could enhance a student's chances of success in this course. The hope is that students will be placed in economic statistics course only after they have acquired the skills necessary to do well.

Many studies have attempted to investigate the factors determining students' performance in a variety of courses and situations. Although economic statistics is a course that all economics and business students must take if they expect to receive a degree, there has been no research to date to understand the factors that determine students' performance in this course. Siegfried and Fels (1979) provide a good survey of earlier studies on determinants of student performance in college courses. Overall, this survey reveals, among other things, that: (1) most of the studies have concentrated on the Principles of Economics (micro and macro) courses; (2) the subdiscipline of economic education is still in the development stage; (3) economic education is in dire need of a formal model with theoretically sound inputs; (4) standard production function studies of college teaching have failed to account for much of the variation in measured output; and (5) existing studies with samples from a few colleges need to be replicated elsewhere. With the exception of student aptitude, measured by such things as SAT/ACT scores and GPA, where there seems to be a fairly consistent result of positive influence on performance, research findings on variables such as instructor effects, gender, class size, and age remain ambiguous (Borg, Mason, and Shapiro 1989; Watts and Bosshardt 1991; Gramlich and Greenlee 1993; Wetzel, O'Toole, and Millner 1991; Bosshardt and Watts 1990; Raimondo, Esposito, and Gershenberg 1990).

Earlier studies cited above were done in institutions such as Purdue University (Watts and Bosshardt), the University of Michigan (Gramlich and Greenlee), the University of Toronto (Anderson, Benjamin and Fuss), the University of North Florida (Borg, Mason and Shapiro), and the University of Massachusetts (Raimondo, Esposito and Gershenberg), and Florida State University (Laband and Piette). Clearly, there is a need for a study carried out on a liberal arts college setting because these colleges attract a different caliber of students. The importance of replication of these studies in other college settings was also emphasized by Siegfried and Fels.

III. DATA

This study was conducted at the State University of New York, College at Brockport (Brockport). Brockport is a state-funded liberal arts college committed to providing quality higher education at a low cost to New York residents. It is accredited by the Board of Regents of the University of the State of New York and by the Middle States Association of Colleges and Schools. Brockport is located 16 miles west of Rochester and 60 miles east of Buffalo. Brockport's structure and curriculum is dedicated to being readily accessible, allowing enrollment of students who range widely in academic ability, age, and racial/ethnic background. One unique feature of Brockport is its high percentage of adult (25 and older) and transfer students. Adult students represent nearly 40 percent of the student body. More than half the new students who entered in the Fall of 1990 were transfers. Transfers come mainly from community colleges with a mean GPA of 2.74 (SUNY Brockport, 1993-1995, 8).

Within this institutional setting, the Department of Business Administration and Economics (Department) offers baccalaureate degrees in four majors _ International Business and Economics, Accounting, Business Administration, and Economics. Recently, the Department was awarded candidacy status by the American Assembly of Collegiate Schools of Business. The Department's total enrollment is approximately 900 students.

Introduction to Statistics (ECN 204) is a prerequisite course for all majors. Students must earn at least a C- (GPA 1.67) in ECN 204 and other prerequisites before they become declared majors. Typically, the Department offers five or six sections of ECN 204 per semester with an enrollment of approximately 150 students. Our data consist of students enrolled in all ECN 204 sections offered in Spring, 1994. The Department offered six sections with a total enrollment of 157 students. There was a consensus among all faculty regarding the topics to be covered at the minimum.

A survey was administered by individual faculty teaching ECN 204 the week prior to the final examination period. The survey instrument covered questions in such areas as student aptitude, maturity, age, effort, and motivation.[1] Students had been informed that the responses would not be examined until the course grades were submitted; and they had the option not to participate in the survey. Final course grades and semester course loads data were obtained from official records. After omitting incomplete observations we ended up with 114 (out of 157) usable observations. This represents 73 percent of all students enrolled in ECN 204 in Spring, 1994.

Table 1 shows a profile of students enrolled in ECN 204. There were 74 Department majors representing 65 percent of all students. The rest were from majors such as Criminal Justice, Recreation and Leisure Studies, and so on. Community college transfers accounted for a little over half the students. Sixty-one percent of the Department majors were transfers. Transfers were about evenly distributed in all five sections. In other words, transfers did not "clump" in one or more sections. Table 2 shows means and standard deviations of the performance of students and some other related statistics. The mean grade for the course was about C+ (2.46). The performance of transfers was one-third quality point better than that of natives. Mathematics was not a prerequisite course for ECN 204 but our students had completed an average of six hours of mathematics courses. Transfers, on average, had completed more mathematics course work than natives.

Although on average, students spent 3.18 hours per week studying for the course, they responded that adequate time of study was higher at 4.08 hours. When asked about the number of hours of study per week, it is typical for students to report hours for the current week. To check for this bias, we asked the students to report the number of hours of study in the previous week (the week before the survey was administered). As Table 2 shows, there is not much variation in the hours reported. Transfers reported more study time, about 0.35 hours than natives. The standard deviations of hours of study in a

Table 1. Profile of Students Enrolled in Introduction to Statistics (ECN 204) Class in Spring, 1994

	Total Students	Native Students as a % of Total Students	Transfer Students as a % of Total Students
Total Students	114	46.5	53.4
Male	55	41.8	58.2
Female	59	50.8	49.2
Department Major	74	39.2	60.8
Other Major	40	60.0	40.0

Table 2. Means and Standard Deviations of Student Performance and other Characteristics (standard deviations in parentheses)

	All Students	Native Students	Transfer Students
GPA	2.46 (1.07)	2.29 (1.19)	2.62 (0.93)
Cumulative GPA	2.66 (0.58)	2.56 (0.47)	2.75 (0.66)
Total Math Hours Taken	5.54 (3.21)	4.28 (2.63)	6.63 (3.29)
Highest Math Grade Earned	2.80 (1.18)	2.46 (1.38)	3.10 (0.89)
Lowest Math Grade Earned	1.76 (1.27)	1.65 (1.29)	1.86 (1.26)
Last Math Grade Earned	2.35 (1.25)	1.99 (1.46)	2.67 (1.06)
Hours Studied per Week	3.18 (1.57)	3.06 (1.36)	3.30 (1.74)
Hours Studied Last Week	3.22 (2.15)	2.96 (1.68)	3.44 (2.48)
Hours of Study per Week Adequate	4.06 (2.06)	3.87 (1.80)	4.22 (2.26)
Age in Years	22.11 (3.80)	20.57 (2.41)	23.44 (4.26)
Credit Hours Taken	13.46 (2.80)	14.09 (2.45)	12.92 (3.01)

typical week, the week before the survey (last week), and adequate per week were high for both groups. The mean age was about 22 years. The mean credit hours taken was 13.46 hours, higher than the official full-time status of 12 hours. Transfers carried fewer credit hours than natives.

IV. THE EMPIRICAL MODEL

Following the literature, we agree that how well a student performs in a course should, among other things, be influenced by such characteristics as aptitude, background, motivation, and maturity. We use cumulative GPA prior to enrolling in ECN 204 as our measure of aptitude. Some studies use standardized test scores such as SAT/ACT as a measure of aptitude. However, we cannot use this since transfers are not required to take SAT/ACT. Besides, cumulative GPA is a common measure of aptitude in the literature. Since we are looking at performance in an introductory economic statistics course, a relevant background might be exposure to college level mathematics. For background, our model includes the total number of credit hours completed in mathematics courses. Following the literature, we use gender as a measure of motivation. For maturity, we include age in our model. We believe that effort is an important factor in students' performance. For effort, we include hours of study per week.

Instructors can affect student performance in a myriad of ways: type and frequency of exams, essay exams versus multiple choice exams, impromptu quizzes versus announced quizzes, grading, style of teaching, cumulative versus non-cumulative exams, knowledge of the material, enthusiasm, and so on. It is extremely difficult to get a meaningful and acceptable measure of instructor effects. Gramlich and Greenlee (1993) found that teacher effects on student performance was minimal. However, Watts and Bosshardt (1991) and Wetzel, O'Toole, and Millner (1991) found that instructors did have a significant effect on students' performance. Since students must identify themselves in the survey, we decided not to ask questions regarding instructors' effect on their performance to avoid potential biases in the responses. However, to capture instructors' effect on performance, we use dummy variables.

Our basic model can be summarized in the following general form:

GRADE = f(D_GENDER, D_TRANSF, CUM_GPA, HRSPWEEK, SEMLOAD, TOMATH, AGE, D_FACi)

where,

GRADE = the letter grade received in ECN 204 ranging from A, A-, ..., D, E (A = 4.0, A- = 3.67, ..., D- = .67, E = 0);

D_GENDER = dummy variable for gender, 1 if male, 0 otherwise;

D_TRANSF = dummy variable for transfer status, 1 if transfer, 0 otherwise;

CUM_GPA = cumulative Brockport GPA prior to enrollment in ECN 204;

HRSPWEEK = number of hours per week spent studying for ECN 204;

SEMLOAD = number of credit hours, including ECN 204, taken during the semester enrolled;

TOMATH = total number of college credits earned in mathematics;

AGE = age at the time of enrollment in ECN 204; and

D_FAC_i = dummy variables for instructors, i = 1, .., 4.

Ceteris paribus, we expect CUM_GPA, TOMATH, HRSPWEEK, and AGE to have a positive effect on performance and SEMLOAD a negative effect. We do not have any *a priori* expectations with regard to the signs of the coefficients of D_GENDER, D_TRANSF, and D_FAC_i.

V. RESULTS

The ordinary least squares (OLS) and ordered probit estimations for various specifications of the original model are reported in Table 4 and Table 5. All estimations contain a common set of independent variables for factors expected to have an impact on student performance and differ only with respect to the variables used to measure maturity and background. The common set of independent variables are D_GENDER, D_TRANSF, CUM_GPA, HRSPWEEK, SEMLOAD, and D_FAC_i.

For maturity we used AGE in equations 1 and 2. For math background we used TOMATH in equations 2 and 4. We also used alternative measures of math and maturity. Total math credits taken as a measure of background for ECN 204 may be misleading. A very weak student may take several math courses such as Introduction to Mathematics, Quantitative Skills, College Algebra, and Precalculus leading to a higher total math credits taken but a very low GPA in math courses. A very strong student may take just one math course such as Finite Mathematics or Business Calculus leading to a lower total math credits taken but a very high GPA in math course. We believe that the highest grade earned in a relevant college level math course is a more appropriate indicator of background for ECN 204 than total math credits taken. We used this measure of math background in equations 1 and 3 where HIMATH stands for the highest math grade (A=4.0, A-=3.67,...E=0.00) earned in any college level math course.

Considering that students may become more mature as they move from freshman to senior level, we created three dummy variables to capture this effect. The dummy variables created are D_FRESH=1 if a student is a freshman, 0 otherwise; D_SOPHO=1 if a student is a sophomore, 0 otherwise; D_JUNIOR=1 if a student is a junior, 0 otherwise. We used this measure of maturity in equations 3 and 4. The simple correlations between all the variables are shown in Table 3.

As shown in Tables 4 and 5, OLS and ordered probit estimates are almost identical; we therefore focus our discussion on OLS results only. The F-statistics reveal that the null hypothesis that the regression coefficients are jointly equal to zero can be rejected for all equations at the 5 percent level. As can be seen from Table 3, multicollinearity is not a serious problem for our equations. Breusch-Pagan tests indicate possible heteroskedasticity for equations 3 and 4. The estimates for these equations are corrected for heteroskedasticity. The overall fits of all the equations are not as good as one would like to see but they are similar or better than what can be found in the literature.

Turning to individual estimates, the coefficient of CUM_GPA has expected positive signs and is significant at the 5 percent level in all equations. Most studies obtained a similar result. The coefficient of HRSPWEEK has the expected positive signs but is not significant in any of the equations. Borg, Mason, and Shapiro (1989) and Siegfried and Fels (1979) also obtained a similar result. The coefficient of SEMLOAD has the expected negative signs but is not significant in any of the equations.

The coefficient of D_GENDER has a negative sign in three equations and a positive sign in one equation, but is significant in none of the equations. The coefficient of AGE has the expected positive sign but is not significant in any equations. Borg, Mason, and Shapiro also found a positive sign. The coefficients of D_FRESH, D_SOPHO, and D_JUNIOR have negative signs and are not significant in any equations.

The coefficient of TOMATH has a negative sign but is not statistically significant. This supports our intuition that prior math courses taken may not necessarily indicate adequate math background for ECN 204. Anderson, Benjamin, and Fuss (1994) is the only study we know of that used math grade, rather than total math credits, as a determinant of performance in economic courses. They used both algebra and calculus grades as determinants of performance. Interestingly, while their coefficients came out positive as expected, neither was significant. However, in our case, not only did the coefficient of the highest math grade (HIMATH) have the expected positive sign, it was also significant at the 5 percent level. Thus, the highest grade in a relevant math class may be a better predictor of performance in ECN 204 than total math credits.

Table 3. Simple Correlation Coefficients of the Variables Included in the Regression Analysis

	GPA	CUM_GPA	D_GENDER	TOMATH	HIMATH	D_FRESH	D_SOPHO	D_JUNIOR	HRS PWEEK	AGE	D_TRANSF	SEMLOAD	FD1	FD2	FD3
CUM_GPA	0.371														
D_GENDER	0.001	-0.009													
TOMATH	-0.003	0.034	0.102												
HIMATH	0.242	0.212	0.096	0.410											
D_FRESSH	-0.097	-0.047	-0.188	-0.289	-0.354										
D_SOPHO	-0.102	-0.195	0.082	-0.153	0.058	-0.314									
D_JUNIOR	0.046	0.047	0.009	0.306	0.109	-0.314	-0.606								
HRSPWEEK	0.147	0.160	-0.125	0.042	0.045	0.001	-0.161	0.024							
AGE	0.291	0.423	0.038	0.222	0.136	-0.292	-0.275	0.246	0.319						
D_TRANSF	0.154	0.159	0.090	0.365	0.273	-0.332	-0.508	0.544	0.076	0.380					
SEMLOAD	-0.179	-0.192	-0.068	-0.051	0.089	0.249	0.082	-0.157	-0.156	-0.593	-0.208				
FD1	0.032	-0.010	-0.057	-0.095	-0.080	-0.008	0.057	0.173	0.007	-0.137	0.025	0.115			
FD2	-0.137	-0.080	0.083	0.155	0.207	-0.203	0.201	0.150	-0.143	0.050	0.206	0.035	-0.452		
FD3	-0.008	0.140	-0.004	0.066	0.047	0.112	-0.097	-0.211	0.164	-0.083	-0.101	0.127	-0.452	-0.253	
FD4	0.071	-0.064	0.041	-0.157	-0.164	0.125	-0.142	-0.193	-0.133	-0.017	-0.231	-0.010	-0.294	-0.164	0.164

Table 4. OLS Regression Results (absolute t-values in parentheses)

Independent Variables	Eq.1	Eq. 2	Eq. 3*	Eq. 4*
CONSTANT	0.175 (0.145)	0.059 (0.048)	0.856 (0.944)	0.949 (1.023)
D_GENDER	-0.034 (0.177)	0.007 (0.039)	-0.035 (0.186)	-0.017 (0.089)
D_TRANSF	0.116 (0.535)	0.235 (1.042)	0.172 (0.838)	0.281 (1.315)
CUM_GPA	0.492[a] (2.680)	0.557[a] (3.001)	0.256[a] (2.792)	0.608[a] (3.310)
HRSPWEEK	0.036 (0.554)	0.039 (0.581)	0.047 (0.743)	0.055 (0.812)
SEMLOAD	-0.028 (0.656)	-0.012 (0.265)	-0.042 (1.086)	-0.023 (0.606)
HIMATH	0.195[a] (2.257)		0.199[a] (2.244)	
TOMATH		-0.016 (0.475)		-0.014 (0.435)
AGE	0.025 (0.677)	0.034 (0.881)		
D_FRESH			-0.043 (0.127)	-0.289 (0.748)
D_SOPHO			-0.059 (0.226)	-0.056 (0.199)
D_JUNIOR			-0.048 (0.212)	-0.078 (0.338)
FD_1	0.215 (0.445)	0.261 (0.528)	0.175 (0.477)	0.160 (0.429)
FD_2	-0.245 (0.479)	-0.093 (0.179)	-0.266 (0.586)	-0.191 (0.422)
FD_3	0.150 (0.030)	0.106 (0.203)	0.046 (0.106)	-0.014 (0.034)
FD_4	0.533 (1.024)	0.547 (0.990)	0.511 (1.321)	0.476 (1.171)
Adj. R^2	0.15	0.11	0.13	0.093
F	2.83[a]	2.28[a]	2.32[a]	1.90[a]
n	114	114	114	114

[a]Significant at the 5% level (one tail test).

*Corrected for heteroskedasticity. The Limdep econometric software utilizes White's consistent estimator of the covariance matrix to detect and correct for hetroskedasticity. The procedure is detailed in Greene (1989, p. 176)

Table 5. Ordered Probit Regression Results (absolute t-values in parentheses)

Independent Variables	Eq.1	Eq. 2	Eq. 3*	Eq. 4*
CONSTANT	-1.170 (0.772)	-1.213 (0.774)	0.057 (0.055)	0.146 (0.135)
D_GENDER	-0.114 (0.501)	0.076 (0.331)	-0.116 (0.500)	-0.107 (0.455)
D_TRANSF	0.102 (0.398)	0.219 (0.792)	0.132 (0.292)	0.258 (0.579)
CUM_GPA	0.649[a] (3.287)	0.717[a] (3.593)	0.686[a] (3.481)	0.774[a] (3.960)
HRSPWEEK	0.013 (0.184)	0.017 (0.257)	0.027 (0.395)	0.036 (0.565)
SEMLOAD	-0.034 (0.695)	-0.020 (0.384)	-0.057 (1.109)	-0.039 (0.721)
HIMATH	0.222[a] (1.98)		0.237[a] (2.081)	
TOMATH		-0.01 (0.244)		-0.007 (0.172)
AGE	0.041 (0.900)	0.047 (1.008)		
D_FRESH			-0.091 (0.139)	-0.352 (0.570)
D_SOPHO			-0.216 (0.369)	-0.179 (0.321)
D_JUNIOR			0.023 (0.047)	-0.049 (0.101)
FD_1	0.246 (0.442)	0.294 (0.518)	0.180 (0.323)	0.184 (0.319)
FD_2	-0.233 (0.424)	-0.058 (1.03)	-0.255 (0.444)	-0.143 (0.238)
FD_3	0.003 (0.006)	0.092 (0.164)	-0.087 (0.154)	-0.044 (0.075)
FD_4	0.670 (0.941)	0.669 (0.949)	0.596 (0.823)	0.585 (0.809)
Log (L)	-148.71	-151.36	-149.00	-151.66
χ^2	33.77	28.46	33.18	27.87
n	114	114	114	114

[a]Significant at the 5% level. *Corrected for heteroskedasticity. The Limdep econometric software utilizes White's consistent estimator of the covariance matrix to detect and correct for hetroskedasticity. The procedure is detailed in Greene (1989, p. 176)

The coefficient of D_TRANSF is not statistically significant in any of the equations. As can be seen from Table 4 and Table 5, this result is independent of how math background or maturity is measured. The findings are also supported by the data presented in Table 2, where transfers and natives seem to be about equal in all aspects. This implies that transfer status may not be an important predictor of performance in ECN 204. While there is a general perception that transfers are not well prepared for four-year college courses, our study finds that the difference in performance of the two groups is not statistically significant.

The coefficients of faculty dummies are not significant, implying that individual instructors do not have a differential impact on performance. This is surprising since one can at least expect significant differences in the grading practices of different instructors. Furthermore, common sense dictates that instructors' impact on student performance should vary. It may be that dummy variables do not capture this effect. Our result is consistent with the findings of Gramlich and Greenlee and contrary to the findings of Watts and Bosshardt.

VI. CONCLUSIONS

Since transfers from junior colleges have become an integral part of higher education, there is a need to understand whether they come fully prepared for four-year college courses. This paper made an attempt to explore this issue in a beginning statistics course in a mid-size four-year public liberal arts college. The paper examined such student characteristics as transfer status, aptitude, background, motivation, maturity, effort, and instructor contribution.

Regression results revealed that the most important determinant of student performance is aptitude, measured by CUM_GPA. A statistically significant positive relationship exists between CUM_GPA and performance in the course. For background, we found that the number of math courses taken has no statistically significant impact on the grade received. Rather, what is important is the highest grade earned in a relevant math course. The higher the math grade received, the better the performance in ECN 204. Maturity and effort measures such as age (or class standing) and hours of study per week did not appear to have any significant impact on performance. Our empirical results also show that gender plays no significant role in determining performance. Contrary to general perception, we find that there is no reason to suspect that transfers, as compared to natives, are poorly prepared for the course. It is surprising that instructors did not have differential impact on performance.

A few interesting policy implications emerge from our study. First, our results indicate that economic statistics teachers should not worry that transfers are at a disadvantage compared to natives. Therefore, they may feel less pressure to reduce the rigor of the course to accommodate transfers. Similarly, transfers may be advised not to be overly concerned with the issue of whether they can perform as well as natives in economic statistics. Second, rather than requiring students to have a certain number of math courses before registering for economic statistics, economics and business departments may want to identify a relevant math course in which students must score a certain threshold grade before they enroll in economic statistics. This information can be passed on to community colleges to help prepare their students. Third, when advising students, faculty members may keep in mind that successful performance in economic statistics may have little to do with gender, age, class standing, transfer status, semester load, and total math credits completed.

We realize that the comparison of performance between transfers and natives can not be judged solely on the basis of one course. There is a need to replicate this study using other courses.

Our model obviously has some limitations. We do not claim to have included all the relevant variables such as high school performance, socio-economic background, race, and transfer shocks. It would be interesting to use actual numeric scores, rather than letter grades (GPA), as the dependent variable to see if there would be any significant changes in our results.[2] Our R^2 values indicate that the model could use some improvement. Clearly, more research needs to be done in similar institutions to provide support for the findings of our study. When a reasonable consensus emerges with regard to the factors that influence student performance, economics and business departments and potential majors stand to gain tremendously.

ENDNOTES

1. The data set and survey instrument are available from the authors upon request.
2. For numeric grades to be applicable, they should come from a standardized test. In our case, since each instructor administered their own test, numeric grades would not be appropriate as dependent variable.

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1. Joseph Cheng
2. Richard Deitz
3. Patricia Hatfield
4. Ilia Kacapyr
5. Thomas Kopp
6. Henry Schwalbenberg
7. Wade Thomas
8. Matha Wojtowycz
9. Joseph Zaremba

NEW YORK STATE ECONOMICS ASSOCIATION (NYSEA)

48th ANNUAL CONVENTION

FINAL PROGRAM

Sheraton Inn – Ithaca, New York

September 29-30, 1995

Friday, September 29

8:00 – 10:00 PM	**NYSEA Convention Opening Reception,** Cortland Room
	Wine and Cheese Reception

Saturday, September 30

8:00 – 10:00 AM	**Convention Registration** (Cortland Room) Pick up final program, receipt/register, location directions, name tags
8:00 – 2:00 PM	**Textbook Display** (Cortland Room) Morning refreshments compliments of Addison-Wesley
12:00 – 1:30 PM	**Luncheon** (Grand Ballroom) Luncheon compliments of Houghton Mifflin Company Speaker: Francine Blau, Cornell University Afternoon refreshments compliments of South-Western College/International Thomson Publishing
8:30 AM	**Session Begins**

SESSION

8:30 – 10:00 AM **Labor** (Library)

Chair: Joseph G. Eisenhauer, Canisius College

Sherry Wetchler, Ithaca College
"The Effect of the Unemployment Insurance Tax on Firm Behavior"

John Robst, SUNY Binghamton
"Human Capital, Atrophy Rates, and Occupational Sex Segregation"

Joseph G. Eisenhauer, Canisius College
"Self-Employment as an Occupational Choice"

David Kaplan, Cornell University
"Asymmetries in Executive Pay for Performance Relationships"

SESSION

8:30 – 10:00 AM **Economic Theory** (Executive Boardroom)

Chair: Roger Hinderliter, Ithaca College

William T. Ganley, Buffalo State College
"A Postmodernist Critique of Economic Methodology: The Neoclassical and Institutional Antagonism"

SESSION

10:15 – 11:45 AM **Education** (Corning Room)

Chair: John Robst, SUNY Binghamton

David Pate and Anthony DiTucci, St. John Fisher College
"Black Student Outcomes During and After Segregation: Maryland, 1950–1960"

Baban Hasnat and Dal Didia, SUNY Brockport
"Are Transfer Students at any Disadvantage: Evidence from Economic Statistics Course"

SESSION

10:15 – 11:45 AM **Finance** (Library)

Chair: Elia Kacapyr, Ithaca College

Joseph Cheng, Ithaca College
"An Alternative Formula for Computing Economic Run Quantity with Higher Profit"

M.E. Ellis, St. John's University
"Assets Growth and Increase in Dividend Announcements"

SESSION **The Economics of Dysfunctional Bureaucracy in Academia***

Chair: Al Lubell, SUNY Oneonta

Discussants:
Bogdan Mieczkowski, Ithaca College
Wade Thomas, SUNY Oneonta
Savo Jevremovic, Alfred University

*Pre-arranged

SESSION

1:45 – 3:15 PM **International and Environmental Economics** (Executive Boardroom)

Chair: Kent Klitgaard, Wells College

Kent Klitgaard, Wells College
"Externalities and Economic Policies: Theoretical Roots and Alternative Visions"

Dal Didia, SUNY Brockport
"Developing Countries, Economic Interactions and Tropical Deforestation"

Fred Floss, SUNY Buffalo and Stanton Warren, Niagara University
"The Relative Importance of Borrowing and Interest Rates as Determinants of the Latin American Debt Crisis"

SESSION

Business Cycles (Corning Room)

Chair: Joseph Zaremba, SUNY Geneseo

Harjit Arora, Le Moyne College
"Recessions: Are They Different?"

Elia Kacapyr, Ithaca College
"Asymmetries of the Business Cycle"

SESSION

Health (Library)

Chair: Donald F. Vitaliano, Rensselear Polytechnic Institute

Dale Tussing, Syracuse University
"TBA"

Martha A. Wojtowycz
"TBA"

Frank W. Musgrave, Ithaca College
"Market Driven Health Care Reform: Any Viable Roles for Government?"

SESSION

3:30 – 5:00 PM **International** (Library)

Chair: Barbara Howard, SUNY Geneseo

Harjit Arora, Le Moyne College
"Maquiladoras, NAFTA and NAFTA-Plus"

Rita Ganguly, SUNY Albany
"Limited Dependent Rational Expectation Model on a Target Zone"

Harjit Arora, Le Moyne College
"The EEC and Its Trade Relations with LDCs and the U.S."

SESSION

3:30 – 5:00 PM **Health and Housing** (Corning Room)

Chair: Sherry Wetchler, Ithaca College

Donald F. Vitaliano, Rensselaer Polytechnic Institute
"Hospital Efficiency in New York State"

Richard Deitz, St. Lawrence University
"The Determinants of Exercise and the Relationship Between Exercise and Age"

Dixie Blackley, Le Moyne College
"An Empirical Analysis of Housing Supply in the U.S.: 1964–1993"

Stephen P. Neun, Utica College
"The Number and Distribution of Primary Care Physicians in New York State"

5:15 – 6:30 PM **NYSEA Business Meeting** (Executive Boardroom)