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How the Demand for Labor May Adapt to the Availability of Labor: A Preliminary Exploration with Historical Data

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ABSTRACT

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This note presents and tests a general model to help explain why the demand for labor adapts to the availability of labor. In particular, we postulate that the cost of hiring declines with a growth in available labor for two reasons: (1) individuals seeking employment would be coming to employers instead of the latter seeking them out and (2) the larger set of potential employees would increase the probability of employers finding individuals suitable for unfilled jobs. Moreover, individuals seeking employment likely encourage employers to think of new ways in which labor can be used. An increase in the number of entrants to the labor force would lower the cost of hiring and increase employment demand at any given wage rate. Hence, a change in the labor force – such as the addition of women or immigrants – does not increase unemployment as much as is predicted for current workers because demand for labor increases as the cost of hiring decreases. Failure to taken into account what we term an – "encouraged employer effect" may also explain why surges in employment are often underestimated.

JEL Classification: J20, J21, J23

Keywords: encouraged employer effect, hiring cost, labor demand, labor force

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Harriet Duleep and Xingfei Liu

Labor supply is typically presented as a function of labor demand in economics text books. Yet, as shown below, employment tracks the labor force. In this paper we posit a general model of how labor demand responds to labor supply and test it with historical data.

[Figure: Historical time series of U.S. employment and the labor force]

I. The Model

We propose the following joint hypothesis: the cost of hiring declines with increases in the amount of labor available for employment, and the employment decisions of firms are inversely related to the cost of hiring.

The cost of hiring should decrease with a growth in the available labor supply (either new entrants or unemployed individuals) for two reasons: individuals seeking employment would be approaching employers instead of the latter seeking them out, and the larger set of potential employees would increase the probability of employers finding suitable individuals for unfilled jobs. Moreover, individuals seeking employment likely encourage employers to think of new ways in which labor can be used. Employment inversely related to hiring costs rests on the assumption that firms minimize costs.

Figures 1 and 2 clarify these ideas. The cost of hiring, L, is a function of the number of persons in the labor force minus the number employed, LF – E. The broken line in Figure 2 represents the traditionally conceived labor demand curve where employment decisions are a function of the wage rate. The continuous line demonstrates the added effect of the cost of hiring, L.

Starting at the equilibrium wage rate, W*, an increase in the wage rate decreases the demand for employment. The increased wage increases the amount of labor available for employment (LF – E), which lowers L. The lower value of L induces additional demand for employment. And additional employment increases L. The process converges somewhere in between, to the right of the original demand curve. Similarly, going below the equilibrium wage rate increases L, which then decreases the demand for employment at any given wage rate.

A shift in the labor supply curve, LF, would also affect the cost of hiring in the same way. For example, an increase in the number of entrants to the labor force would lower L and increase employment demand at any given wage rate.

Insert Figure 1 and Figure 2 here.

A process symmetric to the cost-of-hiring effect occurs from the point of view of labor. An increase in employment or a decrease in the labor force decreases the cost of finding a job, which then increases the labor supply at any given wage rate (Figure 3). This has been referred to as the "discouraged worker effect." We are proposing an "encouraged employer effect."

Insert Figure 3 here.

The general state of the labor market is disequilibrium. We have assumed that observed employment is the minimum of the demand and supply of labor. Referring back to Figure 2, the demand for labor is only observed when the wage rate exceeds the equilibrium wage rate. However, given the difficulty of determining an equilibrium wage rate, we simply assume that employers get as much labor as they want up to full employment, defined as 4% of the labor force unemployed. Beyond this point, the demand for labor is no longer observed.[1] With this simplifying assumption, the proposed model follows.

$$E = \min(E^D, 0.96LF) \quad (1)$$

$$E^D = \beta_1 + \beta_2 W + \gamma L_1 + \beta_3 Z + \varepsilon_1 \quad (2)$$

$$LF = b_1 + b_2 W - \theta L_2 + b_3 F + \varepsilon_2 \quad (3)$$

$$L_1 = \pi_1 + \eta(LF - E) + \varepsilon_3 \quad (4)$$

$$L_2 = \pi_2 + \alpha(LF - E) + \varepsilon_4 \quad (5)$$

Where

$E =$ employment

$E^D =$ demand for labor

$LF =$ the labor force

$W =$ the wage rate

$L_1 =$ the cost of hiring labor for employers

$L_2 =$ the cost of locating employment for labor

$Z =$ variables affecting the demand for labor

$F =$ variables affecting the supply of labor

Support for our hypothesis—the cost of hiring declines with increases in the amount of labor available for employment, and the employment decisions of firms are inversely related to the cost of hiring—requires $\gamma < 0$ and $\eta < 0$.

[1] The assumption is problematic since it is possible for both labor and employers to be constrained at the same level of unemployment. (Structural unemployment may exist.) Even ignoring this consideration, the level of unemployment beyond which employment would not represent labor demand would vary over time.

II. Empirical Specification of the Model

The supply of labor is always observed due to the manner in which the data are collected; individuals who are not working are asked if they are looking for work. The same does not hold true for the demand for labor. According to this model, E^D is only observed when employment is less than .96 LF. Therefore, the model was estimated only using observations where $E < .96$ LF. Substituting in the cost of hiring and searching, and replacing E with E^D yields the following:

$$E^D = (\pi_1 + \beta_1) + \beta_2 W + \gamma\eta(LF - E^D) + \beta_3 Z + (\varepsilon_1 + \gamma\varepsilon_3) \qquad (6)$$

$$LF = (\pi_2 + b_1) + b_2 W - \theta\alpha(LF - E^D) + b_3 F + (\varepsilon_2 + \theta\varepsilon_4) \qquad (7)$$

or

$$E^D = \frac{1}{1+\gamma\eta}[\beta_1^1 + \beta_2 W + \gamma\eta LF + \beta_3 Z + \varepsilon_1 + \gamma\varepsilon_3] \qquad (8)$$

$$LF = \frac{1}{1+\theta\alpha}[b_1^1 + b_2 W + \theta\alpha E^D + b_3 F + \varepsilon_2 + \theta\varepsilon_4] \qquad (9)$$

In most macro-econometric models, the supply of labor is a function of the demand for labor: as employment demand rises, the labor force increases and vice versa (the discouraged worker effect). In the proposed model, the relationship becomes simultaneous: E^D affects LF but LF also affects E^D. Measuring the effect E^D has on LF without taking into account the effect LF has on E^D would produce a biased estimate. Increasing E^D increases LF but an increase in LF further stimulates E^D (Figure 4).

Insert Figure 4 here.

Ignoring the simultaneous nature of the relationship yields estimates which underestimate the effect of E^D on LF. Similarly, measuring the effect of LF on E^D by itself would produce a downward biased estimate.

The equations which were estimated, along with all instrumental variables used in the first stage regression, are presented below:

$$E^D = \frac{1}{1+\gamma\eta}[\beta_1^1 + \beta_2 W + \gamma\eta LF + \beta_3 Y + \beta_4 K_{t-1} + \varepsilon_1 + \gamma\varepsilon_3] \qquad (10)$$

$$LF = \frac{1}{1+\theta\alpha}[b_1^1 + b_2 W + \theta\alpha E^D + b_3 A_{t-1} + b_4 YNL + \varepsilon_2 + \theta\varepsilon_4] \qquad (11)$$

$$Y = f(LF, HJG, RD_{t-1}, VBG_{t-1}, XG, RBILL_{t-1}, M1_{t-1}, M1_{t-2}, V_{t-1}, V_{t-2}, D593, D594, D601) \qquad (12)$$

$$W = f(LF - E, HJG, RD_{t-1}, VBG_{t-1}, YGP, T, PIM, RBILL_{t-1}, M1_{t-1}, M1_{t-2}) \qquad (13)$$

Where

$Y =$	output
$K =$	the capital stock
$A =$	value of non-demand deposit securities
$YNL =$	non-labor income of households
$HJG =$	man-hours employed by the government
$RD =$	the discount rate
$VBG =$	value of government securities
$XG =$	purchases of goods by the government
$RBILL =$	three-month treasury bill rate
$M1 =$	money supply
$V =$	stock of inventories
$D593, 4, 601 =$	dummy variables to capture effect of steel strike in 1959
$PIM =$	implicit price deflator for imports

The data used to estimate the model are the quarterly data used by Fair (1976) in estimating his macroeconomic model. These data were collected for the 1952-I to 1977-I period. Detailed descriptions of how the variables were constructed and adjusted is in Fair (1976, pp. 31-45).[2]

The demand for labor is a function of the wage rate, the cost of hiring, the amount of output that is to be produced, and the amount of capital stock available. The supply of labor is a function of the wage rate, the cost of finding employment, the value of non-demand deposit securities, and non-labor income.

Y and W are endogenous in the model. The tightness of the labor market affects W and the decision as to how much to produce is affected by the amount of available labor. A, YNL, and K are assumed to be exogenous variables. Two-stage-least squares is the appropriate estimation technique. In the first stage, E^D, LF, Y, and W are regressed on a set of exogenous variables. The predicted values are then used to estimate the E^D and LF equations.

The set of exogenous variables are variables thought to affect the endogenous variables in the model, but are not themselves affected by the process described in the model. The following assumptions were used in defining this set. Government policy variables were assumed to be exogenous. This includes both fiscal policies and policies controlled by the Federal Reserve. The implicit price deflator for imports was assumed to be determined abroad. The stock of inventories in the previous period was assumed to affect the decision on how much to produce, but be unaffected by this decision. Finally, time and the constant term are safely classified as exogenous.

[2] Also see Fair and Shiller (1990).

III. The Results

The hypothesis we are testing is that the demand for labor by firms is inversely related to the cost of hiring, and the cost of hiring decreases with the supply of available labor. Referring back to the original structural specification of the model, verification of the hypothesis requires both γ and η to be negative. In the estimating equation for E^D, these two coefficients enter multiplicatively as the coefficient of LF. Therefore, the test of the hypothesis is whether the coefficient of LF, $\gamma\eta$, is significantly greater than 0. The results follow (Table 1).

Insert Table 1 here

The coefficient of LF is significantly greater than 0, supporting the hypothesis. Its estimated effect, 1.18, suggests that an increase of a thousand in the size of the labor force increases the demand for employment by more than a thousand.

Table 2 gives the results from estimating the labor supply equation. The coefficient of E, though small, is significant. Its direction supports the "discouraged worker effect" hypothesis.[3]

Insert Table 2 here

Testing the simultaneity of the demand-for-labor—supply-of-labor relationships

In addition to testing the effect of hiring costs on the demand for labor, we also test the simultaneity of the demand-for-labor—supply-of-labor relationships. Estimating either relationship separately, we had speculated, would result in underestimates of the effect of E on LF and the effect of LF on E. It is thus of interest to compare the above results (Tables 1 and 2) with ones obtained estimating the two equations using OLS (Tables 3 and 4).

[3] We would expect the magnitude of this effect to be larger if this equation were estimated separately on secondary workers.

Insert Table 3 and Table 4 here.

As hypothesized, estimating the effect of the supply of labor on E^D—without taking into account the feedback from employment to labor supply—leads to a smaller estimated coefficient. This was not found to be true, however, for estimating the effect of employment on LF without controlling for the simultaneity.

IV. Sensitivity Tests

Testing the exogeneity of the instruments

If all the variables used as instruments were truly exogenous to the model, then deleting some would yield less efficient estimates, but the estimated coefficients would be about the same. To test the exogeneity of some of the instruments used in the 2SLS regressions, we first removed the stock of inventories as an instrument (Table 5) and then removed the variables controlled by the Federal Reserve (Table 6). In all cases, the estimated standard error increases. The estimated coefficients change, but never radically.

Insert Table 5 and Table 6 here.

Adjusting for serial correlation

When we adjust for serial correlation, the original hypothesis is still supported by the estimated coefficient for LF in the demand for labor equation (Table 7, left-hand side).[4] In the labor supply equation, however, all but one of the estimated coefficients become insignificant after correcting for serial correlation (Table 7, right-hand side). Insert Table 7 here.

[4] Correcting for serial correlation using all the instruments used in the previous regressions would have produced inefficient estimates, given the number of observations. The minimum number of instruments were used that assured consistency.

V. Directions for Further Work

Evidently, one direction for further work is to lengthen, with more recent and earlier data, the time series for estimating the model. Several steps could also be taken to more rigorously test the model.

A truncated dependent variable

Since the demand for labor is not observed beyond a certain point, the model was estimated only on those values for which E<.96LF. The dependent variable for the employment demand equation is truncated. As shown in Figure 5, using only observations for which $E^D < .96LF$ the $E(\varepsilon \mid X) < 0$ and all estimated coefficients will be inconsistent (Hausman and Wise, 1977). This is not a problem for the labor supply since the dependent variable is always observed.

Insert Figure 5 here.

To estimate the demand for labor equation, a tobit model could be used. The likelihood function to be maximized would be

$$L = \pi \frac{1}{\sigma} f\left(\frac{E^D - \gamma Y - \beta X}{\sigma}\right) \pi \left[1 - F\left(\frac{.96LF - \gamma Y - \beta X}{\sigma}\right)\right] \quad (14)$$

where Y is a vector of the endogenous variables in the equation and X, the exogenous variables.

Since Y is correlated with the error term, maximizing L would produce inconsistent estimates. The expression in L must be E^D minus its reduced form. The question then arises whether the structural coefficients for E^D could be retrieved from the coefficients maximized in the likelihood function. This is possible since the estimated structural coefficients from the supply-for-labor equation are available.

Testing for specification error

To more rigorously test for specification error, the estimates obtained using all the instrumental variables, $\hat{\beta}_0$, should be compared with the estimated coefficients deleting questionable instruments, $\hat{\beta}$. A test statistic can be formed which is distributed asymptotically as central χ^2 where K is the number of unknown parameters in β when no misspecification occurs (Hausman, 1978).

Testing $E = E^D$ when $E<.96LF$

Finally, a simple procedure could be performed to test the assumption that $E = E^D$ when $E<.96LF$.[5] The demand for labor equation could be estimated on another set of observations assuming a different truncation point, say .95LF. If the demand for employment were only observed until E=.95LF, then the estimated coefficients would be lower for the estimated equation assuming E^D is observed until employment equals 96% of the labor force.

VI. Conclusion

Labor supply is typically viewed as a function of labor demand. This note posits a general model of how labor demand is a function of labor supply and tests this model with historical data. Our preliminary exploration supports an encouraged employer effect. If this conclusion holds with more rigorous testing, two important implications follow: 1. Failure to take the encouraged employer effect into account may help explain why a change in the labor force—such as the addition of women or immigrants—does not increase unemployment as much as is

[5] The problem of not observing the demand for employment beyond a certain point has been approached in different contexts by investigators studying markets in disequilibrium (e.g., Fair and Jaffee, 1972; Amemiya, 1974; and Maddala and Nelson, 1974).

predicted for current workers. 2. It may also explain why economists often underestimate surges in employment.

Tables and Figures:

Table 1 Regression dependent variable: E^D

Explanatory Variables	Estimated coefficients
Constant	-12473.5 (-.974373)
W	-76.2236 (-3.59428)
LF	1.18090 (4.32941)
Y	43.0529 (3.36011)
K_{t-1}	-14.5547 (-1.22077)

Note: standard error of regression=532.724
t-statistics in parentheses

Table 2 Regression dependent variable: LF

Explanatory Variables	Estimated coefficients
Constant	.547393 (38.6514)
W	.192790E-03 (1.76057)
E	.117375E-05 (3.60197)
A_{t-1}	-1.92100 (-2.76091)
YNL	-144.298 (-3.21963)

Note: standard error of regression=.353186E-02
t-statistics in parentheses

Table 3 Regression dependent variable: E^D

Explanatory Variables	Estimated coefficients
Constant	-733.537 (-.867369E-01)
W	-57.8625 (-3.74513)
LF	.929552 (5.16513)
Y	54.1967 (5.38678)
K_{t-1}	-5.69937 (-.653741)

Note: t-statistics in parentheses

Table 4 Regression dependent variable: LF

Explanatory Variables	Estimated coefficients
Constant	.542368 (40.1506)
W	.174064E-03 (1.65337)
E	.128971E-05 (4.16490)
A_{t-1}	-2.03163 (-3.00952)
YNL	-147.772 (-3.32786)

Note: t-statistics in parentheses

Table 5 Regressions excluding stock of inventories-

dependent variable: E^D		dependent variable: LF	
Explanatory variables	Estimated coefficients	Explanatory variables	Estimated coefficients
Constant	-10817.4 (-.818556)	Constant	.547674 (37.8321)
W	-74.1732 (-3.41364)	W	.194601E-03 (1.74799)
LF	1.14652 (4. 07337)	E	.116706E-05 (3.49826)
Y	42.4379 (3.28276)	A_{t-1}	-1.91083 (-2.71105)
K_{t-1}	-12.4441 (-1.01029)	YNL	-144.504 (-3.21841)

Note: t-statistics in parentheses

Table 6 Regressions excluding variables controlled by the federal reserve-

dependent variable: E^D		dependent variable: LF	
Explanatory variables	Estimated coefficients	Explanatory variables	Estimated coefficients
Constant	-12457.3 (-.725395)	Constant	.546265 (37.5763)
W	-76.8727 (-2.96526)	W	.142233E-03 (1.23762)
LF	1.18175 (3.22290)	E	.121164E-05 (3.61053)
Y	40.5767 (2.65139)	A_{t-1}	-2.18776 (-3.03247)
K_{t-1}	-13.5421 (-.854673)	YNL	-120.673 (-2.60156)

Note: t-statistics in parentheses

Table 7 Regressions correcting for serial correlation -

dependent variable: E^D		**dependent variable: LF**	
Explanatory variables	Estimated coefficients	Explanatory variables	Estimated coefficients
Constant	-55151.1 (-2.16626)	Constant	.606891 (15.3533)
W	-145.565 (-2.70783)	W	.240589E-03 (1.49625)
LF	2.05157 (3.83907)	E	-.341568E-06 (-.445842)
Y	45.1980 (1.71301)	A_{t-1}	0.64027 (-.884826)
K_{t-1}	-57.1612 (-2.51495)	YNL	11.5640 (.413983)
Estimated rho=.823289 standard error=.067		Estimated rho=.861531; standard error=.06	

Note: t-statistics in parentheses

Figure: Historical time series of U.S. employment and the labor force

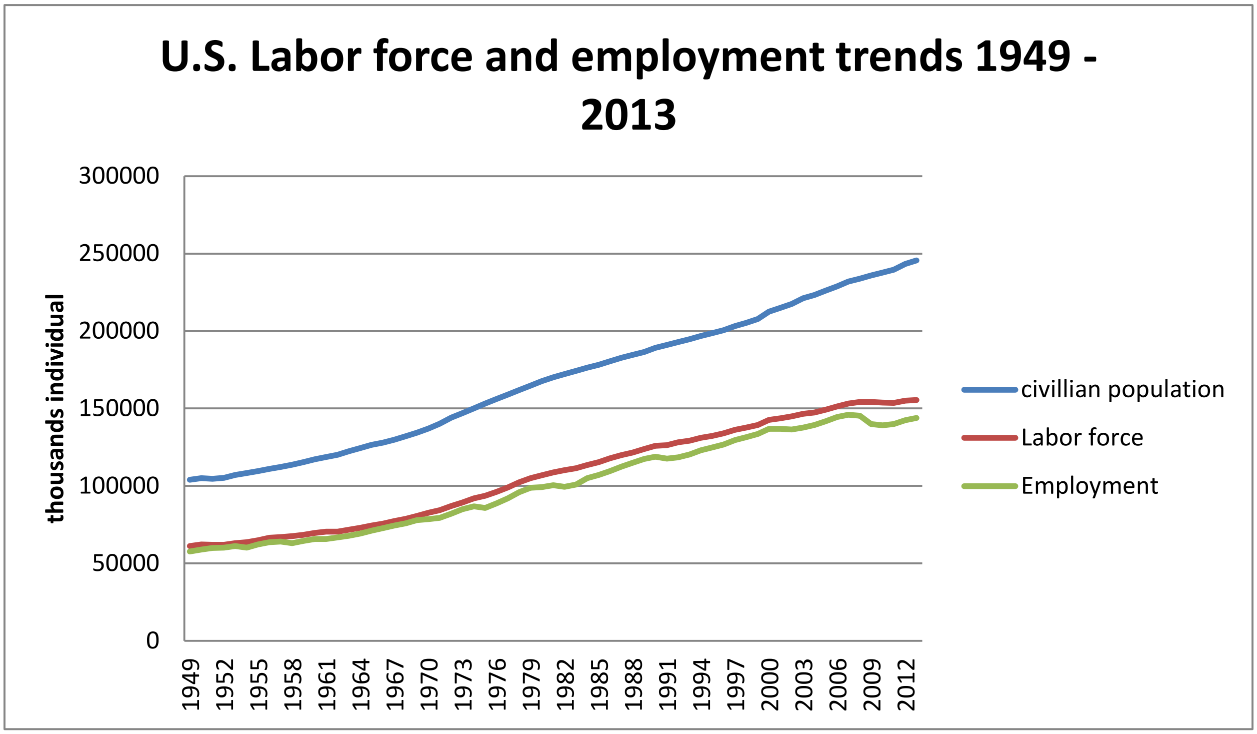


Figure 1

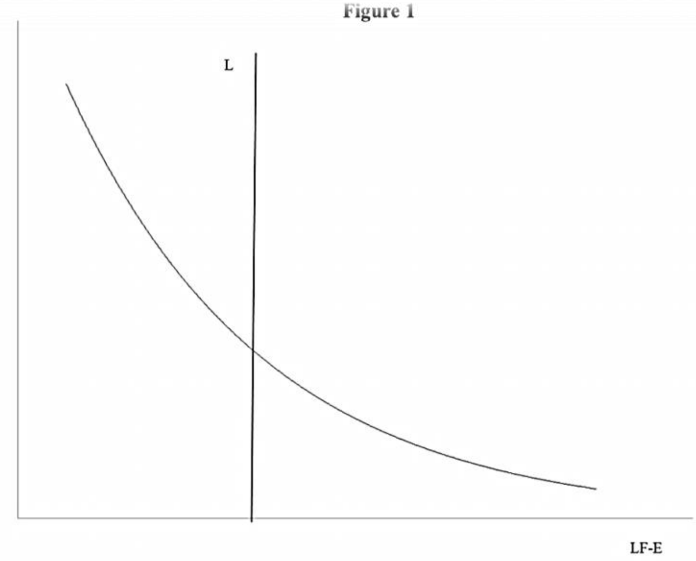


Figure 2

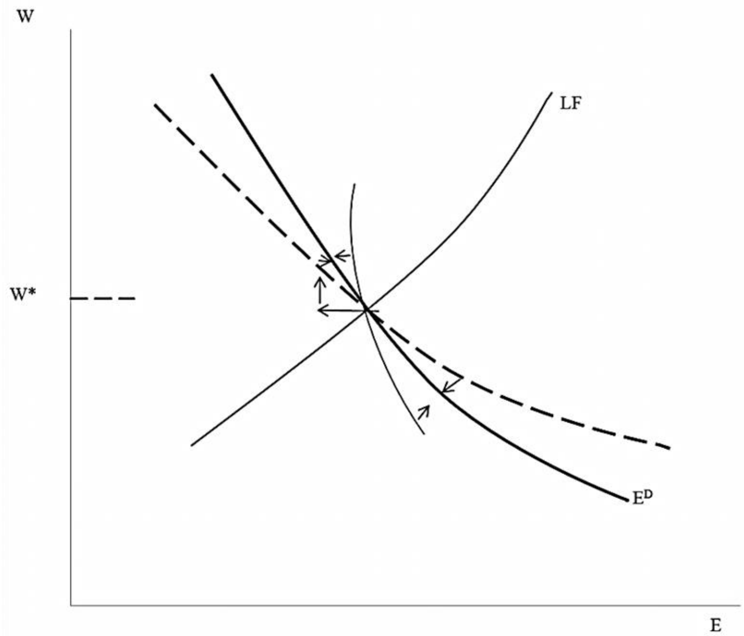


Figure 3

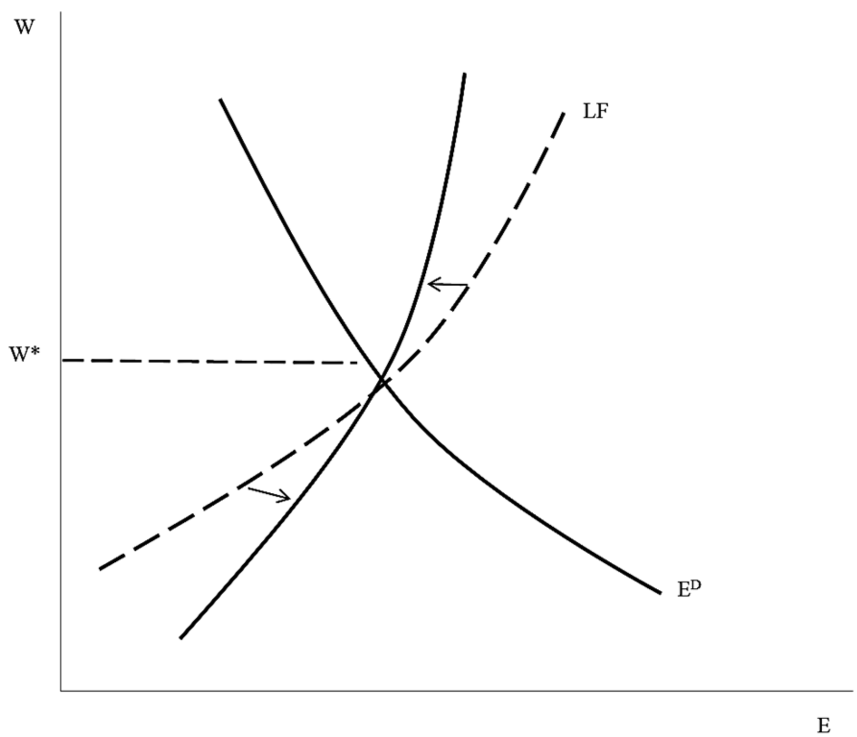


Figure 4

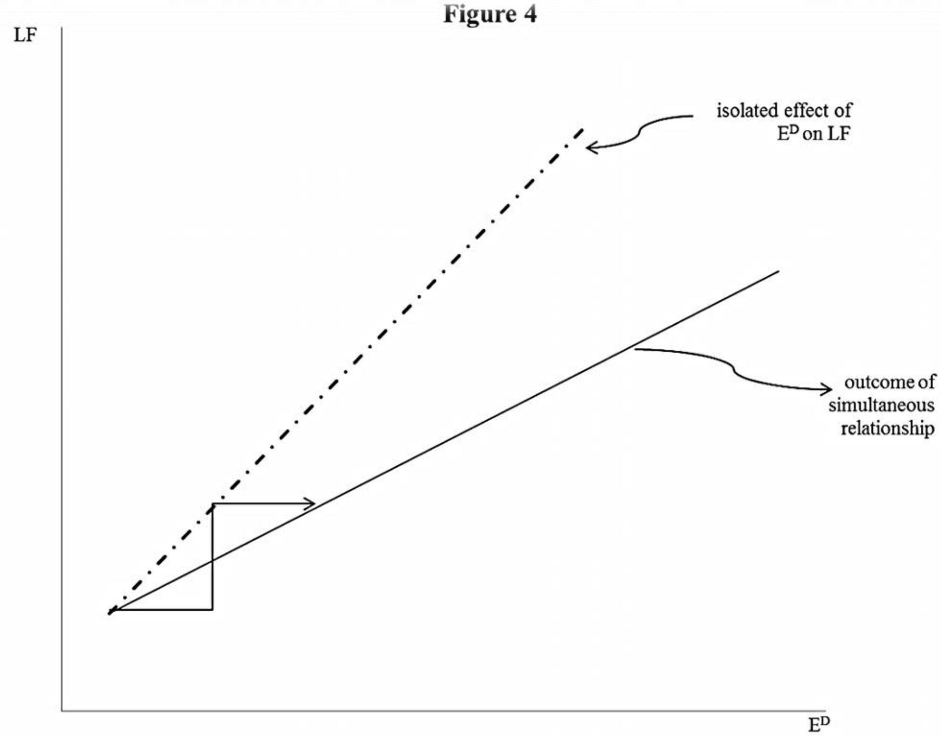
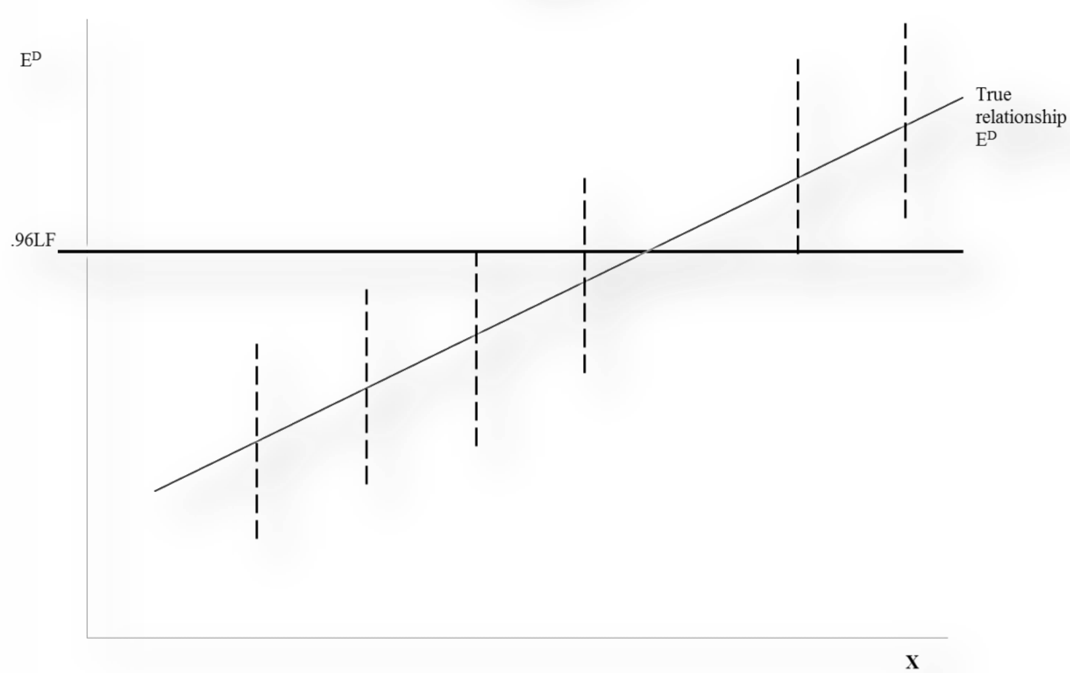


Figure 5



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