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Aggregation and the Measurement of Health Care Costs

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Abstract:

Objectives. This study evaluated the extent to which the causes of variation in health care costs differ by the level at which observations are made.

Methods. More than 30 U.S. and international studies providing empirical estimates of the sources of variation in health care costs were reviewed and arrayed by size of observational units.

Results. As the unit of observation becomes larger, association between health care costs and health status/morbidity becomes weaker and smaller in magnitude, while correlation with per capita income becomes stronger and larger. Individual expenditure variation **within** a particular health care system is largely due to differences in morbidity, but **across** systems, health status has no effect on costs. For nations, differences in per capita income explain over 90% of the variation in both time-series and cross-section.

Conclusions. Units of observation used for analysis of health care costs must be matched to the units at which decision-making occurs. The observed pattern of empirical results is consistent with a multilevel allocative model incorporating aggregate capacity constraints which is obligately ecological at the national level. To the extent that macro constraints determine total budgets, policy interventions at the micro level (substitution of generic pharmaceuticals, use of CEA for allocation of treatments, controls on construction and technology, etc.) can act to improve efficiency, equity and average health status, but will not reduce aggregate per capita costs of medical care.

Aggregation and the Measurement of Health Care Costs:

Analysis of the determinants of health care costs must use units of observation corresponding to the units at which costs are determined. To the extent that expenditure decisions are made at multiple levels, then a multilevel analysis is required. Recently, great interest has been shown in expanding the scope and subtlety of health services research through multilevel analysis. Whereas an earlier generation worried that the use of group data as a proxy for individual effects would lead to commission of the ecological fallacy, many researchers now realize that the expansion of computing power and data sets has led to an over-emphasis of individual attributes, sometimes to the point of neglecting group or context altogether, leading to the opposite extreme of atomistic fallacy. Some aspects of health cannot be accounted for by individual attributes, but in fact demand aggregate ecological anlyses of the system as a whole that explicitly deal with selection, distribution and other contextual effects that transcend and link individuals.[1] Good examples of ecological analysis are still rare, although studies of mortality, birth defects, hospital utilization and other outcomes have been published in the last few years. Although cost is one of the most frequently studied and policy-relevant aspects of health care, it has not yet been solidly placed within a multilevel context. A recent health economics review article[2] identified potential avenues for multilevel analysis, and there is one multilevel analysis of the cost of blood collection in Scotland,[3] but most of the work to date has taken utilization or incidence, rather than cost *per se*, as the outcome for analysis.

Since "costs" are often considered to be additive micro attributes, infinitely divisible and well defined at the individual level, cost may not at first appear to be a variable requiring multilevel contextual analysis. However, while the popular conception of cost is clearly atomistic, most economists would argue that a more realistic view treats costs as context specific ("opportunity cost"), frequently ill-defined at the individual level ("joint cost allocation"), and with major portions that are inherently collective ("public goods"). The use of pooled insurance funding to finance health care also has the effect of loosening the connection between the individual unit of observation (or utilization) and the total costs of the group. Evidence is presented here indicating that the analysis of health care costs, rather than being well circumscribed within a standard analysis of individual variation, truly demands a multilevel structure which is obligately aggregate at the national level. Defined individual "costs" are seen to result more from accounting allocations rather than accurately measuring attributes of individual persons, illness episodes, or medical procedures.

The first section discusses the logical pressures which give rise to the atomistic fallacy. Capacity constraints are recognized as providing boundary conditions and linkages consistent with both aggregate and individual variation. A formal statement of an allocative model is then presented. Next, the empirical results obtained from many analyses of income and health status are placed within this context. Finally, the issue of what sort of multilevel structure is most appropriate for conceptualizing and measuring variation within the various parts of the health care system is discussed.

The Atomistic Fallacy

The logical fallacy of inferring individual behavior or outcomes based on observation of group means has long been recognized, and is most often referred to as the "ecological fallacy.[4]" The reverse, an incorrect inference of group outcome based on observations made across individuals, has been less frequently cited, and the terminology is less clear. Sometimes false micro→macro inference is referred to as the "fallacy of composition," sometimes the "constructivist" or "individualistic" fallacy, or simply considered to be encompassed within the meaning of ecological fallacy. Here, the term "atomistic" fallacy is used to make clear the distinction of micro→macro from the reverse macro→micro inference. Fortuitously, "atom" also brings to mind the familiar distinction between classical and quantum physics, where macro and micro processes appear to function quite differently, although both are consistent with a more general theory linking the levels.

The efficacy of a vaccination program, in terms of probability of disease prevention, often depends upon the prevalence of disease within a community--with the "effect" of vaccination approaching zero as the percentage of the population currently infected approaches either 0% or 100%.[5] In order to capture such differences, a well designed experiment must randomize not only over individuals, but also over communities.[6] The analysis of community level data also allows "community" effects other than disease prevalence to be brought into the analysis (e.g., the interaction with levels of education, population density, etc.). Formally, including the group average (percentage infected) as a variable is a way of incorporating an individual level attribute (infected or not), at the group level. Similarly, one of the early examples of multilevel analysis examined the effect of average community income, as well as individual income, on voting behavior.[7]

The problem of measuring individual income is familiar to most health services researchers. They do not expect a child of a wealthy family to have utilization of orthodontia corresponding to that of a "low income person" (because the child's earnings are zero), but rather to reflect the family income, somehow adjusted for size. Similar problems occur at the other end of the age spectrum where utilization of expensive private nursing facilities depends more on the income of related family members than the current "income" of an 89-year old. Family is a primary grouping, creating a dominant context in which some individual attribute measures are arbitrary or even meaningless.

One form of the atomistic fallacy arises when group behavior is dominated by an external constraint. For example, the likelihood of any given individual residing in a nursing home may be significantly related to the extent and type of disability, but if the occupancy rate of nursing homes in the state is 100%, and there is a moratorium on new construction, changes in the prevalence of disability can have no impact on the percentage of *state* population that is institutionalized. Similarly, the likelihood of a particular person receiving an organ transplant may be significantly related to individual characteristics such as age, disease state, and goodness of match, but in aggregate the number of organ transplants is determined entirely by the number of organs available for transplant (capacity constraint). Individual attributes determine who gets a transplant, not how many are available in total.

Whether the rate of transplant in a specified population is determined by capacity constraints or individual attributes depends upon the size of the unit of observation and the organization of services. If there is a national donor pool, and the study examines the percentage of patients within a single hospital who receive transplants, individual characteristics will dominate. However, at the national level, it will be the number of available donor organs (capacity) which dominates. Consider also how the organization of the health care system can change results. If organ transplants were limited to patients within the hospital where donation occurs, then capacity would be dominant even for hospital level observations. Suppose there is some sort of "mixed" system, with regional donor pools, but favoring local transplant. Then observations made at the hospital or state level would correlate with some mix of individual attributes and group capacity constraints. However, the total number of transplants nationally would still be capacity constrained and independent of individual attributes.[8]

The existence of capacity limits is only too well known to grant applicants. Whereas extra effort will increase the likelihood of a particular proposal being funded in competition with others, the total pool of funds available is fixed. Thus although each proposal's probability of funding is responsive to quality and effort, the group average is not. If there are $4 million in proposals for $1 million in funds, then the group average will be 25% regardless of whether the proposals are long or short, of high quality, or mediocre. Such **budget constraints** are pervasive, and an essential feature of multilevel allocative models.

A Two-Level Allocative Model

In a simple two level allocative model, the total is determined at Level I by some set of variables, and at Level II the total is allocated to individuals by some other set of variables (Figure 1) which may or may not overlap with the Level I variables. Thus for organ transplants, totals are determined by organ availability and harvesting, while allocation is made based on need, match and sometimes geography. For grants, total program size is determined by some foundation or federal agency, and then funding allocations are made based on quality, appropriateness, match and sometimes geography or previous relationships. In the system of equations below, the aggregate total "**X**" is determined by some set of large scale variables (**L**) at the macro level, and allocated across individuals so that each receives some fractional allocation "*a*" of the total which depends on individual attributes (s_i).

$\mathbf{X} = X(\mathbf{L})$ macro determination (level I, **LARGE** variables)

$\boldsymbol{x}_i = a(s_i)*\mathbf{X}$ allocation to individuals (level II, *small* variables)

Although the explanation may be sequential (total determined at level I, *then* allocated at level II) the actual process is usually interactive and simultaneous. "Number of nursing homes" and "which patients are residents" are best viewed as jointly determined, even when there may be some time lag involved. Similarly, although micro and macro are represented as entirely separate here, it is not uncommon for there to be some diffusion between levels. For instance, changes in the method of allocating organs that are perceived as more fair, or more life-prolonging, or more favorable to participating hospitals, may have the effect of increasing the number of organs harvested. Similarly, a particularly good set of grant proposals may lead to some increase in program funding in subsequent years--and an egregious failure is usually sufficient to shrink or eliminate funding. Yet the modification or flexibility of constraints does not mean that they are not real. Budgets do exist, and in the large picture, may fully determine how much can be spent on health care, education, research or transportation.

An alternative multilevel model which does not rely on budget constraints is that developed in education research for estimation of student, teacher and school level effects. In such "general linear models" (which are well described elsewhere)[9] the influence of macro variables adds to (rather than limiting) micro level variation. Since the group mean can go up or down as individual attributes change, aggregate totals are allowed to vary freely. Such freedom is not costless. The type of capacity constraint which facilitates the solution of allocative models (e.g., total kidneys transplanted is limited by the number harvested, total inpatients on each day is limited by the number of beds, or total payments to providers is limited by premiums collected) become problematic in such a general linear model, and is apt to create aggregate specification errors. Whether one should use a general linear or allocative model depends on the characteristics of the process being studied. The usefulness of a model depends primarily on how well it conveys some essential feature of the process, works in practice, fits existing data, and predicts new observations.[10]

Statement of the Problem: Disparity Between Individual and National Cost Variations

Studies of health care costs at the national level show that expenditures rise rapidly with per capita income. However, studies of individual medical costs show only modest effects, or even declines in utilization associated with higher incomes (see Table 1).[11] Reconciling this disparity in empirical results requires that analysis be carried out on multiple levels, with a conceptual framework connecting individual and group (ecological) behavior.[12]

The reliance on insurance to pool funds and pay for health care is a root cause of the divergence between individual and group income effects. With insurance, it is the average income of the group, and the fraction that the group is collectively willing to devote to medical care, which determines the health care budget, not the income of the particular patient being treated. This is clearly seen, for example, in the treatment of the elderly under Medicare. Collective political decisions about what services are to be covered, what payments are to be made to providers, the rules for review and copayments, and so on, are much more important quantitatively in determining overall cost than individual patient decisions about whether or not to seek treatment, or which treatment or prescription to use.[13] It is not that individual decisions are irrelevant, it is just that they are overwhelmed by the group decisions to define and fund the program as a whole. To a considerable extent, insurance converts private medical care into a "public good" for the group which is covered by the plan.

In those types of medical care where insurance is less significant (plastic surgery, eyeglasses, dental care, mental health counseling), atomistic individual behavior is no longer dominated by collective group decision-making, and personal incomes have a large effect upon personal expenditures (as evident in the "Special/Uninsured" section of Table 1). It is the individual, rather than the collective, budget constraint which matters in these cases. In the example of organ transplants discussed above, the relevant capacity constraint could occur at the level of the hospital, the region or the nation, depending upon how transplant services were organized. Similarly, it is the way in which financing and insurance pools are organized which determines the boundaries of the "groups" which are most relevant in determining health expenditures.

Results: Income effects at the individual, regional and national level.

Most studies of individual medical care utilization and expenditure show that the bulk of the explainable variation is attributable to individual differences in health status, with income effects that are small or negative. Conversely, studies of national health expenditures show income effects which are large and dominate all other factors (Table 1). A useful metric is the "income elasticity," or the percentage by which expenditures change for each 1% change in income. If the income elasticity is less than 1.0, then each 1% increase in income leads to less than 1% increase in medical expenditures, so the fraction of total income spent on medical care rises as income rises. Conversely, if income elasticity is greater than 1.0, then the share of total income spent on medical care rises as total income rises.[14] Current income elasticity estimates of (largely insured) medical care at the individual micro level are almost always near 0 or negative. Measured income elasticity at the national macro level is consistently positive and large, usually exceeding 1.0. When the unit of observation is intermediate between the micro and macro level--for example at the level of the hospital, health plan, county or region, then the income elasticity is typically somewhere between 0 and 1.0, that is, between the micro and macro level parameter estimates.

Table 1 presents the results of a number of empirical studies of the effect of income on health care expenditure/utilization, arrayed by increasing level of aggregation. Also presented in Table 1 are some individual level results from prior periods, other countries, or particular types of care where insurance coverage was less common and less complete. While the disparity in the magnitude of income effects across levels of observation is readily apparent, what is perhaps not so evident is the dominance of income effects at the macro level. When carefully specified, income accounts for more than 90% of the total variance in national health expenditures, and virtually all of the explainable variation.[15] That is, once income effects are accounted for, the residual variance in national health expenditures is small, and shows no consistent association with other variables. The dominance of income effects at the national level establishes a very simple form of group budget constraint, and makes the multilevel "allocative model" presented above particularly useful in the analysis of health care costs.

It may seem surprising to many health systems researchers who are used to discussing the effects of technology, disease prevalence, hospital construction, population aging, extent of public financing or legislative elections that such factors are not considered significant explanatory factors for national health expenditures. However, review of empirical studies over the last fifty years makes it apparent than none of the many variables tested for inclusion has had a consistently demonstrable effect. Perhaps most revealing is the examination of the effects of aging on national health expenditures. There is essentially zero correlation between changes in the percentage of the population over age 65 and the share of GDP spent on health care.[16] Aging has a profound effect on *individual* differences in medical expenditures, yet the increase in expenditures on the aged overall is attributable primarily to increased intensity of service rather than changes in the number of elderly or to measures of need or morbidity. For example, from 1980 to 1990 expenditures on acute hospital facility use by aged U.S. Medicare beneficiaries rose from $19,460 million to $47,842 million (146%) due to increased intensity (with per diem payments rising 190%) while the rate of discharges and days per discharge fell and the number of elderly beneficiaries rose by just 5 1/2 million (21%) and their average age by 1/2 year (1%).[17] Aging alone (increases in the number of elderly beneficiaries and increases in their average age) can therefore account for only a small fraction of the increase in Medicare expenditures.

South Africa: the exception which proves the rule. An illuminating exception to the dominance of national per capita is provided by South Africa. In brief, medical care there has been split between a public sector, which serves indigent and low income persons, and a private sector serving the affluent.[18] Both sectors are insured, but they do not pool or transfer funds to each other. Thus the structure of medical financing is that of two nations within a single country. The majority of health expenditures go to the 18% minority with private insurance spending *R*3,400 per person. The public sector, with 82% of the population, can spend only *R*600 per person. Other developed nations often show some differences in the amount of care provided to high and low income groups, but the prevalence of comprehensive social insurance prevents disparities of such a large (>5 : 1) order of magnitude.

Sweden: fiscal balancing removes variation. By refusing to pool funds, separate health care systems can be created within a single nation. Conversely, extensive pooling can homogenize a health care system so that regional variation disappears. Sweden appears to be such a case. Although county councils are the primary health care providers and financial units, extensive central government control and fiscal transfers are used to equalize per capita spending across areas. With variation in expenditures actively eliminated by such central government control, differences in patient characteristics, local supply, risk factors or other variables *cannot* generate any measurable differences in spending. If there are any differences in expenditures associated with differences in the percentage of population over aged 65 (or disabled, or infected with AIDS, etc.), they exist because they are part of the funding formula--they are a result of administrative decisions, and thus cannot be interpreted as independent causal factors.

CONCLUSION

The level of estimation for health care costs must be matched to the level at which spending decisions are made. The consequences of income for spending are established at the level where the budget constraint is fixed. For some types of health care, this is the individual household, for others, the hospital, region or insurance plan, but for much of medicine it is the national budget constraint which is most relevant. Recognition of budget constraints leads to the realization that the effects of many individual and organizational variables will be allocative, distributing the total across patients by need and other characteristics, rather than additive, summing upwards to some flexible aggregate.

The idea that the amount spent on health care is determined by the amount available to spend rather than the amount of disease is not particularly new, and may even border on the obvious. However, this obvious point has not been incorporated into most health policy discussions or used in structuring most of the models developed for empirical analysis in health services research. It has been argued that whenever ideas which are shown to be empirically invalid or logically implausible persistently arise, over and over again in the face of contrary evidence and well-reasoned refutations, it is important to understand why such illogical persistence occurs and what underlying purposes it might serve.[19]

The persistent failure to recognize budgetary constraints, and hence to perceive the extent to which aggregate income determines average individual health care costs, seems to arise from several factors, of which six are briefly mentioned below. First, no patient is average. Their experience arises not from the mean, but from a particular illness. The connection between what is spent on health care and the illness is so overwhelmingly evident that the converse (that total spending would not change whether or not I have a heart attack or AIDS or colon cancer) seems inconceivable. Similarly, the physician deals one-on-one with sick patients, and sicker patients cost more. Thirdly, this personal and clinical focus on individuals resonates with the methodological stance of most economists, which emphasizes the role of prices and individual utility-maximization, rather than the relatively boring and obvious accounting identity forcing all spending to be limited in total by income.[20] Aggregation greatly reduces the number of observations and the scope for application of statistical methods, and thus may make macro analysis of less interest to researchers. Furthermore, the excitement of compiling ever more detailed sets of micro data to obtain greater accuracy and more statistical significance, along with some early embarrassing failures due to ecological fallacies in the analysis of aggregate administrative data, may have conditioned some investigators to be methodologically resistant to a macro perspective, and less willing to consider building models from the top down as well as bottom up. Finally, a macro perspective is not kind to those who wish to use health economics, decision trees, or outcomes research as a means for showing that spending more on a particular drug or home therapy or surgical procedure is "efficient" since "it will save money overall." Legions of proposals for reducing costs by spending more (home health, intermediate units for ventilator patients, laparascopic cholesystectomy, laser surgery, etc.) have proven disappointing once more methodologically sound macro studies were conducted, and yet the idea that some cost-saving innovation *will* come along to save the health care system from itself and avoid the hard political choices which go along with setting budgetary limits is so appealing that it is quite hard to give up.

The job of health policy analysis and health services research is not to raise up pie in the sky nostrums, or even to carry out the evaluations which demonstrate once again that some innovation failed to control costs. It is rather to clarify the process by which the size of the health care pie is determined, and how best to slice it up. "How much to spend" is a question which is too important to be left to the experts--after all, we all work for the system and draw our paychecks from it. Our task is to help the public determine how much the nation can afford, and then study how to work within that budget so as to make the population healthier, better align the interests of patients, providers, insurers and taxpayers, and remove the barriers and distortions which limit satisfaction and access to care--that is, to focus on the meso-level financial and organizational features which structure the provision of medical care.

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13. Note for example that medicare funding largely relies on transfers from one group (taxpayers) to another, with only a small fraction of premiums paid for by beneficiaries. See Getzen TE. *Health Economics: Fundamentals and Flow of Funds*. pp. 388-389. New York: Wiley; 1997.
14. Traditionally, economists term goods and services with income elasticities less than 1.0 “necessities” and goods and services with income elasticities greater than 1.0 “luxuries.” Note that this technical economic terminology bears little relation to the common use of these terms, or their use by other social scientists. The confusion may account for why such a large literature grown up around whether or not health care is a “luxury good.” (see, for example, Parkin DA, McGuire A, Yule B. Aggregate health care expenditures and national income: Is health care a luxury good? *J Health Economics*. 1987; 6:109-127, or Blomqvist AG, Carter RAL. Is health care really a luxury ? *J Health Economics*. 1997; 16:207-230; as well as the many other references to this issue in Getzen (2000)).
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Table 1: Estimated Income Elasticities by Level of Observation:

INDIVIDUALS *[micro]*

General (insured / mixed)	
Newhouse & Phelps (1976)	0.1
AMA (1978)	≈ 0
Sunshine & Dicker (1987) *(NMCUES)*	≈ 0
Manning et al (1987) *(Rand)*	≈ 0
Wedig (1988) *(NMCUES)*	≈ 0
Wagstaff et al (1991)	≤ 0
Hahn & Lefkowitz (1992) *(NMES)*	≤ 0
AHCPR (1997) *(NMES)*	≤ 0
Special / uninsured	
Pre-1960 Expenditure Data	
Falk et al (1933)	0.7
Weeks 1961 *(1955 data)*	0.3
Anderson et al (1960) *(1953 data)*	0.4
Anderson et al (1960) *(1958 data)*	0.2
Other	
USPHS (1960) *(physician visits)*	0.1
USPHS (1960) *(dental vistis)*	0.8
AMA (1978) *(dental expenses)*	1.0 - 1.7
Anderson & Benham (1970) *(physician expenses)*	0.4
Anderson & Benham (1970) *(dental expenses)*	1.2
Silver (1970) *(physician expenses)*	0.85
Silver (1970) *(dental expenses)*	2.4 - 3.2
Newman & Anderson 1972 *(dental expenses)*	0.8
Feldstein (1973) *(dental expenses)*	1.2
Scanlon (1980) *(Nursing Home expenses)*	2.2
Sunshine & Dicker (1987) *(dental expenses)*	0.7 - 1.5
Hahn & Lefkowitz *(dental expenses)*	1.0
AHCPR (1997) *(dental expenses)*	1.1
Parker & Wong (1997) *(Mexico, total expenses)*	0.9 - 1.6

REGIONS *[intermediate]*

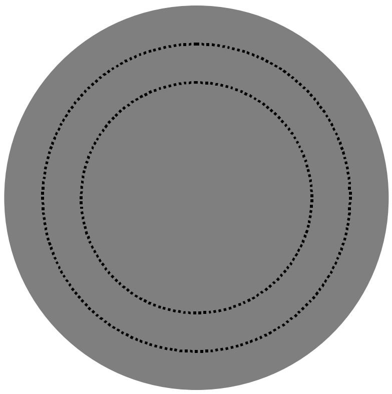
M.Feldstein (1971) (47 states 1958-67, $hospital)	0.5
Fuchs & Kramer (1972) (33 states 1966, $physician)	0.9
Levit (1982) (50 states 1966, 1978, $total)	0.9
McLaughlin (1987) (25 SMSAs 1972-82 $hospital)	0.7
Baker (1997) (3073 US counties 1986-90, $Medicare)	0.8
Di Matteo and Di Matteo (1998) (10 Canadian provinces 1965-91)	0.8

NATIONS *[macro]*

Abel-Smith (1967) (33 countries, 1961)	1.3
Kleiman (1974) (16 countries, 1968)	1.2
Newhouse (1977) (13 countries, 1972)	1.3
Maxwell (1981) (10 countries, 1975)	1.4
Gertler & van der Gaag (1990) (25 countries, 1975)	1.3
Getzen (1990) (United States, 1966-87)	1.6
Schieber (1990) (7 countries, 1960-87)	1.2
Gerdtham et al (1992) (19 countries, 1987)	1.2
Getzen & Poullier (1992) (19 countries, 1965-1986)	1.4
Fogel (1999) (United States, long run)	1.6

Table 1: Estimated income elasticity of health care expenditures (or utilization) from a variety of studies over the last 50 years. Since methodologies vary and elasticities must be interpolated in many cases, readers are cautioned to carefully refer to original sources in the list of references(11a-11af).

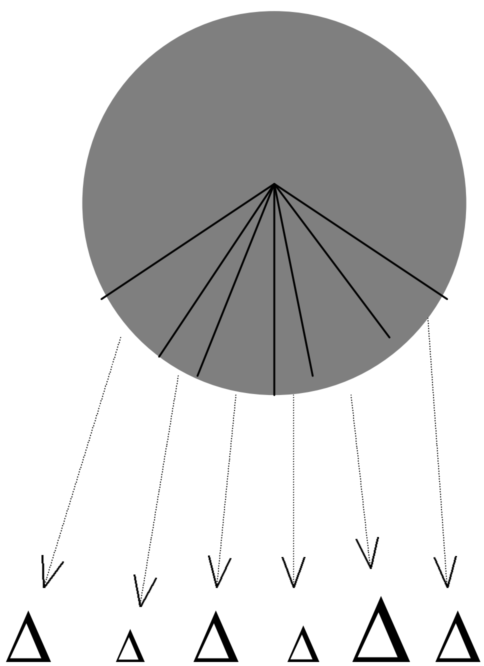
Figure 1: Two-Level Allocative Model



Level I

Determine Size of Total Expenditures

$$\mathbf{X} = X(\boldsymbol{L})$$



Level II

allocate expenditures across individuals

$$x_i = a\,(s_i)^*\mathbf{X}$$