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The Division of Labor is Limited by the Extent of the Market: A Test of the Hypothesis*

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I. Introduction

Adam Smith's statement that the division of labor is limited by the extent of the market is widely cited. Yet there have been few advances in the analytical treatment of the proposition (Stigler, 1977), and empirical support for the hypothesis has consisted mainly of the presentation of illustrative examples, the method used so persuasively by Smith (Hollander, 1977). While most empirical research on the division of labor has concerned manufacturing (Stigler, 1951; Rosenberg, 1963; and Ippolito, 1977), Smith discussed the role of specialization in a much broader range of economic activities. Among the occupations used to illustrate the determinants and consequences of the division of labor, Smith cites philosophers, blacksmiths, porters, carpenters, and masons. In this paper, we subject Adam Smith's hypothesis to an empirical test by examining whether specialization of United States physicians within states in 1949 and 1972 is positively associated with market size.

Testing the hypothesis with physician data has the advantage that both the extent of the market and the degree of specialization are reasonably well defined. The consumption of physician services ordinarily requires the physical presence of the physician. Relatively high transportation costs of bringing patients to physicians or physicians to patients tend to limit the geographic area of the market. In this paper, we use state boundaries as geographic limits to market areas. There are two reasons for this choice. First, a physician practicing in one state cannot treat patients in another state without obtaining an additional license. Thus, in the short run, suppliers of services are relatively immobile across state lines. Second, this limited mobility of physicians across state boundaries results in higher communications costs between physicians across state lines compared to such costs within states. Consequently, for a given distance between patients and producers, patients are more likely to be referred by a physician to other physicians in the same state rather than to physicians in a neighboring state. Thus, a consumer is likely to purchase both primary care and specialty care from physicians practicing in the state in which the consumer resides. Unfortunately, there are no data on the purchase or sale of physician services across state borders or on differences in the prices of physicians' services among

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states which would permit a test of the hypothesis that state boundaries define market areas. However, empirical results similar to those reported below for states are obtained if state economic areas are used as the units of observation or if states among which mobility of patients or physicians across state borders may be more common are aggregated into larger units. Finally, state licensure of physicians combined with American Medical Association accreditation of medical education helps to ensure uniformity of the definition of specialties in different geographical markets (Stevens, 1971).

II. The Model

In this section we present a multi-region general equilibrium model which shows how spatial differences in the demand for physicians' services influence the degree of specialization within a market region. Since changes in the relative mix of specialists among areas are strongly influenced by migration of physicians with specialty training, the model assumes that practitioners are perfectly mobile among regions. We assume also, however, that consumers purchase services and suppliers sell services only in the region of residence.

Quantity of services demanded per capita in region i (Q_{di}/P_i) depends on per capita income (Y_i) and fee for services (F_i):

$$\frac{Q_{di}}{P_i} = \alpha\, Y_i^{\gamma}\, F_i^{\eta}. \tag{1}$$

We assume that the income elasticity of the demand for services (γ) exceeds zero and that the price elasticity of demand (η) is less than or equal to zero.

Output of a typical practice in region i (T_i) is given by

$$T_i = E_i\, H_i^{\beta}\, X_i^{\delta}, \tag{2}$$

where E_i is an index of the efficiency of production, H_i is hours worked by the physician, and X_i is the quantity of a factor such as labor used in producing output. We assume, for simplicity, that hours worked by each physician are fixed and that physicians maximize profits. Profits of a typical firm in i equal

$$\pi_i = F_i\, T_i - wX_i, \tag{3}$$

where w, the price per unit of X_i, is assumed to be the same in all locations. In choosing the profit maximizing level of output, the physician is assumed to treat F_i and w as exogenous. Total output of physicians in region i (Q_{si}) is

$$Q_{si} = N_i T_i, \tag{4}$$

where N_i is the number of physicians in i.

Efficiency depends on the degree of specialization:

$$E_i = (S_i)^{\Omega}, \tag{5}$$

where Ω is the elasticity of efficiency with respect to specialization, and specialization is hypothesized to be related positively to the size of the market (Q_i) and inversely to the area of a region (A_i):

$$S_i = \left[\frac{Q_i}{A_i^{\lambda}}\right]^{\phi}, \tag{6}$$

where S_i is an index of specialization and $Q_i = Q_{si} = Q_{di}$. Adam Smith's hypothesis is that ϕ, the elasticity of specialization with respect to market size, exceeds zero. The elasticity of specialization with respect to area is $-\lambda\phi$.

The specification of equation (6) reflects, in a simple way, Smith's discussion of the influences of the spatial distribution of population and of transportation costs on the limits to market size (Smith, 1937, pp. 17–21). If all individuals in a state had identical incomes, if population were spatially evenly distributed within the state, and if transportation costs were sufficiently high that all services were consumed in local markets, then λ would equal one and specialization would be a simple

function of the 'density' of the market, Q_i/A_i. If transportation costs were zero and all services were still consumed within the state's boundaries, then the effective market for services within the state would be unaffected by distance (or area) or by the spatial distribution of population and λ would equal zero. Finally, if all individuals resided in one central location, then λ would also equal zero, since the degree of specialization would not be affected by area. Thus, λ and therefore the elasticity of specialization with respect to area depend upon transportation costs and the spatial distribution of population.

Equilibrium in the market for physicians' services is obtained when the quantity of services supplied equals the quantity of services demanded in each region, when the sum of the number of physicians in each region equals the total stock of physicians, and when $\pi_1 = \pi_2 = \cdots = \pi_n$, so that physicians have no incentive to migrate among regions. It can be shown that in equilibrium

$$\frac{S_i}{S_j} = \left[\frac{Y_i}{Y_j}\right]^{\gamma\phi\rho}\left[\frac{P_i}{P_j}\right]^{\phi\rho}\left[\frac{A_i}{A_j}\right]^{-\lambda\phi\rho}, \tag{7}$$

where $\rho = 1/(1 + \phi\Omega\eta)$ and i and j are any two of the n regions.[1] It can also be shown that if $\rho < 0$ then an increase in the number of physicians in a region would increase profits per physician (i.e., $\partial\pi_i/\partial N_i > 0$), so that all physicians would locate in the region with the largest demand for their services. Since we do not observe all physicians residing in only one state, this case is empirically irrelevant. Hence, if $\rho > 0$ and if specialization is positively related to the extent of the market ($\phi > 0$), then equation (7) shows that, *ceteris paribus*, specialization in a region is positively related to its per capita income and population and negatively to its area. Finally, note that if the price elasticity of demand equals zero, then the exponent of P_i/P_j equals the elasticity of specialization with respect to market size.

III. Data

Physician data for the years 1949 and 1972 are used to test Smith's hypothesis. For 1949, our measures of specialization are: (1) the proportion of active non-federal physicians in private practice in state i who are not general practitioners (S_{1i}), and (2) the proportion of all active non-federal physicians who are not general practitioners (S_{2i}). The second measure includes as specialists physicians in hospital service and physicians not engaged in private practice.[2] The first measure is too narrow in that some physicians who render specialty care are excluded from both the numerator and denominator; the second is too broad since it counts as specialists some physicians who are engaged in general practice. These data are tabulated from the *American Medical Directory, 1950* and are reported in Pennell and Altenderfer (1952, Table 16, pp. 16–17).

For 1972, we also employ two measures of specialization. The first measure is the proportion of active non-federal physicians who

[1] A mathematical appendix describing the derivation of equation (7) is available upon request. The derivation consists of finding first those combinations of relative fees (F_i/F_j) and relative numbers of practitioners (N_i/N_j) such that maximum profits per physician are equal in all locations and then those combinations of relative fees and relative numbers of practitioners such that the demand for services equals the supply of services in all states. The solution to these equations gives the relative numbers of physicians in each state as a function of the parameters of the model and the relative values of exogenous variables. Solving for S_i/S_j, given the equation for N_i/N_j, is straightforward.

[2] Non-federal physicians in hospital service include physicians 'in hospitals, sanatoriums, and related institutions, regardless of control, engaged in a hospital training program or whose data clearly indicate their general or specialty practice is devoted to institutional care' (Pennell and Altenderfer, 1952, p. 17); non-federal physicians not engaged in private practice include faculty members employed in medical schools on a full-time basis, physicians engaged in research, and those employed by manufacturing organizations or state and local governments.

are not general practitioners (S_{3i}). Physicians whose activity was not classified (approximately four percent of active non-federal physicians) are excluded from both the numerator and denominator of the specialization ratio. The data are from the U.S. Department of Health, Education, and Welfare (1974, Table 91, pp. 180–183). While measuring the division of labor among physicians by the proportion of physicians who have limited the range of medical activities they perform is intuitively appealing, this measure is subject to two shortcomings. First, the activities performed by general practitioners undoubtedly vary with the availability of specialists, so that general practitioners may themselves be specialized. For example, in markets where there are numerous obstetricians, general practitioners are less likely to deliver babies than in markets where there are no obstetricians. Second, the measure does not take into account the division of labor among physicians who are not general practitioners. For these reasons, we also use an entropy measure of the division of labor among physicians:

$$E_i = \sum_{j=1}^{k} p_{ij} \ln(1/p_{ij}), \qquad (8)$$

where E_i is entropy in state i, p_{ij} is the proportion of physicians engaged in the jth specialty, and there are k specialties, including general practitioners as one of the specialties. Entropy is positively related to the division of labor. If there were no division of labor among physicians in a state (i.e., all physicians belonged to the same specialty), then $E_i = 0$. If, on the other hand, physicians were equally divided among specialties then E_i reaches its maximum value $E_i = \ln(k)$ (Theil, 1971, p. 640, fn. 20). For 1972, the data source lists 35 categories of specialists, so that the maximum value of E_i is $\ln(35)$ or 3.5553. The largest category is general practitioners (25.2% of physicians) and the smallest is aerospace medicine (.08% of physicians).

IV. Tests of the Hypothesis

The statistical models to be estimated are:

$$\ln\left[\frac{S_{ti}}{S_{tj}}\right] = \alpha_1 \ln\left[\frac{Y_i}{Y_j}\right] + \alpha_2 \ln\left[\frac{P_i}{P_j}\right] + \alpha_3 \ln\left[\frac{A_i}{A_j}\right] + u_{ij} \qquad (9)$$

and

$$\ln\left[\frac{E_i}{E_j}\right] = \beta_1 \ln\left[\frac{Y_i}{Y_j}\right] + \beta_2 \ln\left[\frac{P_i}{P_j}\right] + \beta_3 \ln\left[\frac{A_i}{A_j}\right] + v_{ij}, \qquad (10)$$

where u_{ij} and v_{ij} are stochastic terms and other variables are as defined in Table I. Hypotheses to be tested are $\alpha_1, \alpha_2, \beta_1, \beta_2 > 0$ and $\alpha_3, \beta_3 < 0$.

Table I gives the mean values of all variables. We initially estimated equations (9) and (10) by ordinary least squares (OLS) regression using all pairs of states ($i \neq j$) as observations. However, since regressions of the squared residuals from these equations on the squares and cross-products of the logarithms of the independent variables indicated the presence of heteroskedasticity, the equations were reestimated by generalized least squares (GLS) according to the procedure suggested by Glejser (1969). Table II presents the GLS estimates.[3] As expected, the coefficients of the logarithms of relative per capita incomes and population sizes are positive and the coefficients of the logarithms of relative geographical areas are negative; all coefficients are statistically significantly different from zero at the .01 level. Thus, Smith's hypothesis that the division of labor is limited by the extent of the market is supported by the empirical analysis. For 1972, the estimated elasticities of specialization with respect to the independent variables using the proportion specialist as an index of specialization are markedly higher (in absolute value) than the corresponding elasticities obtained from the regression using the entropy of the distribution of physicians among specialties as the measure of the division of labor. Equations using the proportion specialist index imply values of λ ranging from .57 to .71; the estimate of λ derived from the entropy equation equals .31.

A comparison of the coefficients reported in column (2) of Table II with those reported in column (3) indicates that the cross-sectional elasticity of specialization with respect to

[3]OLS estimates of the coefficients of the independent variables are extremely close to the GLS estimates; GLS estimates of the standard errors are marginally smaller than the OLS standard errors.

TABLE I. Definitions and Means of Variables

Variable	Definition	Mean
S_{1i}	Proportion of active non-federal physicians in private practice who are not general practitioners, 1949	.49
S_{2i}	Proportion of active non-federal physicians who are not general practitioners, 1949	.56
S_{3i}	Proportion of active non-federal physicians who are not general practitioners, 1972	.78
E_i	Entropy of the distribution of physicians by specialty, 1972	2.72
$\ln P_i$	Natural logarithm of population (in millions)	
	1949	.66
	1972	.90
$\ln Y_i$	Natural logarithm of per capita income (in $1,000's)	
	1949	.31
	1972	1.46
$\ln A_i$	Natural logarithm of area (in 1,000's of sq. miles)	
	1949	3.61
	1972	3.63

TABLE II. Generalized Least Squares Estimates of the Specialization Regressions*

	1949		1972	
Dependent Variable:	$\ln\left[\frac{S_{1i}}{S_{1j}}\right]$	$\ln\left[\frac{S_{2i}}{S_{2j}}\right]$	$\ln\left[\frac{S_{3i}}{S_{3j}}\right]$	$\ln\left[\frac{E_i}{E_j}\right]$
Independent Variables:				
$\ln\left[\frac{Y_i}{Y_j}\right]$	.2061 (.0085)	.2572 (.0083)	.1636 (.0080)	.0858 (.0041)
$\ln\left[\frac{P_i}{P_j}\right]$	.0513 (.0019)	.0278 (.0019)	.0396 (.0011)	.0220 (.0007)
$\ln\left[\frac{A_i}{A_j}\right]$	−.0290 (.0012)	−.0190 (.0011)	−.0283 (.0007)	−.0068 (.0004)
r^2	.49	.45	.55	.36
n	2352	2352	2550	2550

*Standard errors in parentheses.

state income per capita has diminished through time but that the elasticity of specialization with respect to population size has increased. The decline in the income elasticity of specialization may be due to the increased provision of government financing for purchases of medical care by the poor and elderly. However, one must be cautious in drawing firm conclusions from the comparison, since services provided by physicians have changed through time and since the classifications of physicians by specialty differ somewhat from 1949 to 1972 (Theodore, 1971).

Finally, if the price elasticity of demand for physicians' services is close to zero, as some estimates suggest, then the coefficients of P_i/P_j in Table II imply that the elasticity of specialization with respect to market size lies between .02 and .05.[4]

V. Conclusion

In this paper, we have provided empirical evidence which supports Adam Smith's hypothesis that the division of labor is limited by the extent of the market. In both 1949 and 1972, the proportion of physicians in a state who were classified as specialists was positively related to increases in market size arising from increases in population and income per capita; for 1972, similar results were obtained when the entropy of the distribution of physicians among specialties was used as a measure of the division of labor.

[4]There is little agreement on the value of the price elasticity of demand. See Wilson and Boulier (1978) for a review and evaluation of empirical estimates of the price elasticity of demand for physicians services. Our estimates of the price elasticity of demand from time series data (1948 to 1968) is small and not statistically different from zero. Using data reported in Fuchs and Kramer (1972) for states in 1966, we estimate the price elasticity of demand to be only −.08. The American Medical Association Commission on the Cost of Medical Care (1964, p. 65) reports a price elasticity of demand of −.19, but the Commission does not take account of simultaneity in the demand and supply of services in its estimation of the demand equation.

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