

NBER WORKING PAPER SERIES

A FUZZY LOGIC APPROACH TOWARD SOLVING THE ANALYTIC MAZE OF HEALTH
SYSTEM FINANCING

Dov Chernichovsky, Ph.D.
with
Arkady Bolotin, Ph.D.
David de Leeuw, M.A.

Working Paper 8470
<http://www.nber.org/papers/w8470>

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2001

The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

© 2001 by Dov Chernichovsky, Arkady Bolotin and David de Leeuw. All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission provided that full credit, including © notice, is given to the source.

A Fuzzy Logic Approach Toward Solving the Analytic Maze of Health System Financing
Dov Chernichovsky, Arkady Bolotin and David de Leeuw
NBER Working Paper No. 8470
September 2001

ABSTRACT

Improved health, equity, macro-economic efficiency, efficient provision of care, and client satisfaction are the common goals of the health system. The relative significance of these goals varies, however, across nations, communities, and with time. As for health care finance, the attainment of these goals under varying circumstances involves alternative policy options for each of the following elements: sources of finance, allocation of finance, pay to providers, and public-private mix. The intricate set of multiple goals, elements, and policy options defies human reasoning, and, hence, hinders effective policymaking. Indeed, 'health system finance' is not amenable to a clear set of structural relationships. Neither is there a universe that can be subject to statistical scrutiny: each health system is unique. "Fuzzy logic" and its underlying "Expert System" that model human reasoning by managing 'knowledge' close to the way it is handled by human language, provides a powerful tool for systematic analysis of health system finance, and for guiding policy making. Assuming equal welfare weights for alternative goals, and mutually exclusive policy options under each health-financing element, the exploratory model we present here suggests that a German type health system is best. Other solutions depend on the welfare weights and mixes of policy options.

Dov Chernichovsky, Ph.D.
Department of Health Policy & Management
Ben-Gurion University of the Negev
Beer-Sheva, Israel
and NBER
Email: dov@mail.bgu.ac.il

Table of Contents

| | |
|--|-----------|
| Introduction | 3 |
| Part I: Health System Finance—The “Expert System” 5 | |
| Elements of Health System Finance | 5 |
| Level of Health Care Finance | 6 |
| Means and Sources of Financing | 7 |
| Allocation of Finance | 12 |
| Provider Payment and Remuneration Methods (PPRMs) | 17 |
| Public-Private Mix (PPM) | 20 |
| Part II: The Fuzzy Logic Solution 23 | |
| “Expert Knowledge” and Fuzzy Logic | 23 |
| Fuzzy Logic Modeling | 24 |
| Fuzzy Logic Modeling of Health System Finance | 25 |
| Conclusion | 28 |
| <i>References</i> | <i>29</i> |
| <i>Tables</i> | <i>31</i> |
| <i>Figures</i> | <i>37</i> |

Introduction

The financing, organization, and management of the health system, within appropriate regulatory institutional frameworks, are the fundamental means to achieve its goals and qualities: health, equity, macro-economic efficiency or cost control, efficient provision or production of care, and client satisfaction. Improvement of health is the ultimate goal of the health care system. Simultaneously, however, the other qualities of a system, mainly equity, have become objectives in their own right (Chernichovsky, 1995a).

These goals and qualities are universal in scope. Their relative significance, however, varies across nations, communities, and with time. Developing communities may stress health as a major concern; developed communities may stress cost control and client satisfaction (Chernichovsky, 1995b). That is, different circumstances and objectives require distinct systemic solutions involving alternative policy options, encompassing the finance, organization and management of the health system. In other words, we have a dynamic set of goals and means that present policymakers with a perpetually moving target. Indeed, routine reprioritization of health system objectives, identification of constraints and the subsequent necessary tailoring of system financing, organization, and management, constitute the essence of efficient policymaking.

However, the challenge for such policymaking is analytically formidable, since no appropriate structured numerical tools exist to study the complex set of issues that are involved. Consequently, when policymakers and managers discuss health care financing—the focus of this paper—and related organizational and managerial issues with institutions, it is more than likely that each person will possess a different concept or visualization of the issues, and frequently this perspective will seem partial, narrow, and localized because of the wide range of intricate issues that the system involves. Policymakers and managers guide themselves by particular points of reference, experience, and intuition rather than by a systematic or structured approach. This follows because the complex systems involved defy human comprehension and even evade definition. They are marbled with subsystems and sub-subsystems and sub-sub-subsystems, all of unthinkable intricacy (McNeill and Freiberger, 1993).

In this paper we summarize an effort to deal with this challenge, by formalizing a generalized framework or model for the policy analysis of health care system finance, with the aid of “Fuzzy Logic” that models human reasoning by managing ‘knowledge’ close to the way it

is handled by human language. *“Fuzzy Logic is not logic that is fuzzy, but logic that describes and tames fuzziness”* (McNeill and Freiberger, 1993).

This paper consists of two parts. In the first, we design an expert system; we clarify the concepts and the issues of health care financing, so that they can be dealt with systematically via Fuzzy Logic (FL). In the second, we use FL as an approach that helps us overcome the impossibility of providing precise functional structures and supporting statistical evidence for policy guidance. We illustrate the use of this approach for identifying an optimal health care financing policy. Such a policy also implies the way the health system is to be organized, managed, and regulated.

Part I: Health System Finance—The “Expert System”

Elements of Health System Finance

Health care financing comprises the following basic elements:

- Level of finance for health system operations and development;
- Sources and means of financing;
- Allocation of finance or resources;
- Provider compensation or remuneration; and
- Public-private mix.

In a privately financed transaction involving a buyer and a seller, the first four elements are combined functionally and institutionally; ‘buying’ entails an integrated decision about the four elements. The fifth, public-private mix, is not germane in this case. These elements become separate and independent frameworks for a rather complex set of policy options in health systems, where the state, insurers, and care managers become intermediaries between the individuals who pay into the system, and the individuals who benefit from care in lieu of these payments. This is particularly the case in the modern health system (with the United States of America as an exception) that offers universal entitlement to a social package of medical care, to correct for a fundamental failure in the health insurance and care markets (Arrow, 1963). In this case, as well as in the US, there is substantial state involvement in the system along with other intermediaries. The question of public-private mix in the system revolves around the issue of how “private” should complement “public” (Chernichovsky, 2000).

The different elements listed above become means, through different policy options under each element, to achieve the multiple social and economic goals involving the health system. These aspects determine the efficiency of the financing system; that is, to be efficient, policies regarding all elements need to make up a coherent, consistent, and mutually reinforcing set. For any level of health finance, the associations between elements 2–5 and the issues and goals pertaining to the health system and the economy-at-large, are outlined in Table 1. In the publicly supported health care system, levels, means, and sources of finance reflect social and macro-economic choices and policies of which the health system may not constitute the key concern. Simultaneously, the allocation of finance is the key tool, along with appropriate pay-related incentives to provide for dealing with health system policy. Public-private mix affects all.

An elaboration on the elements of health care financing follows, with an outline of the policy options for each and the potential impact of those options on the system's goals.

Level of Health Care Finance

The level of health finance, more often wrongly than rightly, is the major preoccupation within health systems because it is often easier to contend with the 'quantity'—level—rather than with the 'quality' of financing that is associated with the other elements. Level of finance is a function, first and foremost, of the economic development of communities' and individuals' economic well-being. Richer nations and communities spend more on medical care than do their poorer counterparts, both in absolute terms and as a percentage of their Gross Domestic Product (GDP); that is, the income elasticity of health spending is higher than unitary (World Bank, 1993). While this particular assertion can be contested, it is undisputed that income level is the best predictor of health spending (Kornai and McHale, 1999a, 1999b).

Subsequently, the level of finance is influenced by the public-private mix in the system, policy, and politics. Hence, while we can associate marginal or additional aggregate expenditure on medical care, with particular interventions and development programs, there are no objective norms, especially in developed nations, to determine levels of health spending (Chernichovsky, 2000). Indeed, as suggested in Table 1, level of financing depends only marginally on the health system. Moreover, in developed nations, the level of health care financing is, in and of itself, a poor predictor of the population's health status as measured by age-specific mortality rates. The distribution of finance and resources—that are associated with elements 2–3—can be at least as important as their levels, in the determination of the population's health (Macintyre, 1989; Kim and Moody, 1992; Chernichovsky et al., 1998). Level of finance is also not a good predictor of the other direct utilitarian aspects of the health system such as client satisfaction.

That is not to say that for a given health system, level of spending is unimportant. At low levels of spending, resource levels have the potential to influence health levels significantly.¹ Comparatively high levels of finance might enable a health care system to concern itself more than otherwise with issues of equity and client satisfaction (Chernichovsky, 1995b). As for

¹ World Bank data suggest that levels of health spending across nations associated with a per capita Gross National Product (GNP) below about US\$8,000, are to be correlated significantly with life expectancy at birth. The data reflects, however, other environmental and behavioral factors affecting health status (World Bank, 1993, Figure 1.9).

equity, there are simply more resources to redistribute, with a higher likelihood of no health consequences for the relatively well to do, who sacrifice resources in the redistribution process.²

As for client satisfaction, it is assumed, although arguably, that well informed individuals will not trade benefits from effective care for quality of service or amenities. As standards of living rise, the effectiveness of medical care becomes increasingly dubious, however, and the desire for better service (not necessarily care) grows. In other words, with a higher level of spending, and its antecedents, there is a higher demand for quality service in conjunction with a higher level of care.

It can also be argued that ‘more’ might be conducive to waste or production inefficiency. There is no evidence, however, that ‘more’, in and of itself, leads to this inefficiency. The casual observation is that nations who spend comparatively more on health care than less developed nations, also have more efficient medical institutions.

In sum, ‘more’ is always enabling, and desired, from the perspective of the health system. But, partly for this reason, level of finance for medical care, especially under public finance principles, is a policy option for the economy-at-large, but not for the health care system. Therefore, we focus, in the following discussion, on the remaining elements of health care financing. These elements are the main prerogatives of health system policy.

Means and Sources of Financing

The Means and Sources of Financing (MSF) are key for achieving socioeconomic goals in conjunction with the health care system: (vertical) equity and macro-economic efficiency. First and foremost, MSF mirror the types of entitlement to care, whether privately acquired or publicly supported; and, when publicly supported, whether universal or categorical (Chernichovsky, 2000). In addition, MSF influence client satisfaction through the public’s willingness to contribute to the publicly supported system.

The four main means of health system financing are:

- Private funding;
- Social health insurance;

² However, the effectiveness of medical resources does not necessarily measure the utility or gratification they render to those who have gained access to them. Hence, it does not measure the political will to give up these resources. Consequently, it is possible, for example in the US, that in view of high spending levels, a redistribution of access to medical care might indeed increase overall system effectiveness; however, there is no political will to do so.

- Mandatory group insurance; and
- (Government) general revenues.

The last three reflect public finance principles in that they are mandatory and means- (rather than risk-) tested.

Of those, it is important to differentiate between the Social Insurance Model (SIM) and the traditional Continental Model, labeled above as ‘mandatory group insurance’, or the Group Insurance Model (GIM). The latter is close to the private insurance model with community rates. Although fundamentally different, the two are confused with one another and therefore need to be clarified. The two models (a) follow public finance principles, as defined above, and (b) keep separate from the state’s general budget part of the financing of universal or minimum entitlement to care. The two models are, however, fundamentally distinct.

In the GIM, the different contributions are made directly to “insurers” or sickness funds. Germany and Switzerland are examples of the GIM (Beck et al., 2001; Buchner & Wasen, 2001). In the SIM, on the other hand, all mandatory payments, irrespective of source, and including those from the general budget, are paid into a single national or regional public fund that *manages the collection and allocation* of health care finance. This fund, in turn, pays to sickness funds and to providers for care organization management and provision. Except for contributions for small groups with very special needs (e.g., invalids), and risk-sharing and safety net considerations; contributions under SIM, as defined here, are not ‘targeted’ for groups, let alone for individuals. The *allocation* of pooled funds is based on universal entitlement criteria, capitation schemes usually, that are unrelated to particular sources of funding. Israel (Chernichovsky and Chinitz, 1995), Russia (Chernichovsky, Barnum, and Potapchik, 1995), and Colombia (Londono, 2000) are examples. Thus, the SIM has a key feature of general revenues: it separates contributions from entitlement. Simultaneously, although essentially mandatory and tax-based, a substantial share of health care finance maintains a key feature in the traditional insurance schemes (voluntary and mandatory): earmarking.

Consequently, the SIM achieves vertical equity or income solidarity before the distribution of funds to institutions that organize and manage the consumption of care (OMCC institutions) and to providers. The SIM is, therefore, amenable to a prospective allocation mechanism.

The GIM, on the other hand, needs to support equity after funds have been collected by OMCC institutions, to equalize (per any) allocation (criterion) amongst funds. This *ex-post facto*

equalization must consider two elements, level of contributions of different groups—when such contributions are means tested—and the distribution of risk groups—when the allocation is per a risk or cost group. In this case, for vertical and horizontal equity, a retrospective ‘correction’ of the allocation is needed.

While all sources of health finance may be found in various combinations in all health systems, particular categories dominate, or can be said to characterize, a system. Amongst developed nations, for example, private finance mechanisms dominate in the US health care system, while mandatory insurance is typical of Western continental Europe (excluding the Nordic nations and the Netherlands). Social insurance (as defined here) is characteristic of Israel, the Netherlands, and Russia and is of growing importance in Latin America, while general revenues are typical of the Commonwealth (for example, Australia, Canada, the UK) and Nordic nations.

The alternative source and means of financing clearly represent history, and different social philosophies and contracts. Those alternatives entail some basic noteworthy tradeoffs in the context of health financing and related fiscal policy. From the perspective of this discussion, a key issue is the transparency of the link between contributions toward medical care, on the one hand, and control over entitlement, on the other. This link affects (a) the state’s ability to tax for care, or the population’s willingness to contribute, (b) the contributors’ ability to shift the tax burden, and (c) the beneficiaries’ ability to control their entitlement. As argued already, in the domain of private finance, the transparency between individual contributions and ‘entitlement’ to goods and services is at its maximum. This transparency diminishes and fades as the share of general revenue financing rises. Such transparency can, however, be a virtue of public financing of health care. We can reasonably assume that willingness to contribute, or pay, increases with this transparency. Accordingly, so may the willingness, depending on institutional arrangements, to contain costs and promote both consumption and production efficiency.³

Transparency is associated with earmarking, a key characteristic of the GIM and SIM models. In the case of the first, earmarking is associated with the group, usually place of work, union, etc. In this particular case, depending on state regulations, the group can exercise at least some control over the nature of publicly mandated or financed entitlement to care consumption. Often, the qualitative aspects of entitlement can be controlled (e.g., association with particular

providers). If sanctioned, the group may also contribute through ‘supplementary insurance’ and other forms of voluntary or optional payments that increase the members’ benefits beyond the socially mandated minimum. That is, the mandatory contributions can be used to leverage the group’s overall benefits. Especially in this latter case, the group has an interest in promoting health care consumption production efficiency. Those options do not conflict with some universal *ex-post facto* redistribution of funds between high spending OMCC institutions and low spending as done in Switzerland and Germany (Beck et al., 2001; Buchner & Wasen, 2001).

This group sovereignty leads to another dimension with direct fiscal implications: the possibility of shifting the contributions between employers and employees during wage negotiations. It can be further hypothesized that employers can claim that overall contributions, both mandatory and voluntary, are part of labor cost and, depending on employment conditions, can shift a portion of the cost to labor more easily in the GIM than in the SIM.⁴ In the case of the Social Insurance Model as defined here, while contributions remain earmarked, entitlement becomes beyond the control of the contributing group: the link between contributions and entitlement is severed. In this particular regard, SIM has the following key advantages over the GIM:

- The national or regional, rather than group, risk pool ‘allows’ small groups, and individuals, to benefit from (social) insurance which, alternatively, could be expensive or outright prohibitive;
- The public redistributive mechanism can improve equity across groups;
- It saves on the administration of health finance by replacing a ‘patchwork’ of health financing institutions;⁵
- It makes it easier to formulate and execute health policy via health finance; and
- It is a means to increase choice and competition in the system by severing the link between employers’ contributions and their employees’ choice of sickness funds and providers (Chernichovsky, 1998).

³ Consumption efficiency concerns the containment of ‘free rider behavior’ and moral hazard—that is, deliberate consumption at the expense of others.

⁴ In Israel, for example, where employers contributed through 1998 about 30% of overall health care cost to a common pool, the contributions have not been an issue in direct negotiations between labor and employers. Rather, the contributions have been an issue in the negotiations between employers and government, which has controlled the tax rates (“parallel tax”) of these contributions (Chernichovsky and Chinitz, 1995).

⁵ Part of this cost follows the dynamics of the situation: as people change jobs, become unemployed, etc., considerable costs are involved in changing entitlement and financing arrangements.

As suggested elsewhere (Chernichovsky and Potapchik, 1997), the SIM is also conducive to the implementation of a national fiscal policy in conjunction with the earmarked health budget. These benefits are achieved, however, at the cost of the comparative advantages of the GIM over the SIM:

- Willingness to contribute;
- Incentive to promote production and consumption efficiency at the group level; and
- Ability to shift cost of care to labor.⁶

In Table 2, we rank the policy options under “sources and means of financing” by their potential effect on those system goals which they impact: (a) vertical equity and its corollary universality of entitlement; (b) macro-economic efficiency through ability to budget or control aggregate spending; and (c) client satisfaction through willingness to pay or to contribute.⁷ The ranking is used for the purpose of the ensuing Fuzzy Logic analysis in the second part of the paragraph.

Vertical equity is dealt with in the first column, pertaining to universality of entitlement. The argument for this ranking reflects the state’s ‘constitutional’ ability to distance itself from financing medical care, or, alternatively, it reflects the public’s obligation to safeguard a given level of universal entitlement. This discussion postulates that this obligation is highest when financing is through general revenues, and least when under private finance. For reasons discussed above, the SIM is close in ranking to general revenues.

Macro-economic efficiency is considered in the second column. It represents the state’s ability to conduct efficient overall national, social, and macro-economic policy in conjunction with the health system. This includes setting taxes, for example, which affect income distribution, employment, and inflation, that have social and economic implications beyond the health system.

Moreover, this quality of the system represents the state’s ability to control levels of health spending that, in and of themselves, if rising fast, can have adverse effects on economic

⁶ The first two benefits can be restored in the health systems that have institutions or ‘groups’ which organize and manage care for clients (OMCC) such as sickness funds and HMOs (Chernichovsky, 1998). The group, however, is not *contribution-based* but rather *consumption-based*. In other words, the group is formed not around place of work or, for that matter around socioeconomic determinant, but rather around patterns of care consumption. This particular option can be exercised under the general budget as well. But willingness to contribute may still be lower under general taxation.

growth, especially in already developed nations. Here again, general revenues are best; private finance is worst.

Client satisfaction is regarded in the third column. As argued already, it is based on the transparency between contributions and benefits, and the people's willingness to contribute to the system. This transparency is highest under private financing arrangements and lowest under general taxes. Amongst the system based on public financing principles, mandatory contributions are deemed best, as noted in the discussion of the previous section.

Allocation of Finance

The allocation mechanism is the key to the execution of health policy in the system based on public finance principles, particularly in the one that benefits from central funding: general revenues and social security (the SIM) as defined here. Where there is no clear policy or deliberate link between a system's objectives and priorities, on the one hand, and the allocation mechanism, on the other, "policy" follows anyhow, by default. The allocation mechanism mirrors the organization and management, or the administration, of the health system.

As a policy and planning instrument, the allocation mechanism can serve sectoral and regional objectives of the health system, to promote access or 'horizontal equity' and health. In other words, this mechanism can take into account health objectives, risk factors, medical interventions and services, and pertinent social considerations. Consequently, the allocation mechanism can be based on public health objectives (such as preventive care and health promotion), demographic characteristics (age, sex, and standardized mortality), socioeconomic characteristics (social deprivation or other socioeconomic indices), and health care delivery characteristics (medical infrastructure, including training and research). The allocation mechanism has the following dimensions:

- Objectives of allocation;
- Forms of allocation; and
- Recipient institutions.

We focus on the last two because they can incorporate the objectives of allocation: particular public health issues, populations, regions, etc.

⁷ Client satisfaction with the *availability* of public entitlement is a key aspect of the health system. We assume, for now, however, that client satisfaction relates to willingness to contribute. In the ensuing discussion other elements of satisfaction that relate to entitlement, mainly availability of service, come into play.

The major forms of allocation are:

- Budgeting;
- Prospective capitation; and
- Retrospective capitation.

The first two are prospective in nature, setting budgetary limits. While the first may not have distinct criteria, except, say, size of population, the second has criteria such as risk adjusters, commonly ‘age’ and gender, for allocation per standard capita. Retrospective capitation may have the same risk adjusters, but retrospectively adjust for “acceptable” excessive costs. This essentially means that more affluent groups, under the GIM, support less affluent groups for such costs (Buchner & Wasen, 2001). That is, budget-wise, the last is considered relatively more lax than the others.

In Table 3 we rank in order the forms of allocation vis-à-vis system goals. *Equity* is best served by a retrospective capitation because in addition to allocation on presumably need-based criteria, like the prospective capitation, it allows for retrospective correction per ‘acceptable’ realized need. In comparison, budgeting is the worst because it does not correct for need—that is, it is indiscriminate.

Macro-economic efficiency is best served by ‘budgeting’ following the very nature of the process. It is least served by retrospective capitation that allows ex-post adjustment of spending. Prospective capitation is ranked in-between because, contrary to the budget, its recognition of specific needs may lead to fee-for-service-like mechanisms, such as pay for special groups and safety net arrangements.

Micro-economic production efficiency is to an extent a corollary of macro-economic efficiency in the context of the allocation element. The stronger the prospective budgetary control, the higher the incentives for production efficiency. Prospective capitation is considered superior to global budgeting, since it is tailored to specific needs and can enhance health goals, per given levels of spending.

Client satisfaction matches here the rank ordering of horizontal equity, in that the ordering reflects the recipient institutions’ incentive to ‘chase’ after, or satisfy the clients. This incentive can be absent under budgeting. ‘Cream skimming’, the selection of preferred enrollees, is associated with prospective capitation, but is a lesser incentive under the retrospective capitation.

As for recipient institutions, it was earlier suggested that, conceptually, the allocation mechanism is interwoven with payment to providers because ‘payment’ expresses, or follows, an ‘allocation’ decision. This issue has two dimensions with institutional ramifications: (a) the private-public split and (b) the Organization and Management of Care Consumption (OMCC) in the system. As for the first, we suggested that, technically, private for-profit insurers are ‘intermediaries’ who sever the direct financial link between contributors and beneficiaries. However, such insurers and the providers linked to them, at least financially, are not expected to necessarily promote health policy, let alone formulate it. They are expected to serve their clients and market positions. Their pluralistic nature in a private market system makes a health policymaking stance rather impractical. In this particular regard, sickness funds—like those in Germany and Switzerland, that collect funding directly from contributors even when the premium is mandatory and means-tested (the GIM)—are close to the private insurers as far as health system policymaking is concerned; the funds are merely financing administrations, in part, because they are prohibited from providing services. It is only when such insurers are entrusted with a role of managing care for either contributors, beneficiaries, or both, that they develop into the kind of intermediaries most pertinent to this discussion about allocation. Indeed, in the private market and under the GIM, it is possible that such insurers, like American Health Maintenance Organizations (HMOs), would promote individual policies of individual payers, notably large employers, in addition to, or in conjunction with, their market positions. The situation is different when funds are pooled under direct public control, either in the form of general revenues, or in the form of social insurance (SIM), as defined here. In this case, policy objectives, and priorities involving different goals of the health system, become paramount, even by default, since any allocation criteria will entail incentives for recipients to behave in this way or another.

With regard to the second, OMCC, dimension of the ‘pay versus allocation split’, the system can operate in two distinct ways. In the first, the public funding agency pays providers directly. Alternatively, it can almost entirely entrust the public budget to a ‘budget holder’ who is responsible for the Organization and Management of Care for Consumption in the public entitlement. Such budget holding intermediaries can be the following fund-, or budget-holding, OMCC institutions:

- Regional or local administrations (e.g., health regions or districts in the UK, or for that matter, states in federal systems);⁸
- OMCC institutions of different types (e.g., HMOs in the US, and sickness funds in the Netherlands and Israel); and even
- ‘Budget holding’ general practitioners and clinics (as in GP budget holding in the UK).⁹

The budget holding intermediaries can assume (a) part of the state’s responsibilities in managing care, offering decentralization vis-à-vis the state (center);¹⁰ (b) providers’ responsibilities involving economies of scale in care provision, such as central diagnostic and therapeutic centers requiring expensive technology and expertise; and (c) clients’ representation vis-à-vis both the state and providers. Moreover, the system can experiment with alternative health system models under the same entitlement and financing regimes (Chernichovsky, 1995a; Chernichovsky, 1998).

The different options are not mutually exclusive. It is quite possible that different sectoral allocation priorities that are not considered here explicitly, may call for different administrations. Where public health problems are paramount, it is conceivable on efficiency grounds that preventive care is organized and managed by a public administration, and personal curative care by non-governmental OMCC institutions. Yet again, such institutions may not be viable in sparsely populated areas where they may become natural monopolies, akin to public administrations. Indeed, this discussion is rather confined to situations where such institutions are engaged in genuine competition. National OMCC institutions can be mandated to operate as regional cost centers and controlled monopolies.

In Table 4 we rank the potential effects of alternative allocation policy options by recipient institutions on the goals in the publicly supported health system, where the ‘pay-allocation’ split is relevant. As for *equity*, we consider best a regional allocation mechanism to

⁸ The issue of ‘center’ is a matter of degree. The federal government in a federation can also be considered ‘center’ vis-à-vis the states. The decentralization issues do not necessarily concern constitutional and administrative definitions of ‘federalism’, but a rather functional definition concerning the different administrations making up a system (Oates, 1972). For example, although the UK is a unitary state, there is functional federalism in the British health system, through the regional and district allocation processes. On the concept of ‘corporate federalism’ in the health system, involving OMCC institutions rather than state administrations, see Chernichovsky and Potapchik (1999).

⁹ This reasoning can be extended to any situation where a medical institution has appropriated funds prospectively through a budget or a capitation allocation that is independent, in short term, of ex-post production. In this sense, publicly financed hospitals that have full control over the patient might be considered ‘intermediaries’ as well. This reasoning is not applied here, since hospitals are usually not charged with management of community services, while the opposite is common.

regional OMCC institutions. In general, a regional administration, even if public and in a non-federal system (e.g., the UK), can address regional concerns better than a national institution, especially when the allocation mechanism—that is, the British capitation to districts—takes into account local concerns such as social deprivation and health conditions, as well as availability of medical infrastructure. Allocation to national OMCC institutions that are not regionalized, for example Israel, usually permits gravitation of funds (for non-central activities) to urban centers (Chernichovsky and Shirom, 1997). We assume the competing regional OMCC institutions to be a superior model to the regional administration because the former has an incentive to mobilize membership and, hence, to be more equitable in that it is trying to reach out to the population.

Macro-economic efficiency through cost-containment is served best through regional OMCC institutions that need to operate both under a regional budget, usually under a capitation regime, which implies that they need to share in the financial risk of managing their clients. This institutional ‘doubling’ of the budget constraint is believed to make it more effective, compared to a national OMCC operation that can yield much power vis-à-vis budgeting authorities (e.g., Israel). In comparison to OMCC institutions, the regional administration may have more political and institutional leverage to exceed its budget and, hence, in this particular regard is considered inferior to OMCC operations.

Production efficiency of medical care we believe to be served best by OMCC institutions that we assume to manage curative care more effectively than do public administrations and individual practitioners (Chernichovsky, 1998). National OMCC institutions can best exploit economies of scale and may be inclined to use a wider market of providers. Simultaneously, however, regional OMCC institutions may have better control over local provision of care and may control cost of care more effectively.

Client satisfaction we believe to be served least by allocation to public administrations that are managers of care, since they are deemed bureaucratic and least sensitive to clients. The situation in this regard is better with OMCC institutions that need to compete for clients. The regional OMCC institution has a lower ranking than a national institution, because we assume that the former can facilitate less, across the border, choice of care options that can satisfy clients.

¹⁰ Regular budgeting, mainly of hospitals, may fall under this category.

In sum, a distinct allocation system—implying institutional intermediaries between payers and beneficiaries, and universal forms of allocations—provides the health system with a policy implementation instrument, possibly for *functional* federalism (Chernichovsky, 2000; Chernichovsky and Potapchik, 1999).

Provider Payment and Remuneration Methods (PPRMs)

PPRMs bring about incentives and, hence, affect providers' behavior and their approach to clients. Consequently, especially when an explicit allocation mechanism is absent, as may be the case in the Commonwealth health systems, PPRMs are the decisive means to achieve the system's goals. When an allocation mechanism exists, PPRMs need to complement and harmoniously support this mechanism. Moreover, PPRMs, possibly more than other financing elements, need to be supported by regulations to counteract adverse elements that may be associated with incentives. We focus here on the incentives of providers in the community and of hospitals to support different systemic goals under “public contracts”.¹¹

The different common PPRMs are ranked vis-à-vis the systemic goals in Tables 5 and 6. In both tables the *(horizontal) equity* aspect concerns providers' willingness to extend universality or to reach out.

In other words, even under common universal entitlement, providers, working only under public contracts, can be prompted into ‘universality’, seeing more patients, but each patient not comprehensively, or into ‘comprehensiveness’, seeing fewer patients, but each more intensively. The former may result in lower quality care and less overall individual patient satisfaction from service, while the latter may generate waiting lists, lower quality care, as well as lower satisfaction of those on the lists. We adopt the common approach that ‘universality’ is more (vertically) equitable than ‘comprehensiveness’.¹²

Consequently, with regard to community practices, commonly solo practitioners (Table 5), *(horizontal) equity*—as defined here—is best served by capitation.¹³ This assertion follows the provider's incentive to enlist as many potential patients as possible, quite possibly at the

¹¹ “Public Contract” refers to provision of services paid by funds raised through the application of ‘public finance principles’. This contract has nothing to do with the ownership of medical facilities; see Chernichovsky (2000).

¹² Cost-benefit of intervention, in terms of some universal measure of health, for example DALYS (disability adjusted life years saved), is the ultimate yardstick for promotion of horizontal equity. In spite of the rhetoric, ‘universality’ comes down to the application of the ‘fairness principle’ whereby what cannot be extended to all under public entitlement, is extended to none. For an extensive discussion, see Chernichovsky (2000).

¹³ The reader should not confuse capitation as a common allocation mean, and capitation as a pay method.

expense of quality or comprehensiveness. Fee-for-Service (FFS) ranks lower because, contrary to capitation, fee-for-service lends itself to ‘trade’ patients for ‘procedures’ as a means to augment provider income.¹⁴ That is, FFS can be more comprehensive but less universal. The ‘capped fee-for-service’ method, whereby a ceiling and declining marginal fees are set on providers, reduces the incentive to see patients when the marginal effect sets in or when the ‘cap’ becomes effective. Wages for providers in the community are deemed to be the worst for equity, as defined here, because the provider has no marginal incentive to reach out.

Macro-economic efficiency, or the support of cost control via PPRMs, concerns the providers’ ability to create bottom-up pressures to increase cost of care, mainly through volume of service. This ability is highest with FFS and diminishes with the other pay options—capitation and wages—that are prospective, or that have a prospective element, such as ‘capped FFS’. Consequently, capped FFS for providers in the community ranks highest from the perspective of supporting macro cost control efforts. It sets an upper limit to spending, but contrary to wages and capitation, does not preclude, at least theoretically, lower levels of spending than those implied by the cap. Capitation and wages rank intermediately in this regard.

The ‘*production efficiency*’ goal is associated here with ‘*macro-economic efficiency*’. It concerns the providers’ desire to economize on use of resources that can ultimately be shifted to other uses and, hence, benefit the health system and eventually the economy at large. In this regard, capitation—as a pay method—ranks highest because the capitation recipient has an incentive to economize on use of resources, and thereby augment his net income.¹⁵ ‘Budget holding’ arrangements in conjunction with capitation—whereby the community provider is entrusted with the larger part of the budget allocated to the patient, including hospitalization—are even better in supporting production efficiency in that they incorporate system-wide incentives to save via community care operations.

FFS ranks second because the provider has no incentive to economize on medical resources; on the contrary, he uses such resources to augment his income through some mark-up. The capped FFS has a capitation-like result globally, but up to the ceiling, it is like FFS.

¹⁴ Common monitoring mechanisms enforce behavior in favor of more patients because these mechanisms are geared to detect numerous procedures on the same patients.

¹⁵ Even when the direct pay to providers is not affected, and, in the short term there are no financial savings to the system, there may be a ‘spill over’ effect at least in the long term, that resources used in referred services are saved and ultimately diverted to other uses.

Therefore, it ranks between FFS and capitation. Wages rank lowest, since without the profit maximizing incentive of FFS, wage earners have no incentives to economize on resources.

Client satisfaction can best be served with the FFS method that offers the widest incentive and scope to satisfy a client's needs and desires even under public entitlement. This method is followed by capped FFS under which the incentives to satisfy the patient are somewhat depressed eventually. Capitation has a similar effect in that the provider has, on the one hand, an incentive to retain the population he has enlisted, but, on the other hand, has no incentive to supply particular services or procedures which he might have supplied under an FFS method. Compared with the other methods, wages are believed to provide the least financial stimulus to satisfy patients, as wages carry no incentive to see an additional patient or provide an extra procedure.

The discussion of hospitals corresponds in most aspects with the discussion of community providers. FFS has similar effects across the systemic goals. Global budgeting is similar to wages with regard to financial incentives. Hospitals are unique in that they can be paid by 'patient day', by 'case' and by 'Diagnostic Related Groupings' (DRGs).

As for *equity*, DRGs are ranked highest; the hospital has an incentive to see as many cases, but compared with pay 'per case', which does not discriminate cases by severity, the hospital has a lower incentive to discriminate against complicated cases, and, therefore, responds better to need, than 'per case'. Equity-wise, pay by 'patient day' is least desired because it promotes a relatively lengthy stay at the expense of patient turnover. As with global budgeting, 'by patient day' is conducive to waiting lists.

As for *macro-economic efficiency*, global budgets are the best means to control overall cost, followed by DRGs which, contrary to the other methods, especially FFS, have a prospective element: the hospital has relatively little room to manipulate cost, and overall costs are more predictable and controllable. 'Per case' and 'per-diem' are ranked as intermediate options. They are ultimately capped, in the short run, by size of hospital in beds and length of stay.

Production efficiency stimulus is highest with pay per case. This method prompts short stay, and high use of 'medical capital', contrary to 'hotel capital'. Therefore, eventually 'per case' may reduce the need for beds in the population. This is followed by DRGs that produce a similar incentive, but correct for severity.

Client satisfaction in hospitals is best served by FFS. This is followed by pay by 'hospital day' because there is an incentive to admit patients, contrary to the incentive under global

budgeting, and keep the hospitalized patient for as long as deemed ‘needed’. ‘Per case’ and DRGs are intermediate methods in this regard, as they invoke an incentive to ‘get rid’ of the patient.

Public-Private Mix (PPM)

The public-private mix concerns the relative importance of private financing in the health system. The way PPM is applied is a basic qualitative aspect of health care financing. This mix determines, primarily, the system’s effectiveness in attaining its objectives through the other elements, especially those in the public domain. Several key issues need to be reiterated at the outset with regard to private finance. First, as stated already, the ‘private’ transaction ‘collapses’ all elements of financing into one. It eliminates policy controls that can be exercised by potential intermediaries, including the state, operating between payers and beneficiaries.

Following the failures of the health insurance and medical care markets (Arrow, 1963), the higher the share of private finance in total finance, the lower is the system’s effectiveness in promoting equity and controlling overall spending, or macro-economic efficiency, in the system. Second, a less equitable distribution of medical resources can also translate, especially in low-income communities, into lower average levels of health. Third, and noteworthy because of common conceptual confusion between ‘private financing’ and ‘Fee-for-Service’ (FFS), private financing is commonly presumed to make the provider responsive to the client. It should be stressed, however, that provider responsiveness to the client, and production efficiency, are not necessarily related to *sources* of financing, whether public or private, but, indeed, primarily to PPRMs. FFS can be used to promote responsiveness and efficiency, also in ‘public contracts’ based on funds raised through public principles, as suggested in the previous section. That is, private finance is not a necessary condition for satisfying clients. In many cases, e.g. private insurance, it may not be sufficient either.

The PPM can be applied in many ways and take numerous forms involving a multitude of issues.¹⁶ We deal here with those we deem to be the most fundamental to overall financing policy. First and foremost, it is important to differentiate between ‘co-payment’ and ‘extra-billing’. Contrary to the latter, the former, while involving private funds, is often an integral regulatory part of the publicly financed system. A co-payment is levied on a service or product included in public entitlement. Co-payment is often justified as a means to fend off ‘unnecessary

demand’, although with time it may become an ‘indispensable’ source of funding in the publicly supported system.¹⁷ We assume here that co-payment does indeed diminish the use of services under public entitlement and, hence, to be most effective, is not insurable.¹⁸ Moreover, we assume that co-payment is part of the public financing pool and thus, does not constitute, in any direct way, part of the individual provider’s income, hence, affecting the provider’s incentives.

‘Extra billing’ (EB), on the other hand, implies that a *provider* who has a ‘public contract’, financed by funds raised on the basis of public principles, is sanctioned to offer, at his own discretion, services—privately funded in full—in conjunction with those which are part of public entitlement. This ‘integrated system’ exists, for example, in Australia and is common in continental Western Europe. This option is practically prohibited in the ‘segregated system’ of Canada or the UK, for example, where private finance essentially does not mix with public. To simplify the discussion, without loss of generality, we further assume that co-payment and EB are mutually exclusive options.

In Table 7 we rank the different basic PPM options vis-à-vis pertinent systemic goals. As for *equity*—in the publicly supported system and in general—when private finance is separated from public finance (e.g., Canada) *at the point of service provision*, its potential shortcomings in the system are minimized. It practically eliminates the possibility of an open ‘two-tier’ in the publicly financed system.¹⁹ Uninsurable EB is the least equitable because it creates an incentive to prefer the well-to-do even for public entitlement; it opens the way to exploit resources available through public finance patients who can pay privately while depriving those who cannot pay from their public entitlement. It is followed by co-payment. Insurable EB can mitigate the equity issue of EB, because it can make services provided under EB financially more accessible.

Macro-economic efficiency and overall cost control are best served by co-payment (in a segregated system), adding a demand-reduction effect to the providers’ limited ability to leverage private spending in the publicly supported system. They are served least by insurable EB. This option provides, on the one hand, a lever to increase overall spending, and, on the

¹⁶ See Chernichovsky (2000) for an extensive discussion of the concepts and issues.

¹⁷ We do not venture into the issue of long-term vs. short-term impact of co-payment on demand.

¹⁸ Insurable co-payment can nullify the potential ‘demand reduction’ effect of the co-payment and its rationale. This more equitable option can be used to raise funds for the system rather than reducing demand.

¹⁹ Relatively severe supply constraints in publicly supported systems can lead to a system of ‘under the table pay’. Such a system is a matter of culture and low enforcement.

other, can lead to higher demand for care. When not insurable, EB might diminish the demand and cost of care by reducing the demand of some groups.

Production efficiency in the context of PPM concerns the provider's incentive to obstruct services under public entitlement, to promote privately financed demand, thereby reducing the cost-effectiveness of care. We argue that the incentive is highest under insurable EB because, contrary to uninsurable EB, the provider does not feel that the client shoulders the (full) financial burden of the extra service. In this particular regard, co-payment might be conducive to production efficiency. Knowing that the patient may be disinclined to pay another visit because of the co-payment, *ceteris paribus*, the provider—who may also have a lower patient load because of the co-payment—might be inclined to give the best service possible while the patient is with him. The 'segregated system' ranks second best as, contrary to EB, the scope to exploit the patient is not facilitated by diagnosis and treatment under public entitlement.

The discussion of *client satisfaction* is guided here by the 'fairness principle' in the publicly supported system. According to this principle, whatever is not available to all is available to none. Consequently, a segregated system is ranked highest and non-insurable EB, lowest. Co-payment is considered superior to insurable EB, as it provides less incentive to discriminate between patients (Chernichovsky, 2000).

Part II: The Fuzzy Logic Solution

“Expert Knowledge” and Fuzzy Logic

The properties in the tables presented thus far conform to the general characterization of “Expert Knowledge” (EK). Tables 2–7 map inputs—financing policy options—into outputs—health system goals. We use tabulated rules that can be fairly acceptable since they are based on “common knowledge” that follows general observation and whatever data we have. EK may comprise contradictory data since different ‘experts’ may have different opinions. Our own tables, too, are subject to argument. No better solution yet exists, however. Such tables substitute for an inconceivable number of structural equations of unknown specifications that would involve an unthinkable number of variables. Under the best of circumstances, they would be impossible to estimate because of the insufficiency of techniques and the lack of a sampling universe, as, at best, we may have a single observation for any combination of policy options. Furthermore, EK often concerns institutions (e.g., tax methods) and concepts (e.g., equity) of a qualitative nature that, at the outset, may not be amenable to mathematical and statistical modeling and study.

Yet, EK is often considered ‘incomplete’ and ‘inexact’. Consequently, however important and indispensable, EK may be regarded as deficient and not fully reliable for decisionmaking because it is hard to ‘handle scientifically’. As a result, EK is often lost or at best used in a partial and, potentially, even a counterproductive manner, as it often provides a local rather than a system solution. Our approach aims to overcome this problem.

Some basic relevant issues can be discussed through the concept of “uncertainty”, which is used to handle numerically incomplete information. Classical *set theory* and *probability theory* are usually used to deal with “uncertainty” by assigning experience-based probabilities to events. These events can be conditional when we have some underlying structural relationships. Measurement of “uncertainty” is thus based on rather explicit relationships and a sampling universe. Neither of the two may exist even in a perfect world, especially when we explore relationships involving institutions and qualitative judgment, and wish to relate—in a structured manner—institutional ‘outputs’ to ‘inputs’ (e.g., ‘pay method’ to ‘equity’).

Fuzzy set theory (FST) and fuzzy measure theory (FMT) are relatively recent mathematical frameworks significantly broader in handling “uncertainty” than the classical

theories (Klir, 1993). In FST and FMT membership in a set is a matter of degree (Kampe, 1982). The theories deal with propositions of the general type such as “ x is P ” (“the health system is equitable”), where x is an element from a designated universal set X , of, say, equitable health systems ($x \in X$), and P is a relevant property (e.g., equitable, efficient, etc.). The fuzzy set X consists also of elements that conform to the proposition P (“equitable”) *to some degree or extent*. We can argue, rather imprecisely, that a particular system is equitable to some degree. In other words, the fuzzy set that represents “equitability” does not comprise only two elements “yes” (1) and “no” (0) as it does in the case of the classical set theory. Rather, it constitutes an array or range of points, a possibility distribution that fills the interval between “0” and “1”. If in the classical set theory we could say that *a particular system* is either equitable (1) or not (0), in the fuzzy set theory we can consider a degree of “equitability”.

That is, “uncertainty” (imprecision, vagueness, fuzziness) in FST follows subjective, possibly relative, perception, and often conceptual, statistical, and even linguistic deficiencies in the definition of P and its causes (Jang and Gulley, 1995).²⁰

Fuzzy Logic Modeling

A ‘membership function’—a *possibility* distribution—is the main aspect of FST. The function describes the possibility (degree) to which a measurable value belongs to a particular linguistic term like “equitability”, “efficiency”, etc.

The function has the following fundamental properties.

It possesses a kernel, an area, where the proposition is “entirely or mostly true”; the value of the function equals the maximum, conventionally denoted by “1”. It possesses a kernel, a point or range, where the proposition is “entirely or mostly false”; the value of the function equals the minimum, conventionally denoted by “0”. Then, most distinctly, the function is defined below the maximum and above the maximum, indicating the extent to which the proposition is true. Examples of membership functions are given in Figure 1. In the top panel, for example, we say that the statement, “equity is low”, is certainly true [Y-axis = 1] when the numerical, x-axis, score is “1”. The statement is unequivocally false when the score is “3” or more. When the score is 1.5, for example, we suggest that the degree to which ‘equity is low’ is 0.75. The same holds for production (in)efficiency; the statement “production efficiency is low”

is not true beyond a score of “2”. Thus, the only condition a ‘membership function’ needs to satisfy is that it varies between zero and one. The function itself can be a curve whose shape suits some notion of the mapping between values or scores and the validity of a phenomenon (Jang and Gulley, 1995; Klir, 1993). Consequently, the major challenge in FL modeling is to establish, through membership functions, a link between the values of a variable (e.g., an expert’s score such as in the tables above) and a linguistic term, which characterizes an attribute that is examined (e.g., equitability in the health system).

In sum, Fuzzy Logic modeling starts with a systematic description of the object of modeling and then relates ‘inputs’ to ‘outputs’ in a categorical manner, as was done in the first part of this paper. Schematically, the main steps in FL modeling can be described as follows:

- Fuzzification—establishing a membership function with links between some values, not necessarily ordinal, that are associated with a phenomenon (e.g., equity and the degree of “truth” of a given property).
- Inference—constructing rules for inference according to expert knowledge (e.g., “if the source of finance is general taxes, the system is equitable”) and aggregation of knowledge for decisionmaking.

This last step involves aggregation of the results of individual ranking of policy outcomes as demonstrated below.

Fuzzy Logic Modeling of Health System Finance

In the first part of this paper, each policy option under each financing element has been ranked through an assignment of a number that indicates its ability to support particular health system goals. To simplify the presentation we assume:

- All health system goals have equal weights in some social welfare function;
- The rankings of policy options do not indicate relative values in the ability of particular options to attain a given goal. In other words, the ranking is strictly ordinal; and
- Policy options under each financing element are mutually exclusive.

²⁰ We could poll, say, n experts for their views about m health systems and establish ‘probabilities’ about the equitability of a system. This approach, more costly than ‘common knowledge’, may not be deemed to be more scientific than managing ‘common knowledge’ systematically.

As a fundamental framework, we put forward the following three simple rules, to define our universe of aggregate outcomes, with OR and AND logically maximum and minimum operators respectively, and AVR the mean operator amongst different possibility distributions.

Rule 1:

| | | |
|----|--|--|
| If | <i>Equity is low</i> | <i>Then the health care system is poor</i> |
| OR | <i>Macroeconomic efficiency is low</i> | |
| OR | <i>Production efficiency is low</i> | |
| OR | <i>Client satisfaction is low</i> | |

Rule 2:

| | | |
|-----|--|--|
| If | <i>Equity is average</i> | <i>Then the health care system is good</i> |
| AVR | <i>Macroeconomic efficiency is average</i> | |
| AVR | <i>Production efficiency is average</i> | |
| AVR | <i>Client satisfaction is average</i> | |

Rule 3:

| | | |
|-----|---|---|
| If | <i>Equity is high</i> | <i>Then the health care system is excellent</i> |
| AND | <i>Macroeconomic efficiency is high</i> | |
| AND | <i>Production efficiency is high</i> | |
| AND | <i>client satisfaction is high</i> | |

The first rule suggests that if a system “fails” meeting even one goal in a satisfactory manner, the system is considered ‘poor’. The third rule suggests that if a system meets *all* goals to a high standard, it is considered ‘excellent’. This last rule is clearly acceptable. The first, however, is rather strict; a system poor in all regards could be considered very ‘poor’, but a system performing poorly in only one regard could rank ‘intermediate’ in the range between ‘poor’ and ‘good’. Yet we adopt the strict rule, which can be modified, because it simplifies the illustration. This also follows the lack of the assignment of priorities to health system goals.

Now we apply Fuzzy Logic modeling to our “expert data”, in Tables 2–7.

We illustrate it with the aid of Figure 2, where the approach is applied to “fee-for-service for practitioners in the community” according to the data presented in the first line of Table 5. We use the “Implication Method”—that is, the shaping of the fuzzy sets based on the numerical results of fuzzy operators using the simplest triangle membership function approach (Jang and Gulley, 1995).

The first rule stipulates that the system is considered ‘poor’ if it fails on even one criterion. The top left-most membership function indicates that when the score is “1”, it is certainly true that ‘equity is low’. Our score on this particular option is “3” (grey vertical arrow

in Figure 2, per first row in Table 5) indicating, per this particular membership function, that the statement “equity is low” is false. The statement “macro efficiency is low” is fully true (second top function from the left). Given the first rule, it is already sufficient to conclude that according to this policy option, the health care system is surely poor as indicated in the right-, up-most local aggregation panel in Figure 2, by the local aggregation score “1”. It is already clear that there is an element of arbitrariness in the shape of the membership function. It is also clear, however, that the particular shapes hardly influence the inference according to at least our first rule.

For the second rule, we “average” the scores of the membership functions or possibility distributions per the scores in Table 5, indicated by the vertical grey arrows in Figure 2, and return a local aggregation score of 0.4 to the statement that the “system is good”. That is, the system has this outcome to an extent of 0.4. This follows, for example, that the statement “production efficiency is average” is certainly true when the score is 2 (third function from the left, second row), and “equity is average” is true to the extent of 0.6, and so on.

As for the last rule, we can say with confidence that “client satisfaction is high” as it is scored “4” (fourth function from the left on the third panel). This, however, is not the case for the other outcomes. Hence, the aggregate score is “zero”. Consequently, by the third rule it is false to say that the health system is excellent under fee-for-service for community practitioners.

The local aggregation results, in numerical values, are summarized in the lowest panel of Figure 2. They are the projections of the local aggregations. These results yield a weighted average of the local aggregations, of 1.8 [= (1 x 1) + (0.4 x 2) + 0]. This is the overall *numerical* score of this policy option, given our system goals, ranking of options, and inference rules.

This process we just illustrated is now repeated for all twenty-three policy options specified in Tables 2–7, and then all individual aggregations are aggregated again. The overall aggregations are shown in Figures 3–8. Following our illustrations in Figure 2, we see in Figure 6 our aggregation, left panel, compared with the aggregation of other options. On this specific policy option, no system is excellent, but a capped fee-for-service appears to be superior to the others. In Figure 3, for example, we conclude, everything considered, with full certainty that the system is poor when financed through general revenues or private finance as sources of income. We cannot state that any system—given our scoring and inference rules—is ‘excellent’. Mandatory or Group Insurance is possibly superior to Social Insurance. In the same fashion, we

are inclined to ‘give it’ as our expert opinion that allocating resources to regional OMCC institutions might be the least detrimental.

Following this logic, according to the results summarized in Figures 3–7, we conclude that our simplified but rather robust Fuzzy Logic approach suggests the following health finance scheme:

- Mandatory health insurance as a source of health care financing;
- Prospective capitation as an allocation mechanism;
- Regional OMCC institutions as the target of the allocation mechanism;
- Fee-for-service with global capping as a pay mechanism of community-provider compensation;
- Diagnostic related groupings (DRGs) as a mechanism of hospital remuneration; and
- Co-payment or extra-billing as mix of private and public finance in health care system.

This scheme is close to a German-style system.

Conclusion

In this paper we present a general model. The FL model, and the underlying Expert Knowledge system, are easy to modify and refine by adding possibly more socioeconomic goals, and more policy options. Most importantly, however, we can assign weights or priorities to system goals, and allow for mixes of policy options for each health financing element. In addition, the ranking of the policy options can be changed according to some ‘consensus’ process and other available quantitative and qualitative data. All can be entered into a simulation model (work under way) to explore the sensitivity of outcomes to different welfare weights and option mixes. Regardless, the approach can be constantly modified with more data.

References

- Arrow, K.J. 1963. "Uncertainty and the Welfare Economics of Medical Care". *American Economic Review* 53(5):941–973.
- Beck, K., Spycher, S., Holly, A., and L. Gardiol. 2001. "Risk Adjustment in Switzerland". Presented at the Risk Adjustment Network Meeting. Amsterdam (April).
- Buchner, F., and J. Wasen. 2001. "Needs for Further Improvement: Risk Adjustment in the German Health Insurance System". Presented at the Risk Adjustment Network Meeting. Amsterdam (April).
- Chernichovsky, D. 1995a. "Health System Reforms in Industrialized Democracies: An Emerparadigm". *The Milbank Quarterly* 73(3):339–372.
- Chernichovsky, D. 1995b. "What can Developing Economies Learn from Developed Economies?" *Health Policy* 32:79–91.
- Chernichovsky, D. 1998. "Public Choice, Democratization, and Role of the State under the Emerging Paradigm in Health Systems: Capitation Revisited" (in Hebrew). *Bitahon Socialli*. (1996) 47:9–32. English version available.
- Chernichovsky, D. 2000. "The Public-Private Mix in the Modern Health Care System—Concepts, Issues, and Policy Options Revisited". NBER Working Paper No. W7881 (September).
- Chernichovsky, D., Barnum, H., and E. Potapchik. 1996. "Health System Reform in Russia: the Finance and Organization Perspectives". *Economics of Transition* 4(1): 113–134.
- Chernichovsky, D., and D. Chinitz. 1995. "The Political Economy of Health System Reform in Israel". *Health Economics* 4:127–141.
- Chernichovsky, D., Kirsanova, T., Potapchik, E., and E. Sosenskaya. 1998. "Inequality of Health Finance, Resources, and Mortality in Russia: Potential Implications for Health and Medical Care Policy". *Health, Health Care and Health Economics*: 253–270.
- Chernichovsky, D., and E. Potapchik. 1997. "The Role of General Revenues and Fiscal Federalism in Health Systems Based on Mandatory Contributions and Social Insurance: the Case of Russia". Presented at the meetings of the Foundation for International Studies of Social Security. Situnga, Sweden (June).
- Chernichovsky, D., and E. Potapchik. 1999. "Genuine Federalism in the Russian Health Care System; Changing Roles of Government". *Journal of Health Policy, Politics and Law*. Vol. 34. No. 1: 116–114.
- Chernichovsky, D., and A. Shirom. 1997. "Equity and the Israeli Health Care System". In: Kop, Y. (ed.) *The Allocation to Social Services in Israel*. Center for Policy Studies. (Hebrew & English). Jerusalem.

- Jang, R., and N. Gulley. 1995. Fuzzy Logic Toolbox for use with MathLab[®], The Mathworks Inc.
- Kampe de, Feriet J. 1982. "Interpretation of Membership Functions of Fuzzy Sets in Terms of Plausibility and Belief", in M.M. Gupta and E. Sanchez (Eds.). *Fuzzy Information and Decision Process*. Amsterdam: North-Holland: 93-98.
- Kim, K., and Moody, P. 1992. "More Resources Better Health? A Cross-National Perspective". *Journal of Social Science & Medicine* 34(8):837–842.
- Klir, G.J. 1993. "Developments in Uncertainty-Based Information". In: Yovitis M.C. (Ed.), *Advances in Computers*, vol. 36, Academic Press, San Diego, 255–332.
- Kornai, J., and J. McHale. 1999a. "Is Post-Communist Health Spending Unusual? A Comparison with Established Market Economics". Unpublished manuscript (June).
- Kornai, J., and J. McHale. 1999b. "Income, Technology or Demographics? An Accounting for Trends in International Health Spending". Unpublished manuscript (July).
- Londono, J.L. 2000. "Managing Competition in the Tropics". Bogota, Colombia: Mimeo.
- Macintyre, S. 1989. "The Role of Health Services in Relation to Inequalities in Health in Europe". In: Fox, J. *Health Inequalities in European Countries*. London: Gower Publishing Co.: 317–332.
- McNeil, D., and P. Freiburger. 1994. *Fuzzy Logic (The Revolutionary Computer Technology is Changing Our World)*. New York: Touchstone: 11–12.
- Oates, W.E. 1972. *Fiscal Federalism*. New York: Harcourt Brace Jovanovich.
- Wagstaff, A., and E. van Doorslaer. 1992a. "Equity in the Delivery of Health Care: Some International Comparisons". *Journal of Health Economics*. 11: 389–411.
- Wagstaff, A., and E. van Doorslaer. 1992b. "Equity in the Financing of Health Care: Some International Comparisons". *Journal of Health Economics*. 11: 361–387.
- World Bank. 1993. *World Development Report 1993: Investing in Health*. New York: Oxford University Press.

Tables

Table 1: Health System Financing: Elements, Policy Issues and Goals

| Elements | Policy Issues and Goals |
|---|--|
| Sources and means of financing | National social and economic philosophy and policy (<i>in conjunction with the health system</i>): entitlement, income redistribution or 'vertical' equity* and macro-economic policy |
| Allocation of finance or resources | Health system policy : <i>promotion of health, distribution of medical resources or service, and access to care or 'horizontal' equity'</i> ** |
| Provider compensation / remuneration | Provider incentives : <i>quantity and quality of care, cost-containment mechanisms, efficiency of provision, outreach and horizontal equity</i> |
| Public-private mix | Social philosophy and ability to control all of the above, including level of finance |

Notes:

* 'Horizontal equity' refers to people's access to care according to need rather than according to ability to pay (Wagstaff & van Doorslaer 1992a, 1992b). It should be noted that horizontal equity could be an effective mechanism to improve overall health system performance by shifting medical resources where they are most needed and effective. At the same time, horizontal equity could also be a basic element of social justice that has an absolute value. In this latter case people could be entitled to care even if it is deemed ineffective, but still utilitarian for them.

** 'Vertical equity' refers to people's contribution to the system on the basis of ability to pay rather than on the basis of actual or probable cost of care (Wagstaff & van Doorslaer 1992a, 1992b).

Table 2: Sources of Finance—Ranking of Policy Options by their Ability to Achieve System Goals*

(Ranking is ordinal. Ranking across columns should not be numerically correlated.)

| Sources & Means | Policy Goals | (Vertical) Equity & Universal Entitlement | Macro-Economic Efficiency (through social policy and system cost control) | Client Satisfaction (through willingness to contribute) |
|---|--------------|---|---|---|
| Private finance of health care | | 1 (None/Lowest) | 1 | 4 |
| Mandatory, group health insurance—earmarked contributions to insurers | | 2 (Full, except for those who may opt out)** | 2 | 3 |
| Social insurance—earmarked contributions to a state / public ‘pool’ | | 3–4 | 3 | 2 |
| General taxes—General revenues | | 4 (Full/Highest) | 4 | 1 |

Notes:

* Goals that are not listed in this, or any other table, are deemed unaffected by the listed policy options.

** Amongst developed nations, this option applies to Germany. Universal entitlement and vertical equity are combined here to make the presentation easier. It follows that universal entitlement implies some degree of vertical equity.

Table 3: Forms of Allocation—Ranking of Policy Options by their Ability to Achieve System Goals

| Goals Form of Allocation | Horizontal Equity | Macro-Economic Efficiency | Micro-Economic Efficiency | Client Satisfaction |
|-----------------------------|-------------------|---------------------------|---------------------------|---------------------|
| Budgeting | 1 (Lowest) | 3 | 2 | 1 |
| Prospective capitation | 2 | 2 | 3 | 2 |
| Retrospective capitation | 3 (Highest) | 1 | 1 | 3 |

Table 4: Allocation—Recipient Institutions: Ranking of Policy Options by their Ability to Achieve System Goals

| Goals Allocation | (Horizontal) Equity | Macro-Economic Efficiency (through cost controls) | Production Efficiency (through control of providers) | Client Satisfaction (through choice of providers) |
|-------------------------------|---------------------|--|---|--|
| To regional administrations | 2 | 1 | 1 | 1 |
| To national OMCC institutions | 1 (Lowest) | 2 | 2–3 | 2–3 |
| To regional OMCC institutions | 3 (Highest) | 3 | 2–3 | 2–3 |

Table 5: Remuneration of Community Practices—Ranking of Policy Options by their Ability to Achieve System Goals

| Goals Pay Mechanism | Horizontal Equity (through universality) | Macro-Economic Efficiency (through cost control) | Production Efficiency | Client Satisfaction from Service |
|--|---|---|------------------------------|---|
| Fee-for-service | 3 | 1 | 2 | 4 |
| Fee-for-service with a global capping | 2–3 | 4 | 3 | 3 |
| Capitation with fund holding | 4 (Highest) | 3 | 4 | 2 |
| Wages | 1 (Lowest) | 3 | 1 | 1 |

Note:

* Fee-for-service with global capping is a system, most common in Germany, whereby physicians can charge according to fee-for-service up to a given budget or ceiling applied to the individual practitioner or the group.

Table 6: Hospital Remuneration—Ranking of Policy Options by their Ability to Achieve System Goals

| Goals Pay Mechanism | Horizontal Equity (through universality) | Macro-Economic Deficiency | Production Efficiency | Client Satisfaction from Service |
|---|---|----------------------------------|------------------------------|---|
| Fee-for-service | 3 | 1 | 3 | 5 |
| Per case (for given patients) | 4 | 3–4 | 5 | 3–4 |
| Diagnostic related groupings (DRGs) | 5 (Highest) | 3–4 | 4 | 3–4 |
| Per patient-day (for given patients) | 1 (Lowest) | 2 | 2 | 5 |
| Global budget | 1-2 | 5 | 1 | 1 |

Table 7: Public-Private Mix—Ranking of Policy Option by their Ability to Achieve System Goals

| Goals Public-Private Mix | (Vertical) Equity | Macro-Economic Efficiency | Production Efficiency | Client Satisfaction |
|---|--------------------------|----------------------------------|------------------------------|----------------------------|
| Complete separation (e.g., Canada) | 4 (Highest) | 3 | 3 | 4 |
| Co-payment to offset demand (in segregation) | 2 | 4 | 4 | 3 |
| Extra-billing, uninsurable | 1 (Lowest) | 2 | 2 | 1 |
| Extra-billing, insurable | 3 | 1 | 1 | 2 |

Figures

Figure 1: Examples of membership functions used in the fuzzy modeling

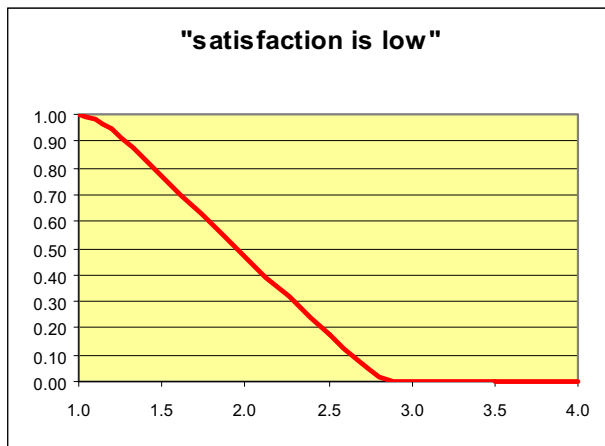
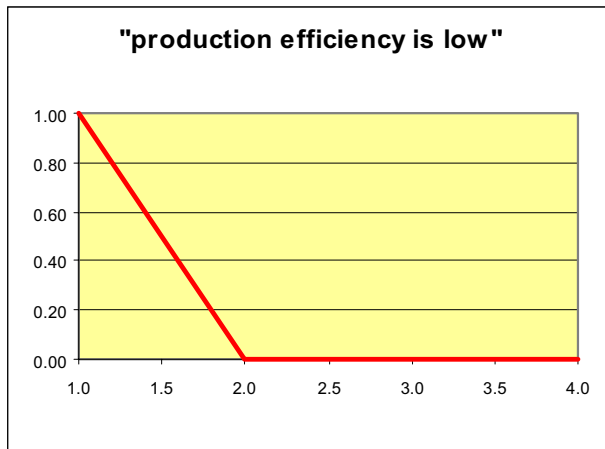
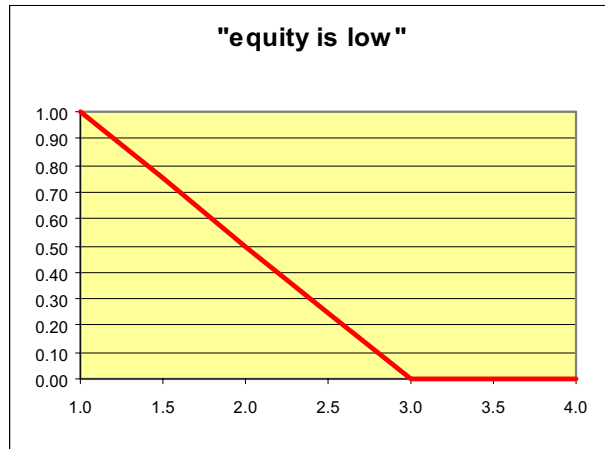


Figure 2: Fuzzification and fuzzy inference: “Fee-for-Service” for community practices

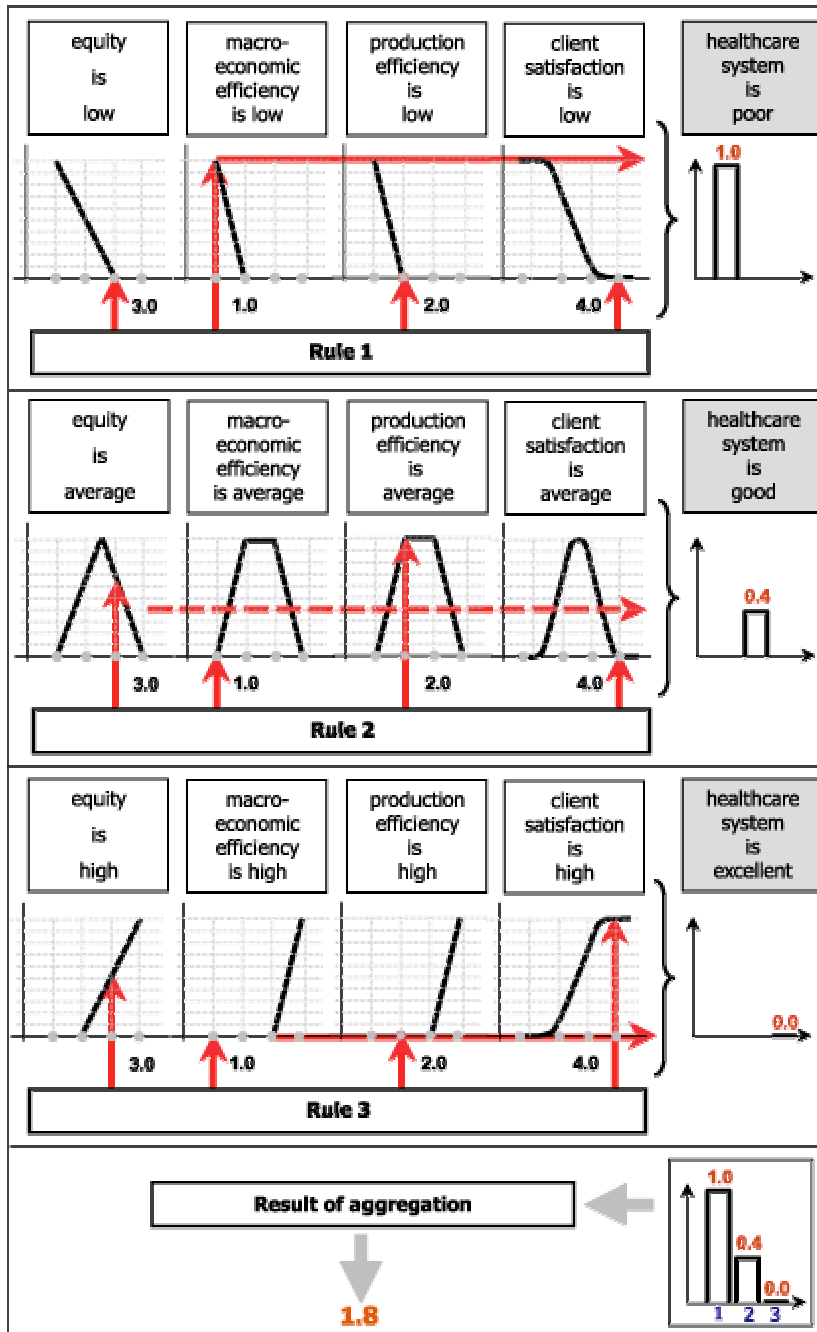


Figure 3: Possibility distributions for different options for sources of finance

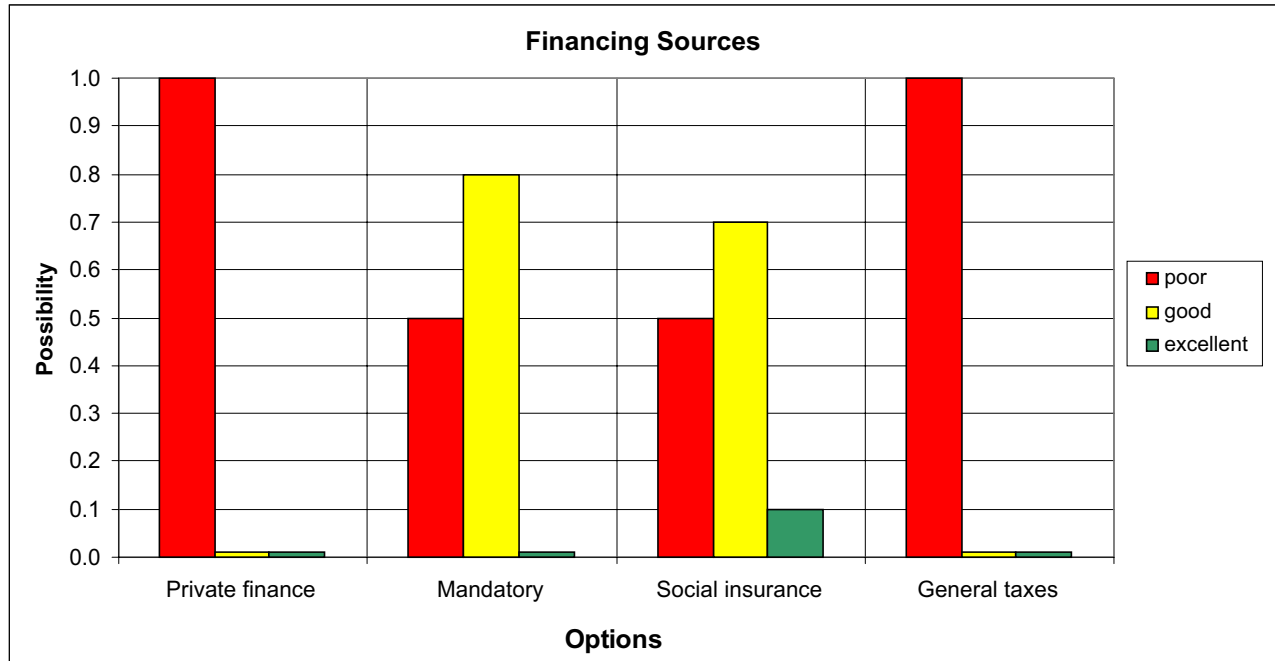


Figure 4: Possibility distributions for different options of allocation

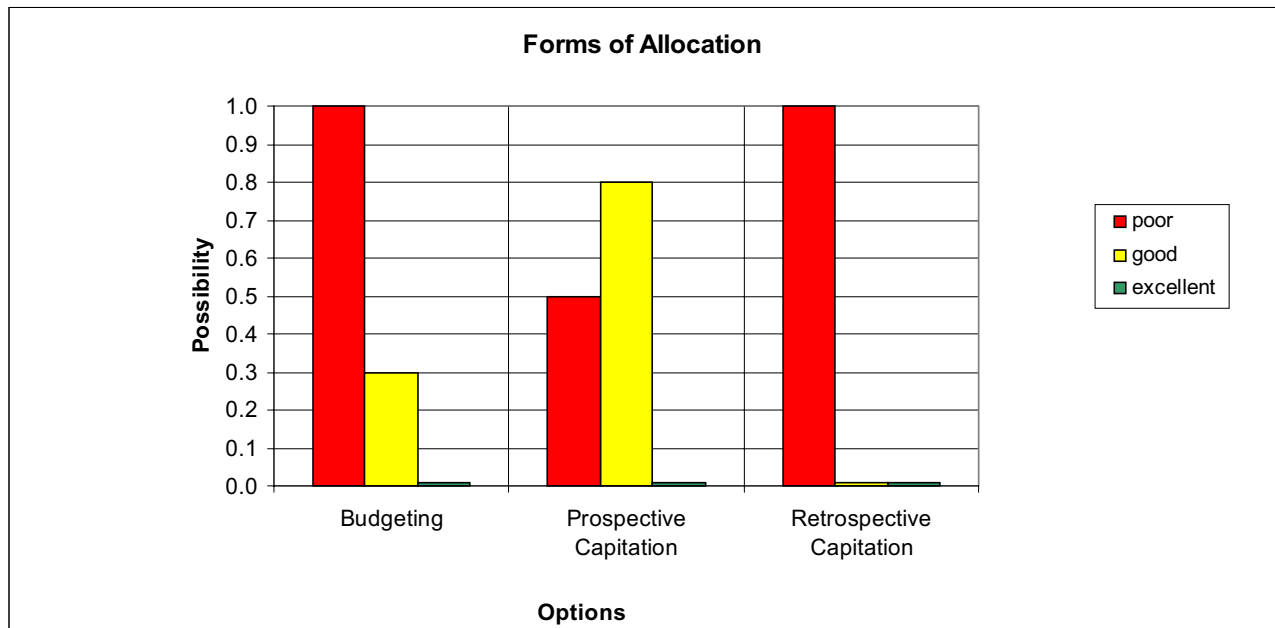


Figure 5: Possibility distributions for different options of recipient institutions

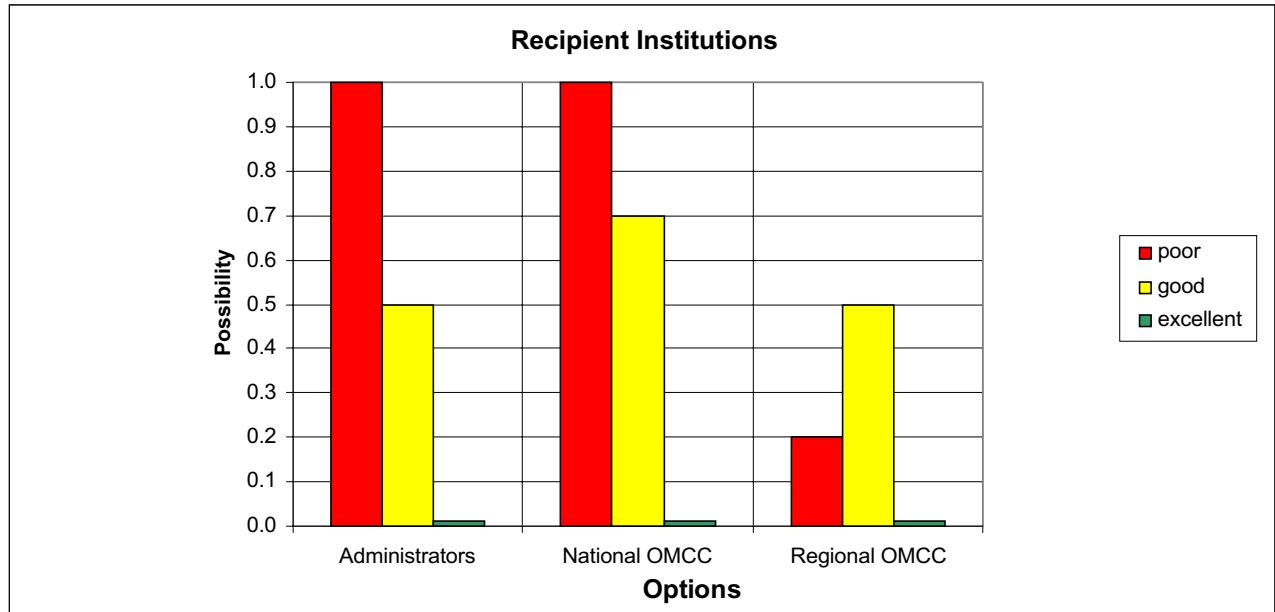


Figure 6: Possibility distributions for different options of community provider remuneration

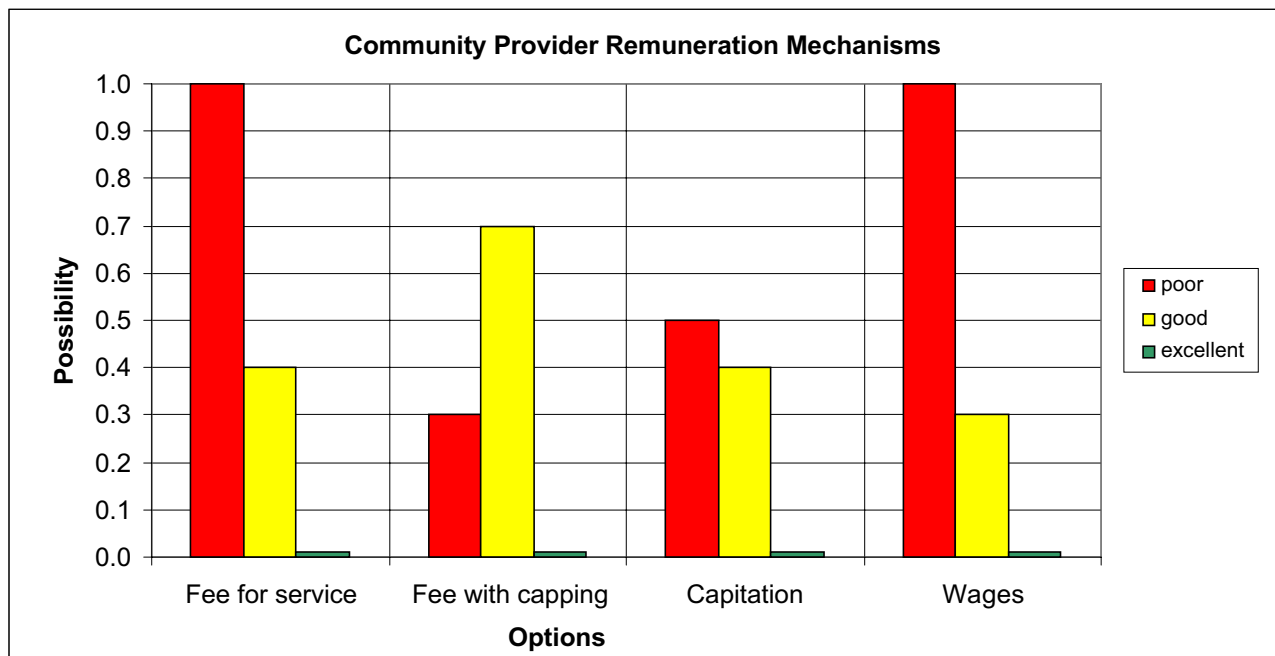


Figure 7: Possibility distributions for different options of hospital remuneration

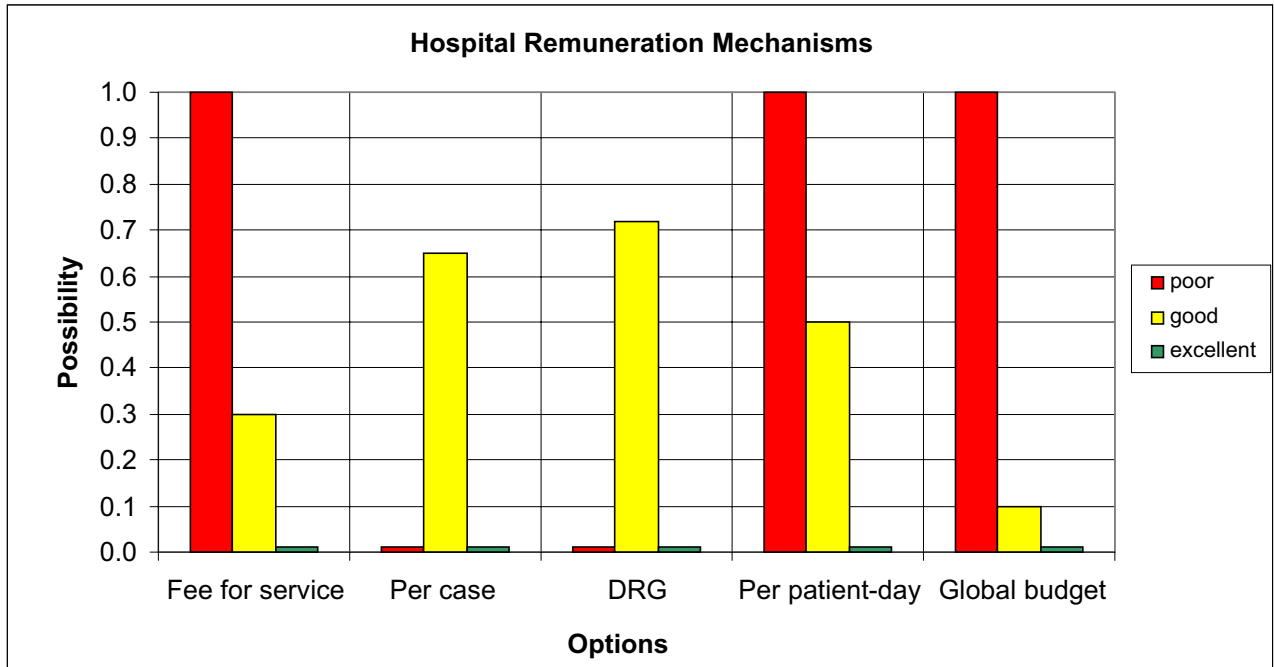


Figure 8: Possibility distributions for different options of public-private mix

