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MANAGED CARE AND MEDICAL TECHNOLOGY GROWTH

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ABSTRACT

Many questions about technology growth and development in health care call for a broad-based characterization of technology availability. In this paper, we explore the possibility of producing aggregated estimates of technology availability by constructing an index of technology availability in hospitals. Our index is based on the number of services provided by a hospital, weighted by how rare those services are. We use the index to examine the relationship between managed care and technology availability in hospitals. We find that managed care may have slowed technology growth in the mid 1980s, but in the early 1990s we find little evidence that technology growth in areas with high-HMO market share is any slower than growth in lower market share areas. To the extent that our index captures variation in the costs of new technologies, this finding leaves open the question of whether managed care can help control long term cost growth by slowing technology adoption. We also discuss the general strengths and weaknesses of indices of the type we develop. One concern arises from the considerable variation across individual technologies. We profile several individual technologies and note that conclusions drawn from the aggregated index may not apply to each of the constituent technologies. Nonetheless, this exercise shows that it is feasible to develop and analyze hospital technology indices if aggregated information about technologies is appropriate to the research question.

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1. Introduction

Between 1993 and 1997, health care spending in the United States grew at an average annual rate of 5 percent, significantly lower than the 12 percent average annual growth experienced between 1966 and 1993. Health expenditures remained at 13.6 percent of U.S. GDP between 1993 and 1997 after rising constantly since 1966 (Levit *et al.*, 1998). This recent decline in spending growth rates has fueled considerable discussion about the effect that the ongoing shift toward managed care has had on expenditures, with a consensus developing that a large part of the expenditure growth slowdown can be attributed to growth in managed care (Levit *et al.*, 1998, Zwanziger and Melnick, 1996). But, while the public and policy makers have welcomed the stabilization of health care expenditures, it is not clear whether managed care has generated one-time savings or whether it will bring about a long-term reduction in spending growth. In fact, forecasts that spending may increase more over the next few years than it did over the past few years call into question the ability of managed care to alter long-term growth rates (Freudenheim, 1998, Winslow, 1998).

For managed care to bring about long-term savings, it must influence the forces that drove the large spending increases observed over the past 3 decades. The most important determinants of health care cost growth are widely thought to be the shift in demographics toward an older, and potentially more expensive, population and the rapid advance in medical technology (Newhouse, 1992, Newhouse, 1993, Weisbrod, 1991). Since managed care is unlikely to change population demographics, influencing technology growth is the most plausible avenue by which it could bring about long-term changes in health care costs.

The chain linking the development, adoption, and use of new technologies is long and, in principle, managed care could influence the availability of medical technologies by intervening at a number of points. At the bedside, managed care plans often attempt to regulate the use of new technologies, particularly those that are very costly. Managed care also could have spillover effects that lead to changes in utilization even among patients not enrolled in managed care plans. Changes in the demand for technologically-focused health care could lead to changes in the propensity of hospitals or other health care providers to invest in new medical equipment or other technologies when they become available. And, technology developers may alter their research and development efforts in response to the perception that managed care will change the demand their new products will face when they reach the marketplace.

In this paper, we focus on the ability of managed care to influence the adoption of new technologies by hospitals. In doing so, we follow a considerable body of research that has focused on the link between HMO activity and the availability of new technologies. Previous work has argued that traditional indemnity health insurance fostered excessive adoption of new technologies through financial incentives that rewarded the use of new and expensive services and lax oversight of provider decision making (Fuchs, 1974, Luft *et al.*, 1986, Weisbrod, 1991). Managed care, which focuses on cost containment, has attempted to alter these financial incentives and improve oversight. Although some early papers questioned the ability of managed care to bring about changes in technology availability (McLaughlin, 1988, Schwartz, 1987, Schwartz, 1994), a handful of more recent papers have presented empirical evidence that managed care does influence the overall availability of medical technologies.[1] Baker (1998) argues that increases in HMO market share are associated with declines in the availability and use of MRI. In a case study in Wisconsin, Hill and Wolfe (1997) observed an increase in joint purchases of magnetic resonance imaging and lithotripsy, and thus a decrease in total purchases, as managed care activity grew. Cutler and McClellan (1996) suggest that increases in HMO market share are associated with decreases in the availability of angioplasty in hospitals. Cutler and Sheiner (1998) studied a wide range of hospital technologies and argue that states with high HMO market shares began the 1980s as faster adopters of new technologies, but had become merely average by the mid 1990s, consistent with the view that managed care can retard technology growth rates.[2]

Virtually all previous studies of technology adoption have examined individual technologies one at a time. This is appealing both because technology availability is measured at the level of individual technologies, and thus individual technologies represent a natural unit of analysis, and because it allows separate conclusions to be drawn for each individual technology. However, focusing on individual technologies also has drawbacks. In many discussions of the effects of managed care on technology adoption, and of other aspects of health care technology growth as well, the notion of health care technology encompasses the broad sweep of new innovations, the rate at which they occur, and the speed with which they are acquired and put into practice. Questions posed this way about technology change call for broad descriptions of technological change and studies of individual technologies are not optimal for providing such large scale, aggregated evidence.

In the hope of providing aggregate information about technology change, we explore the ability of a technology index to summarize technology availability. We construct an index that measures the aggregate availability of a set of new technologies in individual hospitals and in markets. We examine the performance of this index over time in different markets, and conclude that construction and analysis of technology indices is feasible. We then present information about the relationship between managed care activity and technology advancement. We find evidence that areas with high levels of managed care activity started the early 1980s with relatively high average technology index values, but that index values for these areas were similar to, or perhaps even less than, index values in other areas by the late 1980s. In recent years, index values for both high and low market share areas grew at similar rates. We also examine the effects of managed care on the degree of dispersion in technology advancement across hospitals within markets and the interplay between managed care activity and hospital competition.

Painting with a broad brush can be a dangerous thing to do. The term "medical technology" can refer to a vast array of medical equipment, procedures, organizations, and other innovations. Building a single index to summarize the effect of managed care on all of them may provide useful aggregate information, but may also miss important individual effects. To highlight differences across some different types of technologies, we follow the discussion of our index with a presentation of parallel evidence on the adoption of three specific technologies that demonstrate the range of effects managed care can have. The results suggest that the effects of managed care can vary and that caution should be exercised if one wishes to extend the conclusions drawn using index data to individual technologies.

2. An Index of Technology Availability

Background

The term "health care technology" is poorly defined and can refer to a range of advances in medical knowledge that are implemented in patient care, potentially including everything from new equipment and procedures to changes in the organizational structure of institutions. Our approach is to identify a set of things in hospitals that are commonly considered "health care technologies" and can be identified in survey data. In some cases we measure the presence of specific infrastructure items like MRI scanners. In other cases we use the presence of certain types of services, which may represent organizational innovations and are likely to signal the presence of other advanced infrastructure items.

We develop a measure of technology availability that summarizes the range of measurable technologies available in a given hospital in one index value. We hope that this will be useful for studying technology growth rates broadly and will provide valid summary information about the effects of managed care on technology growth. The index we examine is a weighted sum of the number of technologies and services from a predetermined list available in a hospital, with the weights being the percent of hospitals in the United States that do not possess the technology or service.[3] Spetz (1995) terms this index a "Saidin Index." Rare technologies--rare because they are new, expensive or difficult to implement--receive higher weights in this measure. Common technologies, such as operating rooms, receive low weights.

More specifically, to create an index for hospital *i* in year *t*, we begin with a list of technologies available in that year, which we index by $k = 1, ..., K$. For each technology, we assign a weight $a_{k,t}$, where

$$a_{k,t} = 1 - \left(\frac{1}{N_t}\right) \sum_{i=1}^{N_t} \tau_{i,k,t} \quad .$$

N_t is the total number of hospitals in the U.S. and $\tau_{i,k,t}$ takes the value 1 if hospital i has technology k in year t and 0 otherwise. We then use these weights to compute the index $s_{i,t}$ for hospital i in year t:

$$s_{i,t} = \sum_{k=1}^{K} a_{k,t} \tau_{i,k,t}$$

That is, the index for each hospital is the sum across all of the technologies the hospital has of the percent of hospitals in the United States that do not have that technology.

To be useful for analyses, the index should have two properties. First, it should accurately reflect the degree of technology advancement across hospitals at a single point in time. That is, in any given year hospitals with higher values of the index should be "more advanced." While it is not fully clear what "more advanced" means, we believe this index does reflect advancement as it is commonly conceptualized. Adding technologies will increase the index value. Adding technologies that are relatively rare will increase the index value by more than adding technologies that are common. In general, hospitals that have more, rarer technologies will have higher index values than hospitals with fewer, more common technologies.

Two characteristics of this index deserve mention in this context. First, the index rewards technologies based on how uncommon they are. From the standpoint of identifying "high technology" services, high cost services, or even new services, this may not be sufficient. But, as a starting point, relative rarity is a factor that is frequently incorporated into the definition of health care technologies--things that are rare, either because they are expensive, new, or difficult to implement, are more likely to be considered "high technology" items. As a practical matter, identifying whether technologies are more or less common is one of the few methods that can be implemented purely from the data. A second issue stems from the fact that both the number and relative rarity of the technologies enter into the calculation of the index, so the index will not distinguish hospitals that have a small number of rare technologies from hospitals that have many common technologies. There are very few hospitals that have adopted one or two uncommon technologies and also have not adopted a wide range of common technologies, which alleviates this problem in practice.

The second property needed for the index to be valid is the ability to identify changes in technology over time. That is, the index should increase over time with increases in the degree of technology advancement. If a hospital has a higher index value this year than last year, we would like to conclude that the hospital became more advanced. In this regard, the most straightforward implementation of this index can be problematic. Difficulties could arise if one were to identify a new list of technologies and compute a new set of weights measuring the relative rarity of the listed technologies each year, and then compute the index values for each hospital for each year. Because hospitals rarely shut down services, the relative rarity of the technologies, expressed in the weights, could be expected to decline from year to year as more hospitals adopt new technologies over time. The index values would thus tend to fall over time even if hospitals did not change their technology set from one year to the next. A related problem is that the set of technologies under consideration changes from year to year as new technologies are introduced to medicine and to the surveys. The surveys we use to create the index are updated periodically to add new technologies. When the set of technologies changes, discontinuities can be introduced into the time series of index values.

To address these problems, we define indices using a set of technologies and weights that are defined in a base year and held fixed for subsequent years. We then compute index values for each hospital using this fixed set of technologies and weights. For example, we define a list of technologies available in 1983, determine their relative rarity in 1983, and then compute index values for hospitals for all years using the 1983 list and the 1983 weights. This method preserves that ability of the index to function as a useful measure over time. With the weights fixed, increases in the index signify the addition of new technologies. It important to note, though, that this is only valid for a limited period of time. The fixed technology list and weights eventually produce a poor indicator of the current state of the world, and thus have to be updated.

Indices Using 1983 Technologies

We begin by computing an index for each hospital based on the set of available technologies and their relative rarity in 1983. We use data from the American Hospital Association's Annual Survey of Hospitals,[4] which includes information about the presence of a wide range of technologies and services in virtually all hospitals in the United States. To define the set of technologies on which we based our indices, we reviewed the list of technologies included on the 1983 AHA survey and selected a set of technologies that we expect are commonly identified as "high technology items." We eliminated hospital services that are not commonly identified as representing medical technologies, such as psychiatry, social work, volunteer, and chaplaincy services. We also eliminated services that define standard hospital units, such as medical-surgical acute care units. Finally, we required that technologies included on the list be part of the survey in every year from 1983 to 1993, since this study focuses on this

11 year period. These exclusions eliminated about 70% of the services included on the AHA survey in 1983 and produced a base list of 18 technologies.

The first column of Table 1 summarizes the technologies on our list for 1983. The value in the column is the percent of hospitals in 1983 that indicated that they had the technology. To compute an index for each hospital, we determined which of the technologies on the list were present in the hospital. For each technology present, we then determined the percent of hospitals in the country that did not have the technology in 1983 (computed as 100% minus the value in column 1 of Table 1). We then summed these values for each hospital. We term the index based on the 1983 list and relative rarities "Index 83."

In any given year, the value of Index 83 varies widely across hospitals. Figure 1 presents the distribution of the 1983 values of Index 83 across all hospitals in the U.S. Values range from 0 to 7.6, the maximum possible value. A relatively large number of hospitals had none of the technologies on the list, and thus had a zero index value. Most hospitals had index values in the range of 2 to 4.

We computed values of Index 83 for each hospital in each year from 1983 to 1993. The bottom line in Figure 2 graphs the mean value of Index 83 for each year of 1983 to 1993. The mean value increases over time from 3.3 to 3.7 as additional hospitals adopt technologies on the 1983 list.

Indices Based in 1987 and 1991

A difficulty with using Index 83 to track technological change from 1983 to 1993 is the fact that technologies introduced or added to the survey in more recent years are not included in this index, biasing it toward older, established technologies. To update the indices, we recreated the base list and estimates of the relative rarity of each technology using data from 1987 and 1991. This allows us to incorporate new technologies that are added to the AHA survey. The 1987 list includes all of the technologies included in the 1983 list, plus the three additional technologies shown in the second panel of Table 1. The 1991 list includes all of the technologies from the 1983 and 1987 lists and adds the technologies shown at the bottom of Table 1. The second and third columns of Table 1 show the percent of hospitals with each technology in 1987 and 1991.

Using the 1987 and 1991 lists, we computed two more index values for each hospital, which we term "Index 87" and "Index 91." Mean values for these indices are shown in Figure 2. The mean of the 1987 values of Index 87 is 4.5, as opposed to 3.6 for Index 83, reflecting the addition of technologies to the 1987 list. Between 1987 and 1993, the mean value of Index 87 grows to 4.9 as additional hospitals add technologies on the list. The 1991 mean value for Index 91 is 4.8, and the mean grows over time, reaching 5.1 by 1993.

3. The Relationship Between HMO Activity and Technology Index Values

To examine the relationship between managed care activity and technology availability in markets, measured by our indices, we identify a set of Metropolitan Statistical Areas (MSAs) in which hospitals provided technology information, excluding MSAs that had missing technology information for one or more years. This left 261 MSAs for analysis. The MSAs included in the analysis tend to be larger, have more hospitals, and have higher HMO market shares than the MSAs that were excluded. We computed the mean yearly value of the technology indices for each of the 261 MSAs.

We then classified MSAs into high and low HMO groups based on their 1993 HMO market share. The group of high-HMO cities consists of the top quartile of cities, as ranked by HMO market share. The group of low-HMO areas consist of all other areas. High-HMO cities had market shares of at least 19.3% in 1993.

Categorizing areas using 1993 HMO market share accomplishes two things. First, it identifies markets that tend to have high HMO market shares for the entire study period. Other analyses show that the correlations between HMO market share in the early 1990s and market shares for years ranging as far back as 1983 are high (Baker, 1998). Second, areas with high HMO market shares in the early 1990s also generally had a high level of growth in HMO market share after 1983 (Baker, 1998). So, the areas we define as high HMO areas tend to have had relatively high market shares and high levels of growth over the entire study period. Low market share areas will tend to have had low market shares and growth rates.

The estimates of HMO market share on which we rely were constructed using published data from the Group Health Association of America (now the American Association of Health Plans) on the total enrollment and county service area of each HMO operating in the United States. Estimates of total enrollment in each county in the U.S. were computed by apportioning the enrollment of each HMO among the counties in its service area, based on area population and distance from HMO headquarters (Baker, 1995, Baker, 1997). The county-level estimates were then aggregated to form estimates for each MSA.

To examine the relationship between city HMO market share and the technology indices, we estimated regression equations that explain a city's mean technology index value as a function of its HMO market share and a set of control variables. HMO market share effects are captured using a dummy variable for areas with high HMO market shares. The high HMO market share dummy is interacted with dummy variables for each year to measure separate effects of HMOs in each year. The other control variables are: (1) demographic measures, including the log of population, the log of population per square mile, per capita income, and the percent of population over age 65; (2) characteristics of the health care system, including the log of the number of physicians per capita, the log of the number of hospital beds per capita, the mean number of hospital admissions per capita, and the coefficient of variation of admissions per capita; and (3) characteristics of area hospitals, including the number of hospitals with a residency program, the number affiliated with a medical school, the number that are COTH members, the proportion of hospitals that are members of a health system, the proportion that are for-profit, the proportion that are government-owned, and the average distance between hospitals. A set of year dummy variables controls for trends in technology availability over time.

Results from estimating this regression with Index 83 as the dependent variable are displayed graphically in Figure 3, which plots predicted values for the mean of Index 83 for low and high market share areas, controlling for the set of confounding factors listed above. In the early 1980s, low HMO market share areas had lower index values than high market share areas. But, the difference diminished over time so that by 1986, high and low market share areas were essentially the same. After 1986, low market share areas had higher index values for most of the years. While these results suggest different general patterns of technology growth in high and low market share areas, none of the year-by-year differences between high and low market share areas are statistically significant.

Figure 4 presents results for Index 87. Here, the mean technology index value for the high market share areas is always less than that for the low market share areas, but the growth rates for high and low areas are similar. The difference between the high and low market share areas is statistically significant in 1989, and insignificant in the other years. Figure 5 presents results for Index 91. High HMO market share areas again are always below low market share areas, and both appear to be increasing at similar rates over the short time period examined. None of the year-by-year differences for Index 91 are statistically significant.

In some ways, these results suggest the possibility of an HMO effect. High market share areas may have had higher index values in the early 1980s, but by the later 1980s and through the early 1990s high market share areas had lower index values. The differences in the early 1980s are not statistically significant. On the other hand, the results suggest that managed care has not slowed the growth of technology in recent years--results for Index 87 and Index 91 both indicate that index values increased as rapidly in high market share areas as in low market share areas.

One issue that may complicate this analysis is hospital closure. The closure of hospitals with relatively few technologies would tend to raise the average index and vice versa. If there are different rates of hospital closures across areas with high and low HMO market shares, we could misestimate the effects of HMOs. In our data, the mean number of hospitals per MSA falls by about 9% between 1983 and 1993 in high HMO market share areas but only about 3% in low market share areas. If the hospitals that closed in high market share areas were disproportionately low-technology hospitals, this would artificially inflate the mean index value and would cause us to understate the technology-reducing effects of HMOs. We experimented with adding control variables for the number of hospitals in markets and for a range of other hospital characteristics to the regression equations, and found that this did not change our conclusions. We interpret this as evidence that differential rates of hospital closure do not have a strong influence on our findings.

4. HMOs and Technology Dispersion Across Hospitals

In addition to influencing the mean level of technology availability, it is possible that managed care shifts the distribution of technologies across hospitals. Managed care could prompt regionalization of services by encouraging the consolidation of high-tech services into relatively few high-level medical centers that receive referrals from other hospitals. On the other hand, if hospitals perceive the need to compete for managed care contracts through technology adoption, managed care may promote more evenly distributed technological development across hospitals.

To examine whether HMO market share is associated with the dispersion of technologies across hospitals, we computed the coefficient of variation of our technology indices within 254 MSAs that had more than one hospital. The coefficient of variation is defined as the standard deviation of the technology index divided by its mean. A high coefficient of variation in a market suggests that the technology levels of hospitals in that market vary widely, with some hospitals having high index values and others having lower index values. Low coefficients of variation indicate markets in which hospitals have similar levels of technology.

Figure 6 graphs the distribution of the coefficient of variation for Index 83 across markets in 1983. The coefficients of variation range from 0.05 to about 1.75. Mean coefficients of variation are quite stable over time. For Index 83, the mean coefficient of variation ranges from

0.42 to 0.45 between 1983 and 1993. Means for Index 87 and Index 91 are about 0.52 and 0.54, respectively.

To see whether HMO market share is associated with variation in the coefficient of variation we estimated regression equations analogous to those described above that explain the coefficient of variation as a function of HMO market share. In general, we found no relationship between HMO market share and the dispersion of technology index values within markets. Results using Index 83 are presented graphically in Figure 7. Low market share areas started with somewhat higher coefficients of variation in 1983. Between 1986 and 1992, high market share areas have slightly higher coefficients of variation, and the coefficients are nearly identical in 1993. There are no statistically significant differences between high and low HMO areas.

It appears that managed care did not encourage regionalization of medical services, as evidenced by the lack of differences in the coefficients of variation. It is possible that managed care contributed to the regionalization of some services within particular hospitals, but regionalized different services into other hospitals.

5. <u>The Role of Hospital Competition</u>

One factor that could influence the ability of managed care to affect technology availability is hospital competition. HMOs might have less bargaining power in markets with a few dominant hospitals than in markets with many competing hospitals. Hospitals also might compete more aggressively for contracts with insurers in more competitive markets. This competition could take the form of either lower prices or a medical arms race.

We explored this by computing a Hirschman-Herfindahl index, a common measure of the degree of competition in a market (Tirole, 1990), for hospitals in each city. We then divided cities into two categories based on their 1990 Hirschman-Herfindahl index: highly competitive cities are those with Hirschman-Herfindahl indices in the lowest quartile (Hirschman-Herfindahl indices are scaled so that lower values represent higher levels of competition), and all others were grouped as less competitive cities. We added this variable to our models independently and interacted it with the HMO market share dummy variable in each year to see if the effects of HMOs varied by the level of hospital competition. Our results did not show any consistent relationships between HMO market share, hospital competition, and technology growth, and we do not present the details here. The fact that the effects of managed care on technology adoption that we observe were generally uniformly distributed across markets with varying amounts of hospital competition suggests that hospital competition is not a strong determinant of the ability of managed care to influence hospital technology availability.

One should note that HMO market share and hospital competition may be closely related, since HMOs may influence the behavior of hospitals and hospital competition may influence the decisions HMOs make about entry into markets. Since these two variables probably are correlated, our regression analyses may not be able to accurately determine the separate contribution of HMOs and hospital competition.

6. Variation in the Effects of HMOs on the Availability of Individual Technologies

The extent to which variations in technology indices represent changes in each of the underlying constituent technologies can help one interpret information obtained from technology indices. For the question we examine here--the effect of HMOs on technology availability--it is quite possible that the effect of managed care varies from technology to technology. When deciding whether or not to adopt a new technology, we expect that hospitals and other providers will compare the costs and benefits of the new technology, and adopt if the benefits exceed the costs. An important benefit of adopting a new technology is the profit that can be generated by offering the new service. Profits depend on demand for the service, the price that can be charged, and the broader benefits that may accrue if adoption increases the standing of the hospital in the eyes of consumers or improves the hospital's bargaining position in negotiations with health plans.

Managed care can influence the profitability of adopting a new technology in a number of ways. Most importantly, managed care may change demand for services. Managed care organizations have a strong incentive to minimize costs, which may lead them to identify and support services that have high benefit-to-cost ratios. If they are adept at steering their patients toward cost-effective services and away from cost-ineffective services they will change the demand for some technologies. The extent to which demand changes will vary with the cost effectiveness of the services produced by the technology in question.

Managed care organizations also may influence technology availability through negotiation processes. Since managed care organizations typically prefer to contract with hospitals that have low costs and high quality, hospitals may prefer to adopt technologies consistent with these characteristics. Thus, variation in the costs and perceived quality of technologies may drive variation in the effect of managed care on them.

As part of this project, we examined a number of individual technologies in addition to our indices. These analyses suggested that there can be substantial variations in the effects of managed care across technologies. To illustrate, we report results for three technologies here. Cardiac catheterization is a widely practiced diagnostic procedure in which a small tube is threaded into coronary arteries to view their condition. This technology diffused into hospitals during the 1980s and 1990s. We counted the number of hospitals with cardiac catheterization facilities in each MSA in our sample and estimated a regression equation in which the dependent variable was the number of hospitals with cardiac catheterization and the independent variables were all of the control variables described above. From the regression results, we computed the predicted number of cardiac catheterization units in high and low HMO market share cities over time, holding the values of the other control variables fixed. The results are shown in Figure 8. High HMO market share areas had fewer cardiac catheterization units through the 1980s, but availability in high HMO market share areas grew more rapidly. By the early 1990s, high HMO cities had more hospitals with cardiac catheterization units than cities with lower market shares. The difference between high and low market share areas is statistically significant in 1992 and 1993.

Next, we present results from our examination of the presence of level 3 neonatal intensive care units (NICUs). Neonatal intensive care is a hospital unit with a range of high-technology equipment designed to provide care for premature and high risk infants. Level 3 NICUs are the most advanced type of NICU. Neonatal intensive care was developed in the

1960s and diffused rapidly in the 1970s and 1980s. The results of our regression analysis are displayed graphically in Figure 9. Availability of level 3 NICUs fluctuated over time, but there are no statistically significant differences between high and low market share areas.

Diagnostic radioisotope units are used to obtain information about the structure and function of organs by tracing radioactive isotopes that have been consumed by or injected into a patient. This technology had completed its diffusion into hospitals by about 1980. Regression results are displayed in Figure 10. High market share areas started with statistically significantly more units in the early 1980s, but the number of units contracted over time in high market share areas, so that there was no difference in availability by the late 1980s.

We do not intend for these brief analyses of individual technologies to be the final word on the diffusion of cardiac catheterization, neonatal intensive care, or diagnostic radioisotope technology; more careful studies are clearly possible and have been undertaken (e.g., Cutler and McClellan, 1996). Rather, we wish to use the results to demonstrate that results for individual technologies can differ from results obtained using the aggregated index data and that care should be exercised when extrapolating evidence about the effects of managed care on individual technologies from aggregate measures. While we may be able to draw conclusions from indices about general technology availability, and this information may be appropriate for use in some situations, the conclusions may not apply to every technology.

In addition, variation in the effect of HMOs on individual technologies demonstrates the difficulty of drawing conclusions about the impacts of managed care on patient well-being from information about aggregate technological change. Since individual technologies may have unique welfare effects, the interaction between managed care, technology availability, and patient welfare must be assessed one technology at a time to determine the net effect of managed care on consumer welfare.

7. <u>Conclusions and Policy Implications</u>

Our main intent in this paper was to examine the effects of managed care on technology availability using aggregate index data. In our results, managed care may have had some effect on technology availability in the early and mid 1980s. Areas with high HMO market shares had the highest levels of our technology index in the early 1980s, but had index levels equal to, and in some cases less than, low market share areas in the late 1980s and early 1990s. On the other hand, high managed care areas did not have slower technology growth rates than low market share areas in the late 1980s and early 1990s, even when new technologies are incorporated into the indices.

An important policy question is the extent to which managed care can slow health care cost growth by limiting technology growth. We have not designed our technology index specifically to reflect high cost technologies (although it would be possible to build such an index), but we expect that identifying new and relatively rare technologies also captures technologies with high adoption costs to at least some degree. If so, our results provide conflicting evidence about the ability of managed care to contribute to cost savings by slowing the adoption of new technologies. The results from Index 83 suggest that managed care may have helped control the growth rate of new technology availability in the early 1980s, but results from the mid 1980s and early 1990s do not support this conclusion in that technology growth in high and low market share areas was not substantially different. One important caveat is that differential rates of hospital closure in high and low market share areas could have caused us to understate the technology limiting effects of managed care. Although our statistical analysis did not provide reason to believe that differential closure rates are a serious problem, it is possible that they exert some influence on our findings.

It is also important to note that our index can provide evidence only about cost savings that would result from reducing the costs associated with the adoption and installation of new technologies. Some new technologies increase the costs of caring for patients, and others might decrease patient care costs by taking the place of even more expensive technologies. We do not capture patient care costs in our analyses.

A second set of findings indicates that there is little relationship between HMO market share and variation in technology levels across hospitals within markets. This suggests that HMO activity is not associated with the concentration of specialized services in some hospitals, as is common in more regionalized health care systems. We also found no evidence of a relationship between hospital competition and the ability of HMOs to influence technology availability.

The interplay between managed care, hospital competition, the development of new technologies, and hospital decisions about the adoption of available equipment and services is quite complex. It is possible that we have not accounted for all of the confounding factors in our analyses here. It is also possible that we have not fully controlled for the possibility of reverse causality by which technology availability may influence HMOs' location decisions. While these results shed important light on questions about managed care and technology availability, additional work should examine these interactions more completely.

Finally, we conclude that analysis of technology indices can be valuable. Some questions call for aggregated answers, and indices can help provide them. But, as is common with aggregated data, important variations may be missed. The results we present for three individual technologies show three different patterns of HMO effects. This suggests that, while aggregated information about technology availability may be useful for some endeavors, aggregate analyses may also miss important variation at the level of individual technologies.

Table 1: Technologies Included in the Indices

	Percent of Hospitals with the Technology in		
	1983	1987	1991
Included in Index 83			
Ambulatory Surgery	78.2	82.9	81.4
Blood Bank	65.6	63.1	60.0
Cardiac Catheterization Lab	15.6	19.3	25.0
CT Scanner	33.6	51.8	62.4
Diagnostic Radioisotope	59.4	55.0	54.0
Emergency Medicine Department	84.6	83.1	80.5
Hemodialysis	22.5	23.9	23.3
Histopathology Lab	61.1	58.2	56.9
Megavoltage Radiation Therapy	14.4	15.2	16.4
Neonatal ICU	20.3	28.3	28.3
NMR/MRI	2.3	7.8	17.5
Open Heart Surgery	10.3	12.4	14.9
Organ Transplant	5.0	5.0	9.5
Radioactive Implants	20.2	20.6	21.0
Respiratory Therapy	83.5	82.0	79.9
Therapeutic Radioisotope	21.5	21.2	21.7
Ultrasound	69.9	74.9	73.5
X-Ray Radiation Therapy	15.8	15.3	16.2
Added to Index 87			
COPD Unit	---	58.3	58.5
Extracorporeal Shock-Wave Lithotripsy	---	3.2	6.1
Trauma Emergency Service	---	16.4	11.1
Added to Index 91			
Coronary Angioplasty	---	---	17.5
Non-Invasive Cardiac Assessment	---	---	52.9
Orthopaedic Surgery	---	---	65.2
PET Scanner	---	---	1.5
Stereotactic Radiosurgery	---	---	4.6
SPECT Scanner	---	---	19.8

Note: Percents are based on 6,506, 6,425, and 6,176 hospitals in 1983, 1987, and 1991, respectively.

References

Baker, Laurence C., "County-level measures of HMO enrollment and market share," manuscript, Stanford University, February, 1995.

Baker, Laurence C., "The effect of HMOs on fee-for-service health care expenditures: Evidence from Medicare." *Journal of Health Economics*, 16:4 (August, 1997) 453-482.

Baker, Laurence C., "Managed care and technology adoption in health care: evidence from magnetic resonance imaging," manuscript, Stanford University, January, 1998.

Berry, R.E., "On Grouping Hospitals for Economic Analysis." *Inquiry*, 10 (1973) 5-12.

Bryce, C.L. and K.E. Cline, "The supply and use of selected medical technologies." *Health Affairs*, 17:1 (January-February, 1998) 213-224.

Chernew, Michael, A. Mark Fendrick, and Richard A. Hirth, "Managed care and medical technology: implications for cost growth." *Health Affairs*, 16:2 (March/April, 1997) 196-206.

Chernew, Michael, Rod Hayward, and Dennis Scanlon, "Managed care and open-heart surgery facilities in California." *Health Affairs*, 15:1 (Spring, 1996) 191-201.

Cohen, H.A., "Variations in cost among hospitals of different sizes." *Southern Economic*

Journal, 33 (January, 1967).

Cutler, David and Mark McClellan, "The Determinants of Technological Change in Heart Attack Treatment," NBER Working Paper No. 5751, 1996.

Cutler, David M. and Louise Sheiner, Managed Care and the growth of medical expenditures, . 1998.

Edwards, Mary, Jon D. Miller, and Rex Schumacher, "Classification of community hospitals by scope of service: four indexes." *Health Services Research*, 7 (Winter, 1972) 301-313.

Feldstein, M.S., *Economic Analysis for Health Service Efficiency*. 1967, Amsterdam: North Holland.

Freudenheim, Milt. Health Insurers Seek Big Increases in their Premiums. *New York Times*, April 24, 1998.

Fuchs, Victor R., *Who Shall Live? Health, Economics, and Social Choice*. 1974, New York: Basic Books.

Hill, S.C. and B.L. Wolfe, "Testing the HMO competitive strategy: an analysis of its impact on medical resources." *Journal of Health Economics*, 16:3 (June, 1997) 261-286.

Levit, K.R., H.C. Lazenby, and B.R. Braden, "National health spending trends in 1996." *Health Affairs*, 17:1 (January-February, 1998) 35-51.

Luft, Harold S., James C. Robinson, D.W. Garnick, S.C. Maerki, and S.J. McPhee, "The role of specialized clinical services in competition among hospitals." *Inquiry*, 23:1 (Spring, 1986) 83-94.

McLaughlin, Catherine G., "Market responses to HMOs: Price Competition or Rivalry?" *Inquiry*, 25 (Summer, 1988) 207-218.

Newhouse, Joseph P., "Medical care costs: How much welfare loss?" *Journal of Economic Perspectives*, 6:3 (1992) 3-21.

Newhouse, Joseph P., "An iconoclastic view of health cost containment." *Health Affairs*, 12:supplement (1993) 152-171.

Schwartz, William B., "The inevitable failure of current cost containment strategies: Why they can provide only temporary relief." *Journal of the American Medical Association*, 257:2 (January 9, 1987) 220-224.

Schwartz, William B., "In the Pipeline: A wave of valuable medical technology." *Health Affairs*, 13:3 (Summer, 1994) 70-79.

Tirole, Jean, *The Theory of Industrial Organization*. 1990, Cambridge, MA: MIT Press.

Weisbrod, Burton, "The health care quadrilemma: An essay on technological change, insurance, quality of care, and cost containment." *Journal of Economic Literature*, 29 (1991) 523-552.

Winslow, Ron. Back in Trouble: Health-Care Inflation Revives in Minneapolis Despite Cost-Cutting. *Wall Street Journal*, May 19, 1998.

Zwanziger, Jack and Glenn A. Melnick, "Can managed care plans control health care costs?" *Health Affairs*, 15:2 (Summer, 1996) 185-199.

ENDNOTES

1.There is also a related literature that examines whether or not patients enrolled in managed care organizations use new technologies differently than patients with other forms of insurance. This literature tends to find little or no difference between managed care and non-managed-care insurance (e.g. Chernew, Hayward, and Scanlon, 1996, and Chernew, Fendrick and Hirth, 1997). However, this finding does not imply that managed care should not have an effect on system-wide technology availability, which is the focus of this paper.

2.The literature does not uniformly support this view. One recent case study by Bryce and Cline (1998) suggests that market incentives have not ameliorated an oversupply of extracorporeal shock wave lithotripsy, magnetic resonance imaging, cardiac catheterization, organ transplantation, and neonatal intensive care in Pennsylvania.

3.This is not the only technology index that has been proposed. In other contexts, researchers have grouped hospitals according to the services available. For example, Berry (1973) classified hospitals into categories defined by the type of services provided: basic services, quality-enhancing services (e.g., pathology laboratory services, postoperative recovery units, pharmacies), complex services (e.g., physical therapy, intensive care), community services (e.g., occupational therapy, family planning), and special services (e.g., chaplaincy, tests unrelated to the admission provided routinely). Berry argues that hospitals evolve through these categories in the above sequence. More complex measures along these lines were used by Feldstein (1967) and Cohen (1967). These measures are relatively crude indices of technology availability, and we prefer the additional information available when considering more finely detailed categories.

Other authors have examined aggregate technology availability using Guttman scales (e.g. Edwards, Miller, and Schumacher (1972). The Guttman scale for hospitals is a unidimensional measure for which a higher value represents a broader and/or more sophisticated level of services. The scale is defined by a set of technologies and services that might be provided by hospitals, with rarer technologies being assigned higher Guttman values. The scaling assumes a sequential acquisition of technologies and services, and a hospital is assigned the Guttman score of the highest-scoring technology the hospital provides. Because it does not apply a potentially ad-hoc ordering of technologies and does not assume a sequential acquisition process, we believe that our index is a more robust measure of aggregate technology availability.

4.The AHA survey data on technologies almost certainly is subject to measurement error. In our analyses, for example, we encounter fluctuations in the reported presence of technologies within some hospitals that raise questions about the accuracy of the reporting. For this analysis, we accepted the data as reported on the survey.

Figure 1

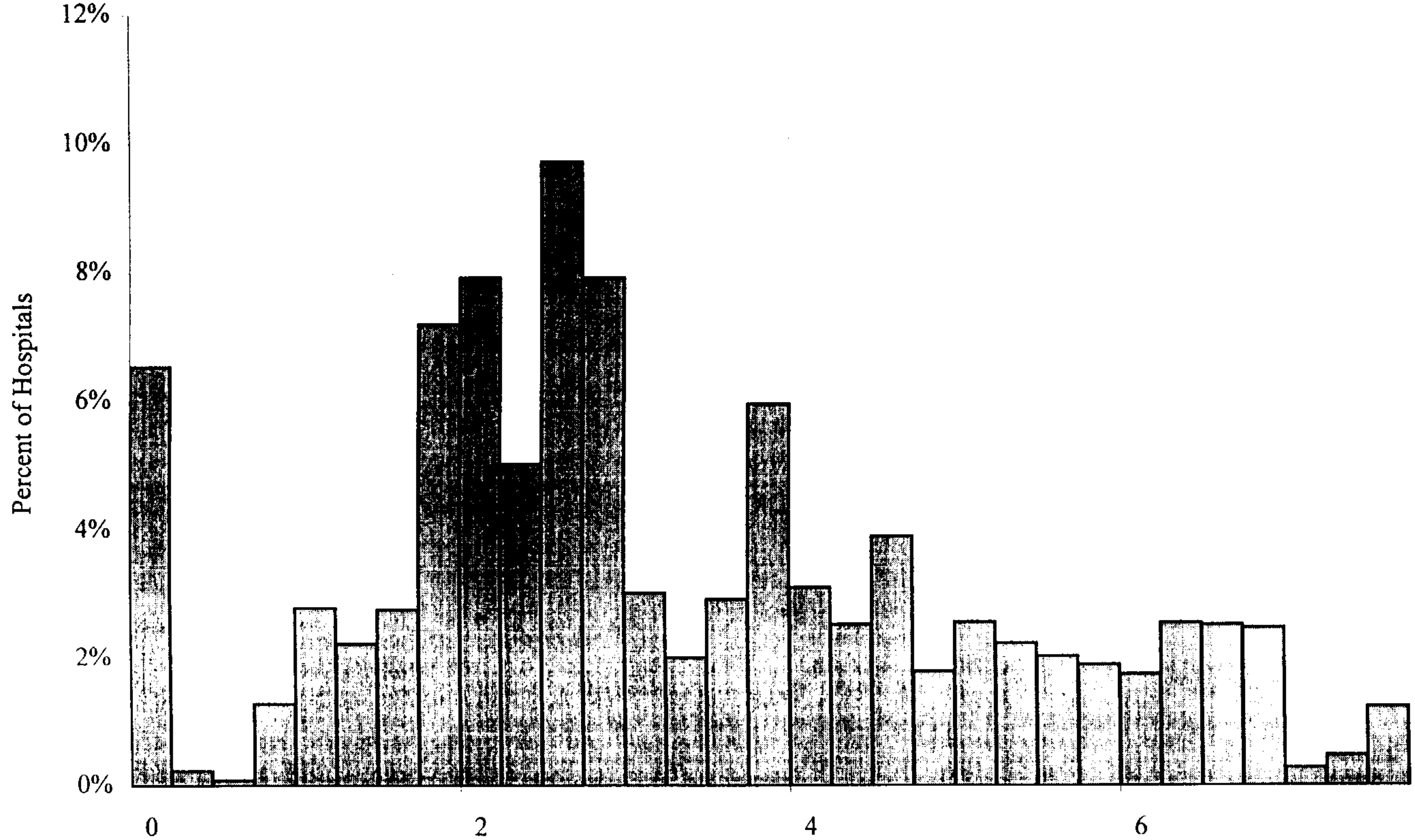


Figure 2

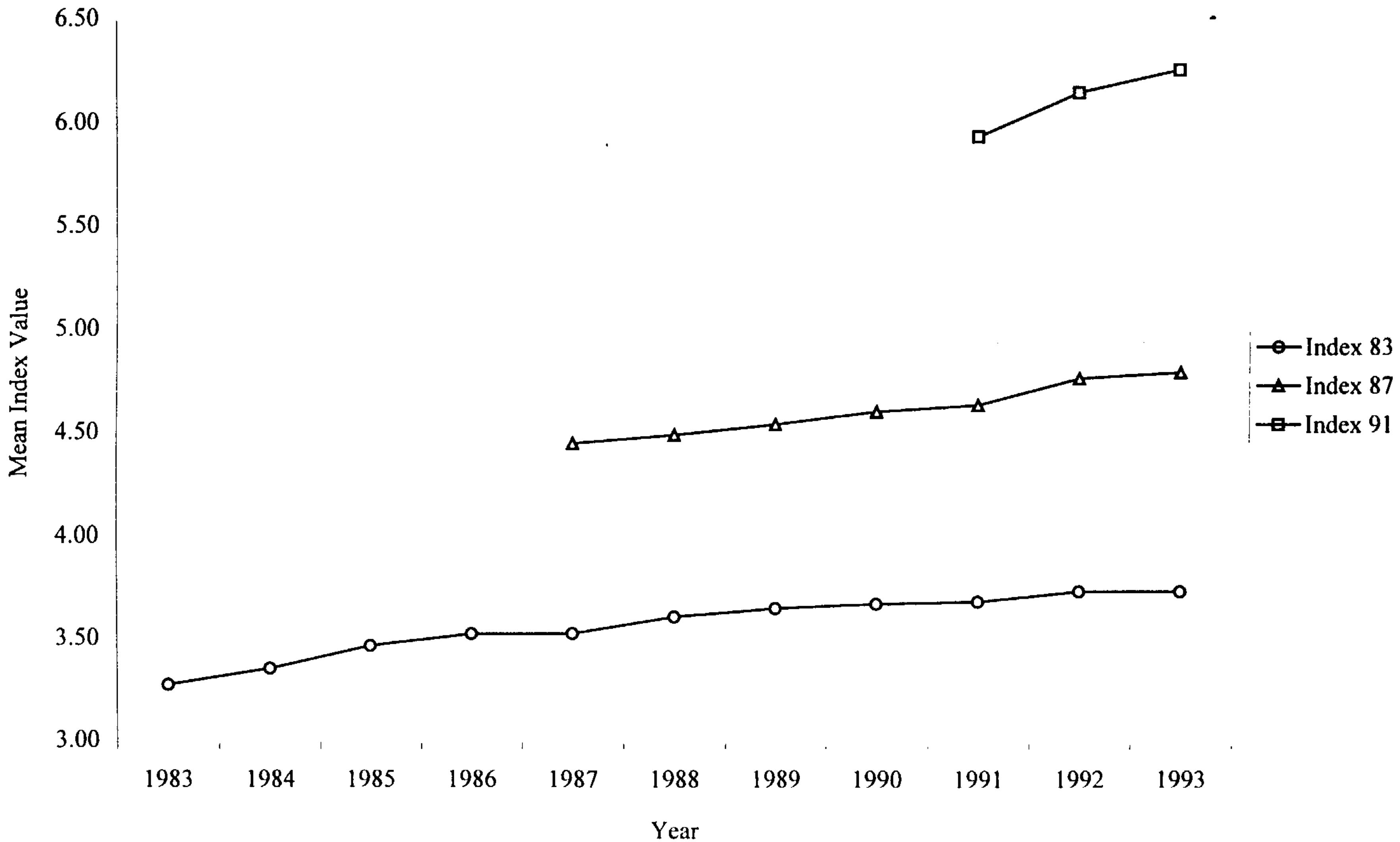

6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
Mean Index Value
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
Year
Index 83
Index 87
Index 91

Figure 3

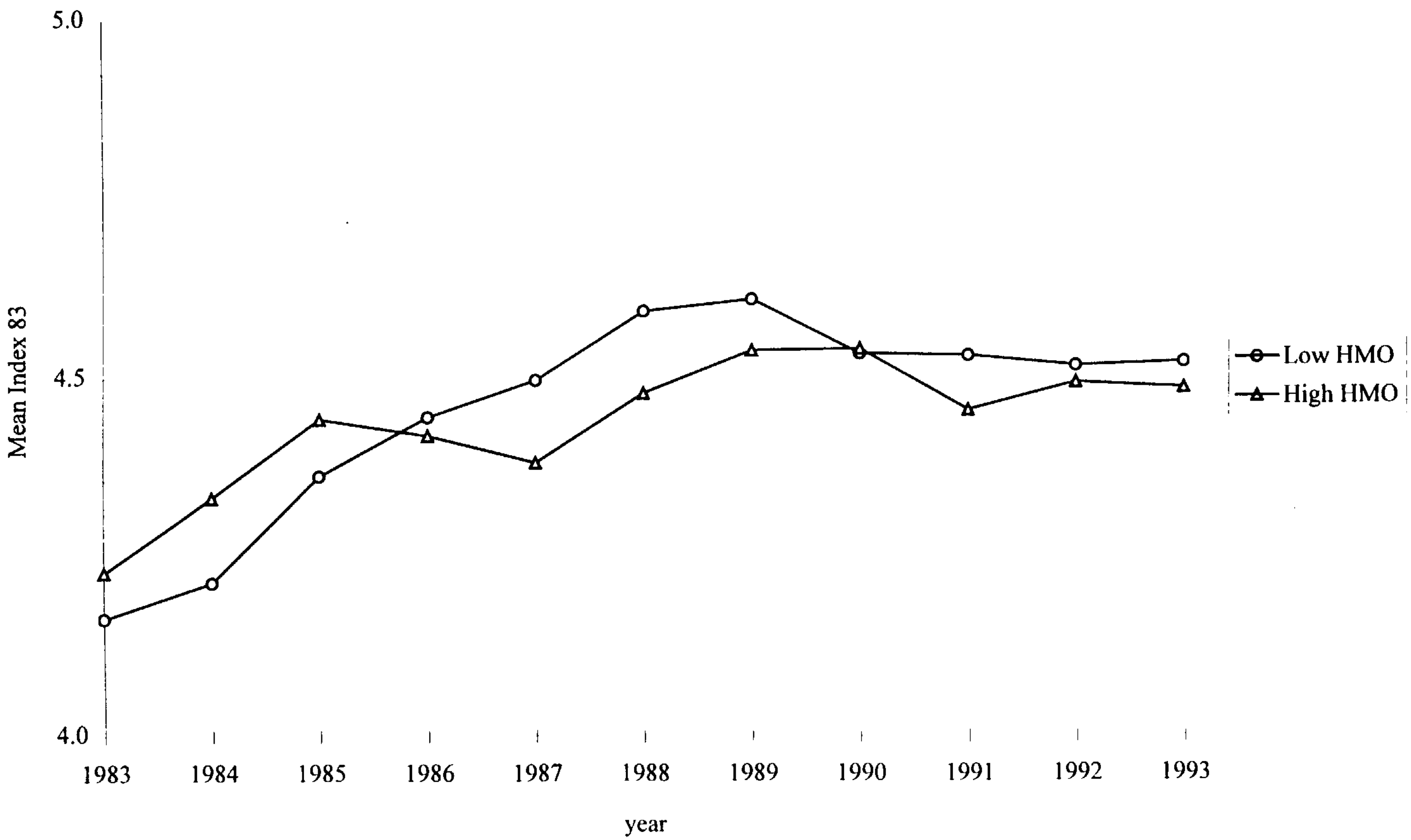

5.0
4.5
4.0
Mean Index 83
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
year
Low HMO
High HMO

Figure 4

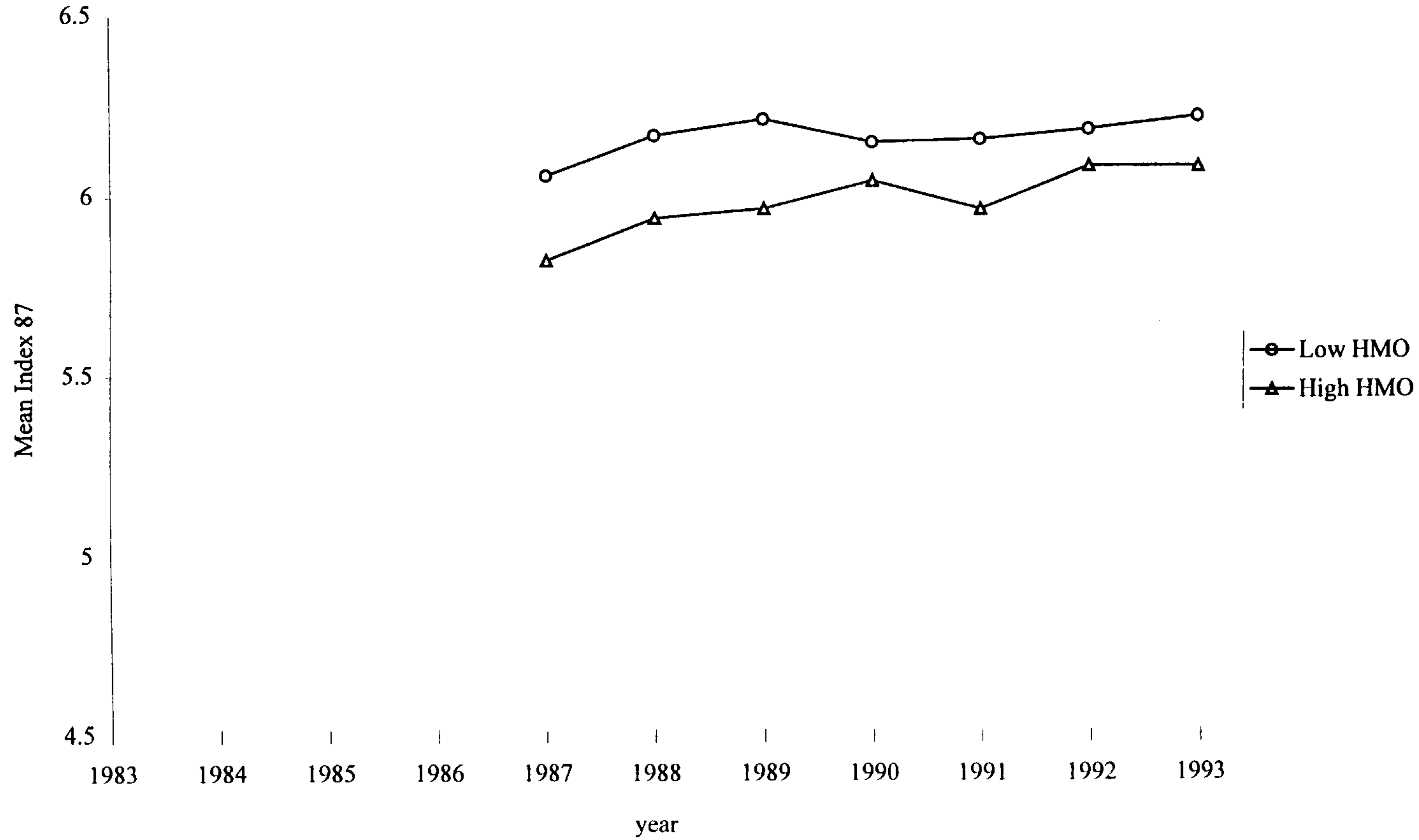
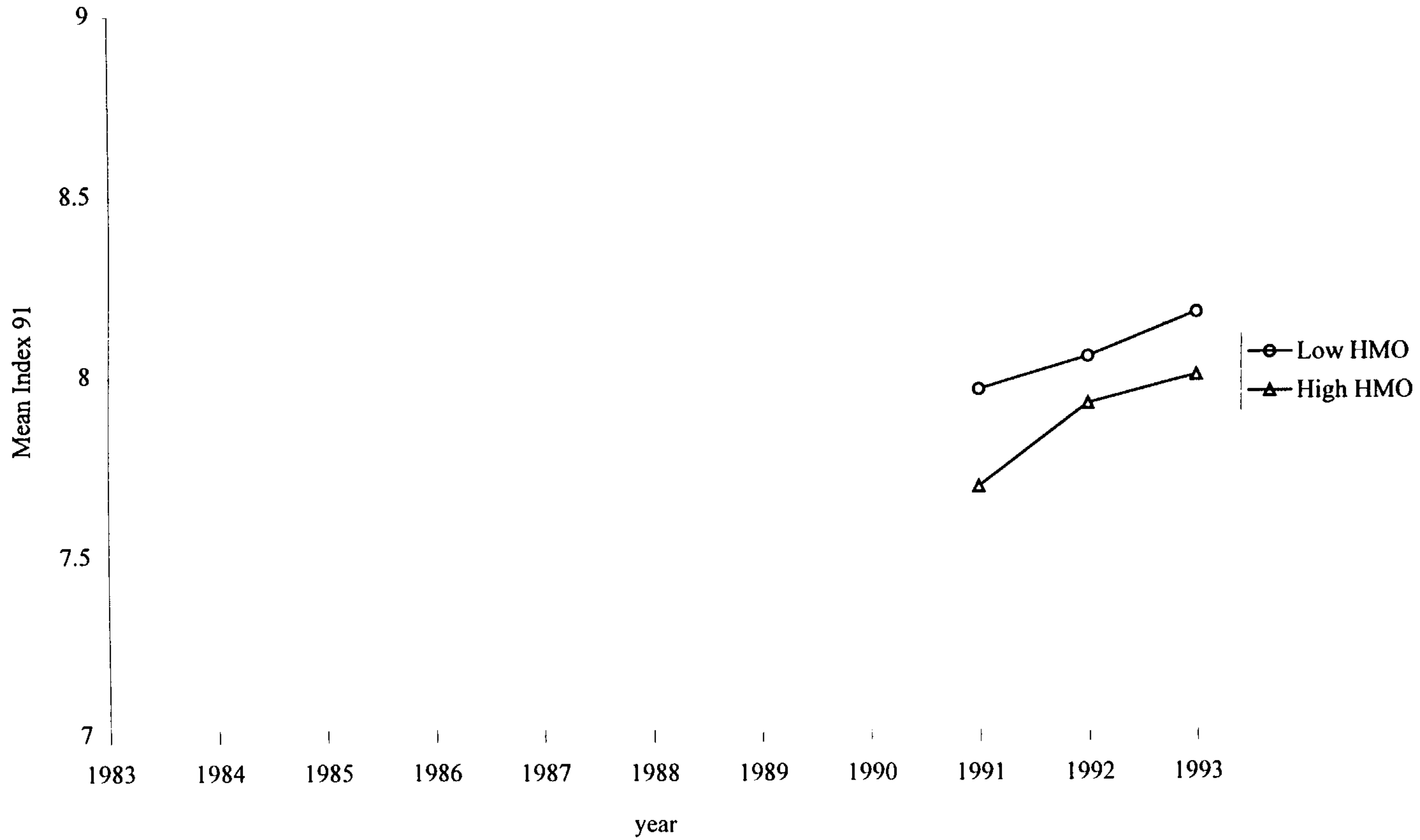
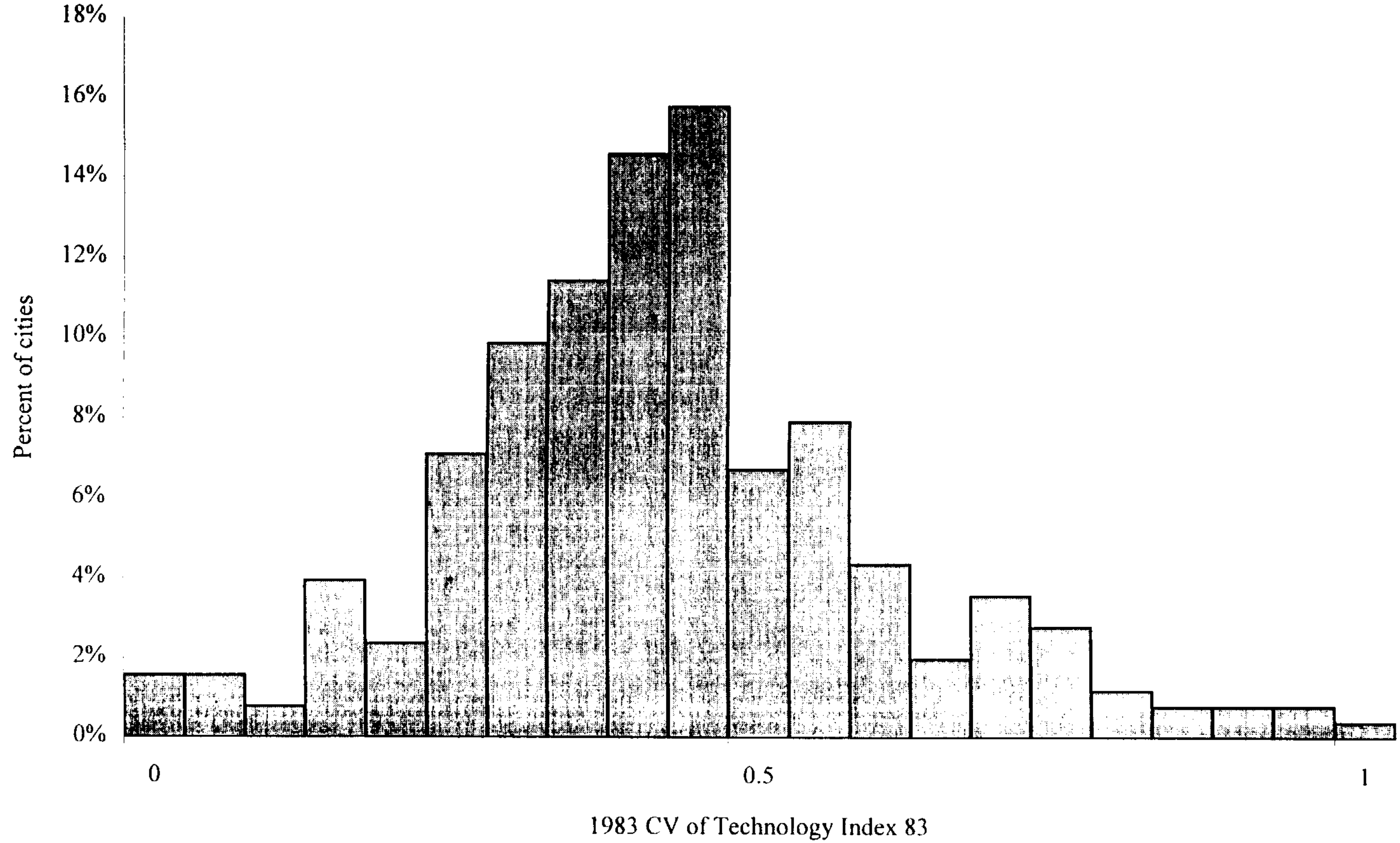

6.5
6
5.5
5
4.5
Mean Index 87
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
year
Low HMO
High HMO

Figure 5



Mean Index 91
9
8.5
8
7.5
7
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
year
Low HMO
High HMO

Figure 6



Percent of cities
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
0
0.5
1
1983 CV of Technology Index 83

Figure 7

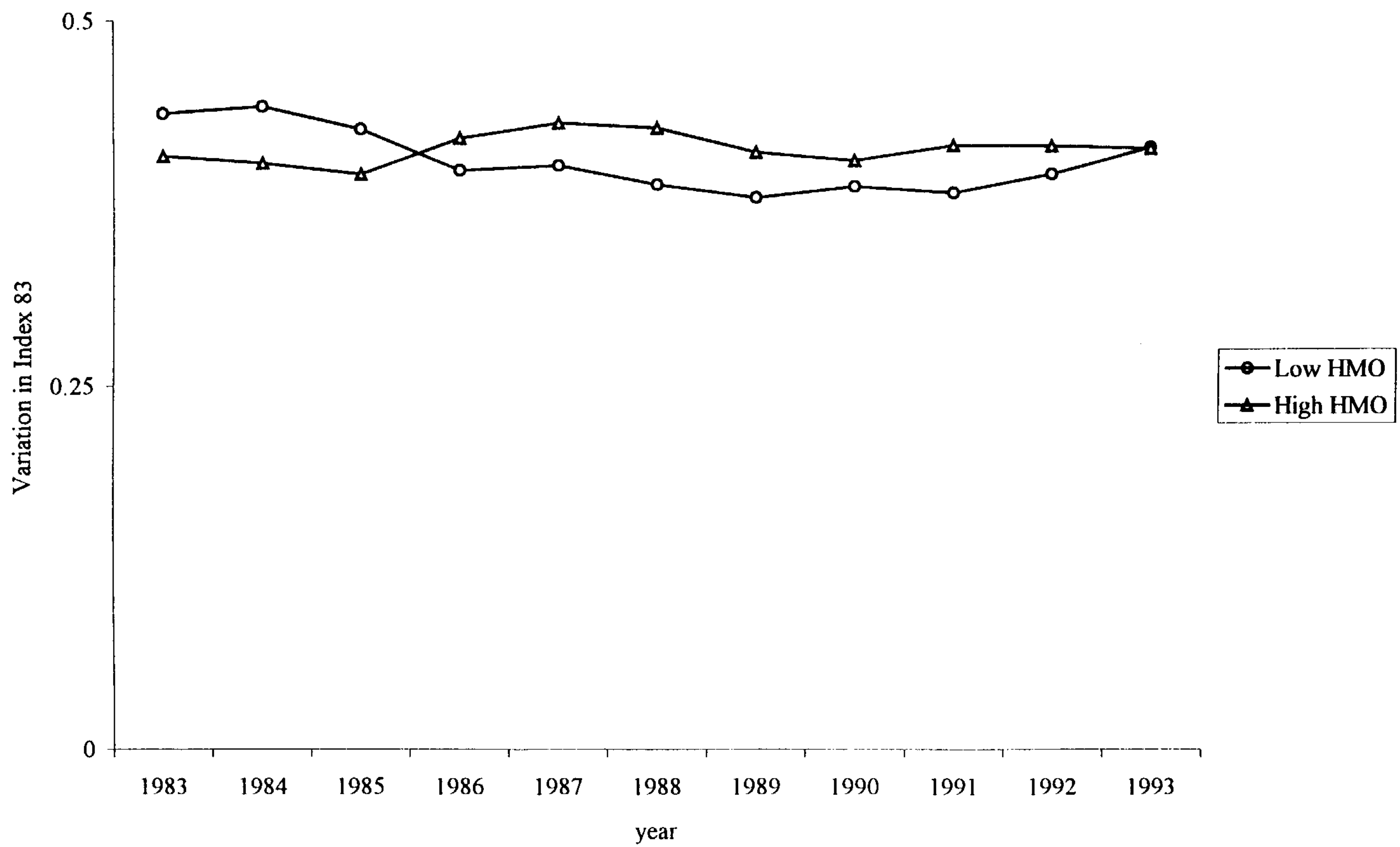

0.5
0.25
0
Variation in Index 83
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
year
Low HMO
High HMO

Figure 8

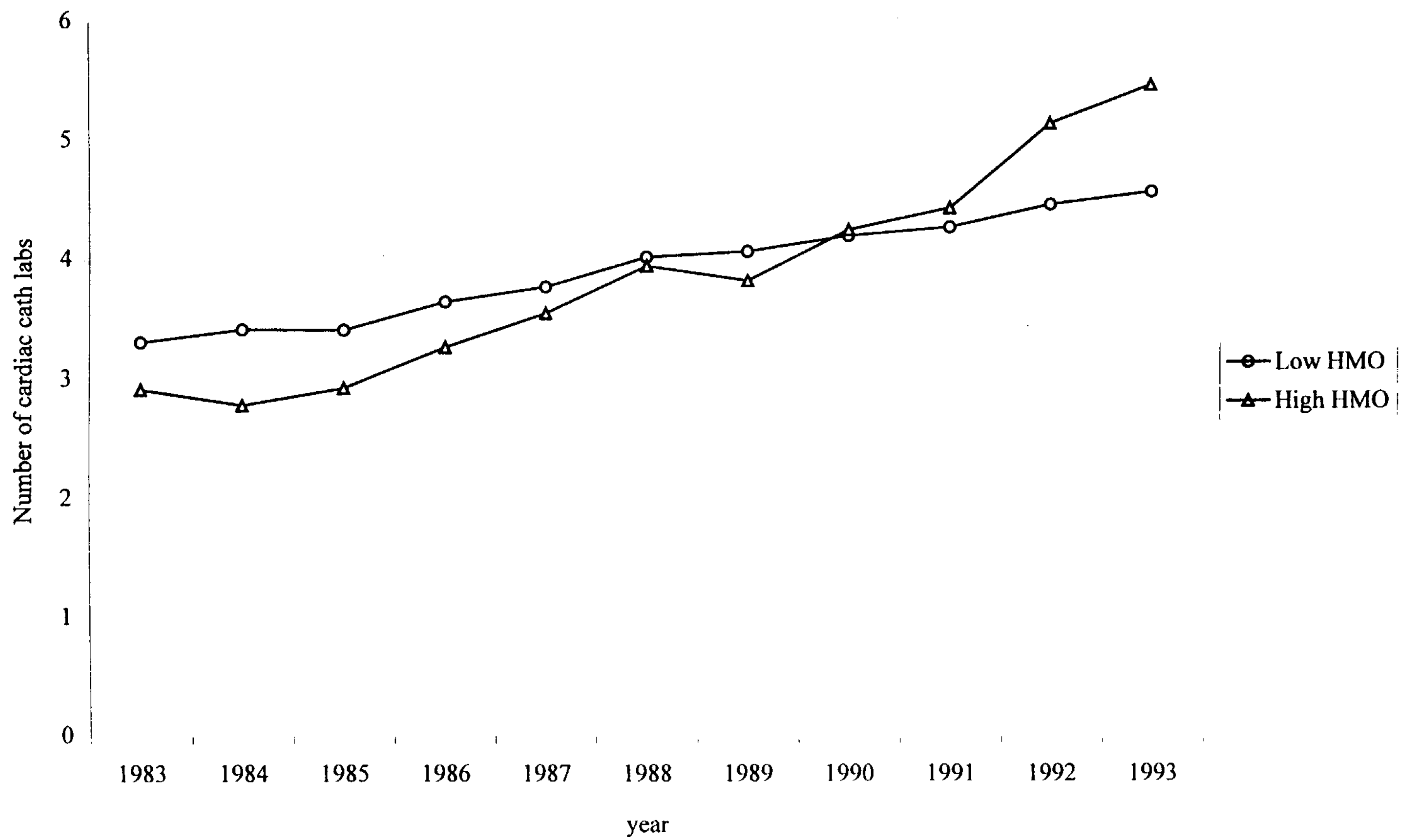

6
5
4
3
2
1
0
Number of cardiac cath labs
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
year
Low HMO
High HMO

Figure 9

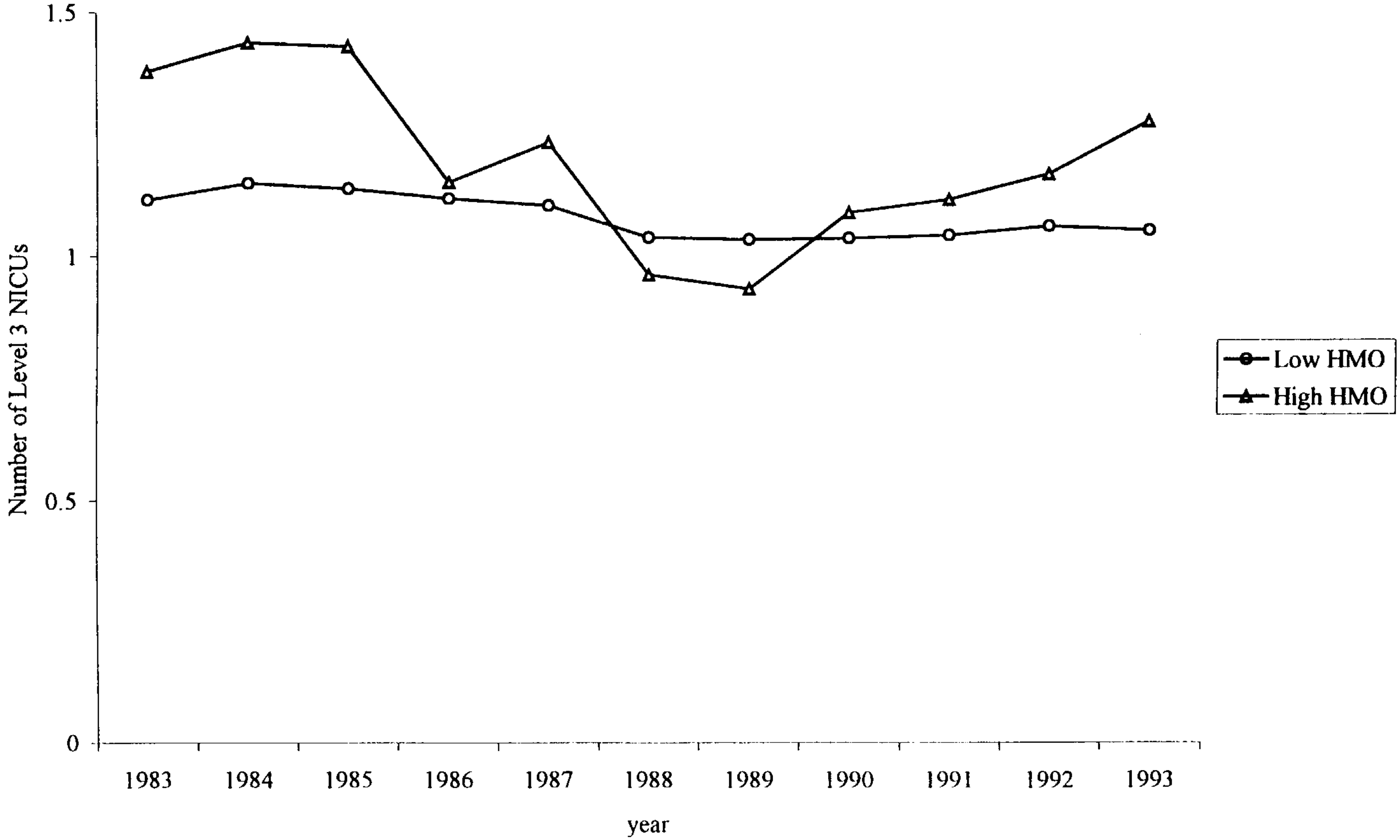
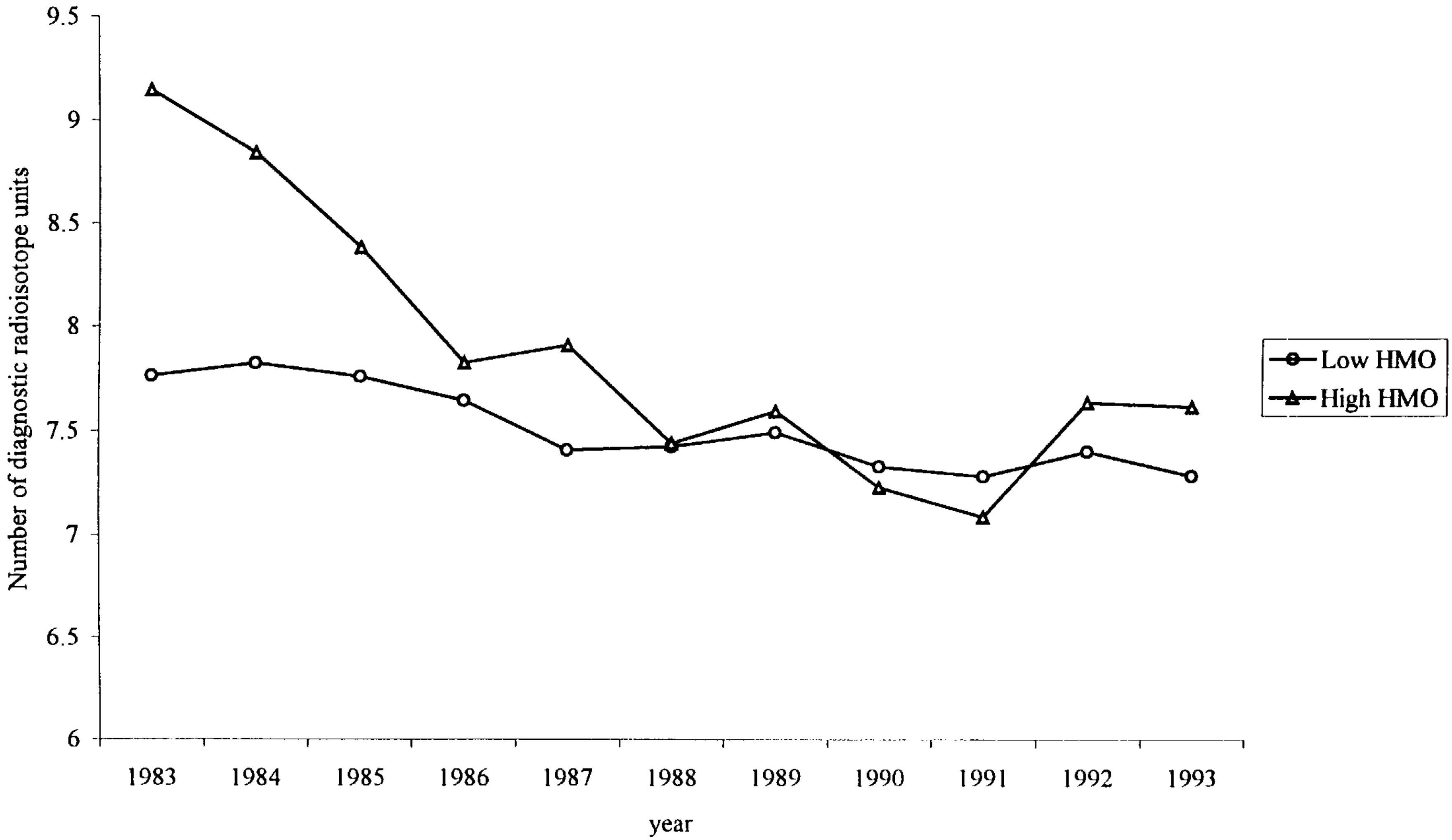

1.5
1
0.5
0
Number of Level 3 NICUs
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
year
Low HMO
High HMO

Figure 10


Number of diagnostic radioisotope units
9.5
9
8.5
8
7.5
7
6.5
6
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
year
Low HMO
High HMO