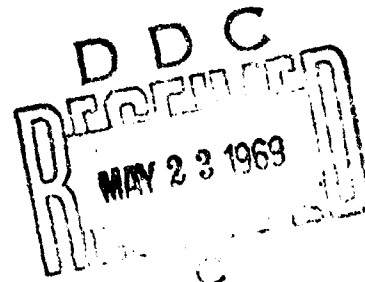THE DEMAND FOR MEDICAL EDUCATION --

A STUDY OF MEDICAL SCHOOL APPLICANT BEHAVIOR

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THE DEMAND FOR MEDICAL EDUCATION -

A STUDY OF MEDICAL SCHOOL APPLICANT BEHAVIOR

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Studies of physician manpower have centered around the question of physician shortages.[**] The authors have raised an important issue, but their analysis does not develop a useful basis for policy prescriptions. This research would be an aid to the policy-maker if estimates of the marginal social rate of return on medical education instead of private returns had been obtained. If this social rate were high relative to other investment opportunities, expanding medical school enrollments would, of course, be an attractive policy.

Although an estimate of this social rate would be relevant to the government decision-maker, it seems inadvisable to attempt to do so at this time. Social rates, derived from private rates of return by enlarging the cost stream to include education costs which are not borne by the student, may be very inaccurate.

[**] See Friedman and Kuznets [8], Hansen [10], and Rayack [13].

Because of consumer ignorance and externalities in the production
and consumption of medical services, physician income is a poor
measure of society's returns from medical education.[*]   Optimiza-
tion techniques may be used to obtain a more accurate approxima-
tion of the physician's shadow price. However, such a study would
necessarily be an analysis of the entire health delivery system
in which physicians are a factor of production. A considerable
amount of behavioral research on the economics of health delivery
should precede an undertaking of this size and complexity.

  If no technical basis for determining the optimal size of
the medical education system presently exists, it is probably
best to leave this matter to the government decision-maker and
medical school administrator who are responsive to political pres-
sures and have a greater familiarity with the institutional frame-
work. In the paper it is assumed that desired enrollment levels
will be ascertained by the public policy decision-maker and medi-
cal educator. The formulation, considered here, may be used by
the decision-maker in planning school enrollments, once he has
determined the desired enrollment level.

  In Section I, salient institutional features of the medical
education system are reviewed. The market for medical education
is placed in a supply and demand framework. In Section II, a
model of student demand for medical education is presented. Com-
ments on the form of the model and associated econometric problems
are found in Section III. Sections IV and V contain the empirical
results. A summary of results and a discussion of the policy
implications which follow from the analysis are found in Section VI.

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[*]See Sloan [17] for an elaboration of this point. Feldman
[6], and Rosenblatt and Suchman [14] provide evidence on the con-
sumer ignorance in this market. Buchanan and Karfolgis [4] and
Weisbrod [19] discuss types of externalities which are prevalent
in this market.

I.   INSTITUTIONAL ASPECTS

As Figure 1 indicates, there are two ports of entry into
the medical profession, the domestic and the foreign medical school.
Historically, the vast majority of practicing physicians have entered
by the former route.[*]   The following characteristics distinguish
this occupation from others which also require a sizeable human
capital investment. B, the number of applicants, greatly exceeds
C, the number of acceptances; B/C has varied about 1.9 over the
period 1926 to 1966, the years for which data are available.
Virtually all who are accepted, enter as freshmen. D-E, attrition,
and G, physician imports, have increased considerably since World
War II. In medicine, graduation from medical school is tantamount
to licensure.

The number of applicants to medical schools is the quantity
of medical education demanded in the demand model which is presented
below. The acceptance variable may be considered a measure of
the quantity of medical education supplied by domestic medical
schools. We exclude the supply side in this article. This does
not mean that demand is more interesting, but rather our emphasis
on demand is a reflection of the paucity of data on determinants
of supply.[**]

A prominant characteristic of the medical education market
is that excess demand for education is regarded as a situation
which all parties expect to persist. Since physician supply is
largely determined by the number of available "slots" in medical
schools, one may question why demand merits attention, aside from
the empirical evidence on occupational choice which the analysis
produces. Demand has policy relevance because medical schools

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[*]If immigration and licensure regulations were eased, a
considerable number of foreign physicians would probably immigrate
to the United States. - There is a substantial difference between
physicians' earnings in the United States and in other countries.
See Scitovsky [16].

[**]Supply is discussed elsewhere. See Sloan [17].

Figure 1

PROCESS OF ENTRY INTO MEDICINE

College Pool $\rightarrow$ Applicants $\rightarrow$ Acceptances $\rightarrow$ Entering Freshmen
A   B   C   D

Domestic $\leftarrow$ Licensures $\leftarrow$ Graduates $\leftarrow$
Additions   F   E
to
Medicine
G

$\downarrow$

Additions $\leftarrow$ Physician
to   Imports
Medicine   H
I
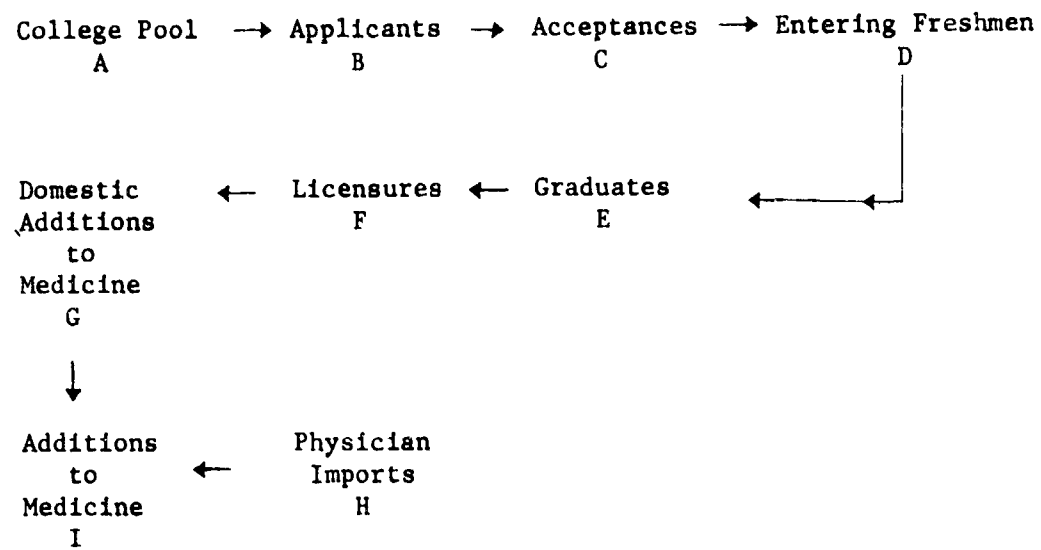
base plans for expansion in part on forecasts of the applicant
pool from which they select their students. Large numbers of appli-
cants allow them to select students who are likely to succeed in
medical school and subsequently in practice.

Medical school administrators want to be assured of ample
numbers of "qualified" applicants for two reasons. First, they
may be characterized as a quality-conscious group. There is a pre-
sumption that good college students are successful in medical school
and become good doctors. Considerable evidence supports the asso-
ciation of college with medical school success. However, the
nexus between performance in medical school and in medical practice,
although presumed to exist, has not been demonstrated.[*] Second,
low-quality students are likely to drop out of medical school.
Medical educators view keeping attrition rates at low levels as
a high priority policy.

The medical school largely depends on foundation and govern-
ment support rather than tuition as its primary sources of funds.
The institution must base its case to these groups on the basis
of high returns, relative to costs to society of investments in
medical education. Dropouts in effect represent total leakages
since non-graduates cannot practice medicine and with very few
exceptions, medical school training cannot be applied in other
occupational pursuits. If attrition rates are high, medical edu-
cators reason that capital will flow elsewhere.

In short, the government policy-maker may affect the size
of the medical education system through measures which increase
the number of applicants. Congress sensed this interrelationship
in recent legislation which provides incentives for medical and
other health manpower institutions to expand. In addition to grants
to these schools for the construction and improvement of existing
teaching facilities, the law includes low-interest rate loans to

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[*]Peterson, et al. [12] found that the better medical student
performs at a higher level for a few years after entering practice,
but this relationship disappears after a few years in practice.

medical students.[*] It is not clear that the demand route is the
most efficient method for increasing medical education production
levels. It is one of several policy alternatives. A prerequisite
for an evaluation of these is further research on the supply side.

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[*]These provisions are contained in PL 88-129 and PL 89-290.

II. DEMAND FOR MEDICAL EDUCATION - THE MODEL

Applicants - The Dependent Variable. The number of applicants
to medical schools in a given year represents the quantity of medi-
cal education demanded. The series includes both filled orders,
applicants who are accepted as well as unfilled, the refused appli-
cants. Cancelled orders, those students who decide against medi-
cine because of entry limitations, are not contained in this series,
but are considered below.* There is evidence that in high applicant
years, the number of "qualified" applicants is also high.

In addition to the total applicant variable, a series which
includes only "A" college record applicants is tested. There is
a close, negative relationship between the percentage of the fresh-
man medical school class which enters with an "A" college average
and the percentage of the class which fails to graduate in four
years. Given this information, it is interesting to test whether
these "A" students respond to the same stimuli as total applicants.
Are these students less likely to be influenced by earnings than
poorer college performers? Although applicants are not disaggre-
gated on the basis of college grades, entering medical school classes
are. If it is assumed that all "A" students are accepted and
attend, the entering class may be used as an applicant series.**

With two exceptions the explanatory variables represent
direct education costs, income in medicine, and opportunity costs

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*This series is to be distinguished from the number of
applications to medical schools which is also available. Applicants
are superior to applications for purposes of demand analysis because
the latter variable embodies the decision to enter medicine as well
as a strategy to gain admission to the educational institution
itself. This model is formulated to produce information about the
former issue. Students who are interested in gaining admission to
medical school now apply to more schools then once was the case.
The applicant and acceptance data are compiled by the American
Association of Medical Colleges. The series is published annually
in the Journal of Medical Education.

**The assumption appears to be a reasonable one. Almost

which are incomes in occupations which are important alternative
careers.

Male College Graduates. Some measure of the pool of potential
applicants is required as the number of student decision-makers
for whom choice of medicine is both marginal and non-marginal
varies over time. Even though male college graduates is an imper-
fect representation of the pool since the A.B. degree has not been
an admission prerequisite, it is the most suitable series available.
This series and variants, such as the male population of age twenty-
two, are utilized by medical educators to forecast applicants.[*]

Price. Price represents the direct cost of medical education. The
series is tuition and fees in the year the applicant, if accepted,
begins his professional education. Stipends awarded to medical
students are subtracted from the tuition and fees series.[**] A
proportion of the stipends, available to veterans under the G.I.
Bill of Rights, is also subtracted from tuition and fees. Prices
for classes entering 1929-1930 through 1957-1958 are medians.

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all accepted applicants enter as freshmen. In 1965, 96 per cent
of the students, who were accepted, attended. And only 13 per
cent o entering medical school freshmen had "A" college records.
In no year does the percentage of "A" students in entering medical
school classes exceed 40 per cent. It seems likely that virtually
rejected students had less than "A" college records.

[*] Including graduates separately as an independent variable
in estimation is preferable to specifying it as a deflator for
applicants. This latter procedure involves a multiplicative rela-
tionship between graduates and the independent variables. There
is no reason to introduce this complexity here.
Source: United States Department of Commerce, Historical Statistics
of the United States from Colonial Time to 1957, and Historical
Statistics Supplement; United States Department of Health, Education
and Welfare, Office of Education, Biennial Survey of Education
(for observations not covered by Historical Statistics and its
Supplement).

[**] Other components of costs, such as student expenses for
room and board, are not included since these would be incurred
irrespective of the occupation which the individual selects.

Thereafter, medians are no longer available, and means are con-
structed from medical college budget data. Judging from cases
where there are overlapping observations, the two segments of our
series appear to be comparable. Prices, deflated by the Consumer
Price Index (1957-1959 = 100), and quantities demanded are plotted
in Figure 2.[*]

      Clearly one major difficulty associated with an aggregate
price variable is that medical school prices are heterogeneous,
and the midpoint of these prices is selected. This deficiency
would render our tests meaningless if there were pronounced move-
ments in the distribution of medical school prices which were large-
ly concealed by the aggregate figure. One such deficiency would
exist, for example, if places in low-tuition, public institutions
grew at a faster rate than in the private, and tuition and fee
levels increased substantially in the latter. This is occurring
in the 1960's, and caution should be exercised in extending a
model which includes an aggregate price term as more post 1960
data become available.

      Price may be expected to have a substantial impact on the
quantity of medical education demanded for two reasons. First,
price affects expected net lifetime returns from medical educa-
tion directly through its impact on the potential applicant's
cost stream. Second, if, as is plausible, the cost of funds varies
directly with the size of investment outlay, many students are
expected to decide against a career in medicine when price is high.

Effective tuition in other fields is considered below.
See Ph.D. Stipends.

      With the exception of the G.I. Bill which has provided sub-
stantial funds to medical students, stipends to medical students
have been low. As recently as 1962, the mean scholarship was
$103. In the mid 1960's the mean has risen rapidly. The estimate
for 1966 is $191. Journal of the American Medical Association
(JAMA), Volume 186, Number 7, p.666 and Volume 202, Number 8, p.197.

Basic source of price data: Education volumes of JAMA.

      [*]All series in this study which are not expressed in physi-
cal units are deflated by the Consumer Price Index.

FIGURE 2
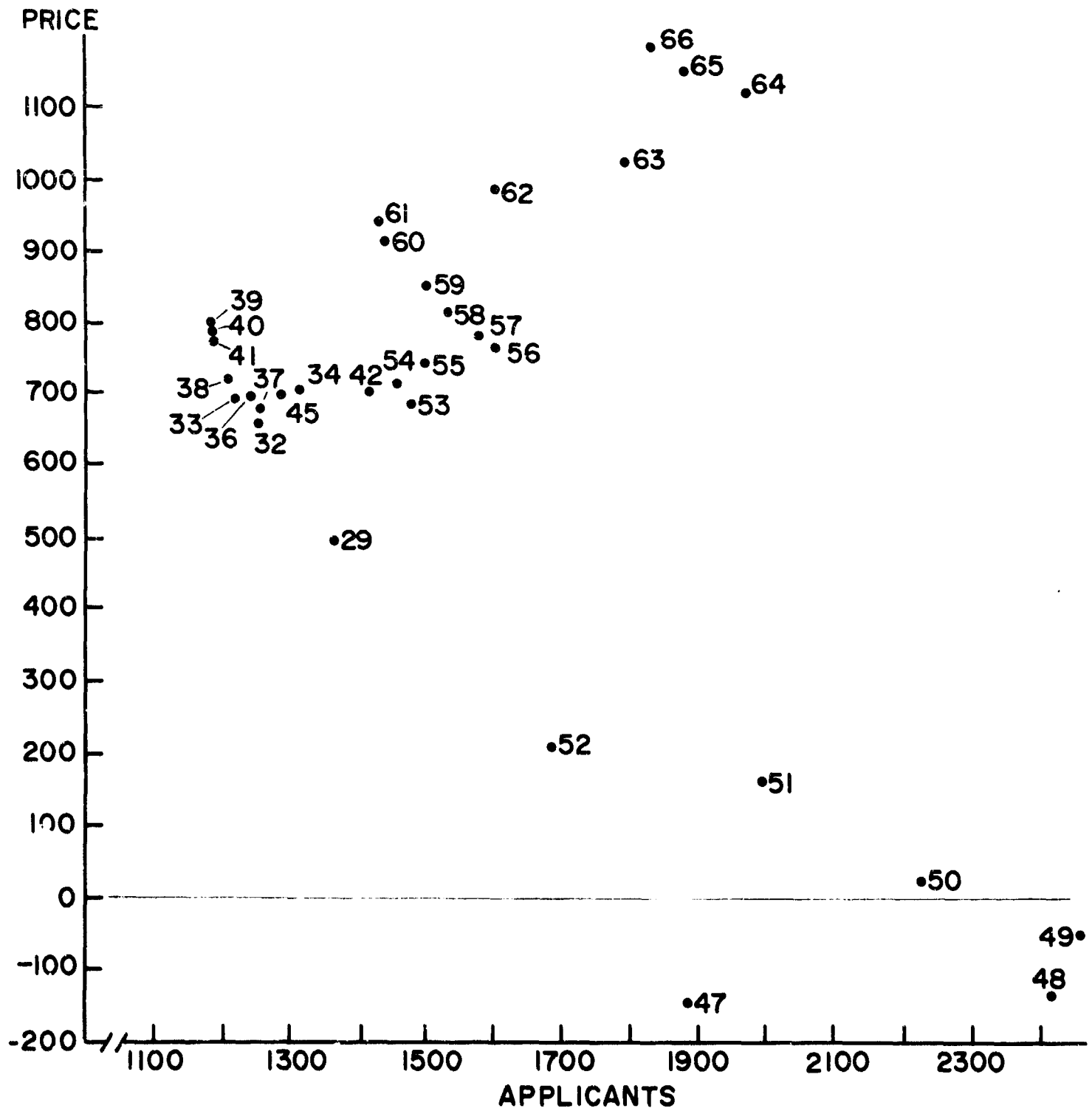
There is considerable evidence that capital markets for educational investments are very imperfect. Typically the student finances a portion of his education internally. Some also obtain funds from external sources, such as foundations or from banks. The supply of funds schedules which students face differ markedly among individuals. The shape and position of this schedule is largely dependent on family wealth which determines the amount which may be financed internally as well as student ability which is related to scholarship support. As supply of funds schedules are probably less than infinitely elastic throughout much of their range, a large number of students may favor small educational investments with low returns over larger ones with higher expected yields, even though the latter may be preferable on a private rate of return criterion.

Figure 3 depicts supply of funds schedules for three hypothetical individuals. As seen in this diagram, the schedule is likely to be discontinuous at points where a given source of funds is exhausted. The three ranges of a schedule such as S_2 may represent borrowing from internal funds, loans from medical societies and commercial banks, and "moonlighting", respectively. One would expect to observe substantial applicant-price elasticities around these discontinuities.[*]

Physician's Income in Independent Professional Practice. Although much has been said about the incentives of high incomes in medicine, there has been no research to determine the magnitude of the response to high earnings. In this model the impact of physician income on occupational choice is measured. The income information is derived from three sources. The method, used to derive the series, and problems of comparability are discussed in an appendix to

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[*] Price may be considered to be predetermined endogenous. Prospective medical students take tuition and fees as given. If a medical school administrator observes that a price increase has a pronounced effect on applicants, he may resist pressures to increase tuition in the future. In any case, medical school tuition decisions precede applications.

FIGURE 3

MARGINAL COST OF FUNDS, r

S₁ S₂ S₃

Price
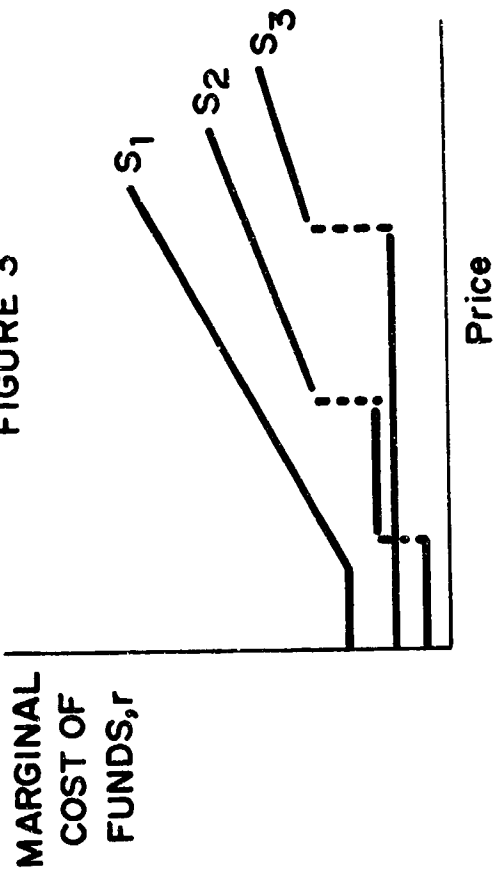
this paper.

Certain types of market information are diffused to interested decision-makers with a lag. Prospective applicants may be aware of physician income levels, but only those of some past period. In a recent survey which investigates, among other topics, labor market information, Freeman finds that students' perceptions of current physician and dentist income levels substantially understate the actual. Students seem to have a much greater awareness of recent earnings developments in all other occupations included in the survey.* Perhaps, income information is more poorly transmitted in non-salaried fields. Or physicians, high earners as a group, and supplying a good which society regards as a merit want, fear redistributive measures, were actual incomes widely known. Unlike other independent variables which enter concurrently with the student's senior college year, this income variable corresponds to his second semester freshman-first semester sophomore year.

The following group of explanatory variables represent returns in alternative occupations. The menu of alternatives to medicine is long, but degrees of freedom considerations place a constraint on the number of occupations which may be included. If the tastes of the student who considers a career in medicine can be identified, the number of alternatives may be narrowed considerably. Some empirical evidence of student career preferences is provided by a survey of graduates of twenty-eight medical schools On the basis of the survey, candidates for inclusion in the model are returns in scientific and engineering professions, law, business, and elementary and high school teaching.**

Foregone earnings are the major cost of a career choice. These opportunity costs might have been incorporated into a more

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*See Freeman [7].
**See Schumacher [15].

inclusive price variable if (1) there were a single major alter-
native to medicine and (2) if the student treated direct and oppor-
tunity costs identically, as economic theory would suggest. Avail-
able evidence suggests that a large portion of opportunity costs
are likely to be financed internally by foregone or postponed con-
sumption. Medical student consumption levels appear to be far
below those of college graduates who are not in graduate school.*

      The following variables are included.

Starting Salaries of Male College Graduates in General Business.
These salaries represent representative offers to college seniors
for positions to be assumed on graduation. The variable measures
disincentives to make further substantial formal investments in
human capital. As business income is specified to correspond to
the prospective student's freshman year in medical school, it can
only have the impact of discouraging students who have already
taken some pre-medical courses.**

Ph.D. Stipends. Stipends in fields leading to the Ph.D. degree
have been large, at least relative to medicine. Although no time
series data on scholarships are available, a longitudinal study
of Ph.D's in the sciences does list sources of financial support
for individuals who have received Ph.D's in selected years between
1935 and 1960 by the year in which they received their degrees.
As these data are published in percentages instead of absolute
amounts, the proportion of support, derived from sources other
than personal savings, husband, wife, father, mother, own earnings,
loans, and other as a measure of stipends available in other fields

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*Based on a comparison of medical student consumption infor-
mation in Altenderfer and West [3] and engineer's data in Dickey
[5].

**Source: Frank Endicott, Trends in Employment of College
and University Graduates in Business and Industry, published annu-
ally by Northwestern University.

is calculated.[*] The proportion of support, derived from these
sources, is subtracted from one. The resulting series is the
percentage of a student's personal expenses in Ph.D. fields not
covered by fellowships. The sign of the coefficient is expected
to be positive.

Median Incomes of Ph.D.'s in the Biological Sciences. Because
of similarities in the technologies of the two disciplines, one
expects to observe a high cross-elasticity of demand between gra-
duate education in biology and in medicine. Other scientific
fields might have been selected, but incomes in other scientific
professions move closely with biology, and therefore we would not
be able to derive reliable estimates for several occupations in
the sciences. The interpretation of our results may be affected
by this tendency of incomes in the sciences to move together.
Coefficient estimates incorporate the effects of a combination
of fields and thus overstate the influence of earnings in biology
on the quantity of medical education demanded.[**]

Supply-Created Demand for Medical Education. We stated above that
demand has an impact on supply. Clearly the interrelationship
need not be unidirectional. Changes in the number of students
accepted may cause shifts in the demand schedule. Shifts due to
a change in the structure of medical education may be distinguished
from those which may occur under the existing system.

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[*] The following fields are included: physiology, pharmacology,
biochemistry, microbiology, botany, genetics, zoology, miscellaneous
biology, medical sciences, agricultural sciences, psychology, soci-
ology, economics, political science, history, geography, mathe-
matics, physics, chemistry, geology, engineering, languages and
literature, arts, humanities, professions, education. Source:
National Academy of Sciences, National Research Council, Profiles
of the Ph.D.'s in the Sciences, Summary Report on Follow-Up of
Doctorate Cohorts, 1935-1960, Publication 1293, Washington, D.C.
1965.

[**]Biologist earnings data are published in bulletins of
the National Science Foundation.

There is scattered evidence in the medical education litera-
ture that many students exclude medicine because their credentials
indicate a near zero probability of acceptance, even if the excess
demand for medical education gap narrowed considerably. These
individuals might emerge as applicants if a number of medical
school administrators' tastes changed from preferring to produce
a Cadillac-type physician to a Volkswagen orientation, a policy
which placed a greater emphasis on physician manpower quantity,
probably at the cost of some quality, and if programs could be
devised to reduce mediocre student dropouts. Because medical
educators have, at least since the Flexner Report, which was pub-
lished in 1910, maintained a Cadillac-orientation, it is not possible
to test this proposition statistically.

One may, however, hypothesize that some students recognize
that the probability of acceptance is greater in some years than
in others. If it appears that the medical education system is
reducing acceptances, some individuals may not apply and take
courses which are relevant for other careers. And if there has
been an expansion of enrollments, these students may become appli-
cants. A comparison of turning points in the applicant and accep-
tance series suggests that supply shifts in t-1, measured by the
number of students which medical schools accept, produce demand
shifts in the same direction in t. Acceptance turning points,
with the exception of the immediate post World War II period,
when other factors dominated, always precede those in the applicant
series by a year. Because lagged acceptances enters the model with
an unexpected negative sign and is insignificant when the years
1947-1952 are included, the variable has been omitted in the final
specification of the model. Although current evidence of the impact
of supply is not strong, the relationships merit further investi-
gation. Studies in the medical education literature, historical
accounts of the medical education market in the 1930's, the turning
points, and research on labor force participation which suggests
a similar mechanism for the labor force as a whole are clues that
the factor is operative. Once sufficient data to estimate a supply

of medical education function are available, it will be possible
to move from a single equation to a recursive description of this
market which incorporates the supply-demand interactions.

III. THE FORM OF THE DEMAND MODEL

Variants of the model in both static and dynamic form are presented
in the following section. In the latter formulation it is assumed
that an equilibrium level of demand is associated with values of
the explanatory variables.

$$\text{Applicants}_t^e = a + b \text{ Graduates}_t + \text{Price}_t \ldots + u_t \quad (1)$$

One major reason for differences between actual and equili-
brium demand is   that   student programs are not easily changed
in many cases. For some individuals course of study changes would
be relatively minor. They might, for example, attend summer school
to take the chemistry course required for admission to medical
school. Other students would require major curriculum adjustments.

It is assumed that a fixed proportion of the discrepancy
between actual and equilibrium demand is made up in each year.

$$\text{Applicants}_t - \text{Applicants}_{t-1} = \quad (2)$$

$$k(\text{Applicants}^e - \text{Applicants}_{t-1})$$

Substituting (1) into (2) one obtains

$$\text{Applicants}_t = (1-k)\text{Applicants}_{t-1} + \quad (3)$$

$$k(b \text{ Graduates}_t + c \text{ Price}_t \ldots) + ka + ku_t$$

It is well-known that ordinary least squares yields incon-
sistent parameter estimates in situations where a lagged dependent
variable is combined with an autocorrelated error term. Further-
more, the Durbin-Watson statistic is biased toward two, leading
the unsuspecting analyst to the false conclusion, in many cases,
that no serial correlation in the disturbance term exists.[*]

A method for deriving consistent parameter estimates, sug-
gested by Wallis, has been applied to a few variants of the model.[**]

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[*] See Griliches [9] and Nerlove and Wallis [11].
[**] See Wallis [18].

The procedure has not been applied generally in this study, and
the results, using the Wallis procedure, are not reported and
discussed here to conserve space. We have relied on ordinary
least squares for two reasons. First, an emphasis on consistency
seems misplaced in situations where there are fewer than twenty
degrees of freedom. Second, in virtually all cases tried, the
estimates of the parameter of the autoregressive scheme were not
significantly different from zero.

Other sources of lags are also relevant. Lags, due to imper-
fect information, have been considered above. Expectation formation
is also a factor. A widely-used formulation of the latter is an
adaptive expectations model which may also be reduced for purposes
of estimation to a structure with a lagged dependent variable.
Implicit in our basic model is the assumption that the decision-
maker expects the incentives to enter medicine to be the same in
period $t + n$ as it is in period t. Preliminary experiments showed
the results could be improved by adding the growth rate of biolo-
gist's income as an independent variable. It is plausible that
student decision-makers place some emphasis on rates of change
in income as well as levels in deriving earnings forecasts.

IV.   EMPIRICAL RESULTS - TOTAL APPLICANTS

Two features of the results which are contained in Tables
1 and 2 merit attention. First, the model accounts for most of
the variation in medical education demand in the historical period.
The variants of a basic model described above, may be used by the
health manpower decision-maker to predict the quantity of medical
education demanded in future years, given information on tuition
and fees, scholarships in medicine and in alternative fields, the
number of college graduates, and incomes in selected occupations.
Second, our results indicate which policy instruments are the
most effective means for inducing larger number of students to apply
to medical school.

Predictive Ability

One major criterion for model evaluation is predictive power.
R^2, corrected for degrees of freedom, is one indicator, but it
is usually high in a time series context. A useful supplement
especially if the series contains a strong non-trend element, is
a plot of actual and estimated values of the dependent variable.
Figures 5 and 6 demonstrate the models' ability to anticipate move-
ments in the medical school applicant series. The plots and Durbin-
Watson statist s indicate that autocorrelation is not serious in
the majority of cases.[*]

Parameter Estimates

Parameter estimates of the total applicant formulation are
found in Tables 1 and 2. These structural estimates are evaluated
in this section, and policies which might be instituted to affect
the quantity of medical education demanded are suggested. Several
variants are presented as multicollinearity is pronounced, and
thus an important aspect of the results is the sensitivity of the

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[*] Durbin-Watson statistics are not presented when two time
periods are used to obtain the parameter estimates.

TABLE 1

Dependent Variable - Applicants Planning to Enter in Year t*.

Variant	Constant	Graduates t (thousands)	Price t	Physician Income t-3	Ph.D. Stipends t-1	Base Business Income t	Applicants t-1	
Period - 1936-1942, 1948-1966								
I	13645.83	31.81^b 8.28	-5.99^b -6.45					$R^2 = 0.81$ $R^2(C) = 0.78$
II	6763.49	13.10 1.18	-2.69 -1.31				0.53 1.79	$R^2 = 0.83$ $R^2(C) = 0.80$
Period - 1936-1942, 1948-1961								
III	17102.15	20.33^b 4.89	-8.82^b -9.48					$R^2 = 0.91$ $R^2(C) = 0.89$
IV	3937.91	12.74 1.39	-10.55^b -12.98	0.43^b 3.74	228.97 1.40			$R^2 = 0.95$ $R^2(C) = 0.94$
V	-2639.02	2.11 0.14	-8.48^b -3.34	0.49^b 3.57	265.21 1.56		0.31 0.86	$R^2 = 0.96$ $R^2(C) = 0.94$

TABLE 1 (cont'd.)

Variant	Constant	Graduates t	Price t	Physician Income t-3	Ph.D. Stipends t-1	Base Business Income t	Applicants t-1	
Period – 1948-1961								
VI	14310.65	5.89 0.79	-10.63[b] - 9.96	0.44[a] 2.53				$R^2 = 0.93$ $R^2(C) = 0.90$ D.W. = 1.70
VII	-42871.20	27.38 1.05	- 7.74[a] - 2.75	0.42 1.89	1143.27[a] 2.27		0.36 0.82	$R^2 = 0.97$ $R^2(C) = 0.94$ D.W. = 1.88
VIII	-42575.06	44.58[a] 2.97	- 9.92[b] -11.49	0.29 2.00	1288.29[a] 2.79			$R^2 = 0.96$ $R^2(C) = 0.94$ D.W. = 2.10
IX	-46488.16	48.96[a] 2.50	- 8.96[b] - 3.33	0.36 1.49	1393.52[a] 2.49	-0.70 -0.38		$R^2 = 0.96$ $R^2(C) = 0.94$ D.W. = 1.94

*The numbers below the coefficients are t-values. $R^2(C)$ is R^2, corrected for degrees of freedom. D.W. is the Durbin-Watson statistic.

[a]Significant at the 5 per cent level using a two-tail test.
[b]Significant at the 1 per cent level using a two-tail test.

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TABLE 2

Period – 1948-1965   Dependent Variable – Applicants Planning to Enter in Year t.

Variant	Constant	Graduates t	Price t	Physician Income t-3	Base Business Income t	Growth Biologist Income t-1	Level Biologist Income t-1	Applicants t-1	
I	6187.01	20.32[a] / 2.35	-10.22[b] / -7.18	0.73[b] / 3.60					$R^2 = 0.83$; $R^2(C) = 0.78$; D.W. = 0.81
II	6578.85	28.52[b] / 3.40	-12.41[b] / -7.87	0.82[b] / 4.52		-79.55[a] / -2.27			$R^2 = 0.88$; $R^2(C) = 0.83$; D.W. = 1.35
III	11019.24	35.49[b] / 3.70	-8.97[b] / -3.05	1.18[b] / 3.76	-3.14 / -1.37	-104.38[a] / -2.72			$R^2 = 0.88$; $R^2(C) = 0.83$; D.W. = 1.46
IV	5845.66	21.81 / 1.69	-13.98[b] / -5.04	0.67[a] / 2.34		-82.59[a] / -2.30	0.75 / 0.70		$R^2 = 0.88$; $R^2(C) = 0.83$; D.W. = 1.57
V	10314.36	31.67 / 2.07	-10.00[a] / -2.27	1.08[a] / 2.39	-2.26 / -1.16	-103.92[a] / -2.60	0.37 / 0.33		$R^2 = 0.90$; $R^2(C) = 0.83$; D.W. = 1.50
VI	-1030.57	-5.86 / -0.41	-2.61 / -0.73	1.33[b] / 4.28	-2.54 / -1.51	-68.67[a] / -2.42	-0.48 / -0.62	0.89[b] / 3.80	$R^2 = 0.96$; $R^2(C) = 0.92$; D.W. = 1.98

FIGURE 4

APPLICANTS

FIGURE 5

APPLICANTS

24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000

— ACTUAL
--- VARIANT I, P. 23
— VARIANT Ⅳ, P. 23
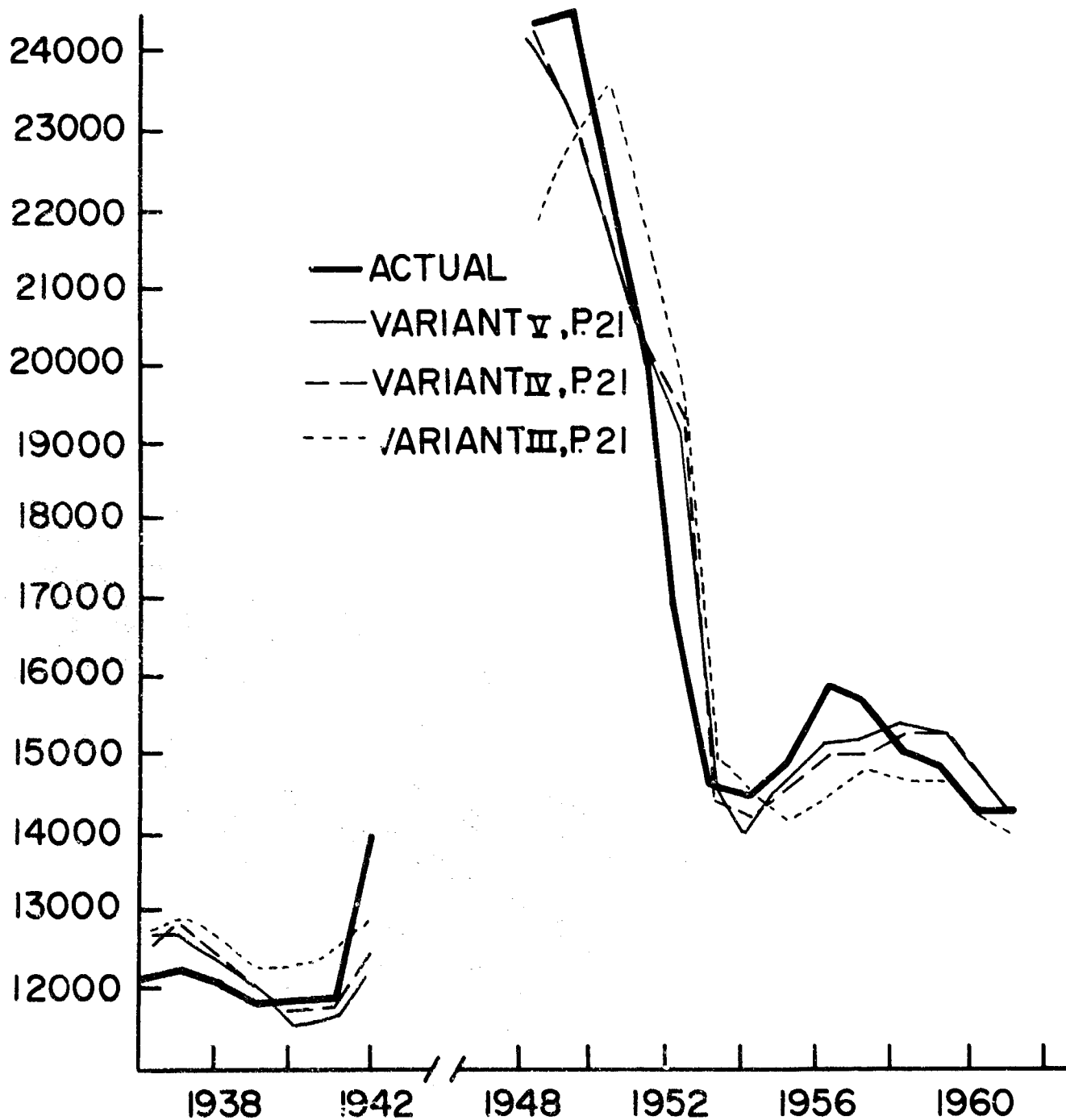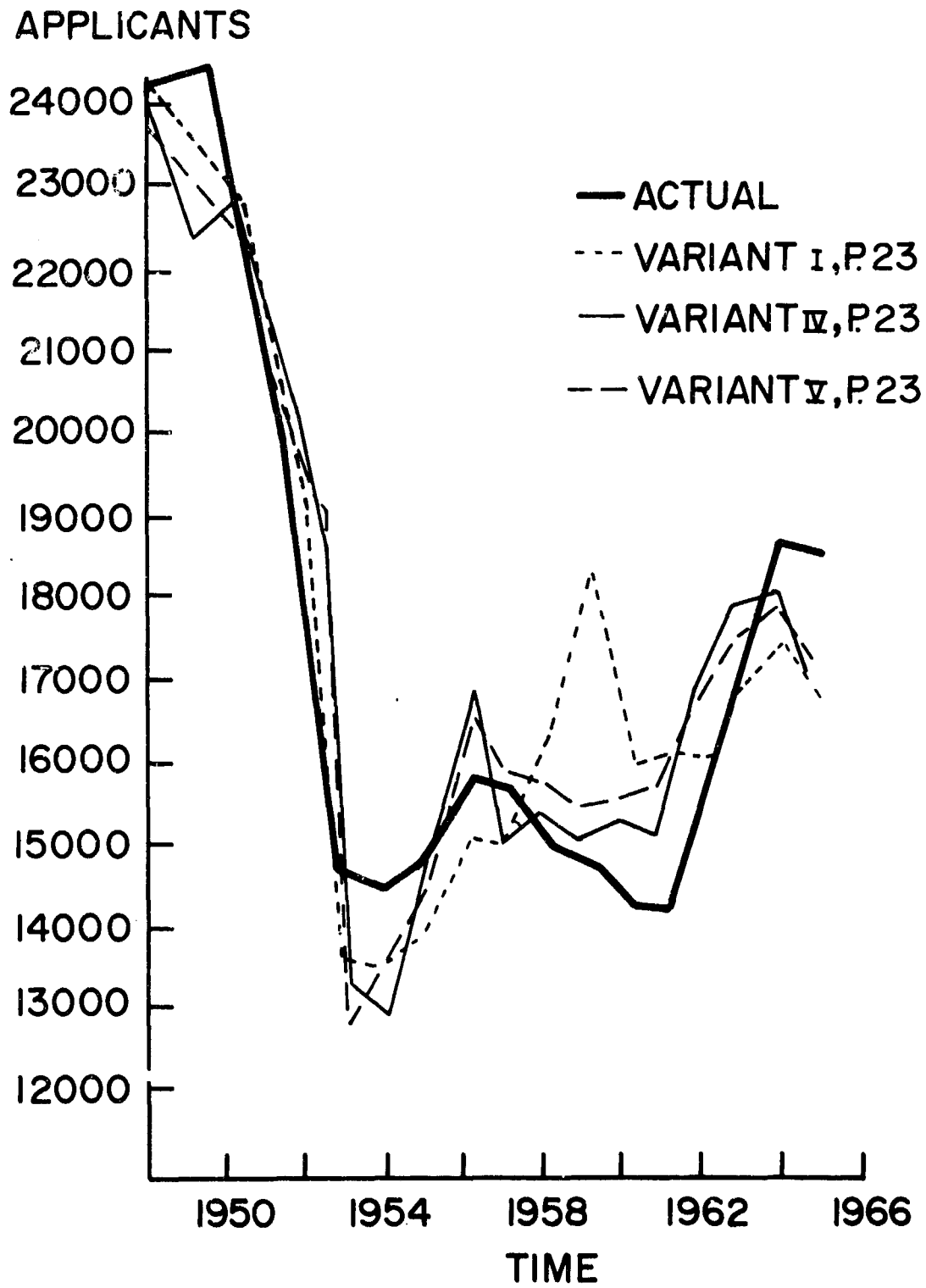-- VARIANT Ⅴ, P. 23

1950   1954   1958   1962   1966

TIME

estimates under alternative modes of specification. Data limi-
tations force us to derive parameter estimates from different time
spans.

Male college graduates is essentially the type of variable
which medical school administrators use to predict the number of
applicants. In isolation it is a poor predictor. For the period
1948-1965, the simple correlation of graduates and applicants is
0.32. With price and physician income included, the partial corre-
lation coefficient is 0.53 (Variant I, Table 2). When business
and biologist income variables are added to these (Variant V,
Table 2), the partial correlation is also 0.53. Graduates does
account for the trend in medical education demand, but fails to
explain the high level of demand in the late 1940's and the early
1950's as well as the peaks and troughs in the series since 1954.
Referring to the parameter estimates which are significant at the
5   per cent level or better, it appears that from 20 to 50 appli-
cants to medical schools are generated from 1,000 male college
graduates.

The results indicate that price, the direct costs of medical
education, have a pronounced impact on the quantity of education
demanded. The variable is significant at the 5 per cent level
or better in all but two variants. The significant coefficients
indicate that each dollar reduction in price may be expected on
the average to generate from six to fourteen applicants.

Reasons for a substantial applicant response to price have
been suggested above. Not only does price affect the net expected
earnings to be derived from an investment in a medical education,
but it also may determine whether or not the student must seek
external funds in an environment where capital rationing is wide-
spread. The parameter estimate of price undoubtedly incorporates
both factors. A combination of scholarships and low interst-rate
loans are thus potentially effective policy instruments to stimulate
applicant activity.

In the vast majority of cases, lagged physician income is

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significant, at least at the 5 per cent level. As all variables,
expressable in monetary units, physician income is in terms of
constant (1957-1959 = 100) dollar per annum terms. The significant
coefficient estimates indicate that   per dollar increase in
physician income, approximately 0.4 to 1.3 individuals are attracted
to medicine. It is not surprising that physician income has a
much smaller impact on medical education than price. Both affect
net earnings. But the capital rationing consideration does not
apply to income. And also changes in earnings which accrue toward
the middle of the physician's career may be expected to have a
small impact on student occupational decisions at almost any posi-
tive discount rate.*

Government subsidies to practicing physicians is the policy
instrument associated with the physician income variable. Such
a scheme will not be attractive to the government decision-maker
for two reasons. First, subsidization of the rich may well violate
distributional constraints. Second, the policy would be much
more costly than a scholarship-loan program. The physician income
are about one-tenth the size of the price parameters. Scholarships
are for four years. The subsidies would have to cover the years
in which the physician is active. The precise cost of an income
payment program depends on whether it is possible to discriminate
between physicians whose behavior may be potentially changed by the
subsidy, and those whose behavior would not. That is, would those
who applied after the program was instituted or would all physicians
receive the subsidies? In either case, the scholarship-loan program
dominates a subsidy scheme.

Stipends in the Ph.D.'s are significant in three of the

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*We have attempted to fit an inverted U shape distributed
lag in physician income to the data by a polynomial interpolation
technique. Instead of the desired inverted U shape, "saucer-shaped"
and "saw-tooth" weight structures have been derived. It is likely
that the poor results reflect inaccurate measurements of physician
income in some years. On the polynomial interpolation technique,
see Almon [1] and [2].

five variants reported in Table 1. Although it appears that scholar-
ships in other fields do have an impact on medical school appli-
cants, the magnitude of the effect may be overstated. The estimates
suggest that a 1 per cent reduction in the amount of a Ph.D. stu-
dent's educational expenses which are not covered by fellowships
would lower the number of applicants to medical schools by over
a 1000. If the annual educational expenses in a Ph.D. program
are $4000, the parameter estimates imply that $40 (or slightly
more) would produce a 1000+ applicant reduction.[*] The largest
price coefficient estimate (-13.98) implies an applicant response
which is about one-half as large.

None of the base business income coefficient estimates are
significant. However in all but one case, they do exceed their
standard errors.[**] The parameter estimates are larger than those
for physician income, but are smaller than the price coefficients.
This behavior is expected as the returns from base business earnings
accrue earlier than those which are considered in the physician
income series. The coefficients are smaller than the price para-
meters because as suggested above, earnings foregone may have a
smaller impact on career decisions than direct costs, and busi-
ness may not be a popular career alternative to medicine for the
type of person who is likely to become a medical school applicant.
Most of the relevant career alternatives to medicine probably require
some formal education at the graduate level.

As seen in Table 2, the biologist income growth variable is
significant in all variants. The corresponding level variable is
not. These results may indicate that over the historical period,
expectations of large gains in income in biology and related scien-
tific fields, such as chemistry, mathematics, and physics, diverted
large numbers of students from a career in medicine. Student fore-

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[*] The amount exceeds $40 if a portion of this fellowship
increase is spent and annual expenses thus exceed $4000.

[**] And thus add to the corrected R^2.

casts were based on recent growth of earnings in these fields.

Figure 5 reveals a substantial improvement in the models' predictive ability with the inclusion of this earnings series, especially in the years, 1957-1962, when applicants declined. After Sputnik, Federal support of the sciences rose markedly. Government grants had a substantial impact on stipends to students in scientific fields as well as on incomes in these occupations. The rate of increase in scientists' earnings has fallen in recent years. At the same time, there have been a larger number of applicants to medical schools.

The biologist earning coefficients indicate that it is important to consider an inward shift in the demand for medical education schedule as one cost of public support of basic and applied science. If biologist earnings were increased 10 per cent from the 1966 level of $12,00C, the coefficients of Variant V, Table 2 would predict a decrease of 1002 applicants to medical schools.

Table 3 summarizes estimates of the time path of the applicant response. Three variants indicate that a major portion of the impact of changes in the explanator variables occurs in the first year. The fourth entry shows a much slower response, but is derived from a variant which contains a sizable amount of multicollinearity and unreasonable parameter estimates for other variables in the model. Evidence on the time path is inconclusive.

TABLE 3

The Time Path of the Response

Table	Variant	1-k	Per Cent Disequilibrium Gap Closed After	
			One Year	Three Years
1	III	0.53	47	85
1	VI	0.31	69	97
1	IX	0.36	64	95
2	VI	0.89	11	30

V.   EMPIRICAL RESULTS - "A" COLLEGE RECORD APPLICANTS

Table 4 and Figure 6 contain empirical results of equations
with applicants with "A" college records as the dependent variable.
As Figure 6 demonstrates, there has been a secular decline in the
number of students with "A" college records entering freshman
medical school classes. As mentioned above, it is assumed in this
study that the number entering is a close approximation to the
number who apply. Our inability to measure "A" applicants directly
may account for the somewhat poorer results in regressions with
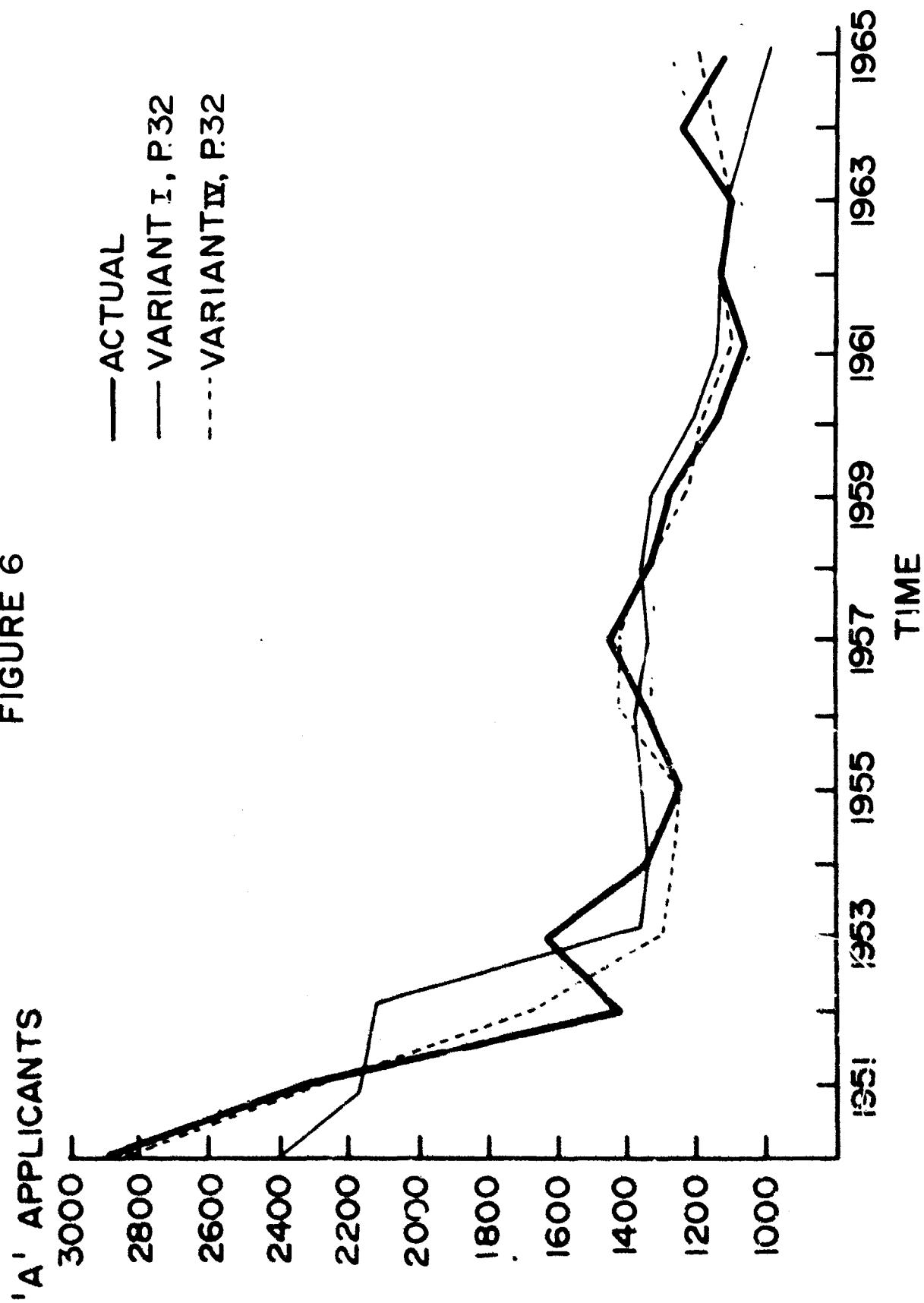this series as the dependent variable.

Both Variants 1 and 4, plotted in Figure 6, approximate the
general movement of the series. The latter is more successful in
predicting the peaks and troughs of the "A" applicant series.
Variant 4's Durbin-Watson statistic, 2.65, indicates some negative
autocorrelation is present. The plot of actual and estimated
values in Figure 6 shows however, that the Durbin-Watson statistic
is high because of a substantial overprediction and underprediction
in 1952 and 1953 respectively.

Several differences between the total and the "A" applicant
results are apparent. In the latter, the graduates variable is sig-
nificant at the 1 per cent level in all cases. Approximately 9 "A"
applicants are generated per 1000 male college graduates. In contrast
to total applicants, price and physician income have no discernable
impact on career decisions of students with superior academic records.
Although the price coefficient is significant at the one per cent
level when price and physician income are the only explanatory
variables (Variant 1, Table 4), it is only a fraction of its stan-
dard error when business income and the growth in biologist earnings
variables are included. Poor performance of the price variable
may reflect data deficiencies. It is likely that the results would
have been more satisfactory if immediate post-World War II obser-
vations had been included. As seen above, effective tuition and
fees were low during these years. Furthermore, the price series

TABLE 4

Period - 1950-1965   Dependent Variable - "A" College Record Applicants Planning to Enter in Year t.

Variant	Constant	Graduates t	Price t	Physician Income t-3	Base Business Income t	Growth Biologist Income t-1	Level Biologist Income t-1	
I	1816.91		-1.64^b	0.05				$R^2 = 0.72$
			-3.50	0.95				$R^2(C) = 0.66$
								D.W. = 2.02
II	2584.82	8.76^b	0.02	-0.12	-0.02	-6.87		$R^2 = 0.90$
		4.11	0.27	-1.48	-0.62	-1.19		$R^2(C) = 0.84$
								D.W. = 1.60
III	2428.02	9.51^b			-0.16	-6.52	-0.28^b	$R^2 = 0.94$
		8.08			-1.10	-1.68	-3.64	$R^2(C) = 0.92$
								D.W. = 2.63
IV	2389.46	9.56^b		-0.02	-0.10	-6.16	-0.27^a	$R^2 = 0.94$
		7.69		-0.29	-0.43	-1.45	-2.88	$R^2(C) = 0.91$
								D.W. = 2.65

FIGURE 6

'A' APPLICANTS

ACTUAL
VARIANT I, P.32
VARIANT IV, P.32

TIME

may be an inappropriate one for an "A" applicant formulation.
Direct costs to "A" students may be lower than to others who per-
formed less well in college as scholarships are available to the
outstanding students. Physician income is not significantly differ-
ent from zero in any of the variants. This variable is not subject
to the two information deficiencies which pertain to price. As
was the case with total applicants, the base business income vari-
able is not significant in any of the variants. However, three
out of four coefficient estimates exceeded their standard errors.
In Table 4 only one coefficient is larger (Variant III).

Also unlike   total applicants, the level of biologist
income is significant, but the growth rate is not. The opposite
result was reported above. Students with superior records seem
to be more responsive to biologist income than students in general.
As stated above, a 10 per cent rise in biologist income from its
1966 level of $12,000 would be expected to produce a 1902 reduction
in medical school applicants. Such an increase would result,
on the basis of the biologist earnings coefficients of Variant IV,
Table 4, in a decrease of 330 "A" applicants. Thus, a large per-
centage of the individuals who would decide against medicine would
be college students with excellent college records.

These results are consistent with the view that income is
less important to the "A" student then to other potential appli-
cants. The former are not responsive to physician income. And
they seem to be more attentive to levels than to rates of change
in earnings in a scientific occupation. Levels may be more impor-
tant to "A" quality candidates for admission than rates of change
in biologist earnings because income enters their career decisions
as a constraint on their behavior. These students are more concerned
about their chances of earning a "reasonable" living in a scien-
tific field. Once earnings in an occupation reach a critical
minimum, other attributes of the occupation become relevant.

VI. CONCLUSIONS AND GENERAL POLICY IMPLICATIONS

A primary purpose of this study has been to provide the
government planners with policy instruments which may be used to
affect production levels of the medical education system. It
has been suggested that one possible way to stimulate medical school
expansion is through policies which act on demand for medical edu-
cation. Two series, total applicants and applicants to medical
schools with superior college records, have been analyzed. The
results indicate that potential medical students are responsive
to differences in expected returns which exist among various occu-
pations. "A" record students are in general less influenced by
earnings. The policy recommendations which follow from the results
are therefore directed to the former group of which the grade "A"
college student is only a very small part.[*] The results indicate
that direct medical education costs have a substantial impact on
occupational choice. Substantial increases in tuition and fees
have decreased student interest in medicine. Furthermore, a com-
bination of high direct costs and very imperfect capital markets
may be expected to serve as a barrier to students who cannot finance
their education internally. Stipends in Ph.D. fields have drawn
potential medical students into these occupations. Clearly, govern-
ment scholarship and loan policies should be reappraised. Earnings
in other occupations do divert some students from medicine. Starting
salaries in business, although never significant at the 5 per cent
level, probably also serve as a disincentive. Biologist income,
a measure of earnings in scientific fields, exerts a sizable influ-
ence on occupational choice. As the government has some control
over earnings in scientific fields through its expenditure policy,
it should reexamine its manpower objectives. Physician income also
has an impact on career decisions. Although it does not appear

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[*]One may surmise that less than 10 per cent of all applicants
in recent years have had "A" records.

that direct payments to physicians are feasible, the public sector may stimulate demand for medical education indirectly by implementing policies, such as health insurance schemes, which have an effect on physician earnings. Finally, although our tests have not yielded evidence in support of this view, it is plausible that supply of medical education has a positive impact on demand.

APPENDIX

Income information is derived from three sources: mean physician income from independent professional practice, 1929-1951, published by the Office of Business Economics of the Department of Commerce (OBE); medians from Medical Economics (ME) for selected years in the 1950's and 1960's; and means from Internal Revenue Services (IRS), published in a recent Organization for Economic Cooperation and Development (OECD) publication. Since the Medical Economics medians exclude physicians aged 65 and over, they are closer to mean than to median OBE data which are also available, but are not used in this study. Even after splicing, we lack income information for 1952-1954, 1957, 1960-61. (See Column 1 of Table A.)

Basically, two approaches are available. One could simply fill in the missing observations by interpolating. Or an instrumental variable could be found, and the values predicted by the instrument, used to derive a consistent series. Largely because the 1955-1956 increase in the interpolated series, column 2 of Table A, seems unreasonable, essentially the latter approach is adopted. The solution is a compromise since estimates from the instrument are included only for years 1952-1961. If estimates for all years were substituted for the original values, information would be lost unnecessarily. Personnel per capita income is the instrument.

TABLE A

DIFFERENCES IN AN INTERPOLATED AND AN

ESTIMATED PHYSICIAN INCOME SERIES (POST WORLD WAR II PERIOD)

	Source (1)	Interpolated (2)	Estimated (3)
1946	OBE	15003	15003
1947	OBE	13787	13787
1948	OBE	13517	13517
1949	OBE	14149	14149
1950	OBE	14702	14702
1951	OBE	14840	14840
1952	missing	15422	16405
1953	missing	16004	17416
1954	missing	16586	17163
1955	ME	17167	18870
1956	IRS-OECD	20253	19797
1957	missing	20839	19902
1958	IRS-OECD	21480	19624
1959	ME	21773	20682
1960	missing	21950	21922
1961	missing	22127	22487
1962	ME	22305	22305
1963	ME	23610	23610
1964	ME	26253	26253
1965	ME	26351	26351
1966	ME	28444	28444

Sources: Office of Business Economics - United States Department of Commerce, Survey of Current Business, August 1949, January 1950, and July 1951.

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