SUBSTITUTION OF GRADUATE BY OTHER LABOUR*

I. RELEVANCE OF SUBJECT

For a long time production functions have been used by economists and tested by econometrists in which labour was considered one homogeneous factor of production. Since 1969 some authors have introduced more than one type of labour and undertaken attempts at estimating the elasticities of substitution between the types of labour considered. The subject is relevant for at least two types of further analysis and policy applications. On the one hand, education planning has to be based on such a more refined production function. In the early phases of education planning a one-to-one correspondence between a future occupation and the necessary type of education was assumed to exist; in other words, a rigid relationship between the quantity of any product and the quantity of a particular type of labour was supposed to be necessary. Reality permits a considerable degree of substitution among types of labour, however, and for a more realistic education planning that degree had to be known quantitatively. This inspired work by BOWLES [1], DOUGHERTY [2], PSACHAROPOULOS [5] and ULLMAN [9].

On the other hand, students of income distribution are in need of more precise information on the possibilities of substitution between various categories of labour, since this influences the demand structure of the labour market. Thus, FREEMAN [3] and this author [6, 7], who have given relatively more attention than some other authors on income distribution to the demand side of the labour market, made attempts to estimate demand functions, partly based on production functions in which several labour categories were distinguished.

Apart from the use for further scientific analysis the subject of substitution between types of labour has an immediate practical aspect when it comes to finding adaptations to changes in trade policies as now required—and rightly so—by the developing countries.

* I am indebted to JAAP JANSEN for having performed the computations.

II. NECESSITY TO SEPARATE DEMAND AND SUPPLY

For a clear analysis of the problems of substitution between various labour types substitution on the demand side—exerted by the organizers of production in the widest sense—and on the supply side, where many individuals have a choice between a range of occupations. Their willingness to change their job will be determined by their preference functions in which not only enter the income attached to each of the possible jobs, but also the satisfaction or dissatisfaction going with them. In part, this satisfaction (positive or negative) will depend on their level of education. (This, by the way, implies the desirability to describe an individual's position *vis-à-vis* his or her job by at least two indicators, one for the education required to do the job adequately and one for the education actually received [7].)

Some of the authors quoted give more explicit attention to this difference between demand side and supply side than others and some remarks on their methods will be made later (*cf. Sections III* and *IV*).

This author was struck by the high elasticity figures obtained by several others, and wondering how to interpret them. Since the question is of particular relevance to the credibility of some calculations, presented earlier, on the possibilities to reduce income differences, a few alternative attempts were undertaken, using, among other material, quite a few figures collected by Messrs BOWLES and DOUGHERTY. I am particularly grateful to Dr. DOUGHERTY who most generously provided me with a vast material collected by him [2].

The study whose results are submitted in this article exclusively deals with the substitution of third-level educated labour by all other. For the interstate American material only the highest educational level has been considered third level (more than 3 year college).

The question whether one can determine, with the aid of figures on prices and quantities exchanged, the demand or the supply function is an old one: various aspects of it have been discussed by FRISCH in 1933 [4]. It is irrelevant whether prices and quantities are referring to one commodity or to the ratios between two commodities; in fact, a price of one commodity is a price ratio for that good relative to the price of money. The simplest illustration of the dilemma is the

situation where both the supply and the demand curve (or line) in the price-quantity diagram have shifted in one direction between all the observations. The observed points are then not lying on the demand or on the supply curve but on the 'historical path', whose slope can be anything. Another possible situation for which the same conclusion applies is the one of random shifts dealt with by FRISCH.

There are various ways out of the dilemma. One is that only one of the curves has shifted; then the observed points are all situated on the other one. This is what BOWLES, DOUGHERTY, PSACHAROPOULOS and ULLMAN have assumed, in order to estimate the short-term demand curve. The elasticities found in this way are reliable only, however, if the correlation coefficient between the price variable and the quantity variable is high; otherwise the regression coefficient found highly depends on whether the first or the second regression has been determined. Our authors take the regression where the quantities are assumed to be given and the price ratios dependent. For a short-term demand curve this can be accepted, but for a long-term demand function this choice is debatable.

Typically short-term reactions are reactions where not only the numbers of people employed, but also and especially, the durable production equipment cannot be changed. As a complement, long-term reactions will contain changes in industries and in technology. It seems natural to me that in the latter type of decisions the organizers of production will start from their information on prices of products as well as production factors, including those of the various types of labour. For this reason I submit that relative quantities also on the demand side should be considered to be the dependent and not the independent variables; of course there will not be a large difference between the alternative results whenever a correlation coefficient close to 1 is obtained. This appears not to be so in the cases of simple correlation presented by two of our authors. Since BOWLES' simple correlation coefficient is -0.55 and DOUGHERTY's -0.42, their elasticities would have to be multiplied by $0.55^2 = 0.30$ and $0.42^2 = 0.176$, respectively, if the other simple regression had been taken. This drastically reduces the elasticities.

Another way of solving the dilemma is that at least one more independent variable is added to each of the equations linking price and quantity variables. These additional variables have often been

called demand or supply 'factors'; they are supposed to co-determine the quantities actually exchanged, looked at from the demand or the supply side, respectively. Both BOWLES and ULLMAN apply this method; BOWLES adds, on the demand side, the percentage of active population in agriculture. ULLMAN, on the demand side, adds the qualities of the types of labour, represented by dummies for the human capital invested in each individual of the two categories—certainly a highly interesting enrichment—and on the supply side adds income and cost of education. BOWLES' elasticity of demand reduces from 8 to 6 for the substitution between second and third-level on the one hand and lower level manpower on the other hand; the correlation coefficient (for this substitution) improves from 0.85 to 0.90. For the substitution between third-level educated labour only and all other labour I calculated, from his figures, but using another additional independent variable *(cf. Section III)*, the improvement was from 0.55 to 0.9.

A third way of separating the demand and supply equation consists of introducing a time lag for one of the relations (or a different time lag for both). Clearly this only makes sense if such a lag actually exists and is of sufficient length. For the supply of university graduates this is not an unrealistic assumption, which was successfully applied by FREEMAN for college-trained technicians. Such a lag implies the development over time as shown in the cobweb theorem. Fluctuations of this kind are common to coffee, pigs and graduates, probably *bien étonnés de se trouver ensemble!*

III. ALTERNATIVE RESULTS FROM BOWLES' (CROSS-NATION) MATERIAL

Since for income inequality reduction the substitution of third-level educated manpower (or womanpower, for that matter) by all other is more relevant than any other substitution (as far as I experienced in my attempts in [6]), I tried to derive the relevant long-term demand and supply elasticities from the two relations:

$$\text{Demand:} \qquad \frac{L_1 + L_2}{L_3} = b_1 \frac{w_1 + w_2}{w_3} + b_2 u + b_3 \qquad (3.1)$$

Table 1

Values Found for Coefficients in (3.1) and (3.2)

	a_1	a_2	a_3	$\bar{R}_{sup}$	b_1	b_2	b_3	$\bar{R}_{dem}$
	−12	−0.236	33.2	0.70	−14.3	−0.375	48.7	0.89
*	(9)	(0.095)	(8.7)		(5.6)	(0.070)	(6.2)	
ε	−1	−1			−1.2			
	109	−0.68		0.47	−7.1	−0.35		0.85
ε	8.5				−0.6			

Supply: $$\frac{L_1 + L_2}{L_3} = a_1 \frac{w_1 + w_2}{w_3} + a_2 L_2 + a_3 \qquad (3.2)$$

Here L_i (in BOWLES' notation) stands for the labour force with education i, w_i for earnings of category i, $i = 3$ stands for more than 11 years of schooling, which is an overestimation of L_3 and an underestimation of w_3, in comparison to my own approaches. Further, u stands for the per mille of the active population in utilities, health services, transportation and communication (ISIC 5 and 7); admittedly an incomplete measure of the services sector, since education and government are not included. The a and b are regression coefficients and their values, together with the corresponding standard deviations (*), elasticities (ε) and corrected multiple correlation coefficients ($\bar{R}$) are given in *Table 1*. The upper half of the table gives coefficients estimated with the aid of the least-squares method for (3.1) and (3.2) in succession, the lower half gives coefficients estimated with the aid of reduced-form equations.

According to the least-squares estimates the supply elasticity is not significantly different from 0; since its algebraic sign is negative, it may be interpreted as a small consumptive aspect of supply but does not leave much room for the investment in human capital aspect. The theory behind the L_2 term is that countries with a large number of people with secundary education have a stronger tendency to be induced to continuing their education. The algebraic sign of a_2 implies no rejection of this theory. The demand equation, in which we are mainly interested, behaves according to expectations: both signs

are correct and the values of the coefficients are significant at the 1 per cent level. The corrected multiple correlation coefficient is satisfactory. The demand elasticity is not significantly different from unity, implying support for the generalized COBB-DOUGLAS production function used in my earlier models.

The reduced-form estimates yield a strongly positive supply elasticity and a demand elasticity half as low even as the least-squares estimate. The multiple correlation coefficients R_p and R_q for the price equation and the quantity equation (both as function of the demand factor and the supply factor) are 0.47 and 0.85 respectively.

IV. ALTERNATIVE RESULTS FROM DOUGHERTY'S CROSS-STATE MATERIAL

I applied a similar procedure to the cross-section material for the 28 most populous American states, collected mainly by DOUGHERTY. The relative employment figure now used was the per millage of effective employment in the experienced labour force in 1959 (equivalent males) with third-level education; the relative income: the ratio of third-level mean income of males aged 25–64 in the experienced labour force to median income. As the additional supply factor I introduced the median years of schooling S (instead of L_2 in BOWLES' case), taken from the U.S. Summary of the 1960 Census of Population; as the additional demand factor v the percentage of the active population employed in transportation, *etc.*, finance, professional services and public administration, from Tables 128 of the State Volumes of the 1960 Census.

The results of the regression analysis applied on these data are given in *Table 2*, where the upper half again gives the estimates obtained by least squares applied to supply and demand equation and the lower half those obtained from reduced-form estimation. In the upper half for the demand equation also the coefficients have been added obtained when price ratios are considered the dependent variable.

From the table we see that this time the multiple correlation coefficients obtained for both the price and the quantity equation are rather satisfactory. The demand elasticity obtained from the second

Table 2

Values Found for Coefficients for U.S. States

	a_1	a_2	a_3	$\bar{R}_{sup}$	b_1	b_2	b_3	$\bar{R}_{dem}$
	24.0	23.8	−186.6	0.81	−17.9	3.58	69.1	0.72
*	(9.9)	(4.0)			(7.0)	(0.86)		
ε	0.54				−0.40			
					−94	2.42	28.3	0.45
ε					− 2.1			
	11.7	5.35			− 3.78	3.30		
ε	2.64			$R_p = 0.80$	− 0.85			$R_q = 0.85$

demand equation (where price ratios were considered dependent) −2.1 comes closer to the ULLMAN figure of −2.5; but the reduced form estimate remains (as an absolute figure) below 1. The conclusion seems warranted that the generalized COBB-DOUGLAS function used in my earlier estimations gives a realistic picture for the substitution elasticity between third-level educated and all other manpower.

V. THE NATURE OF TECHNOLOGICAL CHANGE OVER TIME

ULLMAN [9], apart from finding a rather high elasticity of substitution from his 1910 and 1920 cross section correlations, also states its constancy over the whole period of 1900 to 1963 for the United States. This does not necessarily imply constancy of all parameters of the production function. In my own attempt to work with a generalized COBB-DOUGLAS function, the exponents of each of the factors of production change over time and yet the elasticity of substitution of course remains one between any two factors. Since with a COBB-DOUGLAS production function of degree 1 the exponent ϱ_3 indicates the share of manpower with third-level education, the average income of such manpower will be proportional with ϱ_3/L_3 where L_3 stands for the number of third-level educated. An increase, over time, of L_3 in comparison to $L_1 + L_2$, therefore reduces income in-

equality, if ϱ's remain constant. From cross-section estimates for some countries I derived that ϱ_3 has, however, a tendency to rise with rising average income Y of a nation. Under these circumstances a reduction in income inequality will only occur over time if L_3 rises relatively more quickly than ϱ_3, which I found to be the case for the present situation in the Netherlands [8]. ULLMAN's inventive estimates back to 1900 of relative earnings and relative numbers in his Table 3 enabled me to test my cross-section relation between ϱ_3 and Y for the historical development of the United States between 1900 and 1963; it appeared to be practically identical with my estimate. My approach suggests that it depends on the 'race' between demand for third-level manpower due to technological development and supply of it due to increased schooling, whether the reduction in inequality found for the last century, can be resumed after the stagnant period from 1950 to 1970.

VI. CONCLUSIONS WITH REGARD TO INCOME INEQUALITY

From the preceding sections I submit as conclusions that the results previously presented [6,8] about the possibilities to reduce income differences between third-level educated and all other manpower still stand. In particular, the demand elasticity of substitution between the two types of labour is closer to one than the authors quoted suggest and the theory of the 'race' between technical progress and extension of third-level education finds further support in the income estimates back to 1900 presented by ULLMAN [9].

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SUMMARY

On the basis of statistical material collected by BOWLES (cross section of 18 countries) and DOUGHERTY (cross section of 28 states of the USA), supplemented by the author, the elasticity of substitution between third-level educated and all other labour is reconsidered. The distinction between supply and demand elasticity is dealt with somewhat more explicitly, partly in the spirit of ULLMAN, and in fact of a tradition going back to 1933. By the introduction of one demand and one supply factor alongside with price and quantity ratios lower demand elasticities are found than the three authors quoted, centered around unity.

ZUSAMMENFASSUNG

Der Autor unterbreitet Neuschätzungen der Substitutionselastizität zwischen akademisch ausgebildeter und übriger Arbeit. Dazu benutzt er ein reiches statistisches Material, das Studien von BOWLES und DOUGHERTY (Durchschnittsanalysen für 18 Länder bzw. für 28 USA-Staaten) entnommen und von ihm noch erweitert worden ist. Der Verfasser unterscheidet etwas systematischer zwischen Angebots- und Nachfragesubstitution, wie dies auch von ULLMAN gemäss einer schon seit 1933 bestehenden Tradition vorgeschlagen wird. Durch die Einführung eines weiteren Nachfrage- und eines weiteren Angebotsfaktors findet der Autor niedrigere Nachfrageelastizitäten (in der Umgebung von 1) als die zitierten Autoren.

RÉSUMÉ

L'auteur a reconsidéré les estimations de l'élasticité de substitution entre les personnes à formation universitaire et l'ensemble des autres travailleurs. Il utilise

le matériel statistique dû à M. M. BOWLES (comparant 18 pays) et DOUGHERTY (comparant 28 états des Etats-Unis), qu'il a complété avec d'autres données. L'auteur fait une distinction rigoureuse entre l'offre et la demande, comme l'ont fait également M. ULLMAN et d'autres selon la tradition économétrique depuis 1933. Comme suite de l'introduction d'un facteur spécifique de demande et d'un facteur d'offre à côté de la relation des salaires il aboutit à des valeurs plus modestes de l'élasticité de la demande, situées près de l'unité.