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The Health Care Quadrilemma: An Essay on Technological Change, Insurance, Quality of Care, and Cost Containment

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I. *Introduction*

DURING THE ROUGHLY FOUR DECADES since the end of World War II, the health care system in the United States has experienced historically unprecedented change in three dimensions. First, *new technologies* have revolutionized the ways in which health care is capable of being practiced. Almost all of today's armamentarium of disease diagnosis and treatment devices and techniques were unknown 40 years ago. In the case of prescription drugs, for example, about 10 percent of the 200 largest-selling drugs are new each year; and only 25 percent of the 200 top-selling drugs in 1972 remained in the group 15 years later (David Cleeton, Valy Goepfrich, and Burton Weisbrod 1990).

Second, *the role of health care insurance*—private and public—has expanded dramatically. By 1980, 82.5 percent of the U.S. population had some health care insurance, compared with fewer than 10 percent in 1940.[1]

Third, *personal health expenditures* have soared. From $300 per capita in 1950, they leaped to $1,493 in 1987 (all in 1982 dollars). The percentage of GNP

[1]Throughout the postwar period the expansion of private health care insurance has been spurred by federal tax policy. By making employer-financed health insurance nontaxable income to employees, federal policy distorted worker choice between health insurance and cash wages, encouraging excess health insurance (Martin Feldstein and Elizabeth Allison 1974; Mark Pauly 1974; Bridger Mitchell and Ronald Vogel 1975; Mitchell and Charles Phelps 1976; Amy Taylor and Gail Wilensky 1983; Howard Chernick, Martin Holmer, and Daniel Weinberg 1987).

devoted to medical care has almost tripled over that period—from 4 to 11 percent (U.S. Bureau of the Census 1979, p. 97; U.S. Bureau of the Census 1989, p. 90; Suzanne Letsch, Katherine Levit, and Daniel Waldo 1988).

This paper explains how the expansion of health care insurance has paid for the development of cost-increasing technologies, and how the new technologies have expanded demand for insurance. My goal is less to review the vast literature on the health care system and the rising level of real expenditures on it, than to reflect on the dynamic interplay of incentives for the R & D sector to develop particular kinds of new technologies, the role of the insurance system in that process, and, reciprocally, the long-run effects of new technologies (any new knowledge about health care) on the character of the health care insurance system. The broad model outlined here highlights the ways in which the quality of health care that is technically feasible to supply at any point in time, and the breadth of access to that care, influence each other and the aggregate level of health care expenditures, but the model is not fully specified, nor is it tested rigorously. Thus, this essay should be seen as a personal interpretation—largely positive, rather than normative, in character—of a period of enormous growth and massive change in both the practice and finance of health care.

The central focus on technological change—as an independent variable causing changes in the form and extent of insurance coverage, and as a dependent variable, being influenced by incentives operating through the health insurance system—highlights the impact of incentives; both the pace and types of research and development are functions of rewards that are endogenously variable, as are the comprehensiveness of insurance coverage and the breadth of access to it.[2] The following propositions are set forward: (1) The amount of resources going into the R & D process, and its direction, during some time interval, depend in part on the mechanisms expected to be used to finance the provision of health care in future periods, when the fruits of the research process become marketable. This is simply to say that R & D is influenced by expected utilization, which depends on the insurance system. Reciprocally, (2) the demand for health care insurance depends, in part, on the state of technology, which reflects R & D in prior periods. These relationships help to explain why (3) long-run growth of health care expenditures is a by-product of the interaction of the R & D process with the health care insurance system.[3] I also examine briefly some effects of alternative forms of health care insurance on the quality of care, as distinguished from its quantity, and long-run changes in the definition of "health care" under insurance, as endogenous R & D alters the menu of technically feasible measures.

To understand the markets in which health care is provided and financed, it is useful to consider ways in which health care differs from most other commodities. First, it sometimes involves the preservation of life, or, at least, major effects on the quality of life. Second, it is a technically complex commodity that abounds with informational asymmetries, adverse to consumers (Kenneth Arrow 1963; George Akerlof 1970; Richard Titmuss 1971). Third, and as a result of

[2] Other effects of health insurance, particularly on incentives for utilization of health services, have received considerable attention. For a recent and valuable review see Pauly (1986).

[3] Other forces also affect health care expenditures. Rising real income appears to have a positive effect on demand for health care; an income elasticity of +0.2 (or less) has been estimated from the Rand health insurance experiment (Willard Manning, et al. 1987).

these two characteristics, "nonmarket" (governmental and private nonprofit) suppliers in the health care sector, especially among hospitals, nursing homes, and blood banks, play a large role in influencing the interaction between insurance and R & D.[4]

Because health care affects length and quality of life, many societies have come to accept the normative proposition that "high"-quality care ought to be made available widely, regardless of an individual's ability to pay. This assignment of property right—the breadth of which is under continuing debate—results in pressure on government to finance access to some health care redistributively. In the U.S., private market financing of health care, by individuals and employers, has been supplemented by governmental resources—particularly through the Medicare and Medicaid programs—and to a smaller extent, through private charitable activities.

Another reason—in addition to providing widespread access—for society's willingness to intervene in private health care markets is the substantial informational asymmetries, which give rise to economic and political demands for consumer protection (Arrow 1963; Weisbrod 1978, 1989; Henry Hansmann 1980). The claims that physicians "induce" demand (Arrow 1963; Robert Evans 1974; Gail Wilensky and Louis Rossiter 1983; Rossiter and Wilensky 1984; Uwe Reinhardt 1985; Jerry Cromwell and Janet Mitchell 1986; Miron Stano 1987), that they engage in "defensive medicine"—diagnostic testing and other practices that have no expected benefits for patient health but are defenses in "malpractice" suits (Mohan Garg, Werner Gliebe, and Mounir Elkhatib 1978; Stephen Zuckerman 1984; Patricia Danzon 1985)—and that they perform "unnecessary" surgery[5] may or may not be valid; they are plausible, however, only if physicians are better informed than their patients (Pauly 1979) and do not act as perfect agents.[6] The importance of health care to life and well-being, combined with the limited ability of consumers to make well-informed judgments about quality of care, and with imperfect agency relationships with physicians may help to explain why consumers of health care rely upon public and private nonprofit institutions to an unusual degree.

The remainder of the paper proceeds as follows: Part II contains a brief outline of the recent history of the health care sector in the United States—its evolving technology, changing insurance/finance system, increasing level of real health care expenditures, and the advent of cost control measures. Part III shows how the constellation of services included in "health care" is endogenous, being affected by the interaction of the insurance system and the R & D process. Part IV focuses on the effects of R & D (technological change) on the health care insurance system. Part V looks at the reciprocal effects of the insurance system on the R & D sector. Part VI deals with the effects of alternative insurance systems on quality of care, with the state of technology fixed, and Part VII summarizes and points up some possible generalizations beyond health care.

Finally, examining these interdepen-

[4] Some readers may prefer the term *nonprofit* to *nonmarket*. Whatever term is used, the point is to distinguish private, profit-oriented organizations from the institutions of either government or the private nonprofit sectors. To be sure, government and private nonprofit organizations operate in "markets," in the sense that exchange occurs.

[5] A congressional subcommittee estimated that in 1977 there were 2 million unnecessary operations, at a cost of $4 billion and with a loss of 10,000 lives ("Elective Surgery: Cut it Out" 1979).

[6] Operationalizing the concepts of "induced" demand, "defensive" medicine, and "unnecessary" surgery—each of which reflects a market failure to the extent it occurs—poses serious problems. These issues, however, are beyond the scope of this paper.

dent relationships may help to explain some of the differences across countries in financing of health care and their roles in health care R & D, for the forces at work are not uniquely North American and the policy implications can be generalized. The U.S. is unusual, however, in the extent to which its actions as a producing and a consuming country influence the rate and direction of health care R & D. No other country is so major an actor in both the R & D (producing) sector and the health care (consuming) sector. For most other countries, outputs of the R & D sector are essentially exogenous to their methods of financing health care, and their systems of health care finance are also essentially exogenous to their own R & D activities. Switzerland, for instance, is a substantial producer of health care R & D (especially pharmaceuticals), but it is a small consumer; the United Kingdom and Japan, although they are not trivial elements in the R & D sector, are larger consumers of the outputs of that sector.[7] It is the enormous size and therefore impact of both the producing and consuming elements in the United States that make it such a fine subject for study.

II. *A Brief Recent History of Health Care in the United States: Technological Change and the Growth of Insurance Coverage*

One striking aspect of change in the U.S. health care system since World War II has been the dramatic increase in knowledge of means for diagnosing and treating illness. Fifty years ago, physicians were little more than diagnosticians, their activities being essentially "limited to identification of . . . illness, the prediction of the likely outcome, and then the guidance of the patient and his family while the illness ran its full, natural course" (*Report of the President's Biomedical Research Panel* 1976, appendix A, p. 3). Today, the scope of effective interventions includes kidney dialysis, organ transplants, polio vaccines, arthroscopic surgical techniques, CT scanners, nuclear magnetic resonators, in vitro fertilization. As recently as a decade ago, heart and liver transplants were virtually unknown, but their numbers have soared, from 62 and 26 in 1981 to 1,441 and 1,182 in 1987, respectively (U.S. Bureau of the Census 1989, table 166).

At the same time that the technology of health care has been changing so dramatically, the system for financing health care has also been revolutionized. In the quarter century between 1950 and 1973 alone, the share of health care expenditures that was met by insurance more than tripled, from 12 to 41 percent (U.S. Bureau of the Census 1975, table 105). The mix of private and governmental insurance also changed during that period; while total private expenditures on health and medical services were growing almost sixfold, from $8.7 billion to $59.8 billion (current dollars), government expenditures (Medicare and, to some extent, Medicaid) were leaping fourteenfold, from $2.5 billion to over $37 billion (U.S. Bureau of the Census 1975, table 100). Insurance coverage for "major" or "catastrophic" health care costs has also risen sharply, from 22 percent of the population in 1960 to 73 percent by 1984 (U.S. Bureau of the Census 1987, tables 1, 2, and 137).

Initially, most health insurance was of one particular type, covering a limited menu of only hospital services—perhaps after a small deductible—and paying ("reimbursing") the hospital for the particular services provided to a patient, the payment being equal to the "actual" average cost of treating that patient with

[7] For a broader, European, perspective on health care systems, see Organization for Economic Co-operation and Development (1990).

whatever technology was used (Rosemary Stevens 1989). Included was an approximation of the average variable cost of any diagnostic or therapeutic procedures performed on the patient's behalf, plus a per diem payment for room, board, and basic nursing services, and, in the case of for-profit hospitals, a markup. Thus, the payment received by the hospital was determined retrospectively and was a function of endogenous decisions by the hospital and physician as to length of stay and the resources deployed in treating each specific patient. With hospital revenue being a function of the cost of services provided, there was little incentive to weigh costs against patient benefits. Any diagnostic or therapeutic resource that had a positive expected value of benefits was financially feasible to provide, and even when there was great uncertainty about the probability distribution of benefits from a new, more costly technology, the absence of a budget constraint encouraged its adoption.

By the 1970s, however, the growth of real expenditures on medical care—reflected in rising private insurance premiums, Medicare budgets, and the share of GNP devoted to health care—had become matters of growing public concern. Some attributed this "health care cost inflation" to the insurance system and its effect on demand; retrospective payment arrangements, operating through the insurance system, were encouraging "overuse" of medical resources (M. Feldstein and Bernard Friedman 1977; Pauly 1986). The result was a spate of reforms designed to force health care providers to consider the cost consequences of their decisions. This was done by making more of providers revenue "prospective." HMOs (Health Maintenance Organizations) and, beginning in October 1983, the Medicare DRG (Diagnosis-Related Groups) system for pricing hospital services, are the preeminent examples of this type of reform.

Both HMOs and the Medicare prospective-payment system confront suppliers with the incentive to be more cost-conscious, but they differ in the comprehensiveness of that incentive. Under the current DRG system for paying hospitals, the "fixed" payment for a particular patient is supplemented by additional payments to cover capital costs; thus, there is some incentive for hospitals to substitute capital for labor.[8] In addition, under the DRG system, as under the previous retrospective-pricing system, a hospital's revenue is a function of its admissions of patients; this produces an incentive to hospitalize rather than to utilize approaches that involve nonhospital inputs such as drugs, broad medical management approaches, and instruction of patients in ways to prevent and alleviate problems through life-style and dietary measures. HMOs, which have a contractual responsibility to provide medical services, not simply hospital treatment, and receive a flat annual fee per member, maintain a greater financial incentive to utilize alternatives to hospitalization.

To the extent that cost-based insurance has been at the root of the rising expenditures on health care, however, the causal mechanism is less clear than it seems. The moral hazard effect of insurance could cause patients and their physician-agents to utilize more health care resources, and therefore aggregate health care expenditures to be greater than they would otherwise be; yet it does not follow that insurance would cause expenditures on health care to *grow* more rapidly. Something had to be changing. That "something" could have been the state of technology which, as we will see, was expanding in a systematic direction as a consequence, at least in part, of the par-

[8] I owe this point to an anonymous referee.

ticular form of insurance that had been adopted. An expanding health care insurance system—more widespread coverage of people and broader coverage of health care resources such as pharmaceuticals and chiropractic services—might also account for growth of health care expenditures, but this explanation would pose the question of why insurance coverage would be expanding.[9]

The major theme of this paper is that the demand for health care insurance and the process of technological change are interdependent. A shift away from insurance that paid hospitals and physicians on the basis of endogenously determined "costs incurred" and office visits, to insurance that paid amounts that were largely independent of costs incurred on behalf of any particular patient, represented a major change. It altered incentives to use existing health care resources (that is, their rate of diffusion and utilization) and it altered incentives for the R & D sector to invest in developing medical care techniques that were of higher quality but more costly.

As noted above, the shift in the nature of health insurance has occurred in two principal forms—expansion of HMOs and adoption of the DRG system of hospital pricing. In the decade of the 1980s alone, enrollments in HMOs more than tripled, from 9.1 million in 1980 to 28.6 million in 1987 (U.S. Bureau of the Census 1989, table 148). Under the DRG prospective-payment system, a hospital receives payment (prices) for treatment (e.g., of appendicitis) based on industry-wide costs for each of the 468 DRG categories. Thus, conditional on admission of a patient with a particular diagnosis, what a hospital faces is a price for treatment that is essentially independent of the actual resource cost it incurs (C. Hogan 1988).[10]

Both HMOs and the DRG system of pricing hospital services are potentially revolutionary in their incentive effects on R & D.[11] The fact that the principal objective of each of these forms of prospective pricing was fiscal control is not in doubt (Pauly 1986). Several related matters, however, are far from clear and deserve more research: Why did the shift in insurance mechanisms, from retrospective to prospective, occur when it did? Why did the United States ever start with insurance based on retrospective and fee-for-service pricing; after all, the incentives that cost-based pricing generated were, or at least should have been, apparent long ago, and the fiscal problem, as manifested in the rising share of GNP devoted to health care, has been growing for decades.

In some current research, Paul Boben (1989) presents a model in which retrospective pricing of hospital services and physician services (through fee-for-service payments to physicians on the basis of "usual and customary" fees) is allocatively efficient when there is little insurance coverage and health care prices are determined in relatively competitive markets, but diminishes as that coverage spreads. In this model the discipline of prices on patient and provider behavior that prevails when few people have insurance gives way to growing price insensitivity (inelasticity) with the expansion of insurance. Thus, a "tipping-point" is

[9] Even with constant technology, real costs of health care could increase if input prices rose—for example, because of increased unionization of hospital labor, and this could increase the demand for insurance, ceteris paribus.

[10] The pricing system is not entirely rigid. For example, a hospital may collect from Medicare more than the DRG price for a limited number of unusually high-cost "outliers."

[11] The DRG system of hospital service pricing initially applied only to Medicare patients. It has subsequently been expanded, however, through private arrangements, to a growing number of other patients who are not covered by the Social Security Medicare law.

reached, at which the usefulness of market-determined prices as signals of opportunity costs becomes less than its cost in terms of distorted resource allocations (the moral hazard problem). Such modeling of the social choice of the insurance system is in its infancy.

Many of the issues raised above have received scant attention in the literature. The effect of advancing technology on health care financing arrangements, the incentives for research and development inherent in those financial arrangements, and the implications of those arrangements for the quality of the care provided, are each the subject of later sections, where we will also consider the inevitability that health care expenditures would soar in the post–World War II era. But, first, how do we define "health care"? How is it affected by technological change and how does its definition affect insurance coverage?

III. *Defining "Health Care"*

Up to this point we have been discussing the market for "health care" without defining that market carefully. The endogeneity of the definition of health care under insurance contracts has received some attention (John Goddeeris 1984a, 1984b). Consider two nonmutually exclusive hypotheses concerning the causes and consequences of the definition of health care under insurance: (1) The operational definition of health care, under insurance contracts, is a function of the state of medical technology; (2) the state of medical technology today is a function of economic and political responses to prior definitions of health care coverage under insurance.

The way health care is defined under insurance contracts is important for a number of reasons, positive and normative. It affects the level of insured expenditures, the incentives to utilize resources that are covered relative to those that are not (Paul J. Feldstein 1988), and the incentives for the R & D sector to explore various potential health-promoting technologies. At the operational level, the definition of health care is at issue when coverage for chiropractic care or for "experimental" drugs or other "new" technologies is debated.

The effect of health care insurance on incentives for R & D depends on the operational definition of health care—that is, on the boundaries of the insurance contract. Health insurance contracts do not offer the option of coverage only for particular subsets of technologies, such as those already available at a given point in time (Goddeeris 1984b; Goddeeris and Weisbrod 1985; James Baumgardner 1989). A reasonable conjecture, however, is that health care expenditures today would be substantially lower than they are if health care were being defined, for insurance purposes, as limited to the use of medical technologies available at the time the policy took effect, or at some other fixed date. The more broadly health care is interpreted under the contract, and the more responsive it is to changes in technology, the broader the range of activities over which insurance will encourage R & D.

What determines how health care is defined? I suggest that the R & D process causes the definition of what is covered by health insurance to change in systematic ways. Technological advances are not only expanding the range of medical capabilities for extending life and enhancing health status, as the latter term is customarily understood; they are also presenting opportunities to deal with problems not conventionally considered to be "illnesses," in ways not conventionally considered "health care."[12]

[12] Another example of the need to decide, as a matter of public policy, how to define operationally what is health care involves people with physical dis-

An illustration of this causal process is the current debate over whether health insurance should necessarily cover in vitro fertilization. This has become an issue only in the past few years, when advances in medical capabilities made such fertilization technically feasible. An advance in medical technology has led to pressure to expand the traditional definition of insurance coverage, pressure being felt now through the political system; by 1988 such insurance coverage had been mandated in five states (U.S. Congress 1988),[13] and by the end of 1989, laws requiring insurers to cover such "advanced" treatments for infertility had been enacted in 9 states and bills had been introduced in 18 others (Sonia Nazario 1989).

The effect of technological change on the health insurance market can also be seen with "experimental" drugs. The decision to term a drug experimental is often seen as a statement of the degree of professional knowledge about its safety and efficacy. It is, however, also a statement of whether the drug will or will not be deemed "health care" for insurance purposes, because insurance typically does not cover "experimental" technologies. For example, as long as the AIDS drug, AZT, was termed experimental, its exclusion from coverage under health insurance involved each patient with costs that, until 1990, have been in excess of $8,000 per year, even though conventional hospital-based treatment was covered in traditional fashion.

The hypothesis that the definition of health care is endogenous to the economic-political system in which health care insurance is defined, provided, and financed has important implications, to the extent it is valid. If insurance coverage is defined, as it has been, to encompass new technologies regardless of the costs involved, and to encompass an ever widening concept of health care that is, itself, responsive to the development of new technologies, the R & D sector will continue to face incentives that reward costly new measures relative to cost-reducing innovations. Such a reward system may not be incentive-compatible; new technologies may be developed even though they are welfare decreasing in the sense that the insured population is not willing to pay the real cost of developing and applying the technology (Goddeeris 1984b; Baumgardner 1989).

IV. *Effects of R & D (Technological Change) on the Health Care Insurance System*

Advances in medical technology—involving both diagnostics and treatment—have been, at least arguably, a driving force behind the rapid growth of health care expenditures (Stuart Altman and Robert Blendon 1979; Jean Lacronique and Simone Sandier 1981; Jonathan Showstack, Stephen Shroeder, and Michael Matsumoto 1982; Henry Aaron and William Schwartz 1984; Wilensky 1987). The announcement for a recent (October 1988) conference cosponsored by the American Medical Association acknowledged the benefits from new medical technology but also cited the position that the growth of medical technology is a primary cause of the quadrupling of per capita health care costs between 1970 and 1986. Even if this causation occurs,

abilities. Surgery and physical therapy illustrate "traditional" health care resources employed to reduce the disabilities. City buses that are wheelchair-accessible are unquestionably valuable to the disabled; whether their cost should be regarded as health care expenditures and covered by health care insurance is another matter.

[13] As of May 1988, Arkansas, Hawaii, Maryland, Massachusetts, and Texas had enacted legislation requiring private insurers to provide some coverage for in vitro fertilization procedures. Delaware Blue Cross/Blue Shield began offering coverage voluntarily in response to legislative activity (U.S. Congress 1988).

however—and existing research is far from conclusive on the matter—the mechanism through which it works is not well understood. Neither is it apparent that technological advances would necessarily increase health care expenditures, rather than decrease them.

One mechanism through which technological change could foster increased expenditures on health care would be through its effect on the health care insurance system. If a previously untreatable condition becomes treatable, a possible outcome is that an individual could encounter a larger, but unpredictable, medical care expense for treatment than was previously the case; thus, both the mean and the variance of an individual's health care expenditures associated with that condition could increase.

Pooling of such risks is a logical response. In addition to the increased expected demand for private insurance, collective demand is also likely to increase; the fact that health care, particularly when it has a major effect on life expectancy or quality of life, is widely viewed as a "merit" good (or "altruistic externality"—Pauly 1986) results in public pressure on government to ensure that the care is available to whoever needs it medically, regardless of ability to pay.

An example of such a merit good is organ transplant technology. Reacting to the life-saving aspects of the new transplant technology, the Federal Government Task Force on Organ Transplantation recently proposed that government pay for all organ-transplant operations that patients cannot afford (Robert Pear 1986). Somewhat similar legislation, enacted in 1972—in response to the development of kidney dialysis (not transplant) technology—had the clear effect of increasing health care expenditures; no patient was rationed from access to the technology, and the technology, while life-extending, was more costly in resource terms (although not necessarily in net benefit terms) than simply allowing the victim to go without treatment and, hence, to die.[14] The interplay of financial and political forces following the development of the dialysis technology (Richard Rettig 1980; Rettig and Ellen Marks 1983) and the massive public expenditures that ensued may help to explain why there has been no subsequent U.S. legislation covering such complete treatment for any other disease, and why the British National Health System continues to restrict access to dialysis for persons over age 55.

Life-extending technologies highlight the ambiguity of the concept of a technology being "expenditure increasing." Total health expenditures *over a person's lifetime* are likely to increase if the person lives longer, although that is not necessarily the case. However, expenditures *per year of life* can decrease even if lifetime expenditures increase. A new technology that increases the cost of treating a particular disease but is successful in increasing life expectancy sufficiently to decrease expected health care costs per year of life could diminish the demand for health care insurance; my conjecture is that it would not, but this deserves more attention.[15] The point is that technological change need not increase demand for insurance, even if the change

[14] The view that dialysis and organ transplants are cost (or expenditure) increasing, ceteris paribus, deserves further comment as to what is embedded in the ceteris paribus assumption. One element is the set of probabilities of contracting all other diseases. The assumption that these probabilities are constant with respect to the organ transplant or dialysis decision may not be valid; a person whose life is "saved" through the use of one of these technologies may well face a greater probability of dying from other causes than do people who have not been victims of kidney disease.

[15] The effect of increasing life expectancy on total health care expenditures *as a percentage of GNP* is yet another matter. This depends on the productivity of persons whose lives are extended, as well as on longer-run effects on birth rates.

increases the expected cost of treating a particular illness. It could take forms that decrease either the aggregate expected health care cost for all illnesses, or the variance. Demand for insurance would also decline even if a new technology increased the aggregate expected cost of treatment, if the variance decreased sufficiently.[16]

If we focus on treatment of specific diseases, we find that some innovations decrease the demand for insurance by decreasing both the expected cost of treating that illness, and the cost variance. The Salk and Sabin polio vaccines, for instance, are quite inexpensive to administer, and by providing immunity to the ravaging effects of polio, they have reduced—indeed, virtually eliminated—the variance in health care expenditures associated with contracting that disease and using costly treatment technologies. The potentially enormous expenditures that have been eliminated, which include those associated with decades of use of an iron lung and the lifelong costs associated with being crippled, exceed the cost of providing the vaccinations (Weisbrod 1971). Thus, the polio vaccines, like many other vaccines, have the effect of reducing an individual's expected level of expenditures for treating the disease, as well as the variance around that mean. In the process they reduce the demand for health care insurance.

Organ transplant technology, on the other hand, is a technological advance that has increased both the mean and the variance of desired individual expenditures conditional on medical need. Before the new technology, a person with serious liver malfunction, for example, simply died, with comparatively little health care expenditure.[17] With the new technology it has become possible to spend vast sums on effective treatment. A single liver transplant operation can cost $200,000 or more, and subsequent medical attention and medication to prevent organ rejection typically totals $10,000–$20,000 annually for life (Jan Hudis 1986). Thus, a healthy person with some probability of developing liver disease faced a larger expected financial cost of treatment once the new technology was developed, and a greater variance in cost; conditional on remaining healthy, the person would spend zero on treatment of his or her liver under either technological state—with or without the transplant capability. Conditional on contracting liver disease, however, the person would spend a great deal more on treatment once the new technology became available. As a result, the development of transplant technology increased private demand for health care insurance, ceteris paribus. This is distinct from the increase in demand associated with the merit-good-related desire to provide access to life-saving technology to everyone regardless of ability to pay.[18]

These two cases of technological change—polio vaccines and organ trans-

[16] Even if technological change increases demand for insurance, it need not follow that the amount of insurance purchased would increase. Insofar as the technological changes were cost increasing, the price of insurance coverage would increase, which would diminish insurance purchases. In fact, the negative price effect of an increasing price for health care insurance appears not to have offset the positive demand-shift effect of technological change, judging from the growth in the fraction of the population with insurance; to be sure, however, much of the growth of insurance coverage over the last two decades has been through government rather than direct consumer purchases in private markets.

[17] In fact, however, little is known systematically about the amount of health care expenditures associated with attempts to cope with the debilitating effects of liver dysfunction (or other terminal illnesses), even when life is not prolonged.

[18] Positive income effects associated with rising income could also account for an increase in the demand for health care insurance. One might expect, however, that the income elasticity would be negative, not positive; increased income, ceteris paribus, would increase the person's ability to self-insure (Jan Mossin 1968).

plants—illustrate several points: (1) Some new technologies increase the *expected* health care expenditures for victims of a given disease, ceteris paribus, while others decrease it; (2) some new technologies increase the *variance* of health care expenditures for victims of a given disease, ceteris paribus, while others decrease it; (3) a technology that increases the mean and variance of health care expenditures for a particular disease would tend to increase the demand for health care insurance, while one that decreased them would tend to reduce the demand for insurance. This latter proposition suggests the following conjecture: The growth in insurance coverage, private and public, suggests that the preponderance of technological change in recent decades has increased the means and variances of health care expenditures associated with various diseases, rather than reduced them. Society has tended to develop a growing number of new technologies that permit higher levels of health care expenditures.[19]

Vaccines and transplants also illustrate stages in technical progress. Biologist Lewis Thomas (1975) distinguishes among three levels of technology in medicine: (1) "Nontechnology" tides patients over diseases that are poorly understood. It largely involves reassuring patients, providing hospitalization and nursing, but with little hope; "It is what physicians must do now for patients with intractable cancer, severe rheumatoid arthritis, multiple sclerosis, stroke, and advanced cirrhosis" (p. 37).

(2) At a higher level is "halfway technology." This includes dealing, after the fact, with the incapacitating effects of diseases "whose course one is unable to do very much about." It is technology that adjusts to disease or postpones death. Examples include organ transplantations and artificial organs, and treatment of cancer through surgery, irradiation, and chemotherapy. The cancer measures are halfway technologies because they are directed at "already established cancer cells, but not at the mechanisms by which cells become neoplastic" (p. 39).

(3) "High technology," exemplified by immunization, antibiotics for bacterial infections, and by prevention of nutritional disorders, "comes as a result of a genuine understanding of disease mechanisms, and when it becomes available, it is relatively inexpensive . . . to deliver" (p. 40).

Thomas described the state of technology at a point in time—not the process of change. If, however, we think of a dynamic process, in which knowledge tends to grow from the first of the three levels to the second and then the third, the cost function associated with any particular disease might be inverted-U shaped; it is plausible, although certainly not verified, that health care costs are highest for the halfway technologies. In the extreme case of a nontechnology, when the knowledge base is so weak that there is nothing useful to be done, costs are likely to be low, as they are when the high technology state of knowledge is reached.

The evolution of knowledge about polio is a useful example. Two generations and more ago, the nontechnology stage prevailed. Many victims of the disease died quickly as a result of paralysis; for them, the effects were disastrous but the attendant health care costs were small. Development of the halfway (iron lung) technology prolonged life, but at substantial cost. The high technology polio vaccines (Sabin and Salk) dramatically re-

[19] Treatment of heart attacks is another illustration. One study showed that between 1972 and 1982, treatment of myocardial infarction involving more complex technologies such as cardiac imaging, angiography, and coronary bypass graft surgery was associated with a tripling of physician costs per case (Eric Sawitz et al. 1988).

duced costs associated with polio, virtually eliminating it in the United States—there were 5 cases in 1985, compared with over 38,000 in 1954, before the vaccines were developed.[20]

Insofar as the inverted-U relationship holds between state of technology and resource cost per case, there is an interesting implication. The aggregate effect of technological change on health care costs will depend on the relative degree to which halfway technologies are replacing lower, less costly technologies, or are being replaced by new, higher technologies. The development of halfway technologies was implicitly encouraged by the cost-reimbursement insurance system that has dominated hospital and medical care until recently, because there was little or no incentive for medical care providers to avoid costly technologies that were even marginally effective.[21] Empirical research on how, and how much, the medical R & D process is now being affected by the shift to a prospective-pricing incentive system for cost control is in its infancy; there would seem to be an incentive for R & D to shift toward mechanisms that would bypass the high-cost, halfway states of technology.

Depending on whether technological change is predominantly from nontechnology to halfway, rather than from halfway to full or from nontechnology to full, the demand for insurance is likely to differ. With the demand for insurance being a function of uncertainty of loss, demand should tend to increase most rapidly when changes in technology are of the expenditure-increasing, halfway type. Costly new surgical techniques such as organ transplants and artificial replacement parts spur the demand for insurance; low-cost vaccines diminish it.[22]

Why have there been relatively more developments of technologies like organ transplants than like the polio vaccines? Why, that is, has technological change in health care been "expenditure increasing"? Is it more than chance? To begin examining this issue, we turn to the effect of various kinds of insurance arrangements on incentives for the R & D sector to develop alternative types of technologies. For just as the forms of technological change affect the insurance system, so, too, does the insurance system affect the direction and pace of technological change. Depending on the type of insurance available to consumers, the R & D sector faces differing incentives to search for cost-reducing, "process" innovations relative to quality-increasing but cost-increasing, "product" innovations.

V. *Effects of the Insurance/Finance System on R & D*

Theory suggests the probable direction of the health care finance system's effects on R & D. Depending on hospitals' and physicians' incentives to adopt new technologies (which are contingent on the insurance system through which providers are paid) the R & D sector can face quite different financial incentives for both the level and direction of research. Fiscal pressure on health care providers to contain costs will affect the market for adoption of innovations, and by so doing, will alter R & D in predictable ways.

[20] Vaccines appear to be more cost reducing than they are. If vaccination cost is, say, $5 per person, and if the incidence of the disease is one in 40,000, then the vaccine cost per case *prevented* is $200,000. That may or may not be resource-cost saving, at least with respect to health care costs.

[21] "Halfway" technologies are not the only type of R & D encouraged by cost-based, retrospective insurance. Any technology with positive expected benefits is encouraged.

[22] Thomas' typology applies to technologies used for prevention and treatment. While Thomas does not deal explicitly with technologies used for diagnosis, we can think of those as complements to treatment; that is, costs of treatment include costs of determining which treatment mode to use.

The effects of insurance on R & D are not simply based on the existing insurance system, but on the system expected to exist in the future. The process of developing new medical technologies involves years of planning and research, and, when drugs and medical devices are involved, more years of clinical trials to obtain approval by the Food and Drug Administration; in the case of pharmaceuticals, a period lasting 12–15 years is typical between the initiation of a research process and the marketability of a drug. As a result of this lengthy process, the R & D process depends on forecasts of the health insurance system, for the form of expected insurance coverage will determine the strength of the market for new products. If, for example, decision makers in the R & D sector believed that development of a particular technology that was costly yet effective would cause government to expand insurance to cover it—as was done with kidney dialysis—there could be an incentive to develop the product even though it was not covered under existing insurance.

By directing attention to the effect of health care insurance on R & D, I do not imply that insurance is the only force affecting R & D. Among other forces are the state of scientific knowledge, which affects the probability of scientific success from additional research; demographic variables, which affect the size of potential markets for new products; and political influences on the budget of the National Institutes of Health (NIH), which finances basic research. With respect to the NIH, it would be useful to learn more about the way the size and allocation of its scientific research budget are influenced, perhaps quite indirectly, by the health insurance system, through its impact on the eventual market for new technologies of various types.

Hospitals, physicians, and other health care providers select the resources used to treat any particular patient within the technologically feasible set and subject to revenue constraints. These constraints depend partly on the insurance system, which influences both the diffusion of existing technologies and the expected profitability of potential new technologies (Joseph Newhouse 1981, 1988; Goddeeris 1987). Thus, the following proposition requires testing: The insurance/finance system affects the incentives facing the R & D sector to develop new health care technologies of various "types." Because the demand confronting the health care R & D sector is derived from the demand facing health care providers, alternative insurance/finance systems will have differing long-run effects on the demand for innovations. In particular, insurance mechanisms can differ in the incentives they imply for reducing costs relative to enhancing quality.

The two types of insurance payment mechanisms — "retrospective," which pays a provider on the basis of "costs" incurred, and "prospective," which pays sums that are independent of those costs incurred[23]—imply profoundly different incentives for both the development and diffusion of new technologies.

The claim that hospitals operate according to some "technological imperative" that determines medical choices (Victor Fuchs 1986) and that drives hospitals to adopt the latest technology, regardless of cost, may well have been correct, but the reason may have been less

[23] Arrow (1963) identifies three types of insurance, the third being "indemnity." This type, however, is a special case of prospective coverage in the sense that the insurer pays a fixed amount, conditional on a loss, but independent of the magnitude of the health care costs actually incurred. The indemnity might take the form of a fixed dollar payment for the loss of a limb, or for a given illness. If it took the form of a fixed dollar payment per day of hospitalization, it would have the character of retrospective-type insurance.

mystical than the term suggests. The economic incentives explaining the "rapid and indiscriminate adoption of [medical] innovations" (Fuchs 1986, p. 29), and "the proclivity of doctors and hospitals to adopt almost any plausible new thing—drugs, surgical methods, equipment—that increases capability in any dimension . . . without regard to cost" (Richard Nelson 1972, p. 56), have been documented for such technologies as intensive care units, cobalt therapy, and the electroencephalograph (Louise Russell 1979). One "explanation" offered for the insensitivity to cost is an alleged lack of training of physicians and hospital administrators in weighing marginal benefits against marginal costs (Roger Battistella 1984). Even if this is valid, the impact of insurance-based incentives may well be powerful; "methods of third party payment . . . [do] not give [decision makers] any inducement to acquire that ability" (Fuchs 1986, p. 30).

Analyses of the effect of insurance on the adoption or diffusion of technologies have tended to concentrate on technologies that have already been developed. Less attention has been given to the implicit incentives for the R & D sector to develop various types of innovations. Retrospective pricing sends a clear signal to the R & D sector: *Develop new technologies that enhance the quality of care, regardless of the effects on cost.* Careful analysis remains to be done to distinguish causation from spurious correlation, but it appears that in the post–World War II era this signal produced the two results that could be expected: historically unequaled improvements in medical care technology—drugs, devices, diagnostics, and so on—and unprecedented growth in health care expenditures.[24]

[24] Such increased costs might or might not pass a full benefit-cost test. The point, however, is that they contributed substantially to the accelerated growth of health care expenditures.

Transplantation of natural organs has already been mentioned as an example of a high-cost medical innovation made more likely by retrospective insurance. Another example is development of a wide range of implantable artificial joints and artificial organs. The human body has become increasingly like an automobile, with replacements available for an ever growing number of parts—an arm or a leg, at about $2,000, an elbow at $1,200, an ear at $10,000, and a heart at $50,000–$80,000. They are even available in small, medium, large, and extra large sizes (N. R. Kleinfield 1983). "Installation," of course, is extra, and as with auto parts, is typically many times greater than the price of the part.

Technological advances in recent decades have given us spectacular innovations, but with scant attention to the resource costs of utilizing them. Open heart surgery can replace clogged arteries (coronary artery bypass graft surgery, CABG) but at a cost averaging $46,000 (National Center for Health Services Research and Health Care Technology 1988). A baby born two and a half months prematurely and weighing well under two pounds can be kept alive, but at a cost of $90,000 and with a 10 percent survival rate (Howard French 1989). Ultrasound technology, CT (computerized tomography) scanners, PET (positron emission tomography) scanners, and other diagnostic tools aid in disease detection but often at costs of tens of thousands of dollars per case detected—not counting the subsequent costs of surgery or other treatment. The PET scan, which aids in detecting heart disease at a cost of about $1,800 per test—many times this for each case of heart disease detected—has been argued to be only "slightly" better than the SPECT (single emission computed tomography) scan, which costs less than half (James Schiffman 1989). Under retrospective, cost-based financ-

ing, even small improvements have been adopted by physicians, hospitals, and other institutions which have had little or no incentive to balance social benefits against costs.

Consider, now, the reward structure implicit in an alternative insurance/finance system—*prospective-payment*, in which payment to a service provider is exogenous to provider decisions, conditional on admission of a patient. The particular version that is being applied to hospitals' Medicare patients, and increasingly to other patients as well, confronts a hospital (but not the patient's physician) with an exogenously determined set of prices, one for each of 468 diagnoses made at the time of admission.[25] No longer is gross revenue for treating a particular patient a function of the hospital's decisions on use of resources.

Financial incentives for hospitals under such a prospective payment arrangement differ diametrically from the incentives under retrospective payment. With a hospital's revenue being exogenous for a given patient once admitted, and an HMO's revenue being exogenous for a member for the given year, the organization's financial health depends on its ability to control costs of treatment.[26] Thus, under a prospective payment finance mechanism, the health care delivery system sends a vastly different signal to the R & D sector, with priorities the reverse of those under retrospective payment. The new signal is as follows: *Develop new technologies that reduce costs, provided that quality does not suffer "too much."* (The meaning of "too much" will be examined below.)

When a ceiling was placed on government payment for kidney dialysis, the direction of technical change was affected; large surface dialyzers were developed that cut the time required per session nearly in half, from 6–8 hours down to 3.5–4.5 hours. This led to substantial savings in professional labor costs, which are a major cost component (Rettig 1980).

The shift to a prospective-payment system (PPS) under Medicare appears to have brought about some of the expected changes in utilization of health services. PPS has not diminished use of intensive care units, but it has apparently decreased use of such diagnostic procedures as chest x rays; in the three years prior to PPS, 1980–83, the mean annual change in the number of chest x rays per Medicare patient discharge was zero, while for the 1983–85 period it decreased by 8 percent (Frank Sloan, Michael Morrisey, and Joseph Valvona 1988).

HMOs also present providers with an incentive to increase attention to costs relative to medical benefits. HMOs—which are, in effect, mergers of health care providers and insurers—can be expected to adopt more slowly than would

[25] In some instances diagnostic categories can be altered after admission, on the basis of information not available at admission. This produces some degree of revenue endogeneity, because the hospital and physician can decide on the amount of exploratory effort.

[26] While hospital revenue is largely exogenous once the patient is admitted, a hospital can influence both its gross and net (of cost) revenues through a variety of mechanisms for controlling admissions. A nongovernmental hospital may, for example, choose not to provide particular services such as an emergency room; it can decide which physicians may serve on its medical staff and, hence, which may admit patients; and it can provide its affiliated physicians with subtle but clear signals to "encourage" patients with complex problems to utilize governmental hospitals. Recent research is disclosing that, with the advent of prospective pricing for Medicare patients at most nongovernmental hospitals in 1983, there has been an increase in admissions to Veterans Administration (VA) hospitals, which are not included in the prospective, DRG pricing system; therefore we might expect them to receive more of the patients with illnesses likely to constitute financial "losers" to for-profit and voluntary nonprofit hospitals (Barbara Wolfe 1989). In the long run, when location of a hospital is variable, there is additional discretion for nongovernmental hospitals to locate in areas that are less likely to generate unprofitable cases.

a provider facing a retrospective pricing system, any new technology that is cost increasing, even if more effective. HMOs have been found to have lower costs per patient year than do nonmembers whose insurance was based on retrospective costs, largely attributable to a 30 percent lower rate of hospitalization (Harold Luft 1981); but the rate of introduction of new technologies does not appear to differ, at least as that is reflected in rates of change of per capita costs. The growth rate in total costs per person (including out-of-pocket costs) in the 1960s and 1970s appears to have been about the same (Newhouse et al. 1985) or "only slightly lower" (Luft 1980) for persons in, and those not in, HMOs after making some adjustments for selection bias.

The longer-term effects of PPS and HMOs on the R & D sector are more difficult to discern. There has been no formal modeling of the long-run effects on technical change of alternative payment systems for hospitals and physicians. Early literature attempting to explain the rising level of health care expenditures did not identify an important role for technological change. Subsequent literature sometimes directed attention to the effect of technological change on health care costs (Altman and Blendon 1979), but that change in "quality and style of hospital care" was assumed implicitly to be exogenous—captured econometrically, perhaps, by a time trend (M. Feldstein 1971).

The rate of diffusion of a number of existing technologies has been found to be responsive to insurance-related incentives (Russell 1979; Anthony Romeo, Judith Wagner, and Robert Lee 1984; Lee and Donald Waldman 1985; Sloan et al. 1986). There has been little study, however, of the effects of insurance on the R & D sector—private, governmental, and nonprofit—where new technologies are developed, although the linkage between the insurance system and incentives for the R & D sector has been noted (Paul Joskow 1981; Goddeeris 1984a, 1984b; Goddeeris and Weisbrod 1985; U.S. Congress 1985). The effect of prospective-payment insurance on R & D is illustrated by experience in the late 1980s with the cochlear implant for hearing-impaired persons; scientifically promising research was discontinued as a consequence of its expected unprofitability, which resulted from application of the DRG-pricing system. The 3 M Company, the manufacturer of the first FDA-approved single-channel cochlear implant model, halted research on a multichannel device because of hospitals' financial disincentives (Nancy Kane and Paul Manoukian 1989). Similarly, R & D on assistive communication devices for speech-impaired persons appears to have been retarded by the lack of insurance coverage; Medicare's payment policy favors inpatient over outpatient care, and there was "an administrative decision that the [communication] devices are not prosthetic devices needed for the functioning of a malformed body member" (U.S. Congress, Office of Technology Assessment 1984b, p. 30).

The current climate and incentives facing the R & D sector are not conducive to the development of costly new technologies. Another example is the newly emerging diagnostic procedure known as PET (positron emission tomography), "which produces three-dimensional images that reflect the metabolic and chemical activity of tissue" (see p. 536). PET is in clinical trial, but General Electric Company, its developer, "isn't making the kind of investment it did to rush CT (computerized tomography scanners) and MRI (magnetic resonance imaging devices) to market." According to a General Electric official, "The government is very cautious about approving reimbursement for PET. In the past, if a technology im-

proved patient care, it would be approved. Now it must also be cost-effective" (Naj 1990, p. B4).

There are some further implications of the new incentives for hospitals to reduce costs rather than to increase quality. In the new era of prospective pricing of hospital services, we are likely to see a diversion of R & D resources away from new surgical techniques and toward lower-cost substitutes, frequently pharmaceuticals. Surgical advances can be cost reducing, especially when they substitute for other halfway technologies; angioplasty, for example, substitutes for more costly coronary bypass graft surgery, and kidney transplantation substitutes for years of dialysis. When surgical advances substitute, however, for nontreatment, they are likely to increase the cost of treating the specific illness; because life expectancy may increase, though, the effect on mean annual health care costs per capita is less clear. Surgery is costly, relative to nonsurgical interventions, because it is labor-intensive, "custom" production—performed on a single patient; as such it has limited capacity for taking advantage of scale economies.[27] Increased use of surgery over the 1972–82 period, during which retrospective pricing of hospital services dominated, was the primary source of rising treatment costs for patients admitted to a teaching hospital for acute myocardial infarction, respiratory distress syndrome of the newborn, and other intensive treatments for the critically ill (Showstack, Mary Stone, and Shroeder 1985).[28] New surgical interventions are likely to be less attractive in a cost-containment environment.

By contrast with surgery, research on those pharmaceuticals that decrease expenditures, relative to those that increase quality but increase expenditures, is more attractive under prospective pricing. This is because demand patterns by hospitals (and HMOs) reflect the search for cost-reducing modes of treatment, including substitutes for costly surgical interventions; in particular, the advent of prospective pricing has increased the expected profitability of (a) R & D on drugs than can prevent the onset of costly treatments—vaccines, for example (John Huston and Weisbrod 1988) and of (b) R & D on drugs that substitute for surgery—for example, beta-blockers, which can substitute partially for coronary bypass surgery, and cimetidine, which substitutes for ulcer surgery (John Geweke and Weisbrod 1982).

Effects of PPS insurance on the pharmaceutical industry will not, however, be entirely favorable. Pharmaceuticals are not always substitutes for surgery; they are sometimes complements. Development of a new drug that complements surgery can increase the efficacy of surgery and thereby increase the demand for surgery—with major cost implications. In a cost-containment, insurance-finance environment, pharmaceutical industry R & D faces an incentive to develop drugs that substitute for surgery rather than enhance its efficacy.

Organ transplants illustrate the issue. Liver transplantation, a surgical technique, is effective today largely because of a recent technological advance in pharmaceuticals. The drug, cyclosporine, is

[27] Cost reductions are likely to result, however, from experience—learning-by-doing—which is a function of total accumulated volume, even if not a function of the rate of surgery per unit of time. In a study of six surgical procedures, including coronary artery bypass and hip replacement, between 1984 and 1986, it was found that mortality declined with volume for five of the six procedures, but current cost per case declined with volume for only two of the procedures. Data covered between 646 and 4,738 hospitals, depending on the procedure (Project Hope 1988).

[28] Much of the medical literature reports findings for a single hospital. Whether the findings are generalizable to the entire hospital system is not clear.

crucial, because it suppresses the body's immune-system reaction to the transplanted organ; yet, unlike earlier immunosuppressant drugs, it does not stop the body from fighting off infections.

The good news about this technological breakthrough is that cyclosporine permits people with liver, kidney, and heart failure to be kept alive, living essentially normal lives. The bad news is that the resulting increase in the efficacy of organ transplant surgery has brought sharp increases in the usage of these very costly procedures. Only 26 liver transplants were performed in 1981, and, while increasing to nearly 1,200 by 1987, some 4,000–4,700 persons per year could benefit from the procedure. At a cost of about $200,000 each, plus annual maintenance costs, meeting all the medical needs implies an annual cost of $1 billion for this one procedure (*National Organ Transplant Act* 1983; Pear 1986; "Cyclosporine Turns Five" 1988). Heart, kidney, and other organ transplants suggest many times this level of potential expenditures as a consequence of the pharmaceutical breakthrough. It has also produced political pressure to ensure access to this life-saving technology, regardless of a patient's ability to pay—pressure that is still being suppressed in part by the expedient of terming the procedures "experimental." The enormous expenditure potential of technological advances in drugs is currently highlighted by the drug AZT, which has been shown to be successful in prolonging life for patients with AIDS. The current estimate is that some 600,000 people can benefit from this drug, which, even with very recent reductions in price and dosage, costs about $3,000 per year of treatment (Joann Lublin 1990), for a total potential cost of nearly $2 billion.

Given the current financing environment, why are cost-increasing drugs such as AZT, cyclosporine, and TPA being developed? Cyclosporine came onto the market prior to the advent of PPS, and given the lengthy research and regulatory process in pharmaceutical research, it is reasonably clear that work related to AZT and TPA was well under way by the time prospective-type insurance incentives became powerful in the 1980s. Today, the fiscal pressures operating through Medicare, HMOs, and state Medicaid "formularies"—lists of drugs that will be paid for—are reducing drug company incentives to develop drugs for which "high" prices would be required to make the R & D effort profitable.

The form of insurance affects the direction of R & D not only in terms of quality relative to cost. It also affects the incentive to search for methods to treat the ill rather than to prevent their illness.[29] In general, health insurance has primarily covered treatment in hospitals, with preventive measures having quite limited coverage. As a result, the R & D sector has had less incentive to focus effort on prevention than on treatment, with the exception, perhaps, of vaccinations, for which government subsidization is common. Insofar as preventive measures are covered by insurance, they tend to involve technologies that utilize the "health care sector"—especially physicians and hospitals—even though other measures, such as better diet and exercise, might improve health at lower cost.[30]

[29] In the long run, the price of private health insurance depends on the state of technology. Even so, risk-spreading over all the insured may make it privately profitable for the R & D sector to develop technologies for which the value (willingness to pay) is less than the social cost (Goddeeris 1984a, 1984b; Baumgardner 1989).

[30] Thus, prevention has its halfway technologies, too (as pointed out by an anonymous referee). For many forms of prevention, insurance is inappropriate because there is little uncertainty about the financial expenditure involved (thanks to Mark Satterthwaite for noting this).

I do not intend to imply that a reallocation of resources toward prevention would necessarily be efficient, given the existing state of knowledge (Russell 1986, 1987). Indeed, the concept of efficiency is itself controversial; it certainly can be defined in terms of either the patient's willingness to pay or some measure of health status, and in either private or social terms.[31] The point is that today's state of knowledge about measures for preventing illness and for treating it reflects the historical incentives for R & D of both types, and those incentives have been shaped by the insurance system.

VI. *Effects of Insurance on Choice of Technology and Quality of Health Care in the Short Run, with Technology Given*

In addition to its potential to influence R & D, the health insurance incentive structure also influences the deployment of existing medical technology, with implications for quality and access to care. A retrospective, cost-based reward structure and a prospective reward structure such as a DRG system and an HMO[32] offer very different incentives for provider choice between increasing quality and decreasing costs (Michael Morrisey et al. 1984).

For a given state of technological knowledge, a prospective-payment insurance system provides encouragement, at the margin, to use production processes that reduce cost rather than improve quality. This is particularly so when quality is affected in dimensions that are costly for consumers (or regulators or insurers) to observe. The central point is that in a world of asymmetrically high information costs to consumers relative to service providers (e.g., hospitals and HMOs),[33] it is harder to detect reductions in quality in some forms than in others, and the finance system can influence provider incentives to choose among input combinations that differ in the relative importance of effects that are more and less costly for nonproviders to monitor.

Every commodity—health care or anything else—can be thought of as a bundle of attributes that vary in the cost of monitoring them as well as in their importance to buyers. To simplify, consider two classes of attributes—type I, which is costless to monitor, and type II, which is costly to monitor. If consumers respond largely to the observable, type I attributes, then sellers will find price to be essentially independent of quality in the type II dimensions, and quality in the latter forms will be low (Weisbrod 1988). Price will be a poor gauge of overall quality.

A prospective-payment reward structure such as a DRG system is a price control mechanism. It poses the problem of how to ensure that real prices are not raised through the expedient of reducing

[31] Aaron and Schwartz (1984) define efficiency in medical terms but using a Pareto-like approach: "Medical resources are efficiently used when a given total expenditure cannot be reallocated to alternative kinds of care to achieve an improved medical outcome. . . . . [Thus] it would not be possible to increase total medical benefits by taking some money away from one service, for example cancer chemotherapy, and spending it on another, say x-ray" (pp. 79, 89). Randall Ellis and Thomas McGuire (1986) define efficient supply of care as existing when the physician acts as a perfect agent, weighing a dollar of hospital profit equally with a dollar of benefit to the patient.

[32] There are important differences between an HMO- and a DRG-type payment system—at least as these operate now. For example, the DRG system applies currently only to hospital services, while HMOs cover a wider range of medical services. HMOs may operate their own hospitals, but they typically subcontract with independent hospitals for treatment of HMO members; such subcontracts can take many forms, and with either retrospective or prospective pricing.

[33] An HMO, which vertically integrates a provider group with an insurer, reduces the informational asymmetry between the two, though not between either of them and consumer-patients or regulators.

service quality, especially in the type II dimensions.[34]

The potential effects of price setting by a governmental agency or private insurer when quality is asymmetrically costly to monitor can be seen by comparing the setting of prices for electricity and for care in a hospital or nursing home. A kilowatt-hour of electricity is far more homogeneous and easier to monitor than is a day of care (or any number of other potential measures of output) in a hospital or nursing home.[35] Thus, regulating price does not pose a serious risk that quality of output will be compromised in unobservable ways by the regulatory process. Because of the more complex attributes of the health care system, opportunities are greater for providers to reduce output quality in dimensions that, being costly to monitor, are difficult to embody in a performance contract.

The Joint Commission on Accreditation of Health Care Organizations (JCAH) recognizes implicitly the distinction between type I and type II characteristics for assessing quality of a hospital. In his testimony at the 1973 Senate hearings, the executive director of JCAH said it was concerned with whether a hospital had the physical environment to permit high-quality medicine to be provided, for example, an operative sprinkler system (a type I attribute)—not with the actual clinical practices, for example, how carefully surgery is performed (a type II attribute) (Kathleen Lohr, Karl Yordy, and Samuel Thier 1988).[36]

I remarked earlier that under a prospective-payment system, financial incentives are to cut costs provided quality does not suffer "too much."[37] There are consequences, of course, of cutting quality, and they constrain health care providers: tort law liability for medical malpractice, loss of patients to competitors (Albert Hirschman 1970), loss of donations and volunteer labor, and penalties for violating regulatory rules (Weisbrod and Mark Schlesinger 1986), professional ethics codes, and, in the case of HMOs, possibly greater costs of treating member-patients in the future.[38] Thus, the financial incentive to reduce costs by cutting quality is presumably equated at the margin with the effects of reduced quality on these revenue and cost variables (Robert Woodward and Frederick Warren-Boulton 1984; Ellis and McGuire 1986).[39] Little is known about the quantitative importance of each of these constraints, but because of them, a prospective-payment price control system implicitly encourages health care providers to cut resource use in the type II dimensions—which would minimize revenue losses and other

[34] Throughout this discussion the role of physicians as agents for patients has great importance. I assume that physicians act as imperfect agents, which leaves patients asymmetrically underinformed.

[35] There are other elements of the electric power regulatory process—for example, the "appropriate" level of inputs—that involve asymmetric costs. The literature on the Averch-Johnson effect focuses, in effect, on the difficulty regulators have in determining the degree of overcapitalization of public utilities under rate-of-return regulation (Harvey Averch and Leland Johnson 1962; William Baumol and Alvin Klevorick 1970).

[36] John Porterfield, the JCAH executive director, reportedly said that a hospital reviewer would observe whether the hospital's sprinkler system worked and whether certain medical committees functioned and kept adequate records, but if a surgeon on the staff decided that good quality care required taking out the appendix of all blue-eyed males over age sixteen, that was none of the JCAH reviewers' business.

[37] Morrisey et al. (1984) model the effects on quality of care in a hospital confronted by downward price pressure.

[38] For HMOs the latter effect is attenuated by the uncertainty that the person will remain a member.

[39] Because HMOs involve a prospective payment to cover all "needed" care for the stipulated period, the incentives facing HMOs are analytically very similar to those facing hospitals under DRG pricing; thus, in general, propositions in this section referring to hospitals will also apply to HMOs, mutatis mutandis.

penalties—not in ways that would be socially efficient.[40]

Consumer-patients and donors cannot respond to changes in quality they cannot observe. Thus, given the imperfections in agency relationships (Ellis and McGuire 1986), the shift to a DRG-type prospective-payment insurance system can be expected to cause reductions in quality in precisely those forms that are difficult for insurers to monitor (Weisbrod 1989). This prediction requires testing, which needs to recognize that in a competitive market there can be simultaneous decreases in type II dimensions of quality and increases in type I dimensions. For example, increased "quality" in easily observed forms such as hospital candlelight dinners for maternity patients and spouses can attract patients to a hospital, and free dental or eye checkups can attract members to an HMO, even while quality of medical care is being reduced in more subtle, hard-to-detect forms (Weisbrod 1988, chs. 2, 3, 8).

The reuse of "disposable" items by hospitals illustrates the potential for cutting quality in ways that are difficult for consumers to monitor, and an effect of prospective pricing on the choice of production technology. Until the late 1940s, hospitals reused most medical devices; tubing, syringes, needles, and so on were made to be used, sterilized, and used again. When the new technology of disposables was introduced after World War II, it was quickly adopted by a health care finance system that encouraged the greater convenience and safety of disposables and deemphasized the cost consequences. The expanding system of retrospective-pay health insurance that covered all "reasonable" hospital costs spurred both the development and the adoption of disposable items along with any other technology that was arguably quality enhancing.

Today, with the shift to prospective pricing, sterilization and reuse is returning. This change may or may not be efficient—allocatively or medically. What is striking is that hospitals are reusing items that are labeled by the manufacturers for "one-time-use only" (Alan Otten 1984). Even "disposable" filters for kidney dialysis machines are being reprocessed and reused (U.S. Congress, Office of Technology Assessment 1984a).

These practices reduce hospital costs. They may have no effect on revenues, for they are difficult for consumers (but presumably not their physician-agents) to observe. Thus, the financial consequences are relatively unambiguous. At the same time, the effect on health risks of reusing disposables is not currently known (Flora Chu et al. 1986; National Center for Health Services Research and Health Care Technology 1986). While the safety debate proceeds, the dispute is being resolved in favor of the cost-reducing technology. This is in sharp contrast to the situation in the 1950s, when the incentive structure was reversed; at that time, single-use disposables replaced the prior use-sterilize-reuse technology despite the absence of strong evidence of favorable health effects.

In general, the switch to prospective payment can be expected to bring changes in the technology of health care of just that type: they have clearly favorable effects on costs, but subtle or uncertain, yet presumptively nonpositive, effects on the quality of care. I say "presumptively" nonpositive because, given the state of technical knowledge, any change in resource use that is made after a change in incentives could have been made before; disposables could have been reused earlier.

[40] This is analogous to "skimming" and "creaming" of program participants.

Another quality-related dimension of hospital behavior likely to be affected by a shift to prospective pricing for hospitals is the length of a patient's stay. Confronted, under a DRG-pricing system, by a fixed price for treating each patient, hospitals have a financial incentive to discharge patients earlier (Judith Lave et al. 1988). Even if they do so, however, it is difficult for a patient to determine whether he or she has been discharged "quicker but sicker" (John Heinz 1986). Here, once again, a crucial question is how well asymmetrically underinformed patients are represented by physician-agents.

A reduction in use of hospital inputs is not necessarily inefficient in economic or medical terms; the cost saving may exceed the loss in benefits (although valuing the benefits is difficult), and in some situations there might be no medical benefits at all from, say, a longer hospital stay. Neither, though, is a reduction in inputs necessarily efficient. Input substitutions and cost reductions that may result from the shift from cost-based to prospective insurance cannot be assumed to be efficient or inefficient in a world of asymmetrically underinformed patient-consumers who confront prices that often bear little relationship to real marginal costs. Public policy, if it is to increase allocative efficiency, clearly demands understanding of the effects of pricing and other interventions on both quality and cost, not simply on costs. In particular, there should be attention to the tendency of a prospective payment insurance-pricing system to cause input substitutions that overvalue reductions in easily observed expenditures and undervalue reductions in quality that are more costly to observe.

The response of the health care sector to financial incentives may not be the same for its various institutional elements—private enterprise, governmental, and private nonprofit. In the hospital industry, 65 percent of all short-term beds are in private nonprofit hospitals, 26 percent in governmental. Thirty percent of nursing home beds are in nonprofit (22 percent) or government facilities (8 percent). Of kidney dialysis centers, 48 percent are nonprofit and an additional 12 percent are governmental (Weisbrod 1988). The key question is this: In response to a public policy shift from cost-based to prospective payment to providers, is there a different response—quantitatively or qualitatively—depending on the institutional ownership mix of the industry.[41] Confronted by the incentives that prospective payment provides to discharge patients earlier and to engage in other forms of quality-shaving actions in the type II dimensions, do for-profit, nonprofit, and governmental organizations respond differently?[42] Does institutional form matter?

Finding the answers to these questions requires modeling the behavior of each form of organization and the process of competition among them. There has been some attention to the conditions of equilibrium in institutionally mixed industries (Schiff 1986; Theodore Marmor, Mark Schlesinger, and R. W. Smithey 1986; Charles Phelps and Itai Sened 1989), but strong conclusions have not been reached.

Economic behavior may differ across ownership forms because of differences in objective functions, constraints, or

[41] A related issue is how competition among organizations of various ownership types affects long-run equilibrium, and whether one form of institution can be expected to drive out the others (Jerald Schiff and Weisbrod 1987).

[42] Whether earlier discharge of a hospital patient is a type I or type II attribute is debatable. I regard it as type II. While the length of stay for any patient is easily observed, what is difficult for the patient to observe is whether the length of stay was lower than it would have been if the physician and hospital were not responding to the altered financial incentive of PPS.

both. Profit maximization is typically assumed for the private enterprise components of the health care sector, but a variety of objective functions have been suggested for the nonprofit sector (Newhouse 1970; Karen Davis 1973; Pauly and Michael Redisch 1973; Estelle James 1983; Dennis Young 1983), as have various constraints on the distribution of profit[43] and access to public subsidies and private donations of money and time (Hansmann 1980; Susan Rose-Ackerman 1982; David Easley and Maureen O'Hara 1983; Alphonse Holtmann 1983; Charles Clotfelter 1985; Richard Steinberg 1986; Weisbrod and Nestor Dominguez 1986).[44]

DRG pricing provides the same financial incentive for all hospitals to discharge patients earlier than would a retrospective pricing system, but because of differences in objective functions and constraints, the behavioral responses may differ among institutional forms. There have been studies, for example, of the effect of prospective payment on the condition, at discharge, of elderly patients with hip fractures (Robert Palmer et al. 1989; John Fitzgerald, Patricia Moore, and Robert Dittus 1988) in two nonprofit hospitals, but they have not examined differences across ownership forms.[45]

More generally, neither theory nor empirical tests have resolved the question of whether there are systematic differences among institutional forms. Econometric evidence, while mixed, is growing that when for-profit, nonprofit, and governmental organizations coexist in a given industry—as they do in hospitals and nursing homes, for example—they do behave differently. Differences have been examined in four principal dimensions: (a) access to care, as reflected by admission of uninsured patients—that is, provision of "uncompensated" care—and the use of waiting lists rather than prices, (b) quality of care, (c) cost efficiency, and (d) extent of opportunistic behavior toward asymmetrically underinformed consumers.

Systematic behavioral differences between private firms and nonprofit organizations have been found in some studies (Bradford Gray 1986, which summarizes a number of studies; Regina Herzlinger and William Krasker 1987; Lawrence Lewin, Timothy Eckels, and Linda Miller 1988; Weisbrod 1988; Thomas Selden 1989), but not in others (Robert Clark 1980; Sloan and Robert Vraciu 1983; Gary Gaumer 1986). Nonprofit providers of health care, especially the church-affiliated nonprofits, appear to utilize a somewhat greater proportion of their resources to care for the indigent,

[43] Nonprofit organizations are not legally restricted from engaging in profitable activities; they are, however, restricted in what they may do with any profits. Little explicit attention has been devoted, however, to the enforceability of this constraint (Weisbrod 1988). This is relevant to the "managerial discretion" models of Oliver Williamson (1967), Armen Alchian and Harold Demsetz (1972), and Jean-Luc Migué and Gérard Bélanger (1974).

[44] All organizations, regardless of ownership, confront the same technological constraints, but they face different financial constraints in such forms as nonprofits' exemptions from property and sales taxes, and eligibility for postal subsidies. Charitable contributions of time and money to a nonprofit hospital (but not to a proprietary) might respond positively to the amount of unprofitable services it provides to low-income, uninsured, or other "deserving" persons. The relationship between donations to nonprofit organizations and the tax and expenditure behavior of government—the "crowding out" effect—has also received attention in the public finance literature. At the theoretic level see Peter Warr 1982; Russell Roberts 1984; Theodore Bergstrom, Laurence Blume, and Harold Varian 1986; James Andreoni 1988; for empirical studies see Burton Abrams and Mark Schmitz 1978, 1984; Schiff 1985.

[45] Palmer et al. (1989) found no change in ambulation status, comparing patients discharged from one nonprofit hospital in the several years before and after the change in price incentives. Fitzgerald et al. (1988), studying a single "community" hospital (presumably also a nonprofit), found significantly reduced mobility.

they provide a wider range of services (and in this sense, higher quality), and they take less advantage of their informational advantages over patients.

Neither the underlying theory nor the available, nonexperimental data, however, are yet strong enough to justify confident generalizations about differences in institutional behavior. Measuring quality of service in a hospital (Stephen Shortell and Edward Hughes 1988), controlling for differences in patient conditions, and distinguishing care of the indigent from "bad debts" associated with poor management, all remain subjects for future research, as does any differential responsiveness to the development of new technologies.[46] There is also a question of the appropriate estimation modeling; many econometric efforts to detect differential behavior across institutional forms may have misspecified their models, controlling erroneously for variables such as organization size, which are endogenous to the choice of institutional form (Weisbrod and Elizabeth Mauser 1990).

VII. *Concluding Remarks*

Economists' concerns about skyrocketing health care expenditures have focused heavily on insurance and its encouragement of inefficiently great utilization. Yet it is clear that much of the growth in health care expenditures during the post–World War II period has resulted not from increased prices for existing technologies, but from the price for new technologies. Newly developed technologies have driven up both costs of care and the demand for insurance, while also expanding the range of services for which consumers demand insurance. At the same time, expanding insurance coverage, which includes more people as well as a growing array of health care inputs, has provided an increased incentive to the R & D sector to develop new technologies, and a growing incentive for subsets of consumers who could benefit from particular new technologies to seek a wider definition of what would be covered by insurance. Both the resource costs of health care and our technical ability to prolong life and enhance its quality have risen sharply. The interactive process involving insurance and R & D is still evolving. It is increasingly being influenced by the recent change in incentives associated with the shift from retrospective, cost-based insurance coverage to prospective, exogenously determined pricing.

Although this paper has focused on the health care sector, the kinds of incentive effects it has examined are quite general. As an example of the potential effect of insurance on incentives facing the R & D sector, consider another major area of public policy and expenditure—education. Unlike health care, which has been financed for decades by a retrospective, cost-based finance system, elementary and secondary education has been financed traditionally through what amounts to a prospective payment system; roughly speaking, state and local governments have given the schools a fixed grant per child. This is roughly analogous to a DRG system with a single DRG, so that every patient (child) entering a hospital (school) brings a fixed sum of revenue to the provider. A school district can also be thought of as, like an HMO, providing "comprehensive" services to all "members" (students) in return for a fixed annual fee. By examining how the interaction of finance mechanisms and R & D incentives have operated in the health and education areas, we can gain insight into what the health care system would be like today had we

[46] In a related study of rapidity of introduction of new technologies in HMOs relative to fee-for-service providers, the Rand Corporation health insurance experiment found an apparently slower rate of introduction in HMOs (Newhouse et al. 1985).

taken an alternate route for financing it, as well as how a change in school finance would be likely to affect the education system.

Assume that public schools had been financed differently—in the way hospitals have been financed until recently: (1) school revenue was determined through a retrospective (cost-based) pricing system, in which (2) teachers were empowered to decide what resources should be used (a) to diagnose a particular child's educational "needs" and (b) to meet those needs, and (3) a bill for the cost of the resources used for each child was sent to government or a private insurer and subsequently paid to the school district.

Two questions arise: If such a system had been adopted after World War II for schools, what would have happened over the subsequent 40 years to the level of education expenditures? What would have happened to the pace of technological change in education? The lessons from health care suggest conjectures: If schooling had been "insured" on the basis of retrospective costs, expenditures would have increased far more rapidly than they did; and the pace of technological innovation in schools would have been far greater than it was.

Because education actually utilized a prospective pricing system, while health care utilized a retrospective pricing system, it is interesting to compare the two programs in terms of expenditure growth and technological change. First, with respect to expenditures, the share of GNP devoted to public elementary and secondary education has changed little over several decades (in which enrollments have remained relatively constant); between 1960 and 1985, for example, years of virtually identical enrollments—36.7 million and 36.6 million—public school expenditures increased from 3.03 percent of GNP to 3.42 percent (U.S. Bureau of the Census 1987, tables 186, 190, and 698); meanwhile, health care expenditures were rising from 4.6 percent of GNP to 10.7 percent (U.S. Bureau of the Census 1975, 1987).

Second, with respect to the pace and nature of technological change that might have occurred in education had retrospective pricing prevailed, we can do some informed speculating. To begin, we can compare—impressionistically—the technological change that has occurred in health care and in education. The typical hospital, for example, is barely comparable to its counterpart several decades ago, with entirely new techniques and facilities for diagnosis and treatment. The typical school, however, differs far less from its post–World War II counterpart, utilizing similar classrooms, teachers trained in similar ways, and using instructional techniques that, despite some computerization in recent years, employ capital-labor ratios that have changed relatively little.

We can predict that if retrospective reimbursement had prevailed for schools, the private sector would have devoted more resources to development of "improved" educational diagnostic and learning technologies; had that been the case, we would probably find now that education, like health care, had improved dramatically, but that society was paying a great deal more for it.

Today, the public policy "problems" in health care and in education are perceived to be sharply different, and in ways that correspond to the differences in finance mechanisms (although other forces are doubtless also at work). In health care, the central policy focus is on control of expenditures, quality of care not being seen generally as a problem.[47] In education, it is the reverse—the policy focus is on "low" quality of education,

[47] Problems of the uninsured are serious, but are receiving less attention than is the general problem of cost containment.

control of school expenditures receiving relatively less attention.

The ideas presented above are a mixture of solid knowledge, soft knowledge, and hypotheses requiring testing. In order to expand knowledge about health care and provide financial access to it, we need to understand more fully the dynamic process through which the health insurance sector, private and public, interacts with the R & D sector. This area offers a rich research agenda with enormous potential, for the policy implications extend far beyond health care and across geographical boundaries.

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