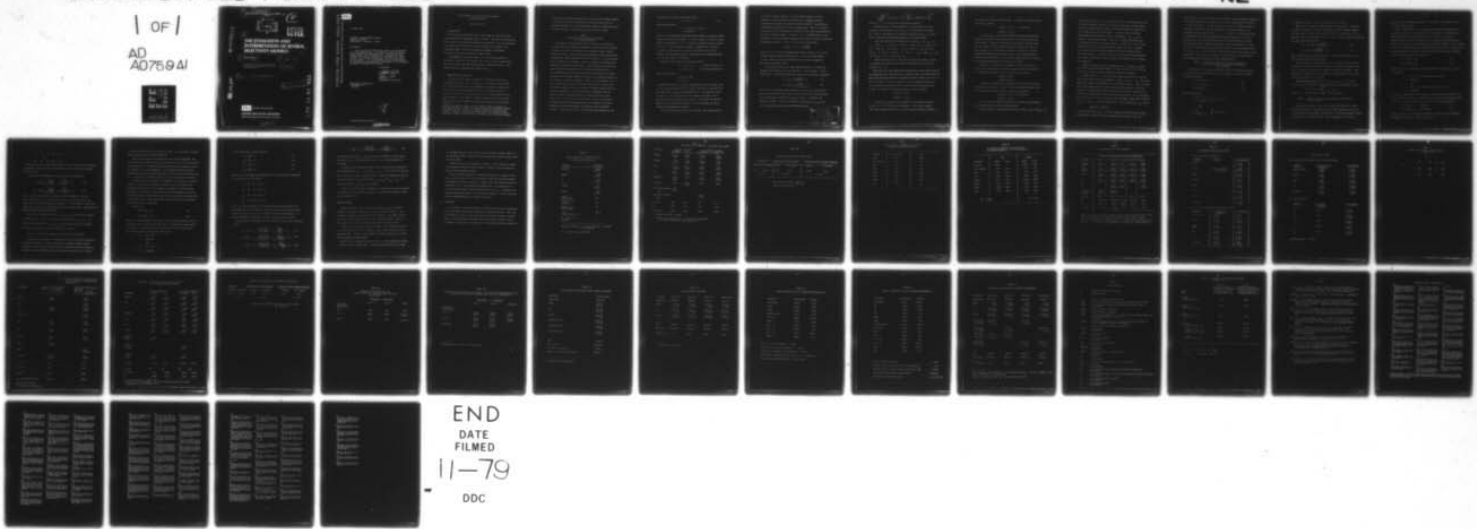
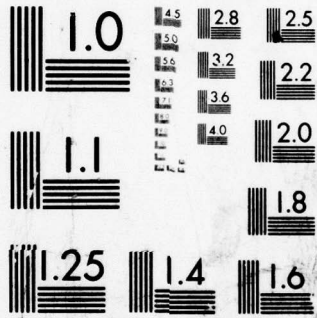


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THE ESTIMATION AND INTERPRETATION OF SEVERAL SELECTIVITY MODELS

10 Robert P. Frost

11 Jun 79

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The Estimation and Interpretation of Several
Selectivity Models

Robert P. Trost*

1. INTRODUCTION

↘ In recent years there have been a large number of studies that deal with the problem of selectivity bias in the data. Here the term "selectivity bias" refers to non-randomly distributed observed data. This non-randomness can occur whenever the data we have are generated by the choices that individuals make. A review of selectivity problems in econometric models can be found in two papers by Maddala (1977).

The purpose of the present paper is to review several models not discussed in Maddala's (1977) papers, and to give a further interpretation of the covariance terms that are particular to selectivity models. This should enhance the understanding of these models. ↗

2. FOUR MODELS OF SELECTIVITY

In this section I present four models of selectivity and discuss the estimation of each. The four models are : (1) measuring the returns of a college education when almost everyone in the sample is working; and when the level of college education does not enter directly into the earnings equations, (2) measuring the returns of a college education when almost everyone in the sample is working; and when the level of college education does enter directly into the earnings equations, (3) measuring

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the returns of a college education, when only part of the sample decides to work, and the level of college does not enter directly into the earnings equations, and, (4) measuring the returns to a specific type of military training. A discussion of these four models follows.

Model 1

A simple model for measuring the returns to a college education

The question this first model tries to answer is: Are expected earnings higher if an individual completes at least one year of college? A naive way to answer this question is to estimate a dummy variable regression equation where earnings are regressed on several explanatory variables and a dummy variable which takes a value of 1 if the individual goes to college and 0 otherwise. There is, however, a self-selectivity problem that needs to be analyzed here. The self-selectivity problem is that some individuals choose to go to college and others do not. If this choosing process is based on potential college versus non-college earnings, then the dummy variable in the above naive approach should not, in general, be treated as exogenous. Rather, if the individuals who go to college are the ones who can most benefit by it, and vice versa for those who choose not to go to college, the dummy variable should be treated as endogenous. The net impact of this endogenous choosing process is that the earnings data we do observe may not be a truly random sample. Here the term "random sample" refers to the sample of college and non-college earnings we would have observed if we could simultaneously measure everybody's earnings both with and without college. In order to correct for this potential non-randomness in the

observed data, I specify the following model.

$$I^* = \gamma^* X - \epsilon^*, \quad (1)$$

where we only observe:

$$I = 1 \text{ iff } I^* \geq 0 \iff \epsilon^* \leq \gamma^* X \\ = 0 \text{ otherwise.}$$

Here I^* is an unobservable underlying index whereby an individual chooses whether or not to go to college, $\epsilon^* \sim N(0, \sigma^2)$ and γ^* is a vector of parameters to be estimated. If $I^* \geq 0$, then the individual chooses college, and if $I^* < 0$ he does not go to college. Although we do not observe the index I^* , we do observe the choice of whether or not to go to college. This observable choice is represented by the dichotomous index $I = 1$ if $I^* \geq 0$ and $I = 0$ otherwise.

The model also specifies two earning equations:

$$E_1 = \beta_1' X_1 + \epsilon_1 \quad (\text{college earnings}) \quad (2)$$

$$E_2 = \beta_2' X_2 + \epsilon_2, \quad (\text{w/o college earnings}), \quad (3)$$

where we only observe;

$$E_1 \text{ iff } I=1, \text{ and}$$

$$E_2 \text{ iff } I=0.$$

In equations (2) and (3), β_1 and β_2 are parameters to be estimated, and ϵ_1 and ϵ_2 are distributed $N(0, \sigma_1^2)$, $N(0, \sigma_2^2)$, respectively. The model does not assume that ϵ_1 and ϵ_2 are independent of ϵ^* . The question we want to answer is: for a given level of the exogenous variables, is the expected value of E_1 greater than, equal to, or less than the expected value of E_2 ? To answer this question we need to estimate β_1 and β_2 . Consider the estimation of β_1 first.

If we could observe earnings E_1 for everyone, then there would be

no serious estimation problem. We could simply estimate β_1 by OLS. Similarly, if the E_1 earnings we do observe are randomly selected from the entire sample, then again OLS would be alright. The problem is, the observed E_1 earnings may not be a random sample. That is, the expectation of E_1 for the sub-sample we do observe may not equal the expectation of E_1 for the entire sample. In fact, if ϵ_1 is correlated with ϵ^* , the observed E_1 will not be random because we only observe E_1 (and the associated disturbance ϵ_1) when $\epsilon^* \leq \gamma^*X$. It can easily be shown that:

$$E(\epsilon_1 | \epsilon^* \leq \gamma^*X) = \sigma_{1\epsilon} \frac{-f(\gamma^*X)}{F(\gamma^*X)}$$

where $\gamma = \gamma^*/\sigma$, $f(\cdot)$ is the standard normal density function, $F(\cdot)$ is the standard normal cumulative function, and $\sigma_{1\epsilon}$ is the covariance between ϵ_1 and ϵ . Proofs of these two expectations can be found in papers by Lee (1976) and Heckman (1976).

To estimate β_1 and β_2 by a least squares procedure, Lee (1976) and Heckman (1976) suggest a two stage procedure. First, estimate γ with a probit model. Second, estimate by least squares the following two equations:

$$E_1 = \beta_1'X_1 - \sigma_{1\epsilon} \frac{f(\hat{\gamma}'X)}{F(\hat{\gamma}'X)} + \eta_1 \quad (2a)$$

$$E_2 = \beta_2'X_2 + \sigma_{2\epsilon} \frac{f(\hat{\gamma}'X)}{1-F(\hat{\gamma}'X)} + \eta_2 \quad (3a)$$

where $\hat{\gamma}$ is the consistent probit estimate of γ , and η_1 and η_2 are disturbances with zero mean. Least square on (2a) and (3a) will yield consistent, albeit inefficient, estimates of $\beta_1, \beta_2, \sigma_{1\epsilon}$ and $\sigma_{2\epsilon}$. Consistent and efficient estimates of all the parameters ($\beta_1, \beta_2, \sigma_{1\epsilon}, \sigma_{2\epsilon}, \sigma_1^2$, and σ_2^2),

can be obtained by maximizing the likelihood function:

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$$L = \prod_{\text{obs.}} \left[\int_{-\infty}^{\gamma'X} g(E_1 - \beta_1'X_1, \epsilon) d\epsilon \right]^I \cdot \left[\int_{\gamma'X}^{\infty} g(E_2 - \beta_2'X_1, \epsilon) d\epsilon \right]^{1-I},$$

where $g(\cdot, \cdot)$ is the bivariate normal density function.

Before going on to the second model, it will be useful to look closer at the covariances, $\sigma_{1\epsilon}$ and $\sigma_{2\epsilon}$. More specifically, we should ask: What is the meaning of a negative (or positive) $\sigma_{1\epsilon}$ or $\sigma_{2\epsilon}$, and what is a meaningful relationship between the two covariances?

There are eight possible outcomes for $\sigma_{1\epsilon}$ and $\sigma_{2\epsilon}$: (1) $\sigma_{1\epsilon} > 0$, $\sigma_{2\epsilon} > 0$ and $\sigma_{1\epsilon} > \sigma_{2\epsilon}$; (2) $\sigma_{1\epsilon} > 0$ and $\sigma_{2\epsilon} > 0$ and $\sigma_{1\epsilon} < \sigma_{2\epsilon}$; (3) $\sigma_{1\epsilon} < 0$, $\sigma_{2\epsilon} < 0$ and $\sigma_{1\epsilon} > \sigma_{2\epsilon}$; (4) $\sigma_{1\epsilon} < 0$, $\sigma_{2\epsilon} < 0$ and $\sigma_{1\epsilon} < \sigma_{2\epsilon}$; (5) $\sigma_{1\epsilon} < 0$ and $\sigma_{2\epsilon} > 0$; (6) $\sigma_{1\epsilon} > 0$ and $\sigma_{2\epsilon} < 0$; (7) $\sigma_{1\epsilon} > 0$, $\sigma_{2\epsilon} > 0$ and $\sigma_{1\epsilon} = \sigma_{2\epsilon}$, and, (8) $\sigma_{1\epsilon} < 0$, $\sigma_{2\epsilon} < 0$ and $\sigma_{1\epsilon} = \sigma_{2\epsilon}$.

Before deciding if any of these eight outcomes make sense, we need to understand what positive and negative covariances imply in terms of equations (1) - (3).

Recall that the choice equation was written with a minus sign in front of the disturbance term. Because of this, a positive sign for the covariance $\sigma_{1\epsilon}$ means that individuals who are not expected to choose college (i.e., $\gamma'X < 0$) but do (because $\epsilon < 0$), have on average lower than expected earnings in the college wage equation (because ϵ_1 will tend to be negative for this group). In terms of the conditional means, a positive $\sigma_{1\epsilon}$ means:

$$E(E_1 | I=1) < B_1'X_1$$

$$E(E_1 | I=0) > B_1'X_1.$$

A positive $\sigma_{2\epsilon}$ means that individuals who are expected to choose college (i.e., $\gamma'X > 0$) but do not (because $\epsilon > 0$), have on average higher than expected earnings in the non-college wage equation (because ϵ_2

will tend to be positive for this group). In terms of conditional means, a positive $\sigma_{2\varepsilon}$ means:

$$E(E_2 | I=0) > B_2'X_2, \text{ and therefore}$$

$$E(E_2 | I=1) < B_2'X_2.$$

So a positive $\sigma_{1\varepsilon}$ means that if both the non-college and college groups go to college, the non-college group would earn more than the college group. Similarly, a positive $\sigma_{2\varepsilon}$ means that if neither group goes to college, the non-college group would again earn more than the college group. So in the case of positive covariances, the non-college group dominates the college groups in both earning equations. Before we decide whether or not these relationships make sense, consider the following interpretation for negative covariances.

A negative $\sigma_{1\varepsilon}$ means that individuals who are not expected to choose college but do, have on average higher than expected earnings in the college wage equation. That is, a negative $\sigma_{1\varepsilon}$ implies:

$$E(E_1 | I=1) > B_1'X_1$$

$$E(E_1 | I=0) < B_1'X_1.$$

A negative $\sigma_{2\varepsilon}$ means that individuals who are expected to choose college but do not, have on average lower than expected earnings in the non-college wage equation. That is, a negative $\sigma_{2\varepsilon}$ implies:

$$E(E_2 | I=0) < B_2'X_2, \text{ and therefore}$$

$$E(E_2 | I=1) > B_2'X_2.$$

So in the case of negative covariances, the college group dominates the non-college group in both earnings equations.

At first glance, it might appear that only outcome 5 ($\sigma_{1\varepsilon} < 0$ and $\sigma_{2\varepsilon} > 0$)

makes intuitive sense. That is, one might expect the college group to have a higher college wage (relative to the non-college group's college wage); and the non-college group to have a higher non-college wage (relative to the college group's non-college wage). I suppose another reasonable guess might be that outcomes 3 and 4 - where both $\sigma_{1\epsilon}$ and $\sigma_{2\epsilon}$ are negative - make intuitive sense. That is, the college group dominates the non-college group in both wage equations. Perhaps the least appealing outcomes that initially come to mind are outcomes 1, 2 and 6. Outcomes 1 and 2 say that the non-college group dominates the college group in both wage equations. Outcome 6 says that the non-college group dominates the college wage equation and the college group dominates the non-college wage equation.

However, initial guesses are sometimes wrong. In actuality, outcomes 2, 4 and 5 are plausible and outcomes 1, 3 and 6 are not. To see this, one only needs to look at Ricardo's theory of comparative advantage.

Consider outcome 2. In this case the college group earns less than the non-college group in both wage equations. However, since $\sigma_{1\epsilon} < \sigma_{2\epsilon}$, the college group has a comparative advantage in the college wage equation. That is, while the college group has lower than mean earnings ($B_1'X$ and $B_2'X_2$) in both wage equations, the difference between mean and actual earnings is smaller in the college wage equation than in the non-college wage equation. So if individuals base the college decision on potential earnings and $B_1'X_1 = B_2'X_2'$, then on average $B_1'X_1' + \epsilon_1 > B_2'X_2' + \epsilon_2$ for the college group. This is because $\sigma_{1\epsilon} < \sigma_{2\epsilon}$ implies

$$E(E_1 | I=1) > E(E_2 | I=1),$$

in the case where $B_1'X_1 = B_2'X_2$. A similar argument can be made if $B_1'X_1 \neq B_2'X_2$. In other words, a model that says individuals choose college if $E_1 > E_2$

implies that $\sigma_{1\epsilon} < \sigma_{2\epsilon}$ is the most sensible outcome. Similar arguments concerning the logical consistency of outcomes 4 and 5, and the inconsistency of outcomes 1, 3 and 6 can be made. So long as the only criterion for choosing college is relative earnings in the two wage equations, the necessary condition for consistency of the model is that $\sigma_{1\epsilon} < \sigma_{2\epsilon}$. Of course, if the individual looks at intangibles other than earnings when deciding or whether or not to go to college, any of the 6 outcomes mentioned could be consistent with the model. But even under the most general specification of the choice equation, so long as relative earnings enters into the choice equation, the most plausible result is that $\sigma_{1\epsilon} < \sigma_{2\epsilon}$. Finally, outcomes 7 and 8 neither refute nor support a priori expectations. Since they are in essence "neutral outcomes," nothing needs to be said about their consistency with the underlying model.

Model 2: A Selectivity Model of Education and Earnings
When the Amount of College Enters Simultaneously
Into the Model

In this model, let S^* denote the "desired" years of college education and S the actual years of college education. E_1 and E_2 are as defined in model 1.

The model now becomes:

$$S = S^* = \gamma^*X - \epsilon^* \quad (1)$$

$$E_1 = \alpha S + B_1'X_1 + \epsilon_1 \quad (2)$$

$$E_2 = B_2'X_2 + \epsilon_2 \quad (3)$$

where we only observe:

$$\left. \begin{aligned} S = S^* &= \gamma^*X - \epsilon, \\ E_1 &= \alpha S + B_1'X_1 + \epsilon_1 \end{aligned} \right\} \text{ iff } S^* \geq 0$$

,and,

$$\left. \begin{aligned} S &= 0 \\ E_2 &= B_2'X_2 + \epsilon_2 \end{aligned} \right\} \text{ iff } S^* < 0$$

The assumptions about ϵ , ϵ_1 and ϵ_2 are the same as in model 1.

Model 2 is a simultaneous equations model with selectivity. Estimation of model 2 is discussed in detail in Kenny et.al. (1978), and Lee, Maddala and Trost (1977). Briefly, what we do is estimate γ^* and σ^2 (=var. of ϵ^*) in equation 1 with a Tobit program and get $\hat{S} = \hat{\gamma}^* X$. We then estimate the following two stage regression equations:

$$E_1 = \alpha \hat{S} + B_1' X_1 - \sigma_{1\epsilon} \frac{f(\gamma' X)}{F(\gamma' X)} + \eta_1 \quad (2a)$$

$$E_2 = B_2' X_2 + \sigma_{2\epsilon} \frac{f(\gamma' X)}{1-F(\gamma' X)} + \eta_2, \quad (3a)$$

where $\hat{\gamma} = \gamma^*/\sigma$ and η_1 and η_2 have zero means. The covariance terms $\sigma_{1\epsilon}$ and $\sigma_{2\epsilon}$ have the same interpretation as before.

The main difference between models 1 and 2 is that the choice equation in model 2 is a Tobit type equation rather than a probit type equation, and years of college enters directly in model 2's college wage equation. Other than these two differences, the estimation and interpretation of $\sigma_{1\epsilon}$ and $\sigma_{2\epsilon}$ is the same in model 2 as in model 1.

Maximum likelihood estimates of γ , B_1 , B_2 , $\sigma_{1\epsilon}$, $\sigma_{2\epsilon}$, σ_1^2 , σ_2^2 and σ^2 in model 2 can be obtained by maximizing the following likelihood function:

$$L = \prod_{S>0} g(\epsilon, \epsilon_1) \prod_{S=0} \int_{-\infty}^{\gamma' X} g(\epsilon, \epsilon_2) d\epsilon,$$

where $g(\cdot, \cdot)$ is the bivariate normal density function.

Model 3: A Model of Labor Force Participation, Wages and the Returns to College.

The purpose of models 1 and 2 was to measure the effect of a college education on earnings; taking into account possible selectivity bias in the observed college and non-college earnings data. Those models assumed, however, that everyone in the sample worked. If this assumption is not valid, a

different model and estimation technique is necessary. A discussion of this alternative model follows.

Model 3 extends model 1 by incorporating the decision of whether or not to work into the model. By specifying the earnings model in this fashion, it becomes apparent that observed earnings may be subject to two types of self-selectivity. First, the college versus non-college earnings data may be subject to the type of self-selectivity bias discussed in models 1 and 2. Second, since we only observe the wages of individuals who choose to work, the wage data may also be subject to the type of self-selectivity bias discussed in Heckman (1974) and Nelson (1977). Thus, model 3 is:

$$I_C^* = B_C^* X_C - \epsilon_C^* \quad (1a)$$

$$I_P^* = B_P^* X_P - \epsilon_P^* \quad (1b)$$

where $f(\epsilon_C^*, \epsilon_P^*)$ is distributed bivariate normal with correlation ρ_{PC} , and we only observe:

$$I_C = 1 \quad \text{iff } I_C^* \geq 0 \quad (\text{Choose college in year } t) \\ = 0 \quad \text{otherwise}$$

and

$$I_P = 1 \quad \text{iff } I_P^* \geq 0 \quad (\text{Choose to work in year } t + n) \\ = 0 \quad \text{otherwise.}$$

Here I_C^* is an unobservable index whereby an individual decides whether or not to go to college, and I_P^* is an unobservable index whereby an individual decides whether or not to work. Model 3 also specifies two earnings equations:

$$E_1 = B_1' X_1 + \epsilon_1 \quad (\text{college}) \quad (2)$$

$$E_2 = B_2' X_2 + \epsilon_2 \quad (\text{w/o college}) \quad (3)$$

where, $E_1, E_2, \beta_1, \beta_2$ are previously defined, ϵ_1 and ϵ_2 are not necessarily independent of ϵ_C^* and ϵ_P^* , and we only observe:

$$E_1 \quad \text{iff} \quad I_c = 1 \quad \text{and} \quad I_p = 1$$

and

$$E_2 \quad \text{iff} \quad I_c = 0 \quad \text{and} \quad I_p = 1.$$

I could also specify two shadow wage equations, but this point will be discussed elsewhere in a paper by Fische, Trost and Lurie (1979), and is also discussed in Nelson (1977).

If ε_c^* and ε_p^* are independent, B_1 and B_2 can be estimated from:

$$E_1 = B_1' X_{1p} - \sigma_{1\varepsilon_p} \frac{f(\hat{B}_p' X_{1p})}{F(\hat{B}_p' X_{1p})} - \sigma_{1\varepsilon_c} \frac{f(\hat{B}_c' X_{1c})}{F(\hat{B}_c' X_{1c})} + \eta_1 \quad (2a)$$

$$E_2 = B_2' X_{2p} - \sigma_{2\varepsilon_p} \frac{f(\hat{B}_p' X_{2p})}{F(\hat{B}_p' X_{2p})} + \sigma_{2\varepsilon_c} \frac{f(\hat{B}_c' X_{2c})}{1-F(\hat{B}_c' X_{2c})} + \eta_2, \quad (3a)$$

where σ_{ij} 's are covariances, \hat{B}_p and \hat{B}_c are probit estimates of (1a) and (1b), respectively, and η_1 and η_2 have zero means. If ε_c^* and ε_p^* are not independent the estimation approach is similar, but (2a) and (2b) are messier, and B_p and B_c have to be estimated with a bivariate probit model. Details will be given in Fische, Trost and Lurie (1979).

The expected relationship between $\sigma_{1\varepsilon_c}$ and $\sigma_{2\varepsilon_c}$ has already been discussed in models 1 and 2. That is, the model only makes sense if $\sigma_{2\varepsilon_c} > \sigma_{1\varepsilon_c}$. The expected relationships for $\sigma_{1\varepsilon_p}$ and $\sigma_{2\varepsilon_p}$ can only be discussed in the context of shadow wage equations, which are not present in model 3.

Model 4: The Effect of Military Training on Civilian Earnings

The purpose of this model is to measure the returns to military occupational training in electronics. A naive procedure is to estimate a dummy variable regression equation where civilian earnings are regressed on several explanatory variables and a set of dummy variables that depend on whether or not a veteran

receives military training in electronics, and/or, a veteran takes a civilian job in electronics after leaving the service.

There are two selectivity problems that flaw the naive approach. The first selectivity problem is that some veterans choose to work in related jobs while others do not. Although the usual procedure treats occupational choice as exogenous, it is really endogenous. The observed earnings differences between those who choose related jobs and those who choose unrelated jobs will not, in general, give unbiased estimates of the earnings effect of training.

A second selectivity problem also complicates the analysis of veterans' earnings. This is the occupational assignment process that occurs upon entering military service. New entrants are assigned to various military occupations on the basis of observable educational background and upon their preferences and other unobservable factors such as occupations available when they entered service. This occupational selection process may also distort post-service earnings comparisons.

The model is:

$$YM^* = B_m^* X_m - \epsilon_m^* \quad (1a)$$

$$YC^* = B_C^* X_C + \alpha YM - \epsilon_C^* \quad (1b)$$

Here YC^* is an unobservable index whereby a veteran chooses whether to work in electronics after leaving the military, YM^* is an unobservable index whereby an individual is chosen for military electronics training, ϵ_m^* and ϵ_C^* are distributed bivariate normal, and we only observe:

$$YM = 1 \quad \text{iff} \quad YM^* \geq 0$$

$$= 0 \quad \text{otherwise}$$

and

$$YC = 1 \quad \text{iff} \quad YC^* \geq 0$$

$$= 0 \quad \text{otherwise.}$$

I also specify four earnings equations:

$$Y_1 = \beta_1' X_1 + \epsilon_1 \quad (2)$$

$$Y_2 = \beta_2' X_2 + \epsilon_2 \quad (3)$$

$$Y_3 = \beta_3' X_3 + \epsilon_3 \quad (4)$$

$$Y_4 = \beta_4' X_4 + \epsilon_4 \quad (5)$$

where ϵ_1 to ϵ_4 are normally distributed and are not necessarily independent of ϵ_m^* and ϵ_c^* ; and we only observe

$$Y_1 \quad \text{iff} \quad YM = 1; YC = 1$$

$$Y_2 \quad \text{iff} \quad YM = 0; YC = 1$$

$$Y_3 \quad \text{iff} \quad YM = 1; YC = 0$$

$$Y_4 \quad \text{iff} \quad YM = 0; YC = 0.$$

Here Y_1 is civilian earnings if the veteran receives military training in electronics ($YM = 1$) and chooses to take a civilian job in electronics after leaving the service. Y_2 to Y_4 are civilian earnings defined similarly. A complete explanation of the model is given in Trost and Warner (1978).

If ϵ_m^* and ϵ_c^* are independent, we can estimate B_1 to B_4 and the covariances σ_{ij} from:

$$Y_1 = \beta_1' X_1 - \sigma_{1c} \frac{f(\beta_1' X_1 + \alpha YM)}{F(\beta_1' X_1 + \alpha YM)} - \sigma_{1m} \frac{f(\beta_1' X_1)}{F(\beta_1' X_1)} + \eta_1 \quad (2a)$$

$$Y_2 = \beta_2' X_2 - \sigma_{2c} \frac{f(\beta_2' X_2 + \alpha YM)}{F(\beta_2' X_2 + \alpha YM)} + \sigma_{2m} \frac{f(\beta_2' X_2)}{1 - F(\beta_2' X_2)} + \eta_2 \quad (3a)$$

$$Y_3 = \beta_3' X_3 + \sigma_{3c} \frac{f(\beta_3' X_3 + \alpha YM)}{1 - F(\beta_3' X_3 + \alpha YM)} - \sigma_{3m} \frac{f(\beta_3' X_3)}{F(\beta_3' X_3)} + \eta_3 \quad (4a)$$

$$Y_4 = B_4' X_4 + \sigma_{4\epsilon_c} \frac{f(B_c' X_c + \hat{\alpha} Y_M)}{1 - F(B_c' X_c + \hat{\alpha} Y_M)} + \sigma_{4\epsilon_m} \frac{f(B_m' X_m)}{1 - F(B_m' X_m)} + \eta_4. \quad (5a)$$

In equations 2a to 5a, B_c , $\hat{\alpha}$ and B_m are probit estimates of the two choice equations, the σ_{ij} 's are covariances, and η_1 to η_4 are disturbances with zero means.

If veterans look at relative earnings when choosing civilian employment, then we should expect $\sigma_{3\epsilon_c} > \sigma_{1\epsilon_c}$ and $\sigma_{4\epsilon_c} > \sigma_{2\epsilon_c}$. Also, if the military only gives electronics training to men who have "a comparative advantage in gaining from the training," then we would expect $\sigma_{2\epsilon_m} > \sigma_{1\epsilon_m}$ and $\sigma_{4\epsilon_m} > \sigma_{3\epsilon_m}$. We might also expect $\sigma_{1\epsilon_m}$ to $\sigma_{4\epsilon_m}$ to be negative.

Finally, if ϵ_m^* and ϵ_c^* are not independent, the model can still be estimated but equations 2a to 5a are more complicated. Details will be given in Fische, Trost and Lurie (1979).

3. EMPIRICAL RESULTS

Estimates of models 1 to 4 are given in Tables 1a to 4g, and Table 5 defines the variables. Tables 1a to 1c contain estimates of Model 1. The estimates are based on the Parnes data for young men. Since almost all the men in the sample have jobs, model 1 is the appropriate model. Details of the estimates are given in a paper by Fische, Trost and Lurie (1979).

Tables 2a to 2d contain estimates of Model 2. The estimates are based on the project talent data for young men. Again, almost all the men in the sample had jobs. Details of the estimates are given in Kenny, et.al. (1979) and Lee, Maddala and Trost (1977).

Tables 3a to 3d contain estimates of Model 3. These estimates are based on the Parnes data for young women. Since only about one-half of the women

in the sample had jobs in the year we used to estimate the model, Model 3 is the appropriate model. Details of these estimates will appear in Fische, Trost and Lurie (1979).

Tables 4a to 4g contain estimates of Model 4. These estimates are based on the earnings records of 11,941 veterans. Details of these estimates are given in Trost and Warner (1978).

While a complete discussion of these tables would be too lengthy to give here, it may be useful to see if the estimated covariances have the expected relationships discussed in section 2. Table 6 gives the estimated covariances for models 1 to 4. The expected relationships were: the covariances in col (2) should be greater than the covariances in col. (1). In general, this expected relationship holds. So the estimates of Models 1 to 4 are consistent with the proposed hypotheses presented in section 2.

4. CONCLUSION

In this paper I review four models of selectivity and give an interpretation of the covariance terms that are particular to selectivity models. While some of the models I examine in this paper have been discussed elsewhere, the hypothesis I present about the expected relationship between covariance is new. In general, I found that the estimates of the four models support my hypothesis.

TABLE 1A

Probit Estimates of College Decision*
for Young Men (Parnes Data)

<u>Variable</u>	<u>Estimates</u>
Constant	-6.4881 (20.52)
DBLACK	.3768 (3.42)
IQ	.0478 (17.38)
DSOUTH	.16 (2.22)
EDFEM	.136 (10.41)
Number of Observations	1863
Number of 1's (college)	906
Number of 0's (w/o college)	957
-2*Log (likelihood ratio)	605.65
DF (Degrees of Freedom)	4

*Dependent Variable = 1 if individual goes to college
= 0 if otherwise

**t - values are in parentheses

TABLE 1B
Two Stage and OLS Results* : Young Men (Parnes Data)

Variables	College**		w/o College**	
	Two Stage	Estimates OLS	Two Stage	Estimates OLS
DSOUTH	-.0028 (.09)	-.0005 (.01)	-.1923 (7.05)	-.1885 (6.89)
DBLACK	-.0854 (1.56)	-.0842 (1.54)	-.1098 (2.89)	-.0826 (2.24)
AGE	.0619 (11.98)	.062 (12.00)	.0286 (6.82)	.0273 (6.53)
IQ	.002 (.89)	.0028 (2.40)	-.0002 (.01)	.0044 (4.33)
DMARRIED	.1946 (6.08)	.1941	.1379 (4.73)	.1387 (4.74)
Constant	-.3267	-.43495 (6.07)	.6014	.3056
Truncation Variable	.0297			
$\frac{-f}{F}$	(.42)			
Truncation Variable			.1868	
$\frac{f}{1-F}$			(2.83)	
# of Obs.	904	904	957	957
-2 R	.2229	.2236	.1793	.1732
Std Error	.43174	.43154	.38252	.38393

* Dependent Variable= Ln (wage)

** t-Values are in parentheses. For the two stage estimates the t-values overstate the true asymptotic t's.

Table 1c

Mean Wages for Young Men (Parnes Data)

Raw Data		Predicted* from OLS Estimates		Predicted* from two Stage Estimates	
college	w/o college	college	w/o college	college	w/o college
\$5.55	\$4.58	\$4.29	\$4.29	\$4.40	\$3.76
$\Delta = \$0.97$		$\Delta = \$0.0$		$\Delta = \$0.64$	

*predictions are based on Age =26,
 IQ = 100,
 North, white and single.

PROBIT EQUATION TO EXPLAIN THE DECISION OF
WHETHER OR NOT TO GO TO COLLEGE

<u>Variable</u>	<u>Coeff. Est.</u>	<u>S.E.</u>
Const.	-5.259	2.108
Rural (Dummy)	- .164	.093
Split	- .078	.145
MATH	.015	.001
MOCWAG	.922	.589
EDMAL	.044	.017
EDFEM	.029	.019
CHIL	- .057	.021

Table 7b

OLS AND TOBIT EQUATIONS EXPLAINING YEARS
OF COLLEGE EDUCATION S. (S = 0 for 464 obs.)

<u>Variable</u>	<u>OLS</u>		<u>Tobit</u>	
	<u>Coeff.</u>	<u>S.E.</u>	<u>Coeff.</u>	<u>S.E.</u>
Constant	-8.091		-12.805	3.169
Rural (Dummy)	- .100	.136	- .270	.203
Split	- .297	.213	- .415	.321
MATH	.0290	.0014	.0415	.0022
MOCWAG	1.675	.629	2.2538	.8881
EDMAL	.0627	.0230	.0923	.0333
EDFEM	.0879	.0264	.1153	.0384
CHIL	- .1264	.0307	- .1916	.0456

$\bar{R}^2 = .3620$
 SE = 2.0206

$\sigma_1 = 2.7645$

Table 2c

OLS ESTIMATES OF EARNINGS EQUATIONS

Variable	Coefficients and (in parentheses) standard errors				
	Eq. 3.1	Eq. 3.2	Eq. 3.3	Eq. 3.4	Eq. 3.5
Married (Dummy)	.1534 (.0264)	.1537 (.0260)	.1553 (.0261)	.2671 (.0481)	.0991 (.0306)
Rural (Dummy)	-.0752 (.0260)	-.0748 (.0257)	-.0717 (.0257)	-.1457 (.0401)	-.0260 (.0333)
MATH	.0019 (.0003)	.0013 (.0003)	-.0012 (.0003)	.0010 (.0005)	.0014 (.0004)
HC	-.0115 (.0052)	-.0084 (.0052)	-.0090 (.0052)	.0089 (.0079)	-.0228 (.0069)
S		.0437 (.0072)	.0321 (.0051)		.0406 (.0074)
College Ed. (Dummy)	.0749 (.0256)	-.0812 (.0361)			
Constant	5.803	5.851	5.833	5.762	5.825
R^2	.09466	.11769	.11507	.09272	.10411
S.E.	.3925	.3875	.38804	.3927	.3804
# of obs.	1373	1373	1373	464	909

In Eq. 3.1 years of college is omitted. Only college education dummy is used.
 In Eq. 3.2 both years of college and college education dummy are used.
 In Eq. 3.3 only years of college is used. The college dummy is dropped.
 Eq. 3.4 is a separate earnings equation for those with no college education.
 Eq. 3.5 is a separate earnings equation for those with college education.

Table 2a

ML Estimates of the Complete Model

I. Years of College Education S

<u>VARIABLES</u>	<u>Tobit ML</u>	<u>ML Estimation</u>
Rural		-0.2731 (0.1869)
Split	same as estimates in table 2b	-0.4095 (0.3038)
MATH		0.0421 (0.0023)
MOCWAGE		2.3930 (0.8572)
EDMAL		0.0914 (0.0305)
EDFEM		0.1146 (0.0369)
CHIL		-0.1912 (0.0449)
Constant		-13.3150 (3.0666)

II. Earnings of Individuals with College Education

<u>VARIABLE</u>	<u>Two Stage Consist. Estimation</u>	<u>ML Estimation</u>
Marital Status	0.1029 (0.0314)	0.1033 (0.0324)
Rural	-0.0272 (0.0349)	-0.0174 (0.0405)
MATH	0.0013 (0.0009)	0.0012 (0.0009)
HC	-0.0280 (0.0070)	-0.0278 (0.0066)
S	0.0466 (0.0333)	0.0378 (0.0177)
Constant	5.8211 (0.1710)	5.8851 (0.0849)

Table 2d (Continued)

III. Earnings of Individuals with NO College Education

<u>VARIABLES</u>	<u>TWO STAGE CONSIST ESTIMATION</u>	<u>ML ESTIMATION</u>
Marital Status	.2719 (.0475)	0.2696 (0.0454)
Rural	-.1088 (.0472)	-0.1096 (0.0454)
MATH	-.0022 (.0014)	-0.0022 (0.0006)
HC	.0097 (.0078)	0.0101 (0.0082)
Constant	5.7483 (.0719)	5.7384 (0.0741)

IV. Error Variances

<u>VARIABLES</u>	<u>CONSISTENT ESTIMATION</u>	<u>ML ESTIMATION</u>
σ_1^2	7.6425	7.3790 (0.4974)
σ_2^2	0.1495	0.1509 (0.00008)
σ_3^2	0.1519	0.2058 (0.0021)
$\sigma_{1\epsilon}$	-0.00259	0.0022 (0.1375)
$\sigma_{2\epsilon}$	0.7979	0.7962 (0.0459)

Likelihood value = - 3198.72

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Table 3a
Number of Observations for Young Women
(Parnes Data)

		IC		
		1	0	
IW	1	550	620	$\Sigma = 1170$
	0	270	759	$\Sigma = 1029$
		<hr/>	<hr/>	<hr/>
		820	1379	2199

Table 3B: Probit Estimates of College and Work
Decision Functions for Young Women
(Parnes Data)

<u>Variables</u>	College Decision Estimates* Dep.Var. = 1 if college = 0 w/o college	Labor Force Participation Estimates* Dep. Var. = 1 if work = 0 Not Work
DBLACK	.6243 (6.995)	.2268 (2.70)
Age		-.0322 (3.00)
IQ	.0348 (13.92)	.00989 (4.61)
DMarried		-.4268 (5.93)
DNE	-.2121 (2.17)	-.1748 (1.83)
DNC	-.2427 (2.65)	-.0789 (.89)
DSOUTH	.0066 (.07)	.099 (1.13)
EDFEM	.1848 (14.44)	
DCHIL		-.9883 (16.28)
Constant	-5.9475 (19.93)	.7723 (2.07)
# of Obs.	2199	2199
# of 1's	820	1170
# of 0's	1379	1029
-2xlog (Likelihood Ratio)	605.44	483.63
DF (Degrees of Freedom)	6	8
* t-values are in parentheses		

Table 3C: OLS and Two Stage Regression Results*
for Young Women (Parnes Data)

VARIABLES	College Estimates*		w/o College Estimates**	
	TWO STAGE	OLS	TWO STAGE	OLS
DBLACK	.1536 (3.29)	.1587 (3.43)	-.0182 (.43)	.0170 (.43)
AGE	.0437 (6.73)	.0355 (5.85)	.0139 (2.56)	.0116 (2.17)
IQ	.0043 (2.26)	.00387 (2.97)	.00158 (.88)	.0049 (4.10)
DMARRIED	.0339 (.87)	-.0414 (1.29)	.0142 (.38)	-.0153 (.48)
DNE	.0614 (1.21)	.0559 (1.11)	.0223 (.43)	.00689 (.13)
DNC	-.00996 (.21)	-.0022 (.04)	-.0476 (.99)	-.0705 (1.50)
DSOUTH	-.0641 (1.41)	-.0478 (1.04)	-.1529 (3.28)	-.1561 (3.341)
$\frac{-f(\hat{B}'_C X_C)}{F(\hat{B}'_C X_C)}$	-.0730 (1.33)			
$\frac{f(\hat{B}'_C X_C)}{1-F(\hat{B}'_C X_C)}$.1406 (2.10)	
$\frac{-f(\hat{B}'_W X_W)}{F(\hat{B}'_W X_W)}$.2143 (3.31)		.0831 (1.58)	
CONSTANT	4.3449	4.581	5.2488	5.0127
# of Obs.	550	550	620	620
Std. Error	.3592	.36285	.3595	.36102
R^2	.10345	.08514	.07324	.0655

*Dependent Variable = $\ln(\text{wage} \times 100)$

** t-values are in parentheses. For the two stage estimates the t-values overstate their true asymptotic t's.

Table 3D: Mean Wages for Young Women (Parnes Data)

<u>Raw Data</u>		<u>Predicted from OLS Estimates*</u>		<u>Predicted from two Stage Estimates*</u>	
College	w/o College	College	w/o College	College	w/o College
\$3.97	\$3.24	\$3.62	\$3.32	\$3.69	\$3.20
$\Delta = \$.73$		$\Delta = \$.30$		$\Delta = \$.49$	

* Predictions are based on Age = 26, IQ = 100, Single, West and White.

TABLE 4a
 NUMBER OF OBSERVATIONS, BY
 TYPE OF MILITARY TRAINING AND CIVILIAN
 OCCUPATION

<u>Civilian Occupation</u>	<u>Military</u>	<u>Training</u>	Total
	YM = 1	YM = 0	
YC = 1	806	867	1673
YC = 0	<u>4124</u>	<u>6144</u>	<u>10,268</u>
Total	4930	7011	11,941

TABLE 4b

AVERAGE YEARLY EARNINGS AND STANDARD DEVIATION OF EARNINGS 1970-74,
BY TYPE OF MILITARY TRAINING AND CIVILIAN OCCUPATION*

	<u>Military</u>	<u>Training</u>	
	YM = 1	YM = 0	Marginal
<u>Civilian</u> <u>Occupation</u>			
YC = 1	9400 (2919)	8958 (2925)	9171 (2930)
YC = 0	8352 (2933)	8775 (3411)	8605 (3234)
Marginal	8524 (2956)	8798 (3355)	

*Standard deviations in parentheses.

TABLE 4c
OLS EARNINGS REGRESSION WITH DUMMY VARIABLES*

Variable	Coefficients
Intercept	1106.64
AFQT	13.62 (10.57)
ED	522.11 (25.12)
White	586.43 (4.72)
D1(YM=1;YC=1)	695.19 (6.06)
D2(YM=0;YC=1)	368.47 (3.34)
D3(YM=1;YC=0)	-109.25 (1.76)

RSQ	.10512
Std. Error	3026.90
No. of Observations	11941
Mean of Dependent Variable	8684.77

*T-values in parentheses

TABLE 4d
OLS EARNINGS EQUATIONS*

Variable	YM=1;YC=1	YM=0;YC=1	YM=1;YC=0	YM=0;YC=0
Intercept	2386.76	3404.63	2777.55	184.16
AFQT	21.19 (4.51)	23.17 (5.34)	10.91 (5.28)	13.80 (7.28)
Ed	427.29 (3.93)	297.71 (3.40)	404.73 (10.63)	587.21 (21.56)
White	650.93 (1.01)	793.74 (1.62)	301.37 (1.45)	709.89 (4.17)
<hr/>				
RSQ	.06649	.07733	.05612	.12837
Std Error	2822.38	2811.77	2850.62	3185.22
No. of Observations	806	867	4124	6144

*t-value in parentheses

TABLE 4e
 PROBIT ANALYSIS ON THE DEPENDENT VARIABLE YM

Variable	Coefficient	t-value
Intercept	-.4617	6.38
Army	-.1343	2.80
Navy	.0852	1.65
Marine Corps	-.6753	7.78
Enlistee	.4306	14.20
Race	.1118	2.09
Ed < 11	.2193	5.50
Ed = 11	-.0269	.45
Ed > 12	-.7323	18.42
APQT	.0020	3.65

Number of Observations = 11941

Number trained in electronics = 4903

Number not trained in electronics = 7011

-2x Log of Likelihood Ratio (df = 9) = 1034.132

Log of Likelihood function = -7577.5436

TABLE 4f
 PROBIT ANALYSIS OF THE DEPENDENT VARIABLE YC

Variable	Coefficient	t-Value
intercept	-1.5487	14.59
E4	.0632	1.14
E5	.1494	2.59
E6	.0544	.37
Army	- .1262	2.12
Navy	- .0259	.43
Marine Corps	- .2273	2.08
Enlistee	- .0432	1.12
Race	.1623	2.20
Ed < 11	.0201	.39
Ed = 11	- .0063	.08
Ed > 12	- .5126	10.18
AFQT	.0065	9.50
YM	.1038	3.43

Number of Observations	= 11941
Number taking Civilian jobs in electronics	= 1673
Number taking non-electronics civilian jobs	= 10268
-2x Log of likelihood ratio (df=13)	= 248.656
Log of likelihood function	= -4713.6279

TABLE 4g

TWO STAGE ESTIMATES OF EARNINGS EQUATIONS*

Variable	YM=1;YC=1	YM=0;YC=1	YM=1;YC=0	YM=0;YC=0
intercept	6871.97	7855.36	1189.68	- 248.14
AFQT	4.79 (.64)	11.04 (1.74)	5.05 (1.50)	5.59 (2.04)
Ed	422.30 (3.63)	377.18 (3.72)	367.83 (8.90)	613.80 (16.53)
White	1161.39 (1.75)	1065.85 (2.13)	444.95 (2.05)	889.79 (5.02)
$\frac{-f(\hat{\beta}'_m X_m)}{F(\hat{\beta}'_m X_m)}$	-2028.69 (3.53)		-1243.01 (4.83)	
$\frac{f(\hat{\beta}'_m X_m)}{1-F(\hat{\beta}'_m X_m)}$		- 961.35 (1.54)		-1390.30 (4.96)
$\frac{-f(\hat{\beta}'_c \tilde{X}_c)}{F(\hat{\beta}'_c \tilde{X}_c)}$	3837.35 (3.05)	2689.92 (2.70)		
$\frac{f(\hat{\beta}'_c \tilde{X}_c)}{1-F(\hat{\beta}'_c \tilde{X}_c)}$			3754.57 (3.04)	5251.47 (4.92)
RSQ	.07997	.08294	.06099	.13254
Std Error	2801.92	2803.20	2843.26	3177.61
No. of Observations	806	867	4124	6144

*The t-values in parentheses are slightly biased. See Lee, Maddala and Trost (1977) for a discussion.

Also, B_c contains B_c and α ; and \tilde{X}_c contains X_c and YM.

TABLE 5

List of Variables

E	= Natural logarithm of hourly wage
Y	= Annual Earnings
S	= Years of college education in 1971
MATH	= Score on a composite of mathematics achievement tests in 1960
SPLIT	= 0 if children living with both mother and father in 1960 = 1 otherwise
EDMAL	= Years of father's education
EDFEM	= Years of mother's education
RURAL	= 1 if pupils in grades 9 - 12 came from an area primarily small town (under 5,000 people) or rural farm =0 otherwise
MOCWAC	= (mean occupational wage) Log of mean earnings (as of 1960) of full time workers in father's occupation
HC	= Number of jobs held between 1965 and 1970
DBLACK	=1 if non-white =0 otherwise
DSOUTH	=1 if live in South =0 otherwise
DNE	=1 if live in Northeast =0 otherwise
DNC	=1 if live in North Central =0 otherwise
DMARRIED	=1 if married =0 otherwise
DCHIL	=1 if have children \leq 5 years of age =0 otherwise
IQ	= IQ Score
AGE	= Age in years
AFQT	= Armed Forces Qualifying Test (an IQ type test)
White	=1 if white =0 if otherwise
YM	=1 if individual receives military training in electronics =0 otherwise
YC	=1 if individual takes a civilian job in electronics after the military =0 otherwise
IC	=1 if individual goes to college =0 otherwise
IW	=1 if individual works =0 otherwise

Table 6: A Comparison of Estimated Covariances
for Models 1 to 4

<u>Model</u>	<u>Col. 1*</u> Estimated covariance between decision equation and earnings equation in regime where $I = 1$	<u>Col. 2**</u> Estimated covariance between decision equation and earnings equation in regime where $I = 0$
1. Model 1: compare $\sigma_{1\epsilon}$ to $\sigma_{2\epsilon}$.0297	.1868
2. Model 2: compares $\sigma_{1\epsilon}$ to $\sigma_{2\epsilon}$.0022	.7962
3. Model 3: compares $\sigma_{1\epsilon}$ to $\sigma_{2\epsilon}$	-.0730	.1406
4. Model 4: compares $\sigma_{1\epsilon c}$ to $\sigma_{3\epsilon c}$	3837.35	3754.57
compares $\sigma_{2\epsilon c}$ to $\sigma_{4\epsilon c}$	2689.92	5251.47
compares $\sigma_{1\epsilon m}$ to $\sigma_{2\epsilon m}$	-2028.69	-961.35
compares $\sigma_{3\epsilon m}$ to $\sigma_{4\epsilon m}$	-1243.01	-1390.30

* $\sigma_{1\epsilon}, \sigma_{1\epsilon c}, \sigma_{2\epsilon c}, \sigma_{1\epsilon m}, \sigma_{3\epsilon m}$

** $\sigma_{2\epsilon}, \sigma_{3\epsilon c}, \sigma_{4\epsilon c}, \sigma_{2\epsilon m}, \sigma_{4\epsilon m}$.

References

- Fishe, R., R.P. Trost and P. Lurie, "A Simultaneous Equations Model of Earnings, College Choice and Labor Force Participation Using the Parnes Data on Young Men and Young Women," 1979, manuscript in preparation.
- Heckman, J., "Shadow Prices, Market Wages, and Labor Supply," Econometrica July 1974, pp. 455-462.
- Heckman, J., "The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models," Annals of Economic and Social Measurement, 1976, pp. 475-492.
- Kenny, L., L.F. Lee, G.S. Maddala and R.P. Trost, "Returns to College Education: An Investigation of Self-Selection Bias Based on the Project Talent Data," International Economic Review, forthcoming 1979.
- Lee, L.F., "Unionism and Wage Rates: A Simultaneous Equations Model with Qualitative and Limited Dependent Variables," Discussion paper, University of Florida, 1976, forthcoming in International Economic Review.
- Lee, L.F., G.S. Maddala and R.P. Trost, "On the Asymptotic Covariance Matrices of Two Stage Probit and Two Stage Tobit Methods for Simultaneous Equations Models with Selectivity," 1977, and forthcoming in Econometrica.
- Maddala, G.S., "Self-Selectivity Problems in Econometric Models, in Applications of Statistics, P.R. Krishniah, ed., 1977.
- Maddala, G.S., "Identification and Estimation Problems in Limited Dependent Variable Models," in Natural Resources, Uncertainty and General Equilibrium Systems, Essays, in memory of Rafael Lusky, G.S. Maddala and P. Friedman, ed., 1977.
- Nelson, F.D., "Censored Regression Models with Unobserved, Stochastic Censoring Thresholds," Journal of Econometrics, Nov. 1977, pp. 309-327.
- Trost, R.P. and J.T. Warner, "The Effects of Military Training on Civilian Earnings: An Income Selectivity Approach," Working paper, Center for Naval Analyses, 1978.

CNA Professional Papers – 1973 to Present*

- PP 103
Friedheim, Robert L., "Political Aspects of Ocean Ecology" 48 pp., Feb 1973, published in *Who Protects the Oceans*, John Lawrence Hargrove (ed.) (St. Paul: West Publ'g. Co., 1974), published by the American Society of International Law AD 757 936
- PP 104
Schick, Jack M., "A Review of James Cable, Gunboat Diplomacy Political Applications of Limited Naval Forces," 5 pp., Feb 1973. (Reviewed in the American Political Science Review, Vol. LXVI, Dec 1972)
- PP 105
Corn, Robert J. and Phillips, Gary R., "On Optimal Correction of Gunfire Errors," 22 pp., Mar 1973, AD 761 674
- PP 106
Stoloff, Peter H., "User's Guide for Generalized Factor Analysis Program (FACTAN)," 35 pp., Feb 1973, (Includes an addendum published Aug 1974) AD 758 824
- PP 107
Stoloff, Peter H., "Relating Factor Analytically Derived Measures to Exogenous Variables," 17 pp., Mar 1973, AD 758 820
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McConnell, James M. and Kelly, Anne M., "Superpower Naval Diplomacy in the Indo-Pakistani Crisis," 14 pp., 5 Feb 1973, (Published, with revisions, in *Survival*, Nov/Dec 1973) AD 761 675
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Berghofer, Fred G., "Salaries—A Framework for the Study of Trend," 8 pp., Dec 1973, (Published in *Review of Income and Wealth*, Series 18, No. 4, Dec 1972)
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Ginsberg, Lawrence H., "ELF Atmosphere Noise Level Statistics for Project SANGUINE," 29 pp., Apr 1974, AD 786 969
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Ginsberg, Lawrence H., "Propagation Anomalies During Project SANGUINE Experiments," 5 pp., Apr 1974, AD 786 968
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Maloney, Arthur P., "Job Satisfaction and Job Turnover," 41 pp., Jul 1973, AD 768 410
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Silverman, Lester P., "The Determinants of Emergency and Elective Admissions to Hospitals," 145 pp., 18 Jul 1973, AD 766 377
- PP 116
Rehm, Allan S., "An Assessment of Military Operations Research in the USSR," 19 pp., Sep 1973, (Reprinted from *Proceedings, 30th Military Operations Research Symposium (U)*, Secret Dec 1972) AD 770 116
- PP 117
McWhite, Peter B. and Ratliff, H. Donald,* "Defending a Logistics System Under Mining Attack,"** 24 pp., Aug 1976 (to be submitted for publication in *Naval Research Logistics Quarterly*), presented at 44th National Meeting, Operations Research Society of America, November 1973, AD A030 454
*University of Florida
**Research supported in part under Office of Naval Research Contract N00014-68-0273-0017
- PP 118
Barfoot, C. Bernard, "Markov Duels," 18 pp., Apr 1973, (Reprinted from *Operations Research*, Vol. 22, No. 2, Mar-Apr 1974)
- PP 119
Stoloff, Peter and Lockman, Robert F., "Development of Navy Human Relations Questionnaire," 2 pp., May 1974, (Published in *American Psychological Association Proceedings, 81st Annual Convention, 1973*) AD 779 240
- PP 120
Smith, Michael W. and Schrimper, Ronald A.,* "Economic Analysis of the Intracity Dispersion of Criminal Activity," 30 pp., Jun 1974, (Presented at the Econometric Society Meetings, 30 Dec 1973) AD 780 538
*Economics, North Carolina State University.
- PP 121
Devine, Eugene J., "Procurement and Retention of Navy Physicians," 21 pp., Jun 1974, (Presented at the 49th Annual Conference, Western Economic Association, Las Vegas, Nev., 10 Jun 1974) AD 780 539
- PP 122
Kelly, Anne M., "The Soviet Naval Presence During the Iraq-Kuwaiti Border Dispute: March-April 1973," 34 pp., Jun 1974, (Published in *Soviet Naval Policy*, ed. Michael McGwire; New York: Praeger) AD 780 592
- PP 123
Petersen, Charles C., "The Soviet Port-Clearing Operation in Bangladash, March 1972-December 1973," 35 pp., Jun 1974, (Published in Michael McGwire, et al. (eds) *Soviet Naval Policy: Objectives and Constraints*, (New York: Praeger Publishers, 1974) AD 780 540
- PP 124
Friedheim, Robert L. and Jehn, Mary E., "Anticipating Soviet Behavior at the Third U.N. Law of the Sea Conference: USSR Positions and Dilemmas," 37 pp., 10 Apr 1974, (Published in *Soviet Naval Policy*, ed. Michael McGwire; New York: Praeger) AD 783 701
- PP 125
Weinland, Robert G., "Soviet Naval Operations—Ten Years of Change," 17 pp., Aug 1974, (Published in *Soviet Naval Policy*, ed. Michael McGwire; New York: Praeger) AD 783 962
- PP 126 – Classified.
- PP 127
Dragnich, George S., "The Soviet Union's Quest for Access to Naval Facilities in Egypt Prior to the June War of 1967," 64 pp., Jul 1974, AD 786 318
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Stoloff, Peter and Lockman, Robert F., "Evaluation of Naval Officer Performance," 11 pp., (Presented at the 82nd Annual Convention of the American Psychological Association, 1974) Aug 1974, AD 784 012
- PP 129
Holen, Arlene and Horowitz, Stanley, "Partial Unemployment Insurance Benefits and the Extent of Partial Unemployment," 4 pp., Aug 1974, (Published in the *Journal of Human Resources*, Vol. IX, No. 3, Summer 1974) AD 784 010
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Dismukes, Bradford, "Roles and Missions of Soviet Naval General Purpose Forces in Wartime: PROSSBN Operation," 20 pp., Aug 1974, AD 786 320
- PP 131
Weinland, Robert G., "Analysis of Gorshkov's Navies in War and Peace," 45 pp., Aug 1974, (Published in *Soviet Naval Policy*, ed. Michael McGwire; New York: Praeger) AD 786 319
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Kleinman, Samuel D., "Racial Differences in Hours Worked in the Market: A Preliminary Report," 77 pp., Feb 1975, (Paper read on 26 Oct 1974 at Eastern Economic Association Convention in Albany, N.Y.) AD A 005 517
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Squires, Michael L., "A Stochastic Model of Regime Change in Latin America," 42 pp., Feb 1975, AD A 007 912
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Root, R. M. and Cunniff, P. F.,* "A Study of the Shock Spectrum of a Two-Degree-of-Freedom Non-linear Vibratory System," 39 pp., Dec 1975, (Published in the condensed version of *The Journal of the Acoustic Society*, Vol 60, No. 6, Dec 1976, pp. 1314
*Department of Mechanical Engineering, University of Maryland.
- PP 135
Goudreau, Kenneth A.; Kuzmack, Richard A.; Wiedemann, Karen, "Analysis of Closure Alternatives for Naval Stations and Naval Air Stations," 47 pp., 3 Jun 1975 (Reprinted from "Hearing before the Subcommittee on Military Construction of the Committee on Armed Service," U.S. Senate, 93rd Congress, 1st Session, Part 2, 22 Jun 1973)
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Stallings, William, "Cybernetics and Behavior Therapy," 13 pp., Jun 1975
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Petersen, Charles C., "The Soviet Union and the Reopening of the Suez Canal: Mineclearing Operations in the Gulf of Suez," 30 pp., Aug 1975, AD A 015 376

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- PP 138
Stallings, William, "BRIDGE: An Interactive Dialogue-Generation Facility," 5 pp., Aug 1975 (Reprinted from IEEE Transactions on Systems, Man, and Cybernetics, Vol. 5, No. 3, May 1975)
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Morgan, William F., Jr., "Beyond Folklore and Fables in Forestry to Positive Economics," 14 pp., (Presented at Southern Economic Association Meetings November, 1974) Aug 1975, AD A 015 293
- PP 140
Mahoney, Robert and Druckman, Daniel*, "Simulation, Experimentation, and Context," 36 pp., 1 Sep 1975, (Published in Simulation & Games, Vol. 6, No. 3, Sep 1975)
*Mathematica, Inc.
- PP 141
Mizrahi, Maurice M., "Generalized Hermite Polynomials,"* 5 pp., Feb 1976 (Reprinted from the Journal of Computational and Applied Mathematics, Vol. 1, No. 4 (1975), 273-277).
*Research supported by the National Science Foundation
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Lockman, Robert F., Jehn, Christopher, and Shughart, William F. II, "Models for Estimating Premature Losses and Recruiting District Performance," 36 pp., Dec 1975 (Presented at the RAND Conference on Defense Manpower, Feb 1976; to be published in the conference proceedings) AD A 020 443
- PP 143
Horowitz, Stanley and Sherman, Allan (LCDr., USN), "Maintenance Personnel Effectiveness in the Navy," 33 pp., Jan 1976 (Presented at the RAND Conference on Defense Manpower, Feb 1976; to be published in the conference proceedings) AD A021 581
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Durch, William J., "The Navy of the Republic of China - History, Problems, and Prospects," 66 pp., Aug 1976 (To be published in "A Guide to Asiatic Fleets," ed. by Barry M. Blechman; Naval Institute Press) AD A030 460
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Kelly, Anne M., "Port Visits and the "Internationalist Mission" of the Soviet Navy," 36 pp., Apr 1976 AD A023 436
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Palmour, Vernon E., "Alternatives for Increasing Access to Scientific Journals," 6 pp., Apr 1975 (Presented at the 1975 IEEE Conference on Scientific Journals, Cherry Hill, N.C., Apr 28-30; published in IEEE Transactions on Professional Communication, Vol. PC-18, No. 3, Sep 1975) AD A021 798
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Kessler, J. Christian, "Legal Issues in Protecting Offshore Structures," 33 pp., Jun 1976 (Prepared under task order N00014-68-A-0091-0023 for ONR) AD A028 389
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McConnell, James M., "Military-Political Tasks of the Soviet Navy in War and Peace," 62 pp., Dec 1975 (Published in Soviet Oceans Development Study of Senate Commerce Committee October 1976) AD A022 590
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Squires, Michael L., "Counterforce Effectiveness: A Comparison of the Tsipis "K" Measure and a Computer Simulation," 24 pp., Mar 1976 (Presented at the International Study Association Meetings, 27 Feb 1976) AD A022 591
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Kelly, Anne M. and Petersen, Charles, "Recent Changes in Soviet Naval Policy: Prospects for Arms Limitations in the Mediterranean and Indian Ocean," 28 pp., Apr 1976, AD A 023 723
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Horowitz, Stanley A., "The Economic Consequences of Political Philosophy," 8 pp., Apr 1976 (Reprinted from Economic Inquiry, Vol. XIV, No. 1, Mar 1976)
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Mizrahi, Maurice M., "On Path Integral Solutions of the Schrodinger Equation, Without Limiting Procedure,"* 10 pp., Apr 1976 (Reprinted from Journal of Mathematical Physics, Vol. 17, No. 4 (Apr 1976), 566-575).
*Research supported by the National Science Foundation
- PP 153
Mizrahi, Maurice M., "WKB Expansions by Path Integrals, With Applications to the Anharmonic Oscillator,"* 137 pp., May 1976, AD A025 440
*Research supported by the National Science Foundation
- PP 154
Mizrahi, Maurice M., "On the Semi-Classical Expansion in Quantum Mechanics for Arbitrary Hamiltonians," 19 pp., May 1976 (Published in Journal of Mathematical Physics, Vol. 18, No. 4, p. 786, Apr 1977), AD A025 441
- PP 155
Squires, Michael L., "Soviet Foreign Policy and Third World Nations," 28 pp., Jun 1976 (Prepared for presentation at the Midwest Political Science Association meetings, Apr 30, 1976) AD A028 388
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Stallings, William, "Approaches to Chinese Character Recognition," 12 pp., Jun 1976 (Reprinted from Pattern Recognition (Pergamon Press), Vol. 8, pp. 87-98, 1976) AD A028 692
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Morgan, William F., "Unemployment and the Pentagon Budget: Is There Anything in the Empty Pork Barrel?" 20 pp., Aug 1976 AD A030 455
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Haskell, LCDr. Richard D. (USN), "Experimental Validation of Probability Predictions," 25 pp., Aug 1976 (Presented at the Military Operations Research Society Meeting, Fall 1976) AD A030 458
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McConnell, James M., "The Gorshkov Articles, The New Gorshkov Book and Their Relation to Policy," 93 pp., Jul 1976 (Published in Soviet Naval Influence: Domestic and Foreign Dimensions, ed. by M. McGwire and J. McDonnell; New York: Praeger, 1977) AD A029 227
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Wilson, Desmond P., Jr., "The U.S. Sixth Fleet and the Conventional Defense of Europe," 50 pp., Sep 1976 (Submitted for publication in Adelphi Papers, I.I.S.S., London) AD A030 457
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Melich, Michael E. and Peet, Vice Adm. Ray (USN, Retired), "Fleet Commanders: Afloat or Ashore?" 9 pp., Aug 1976 (Reprinted from U.S. Naval Institute Proceedings, Jun 1976) AD A030 458
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Friedheim, Robert L., "Parliamentary Diplomacy," 106 pp. Sep 1976 AD A033 306
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Lockman, Robert F., "A Model for Predicting Recruit Losses," 9 pp., Sep 1976 (Presented at the 84th annual convention of the American Psychological Association, Washington, D.C., 4 Sep 1976) AD A030 459
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Ralston, James M., "A Diffusion Model for GaP Red LED Degradation," 10 pp., Nov 1976, (Published in Journal of Applied Physics, Vol. 47, pp. 4518-4527, Oct 1978)

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Mahoney, Robert B., Jr., "A Comparison of the Brookings and International Incidents Projects," 12 pp. Feb 1977 AD 037 206
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Levine, Daniel; Stoloff, Peter and Spruill, Nancy, "Public Drug Treatment and Addict Crime," June 1976. (Published in *Journal of Legal Studies*, Vol. 5, No. 2)
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Felix, Wendi, "Correlates of Retention and Promotion for USNA Graduates," 38 pp., Mar 1977, AD A039 040
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Lockman, Robert F. and Warner, John T., "Predicting Attrition: A Test of Alternative Approaches," 33 pp. Mar 1977. (Presented at the OSD/ONR Conference on Enlisted Attrition Xerox International Training Center, Leesburg, Virginia, 4-7 April 1977), AD A039 047
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Kleinman, Samuel D., "An Evaluation of Navy Unrestricted Line Officer Accession Programs," 23 pp. April 1977. (To be presented at the NATO Conference on Manpower Planning and Organization Design, Stresa, Italy, 20 June 1977), AD A039 048
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Stoloff, Peter H. and Balut, Stephen J., "Vacate: A Model for Personnel Inventory Planning Under Changing Management Policy," 14 pp. April 1977. (Presented at the NATO Conference on Manpower Planning and Organization Design, Stresa, Italy, 20 June 1977), AD A039 049
- PP 180
Horowitz, Stanley A. and Sherman, Allan, "The Characteristics of Naval Personnel and Personnel Performance," 16 pp. April 1977. (Presented at the NATO Conference on Manpower Planning and Organization Design, Stresa, Italy, 20 June 1977), AD A039 050
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Balut, Stephen J. and Stoloff, Peter, "An Inventory Planning Model for Navy Enlisted Personnel," 35 pp., May 1977. (Prepared for presentation at the Joint National Meeting of the Operations Research Society of America and The Institute for Management Science, 9 May 1977, San Francisco, California), AD A042 221
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Murray, Russell, 2nd, "The Quest for the Perfect Study or My First 1138 Days at CNA," 57 pp., April 1977
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Kassing, David, "Changes in Soviet Naval Forces," 33 pp., November, 1976. (Published as part of Chapter 3. "General Purpose Forces: Navy and Marine Corps," in *Arms, Men, and Military Budgets*, Francis P. Hoerber and William Schneider, Jr. (eds.), (Crane, Russak & Company, Inc.: New York), 1977), AD A040 106
- PP 184
Lockman, Robert F., "An Overview of the OSD/ONR Conference on First Term Enlisted Attrition," 22 pp., June 1977. (Presented to the 39th MORS Working Group on Manpower and Personnel Planning, Annapolis, Md., 28-30 June 1977), AD A043 618
- PP 185
Kassing, David, "New Technology and Naval Forces in the South Atlantic," 22 pp. (This paper was the basis for a presentation made at the Institute for Foreign Policy Analyses, Cambridge, Mass., 28 April 1977), AD A043 619
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Mizrahi, Maurice M., "Phase Space Integrals, Without Limiting Procedure," 31 pp., May 1977. (Invited paper presented at the 1977 NATO Institute on Path Integrals and Their Application in Quantum Statistical, and Solid State Physics, Antwerp, Belgium, July 17-30, 1977) (Published in *Journal of Mathematical Physics* 19(1), p. 298, Jan 1978), AD A040 107
- PP 187
Coile, Russell C., "Nomography for Operations Research," 35 pp., April 1977. (Presented at the Joint National Meeting of the Operations Research Society of America and The Institute for Management Services, San Francisco, California, 9 May 1977), AD A043 620
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Durch, William J., "Information Processing and Outcome Forecasting for Multilateral Negotiations: Testing One Approach," 53 pp., May 1977 (Prepared for presentation to the 18th Annual Convention of the International Studies Association, Chase-Park Plaza Hotel, St. Louis, Missouri, March 16-20, 1977), AD A042 222
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Coile, Russell C., "Error Detection in Computerized Information Retrieval Data Bases," July, 1977, 13 pp. Presented at the Sixth Cranfield International Conference on Mechanized Information Storage and Retrieval Systems, Cranfield Institute of Technology, Cranfield, Bedford, England, 26-29 July 1977, AD A043 580
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Mahoney, Robert B., Jr., "European Perceptions and East-West Competition," 96 pp., July 1977 (Prepared for presentation at the annual meeting of the International Studies Association, St. Louis, Mo., March, 1977), AD A043 661
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Holen, Arlene, "Effects of Unemployment Insurance Entitlement on Duration and Job Search Outcome," August 1977, 6 pp., (Reprinted from *Industrial and Labor Relations Review*, Vol. 30, No. 4, Jul 1977)
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Horowitz, Stanley A., "A Model of Unemployment Insurance and the Work Test," August 1977, 7 pp. (Reprinted from *Industrial and Labor Relations Review*, Vol. 30, No. 40, Jul 1977)
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Classen, Kathleen P., "The Effects of Unemployment Insurance on the Duration of Unemployment and Subsequent Earnings," August 1977, 7 pp. (Reprinted from *Industrial and Labor Relations Review*, Vol. 30, No. 40, Jul 1977)
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Brechtling, Frank, "Unemployment Insurance Taxes and Labor Turnover: Summary of Theoretical Findings," 12 pp. (Reprinted from *Industrial and Labor Relations Review*, Vol. 30, No. 40, Jul 1977)
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Ralston, J. M. and Lorimor, O. G., "Degradation of Bulk Electroluminescent Efficiency in Zn, O-Doped GaP LED's," July 1977, 3 pp. (Reprinted from *IEEE Transactions on Electron Devices*, Vol. ED-24, No. 7, July 1977)
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Wells, Anthony R., "The Centre for Naval Analyses," 14 pp., Dec 1977, AD A049 107
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Durch, William J., "Revolution From A F.A.R. - The Cuban Armed Forces in Africa and the Middle East," Sep 1977, 16 pp., AD A046 268
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Durch, William J., "The Cuban Military in Africa and The Middle East: From Algeria to Angola," Sep 1977, 67 pp., AD A045 675
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Feldman, Paul, "Why Regulation Doesn't Work," (Reprinted from *Technological Change and Welfare in the Regulated Industries and Review of Social Economy*, Vol. XXIX, March, 1971, No. 1.) Sep 1977, 8 pp.
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Wells, Anthony R., "The 1987 June War: Soviet Naval Diplomacy and The Sixth Fleet - A Re-appraisal," Oct 1977, 36 pp., AD A047 236
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Coile, Russell C., "A Bibliometric Examination of the Square Root Theory of Scientific Publication Productivity," (Presented at the annual meeting of the American Society for Information Science, Chicago, Illinois, 29 September 1977.) Oct 1977, 6 pp., AD A047 237
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Goldberg, Lawrence, "Cost-Effectiveness of Potential Federal Policies Affecting Research & Development Expenditures in the Auto, Steel and Food Industries," 36 pp., Oct 1977, (Presented at Southern Economic Association Meetings beginning 2 November 1977)
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Kassing, David, "Protecting The Fleet," 40 pp., Dec 1977 (Prepared for the American Enterprise Institute Conference on Problems of Sea Power as We Approach the 21st Century, October 6-7, 1977), AD A049 109
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Weinland, Robert G., "A Somewhat Different View of The Optimal Naval Posture," 37 pp., Jun 1978 (Presented at the 1976 Convention of the American Political Science Association (APSA/IUS Panel on "Changing Strategic Requirements and Military Posture"), Chicago, Ill., September 2, 1976)
- PP 215
Coile, Russell C., "Comments on: *Principles of Information Retrieval* by Manfred Kochen, 10 pp., Mar 78, (Published as a Letter to the Editor, *Journal of Documentation*, Vol. 31, No. 4, pages 298-301, December 1975)
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Coile, Russell C., "Lotka's Frequency Distribution of Scientific Productivity," 18 pp., Feb 1978, (Published in the *Journal of the American Society for Information Science*, Vol. 28, No. 6, pp. 366-370, November 1977)
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Coile, Russell C., "Bibliometric Studies of Scientific Productivity," 17 pp., Mar 78, (Presented at the Annual meeting of the American Society for Information Science held in San Francisco, California, October 1976.)
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"Portions of this work were started at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, B.C., Canada
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"Portions of this work were completed at the Institute of Applied Mathematics and Statistics, University of British Columbia, Vancouver, Canada.
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