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Use of a Help-Wanted Index to Assess Marketplace Demand for Ophthalmologists

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USE OF A HELP-WANTED INDEX TO ASSESS MARKETPLACE DEMAND FOR OPHTHALMOLOGISTS

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Objective:

To develop a help-wanted index (HWI) to measure trends in marketplace demand for ophthalmologists, then to identify the economic drivers of these trends and the responsiveness of the ophthalmology community to marketplace demand.

Methods:

Retrospective review of physician recruitment advertisements appearing in the following journals: *Ophthalmology, American Journal of Ophthalmology and Archives of Ophthalmology* from January 1980 through June 2006.

Abstract:

Over the 26 year study period a consistent increase in the demand for academic ophthalmologists was noted (34% of HWI in 1980 to 74% in 2005). There was also a consistent increase in the demand for specialists (31% of HWI in 1980 to 80% in 2005), especially demand for retina specialists. There were no consistent geographical trends in demand. Need for academic ophthalmologists seems to be correlated with national research expenditure and stock market gains ($p = 0.00191$), while demand for private practice ophthalmologists seems to be correlated with the national economic wellbeing, as measured by Gross Domestic Product (GDP) ($p<0.001$). Further analysis indicated that training programs ($p = 0.0456$), residency applicants ($p = 0.0128$) and fellowship applicants ($p = 0.0198$) respond to marketplace demand. Furthermore salaries of academic ophthalmologists ($p = 0.0226$), and retina specialists ($p = 0.0418$) are statistically influenced by marketplace demand.

Conclusions:

Long run trends in the HWI data suggest a chronic scarcity of academic ophthalmologists, and the emergence of need for a more specialized workforce, which may lead to increased competition for fellowship positions. This study suggests that the ophthalmology community is quick to respond to marketplace demand. Since HWIs are useful tools for assessing the marketplace need for ophthalmologists, an ongoing HWI will provide timely information about the demand for physicians in a rapidly changing health care system.

Introduction

In order to develop reasonable strategies for optimizing the level of employment, policy makers should have good knowledge about both the supply for labor, i.e. the number of available workers, and the demand for labor, i.e. the number of unfilled jobs.[1] In medical specialties, labor supply information has been obtained by assessing the current number of practitioners, usually via surveys of the membership of the specialty's professional and board certification organizations,[2,3] supplemented by the specialty's rates of entry and exit. Rates of entry are usually estimated by analysis of the number of trainees.[4-6] Rates of exit are mainly estimated by analysis of the rates of death and retirement from the specialty,[5,7] and to a lesser extent by measures of the rates at which residents leave training programs unfinished and frustrated job-seekers (usually new trainees) switch to other specialties or engage in further training to weather storms in the marketplace.[8,9,10,11,12]

Theoretically, unsatisfied demand for labor is equivalent to the aggregate number of unfilled jobs.[1] The practical difficulty of collecting job vacancy data is attested to by the many starts and stops in the collection of national job vacancy data in the United States. During the Second World War, and then later during the U.S.-Korean War, job vacancy data was collected to identify and alleviate labor shortages during the war efforts; however, data collection only lasted for the duration of the respective conflicts. Spurred by the 1962 President's Committee to Appraise Employment and Unemployment Statistics, which declared that "It is doubtful that any suggestion for the improvement of knowledge about the Nation's labor markets was more frequently voiced to this Committee than that calling for job vacancy statistics", the Bureau of Labor Statistics

began collecting job vacancy data via the Job Opening-Labor Turnover Survey (JOLTS) and published them in the Labor Turnover Survey in April 1969. However, in 1973, the job vacancy data collection was cancelled due to concerns about the quality and usefulness of the data. Following at least two failed intervening pilot, job vacancy data collecting programs, JOLTS was reborn in 1999, but validated and reliable monthly data has only been available since April 2004.[13-16] Generally, useful job vacancy information is difficult to obtain. In medical fields, this difficulty is likely to be compounded, especially in fields with smaller group sizes and high geographical dispersion. Because of greater accessibility, the academic segment of a medical specialty may be more amenable to estimates of its job vacancy rate. C. D. Maynard of the Wake Forest University School of Medicine calculated an average annual job vacancy from annual surveys of the heads of academic radiology departments that belonged to the Society of Chairmen of Academic Radiology Departments.[17,18]

Historically, economists have used Help-Wanted Index (HWI) data as a proxy for unavailable job vacancy data. A Help-Wanted Index (HWI), which is a compilation of the volume of advertisements for workers assessed over a specific time period, is an indirect measure of job vacancy rates.[19] HWIs have generally measured either the area of space dedicated to advertisements, e.g. the inches of advertisement columns, or the number of positions that is advertised. The earliest recorded HWI was compiled in 1893 by British Board of Trade's Labor, as part of an attempt to characterize and address the unemployment problem during the Depression of 1893. According to the Board of Trade, during 1893, Britain was the only European country in which newspaper-based job advertising was so prevalent that an analysis of unemployment necessitated an analysis of

newspapers.[20] By 1909, British economist, W.H. Beveridge extended the Board of Trade's work by noting the economic sectors that used newspaper advertising. Furthermore, Beveridge stated that newspaper advertising was "a last resource for finding work or workpeople in all occupations".[21]

Just as the Depression of 1893 had generated interest in studying employment in England, the Great Depression generated interest in the study of factors that affected unemployment in the United States. During this period, Anne Bezanson, a Wharton School of Finance professor, noted that HWIs had been used by entities such as trade associations, public utilities, and large-scale enterprises as a "general indicator of the employment situation in the market." A HWI had even been used to "obtain continuous indication of the probable future expansion" of Philadelphia. Bezanson developed the Philadelphia Index, a Philadelphia-based HWI which disaggregated advertisements by industry, enabling Bezanson to "trace the changes in demand for various wage-earning groups." Bezanson made the first demonstration of the idea that HWIs actually tracked demand for labor, by showing the close correlation of the Philadelphia Index with actual employment and turnover data in the industries that she tracked. By demonstrating that her HWI anticipated peaks and lagged behind troughs in employment, Bezanson confirmed Beveridge's earlier notion that newspaper advertising was a last resort means of acquiring labor.[22]

In 1927, William A. Berridge, an economist working for the New York Metropolitan Life Insurance Company, started a national HWI in order to determine if the company's poor sales were a result of a poor economy or an unmotivated sales force. Berridge's HWI was eventually taken over, albeit with some modifications, by the

Conference Board, a non-profit business research organization.[23,24] The Conference Board's HWI is recognized as the best source of United States labor demand data; it has been has been extensively validated with job vacancy data,[19,25] and it has been extensively studied by many economists. Robert M. Solow, the 1987 Economics Nobel Prize laureate, used the Conference Board's HWI to provided a statistical rationale for Berridge's and Bezanson's earlier observations about newspaper advertising being an employment recruitment means of last resort.[19,26-29]

The first mention of HWIs in the medical literature was probably in ophthalmology. In 1978, editor Robert Reinecke reproduced a series of HWIs for various physician specialties (ophthalmology/otolaryngology, general/family practice, internal medicine, surgery, orthopedic surgery, urology, pathology, radiology, pediatrics, obstetrics/gynecology, anesthesiology and psychiatry) developed by Lamson-Griffiths Associates of Chicago in one of the appendices included in the first installment of the five-part Ophthalmology (Eye Physician and Surgeon) Manpower Studies for the United States. Reinecke included the HWI because of the "uniqueness" of the data in the literature.[4] In 1996, Seifert et al used HWIs to assess the marketplace demand for internal medicine, family practice, pediatrics, anesthesiology, pulmonology, and orthopedic surgery physicians.[30] This work represents the first use of an academically developed HWI to assess demand for physicians. In 1998, Preheim used a HWI to assess the impact that the managed care environment had on the demand for infectious disease specialists.[31] This work was extended by Tice et al, who further characterized the demand for infectious disease specialists relative to other internal medicine specialists.[32]

Subsequently, there have been several papers using HWIs to assess demand for radiologists[18,33-37]

The Ophthalmology Manpower Studies are a study in the applicability of HWI data to ophthalmology. The Manpower Studies were a response to the United States General Accounting Office's concerns about the over-specialization of the physician workforce, the excess numbers of ophthalmologists (among other specialists) and the geographical misdistribution of physicians in the United States. In this series of studies, the American Academy of Ophthalmology attempted to address the problem of the demand for ophthalmologists by estimating theoretic demand for ophthalmologists. The essence of this technique was to estimate the national incidence of the major diseases treated by ophthalmologists, the amount of time needed to treat the average patient, and the average annual amount of time that ophthalmologists work. The estimated time to treat a patient is multiplied by the estimated national disease incidence. This product is then divided by the estimated length of the physician work-year to arrive at the estimated demand for ophthalmologists. A major limitation of this technique is that it is based on a number of assumptions about what the future demand for ophthalmologists might be, rather than a more direct measure of demand, which an HWI would provide. The dependence of these studies on assumptions explains why the Manpower Studies and Graduate Medical Education national Advisory Committee, which conducted a similar study at about the same time, arrived at very different numbers for the projected 1990 demand for ophthalmologists (20,000 and 11,600 respectively).[4,38-40] In 1995 and 1998, under the AAO commissioned Eye Care Workforce Study, Lee et al updated the Manpower Studies using enhanced data collection and statistical techniques to ensure

reduced variability of the results with variation in the underlying assumptions.[2,41,42] In spite of the technical improvements on the Manpower Studies, the Eye Care Workforce Study did not resolve the fundamental problem of the Manpower Studies—it did not measure demand for ophthalmologists, instead, making assumptions and then estimating demand. As a result of the problems with their methodology, their results do not conform with reality. In their article, "*How Many Ophthalmic Plastic Surgeons Should Be Trained?"*, Penne and Lemke note that the Eye Care Workforce Study projected an excess of 88 full time oculoplastic surgeons in the year 2000, when these projections are corrected for data errors the projected excess mushrooms to 232 oculoplastic surgeons. However, this excess never came to be. Penne and Lemke believe, quite contrary to the Eye Care Workforce Study, that there are not enough oculoplastic surgeons. Penne and Lemke blame the shortcomings of the Eye Care Workforce Study on the fact that the projections were based on static assumptions that, for example, did not foresee the expansion in the type of procedures that oculoplastic surgeons perform. The authors concluded that a more continuous monitoring of demand was required, but questioned the wisdom of repeating the Eye Care Workforce Study, because of its great expense and limited usefulness.[43,44]

HWIs can overcome the problems noted by Penne and Lemke. HWIs are dynamic tools that directly measure workforce demand and thus eliminate the errors and bias inherent to theoretic workforce demand estimates. HWIs are also relatively inexpensive to generate, which facilitates the collection of continuous labor demand data. Furthermore, historical demand data can be obtained, and this data can be analyzed to test hypotheses about which factors labor demand is correlated with, which in turn will enable

more robust prediction models. Therefore, HWIs can provide a useful supplement to, and a reality check for ophthalmology workforce demand estimates. As an initial step toward this goal, a HWI for ophthalmology was compiled for the period from January 1980 through June 2006. The HWI was then used to elucidate the economic factors that affect demand for both academic and private practice ophthalmologists. Finally, the HWI was used to assess the impact of marketplace demand on training programs, ophthalmology residents, medical students and compensation of ophthalmologists.

Methods

All job advertisements in the journals *Ophthalmology, American Journal of Ophthalmology, and Archives of Ophthalmology* during the 318 month period from January 1980 through June 2006 were reviewed. Each job advertisement was disaggregated into the number of individuals positions advertised and each position was coded. Coding was done along three axes: practice type, geography, and subspecialty.

Advertisements were coded into one of three practice types: academic, private and government. In order to be coded as an academic position, the originating institution had to be an academic center, an academic center affiliate, or the position had to be advertised as either an academic appointment or a professorship. Positions at Veterans Affairs hospitals were also coded as academic positions because virtually all advertisements from Veterans Affairs hospitals, mentioned academic affiliations and offered professorships. Positions that were described as partnership track or private practice positions were not encoded as academic jobs. Positions were coded as government jobs if they involved working for governmental agencies other than the Department of Veterans Affairs. All other positions were designated as private practice positions.

Geographical coding within the United States was done according to the scheme summarized in Table 1.[33] Positions outside the United States were either coded as Canadian or International.

Advertisements were divided among sixteen subspecialty groups, namely: general (or comprehensive) ophthalmology, retina, cornea (and or anterior segment), glaucoma, uveitis, pediatrics, oculo-plastics, neuro-ophthalmology, research, pathology, cataracts, low vision, oncology, education, and leadership. Jobs that did not fit into any of the preceding categories were coded as other. The positions were further subcategorized into part-time, research, education, and leadership positions within specialties. For example an advertisement for a purely research positions in glaucoma, would be coded as a glaucoma position and sub-coded as a research positions, while an advertisement for an ophthalmologist researcher would simply be coded as a research position, without sub-coding. Retina jobs were sub-coded as medical retina or vitreo-retinal surgery positions. General ophthalmology was used for advertisements for general (or comprehensive) ophthalmologists, positions without subspecialty designations, and positions mentioning more than two subspecialties. In cases where two subspecialties were mentioned for a single position, the position was coded as 0.5 of each of the mentioned specialty positions. Advertisements for directors of residency programs were categorized as education positions. Advertisements for leaders of ophthalmology departments or of ophthalmology departments in satellite locations were coded as leadership positions. Positions which involved research for more than 50% of the time were coded as research positions.

Coded positions were aggregated on a monthly basis to generate the HWI. To determine the economic factors that drive demand for ophthalmologists, multiple regression analysis was used to discern relationships between sub-components of the annualized HWI and various economic variables. Only real (inflation-adjusted) variables were used for the analysis. If only nominal (non-inflation-adjusted) data were available from the various sources, the nominal data were adjusted by dividing the variable by the ratio of the Consumer Price Index (CPI) values for the year in question and the year preceding it. Symbolically, real X_n = nominal X_n*(CPI_n/CPI_{n-1}), for variable X in year n. CPI data was obtained from the U.S. Department of Labor's Bureau of Labor Statistics.[45]

The variables and HWI sub-components that are used in this paper are described below:

- ***Research funding*** refers to the annual amount of money that is spent on research activities. Research refers to an aggregate of private, federal, state and local government monies dedicated to research. These numbers were obtained from the U.S. Department of Health and Human Services' Centers for Medicare and Medicaid Services.[46]
- ***S&P*** is the annual percentage appreciation or depreciation of the Standard and Poor's 500 stock market index. S&P was calculated by dividing the adjusted closing price of the S&P 500 on the last trading day of a particular year with the price on the first trading day of that year. Symbolically $S\&P_n$ = ($price_{\text{last trading day}}/price_{\text{first trading day}}$). Data for the S&P 500 was obtained from Yahoo! Finance using the ticker symbol: ^GSPC.[47]
- ***GDP*** refers to the Gross Domestic Product, which is the sum of all goods and services produced in a country in a year. The GDP data used for this analysis was obtained from U.S. Department of Commerce's Bureau of Economic Analysis.[48]
- ***Other professionals*** refers to out-of-pocket expenditures on the category designated by the Centers for Medicare and Medicaid Services as "Other Professional Services." Other Professional Services, is defined as "services provided in establishments operated by health practitioners other than physicians and dentists. These professional services include those provided by private-duty

nurses, chiropractors, podiatrists, ***optometrists***, and physical, occupational and speech therapists, among other" (my emphasis).[46]

- ***Offered fellowships*** is the annual number of ophthalmology fellowship positions offered by training institutions. This information is published by the Association for University Professors of Ophthalmology's Fellowship Match Report.[49]
- ***Fellowship applicants*** is the annual number of applicants to ophthalmology fellowship programs. This number is the sum of applicants to the various ophthalmology fellowship programs. These numbers are published in the Association for University Professors of Ophthalmology's Fellowship Match Report.[49]
- ***Residency applicants*** is the number of applicants who register for the San Francisco Matching Program. This information was obtained from the Association for University Professors of Ophthalmology's Ophthalmology Match Report.[50]
- **Physician compensation variables**. Physician compensation data from Medical Group Management Association's Physician Compensation and Production Survey series.[51] The specific compensation categories used in this paper are listed below.
    - ***Median academic compensation*** is the median total compensation of academic ophthalmologists
    - ***Mean academic base compensation*** is the mean base salary of academic ophthalmologists
    - ***Mean retina compensation*** is the mean total compensation of retina specialists
    - ***Median academic retina compensation*** is the median compensation of academic retina specialists
- ***Academic HWI*** is the annualized sum of all advertisements for academic ophthalmologists. The *Academic HWI* is a proxy for the marketplace demand for academic ophthalmologists.
- ***Private practice HWI*** is the annualized sum of all advertisements for private practice ophthalmologists. The *Private practice HWI* is a proxy for the marketplace demand for private practice ophthalmologists.

- ***Private specialist HWI*** is the annualized sum of all advertisements for non-generalist, private practice ophthalmologists. This series was obtained by subtracting general practice positions from the private HWI. The *Private specialist HWI* is a proxy for the marketplace demand for private practice specialists.
- ***Academic retina HWI*** is the annualized sum of all advertisements for academic retinal specialists. *Academic retina HWI* is a proxy for the marketplace demand for academic retinal specialists.

Southeast	**Midwest**	**Northeast**	**Southwest**	**Northwest**	**California**
Alabama	Colorado	Connecticut	Arizona	Alaska	California
Arkansas	Illinois	Delaware	Hawaii	Idaho	
Florida	Indiana	Maine	Nevada	Montana	
Georgia	Iowa	Massachusetts	New Mexico	Oregon	
Gulf Coast	Kansas	New Hampshire	Oklahoma	Washington	
Kentucky	Michigan	New Jersey	Texas	Wyoming	
Louisiana	Minnesota	New York	Utah		
Maryland	Missouri	Pennsylvania			
Mississippi	Nebraska	Rhode Island			
North Carolina	North Dakota	Vermont			
South Carolina	Ohio				
Tennessee	South Dakota				
Virginia	Wisconsin				
Washington DC					
West Virginia					

Table 1. Geographical coding scheme for HWI derived from Forman et al. *Changes in the Market for Diagnostic Radiologists Measured through a Help Wanted Index* AJR 2000; 174; 933-938.

Results

Help Wanted Index 1980-2006

General Trends

Between January 1980 and June 2007, 15,283 positions were advertised in *Ophthalmology, Archives of Ophthalmology,* and the *American Journal of Ophthalmology*. The annual number of advertised positions started at 264 ads in 1980

and peaked at 944 in 1990; it subsequently fell to a nadir of 291 in 1996, then peaked at 734 in 2001; it then fell to an apparent minimum of 450 in 2004, but rose to 663 in 2005.

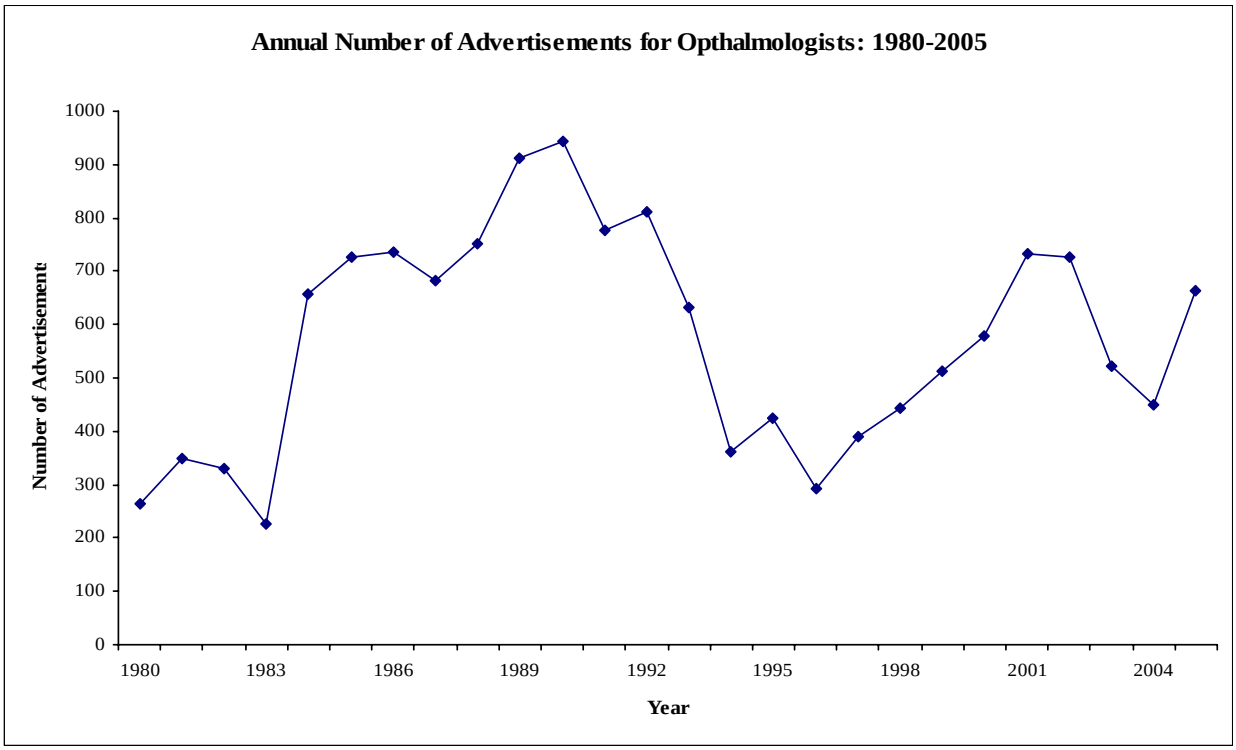

Fig. 1: Annual number of advertisements for ophthalmologists from 1980 through 2005.

Analysis of monthly number of ads (Figure 2) revealed local maxima in June 1990 and January 2002, and local minima in October 1996 and February 2005. The alternating periods of increase and decrease in the total number of ads—January 1980 through June 1990, July 1990 through October 1996, November 1996 through January 2002, and February 2002 through February 2005—provide a natural basis for analyzing the trends within the ophthalmology job market.

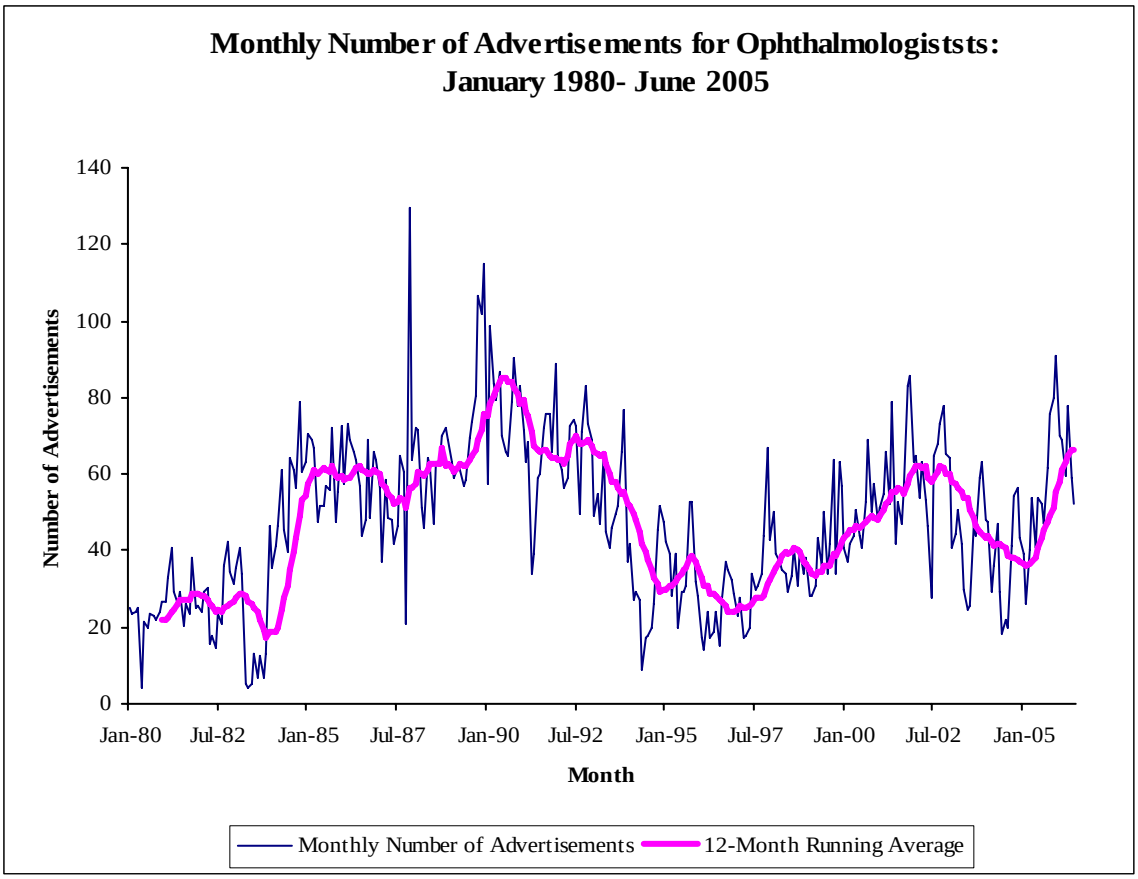

Fig. 2: Monthly number of advertisements for ophthalmologist from January 1980 through June 2006.

Practice Type Trends

Between January 1980 and June 2006, 61.3 percent (9,735) of all advertisements was for private practice positions, 38.1 percent (5,822) was for academic positions and 0.6 percent (86) was for government positions. A comparison between the periods January 1980 through June 1990 (increasing total ads) and July 1990 through October 1996 (decreasing total ads) revealed an increase in the proportion of academic advertisements (24.8% to 32.4%, $p < 0.001$) and a decrease in the proportion of private practice ads (74.9% to 66.8%, $p < 0.001$). Between the periods July 1990 through October 1996 and November 1996 though January 2002, there was a further decrease in the proportion of private practice advertisements (66.8% to 51.7%, $p < 0.001$) to with a concurrent increase in the proportion of academic ads (32.4% to 27.4%, $p < 0.001$).

Between the periods November 1996 through January 2002 and February 2002 through February 2005, the proportions of private practice ads decreased even further (51.7% to 36.3%, $p < 0.001$), and the proportion of academic advertisements increased (47.2% to 63.4%, $p < 0.001$). This may suggest that academic institutions have had an increasingly difficult time attracting ophthalmologists.

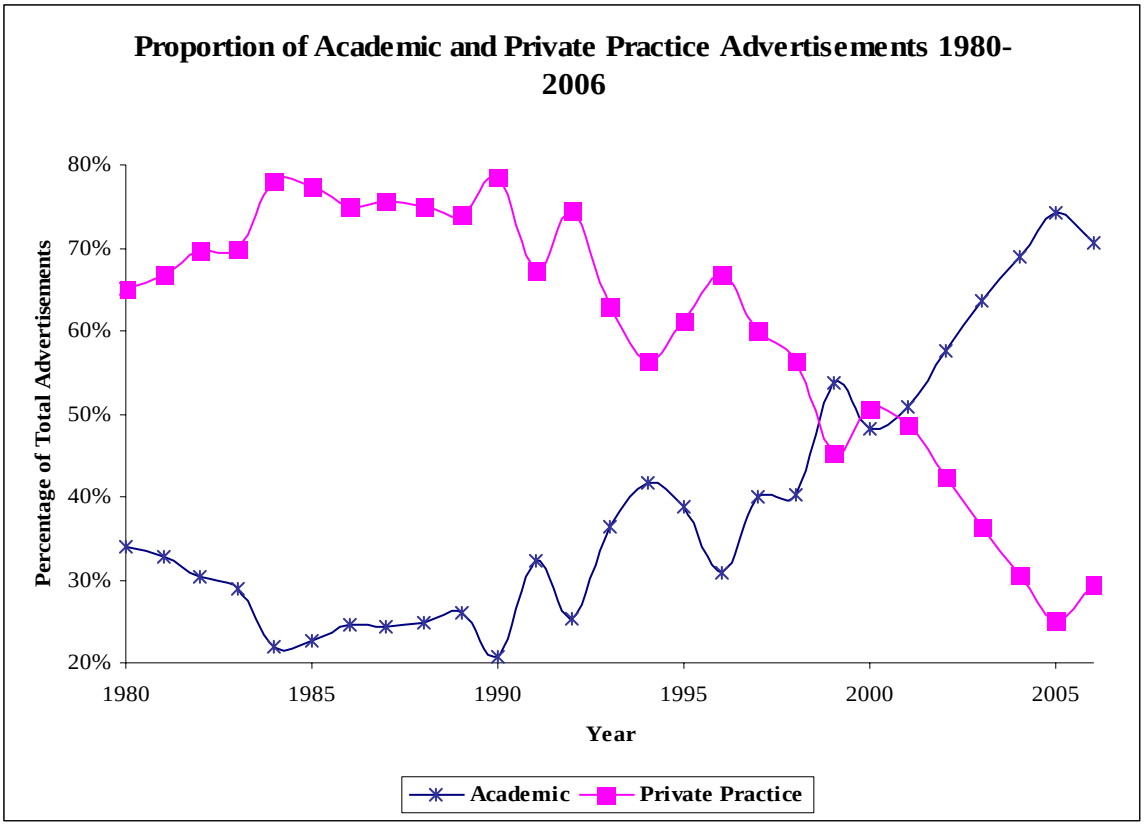

Figure 3. Academic and private practice ads as a percentage of total advertisements from 1980 through 2006.

Geographical Trends

Between January 1980 and July 2006, 27.4 percent of positions originated from the Midwest, 23.7 percent from the Southeast, 21.2 percent from the Northeast, 9.3 percent from the Southwest, 8.5 percent from California, 4.3 percent from the Northwest, 0.6 percent from Canada, 2.8 percent from foreign countries other than Canada, and 2.1 percent were unspecified. Comparing the period from January 1980 through June 1990

(increasing total ads) to the period from July 1990 through October 1996 (decreasing total ads), statistically significant decreases in the proportion of Midwestern (30.7% to 26.5%, $p < 0.001$), Californian (10.2% to 6.6%, $p < 0.001$) and Southwestern (9.2% to 5.3%, $p < 0.001$) ads, and increases in Northeastern (21.1% to 25.0%, $p < 0.001$), Southeastern (19.6% to 24.9%, $p < 0.001$), and Northwestern (3.0% to 4.3%, $p < 0.001$) ads can be seen. A comparison of the period July 1990 through October 1996 (decreasing ads) to the period from November 1996 through January 2002 (increasing ads) revealed a statistically significant decrease in the proportion of Northeastern ads (25.0% to 17.3%, $p < 0.001$), with statistically significant increases in the proportions of Southeastern (24.9% to 27.8%, $p = 4.58 \times 10^{-3}$), Californian (6.6% to 9.6%, $p < 0.001$), Southwestern (5.3% to 8.3%, $p < 0.001$), and Northwestern (4.3% to 6.8%, $p < 0.001$) ads. A comparison of the period from November 1996 through January 2002 (increasing ads) to the period from February 2002 to February 2005 (decreasing ads) revealed significant decreases in proportions of Californian (9.6% to 6.8%, $p < 0.001$) and Northwestern (6.8% to 4.4%, $p < 0.001$) ads, with corresponding increases in the proportions of Northeastern (17.3% to 21.0%, $p = 0.00121$) and Southwestern ads (8.3% to 11.9%, $p < 0.001$). These data suggest that the decrease in the total number of ads between July 1990 and October 1996 was driven by decreases in demand from the Midwest, Southwest and California. The increase in demand between November 1996 and January 2002 was driven by increase in demand from the Southeast, Northwest, Southwest and California. While the decrease in demand between February 2002 and February 2005 was driven by decreases in demand from California and the Northwest. The most recent data indicate that current demand is

driven by demand from the Northeast. Overall, these data indicate that none of the regions of the United States have experienced chronic shortages of ophthalmologists.

Subspecialty Trends

Between January 1980 and July 2000, 38.9% of advertised positions were for general ophthalmologists, 22.8% for retina specialists, 9.0% for pediatric ophthalmologists, 6.9% for cornea specialists, 3.9% for oculoplastic surgeons, 3.5% for leadership positions, 2.5% for neuro-ophthalmologists, 1.5% for researchers, and the remaining 2.5% was for ocular pathologists, cataract surgeons, uveitis specialists, residency program directors, oncology specialists and other specialist ophthalmologists. A comparison of the period January 1980 through June 1990 (increasing ads) and the period July 1990 through October 1996 (decreasing ads) revealed decreases in the proportions of ads for general ophthalmologists (50.7 % to 37.3%, $p < 0.001$), neuro-ophthalmologists (2.6% to 1.8%, $p = 0.00317$), and ocular pathologists (1.1% to 0.6%, $p = 0.00337$), with increases in the proportions of ads for retinal specialists (17.8% to 25.0%, $p < 0.001$), glaucoma specialists 4.9% to 10.5%, $p < 0.001$), pediatric ophthalmologists (7.8% to 9.0%, $p = 0.0230$), oculoplastic surgeons (2.8% to 3.6%, $p = 0.0128$), and researchers (1.0% to 1.8%, $p < 0.001$). A comparison of the periods from July 1990 through October 1996 (decreasing ads), with the period from November 1996 through January 2002 (increasing ads) reveals decreases in the proportion of ads for general ophthalmologists (37.3% to 30.4%, $p < 0.001$), glaucoma specialists (10.5% to 8.5%, $p = 0.00691$), ocular pathologists (0.6% to 0.2%, $p = 0.00342$) and residency program directors (0.3% to 0.0%, $p = 0.00230$). These decreases were offset by increases in the proportions of pediatric

specialists (9.0% to 10.4%, $p = 0.0312$), cornea specialists (5.7% to 9.1%, $p < 0.001$), oculoplastic surgeons (3.6% to 4.5%, $p = 0.0407$), leadership roles (2.9% to 5.4%, $p < 0.001$), neuro-ophthalmologists (1.8% to2.6%, $p = 0.0123$), ocular oncologists (0.1% to 0.3%, $p = 0.0195$), and low vision specialists (0.0% to 0.1%, $p = 0.0415$). A comparison between the periods November 1996 through January 2002 and February 2002 through February 2005 revealed that the proportions of general ophthalmologists (30.4% go 23.1%, $p < 0.001$), leadership roles (5.4% to 3.8%, $p = 0.00422$), cataract specialists (0.7% to 0.0%, $p = p < 0.001$), and low vision specialists (0.1% to 0.0%, $p = 0.0415$) decreased. Furthermore, the proportions of retina specialists (25.2% to 29.0%, $p = 0.00275$), glaucoma specialists (8.7% to 10.8%, $p = 0.0130$), neuro-ophthalmologists (2.6% to 3.6%, $p = 0.0329$), uveitis specialists (0.4% to 1.0%, $p = 0.0152$), ocular pathologists (0.2% to 0.5%, $p = 0.0353$), and educators (0.0% to 0.9%, $p = 7.62 \times 10^{-5}$) increased in spite of the decrease in total advertisements. Between 1996-2001 and 2002-2005 a significant decrease occurred in generalist positions (73.3% to 65.3%, $p = 0.00030$), with a concomitant significant increase in specialist positions (13.0% to 21.3%, $p = 5.91 \times 10^{-6}$). Overall these data indicate that since 1980, irrespective of the changes in total demand for ophthalmologists, demand for general ophthalmologists has decreased and demand for specialists has increased (Figure 4). Analysis of the demand for specialists reveals that the demand for retinal specialists has increased throughout the study period, while demand for leadership roles and cornea, cataract, low vision and oncology specialists has generally tracked total demand. Interestingly, the demand for glaucoma specialists has been counter-cyclic, i.e. when general demand increases, the demand for glaucoma specialists decreases, and vice versa.

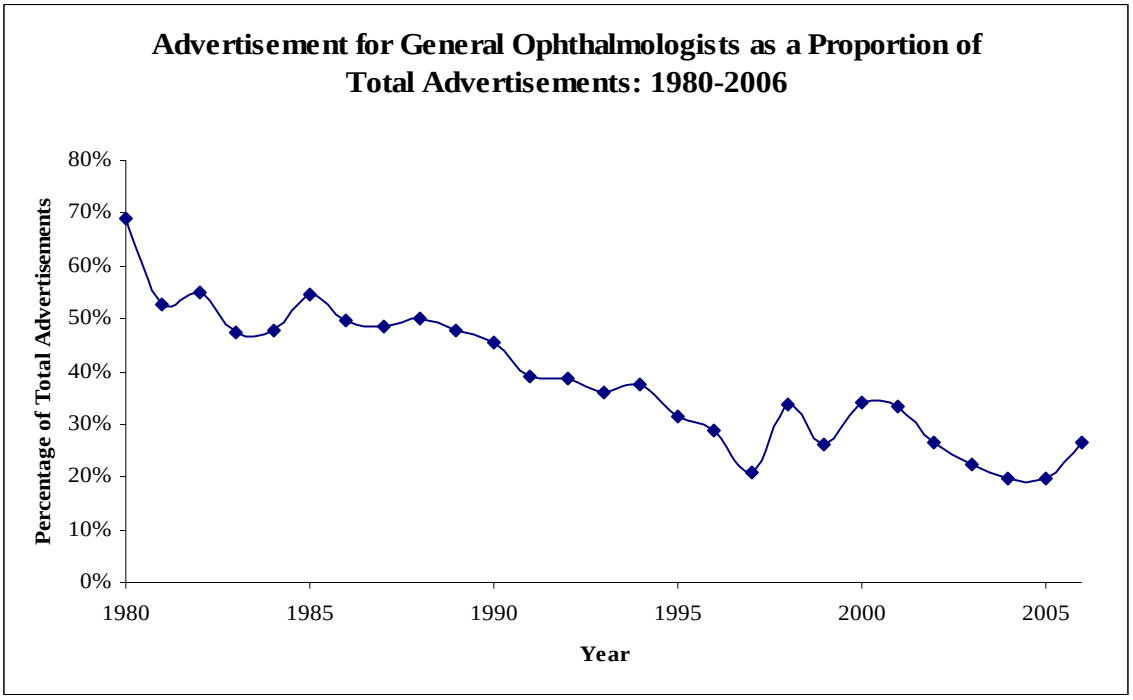

Figure 4. Advertisements for general ophthalmologist as a percentage of total advertisements from 1980 through 2006.

Help Wanted Index: The Current Market 2004-2006

General Trends

During the twelve month period from July 2004 through June 2005, a total of 497 positions for ophthalmologists were advertised, representing a 0.4% increase relative to the preceding twelve months. However, between July 2005 and June 2006, a total of 796 positions were advertised, representing a 60.2% increase relative to the previous year. These data imply a recent dramatic increase in demand for ophthalmologists.

Practice Type Trends

When the two year period from July 2004 through June 2006, was compared to the preceding two years, an increasing proportion of academic advertisements was noted (61.4% to 72.4%, $p < 0.001$). This relative increase in the proportion of academic advertisements agreed well with the longer term trends (fig. 3). However, when the most

recent year of data was compared to the preceding year, a significant decrease in the proportion of academic advertisements was observed (76.1% to 70.1%, $p = 0.0083$). Overall, these data indicate that during the period from 2004 to 2006 there may have been an increase in the demand for private practice ophthalmologists.

Geographic Trends

Between July 2005 and June 2006, 24.5% of advertisements were for positions in the Southeast, 21.9% in the Southwest, 21.6% in the Midwest, 20.0% in the Northeast, 5.4% in California, and 1.4% for positions outside the United States. The geographic origins of 0.3% of the positions were unspecified. When the July 2005 through June 2006 period is compared to the previous year, a significant increase in the proportions of Northeastern ads (12.2% to 20.0%, $p < 0.001$) can be seen along with decreases in the proportion of Southwestern (26.6% to 21.9%, $p = 0.0282$) and Southeastern (32.0% to 24.5%, $p = 0.00190$) ads. Overall, these data suggest that there may be a recent increase in demand for ophthalmologists in the Northeast.

Subspecialty Trends

Between July 2005 and June 2005, 26.8% of all advertised positions were for retina specialists, 24.0% for generalists, 13.5% for glaucoma specialists, 8.8% for oculoplastic surgeons, 8.4% for cornea specialists, 7.9% for pediatric ophthalmologists, 3.4% for leadership roles and 2.4% each for neuro-ophthalmologists, researchers and other specialists. When compared to the preceding 12 months, there were significant increases in the proportion of ads for generalists (18.7% to 24.0, $p = 0.0112$), oculoplastic surgeons (4.1% to 8.8%, $p < 0.001$), and neuro-ophthalmologists (0.4% to 2.4%, $p < 0.001$), and

significant decreases in the proportion of ads for pediatric ophthalmologists (14.3% to 7.9%, $p < 0.001$) and leadership positions (6.4% to 3.4%, $p = 0.00840$). These data imply a recent increase in the demand for generalists, oculoplastic surgeons and neuro-ophthalmologists, but a decrease in demand for pediatric ophthalmologists and leadership roles.

Economic Determinants of the Demand for Ophthalmologists

Academic Demand

Multiple regression analysis revealed that a statistically significant ($p = 0.00191$, adjusted R square = 0.397) estimate of the year-to-year percentage change in the academic HWI (Fig. 5) could be made with the following equation:

$$\Delta Academic\ HWI_n = 5.00*\Delta Research\ funding_n + 0.92*\ S\&P_{n-2} - 1.31. \quad \text{(Equation 1)}$$

Δ refers to the percentage change in the variable that it precedes relative to the previous year. Symbolically $\Delta X = (X_n - X_{n-1})/X_{n-1.}$ The regression equation is best interpreted in the following manner: for every unit percentage increase in national healthcare expenditure there is a 5.0 percent increase in the number of advertisements for academic ophthalmologists. Furthermore, for every unit percent gain in the S&P 500, there is, on average, a 0.9 percent increase in the number of advertisements for ophthalmologists two years later.

Private Demand

A statistically significant ($p < 0.001$, adjusted R square = 0.444) estimate of the year-to-year percentage changes of the private practice HWI (Fig. 6) can be made with the following equation:

$$\Delta Private\ practice\ HWI_n = 4.63*\Delta GDP_n + 1.04*\Delta Other\ professionals_n - 0.64.$$

(Equation 2)

The best interpretation of the regression equation is that for every unit percentage change in GDP there is a 4.6 percent change in the number of advertisements for ophthalmologists in private practice, and for every unit percent change in out of pocket expenditure on other Professional Services, there is a 1.0 percent change in the number of advertisements for ophthalmologists in private practice.

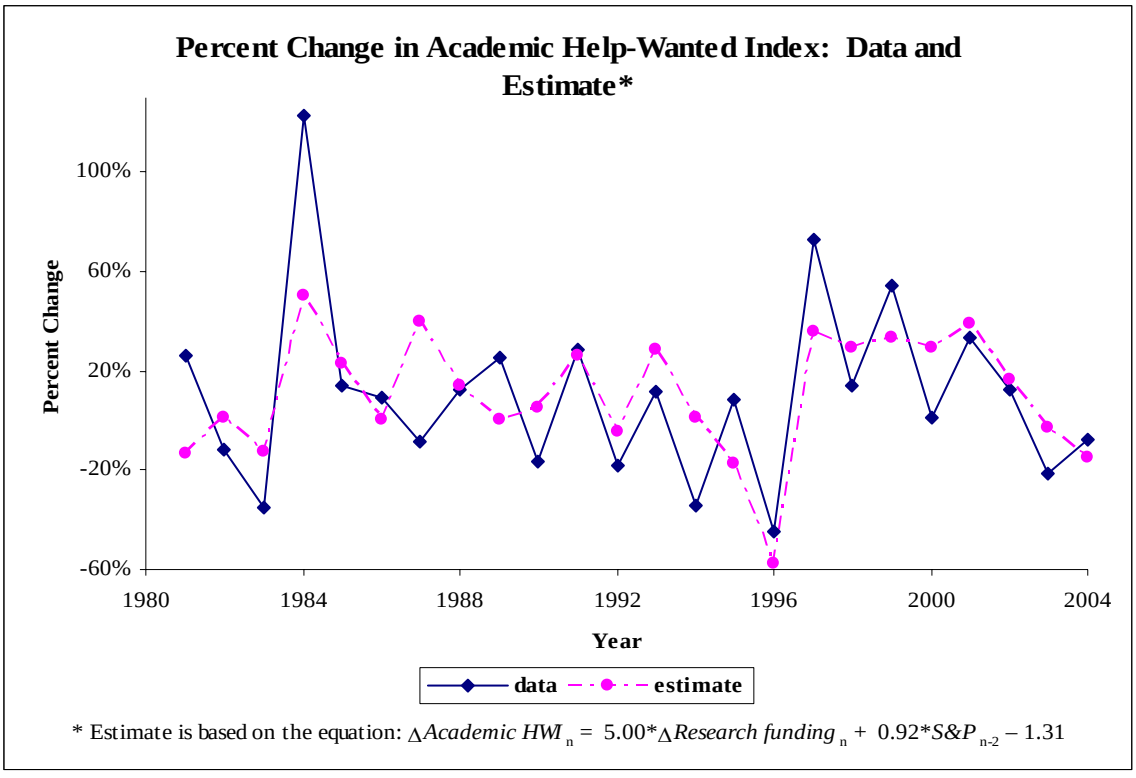

Figure 5. The data curve represents the year-to-year percentage changes in the academic HWI from 1981 to 2004. The estimate curve represents an estimate of the data curve that was based on national research expenditure and stock market gains using the formula: $\Delta Academic\ HWI_n = 5.00*\Delta Research\ funding_n + 0.92*S\&P_{n-2} - 1.31$.

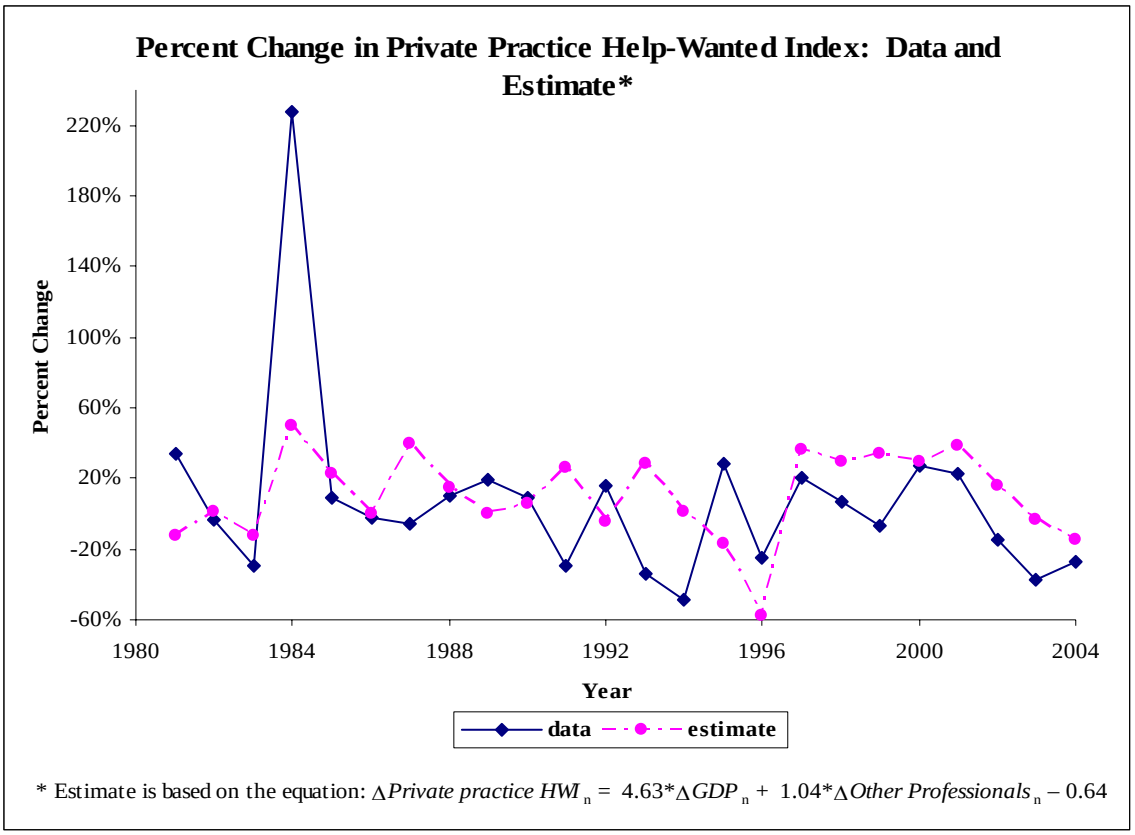

Figure 6. The data curve represents the year-to-year percentage changes in the private practice HWI from 1981 to 2004. The estimate curve represents an estimate of the data curve that was based on national research expenditure and stock market gains using the formula: $\Delta private\ HWI_n = 4.63*\Delta GDP_n + 1.04*\Delta other\ professionals_n - 0.64$.

Responsiveness of the Ophthalmology Community to Marketplace Demand

Training Programs

Simple regression analysis revealed that a statistically significant p = 0.0456, adjusted R square = 0.712) estimate of the year-to-year percentage change in the number of ophthalmology fellowship positions offered by training programs could be made with the following equation:

$$\Delta Offered\ fellowship_n = 0.11*\Delta Private\ specialist\ HWI_{n-1} + 0.0092. \quad \text{(Equation 3)}$$

The variable *Private specialist HWI* refers to the portion of the HWI advertising for private practice specialist ophthalmologists. The private specialist HWI is the private practice portion of the HWI with the number of comprehensive ophthalmology positions subtracted out. The interpretation of the regression equation is that for every unit

percentage change in the demand for private practice specialists in a given year, there is a 0.11 percent change in the number of fellowship positions offered by training programs during the following year.

Fellowship Applicants

A statistically significant estimate ($p = 0.0198$, adjusted R square = 0.832) of the year-to-year percentage change in the number of applicants to fellowship programs can be made with the following equation:

$$\Delta Fellowship\ applicants_n = 0.30*\Delta Private\ specialist\ HWI_{n-1} + 0.013. \quad \text{(Equation 4)}$$

The interpretation of the regression equation is that for every unit percentage change in the demand for private practice specialists in a given year, there is a 0.30 percent change in the number of residents applying to ophthalmology fellowships during the following year.

Medical Students

Based on data from 1995 through 2005, a statistically significant estimate ($p = 0.0128$, adjusted R square = 0.630) of the year-to-year percentage change in the number of medical students applying to ophthalmology residency programs can be made with the following equation:

$$\Delta Residency\ applicants_n = 0.12*\Delta Private\ practice\ HWI_{n-2} - 0.11\Delta Academic\ HWI_{n-2}. - 0.0010 \quad \text{(Equation 5)}$$

The interpretation of the regression equation is that for every unit percentage change in the demand for private practice ophthalmologists in a given year, there is a 0.12 percentage change in the number of medical students applying to ophthalmology residency programs two years later. Interestingly, for every unit percentage increase in

the demand for academic ophthalmologists, there is a corresponding 0.11 percent decrease in the number of medical students applying to ophthalmology programs.

Physician Compensation

Using simple linear regression on data from 2000 through 2005, a statistically significant estimate ($p = 0.0226$, adjusted R square = 0.817) of the year-to-year percentage change in the median compensation of academic ophthalmologists can be made using the following equation:

$$\Delta Median\ academic\ compensation_n = 0.13*\Delta HWI_n + 0.0085.$$

(Equation 6)

The interpretation of the regression equation is that, in a given year, a unit percentage change in the HWI, results in a 0.13 percentage change in the median compensation of academic ophthalmologists. Furthermore, the mean base salaries of ophthalmologists can be estimated ($p = 0.0351$, adjusted R square = 0.757) with the following equation:

$$\Delta Mean\ academic\ base\ compensation_n = 0.24*\Delta Academic\ HWI_{n-1} + 0.021.$$

(Equation 7)

The interpretation of the above equation is that for every unit percentage change in the academic HWI in a given year, there is a corresponding 0.24 percent change in the mean base compensation of academic ophthalmologists during the following year. Similarly, the year-to-year percentage change in mean compensation for retina specialists can be estimated from year-to-year percentage changes in the academic retina portion of the HWI. Specifically, each unit percentage change in the academic retina portion of the HWI results in a 0.06 percent change in the mean compensation of retinal specialists ($p =$

0.0418, R square = 0.447). This relationship can be expressed with the following equation:

$\Delta Mean\ retina\ compensation_n = 0.058*\Delta Academic\ retina\ HWI_n + 0.018.$

(Equation 8)

Furthermore, the year-to-year percentage changes in the median compensation of academic retina specialists can be estimated (p = 0.0401, adjusted R square = 0.735) with the following equation:

$\Delta Median\ academic\ retina\ compensation_n = 0.15*\Delta\ Academic\ retina\ HWI_{n-2} - 0.070.$

(Equation 9)

The interpretation of the above equation is that for every unit percentage change in the academic retina portion of the HWI in a given year, there is a 0.15 percent change in the median compensation of academic retina specialists two years later.

Discussion

Study Limitations

The most significant limitation of the HWI developed in this paper is that it does not capture any information about jobs that are not advertised in *Ophthalmology, the American Journal of Ophthalmology*, and *Archives of Ophthalmology*. If ophthalmology practices increasingly shift their advertising away from journal adverting and towards other vehicles such as informal networks, headhunter firms, or online placement services, the HWI will become less representative of the demand for ophthalmologists. Given general contemporary trends towards increased internet utilization, future studies should attempt to incorporate internet based advertisements into the HWI. A second limitation of

HWIs is that they are a leading indicator of the peak of the market, and a leading indicator of the troughs in the market. One study noted that the HWI peaks and troughs occurred within 3-to-5 months of the actual employment cycle extremes.[52] The distortion of the HWI at the extremes of the labor market cycle is a result of employers aggressively advertising when competition for employees is perceived to be high and under-advertising when competition is perceived to be low. Therefore, in the absence of a statistical correction to the data, care must be taken in interpreting the HWI at the extremes of the labor market cycle. A final limitation of HWIs is that they are descriptive, not prescriptive—for example a HWI can indicate that the demand for ophthalmologists has decreased, but as a stand-alone tool, the HWI does not reveal the reasons for decrease in demand. As a result the HWI must be carefully interpreted within the context of the market.

Practice Type Trends

The HWI suggests that the market place demand for academic ophthalmologists has increased between 1980 and 2006. The proportion of advertisements for academic ophthalmologists has generally increased since 1980 (Figure 3), implying that the demand for academic ophthalmologists relative to that for private practice ophthalmologists has steadily increased since 1980. The last year of the HWI indicates that the demand for academic ophthalmologists from July 2005 through June 2006 had decreased relative to the previous year, but only future studies will determine if this will become a longer term trend. The high demand for academic ophthalmologists can be understood as result of a lack of academically inclined ophthalmology residents if the HWI data is considered in tandem with the trends in the number of residency applicants

and the number of advertisements for academic and private practice ophthalmologists. These trends are summarized in Equation 5 ($\Delta Residency\ applicants_n = 0.12*\Delta Private\ practice\ HWI_{n-2} - 0.11\Delta Academic\ HWI_{n-2}. - 0.0010$). The trends in residency application and demand for private practice and academic ophthalmologists suggest that more people apply to ophthalmology residency programs when there is high marketplace demand for private practitioners, but fewer people apply when there is high demand for academic ophthalmologists—implying that ophthalmology residency may be less inclined towards academic ophthalmology. This potential reduced interest in academic ophthalmology can be verified and the reason for it can be elucidated by interviewing ophthalmology applicants and residents.

Geographic Trends

The HWI data indicates that there has not been any long-term scarcity of ophthalmologists, in any of the geographical areas of the United States--at least at the level of aggregation presented in Table 1. The Manpower Distribution section of the Ophthalmology Manpower Studies, by analyzing the ophthalmologists-to-population ratios in all of the geographical sub-units of the United States demarked by zip codes, concluded that between 1982 and 1983 most Americans has ready access to ophthalmologists.[40] Taken together, the HWI information and the Manpower Studies suggest that since the 1980s, Americans in all geographic areas have had ready access to ophthalmologists.

Subspecialty Trends

According to the HWI there has been a trend towards specialists. Growing demand for specialists suggests that fellowship training might become increasingly

necessary to secure employment as an ophthalmologist. As fellowship training becomes more important, increased enrollment in fellowship programs, and or increased competition for fellowship positions will be expected (this may be discernable from San Francisco Matching Program Fellowship data). Trends in the number of offered fellowship positions and in the demand for private practice specialist ophthalmologists suggest that the number of offered fellowship positions is positively correlated with the demand for private practice specialist ophthalmologists. This correlation is summarized in Equation 3 ($\Delta Offered\ fellowship_{n} = 0.11*\Delta Private\ specialist\ HWI_{n-1} + 0.0092$). Future increases in the number of offered ophthalmology fellowship positions (which may be also be discernable from San Francisco Matching Program Fellowship data) may therefore also be used to support the contention that future demand for specialist ophthalmologists has increased.

Economic Determinants of the Demand for Ophthalmologists

Trends in the demand for academic ophthalmologists, research funding and the stock market, suggest that the demand for academic ophthalmologist is positively correlated with both national research expenditure and the stock market gains. This relationship is summarized in Equation 1 ($\Delta Academic\ HWI_{n} = 5.00*\Delta Research\ funding_{n} + 0.92*\ S\&P_{n-2} - 1.31$). The correlation of the demand of academic ophthalmology and research expenditure is logically consistent with the fact that research is an important part of the work that academic ophthalmologists conduct, and the contention that more funds to conduct research, on average, will enable institutions to hire more researchers.

On the surface, the correlation of the demand for academic ophthalmologists with the stock market seems surprising; however this apparent contradiction is easily resolved

when one considers the sources of funds available to academic medical institutions. Academic medical institutions have several types of funding which include, reimbursements for hospital care, faculty practice income, student tuition, gifts, philanthropy, investment income, endowment income, grants, contracts and government appropriations.[53,54] Many of these sources of income are influenced by the economy and the stock market, but the clearest impact of the stock market can be seen in educational endowments, private foundations and corporations. [55] A survey of general medicine departments revealed that 74% of institutions had endowments.[56] There is some historical evidence indicating that educational endowments have grown significantly when the stock market has done well and that a portion of these gains have been used in part to increase both faculty size and the compensation.[57] With respect to private foundation grants, there is evidence that total spending of U.S. grant-making nonprofit organizations, such as the Howard Hughes Medical Research Institute, the Rockefeller Foundation and the Bill and Melinda Gates Foundation, mirrored changes in the stock market, as measured by the Dow Jones Industrial Average. [58] Furthermore, these foundations cut back spending when the stock market does poorly; for example, when the stock market downturn reduced the size of their endowments, the Howard Hughes Medical Research Institute announced a 10% ($100 million) cut in their support of research, and the Rockefeller Foundation reported a 20% ($120 million) reduction in grants.[58-60] Since the portion of these grants used to fund scientific research has remained relatively constant over time, scientific grants from non-profit foundations can be said to grossly track the stock market. Since 1972, industry has funded 3.9-7.4% of all academic scientific research.[61] Industry may fund academic life sciences more heavily; for example, in 1994,

industry funded 11.7% of academic life science research, but only 6.8% of all academic scientific research. Industrial support of academic scientific research tends to be applied research, project-specific and of limited duration--usually two years or less.[55,61-63] The limited nature of the financial relationship between industry and academia suggests that it can be easily severed. There is some evidence that companies do cut their research and development budgets when the stock market does poorly.[64] Overall, given the impact of the stock market on academic scientific research, it is plausible that the stock market could impact the demand for academic ophthalmologists.

Trends in the demand for private practice ophthalmologists, GDP growth and the out-of-pocket expenditure on non-physician health care professionals suggests that the demand for private practice ophthalmologists is positively correlated with both GDP growth and the out-of-pocket spend on non-physician health care professions (a category that includes optometrists). This correlation in summarized in Equation 2 ($\Delta Private\ practice\ HWI_n = 4.63*\Delta GDP_n + 1.04*\Delta Other\ professionals_n - 0.64$). The correlation between the demand for private practice ophthalmologists and GDP growth is supported by Cooper et al in the paper "*Economic and Demographic Trends Signal An Impending Physician Shortage*", which reports that the economy is the major factor determining use of physician services, and that level of use are closely tied to real GDP. Cooper et al demonstrate that the number of active physicians in the United States, between 1929 and 2000 has been linearly dependent on real GDP, (generally a 1% increase in GDP results in a 0.75% increase in demand for physicians), but that this relationship varies depending on the type of physician.[65] Other researchers have confirmed this relationship.[66,67] Holahan and Pohl observe that periods of GDP growth have led to a favorable job

market, increased employment and increased employment-based health insurance; and that periods of reduced GDP growth are characterized by the reduced fortunes of companies which leads to reduced employment, reduced rates of employer-based health insurance, and individual employees assuming the cost of health insurance. [68] Therefore, the positive relationship between GDP growth and the demand for private practice ophthalmologist probably reflects both the increased number of patients who are insured and can thus afford ophthalmologic care during periods of high GDP growth and the reduced number of patients who are insured and can afford ophthalmic care during periods of low or negative GDP growth.

The relationship between the demand for private practice ophthalmologists and the out-of-pocket expenditure on other professional services is hard to interpret because the other professional services data aggregates optometrist data with that of other non-physician professionals. If the other professional services variable is merely tracking how much out-of-pocket money the average patient can afford to spend on healthcare, the interpretation of the correlation becomes quite clear—the other professional services variable, much like GDP, becomes a measure of the aggregate patient's ability to pay for health care. However, if the other professional services variable is tracking the aggregate patient's spend on optometrists, the implication is that because ophthalmologists and optometrists see the same type of patients their incomes depend on the aggregate demand for ophthalmic care and are thus highly correlated. At an aggregate level this putative correlation between the incomes of ophthalmologists and optometrists will exist, on matter how cooperative or competitive the relationship between both types of providers is. If it is cooperative, increased referral with increased patient volume will be the

proximate cause of the correlation in incomes; while if it is competitive, limited manpower, will be the proximate cause of the correlation. To prove this relationship a correlation should be demonstrated between the salaries of ophthalmologist and optometrists, or the demand for their services (for example comparing a HWI for optometrist to a HWI for ophthalmologists).

Responsiveness of the Ophthalmic Community to Marketplace Demand

Trends in the number of fellowship positions and the demand for specialist ophthalmologists suggests that the number of ophthalmology fellowship positions is positively correlated with the previous year's demand for specialist ophthalmologists. This correlation is summarized in Equation 3 (Δ*offered fellowships*$_n$ = 0.11*Δ*private specialist HWI*$_{n-1}$ + 0.0092) The suggestion that the number of available fellowship positions responds to the most recent demand for the fellowship graduates, is equivalent to the suggestion of a built-in check against the oversupply and undersupply of residents, based on the best available information. Penne and Lemke suggest that projections about the oversupply of oculoplastic surgeons did not materialize, in part, because of the dynamic nature of the number of offered fellowship positions.[43] There is some evidence from gastroenterology and neuroradiology that the number of fellowship positions can change in response to perception of demand for the trained fellows, and moreover, that the number of fellowship applicants also respond to these changes.[69,70]

Trends in the number of applicants to fellowship programs and the demand for private practice specialist ophthalmologists suggests that the number of ophthalmology fellowship applicants is positively correlated with the previous year's demand for specialist ophthalmologists. This correlation is summarized in Equation 4

(Δ*fellowship applicants*$_n$ = 0.30*Δ*private specialist HWI*$_{n-1}$ + 0.013). Earlier, Gedde et al reported that the perception of a favorable job market was a statistically significant factor determining application to ophthalmology fellowship programs.[71] The correlation between demand and fellowship applications suggests that ophthalmology fellowship applicants use the previous year's demand information to make their decisions to apply, which is in essence the best available information about the job market. Unfortunately, the source of the market demand information cannot be specified by HWI analysis.

Trends in the number of applicants to ophthalmology residency programs, the demand for private practice ophthalmologists and the demand for academic ophthalmologists suggest that the number of residency applicants is positively correlated with the demand for private practice ophthalmologists and negatively correlated with the demand for academic ophthalmologists. These correlations are summarized in Equation 5 (Δ*Residency applicants*$_n$ = 0.12*Δ*Private practice HWI* $_{n-2}$ - 0.11Δ*Academic HWI* $_{n-2}$. – 0.0010). In contrast to fellowship applicants, who react to demand information that is one year old, residency applicants seem to react to demand information that is two years old; which can be explained by the fact that fellowship applicants (mostly residents) have greater exposure to the ophthalmic community and thus more up-to-date information about the demand for ophthalmologists than residency applicants (mostly medical students). Interestingly, the trends summarized by equation 5 suggest that there is an increase in the number of applicants to ophthalmology residency programs when there is greater demand for private practice ophthalmologists, but there is a decrease in the number of applicants when there is greater demand for academic ophthalmologists. According to the literature, the completion and publication of research in medical school,

structured medical student research programs, the desire to teach, the desire for intellectual stimulation, mentors, role models and career guidance are factors that are positively correlated with the decision to pursue an academic career.[72-78] Currently, there is high demand for academic ophthalmologists (Figure 3), which may mean that the current faculty are likely to be working harder and have less time to pursue their own research endeavors, and provide medical students with gratifying research experiences, effective mentorship, and positive career guidance. Therefore, it is possible that increased need for academic ophthalmologists places demands on the current ophthalmology faculty that reduces their ability to effectively recruit medical students into the field. Another possible explanation hinges on the "generational" trend that lifestyle priorities may be becoming more important in determining the career choices of medical students.[79-83] Given the increased demand for academic ophthalmologists, the current faculty works harder, making their apparent lifestyles seem less appealing to students that think that lifestyle factors are important. And yet another potential explanation is based on the trend towards increased medical student indebtedness,[84-86] and the trend towards medical students increasingly considering their educational debts and income potential as factors in determining their career decisions.[79,84,87-90] It is possible that as a result of their increased debt burdens and the reduced earning potential of academic physicians vis-à-vis private practitioners[51], medical students have become less interested in academic medicine. It is important to note that there was a statistically significant decrease in the relative demand for academic ophthalmologists during the last year of the series (Figure 3), this may indicate that a plethora of factors under the general rubric of the forces of supply and demand may be addressing the issue of the lack of academic

ophthalmologists. Furthermore, the correlation between research funding and the demand for academic ophthalmologists (Equation 1), suggests that increased research funding for ophthalmology may be a policy tool that could be used to recruit more academic ophthalmologists.

Trends in the compensation and marketplace demand for ophthalmologists suggest that ophthalmologists' compensation is correlated with the demand for ophthalmologist. These correlations are summarized in Equations 6 through 9. As expected, when demand is higher, salaries are higher and when demand is lower, salaries are lower. It is important to note that salaries depend both on supply and demand, but given the absence of data series about the supply of various types of ophthalmologists, the supply side could not be incorporated into this analysis. Probably because of the relative lack of new academic ophthalmologists, statistically significant results were obtained for the compensation of academic ophthalmologists, without using supply data.

Overall, HWIs may be a reasonable technique for assessing demand for ophthalmologists. HWI data was used not only to portray the cyclical nature of the demand for various types of ophthalmologist during the 26 year period from 1980 to 2006, but also to highlight trends towards an undersupply of academic ophthalmologists, the emergence of an increasingly specialized ophthalmology workforce and the lack of geographical mal-distribution of ophthalmologists. Further analysis of the HWI data has enabled the elucidation of the highlight the macroeconomic factors associated with the fluctuations of demand for the various types of ophthalmologists. It was demonstrated that the demand for academic ophthalmologists is correlated with both national expenditure on research and gains in the stock market. The demand for private practice

ophthalmologists was demonstrated to be correlated to national economic wellbeing, as measured as GDP growth, and gross out-of-pocket expenditure on non-physician health care professionals. Analysis of HWI data has also enabled the assessment of the response of the ophthalmic community to changes in demand. The number of ophthalmology fellowship applicants in a given year was demonstrated to be correlated to the demand for specialists in the previous year. The number of fellowship positions in a given year was shown to be correlated to the demand for specialists during the previous year. Likewise, the number of applicants to ophthalmology residency programs in a given year was demonstrated to be positively correlated to the demand for private practice ophthalmologists two years earlier, and negatively correlated to the demand for academic ophthalmologists two years earlier. Furthermore, the compensation for ophthalmologist was demonstrated to be correlated with demand, with compensation increasing when demand was high and decreasing when demand was low. Since HWIs are useful tools for assessing the marketplace need for ophthalmologists, an ongoing HWI will provide timely information about the demand for physicians in a rapidly changing health care system.

Conflict of Interest Statements

The author is not involved in any financial or personal relationships that could impact the outcomes of this study.

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