Explorations into the Production of State Government Services: Education, Welfare and Hospitals*

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Abstract

This paper explores the production characteristics of three important U.S. state government services--public higher education, public welfare, and state psychiatric hospitals—during the last half of the twentieth century. We estimate translog cost functions for the three services and find that their production attributes are similar in a number of respects. First, production exhibits substantial economies of scale; unexploited scale economies are so severe that the average state operates on the negative portion of its marginal cost curve. Second, the analysis of technical change indicates that public education, welfare, and hospitals are affected by severe technical regression in all states, in both the long run and short run. Third, production of all three services is overcapitalized in most states; the provision of these services is not long-run efficient. Finally, we show that the Baumol-Oates cost disease of lagging productivity growth is rampant in all three services; only the short-run productivity growth in education matches the performance of the private sector, as technical regression is more than offset by the productivity-enhancing scale effect of increased enrollments.

Keywords: public services, translog cost function, scale economies, technical regression, long-run cost efficiency, technology growth

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1. Introduction

This paper explores the production characteristics of three important U.S. state government services: public higher education, public welfare, and state psychiatric hospitals. We estimate translog cost functions for the three public services across the 48 continental U.S. states during the last half of the twentieth century.

Our analysis is meant to be preliminary in spirit. The states have recorded data on output and inputs for these three services for over fifty years, mostly at the request of the federal government, and various federal (and other) agencies have published the data in readily available sources. The question we ask is: What can we learn about the production characteristics of these services from the published data? The answer, unfortunately, is: Quite a bit less than we would ideally like to know. The data are too broadly rendered to yield definitive conclusions. Often the results can only raise questions awaiting more detailed analysis. Nonetheless, these are the data routinely available to researchers and they happen to tell a number of intriguing stories. Our results challenge several of the assumptions about public service provision that have become commonplace in the empirical analysis of state and local government behavior.

In particular, we find that production of all three services is non-homogeneous and exhibits substantial economies of scale. Unexploited scale economies are so large that estimated marginal costs are negatively sloped at the point of approximation. The production of all three services does not appear to be long-run efficient; on the contrary, we find that the three public services are overcapitalized relative to the optimum for the vast majority of states throughout the sample period. We also find that the Baumol-Oates (1975) cost disease of lagging productivity growth afflicts all three services, with the exception of public higher education in the short run.

The paper is organized as followings: Section 2 describes alternative strategies for modeling state governments and explains why we chose the one we did; Section 3 presents the econometric model; Section 4 describes our data; Section 5 discusses our estimation strategy; Section 6 presents the results; and Section 7 offers a number of conclusions based on the results.

2. Modeling State Governments

Our analysis represents the first part of an ongoing two-part examination of state government behavior using an approach inspired by Inman (1979). Inman argues that models of state (and local) governments should explicitly recognize that states (localities) are both consumers and producers of public services. Let the demand-consumption side of the model be represented in the traditional consumer-theoretic manner as

$$\underset{Q_k,T}{\text{Max}} \quad U(Q_k; Y - T), \quad s.t. \quad \sum_k q_k Q_k = T + \overline{G}\text{, where:}$$

Q_k = output of the k-th public service;

Y = state income;

T = taxes;

$\overline{G}$ = exogenous grants-in-aid from other governments;

q_k = the supply price of the k-th service, defined net of endogenous matching grants-in-aid.

A central issue in modeling the demand side is specifying whose utility function is being maximized. The median voter has surely been the most popular choice of empirical researchers, in which case that voter's budget constraint and his/her perceptions of supply prices and grants-in-aid parameters become essential ingredients of the analysis.[1] For our purposes it will suffice to leave vague the underlying process generating utility.

Let the production side of the model be represented by the standard neoclassical production function

$$Q_k = Q^k(L_k, M_k, K_k)\text{, where}$$

L_k = labor used in the production of the k-th service;

M_k = materials used in the production of the k-th service;

K_k = capital used in the production of the k-th service;

[1] Inman also chooses the median voter as the source of demand when describing his complete model.

with associated factor prices P_L^k, P_M^k, P_K^k, each reflecting the opportunity cost of the factors.

At this point one can proceed in either of two ways. Inman (1979) suggests combining consumption and production into a single model by: (a) using the production functions to substitute for the Q_k in the utility function; (b) substituting factor costs ($P_L^k L_k + P_M^k M_k + P_K^k K_k$) for $\sum_k q_k Q_k$ in the budget constraint; (c) adjusting the budget constraint for any deficits (surpluses) occasioned by increasing (decreasing) returns to scale production; and (d) maximizing U with respect to the L_k, M_k, K_k, and T. The first-order conditions yield the three factor demand equations for each service and a tax equation, each as functions of utility parameters, production parameters, state income, exogenous grants, and matching grant parameters if a grant is an endogenous matching grant.

An alternative approach, and the one used here, assumes that the state proceeds in two distinct stages. First it attempts to discover the long-run and short-run production characteristics of each service, including total and marginal costs, by solving the standard cost minimizing problems:

Long run (LR):

$$\underset{L_k,M_k,K_k}{\text{Min}} \quad P_L^k L_k + P_M^k M_k + P_K^k K_k, \quad s.t. \quad Q_k = Q^k\left(L_k, M_k, K_k\right);$$

Short run (SR):

$$\underset{L_k,M_k}{\text{Min}} \quad P_L^k L_k + P_M^k M_k, \quad s.t. \quad Q_k = Q^k\left(L_k, M_k; \overline{K}_k\right).$$

The resulting marginal costs then substitute for the supply prices, q_k, in a second demand-consumption stage of the model, with appropriate adjustments in the budget constraint for any deficits or surpluses at the marginal cost prices. Presumably the state uses short-run marginal costs if long-run and short-run marginal costs differ. Actual service levels are then determined by an appropriate utility maximizing process. This paper considers only the production stage of the model.

A two-stage specification seems prudent for empirical research as a way of minimizing specification bias given that the underlying utility-generating political process is so problematic. For instance, the median voter model is not especially compelling at the state level. However our two-stage approach happens to be consistent with most median voter based analyses of local governments, in which the supply prices, q_k, are assumed proportional to the MC_k. Marginal costs are in turn related to available wage data by a chain of reasoning that (usually) ignores material inputs, assumes that production is both homogeneous in labor and capital and long-run efficient, and further assumes that the price of capital is constant across local governments in the sample.[2]

Isolating production may not avoid specification bias, of course, if only because the assumption of cost minimization is also suspect. Production decisions are under the control of bureaucrats who have no inherent reason to favor cost minimizing production. Nonetheless we maintain the assumption of cost minimization in this study because we think it is the best, and certainly most flexible, baseline approach for a preliminary investigation. Perhaps some readers will view the results as ammunition against the assumption. The only direct evidence we can provide is a test of long-run cost minimizing behavior based on estimates of each state's marginal cost of capital derived from analyzing production in the short run. There is also some indirect evidence suggesting the possibility of inefficient, rent-seeking bureaucratic behavior.

3. The Econometric Model

We chose to analyze public higher education, public welfare, and state psychiatric hospitals, for two reasons. First, they are three of the more important services financed from the states' general (non-highway) funds. Second, the data required to construct reasonable and consistent output, factor input, and factor cost variables are available for these services from easily accessible, published sources for each state over a long period of time. The key is the output data. The factor data are available for most state services,

[2] An example in the spirit of our analysis is Fortune (1983). Fortune employs the translog approach to estimating supply characteristics for local government services in Ohio under the maintained hypotheses of CRS, long-run cost minimization, and output a function of capital and labor only. He also aggregates over all services.

but usable annual output data exist only for these three services. Our sample is a pooled cross-section of observations on each of the 48 continental states from fiscal year (FY) 1953 through FY 2003 for public higher education and welfare, and from FY1953 through FY 1996 for state psychiatric hospitals. (Refer to Section 4, below, for details on data collection and construction.)

The estimation employs the translog approximation to the cost function (both short-run and long-run), with the point of approximation at the overall sample means of the explanatory variables.

Define for each service, k, the vectors

$$\text{LR:} \quad \vec{X}^k_{st} = \left[\ln\left(\frac{Q^k_{st}}{\overline{Q}^k}\right), \ln\left(\frac{P^k_{L,st}}{\overline{P}^k_L}\right), \ln\left(\frac{P^k_{M,st}}{\overline{P}^k_M}\right), \ln\left(\frac{P^k_{K,st}}{\overline{P}^k_K}\right), T \right]$$

$$\text{SR:} \quad \vec{X}^k_{st} = \left[\ln\left(\frac{Q^k_{st}}{\overline{Q}^k}\right), \ln\left(\frac{P^k_{L,st}}{\overline{P}^k_L}\right), \ln\left(\frac{P^k_{M,st}}{\overline{P}^k_M}\right), \ln\left(\frac{K^k_{st}}{\overline{K}^k}\right), T \right]$$

with elements X^k_{ist}, where:

k = education, welfare, hospitals;

s = 1, ..., 48 (states);

t = 1, ..., 51 (years); (= 1,…, 44 for state psychiatric hospitals)

Q^k = output of service k;

P^k_L = the price of labor employed in service k;

P^k_M = an index for the price of materials employed in service k;

P^k_K = the cost of capital for service k;

K^k = the capital stock used in the production of service k;

T = time;

$\overline{Q}^k$ = the overall sample mean of Q^k, etc.

The translog system of equations to be estimated for each service consists of the cost function and the related share-of-total cost equations. Using the above notation, we represent the system for service k as:

$$\ln AC^k_{st} = \alpha_0 + \sum_i \alpha^k_i X^k_{ist} + \frac{1}{2}\sum_i \sum_j \gamma^k_{ij} X^k_{ist} X^k_{jst} + e^k_{st} \qquad (1)$$

with i,j = all elements in $\vec{X}$, and:

$$S_{jst}^{k} = \alpha_{j}^{k} + \sum_{i} \gamma_{ji} X_{ist}^{k} + e_{jst}^{k} \tag{2}$$

where i = all elements in $\vec{X}$;

j = $P_L^k,\ P_M^k,\ P_K^k$: *LR;*

= $P_L^k,\ P_M^k$: *SR;*

$AC_{st}^{k} = \left(P_{L,st}^{k} L_{st}^{k} + P_{M,st}^{k} M_{st}^{k} + P_{K,st}^{k} K_{st}^{k}\right) / Q_{st}^{k} \quad : LR$

$= \left(P_{L,st}^{k} L_{st}^{k} + P_{M,st}^{k} M_{st}^{k}\right) / Q_{st}^{k} \quad : SR$

S_{jst}^{k} = the share of factor j's cost to total variable cost for service k;

$= P_{j,st}^{k} F_{j,st}^{k} / TVC_{st}^{k} = \partial \ln AC^{k} / \partial \ln P_{j}^{k} \equiv \partial \ln TC^{k} / \partial \ln P_{j}^{k}$.

(Note: $F_{j,st}^{k}$ = factor j; $P_{j,st}^{k}$= the price of factor j.)

$\vec{\alpha}_{i}^{k} = \left(\alpha_{Q}^{k}, \alpha_{L}^{k}, \alpha_{M}^{k}, \alpha_{K}^{k}, \alpha_{T}^{k}\right)$;

$\vec{\gamma}_{ij}^{k} = (\gamma_{QQ}^{k}, \gamma_{QL}^{k}, \gamma_{QM}^{k}, \gamma_{QK}^{k}, \gamma_{QT}^{k}, \gamma_{LL}^{k}, \gamma_{MM}^{k}, \gamma_{KK}^{k}, \gamma_{LM}^{k}, \gamma_{LK}^{k},$
$\gamma_{MK}^{k}, \gamma_{LT}^{k}, \gamma_{MT}^{k}, \gamma_{KT}^{k}, \gamma_{TT}^{k})$,

(Note: subscript K refers to P_K^k in the long run, K^k in the short run.)

For the sake of completeness we also estimated a single miscellaneous category consisting of all other general fund services, e.g.: general government, public safety, and so on. Since output is not defined all one can do is estimate the share equations under the maintained assumption of CRS production, such that $\gamma_{jQ}^{k} = 0$, all $j = P_L^k, P_M^k$, P_K^k (P_L^k, P_M^k in the short run). The coefficient estimates from the share equations permit a limited analysis of these services' production attributes.

The cost minimization hypothesis imposes three sets of restrictions on the factor price coefficients:[3]

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[3] See Christiansen and Greene (1976) for a discussion of the coefficient restrictions. Gollop and Roberts (1983) and Friedlaender and Spady (1981) are also excellent general sources on the translog technique,

a) Symmetry across share equations requires that $\gamma_{ij}^{k} = \gamma_{ji}^{k}$, where *i* and *j* refer to regressors P_L^k, P_M^k, P_K^k in the long run, and to P_L^k, P_M^k in the short run.

b) Adding-up restrictions across share equations

Because the dependent share variables sum to unity, all of the following restrictions necessarily apply:

(1) $\sum_i \alpha_i^k = 1$;

(2) $\sum_j \gamma_{ij}^k = \sum_i \gamma_{ij}^k = \sum_i \sum_j \gamma_{ij}^k = 0$;

(3) $\sum_i \gamma_{iQ}^k = 0$;

(4) $\sum_i \gamma_{iT}^k = 0$;

(5) $\sum_i e_{ist}^k = 0$ i.e., the error covariance matrix for the share equations is singular,

where *i, j* = P_L^k, P_M^k, P_K^k: *LR;*

= P_L^k, P_M^k: *SR.*

c) Concavity in factor prices

The necessary and sufficient condition for concavity is that the matrix $M^k = [\Theta_{ij}^k + s^k s^{k'} - S^k]$ be non-positive definite,

where *i, j* = P_L^k, P_M^k, P_K^k: *LR;*

= P_L^k, P_M^k: *SR;*

Θ_{ij}^k = the matrix of second order factor price coefficients γ_{ij}^k;

$s^{k'}$ = the vector of shares;

= [S_L^k, S_M^k, S_K^k]: *LR*;

= [S_L^k, S_M^k]: *SR*;

S^k = the diagonal matrix of shares;

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especially the interpretation of parameter estimates. We borrowed liberally from both sources in the presentation of our results.

$$= \begin{bmatrix} S_L^k & 0 & 0 \\ 0 & S_M^k & 0 \\ 0 & 0 & S_K^k \end{bmatrix} : \quad LR \qquad = \begin{bmatrix} S_L^k & 0 \\ 0 & S_M^k \end{bmatrix} : \quad SR \,.$$

Since we are ultimately interested in computing marginal costs for these services at every sample point we chose to impose concavity everywhere in the sample.[4]

The primary advantage of the translog formulation is its convenience. F-tests on subsets of the coefficients yield information on the nature of technical change, and on whether production can be characterized as homothetic (and homogeneous) throughout the sample. Simple linear combinations of coefficient estimates and data generate a number of important production attributes for each state, including marginal costs, the marginal cost of capital, the extent of scale economies, the sources and magnitude of productivity growth, factor demand elasticities, and Allen partial elasticities of substitution between the factors. It is also easy to compare relative service costs across the states along a number of dimensions. The details of these analyses and the results obtained for each service appear in Section 6, below.

4. Data

Discussions of data collection and construction are typically left to appendices, but that would not be appropriate here. Empirical public sector analysis has always been plagued by imperfect data and this study is no exception. Indeed one of the outstanding questions of our research is whether the data routinely available for the three services are sufficiently good to support at least a qualitative assessment of their supply

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[4] A common technique for imposing concavity, due Lau (1978), involves restricting the coefficient matrix θ_{ij}^k to be non-positive definite (the share matrix ($s^k s^{k'} - S$) is necessarily nonpositive definite). A drawback to Lau's approach, however, is that the restrictions are overly severe, especially if concavity is required only within sample. In light of this we employed a method due Anderson (1982, 1983) which involves estimating the system and then forcing the trace of M^k until concavity is satisfied everywhere in the sample. The coefficients are restricted such that all the first-order principal minors are ≤ 0 and then, if necessary, restricted further until the second order principal minors are ≥ 0. While the forcing restrictions are somewhat arbitrary for the second order principal minors, the adjustments from the unrestricted estimates are usually far less radical than those required by the Lau technique. Also, the second-order adjustment applies only to the long-run since the full matrix M^k is singular.

characteristics. Different readers will undoubtedly reach different judgments but, in any event, a brief discussion of the data is certainly in order.[5]

4.1 Output variables

Education: State Departments of Education are primarily responsible for the provision of higher education. Hence we chose fall enrollments in public higher education as the measure of output for the fiscal years 1953-2003, with enrollments in the fall of year *t* corresponding to fiscal year (*t+1*).[6] The series has been reported annually since the mid 1960's in the *Statistical Abstract of the United States, 19xx*.[7] Earlier data were obtained from two publications of the U.S. Department of Health, Education and Welfare.[8]

Using enrollment data for output forces the interpretation that states are only concerned with costs per student, independently of any considerations of the quality of education. This is unavoidable given that no quality data are available by state for the entire sample period. Of course the issue of how to measure quality is problematic at best, especially given that curricula are not standardized across the states. And the reality of fiscal constraints may dictate that costs per student are the principal supply consideration in any event. All we can note in this regard is that our estimates of technical change suggest that quality is an important, unmeasured factor.

Welfare: The output variable for welfare is the total number of recipients receiving cash payments under Supplemental Security Income (SSI) and Aid to Families with Dependent Children (AFDC) in December of each year, as reported in the *Social Security*

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[5] This section conveys the essential points of our data construction without detailing various minor problems that arose in individual states over parts of the sample period. Full details will be furnished upon request.

[6] We have used enrollment in public "institutions of higher education" reported until the fall of 1996, and public "degree-granting institutions" starting in the fall of 1997.

[7] The *Statistical Abstract* does not provide enrollment data for fiscal years 1990, 1992, 1994, 1999, 2002; for these years, we found data in the *Digest of Education Statistics* published by the U.S. National Center for Education Statistics, available at http://165.224.221.98/programs/digest/.

[8] Currently the U.S. Department of Health and Human Services. The publications are the *Biennial Survey of Education*, and *Opening (Fall) Enrollment in Higher Education, 19xx*. There are problems with missing data in these earlier years surveyed, however, since the government surveyed educational enrollments only every other year during the 1950's, and we found no reported data for 1961-64. The missing data were created by geometric interpolation.

Bulletin, Annual Statistical Supplement.[9] The SSI data include cases receiving state supplementation only. SSI, which took effect in January 1974, consolidated three separate programs, Old Age Assistance, Aid to the Blind, and Aid for the Disabled. Hence from December 1952 to December 1973 the output variable equals the sum of the recipients for the three earlier programs. AFDC was replaced in 1996 by Temporary Assistance for Needy Families (TANF), so that the ouput variable from December 1966 to December 2002 is the number of TANF recipients. The data are enumerated in actual numbers of recipients, with December of year *t* corresponding to fiscal year *t+1*.

There are no missing data points. However, because of the way in which our cost data are reported we were only able to obtain estimates for the 32 states that did not require local administration of any of these programs throughout the sample period. This is unfortunate since a number of the important welfare states (e.g., New York and California) do require local administration.[10] We should also note that the recipient data have two obvious omissions, Medicaid recipients and recipients on General Relief. While data on Medicaid recipients are reported it is impossible to determine how many of the Medicaid recipients were also receiving cash payments under one of the four programs. Presumably most were, but some states provide Medicaid to "medical needy" families, those with "low" income but not low enough to qualify for cash support. Data on recipients of General Relief are not readily available.

Hospitals: State hospital expenditures are primarily directed towards the mentally ill in the form of state psychiatric hospitals. For the purpose of this study, we used data on year-end residents of psychiatric hospitals provided by the *Statistical Abstract of the*

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[9] For SSI, we have used the total number of persons receiving federally administered payments in December of each year; starting with December 1998, data is available in electronic format at http://www.ssa.gov/policy/data_sub109.html. For AFDC/TANF, we have used the number of total recipients for December of each year; monthly AFDC (from July 1959 until September 1996) and TANF (after October 1996) caseload data is provided by the Administration for Children and Families, the U.S. Department of Health and Human Services, available in electronic format at http://www.acf.dhhs.gov/programs/ofa/caseload/monthlyindex.htm.

[10] The 32 state-administered states are: Alabama, Arizona, Arkansas, Connecticut, Florida, Georgia, Idaho, Illinois, Iowa, Kentucky, Louisiana, Maine, Michigan, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Washington, and West Virginia. See Tresch (1973).

United States, 19xx for fiscal years 1953-1981[11]; we also use the American Hospital Association's *Annual Survey of Hospitals* to build output values for fiscal years 1982-1995.[12] The residents are enumerated in thousands of patients, with the data for the end of calendar year *t* corresponding to fiscal year (*t+1*).[13] Finally, two states – Montana and South Dakota – reported zero resident patients for several years during the 1980s; therefore, we have performed the analysis for hospitals only on the other 46 states.

4.2 Factor Prices

Wages: We used data on wages and employment from the Bureau of Labor Statistics' *Public Employment in 19xx* for fiscal years 1953-1980.[14] We also used data from the U.S. Census Bureau's *Annual Survey of State and Local Government Employment and Census of Governments* database, to construct wages and employment for fiscal years 1981-2003. The two datasets report monthly payroll and employment (full-time equivalent) by state governments for October (up to 1995) and May (starting in 1997) each year. Subtotals cover a number of individual categories, including education ("total higher education"), public welfare, and hospitals.[15]

Wages are computed as the average wage, equal to total annual payroll divided by total employment, with the October wage in year t corresponding to the wage applicable

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[11] There are four years of missing data between 1953 and 1981, which were filled by geometric interpolation.

[12] Psychiatric hospitals and institutions were referred to as mental hospitals and institutions in the early years of the data.

[13] The *Statistical Abstract* reports the number of year-end residents in calendar years 1952-1980, which represent fiscal years 1953-1981. Unlike the *Statistical Abstract*, the *Annual Survey of Hospitals* provides the average number of residents for calendar years 1982-1995, with the exception of years 1983 and 1993 which we fill by interpolation. Then we construct the output values for fiscal years 1983-1995 as FY(t+1) = 0.5*[CY(t)+CY(t+1)]. Finally, fiscal year 1982 is interpolated from data for fiscal years 1981 and 1983.

[14] These data have been published continuously since the 1920's. The only break during our sample period occurred in 1957, with the missing data filled by interpolation. The data were published in print form until 1991 in *Public Employment in 19xx*. From 1992 on, they are available in electronic form on the U.S. Census Bureau's website under the heading State Government Employment and Payroll Data. <http://www.census.gov/govs/www/apesst.html> The Census Bureau's *Annual Survey….* database was provided to us in electronic format by John Curry of the Census Bureau.

[15] The payroll, employment and materials data provided by the Bureau of Labor Statistics between 1953 and 1961 includes both "Institutions of higher education" and "Other education" (without a breakdown being provided), and thus covers a broader field than the one implied by the "Total higher education" definition used after 1962. Therefore, we have scaled down the values of payroll, employment and materials for 1953-1961 by the average fractions derived from overlapping data provided by the two datasets for 1962-1979.

for fiscal year *(t+l)*, and the May wage in year *t* corresponding to the one for fiscal year *t*. The wage data are enumerated as annual salaries, obtained as the average October/May wage times 12, in thousands of dollars.

Materials price index: There are no published materials price indices for each state throughout the sample period. In lieu of state specific series we began with the wholesale index for all intermediate materials, supplies, and components (and comparable earlier series) for the United States as reported in the *Statistical Abstract*. At this point there are two viable choices. One can either assume that materials prices are constant across states in any given year or, alternatively, that they depart from the national average as do the individual state consumer price indices. Either assumption is undoubtedly flawed, but the latter strikes us as by far the more plausible.

The problem, then, becomes one of estimating individual state CPI's, since CPI data by state are also unavailable throughout the sample period. The *Statistical Abstract* has, however, reported annual CPI's for a number of individual cities continuously since the 1920s. We began with this series, allocating to each state either: (1) the index reported for a city within the state, or (2) a straight average of city indices within the state if there was more than one city listed for a state, or (3) the index for the city nearest to the state capital if no city in the state is listed. The index for December of year *t* corresponds to the index for fiscal year (*t+1*). There remains the problem of making each of the city indices comparable to one another, which requires at least one year of data comparing relative prices across cities for a common set of goods. The BLS published surveys of the costs of intermediate budgets for four-person families across various cities and non-metropolitan areas in the Springs of 1969 and 1970.[16] A linear combination of these was taken as the comparable index for December of 1969 (fiscal year 1970), which was then adjusted such that the overall U.S. average = 100. We then revalued each individual state index to December 1969 = 100 and used the across-city numbers as a common multiple

[16] *3 Budgets: For an Urban Family of Four Persons, 1969—70*, Supplement to Bulletin 1570—5, U.S Department of Labor, Bureau of Labor Statistics, Washington, D.C.: U.S. Government Printing Office, 1972.

to adjust each state's index for December 1969 (and all other years).[17] This gave us a comparable CPI index for all states. The final step involved resetting both the U.S. index of intermediate products and the overall U.S. CPI to December 1969 = 100 and computing the individual state materials price indices as

$$MPI_t^{state} = CPI_t^{state} (MPI_t^{US} / CPI_t^{US}). \tag{3}$$

The single state specific index MPI_t^{state} is assumed to apply to all service categories.[18]

<u>The cost of capital</u>: The cost of capital is the most deeply constructed price index. We began with the Christensen-Jorgenson (1969) formula, appropriately reinterpreted for state governments. Define the cost of capital for each state, *s*, in time *t* as

$$P_{K,st} = P_{t-1}^s \, i_t^{public,s} + P_t^s \delta_t^s - (P_t^s - P_{t-1}^s), \tag{4}$$

where $P_{K,st}$ = the cost of capital for state s in time *t*;

P_t^s = a state specific index of the supply price of capital goods in time *t*;

$i_t^{public,s}$ = the *nominal* public rate of discount for state *s* in time *t*;

δ_t^s = the appropriate rate of depreciation for state *s* in time *t*;

$(P_t^s - P_{t-1}^s)$ = state specific nominal capital gains.

Note that $P_{K,st}$ is nominal as required for cost function analysis.

Computing each of the key terms P_t^s, $i_t^{public,s}$, and δ_t^s required a set of simplifying assumptions. To arrive at P_t^s we began with the overall U.S. index on producer finished goods-capital equipment (and comparable earlier series) as reported in the *Statistical Abstract*.[19] As is true with the materials price index, one can either assume that supply

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[17] The Consumer Price Index series are expressed as 1982/84 = 100; therefore, we used .367 as the conversion factor to obtain 1969=100.

[18] We used the Producer Price Index for "Intermediate materials, supplies, components" provided by the *Statistical Abstract* as the U.S. Materials Price Index. The series are measured as 1982=100; therefore, we used .341 as the conversion factor to obtain 1969=100.

[19] We used the Producer Price Index series for "Finished goods – capital equipment" provided by the *Statistical Abstract* as the U.S. Capital Goods (Investment) Price Index. The series is measured with 1982=100; we used .383 as the conversion factor to 1969=100.

prices are constant across states or vary with the individual states' CPI's. The former assumption is favored in empirical analyses of local governments but we believe the latter is more plausible, even at the state level. Surely not all capital inputs are purchased in single-price national markets. Hence we distributed the U.S. producer price index across states by means of our constructed state specific CPI's, exactly as with the U.S. materials price index. A single index applies to all categories of capital.

Regarding $i_t^{public,s}$, we were forced to assume that the public rate of discount should reflect the marginal rate of substitution between the present and future, and that the MRS is well-proxied by a municipal bond rate. These assumptions are debatable, but standard practice in empirical analysis. The question then is: which municipal bond rate? We constructed state and category specific rates as follows. Moody's Municipal and Government Manual has listed the bond ratings for all individual state bond issues throughout almost all of the sample period.[20] It is also possible in many cases to relate the issues to particular categories (e.g., a bond issue for college dormitories). We used the latest issue for each state, by category if possible, as an indication of the rating applicable on the margin. Moody's also publishes for December of each year the rates on 10-year state bond issues, by rating. We attached these numbers to the individual state ratings to construct a series of state specific, and category specific, public rates of discount throughout the sample period.[21]

To compute δ_t^s we used estimates by Hulten and Wycoff (1981) on depreciation of structures and equipment for the United States. They estimate a 13.3% depreciation rate for equipment and a 3.7% rate for structures, on average. They also report estimates of 1.88% for educational structures, and 2.33% for hospitals and institutions. Aggregate capital expenditure data from *State Government Finances in 19xx* indicated that state non-highway capital outlays are roughly 80% structures and 20% equipment. Hence we

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[20] Mood's published the data until 1999 in *Moody's Municipal and Government Manual*, New York, Moody's Investor Service, Inc., 1955-1999. From 2000 to 2003, the data appear in *Mergent Municipal & Government Manual*, New York, FIS, a Mergent Co., 2000-2003.

[21] First, we collected the ratings by states and years (ranging between Aaa and Baa). Second, we assigned the corresponding interest rates to each rating and year, as follows: (a) We directly applied the ten year state bond yields (December) to all ratings of Aaa or Aa; (b) For all states/years with ratings of A (or Baa), we constructed the yield as *Municipal A (or Baa) * (State Aa / Municipal Aa),* where "Municipal" stands for the long term municipal bond yield, and "State" stands for the ten year state bond yields, all using December values. Finally, the December rating/yield of calendar year t corresponds to fiscal year t+1.

constructed category specific rates of depreciation using weights of .8 and .2, and assuming depreciation rates of 13.3% for equipment, 3.7% for welfare and miscellaneous structures, 1.88% for educational structures, and 2.33% for hospitals. This generated depreciation rates of 4.16% for education capital, 5.62% for welfare and miscellaneous capital, and 4.52% for hospital capital. Depreciation rates were assumed constant across states and over time for lack of any viable alternative.

As it turned out we were unable to apply the Jorgenson formula even with all these assumptions. $P_{k,st}$ was negative for many states in the early years of the sample and often throughout the 1970's because of rapid inflation of capital goods supply prices. While the cost of capital may actually have been negative in some years, the translog function cannot accept negative values. Hence we were forced to assume that states ignore inflation of asset specific prices (the P_t^s), but compensate by removing expected inflation of the general price level from $i_t^{public,s}$. Hence $P_{k,st}$ reduces to

$$P_{K,st} = P_{t-1}^s \, r_t^{public,s} + P_t^s \delta_t^s, \qquad (5)$$

where $r_t^{public,\,s}$ = the real public rate of discount, and

$$r_t^{public,s} = i_t^{public,s} - E[CPI_t^s], \qquad (6)$$

where $E[CPI_t^s]$ is the expected annual rate of inflation in the individual states' CPI's, assumed equal to its average annual inflation rate over the past 10 years, (t-1) ... (t-10).

All $P_{K,\,st}$ computed in this manner were positive. Note, too, that $P_{K,\,st}$ is both state and category specific given our entire set of assumptions.

4.3 Total (nominal) factor costs and the cost shares

The Department of Commerce has published detailed data on individual state governments' costs and revenues, by category, for each fiscal year continuously since the late 1930's, and intermittently before that back to the 1920's. The data are currently available on the Census Bureau's website under the heading State Government Finances. Education, public welfare, and hospitals have always been listed as separate categories. The cost data have always distinguished between direct costs (factor costs) and intergovernmental expenditures (grants-in-aid – transfer payments) and, within direct costs, between current costs and capital outlays. By combining these data with the payroll data (see above) we were able to divide total direct costs into separate labor, materials and capital components.[22] All costs are enumerated in thousands of dollars.

Labor: Labor costs were taken directly from the total payroll data described above.

Materials: Having thus computed payroll costs for the fiscal year, we computed the material costs by subtracting the annual payroll costs from the total direct costs net of capital outlays (i.e., "current operations" in the Census dataset) for total higher education, welfare and hospitals.[23]

Capital: Capital costs are defined for each category as:

$$Capital\ Cost_t^s = P_{K,st} K_t^s, \qquad (7)$$

where K_t^s = the real stock of capital for state s in time t;

$P_{K,st}$ = the opportunity cost of capital, described above.

The real capital stock was computed by: (a) deflating the capital outlay series reported in *State Government Finances* by the state specific price index of capital goods described above, (b) assuming depreciation rates also as described above, and (c)

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[22] The Census Bureau has the data on electronic format on its website for every fiscal year beginning in 1992. http://www.census.gov/govs/www/state.html Before 1992, the data were published in print form in *State Government Finances in 19xx*. We relied heavily on a database entitled *Historical Database of Government Finances*, which was provided to us in electronic format by John Curry of the Census Bureau. It combines the data from *State Government Finances* for 1951-1977 with data from the Census' estimates database for the period from 1977 to 2003.

[23] Computing materials as a residual based on two separate data sources runs the risk of compounding reporting errors and thereby generating nonsensical values. Our only checks on potential problems within each state were the computed materials values themselves, that is, if materials costs were negative or unduly large or small relative to values in surrounding years. These problems occurred remarkably infrequently and most often clearly resulted from transcription error. There were a few unexplainable outliers, for which we substituted interpolated data.

computing the capital stock in each year from the investment series according to the relationship $K_t = I_t + (1-\delta)K_{t-1}$. The only problem concerned the choice of a base year. State data went unpublished from 1929-1935, which means there is a seven year break in the capital outlay series. Rather than interpolate from series prior to 1929, we set $K_{1936} = 0$. This generates some bias for the early years in our sample since capital in place in 1936 would not have been fully depreciated by the early and mid-1950s, given the assumed depreciation rates. However, capital outlays were dramatically higher in the 1950s and 1960s than in the 1920s even in real terms, so that the bias is unlikely to be important, even in the early years of our sample.[24]

Factor shares: The shares are simply the ratio of each cost component to the sum of the cost components. For the short run, total variable costs = payroll + materials costs.

We were also able to construct total costs and factor shares for all non-highway general expenditures other than education, welfare, and hospitals. This comprised the miscellaneous category.[25]

The overall sample mean values of the shares for the long run and short run are as follows:

Long-run factor shares			
	S_L	S_M	S_K
Education	.591	.326	.082
Welfare	.480	.509	.010
Hospitals	.612	.337	.052
Miscellaneous	.261	.685	.053
Short-run factor shares			
Education	.645	.355	-
Welfare	.486	.514	-
Hospitals	.646	.354	-
Miscellaneous	.275	.725	-

Three facts stand out. First, materials are a very important factor of production for

[24] We should also note that we were able to compute the state specific price index for capital goods, P_t^s, back to 1936 using the method described above.

[25] The price of labor was taken as the ratio between miscellaneous total payroll and miscellaneous total employment (i.e., obtained by subtracting higher education, welfare and hospitals payroll and employment from the corresponding totals). Nominal materials were derived by subtracting the annual miscellaneous payroll from the miscellaneous total expenditures. Similarly, the miscellaneous capital outlays were derived by subtracting the higher education, welfare and hospitals capital outlays from the total. The cost of capital, and capital stock calculations assumed a depreciation rate of 5.62%.

all state services. They should not be ignored when estimating service costs. Second, the three categories we have chosen to highlight appear to use substantially different production technologies from those comprising the miscellaneous category. The miscellaneous category is much less labor intensive and much more materials intensive. Finally, capital is the least important component of cost for all state services, by a wide margin. The production of state services is decidedly labor and materials intensive in an absolute sense.

4.4 Time

The time dummy was set to range from [–25, 25] so that its value would be zero at the point of approximation, taken as the mean of all independent variables. Recall that *T* does not enter the translog system in log form.

5. Estimation

The translog equations (1) and (2) were estimated as a complete system, with the symmetry and adding up coefficient restrictions imposed, using the Zellner seemingly unrelated estimator to account for the contemporaneous correlation of the errors across the share equations within each state.[26]

The Zellner estimator was not applied to the raw data. We made two prior adjustments in the data, each attempting to capture possible differences across states in the sample.[27] First, we assumed as a maintained hypothesis that the constant term in the cost function varies across states, either because of efficiency differences not otherwise captured by the cost function, and/or quality and other programmatic differences among the states. The factor shares are assumed to be unaffected by these differences.

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[26] We chose the Stata version of the Zellner estimator (*sureg*), which has three attractive features: (a) the estimates are maximum likelihood and therefore invariant to the share equation deleted; (b) Stata is designed for ease of specifying maintained linear restrictions on coefficients both within and across equations, and for testing additional linear restrictions on coefficients; and (c) the *isure* option of Stata's *sureg* command offers an iterative estimation procedure with the maintained coefficient restrictions holding at each iteration.

[27] The two data adjustments mentioned in this section do not apply to the miscellaneous category. The miscellaneous share equations were estimated by OLS on the raw data.

Estimating separate constant terms entails demeaning all variables in the cost function (but only the cost function) by subtracting, for each state, the within-state means over the 51 years (44 years for hospitals), and estimating the cost function without a constant term. The state specific constant terms are then computed as:

$$\hat{\alpha}_{os} = Y_{s\bullet} - \sum_k \hat{b}_k X_{ks\bullet}, \; s = 1,\ldots,48, \tag{8}$$

where $Y_{s\bullet}, X_{ks\bullet}$ = the demeaned dependent and *k* independent variables, respectively;

$\hat{b}_k$ = the coefficient estimates on the *k* independent variables.

Given that the cost function is in log form, and that the raw independent variables are defined as ratios of their overall sample means, $e^{\hat{\alpha}_{os}}$ represents the average costs each state would experience if it were operating at the point of approximation, the *overall* sample mean for each independent variable.

The second adjustment allows for the possibility of both heteroscedasticity of the error terms across states in any given year and autocorrelation. We first performed a Prais-Winsten OLS regression on the demeaned average cost equation with heteroscedastic panels and with no constant, in order to estimate a first-order autocorrelation coefficient ρ (assumed equal for all states in the version we chose) and a state-specific sum of squared residuals, S^2_{su}.[28] Then we used the estimates of ρ and S^2_{su} to transform the independent and dependent variables of both the average cost and share equations according to the relationships:

$$Y^*_{st} = (Y_{s,t} - \rho Y_{s,t-1}) / S_{su} \qquad X^*_{st} = (X_{s,t} - \rho X_{s,t-1}) / S_{su}.$$

[28] Stata's *xtpcse* command calculates panel-corrected standard error (PCSE) estimates for linear cross-sectional time-series models where the parameters are estimated by OLS or Prais-Winsten regression. When computing the standard errors and the variance-covariance estimates, it assumes that the disturbances are heteroskedastic and contemporaneously correlated across panels. We used the following *xtpcse* options: *noconst*; *hetonly* (specifies that the disturbances are assumed to be panel-level heteroscedastic only with no contemporaneous correlation across panels); *correlation(ar1)* (specifies that, within panels, there is first-order autocorrelation AR(1) and that the coefficient of the AR(1) process is common to all the panels).

We then applied the Zellner estimator for the entire translog system to the transformed data.[29]

6. Results

Table 1 lists the coefficient estimates (with standard errors in parentheses) of the long-run and short-run average cost functions described by equation (1) for education, welfare, and hospitals, and the coefficient estimates of the long-run and short-run share equations for the miscellaneous category.

The interpretation of results for each service proceeds along three lines: a characterization of the underlying production technology; a comparison of relative costs across states; and an analysis of the sources and extent of productivity growth. We will discuss each service function in turn, with the details of the various hypothesis tests and data manipulations incorporated into the discussion of the results for education.

6.1. Education

a) Characteristics of the production technology

The coefficient estimates reveal four important properties of the production technology: the extent of scale economies; the nature of technical change; whether or not production is efficient in the long run; and both the own price elasticities of factor demands and the Allen partial elasticities of substitution between the factors.

[29] Judge, et al. (1980) recommend estimating ρ and S_{su}^2 separately for each equation in the system estimation. This, however, destroys the property of invariance to the deleted share equation for the translog system, and the estimates were fairly sensitive to the choice of the deleted equation. We therefore transformed all data using the ρ and S_{su}^2 estimates from the unrestricted average cost equation to preserve the invariance property.

Scale economies

One of the more striking results of the regression analysis is the general finding of substantial economies of scale for all services, in both the long run and short run. The only exception is the miscellaneous category, for which CRS is a maintained hypothesis.

The analysis of scale economies proceeds in four steps. First we test the hypothesis of CRS throughout the sample, or $\partial \ln AC/\partial \ln Q = 0$. This holds if $\alpha_Q = 0$ and $\gamma_{iQ} = 0$ for all i. Failing that, the second step tests for homogeneity, i.e., is $\partial \ln AC/\partial \ln Q$ = constant? This requires $\gamma_{iQ} = 0$, all i. Failing that, the third step tests for homotheticity, i.e., are the factor shares independent of output at given factor prices? This requires that $\gamma_{jQ} = 0$, where j refers to regresors P_L, P_M, P_K in the long run, and to P_L, P_M in the short run.

The results of these tests for all service categories, long run and short run, appear in Table 2, along with the corresponding critical values of the F statistic at the 90%, 95%, and 99% confidence levels. The tests for education overwhelmingly reject all three hypotheses in the long run, and CRS and homogeneity in the short run. Short-run homotheticity can be rejected at the 95% confidence level, but not at the 99% confidence level.

If homotheticity is rejected for the overall sample, then the final step is to calculate returns to scale at every point in the sample, defined as the elasticity of cost with respect to output, other things equal. In terms of average costs,

$$S_{Q_{st}} \equiv \frac{\partial \ln AC}{\partial \ln Q} = \alpha_Q + \alpha_{QQ} \ln\left(\frac{Q_{st}}{\bar{Q}}\right) + \sum_j \gamma_{Qj} \ln\left(\frac{X_{jst}}{\bar{X}_j}\right) + \gamma_{QT} T \; , \qquad (9)$$

where $j = P_L^k, P_M^k, P_K^k$: $\quad LR$;

$\quad = P_L^k, P_M^k, K$: $\quad SR$,

with $S_Q < 0$ showing increasing returns, $S_Q = 0$ constant returns, and $S_Q > 0$ decreasing returns to scale.

Since the only differences in S_Q across states and over time result from different values of within sample data, we present the mean values of S_Q for each state over the 51 years. Reported standard deviations are computed relative to the vector of state means.

This method of presenting the results applies whenever data and coefficient estimates are combined. Table 12 reports the mean values of S_Q for each state.

All states exhibit substantial economies of scale in the production of higher education, in both the long run and short run. The overall long-run mean value of S_Q is –.620, with a minimum of –.625, a maximum of –.612, and a standard deviation of .003. Short-run production is much the same. The overall mean is –.765, with state means ranging from –.966 to –.631, and a standard deviation of .067.

A supporting piece of evidence on the prevalence of scale economies comes from analyzing the slope of marginal costs. At the point of approximation, the slope equals $(AC/Q)\ [\gamma_{QQ} + \alpha_Q + \alpha_Q^2]$, which is positive or negative depending on the sign of the bracketed expression. The slopes are negative at the point estimates of α_Q and γ_{QQ} in both the long run and short run, indicating that unexploited scale economies were so severe throughout the sample period that an "average" state was providing higher education on the negative portion of its marginal cost curve.

Technical change

The analysis of technical change proceeds along lines similar to that of scale economies. Pure technical change refers to the partial derivative of cost (either total or average) with respect to time. The first question is whether costs are changing over time throughout the sample, other things equal. The null hypothesis of unchanging costs requires that $\alpha_T = \gamma_{iT} = 0$ for all i.

As Table 2 indicates, this is overwhelmingly rejected for education in both the long run and short run. Assuming, then, that costs are varying over time, the next question concerns the nature of technical change: is it Hicks neutral, or factor saving/using? The null hypothesis of Hicks' neutrality requires:

$$\gamma_{jT} = 0, \qquad j = P_L, P_M, P_K: \qquad LR;$$
$$= P_L, P_M: \qquad SR;$$

i.e., that factor shares are independent of time. If Hicks' neutrality is rejected, technical change is characterized as factor-saving (factor-using) if $\gamma_{jT} < 0$ ($\gamma_{jT} > 0$). This follows since an increase in a factor's price reduces its use in production. If time reduces the factor price derivative, then the effect of relying less on this factor is diminishing cost (enhancing technical change) over time. Hence technical change is factor saving (and vice versa). As Table 2 indicates, Hicks' neutrality is soundly rejected both in the long run and short run for education. Additionally, the long-run coefficient estimates indicate that technical change is materials-using ($\gamma_{MT} > 0$), and labor- and capital- saving (γ_{LT}, $\gamma_{KT} < 0$).

Having rejected the hypothesis that costs are unchanging over time, technical change at each point in the sample can be evaluated as (measured positively)

$$V_{T_{st}} \equiv -\frac{\partial \ln AC}{\partial T} = -\left[\alpha_T + \sum_j \gamma_{jT} \ln\left(\frac{X_{jst}}{\overline{X}_j}\right) + \gamma_{QT} \ln\left(\frac{Q_{st}}{\overline{Q}}\right) + \gamma_{TT} T\right], \quad (10)$$

where j $= P_L, P_M, P_K$: LR;

$= P_L, P_M$: SR.

Table 12 reports the mean values of V_T for each state, for both the long run and short run. The results are striking. Pure technical regression is pervasive in public higher education, in both long-run and short-run production. All state means are negative in the long run. The overall average technical regression is 3.35% per year, with a maximum of 3.66%, a minimum of 2.93%, and a standard deviation of .16%. Technical regression is less severe in the short run, but still the overriding characteristic across the states. The overall mean technical regression is 2.07% per year, with a maximum of 2.67%, a minimum of 1.17%, and a standard deviation of .29%.

These findings certainly provide a bleak assessment of states' abilities to produce higher education, enough so as to question whether some unmeasured effect is generating the results. An obvious candidate is quality change – states are knowingly spending more per student over time in order to improve the average quality of the product. An example that comes immediately to mind is the explosion of student services in higher education in the last thirty or so years of the sample, with the concomitant increase in administrative expenses. But then one might expect technical change to be labor using in our framework, whereas it is labor saving. Perhaps audio-visual and computer technologies have made a difference. If so, however, one might expect technical change to be capital and materials using, whereas our results indicate it is material using but capital saving, even given a "misspecified" output variable. Alternatively, perhaps educational administrators have become more adept at rent extraction, in line with the theory of bureaucracy. If this is so, the results are indicating that cost minimization is the wrong maintained hypothesis. (See immediately below for some additional evidence on this possibility).

All this is speculation, of course, in the nature of questions for future research. It is difficult to accept a finding of pure technical regression on face value. Yet we find technical regression for all three state services.

Long-Run Cost Efficiency

Estimating a short-run cost function permits a direct test of long-run production efficiency. Is $MC_K \equiv -\frac{\partial VC_{SR}}{\partial K} = P_K$, the standard criterion for the optimal capital stock at any given output? MC_K follows directly from the log derivative of short-run cost with respect to capital:

$$MC_K \equiv \frac{\partial VC}{\partial K} = \frac{VC}{K}\frac{\partial \ln VC}{\partial \ln K} = \frac{VC}{K}\frac{\partial \ln AC}{\partial \ln K}. \quad (11)$$

Hence

$$MC_{K_{st}} = \left(\frac{VC}{K}\right)\left[\alpha_K + \sum_j \gamma_{jK} \ln\left(\frac{X_{jst}}{\overline{X}_j}\right) + \gamma_{KK} \ln\left(\frac{K_{st}}{\overline{K}}\right) + \gamma_{QK} \ln\left(\frac{Q_{st}}{\overline{Q}}\right) + \gamma_{TK} T\right] \quad (12)$$

at every point in the sample, where $j = P_L, P_M$.

The mean values of MC_K for each state reported in Table 12 overwhelmingly reject long-run production efficiency. MC_K is *positive* in all states, not negative as required, with an overall mean of .521, a range of .256 to 1.013, and a standard deviation of .130. This strongly suggests that higher education is overcapitalized as indicated in

Figure 1. When the capital stock is already too large, increasing capital by even more shifts the short-run average cost curve from AC_{SR}^{1} to, AC_{SR}^{2} and thus raises the short-run average costs of producing a given amount of output from AC^{1} to AC^{2}.[30] Of course the finding of overcapitalization calls into question the validity of all the long-run cost estimates since cost-minimization is a maintained hypothesis. As we have seen, however, the short-run and long-run estimates have revealed similar production characteristics, a pattern that continues throughout the analysis of the results. Nonetheless, the MC_K estimates suggest that there is merit to exploring theories of bureaucracy in the provision of state educational services, since those theories rest upon various kinds of production inefficiency.

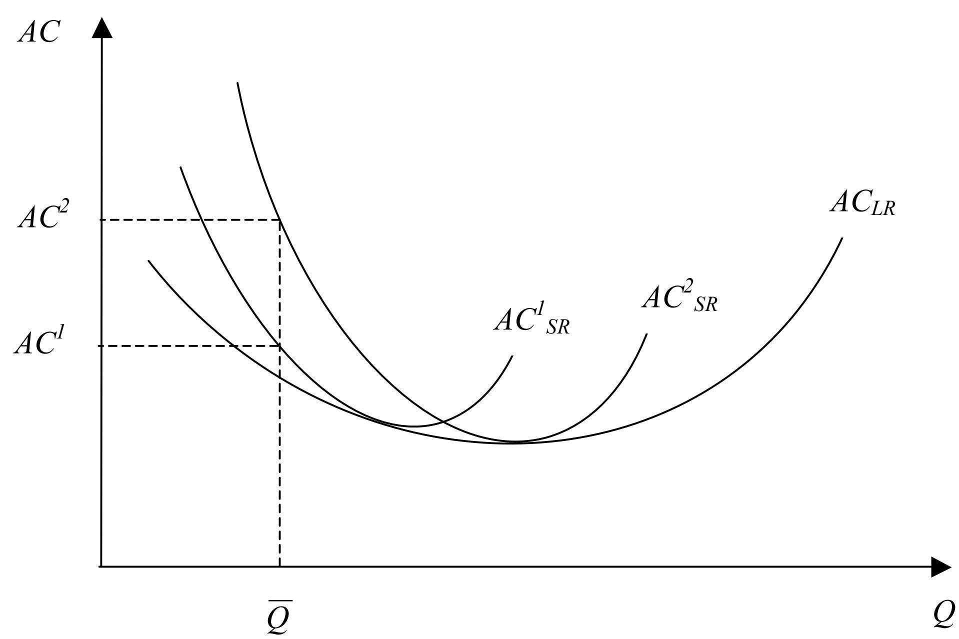

Figure 1: Overcapitalization in higher education

Factor Demands

Tables 15 and 19 report the mean values within each state of own price elasticities (η_{ii}) and Allen partial elasticities of substitution (σ_{ij}), for the long run and short run, where:

[30] Presumably MC_K could be positive with undercapitalization depending on the shape of the AC_{SR} curves, but this is unlikely.

$$\eta_{ii} = \left(\gamma_{ii} + S_i(S_i - 1)\right) / S_i, \qquad (13)$$

$$\sigma_{ij} = \left(\gamma_{ij} + S_i S_j\right) / S_i S_j, \qquad (14)$$

where i, j = P_L, P_M, P_K: LR;

= P_L, P_M: SR;

S_i (S_j) = factor shares, evaluated at every point in the sample.

All factors are substitutes in the long-run production of higher education in all states, and factor demands are uniformly inelastic in both the long run and short run. Given concavity, labor and materials must be substitutes in the short run. The summary data for the long run and short run are as follows:

Education, long-run factor elasticities				
	Mean	Standard Deviation	Minimum	Maximum
η_{LL}	–.336	.037	–.404	–.259
η_{MM}	–.616	.033	–.682	–.531
η_{KK}	–.887	.008	–.899	–.862
σ_{LM}	.840	.017	.789	.866
σ_{LK}	.649	.058	.445	.742
σ_{MK}	1.620	.201	1.411	2.544
Education, short-run factor elasticities				
η_{LL}	–.302	.041	–.392	–.214
η_{MM}	–.539	.031	–.600	–.464
σ_{LM}	.841	.016	.792	.860

b) <u>Relative costs</u>

Recall that our cost analysis is primarily directed towards obtaining estimates of marginal costs for each state at every point in the sample, which estimates will then be used as supply prices in a demand-oriented model of the state budgetary process. Presumably short-run marginal costs are most directly relevant as supply prices. In light of this goal, the estimates for education, welfare and hospitals can be viewed as quite successful. Marginal costs are positive at every sample point for education and welfare in the long run; they are positive at most of the observation points for hospitals in the long run, as well as for education, welfare and hospitals in the short run.[31] In this section we are only concerned with the relative values of marginal costs across states.[32]

Marginal costs of output at every sample point are defined as

$$MC_Q \equiv AC\frac{\partial \ln TC}{\partial \ln Q} = AC\left[1+\frac{\partial \ln AC}{\partial \ln Q}\right], \qquad (15)$$

$$MC_{Q_{st}} = AC_{st}\left[1+\alpha_Q+\alpha_{QQ}\ln\left(\frac{Q_{st}}{\overline{Q}}\right)+\sum_j \gamma_{Qj}\ln\left(\frac{X_{jst}}{\overline{X}_j}\right)+\gamma_{QT}T\right], \qquad (16)$$

where X_j $= P_L, P_M, P_K$: LR;

$= P_L, P_M$: SR.

Table 3 reports the mean values of MC_Q for each state during the sample period. There is considerable variation in costs in both the short run and long run. For the long run, the mean value of marginal cost is $1,610 per pupil, with a minimum of $924, a maximum of $2,760 and a standard deviation of $358. For the purpose of cross-state comparisons, we deflate the MC_Q by the CPI for each state during the sample period in order to remove one obvious reason why the costs might differ, the difference in price indices across states and time. Using the deflated cost data, a rough assessment of relative costs can be obtained by labeling high (low) cost states as those having mean costs between one and two standard deviations from the overall mean, and very high (very low) cost states as those having mean costs more than two standard deviations from the mean.[33] This produces the following categorization of relative long-run costs.

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[31] Short-run marginal costs are negative at 46 out of 2448 sample points for education, and at 19 out of 1632 sample points for welfare. For hospitals, long-run marginal costs are negative at 20 out of 1978 sample points, and short-run marginal costs are negative at 47 out of 1978 observations.

[32] For education, short-run marginal costs are negative for California during 1976-2003, Florida during 2000-2003, Illinois in 2003, Nevada in 1986, New York in 2003 and Texas during 1993-2003. The result is likely due to the relatively large negative value of α_Q as well as to the negative value of γ_{QT}, that drive marginal costs down (the latter especially during the later years).

[33] The deflated marginal cost data are available upon request. Since differences in marginal costs are solely attributable to the data, comparisons across states are necessarily arbitrary.

Education, long-run marginal costs			
Very High	High	Low	Very Low
Delaware, Vermont	Indiana, Iowa, New Mexico, South Carolina, Utah	Arizona, California, Florida, Illinois, Massachusetts, Missouri, New York	n/a

Short-run marginal costs display roughly the same variation across the states; they were positive in all of the states except for California. The overall mean is $634 per pupil, with a minimum of $ –88 ($136 not counting California), a maximum of $2,063, and a standard deviation of $395. Using marginal cost data deflated by CPI, our categorization of high (low) and very high (very low) cost states produces the following breakdown:

Education, short-run marginal costs			
Very High	High	Low	Very Low
Delaware, Vermont	Montana, New Hampshire, North Dakota, South Dakota	Arizona, California, Illinois, New York, Ohio, Texas	n/a

A second comparison of relative state costs employs the state specific constants in the average cost functions, α_{OS}. Recall that $e^{\alpha_{os}}$ measures the average cost state *s* would experience if it operated at the mean values of all explanatory variables. As such it also serves as a shift parameter in the marginal cost function at the point of approximation. Hence, the cost comparisons using $e^{\alpha_{os}}$ reflect differences in costs not captured by differences in values of the explanatory variables, whereas the comparison using MC_Q is an amalgam of both measured and unmeasured differences among the states.

The values of $e^{\alpha_{os}}$ are reported in Table 3. The overall mean value in the long run is $3,333, with a minimum of $1,139, a maximum of $7,793, and a standard deviation of $1,527. The overall short-run mean is $3,093, with a minimum of $1,508, a maximum of $5,975, and a standard deviation of $868. The long-run and short-run characterizations of high (low) and very high (very low) cost states are as follows:

Education, long-run average costs			
Very High	High	Low	Very Low
California, Michigan, Texas	Illinois, Indiana, Ohio	Idaho, Maine, Montana, Nevada, New Hampshire, North Dakota, Rhode Island, South Dakota, Vermont, Wyoming	n/a
Education, short-run average costs			
California	Indiana, Michigan, North Carolina, Ohio, Texas	Idaho, Montana, Nevada, New Hampshire, North Dakota, Rhode Island, South Dakota, Vermont, Wyoming	n/a

The two measures of relative state costs rank the states differently, but several consistencies should be noted. In the long run, the majority of states fall within one standard deviation of the mean under each measure (i.e. 34 and 32 states respectively). Both measures rank Indiana as a high cost state. In the short run, the majority of states also fall within one standard deviation of the overall mean under both measures (i.e. 36 and 33 states respectively). However, there was no overlap under the two measures in the short run.

In concluding this section, we should stress that the term “high cost” (“low cost”) should not be taken as critical (exemplary). Given the scope of this study all we can do is identify outliers. Since both relative cost measures involve unmeasured effects there is no way of determining the extent to which these cost differences reflect different underlying production efficiencies and factor costs, or programmatic differences in educational curricula. These remain questions for future research.

c) <u>Productivity growth</u>

Productivity growth in the production of state (and local) services gained prominence as an empirical research question with the publication of the Baumol-Oates

(1975) cost disease model. The authors speculated that the combined problems of lagging productivity growth and fiscal illusion regarding increasing tax rates would retard expansion of the state/local public sectors. Our analysis supports their speculation of lagging productivity growth for welfare and hospitals. The results for education are mixed, enough so as to cast reasonable doubt on their hypothesis. Of course all such statements must be tempered by the caveat that output might be misspecified in each category.

Productivity growth refers to the time derivative of average costs holding factor prices constant (and capital in the short run). In terms of the translog cost function,

$$V_G \equiv -\left.\frac{\partial \ln AC}{\partial T}\right|_{\overline{P}(\overline{K})} \equiv -\left(\frac{\partial \ln AC}{\partial \ln Q}\right)\frac{\partial \ln Q}{\partial T} - \frac{\partial \ln AC}{\partial T}, \tag{17}$$

$$V_G \equiv -S_Q \frac{\partial \ln Q}{\partial T} + V_T, \tag{18}$$

with productivity growth measured positively, and S_Q, V_T as defined previously. The first term is a scale effect, the productivity or average cost effect of moving along a given average cost curve. The second term is pure technical change, the shift in the average cost curve over time at a given level of output.

Equation (18) presents the instantaneous change in productivity. The discrete measure of productivity growth is a Tornqvist index of the two effects, between times *T* and *T-1*, or[34]

$$\overline{V}_G = -\overline{S}_Q\left[\ln Q(T) - \ln Q(T-1)\right] + \overline{V}_T, \tag{19}$$

where $-\overline{S}_Q = -(1/2)[S_Q(T) - S_Q(T-1)]$;

$\overline{V}_T = (1/2)[V_T(T) + V_T(T-1)]$.

[34] For further discussion of the discrete productivity measure see Gollop and Roberts (1983).

Since the enrollments in public higher education grew steadily throughout the sample period, the preceding analysis suggests that productivity growth in education was the net result of two offsetting tendencies throughout the sample period. Pure technical regression served to shift cost curves up over time, but scale economies allowed states to move down their individual cost curves as enrollments increased. Table 6 reports the long-run average growth in productivity, along with the two separate effects, for each state during the sample period. The summary data (expressed as percents) are as follows:

Education, long-run productivity growth				
	Mean	Standard Deviation	Minimum	Maximum
$\overline{V}_G$	–.32	.63	–1.38	1.76
$-\overline{S}_Q(\Delta \ln Q)$	3.03	.59	2.27	5.30
$\overline{V}_T$	–3.35	.15	–3.66	–2.92

For long-run education, although the two effects roughly offset one another, productivity growth was negative for the vast majority of the states under review across the sample period (i.e., in 35 out of 48 states). Notice that all states experienced positive scale effects and technical regression, on average, throughout the sample period. Also, the bounds on productivity growth are fairly tight, and probably below private sector productivity growth for all but the most productive states.

Table 7 reports the short-run average growth in productivity and the two separate effects for each state during the sample period. The summary data are as follows:

Education, short-run productivity growth				
	Mean	Standard Deviation	Minimum	Maximum
$\overline{V}_G$	1.36	.94	–.57	3.71
$-\overline{S}_Q(\Delta \ln Q)$	3.43	.75	2.10	5.43
$\overline{V}_T$	–2.07	.29	–2.67	–1.16

The short-run analysis is far more sanguine. Productivity growth was positive for all states with the exceptions of Delaware, North Dakota and Vermont. Relative to the long run, the scale effect is generally stronger and technical regression generally weaker, with the net result that overall productivity growth was 1.36% per year. This is reasonably close to published data on private sector productivity growth during the sample period.

Overall, then, the analysis of productivity gives mixed signals for education. Recall, however, that our analysis of the marginal costs of capital does not support the hypothesis of long-run cost minimization. When this is combined with the evidence of short-run productivity growth roughly comparable to private sector estimates, we believe our results cast reasonable doubt on the Baurnol-Oates cost disease hypothesis for higher education during the sample period. There was cost-disease in the pure sense of adversely shifting AC curves, but not in terms of overall productivity growth.

6.2 Welfare

a) Characteristics of the production technology

Scale economies

Table 2 reveals that the hypothesis tests on the coefficients of the long and short run cost functions for welfare are generally consistent with their counterparts for education. CRS, homogeneity, and homotheticity are all soundly rejected both in the long run and short run.

The analysis of scale economies at every point in the sample, $S_Q = \partial lnAC/\partial lnQ$, shows roughly similar results in the long run and short run. Table 13 reports the average values of S_Q for each state during the sample period. There are extreme scale economies for the long run in all 32 of the state-administered programs. The overall mean is –.803, with a range of –.891 to –.721, and a standard deviation of .055. Scale economies in the short run are roughly the same, the overall average being –.784. There is slightly more variation across states, although no state exhibited decreasing returns to scale in the short run on average throughout the sample period. S_Q ranges from –.935 to –.619, with a standard deviation of .098.

The slopes of long-run and short-run marginal costs at the point of approximation are both negative, indicating the existence of unexploited scale economies throughout the sample period; i.e., an "average" state was providing welfare on the negative portion of its marginal cost curve.

Technical change

The F tests in Table 2 soundly reject the hypothesis that costs do not vary over time for both the long run and short run. Hicks neutral technical change is also rejected in both the long run and short run. Since γ_{LT} and γ_{KT} are negative and γ_{MT} is positive in both the long run and short run, technical change is consistently labor and capital-saving, as well as materials-using (just as for long-run education).

The analysis of pure technical change ($-V_T = -\partial lnAC/\partial T$) at every point in the sample indicates that welfare in all states is afflicted with severe technical regression in both the long run and short run. Table 13 reports the average value of V_T for each state throughout the sample period. In the long run, the overall mean technical regression is 6.63% per year, with a maximum of 6.90%, a minimum of 6.22%, and a standard deviation of .16%. The short-run experience is much the same. The short-run mean is 6.20% per year, with a range of 6.69% to 5.56%, and a standard deviation of .32%. Since dynamic inefficiencies of this magnitude are difficult to imagine, one again searches for an unmeasured factor that could be generating the results. There does appear to be an obvious candidate worth pursuing in future research-- the proliferation and growth of various in-kind services throughout the sample period. These services may well be more costly to provide than straight cash transfers, in which case the technical regression is actually monitoring a consistent change in the composition of the product. If this speculation is correct it raises an important question: Since recipients presumably would prefer cash, should states bear the apparently substantial additional costs of providing in-kind services? Of course, there may well be other reasons why costs have been increasing over time. The possibility of increasingly effective, and inefficient, bureaucratic behavior should certainly be considered.

Long-run cost efficiency

The marginal costs of capital derived from the coefficient estimates of the short-run average cost function suggest that welfare services are overcapitalized, although there is more variation across states here than for education. Table 13 shows that the average value of MC_K was positive in all states – with the exception of Alabama and Georgia – during the sample period. The overall mean value of MC_K is .928, against an overall mean cost of capital of .129. The standard deviation of the individual state means is quite large, 1.361, but is generated mostly by the two outlier states with unusually low MC_K values; the means range from – 5.804 to +2.601. Overall, the results provide evidence of overcapitalization within most states.

Factor demands

Tables 16 and 20 report the average value of own price elasticities and Allen partial elasticities of substitution for each state throughout the sample period, for the long run and short run. The factor demand attributes for welfare are different from those for education. Labor and materials and materials and capital are substitutes for one another in the long run, whereas labor and capital are complements in most of the states (21 out of 32). The demands for labor and materials are own-price inelastic in both the long run and short run in all states. The demand for welfare capital is slightly more elastic than in education, to the point that it is nearly unit elastic in all states.

The summary data are as follows:

Welfare, long-run factor elasticities				
	Mean	Standard Deviation	Minimum	Maximum
η_{LL}	-0.452	0.055	-0.586	-0.348
η_{MM}	-0.439	0.060	-0.561	-0.305
η_{KK}	-0.990	0.005	-0.997	-0.974
σ_{LM}	0.880	0.025	0.784	0.900
σ_{LK}	-0.566	1.053	-4.017	0.651
σ_{MK}	2.510	1.249	1.425	6.597
Welfare, short-run factor elasticities				
η_{LL}	-0.455	0.057	-0.594	-0.345
η_{MM}	-0.427	0.059	-0.547	-0.290
σ_{LM}	0.882	0.024	0.789	0.904

b) Relative costs

The attempt to estimate marginal costs of output at every point in the sample was quite successful, as almost all of the short-run marginal costs for welfare are positive. The negative short-run estimates occurred in only a few states and mostly during the first years of the sample (a total of 19 out of 1632 observations).[35] In a purely mechanical sense the culprit appears to be the relatively large positive value of γ_{QT}, which exerts a strong negative pull on marginal cost estimates in the early years. However, the mean values of short-run marginal costs are positive for all states.[36]

Table 4 reports the average values of marginal cost for each state during the sample period. There is even more variation in costs across the states than for education. In the long run, the overall mean value of marginal cost is \$195.19 per recipient, with a range of \$97.43 to \$329.46, and a standard deviation of \$62.99. The short-run variability is even larger, with an overall mean of \$129.37 per recipient, a minimum of \$68.90, a maximum of \$376.90, and a standard deviation of \$74.43.

Using the marginal cost data deflated by the individual state CPIs, we characterize high (low) cost states as those between one and two standard deviations from the mean, and very high (very low) cost states as those greater than two standard deviations from the mean. The analysis yields the following breakdown:

Welfare, long-run marginal costs			
Very High	High	Low	Very Low
Michigan, Oregon, Pennsylvania	Illinois, Iowa, Washington	Alabama, Mississippi	-
Welfare, short-run marginal costs			
Michigan Oregon Pennsylvania	Illinois	Idaho, Montana, Nevada, North Dakota, Rhode Island, South Dakota	-

[35] These were Connecticut from 1953-1957, Idaho from 1999-2001, Montana from 1961-1965 and Nevada from 1953-1958.

[36] MC_Q at the point of approximation is $\overline{AC}[1+\alpha_Q]$, which is positive in both the long run and short run for all services in all states. $\overline{AC}$ refers to AC at the point of approximation, $e^{\alpha_{0s}}$, which is state-specific.

Analyzing relative state costs by means of average costs at the point of approximation yields roughly the same degree of variation. Table 4 reports the individual state values of $e^{\alpha_{os}}$. The summary data are:

Welfare, average costs	Mean	Standard Deviation	Minimum	Maximum
Long run	$461.97	$301.84	$129.84	$1,350.22
Short run	$466.54	$275.55	$150.10	$1,319.64

The high (low) and very high cost states based on the constant terms are:

Welfare, long-run average costs			
Very High	High	Low	Very Low
Pennsylvania	Illinois, Michigan, Texas, Washington	Idaho, Nevada, North Dakota	-
Welfare, short-run average costs			
Pennsylvania	Illinois, Michigan, Texas, Washington	Idaho, Montana, Nevada, North Dakota, South Dakota	-

The two characterizations of relative state costs yield similar rankings in two respects. First, the majority of states lie within one standard deviation of the mean under each measure, i.e. 26 states in both the long run and the short run for marginal costs, and 28 and 26 for average costs. Secondly, Illinois, Michigan, Pennsylvania and Washington ranked as high (or very high) cost states in the long run. In the short run, Illinois, Michigan and Pennsylvania ranked as high (or very high) cost states, whereas Idaho, Montana, Nevada, North Dakota and South Dakota were low cost states.

Perhaps the cost differences uncovered by these measures simply reflect differences in the level and composition of in-kind services. We leave this as a question for future research.

c) <u>Productivity growth</u>

Productivity growth in the provision of welfare services appears to support the Baumol-Oates cost disease hypothesis with a vengeance. Productivity growth was negative for *all* states, on average, during the sample period, for both long-run and short-run production. In the case of welfare, recipients did not increase in sufficient numbers to permit the productivity enhancing effect of scale economies to overcome the depressing effects of severe technical regression.

Tables 8 and 9 report the mean values for all states of the discrete Tornqvist index of productivity growth with the separate scale and technical change effects, for the long run and short run.

The summary data are as follows:

Welfare, long-run productivity growth				
	Mean	Standard Deviation	Minimum	Maximum
$\overline{V}_G$	–5.46	1.12	–7.25	–1.23
$-\overline{S}_Q(\Delta \ln Q)$	1.17	1.10	.60	5.37
$\overline{V}_T$	–6.62	0.16	–6.89	–6.22
Welfare, short-run productivity growth				
$\overline{V}_G$	–5.06	1.23	–6.69	–0.39
$-\overline{S}_Q(\Delta \ln Q)$	1.14	1.14	–0.66	5.56
$\overline{V}_T$	–6.20	.32	–6.69	–5.56

As indicated previously, the growth of in-kind services may well explain the dramatic increase in costs per recipient throughout the sample period, but they are unlikely to be the entire story. Persistent cost increases of this magnitude certainly lend credence to a cost disease scenario, one rather more virulent than Baumol-Oates imagined.

6.3 Hospitals

a) <u>Characteristics of the production technology</u>

<u>Scale economies</u>

Our findings on scale economies for state psychiatric hospitals continue the pattern established for education and welfare. The F-tests reported in Table 2 soundly reject the hypotheses of CRS, homogeneity and homotheticity for both the long run and short run. The calculations of scale economies at every point in the sample

($S_Q = \partial lnAC/\partial lnQ$) reveal enormous scale economies in both the long run and short run. Table 14 reports the average values of S_Q for each state over the sample period. The overall mean in the long run is –.918, with a range of –.952 to –.865, and a standard deviation of .022. The short-run overall mean is –.887, with a minimum of –.957, a maximum of –.796, and a standard deviation of .036. Moreover, the point estimates of the slopes of long-run and short-run marginal costs at the point of approximation are negative.

Technical change

The characteristics of technical change for hospitals are similar to those for education. The F-tests in Table 2 overwhelmingly reject the hypothesis that costs are unrelated to the passage of time. They also show that Hicks' neutrality can be rejected in both the long run and the short run. Since $\gamma_{LT} > 0$ and γ_{MT}, $\gamma_{KT} < 0$ in the long-run cost function, technical change is revealed to be labor using and both materials and capital saving in the long run.

Finally, the calculations of technical change at every point in the sample ($-V_T = -\partial lnAC/\partial T$) reveal that all states suffered from severe technical regression on average, in both the long run and short run, with little variation across states. Table 14 reports the average values of $-V_T$ for each state over the sample period. The long-run and short-run experiences are quite similar. The overall long-run mean regression is 3.66% per year, with a range of 4.81% to 2.68%, and a standard deviation of .45%. The overall short-run mean regression is 2.93% per year, with a range of 4.85% to 1.63%, and a standard deviation of .77%.

Presumably unmeasured quality changes are responsible for the steady increase in costs over time. We would only note that the occasional horror stories about deteriorating conditions and patient neglect in state psychiatric hospitals and institutions would appear to be inconsistent with our results. Declining resources per patient should yield positive estimates of technical change with numbers of patients as the single output variable.

Long-run cost efficiency

Table 14 reports the average values of MC_K for each state throughout the sample period. The numbers provide evidence of overcapitalization, thus rejecting long-run cost efficiency in production. Despite the substantial amount of variation across the states, the average values of MC_K are positive for all states. The overall mean is .420, the standard deviation is .157, and the individual state means range from a low of .151 to a high of .807, indicative of significant overcapitalization.

Factor demands

Tables 17 and 21 report the average values of own-price elasticities and Allen partial elasticities of substitution for each state throughout the sample period, for the long run and short run. The results differ from those for both education and welfare. Factor demands for labor and materials are highly own-price elastic in all states in both the long run and short run. In contrast, the demand for capital is inelastic in all states, but close to unit-elastic. Labor and materials are substitutes in the long run and short run in every state, as are labor and capital in the long run, whereas materials and capital are complements in the long run in every state. The cross-price elasticities are very large for all pairs of factors in both the long run and short run.

The summary data are as follows:

Hospitals, long-run factor elasticities				
	Mean	Standard Deviation	Minimum	Maximum
η_{LL}	–2.528	.217	–2.976	–1.887
η_{MM}	–4.021	1.307	–8.440	.649
η_{KK}	–.948	.012	–.973	–.916
σ_{LM}	6.639	1.362	1.279	11.395
σ_{LK}	4.450	1.113	2.663	7.264
σ_{MK}	–5.357	3.406	-24.598	.830
Hospitals, short-run factor elasticities				
η_{LL}	–1.789	.183	–2.387	–1.471
η_{MM}	–3.555	1.147	–7.397	.454
σ_{LM}	5.344	1.062	1.306	8.985

b) Relative costs

The hospital equations were also successful in terms of generating reasonable estimates of marginal output costs. Long-run marginal costs were negative in only 20 observations and the short-run marginal costs were negative in 47 out of 1978 observations.[37] The mean values of both long-run and short-run marginal costs are positive for all states, however.

Table 5 reports the average values of long-run and short-run marginal costs for each state during the sample period. The most striking feature is the substantial variation across states, far more so than for education and welfare (even ignoring the negative values). The overall mean in the long run is $8,538.34 per patient, with a range (of positive estimates) of $2,125.30 to $21,751.13, and a standard deviation of $3,943.26. The overall short- run mean is $11,734.17, with a minimum (positive) of $2,964.98, a maximum of $24,120.12 and a standard deviation of $4,991.46. Using marginal cost data deflated by individual state CPIs, our characterization of high (low) and very high (very low) cost states yields the following breakdown:

Hospitals, long-run marginal costs			
Very High	High	Low	Very Low
Iowa	Arkansas, California, Louisiana, Michigan, Utah	Delaware, Maine, Mississippi, New Hampshire, Ohio, Vermont, West Virginia, Wyoming	-
Hospitals, short-run marginal costs			
Iowa, Louisiana	Alabama, California, Michigan, Oklahoma, Texas	Delaware, Idaho, Maine, New Hampshire, Ohio, Vermont, Wyoming	-

[37] Most of the time, these instances occurred in the first years of the sample. In a purely mechanical sense the problem arose because each state was winding down its state psychiatric hospital facilities, generating huge negative values for $\ln(Q/\overline{Q})$ in the corresponding years. This, coupled with a relatively large positive coefficient estimate on γ_{QQ}, led to the negative estimates. For the long run, the states were Idaho (1953), Mississippi (1953, 56), Nevada (1953-54), New Mexico (1953-57), Rhode Island (1953) and Wyoming (1954-56). For the short run, the states were Arizona (1953, 1955-57), Arkansas (1953 and 1980), Delaware (1953-56), Idaho (1953-60), Louisiana (1953-54), Mississippi (1953-54), Nevada (1953-57), New Mexico (1953-61), Rhode Island, Utah and West Virginia (all in 1953), as well as Wyoming (1953-61).

The state specific constant terms also reveal substantial variability. Table 5 reports the individual state values of $e^{\alpha_{os}}$, the average costs at the point of approximation. The overall mean in the long run is $24,326.53, with a range of $1,826.32 to $117,299.70, and a standard deviation of $21,928.93. The overall short-run mean is $23,416.57 with a minimum of $3,963.73, a maximum of $70,472.63 and a standard deviation of $13,785.48. The high (very high) cost and low cost states are as follows:

Hospitals, long-run average costs			
Very High	High	Low	Very Low
California, New York	Illinois, Michigan Texas	Illinois, Michigan, Ohio, Pennsylvania, Texas	-
Hospitals, short-run average costs			
California, New York	Louisiana, Michigan, Ohio, Pennsylvania, Texas	Delaware, Idaho, Maine, Nevada, New Hampshire, North Dakota, Vermont, Wyoming	-

The two relative cost measures place 32 and 36 states respectively within one standard deviation of the mean in the long run, and 32 and 31 states within one standard deviation of the mean in the short run, although the standard deviations are admittedly quite large. California and Michigan are characterized as high (or very high) cost states, whereas Ohio is a low-cost state in the long run, under both measures. California, Louisiana, Michigan and Texas are similarly characterized as high (or very high) cost states in the short run, with Delaware, Idaho, Maine, New Hampshire, Vermont and Wyoming as low cost states. Explaining why these cost differences exist remains a question for future research. There may well be significant quality or programmatic differences in hospital services among the states, unmeasured in our analysis.

c) <u>Productivity growth</u>

Tables 10 and 11 report the mean state values of the discrete Tornqvist index of productivity growth, along with the separate scale and technical change effects, for the long run and short run. The productivity performance for hospitals is by far the worst of the three services. All states suffered persistent productivity deterioration, with the overall annual cost increases averaging –7.35% in the long run and –6.49% in the short run. The summary data are as follows:

Hospitals, long-run productivity growth				
	Mean	Standard Deviation	Minimum	Maximum
$\overline{V}_G$	–7.35	1.65	–10.21	–1.56
$-\overline{S}_Q(\Delta \ln Q)$	–3.70	1.60	–6.69	2.50
$\overline{V}_T$	–3.66	.45	–4.80	–2.66
Hospitals, short-run productivity growth				
$\overline{V}_G$	–6.49	1.80	–9.11	.61
$-\overline{S}_Q(\Delta \ln Q)$	–3.55	1.57	–6.46	2.68
$\overline{V}_T$	–2.94	.77	–4.85	–1.64

State psychiatric hospitals were caught in a double bind. They were afflicted with technical regression, as were all three services. They also exhibited substantial scale economies. But the patient census was generally declining throughout the sample period, so that the scale effect worked against productivity growth. States were moving back up sharply declining AC curves, while the AC curves were simultaneously shifting upwards over time. The net result was disastrous in terms of productivity growth. Properly measured quality changes could temper these results but it is at least plausible that the declining patient census would increase per-patient costs through the scale effect alone.

6.4 Miscellaneous

The maintained hypothesis of CRS for the all other miscellaneous category of general fund expenditures does not appear terribly reasonable given our finding of pervasive scale economies. The only defense one can offer is that the production technologies of the remaining services appear to be quite different in the sense that the shares of labor and materials are essentially reversed. Furthermore, even if the hypothesis is false it may not significantly affect the estimates of the only two production characteristics that can be analyzed absent the cost function: the nature of technical change and the factor demand attributes. Neither depends on estimated output coefficients.

Technical change

Table 1 reports the coefficient estimates for the share equations. The estimates tell a consistent story with respect to technical change. Time enters significantly in all long-run and short-run share equations, thereby rejecting the hypothesis of Hicks neutrality. In the long-run equations $\gamma_{LT} < 0$ and γ_{MT}, $\gamma_{KT} > 0$. In the short-run share equation, $\gamma_{LT} < 0$, $\gamma_{MT} > 0$. Hence technical change is labor-saving and materials-using in both the long run and short run, and capital-using in the long run.

Factor demands

Tables 18 and 22 report the average values of own price elasticities and Allen partial elasticities of substitution for each state during the sample period for the long and short run. Labor is a substitute for materials in every state both in the long run and short run, and capital is a complement for labor and a substitute for materials in every state in the long run. The demands for labor and materials are own-price inelastic for all states in both the long run and short run. The demand for capital is also inelastic in all states in the long run.

The summary data are as follows:

Miscellaneous, long-run factor elasticities				
	Mean	Standard Deviation	Minimum	Maximum
η_{LL}	–.300	.027	–.349	–.219
η_{MM}	–.185	.041	–.265	–.121
η_{KK}	–.248	.207	–.613	.557
σ_{LM}	.533	.040	.445	.593
σ_{LK}	–2.436	1.689	–8.543	–.310
σ_{MK}	.499	.118	.072	.728
Miscellaneous, short-run factor elasticities				
η_{LL}	–.367	.021	–.399	–.303
η_{MM}	–.150	.040	–.233	–.087
σ_{LM}	.516	.045	.412	.586

Whether these properties would hold for the individual services within our blanket miscellaneous category is, of course, problematic.

7. Conclusions

The estimated translog cost functions for three important state services – public higher education, public welfare, and state psychiatric hospitals – reveal that their production attributes are similar in a number of respects. Most importantly:

1) Scale economies are a persuasive phenomenon in all states in both the long run and the short run. Indeed, scale economies are so substantial that estimated marginal costs are negatively sloped at the point of approximation.

2) Labor, materials, and capital are generally substitutes in the production of all three services in all states, with these exceptions in the long run: Labor and capital are complements in the provision of welfare services in 22 out of the 32 states in our sample, and also for the miscellaneous category in all states. Materials and capital are complements in the hospitals category in all states in the long run, with the exception of Maryland. Additionally, the demand for all factors is own-price inelastic in education, welfare, and the miscellaneous category in both the long run and short run. The single exception is the state psychiatric hospitals, for which the demands for labor and materials are highly own-price elastic in both the long run and short run. The long-run demand for capital is inelastic, but close to unit-elastic, the same as it is for education and welfare.

3) The record of productivity growth for these services is generally dismal. On the surface at least, Baumol-Oates' public sector cost disease appears to have run rampant. Only education escaped during the sample period, and then only in the short run.

All services in all states are afflicted with substantial pure technical regression, in both the long run and short run. Average costs were consistently shifting upward throughout the sample period. This effect was offset to some extent in education and welfare by expanding services, which were able to take advantage of the substantial scale economies. For hospitals, however, the scale effect reinforced technical regression because the patient census has generally been declining since the early 1960s. Overall, productivity growth in welfare and hospitals was negative, on average, for all states in both the long run and short run, and negative in the majority of states for education in the long run. Only the short-run productivity growth in education appeared to match the performance of the private sector during the sample period. Even here technical regression was the norm, although it was more than offset by the productivity enhancing scale effect as enrollments increased during the sample period.

4) Statistical analysis of the cost function estimates overwhelming rejects homotheticity for all three services in the long run and for welfare and hospitals in the short run. It is unable to reject the hypothesis that short-run production is homothetic for education, but only at the 99 percent confidence level.

5) The production of all three services does not appear to be long-run efficient. Estimates of marginal capital costs derived from the short-run cost function indicated that MC_K are positive, on average, for all states throughout the sample period (with the exception of welfare in Alabama and Georgia), strong evidence that these public services are overcapitalized relative to the optimum.

The production attributes of the three services differ in one significant respect. Although pure technical regression is close to universal for all services in all states, the pattern of technical change varies across the services in the long run. Technical change is labor-saving and materials-using in education and welfare, and labor-using and materials-saving in the psychiatric hospitals. The only consistency occurred with respect to capital. Technical change is capital-saving for all three services. Finally, technical change in the miscellaneous category is labor-saving and materials-using in both the long run and short run, and capital-using in the long run.

All conclusions must be tempered by the caveat that the data, having been collected from readily available sources, are far from ideal. This is particularly true of the output data. Nonetheless, we believe this study represents the first attempt at estimating the production characteristics of individual state services by methods that do not impose unwarranted a priori restrictions on the production technologies. And many of the results are plausible. For instance, we were generally able to obtain reasonable estimates of individual states' short-run marginal costs for the three services.

There was one notable warning of possible misspecification bias, our finding of pure technical regression for all three services. We speculated on some possible sources of bias, such as the lack of quality corrected output data and/or the presence of rent-seeking bureaucrats, but these remain pure speculations given the limitations of our data. Along the same lines, we are unable to explain why marginal and average costs varied across the states throughout the sample period.

At the very least, though, our study would appear to challenge the common practice in empirical analysis of making a number of simplifying assumptions so that wage data can be used as a proxy for production costs. Many of these assumptions do not stand up to our analysis. We also hope to encourage more research on state governments per se. The states provide an important range of services that deserve far more research attention than they have received from economists.

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Table 1: Parameter Estimates

A. Education

	Long Run		Short Run	
α_0	1.0982		1.0902	
α_Q	-0.6186	(0.0234)	-0.8099	(0.0274)
γ_{QQ}	-0.0018	(0.0089)	-0.0625	(0.0142)
α_L	0.5770	(0.0046)	0.6227	(0.0044)
α_M	0.3327	(0.0047)	0.3773	(0.0044)
α_K	0.0904	(0.0016)	0.4503	(0.0235)
γ_{LL}	0.0210	(0.0000)	0.0168	(0.0000)
γ_{MM}	0.0084	(0.0025)	0.0168	(0.0000)
γ_{KK}	0.0010	(0.0000)	0.0169	(0.0166)
γ_{LM}	-0.0284	(0.0025)	-0.0335	(0.0000)
γ_{LK}	-0.0136	(0.0025)	0.0030	(0.0084)
γ_{MK}	0.0116	(0.0025)	0.0030	(0.0084)
γ_{LQ}	0.0263	(0.0043)	0.0207	(0.0081)
γ_{MQ}	-0.0275	(0.0044)	-0.0207	(0.0081)
γ_{KQ}	0.0012	(0.0015)	0.0631	(0.0259)
α_T	0.0321	(0.0012)	0.0185	(0.0013)
γ_{TT}	-0.0003	(0.0000)	-0.0001	(0.0000)
γ_{LT}	-0.0019	(0.0003)	-0.0021	(0.0003)
γ_{MT}	0.0028	(0.0004)	0.0021	(0.0003)
γ_{KT}	-0.0010	(0.0001)	0.0028	(0.0016)
γ_{QT}	-0.0015	(0.0008)	-0.0054	(0.0014)
Observations	2,400		2,400	
R^2	0.8558		0.8853	

Table 1: Parameter Estimates (continued)

B. Welfare

	Long Run		Short Run	
α_0	-0.9682		-0.9199	
α_Q	-0.7709	(0.0303)	-0.7656	(0.0300)
γ_{QQ}	0.0248	(0.0109)	0.0555	(0.0115)
α_L	0.4981	(0.0065)	0.5093	(0.0063)
α_M	0.4914	(0.0065)	0.4907	(0.0063)
α_K	0.0105	(0.0004)	0.0991	(0.0211)
γ_{LL}	0.0130	(0.0007)	0.0115	(0.0000)
γ_{MM}	0.0100	(0.0000)	0.0115	(0.0000)
γ_{KK}	0.0000	(0.0000)	0.0260	(0.0067)
γ_{LM}	-0.0230	(0.0007)	-0.0230	(0.0000)
γ_{LK}	-0.0030	(0.0007)	0.0071	(0.0060)
γ_{MK}	0.0030	(0.0007)	0.0071	(0.0060)
γ_{LQ}	0.0207	(0.0053)	0.0180	(0.0056)
γ_{MQ}	-0.0188	(0.0053)	-0.0180	(0.0056)
γ_{KQ}	-0.0019	(0.0003)	-0.0572	(0.0129)
α_T	0.0644	(0.0012)	0.0581	(0.0018)
γ_{TT}	-0.0004	(0.0001)	-0.0004	(0.0001)
γ_{LT}	-0.0092	(0.0005)	-0.0098	(0.0006)
γ_{MT}	0.0093	(0.0005)	0.0098	(0.0006)
γ_{KT}	-0.0001	(0.0000)	-0.0041	(0.0014)
γ_{QT}	-0.0011	(0.0008)	0.0015	(0.0012)
Observations	1,600		1,600	
R^2	0.8791		0.9005	

Table 1: Parameter Estimates (continued)

C. Hospitals

	Long Run		Short Run	
α_0	2.8013		2.9661	
α_Q	-0.8944	(0.0210)	-0.8489	(0.0238)
γ_{QQ}	0.0076	(0.0069)	0.0261	(0.0135)
α_L	0.4791	(0.0138)	0.5801	(0.0117)
α_M	0.4483	(0.0130)	0.4199	(0.0117)
α_K	0.0726	(0.0015)	0.2209	(0.0271)
γ_{LL}	-0.5500	(0.0000)	-0.4447	(0.0000)
γ_{MM}	-0.4861	(0.0025)	-0.4447	(0.0000)
γ_{KK}	0.0000	(0.0000)	-0.0072	(0.0170)
γ_{LM}	1.0361	(0.0025)	0.8894	(0.0000)
γ_{LK}	0.0639	(0.0025)	-0.0236	(0.0123)
γ_{MK}	-0.0639	(0.0025)	-0.0236	(0.0123)
γ_{LQ}	0.0699	(0.0100)	0.0709	(0.0117)
γ_{MQ}	-0.0669	(0.0095)	-0.0709	(0.0117)
γ_{KQ}	-0.0031	(0.0011)	-0.0245	(0.0274)
α_T	0.0423	(0.0016)	0.0370	(0.0018)
γ_{TT}	-0.0009	(0.0001)	-0.0005	(0.0001)
γ_{LT}	0.0278	(0.0012)	0.0188	(0.0013)
γ_{MT}	-0.0237	(0.0011)	-0.0188	(0.0013)
γ_{KT}	-0.0042	(0.0001)	0.0008	(0.0028)
γ_{QT}	0.0013	(0.0010)	0.0052	(0.0024)
Observations	1,932		1,932	
R^2	0.9438		0.9502	

Table 1: Parameter Estimates (continued)

D. Miscellaneous

	Long Run		Short Run	
α_L	0.2735	(0.0020)	0.2861	-
α_M	0.6743	(0.0022)	0.7139	(0.0030)
α_K	0.0622	-		
γ_{LL}	0.1014	(0.0090)	0.0879	-
γ_{MM}	0.0863	(0.0105)	0.0879	(0.0100)
γ_{KK}	0.0367	-		
γ_{LM}	-0.0755	(0.0094)	-0.0879	(0.0100)
γ_{LK}	-0.0259	(0.0024)	-0.0007	-
γ_{MK}	-0.0108	(0.0025)	0.0007	(0.0018)
γ_{LT}	-0.0057	(0.0002)	-0.0054	-
γ_{MT}	0.0038	(0.0002)	0.0054	(0.0003)
γ_{KT}	0.0019	-		
Observations	2,448		2,448	
R^2, S_L	0.4026			
R^2, S_M	0.1740		0.3511	

Note:

(a) The coefficients α_K and γ_{jK} are associated with the price of capital $\ln\left(\frac{P_{K,st}}{\bar{P}_K}\right)$ in the long-run equations, and with the capital stock $\ln\left(\frac{K_{st}}{\bar{K}}\right)$ in the short-run equations.

(b) The constant term α_O refers to the average of the state specific constant terms in the equation, welfare and hospital equations. The state specific average costs at the point of approximation, $e^{\alpha_{os}}$, appear in Tables 3, 4 and 5.

Table 2: F-tests, Returns to Scale and Technical Change

EDUCATION	Long Run		Short Run	
1. Constant Returns	189.08	(5, 7168)	323.18	(5, 4774)
2. Homogenous	10.99	(4, 7168)	21.57	(4, 4774)
3. Homothetic	19.49	(2, 7168)	6.48	(1, 4774)
4. Overall Technical Change	266.97	(5, 7168)	86.51	(5, 4774)
5. Hicks Neutral	53.53	(2, 7168)	36.79	(1, 4774)

WELFARE	Long Run		Short Run	
1. Constant Returns	186.53	(5, 4768)	184.01	(5, 3174)
2. Homogenous	15.94	(4, 4768)	10.07	(4, 3174)
3. Homothetic	29.13	(2, 4768)	10.16	(1, 3174)
4. Overall Technical Change	836.74	(5, 4768)	304.60	(5, 3174)
5. Hicks Neutral	170.24	(2, 4768)	314.78	(1, 3174)

HOSPITALS	Long Run		Short Run	
1. Constant Returns	720.15	(5, 5764)	589.65	(5, 3838)
2. Homogenous	17.38	(4, 5764)	13.99	(4, 3838)
3. Homothetic	24.90	(2, 5764)	36.97	(1, 3838)
4. Overall Technical Change	360.11	(5, 5764)	191.62	(5, 3838)
5. Hicks Neutral	531.62	(2, 5764)	220.22	(1, 3838)

CRITICAL VALUES

D/F	90%	95%	99%
(1, ∞)	2.71	3.84	6.63
(2, ∞)	2.30	3.00	4.61
(3, ∞)	2.08	2.60	3.78
(4, ∞)	1.94	2.37	3.32
(5, ∞)	1.85	2.21	3.02

Table 3: Education, Marginal and Average Cost, State Averages ($/student)

	LRMC	SRMC	LRAC	SRAC
Alabama	1,736.38	682.20	3,984.29	3,376.86
Arizona	1,003.23	262.88	2,422.14	2,655.80
Arkansas	1,759.22	871.94	2,571.08	2,720.95
California	976.20	-87.55	7,792.72	5,974.59
Colorado	1,645.00	573.46	3,606.29	3,559.78
Connecticut	1,594.36	583.21	2,149.37	2,582.23
Delaware	2,574.58	1,827.69	2,015.10	2,378.29
Florida	923.74	202.03	3,539.78	3,353.75
Georgia	1,806.13	706.93	4,351.64	3,454.92
Idaho	1,566.68	922.25	1,591.76	1,986.52
Illinois	1,066.59	227.52	4,969.42	3,439.08
Indiana	2,135.26	810.40	5,453.98	3,998.15
Iowa	1,978.40	936.76	3,680.41	3,530.34
Kansas	1,214.98	425.24	2,792.87	3,098.73
Kentucky	1,814.72	789.05	3,374.61	2,754.18
Louisiana	1,651.80	649.90	4,085.16	3,558.60
Maine	1,822.24	1,036.61	1,613.31	2,298.16
Maryland	1,336.82	406.25	3,061.39	3,042.17
Massachusetts	1,542.18	528.50	2,770.51	2,488.15
Michigan	1,566.71	350.19	6,574.26	4,527.34
Minnesota	1,845.75	703.36	4,304.57	3,588.29
Mississippi	1,329.81	533.76	2,549.96	2,876.70
Missouri	1,268.43	395.95	3,106.38	3,093.59
Montana	1,679.43	1,046.53	1,576.08	1,926.00
Nebraska	1,380.29	597.13	2,335.59	2,789.85
Nevada	1,321.60	736.57	1,186.78	1,636.76
New Hampshire	1,937.28	1,199.12	1,495.61	2,052.28
New Jersey	1,375.51	391.72	2,951.04	2,927.85
New Mexico	1,804.12	930.75	2,792.79	3,135.98
New York	1,251.39	165.01	4,666.08	3,278.43
North Carolina	1,611.00	497.85	4,674.33	4,108.03
North Dakota	1,954.57	1,227.25	1,756.03	2,116.40
Ohio	1,547.86	350.44	5,679.65	4,294.53
Oklahoma	1,573.07	565.33	3,746.14	3,694.71
Oregon	1,340.09	486.15	2,606.92	2,822.35
Pennsylvania	1,600.66	439.59	4,500.64	3,623.51
Rhode Island	1,646.14	894.97	1,362.88	1,979.71
South Carolina	1,896.51	843.44	3,426.07	3,395.55
South Dakota	1,627.17	1,096.67	1,573.35	1,989.85
Tennessee	1,684.14	652.25	3,818.73	3,191.42
Texas	1,278.88	136.57	6,782.54	4,770.26
Utah	2,080.38	1,022.88	3,177.34	3,344.39
Vermont	2,759.89	2,062.86	1,525.64	2,079.20
Virginia	1,572.75	427.78	4,191.13	3,919.06
Washington	1,763.46	555.64	4,337.82	3,737.06
West Virginia	1,562.19	727.47	2,214.71	2,429.71
Wisconsin	1,527.35	499.16	4,105.83	3,356.08
Wyoming	1,366.90	926.35	1,139.23	1,508.32

Table 4: Welfare, Marginal and Average Cost, State Averages ($/recipient)

	LRMC	SRMC	LRAC	SRAC
Alabama	97.43	129.28	335.49	355.42
Arizona	175.50	179.76	326.14	359.76
Arkansas	156.99	187.22	288.09	323.83
Connecticut	204.55	220.90	554.01	484.49
Florida	163.52	214.33	663.10	671.02
Georgia	148.75	237.32	407.38	409.32
Idaho	197.32	68.90	144.26	165.99
Illinois	308.39	322.02	1,049.97	942.53
Iowa	273.80	198.38	471.10	437.05
Kentucky	173.98	212.48	511.45	523.35
Louisiana	124.63	147.12	603.24	581.02
Maine	185.69	240.85	244.88	300.22
Michigan	326.51	342.40	1,042.63	980.39
Mississippi	104.83	129.70	390.21	418.68
Missouri	149.74	165.48	548.99	570.98
Montana	167.34	129.84	181.98	188.05
Nevada	159.65	126.10	129.84	150.10
New Hampshire	219.25	145.66	171.97	213.42
New Mexico	143.33	168.34	300.01	320.43
North Dakota	223.21	97.34	136.30	157.50
Oklahoma	212.55	163.09	540.94	519.67
Oregon	329.46	358.10	565.49	645.74
Pennsylvania	321.13	376.90	1,350.22	1,319.64
Rhode Island	184.94	139.19	275.35	263.22
South Carolina	166.37	170.03	379.15	402.10
South Dakota	156.23	99.15	166.58	190.54
Tennessee	154.09	204.53	534.26	540.04
Texas	194.20	204.69	954.90	885.27
Utah	210.60	184.68	229.15	264.57
Vermont	192.61	172.34	164.35	206.25
Washington	284.83	256.41	774.22	758.80
West Virginia	134.75	163.27	347.42	379.73

Table 5: Hospitals, Marginal and Average Cost, State Averages ($/patient)

	LRMC	SRMC	LRAC	SRAC
Alabama	11,289.69	16,601.39	22,925.19	28,624.95
Arizona	5,124.45	6,641.79	6,103.17	10,173.58
Arkansas	13,006.63	14,914.82	12,564.59	17,231.65
California	15,251.12	21,872.66	69,777.36	51,665.86
Colorado	8,156.67	11,365.38	14,819.41	19,526.03
Connecticut	13,298.07	18,232.19	25,352.27	22,657.33
Delaware	3,118.87	4,450.17	4,866.25	8,061.17
Florida	4,933.51	7,742.66	27,372.11	26,655.56
Georgia	6,042.99	9,385.21	24,511.81	23,944.87
Idaho	4,349.28	4,752.26	2,867.71	4,872.98
Illinois	7,818.45	10,454.99	48,287.21	36,417.87
Indiana	6,794.76	10,082.89	24,784.71	24,107.16
Iowa	21,751.13	24,120.12	20,283.61	24,883.50
Kansas	7,415.92	10,220.25	17,349.21	21,181.89
Kentucky	7,966.60	10,335.04	14,420.99	17,068.90
Louisiana	14,478.94	20,451.66	42,083.24	40,200.64
Maine	3,197.37	4,492.30	5,310.33	8,759.10
Maryland	6,122.09	8,744.61	27,211.04	26,285.44
Massachusetts	10,369.48	14,743.16	41,214.46	35,611.91
Michigan	15,925.17	20,935.50	46,891.22	38,087.48
Minnesota	10,706.17	15,065.58	26,518.92	26,745.20
Mississippi	3,913.60	6,593.37	15,674.80	19,968.02
Missouri	6,862.71	10,019.63	24,607.90	26,996.83
Nebraska	10,490.93	13,777.51	11,455.77	17,599.27
Nevada	6,778.65	7,793.68	1,826.32	3,963.73
New Hampshire	2,345.03	3,182.07	4,287.35	6,989.72
New Jersey	8,158.19	11,968.69	30,951.80	26,421.42
New Mexico	8,562.14	11,824.49	8,077.45	14,320.30
New York	9,730.76	14,315.61	117,299.70	70,472.63
North Carolina	7,931.76	11,629.98	30,095.55	27,752.13
North Dakota	4,795.90	6,612.99	4,694.20	8,840.91
Ohio	12,272.72	16,900.18	46,336.82	38,856.61
Oklahoma	7,905.02	10,399.97	19,227.81	20,665.85
Oregon	10,164.28	15,097.34	13,678.61	17,688.59
Pennsylvania	6,952.52	10,514.39	66,504.26	45,709.14
Rhode Island	10,685.35	13,639.06	8,487.92	14,470.56
South Carolina	9,014.72	13,532.14	19,338.68	22,435.14
Tennessee	7,323.45	10,617.31	20,742.56	21,057.44
Texas	11,014.10	16,485.23	56,328.61	48,812.31
Utah	12,627.58	15,312.14	7,776.42	12,579.05
Vermont	2,125.30	2,964.98	2,583.01	5,075.60
Virginia	8,664.23	13,452.83	37,089.39	35,954.24
Washington	10,392.65	14,293.37	17,035.54	19,430.01
West Virginia	4,588.06	7,064.24	9,949.19	14,627.57
Wisconsin	8,304.75	10,741.11	17,119.90	18,462.99
Wyoming	4,041.89	5,434.83	2,336.23	5,249.25

Table 6: Education (Long Run), Average Annual Productivity Growth ($\overline{V}_G$) – State Averages with Scale Effect ($-\overline{S}_Q \Delta \ln Q$) and Pure Technical Change ($\overline{V}_T$) (percent)

	TOTAL	SCALE	TIME
Alabama	-0.23	3.08	-3.31
Arizona	0.76	4.04	-3.28
Arkansas	-0.72	2.72	-3.44
California	0.29	3.21	-2.92
Colorado	0.00	3.29	-3.29
Connecticut	-0.69	2.70	-3.39
Delaware	-0.82	2.75	-3.58
Florida	1.21	4.39	-3.19
Georgia	0.11	3.40	-3.30
Idaho	-0.61	2.94	-3.54
Illinois	-0.07	3.06	-3.13
Indiana	-0.66	2.61	-3.27
Iowa	-0.75	2.60	-3.34
Kansas	-0.82	2.52	-3.34
Kentucky	-0.31	3.04	-3.35
Louisiana	-0.55	2.75	-3.31
Maine	-0.48	3.10	-3.58
Maryland	0.04	3.33	-3.29
Massachusetts	0.28	3.61	-3.34
Michigan	-0.75	2.37	-3.12
Minnesota	-0.43	2.82	-3.25
Mississippi	-0.63	2.75	-3.38
Missouri	-0.22	3.09	-3.31
Montana	-1.06	2.47	-3.53
Nebraska	-0.90	2.55	-3.44
Nevada	1.76	5.30	-3.53
New Hampshire	-0.66	2.95	-3.60
New Jersey	0.90	4.15	-3.25
New Mexico	-0.12	3.33	-3.45
New York	-0.82	2.28	-3.09
North Carolina	0.22	3.47	-3.26
North Dakota	-1.24	2.27	-3.51
Ohio	-0.65	2.52	-3.18
Oklahoma	-0.98	2.35	-3.33
Oregon	-0.26	3.08	-3.33
Pennsylvania	0.27	3.48	-3.21
Rhode Island	-0.69	2.88	-3.56
South Carolina	-0.05	3.34	-3.39
South Dakota	-1.03	2.52	-3.54
Tennessee	-0.33	2.98	-3.32
Texas	0.12	3.21	-3.09
Utah	-0.45	2.98	-3.43
Vermont	-1.38	2.28	-3.66
Virginia	0.47	3.74	-3.27
Washington	-0.27	2.98	-3.25
West Virginia	-1.05	2.37	-3.42
Wisconsin	-0.39	2.85	-3.24
Wyoming	-0.70	2.89	-3.59

Table 7: Education (Short Run), Average Annual Productivity Growth ($\overline{V}_G$) – State Averages with Scale Effect ($-\overline{S}_Q \Delta \ln Q$) and Pure Technical Change ($\overline{V}_T$) (percent)

	TOTAL	SCALE	TIME
Alabama	1.44	3.52	-2.08
Arizona	2.96	4.81	-1.85
Arkansas	0.78	3.05	-2.27
California	3.43	4.60	-1.16
Colorado	1.88	3.83	-1.95
Connecticut	0.87	2.94	-2.08
Delaware	-0.01	2.60	-2.61
Florida	3.71	5.43	-1.72
Georgia	1.95	4.02	-2.08
Idaho	0.65	3.07	-2.42
Illinois	2.04	3.76	-1.71
Indiana	0.96	3.00	-2.04
Iowa	0.82	2.94	-2.13
Kansas	1.05	3.00	-1.95
Kentucky	1.26	3.44	-2.18
Louisiana	1.05	3.12	-2.07
Maine	0.78	3.16	-2.38
Maryland	1.97	3.89	-1.92
Massachusetts	1.95	4.01	-2.06
Michigan	1.25	2.96	-1.70
Minnesota	1.33	3.29	-1.97
Mississippi	1.06	3.14	-2.08
Missouri	1.62	3.57	-1.94
Montana	0.03	2.46	-2.43
Nebraska	0.68	2.83	-2.15
Nevada	2.91	5.27	-2.36
New Hampshire	0.46	2.96	-2.50
New Jersey	2.94	4.77	-1.83
New Mexico	1.34	3.61	-2.27
New York	1.41	2.99	-1.58
North Carolina	2.20	4.13	-1.93
North Dakota	-0.08	2.32	-2.40
Ohio	1.45	3.20	-1.75
Oklahoma	0.71	2.72	-2.01
Oregon	1.55	3.53	-1.98
Pennsylvania	2.21	4.08	-1.86
Rhode Island	0.53	2.87	-2.34
South Carolina	1.52	3.72	-2.20
South Dakota	0.11	2.57	-2.45
Tennessee	1.27	3.35	-2.08
Texas	2.69	4.28	-1.58
Utah	1.20	3.43	-2.22
Vermont	-0.57	2.10	-2.67
Virginia	2.48	4.38	-1.90
Washington	1.63	3.54	-1.91
West Virginia	0.29	2.51	-2.22
Wisconsin	1.44	3.34	-1.90
Wyoming	0.20	2.72	-2.52

Table 8: Welfare (Long Run), Average Annual Productivity Growth ($\overline{V}_G$) – State Averages with Scale Effect ($-\overline{S}_Q \Delta \ln Q$) and Pure Technical Change ($\overline{V}_T$) (percent)

	TOTAL	SCALE	TIME
Alabama	-5.95	0.52	-6.47
Arizona	-3.52	3.18	-6.70
Arkansas	-6.72	0.04	-6.75
Connecticut	-4.64	1.96	-6.61
Florida	-4.48	2.06	-6.54
Georgia	-5.18	1.21	-6.39
Idaho	-6.22	0.52	-6.74
Illinois	-5.46	0.86	-6.32
Iowa	-6.11	0.50	-6.62
Kentucky	-5.59	1.02	-6.62
Louisiana	-6.40	0.04	-6.44
Maine	-5.68	1.09	-6.77
Michigan	-4.96	1.26	-6.22
Mississippi	-5.88	0.79	-6.67
Missouri	-6.72	-0.01	-6.71
Montana	-5.99	0.77	-6.76
Nevada	-1.23	5.38	-6.61
New Hampshire	-5.48	1.42	-6.90
New Mexico	-4.90	1.82	-6.72
North Dakota	-6.59	0.19	-6.78
Oklahoma	-7.25	-0.60	-6.64
Oregon	-4.98	1.69	-6.67
Pennsylvania	-5.00	1.39	-6.40
Rhode Island	-4.74	1.99	-6.73
South Carolina	-5.41	1.23	-6.64
South Dakota	-6.99	-0.16	-6.83
Tennessee	-5.18	1.39	-6.57
Texas	-5.00	1.45	-6.45
Utah	-5.47	1.18	-6.65
Vermont	-5.32	1.52	-6.84
Washington	-5.17	1.36	-6.53
West Virginia	-6.54	0.28	-6.81

Table 9: Welfare (Short Run), Average Annual Productivity Growth ($\overline{V}_G$) – State Averages with Scale Effect ($-\overline{S}_Q \Delta \ln Q$) and Pure Technical Change ($\overline{V}_T$) (percent)

	TOTAL	SCALE	TIME
Alabama	-6.31	0.34	-6.66
Arizona	-3.25	3.05	-6.31
Arkansas	-6.61	0.06	-6.67
Connecticut	-3.61	2.27	-5.88
Florida	-4.63	1.80	-6.43
Georgia	-5.47	1.07	-6.54
Idaho	-5.71	0.51	-6.22
Illinois	-4.65	0.91	-5.56
Iowa	-5.15	0.54	-5.69
Kentucky	-5.21	0.99	-6.20
Louisiana	-5.85	0.07	-5.93
Maine	-5.66	1.04	-6.69
Michigan	-4.48	1.14	-5.63
Mississippi	-5.86	0.67	-6.54
Missouri	-6.69	-0.13	-6.56
Montana	-5.22	0.80	-6.02
Nevada	-0.39	5.65	-6.04
New Hampshire	-5.15	1.40	-6.55
New Mexico	-4.31	1.91	-6.22
North Dakota	-6.13	0.15	-6.28
Oklahoma	-6.53	-0.66	-5.88
Oregon	-4.71	1.63	-6.34
Pennsylvania	-4.96	1.16	-6.12
Rhode Island	-3.63	2.22	-5.85
South Carolina	-5.08	1.13	-6.21
South Dakota	-6.46	-0.18	-6.29
Tennessee	-4.91	1.31	-6.22
Texas	-4.51	1.36	-5.86
Utah	-4.98	1.22	-6.20
Vermont	-5.01	1.53	-6.54
Washington	-4.45	1.35	-5.80
West Virginia	-6.26	0.28	-6.54

Table 10: Hospitals (Long Run), Average Annual Productivity Growth ($\overline{V}_G$) – State Averages with Scale Effect ($-\overline{S}_Q \Delta \ln Q$) and Pure Technical Change ($\overline{V}_T$) (percent)

	TOTAL	SCALE	TIME
Alabama	-6.37	-2.77	-3.61
Arizona	-4.55	-1.11	-3.44
Arkansas	-8.13	-5.09	-3.04
California	-8.44	-3.64	-4.80
Colorado	-7.58	-3.40	-4.18
Connecticut	-7.78	-3.77	-4.01
Delaware	-6.04	-2.68	-3.36
Florida	-5.42	-1.70	-3.72
Georgia	-6.89	-3.15	-3.74
Idaho	-7.60	-4.22	-3.39
Illinois	-9.20	-4.94	-4.26
Indiana	-6.96	-3.37	-3.59
Iowa	-10.18	-6.45	-3.73
Kansas	-6.48	-2.98	-3.50
Kentucky	-7.77	-4.42	-3.35
Louisiana	-6.46	-3.10	-3.36
Maine	-7.07	-3.54	-3.54
Maryland	-7.36	-3.34	-4.02
Massachusetts	-9.35	-5.63	-3.72
Michigan	-9.53	-4.79	-4.74
Minnesota	-8.06	-3.88	-4.17
Mississippi	-4.71	-2.05	-2.66
Missouri	-7.93	-4.53	-3.40
Nebraska	-8.04	-4.74	-3.30
Nevada	-1.56	2.50	-4.06
New Hampshire	-7.48	-4.06	-3.42
New Jersey	-7.96	-4.03	-3.93
New Mexico	-3.96	-0.83	-3.13
New York	-8.64	-4.16	-4.48
North Carolina	-6.55	-2.74	-3.81
North Dakota	-8.27	-4.99	-3.28
Ohio	-9.20	-5.25	-3.95
Oklahoma	-7.79	-4.51	-3.29
Oregon	-6.90	-3.14	-3.76
Pennsylvania	-7.85	-3.73	-4.12
Rhode Island	-10.21	-6.69	-3.52
South Carolina	-6.91	-3.48	-3.44
Tennessee	-6.85	-3.55	-3.29
Texas	-6.71	-2.96	-3.75
Utah	-5.21	-1.73	-3.48
Vermont	-9.04	-5.67	-3.37
Virginia	-6.18	-2.72	-3.45
Washington	-7.53	-3.68	-3.85
West Virginia	-9.04	-6.30	-2.74
Wisconsin	-8.57	-4.46	-4.11
Wyoming	-7.87	-4.60	-3.27

Table 11: Hospitals (Short Run), Average Annual Productivity Growth ($\overline{V}_G$) – State Averages with Scale Effect ($-\overline{S}_Q \Delta \ln Q$) and Pure Technical Change ($\overline{V}_T$) (percent)

	TOTAL	SCALE	TIME
Alabama	-5.61	-2.58	-3.03
Arizona	-3.39	-1.15	-2.24
Arkansas	-7.19	-5.13	-2.06
California	-7.94	-3.42	-4.52
Colorado	-6.46	-3.34	-3.11
Connecticut	-7.04	-3.64	-3.40
Delaware	-4.76	-2.59	-2.17
Florida	-4.93	-1.52	-3.41
Georgia	-6.35	-2.92	-3.43
Idaho	-6.08	-4.28	-1.80
Illinois	-8.77	-4.70	-4.07
Indiana	-6.40	-3.19	-3.21
Iowa	-9.11	-6.39	-2.73
Kansas	-5.62	-2.94	-2.68
Kentucky	-6.96	-4.32	-2.64
Louisiana	-5.96	-3.01	-2.94
Maine	-5.85	-3.43	-2.42
Maryland	-6.63	-3.15	-3.49
Massachusetts	-8.85	-5.37	-3.48
Michigan	-8.77	-4.53	-4.24
Minnesota	-7.24	-3.76	-3.48
Mississippi	-4.28	-1.95	-2.33
Missouri	-7.31	-4.29	-3.02
Nebraska	-6.94	-4.65	-2.29
Nevada	0.62	2.68	-2.06
New Hampshire	-6.24	-3.92	-2.33
New Jersey	-7.49	-3.77	-3.72
New Mexico	-2.73	-0.88	-1.85
New York	-8.65	-3.80	-4.85
North Carolina	-6.00	-2.61	-3.39
North Dakota	-6.89	-4.86	-2.03
Ohio	-8.70	-4.92	-3.79
Oklahoma	-7.10	-4.38	-2.72
Oregon	-5.90	-3.09	-2.82
Pennsylvania	-7.67	-3.46	-4.21
Rhode Island	-8.84	-6.46	-2.38
South Carolina	-6.16	-3.25	-2.91
Tennessee	-6.29	-3.37	-2.92
Texas	-6.37	-2.76	-3.60
Utah	-3.81	-1.84	-1.98
Vermont	-7.49	-5.49	-2.00
Virginia	-5.75	-2.52	-3.23
Washington	-6.64	-3.61	-3.03
West Virginia	-8.12	-6.00	-2.11
Wisconsin	-7.69	-4.24	-3.45
Wyoming	-6.19	-4.55	-1.64

Table 12: Education, Economies of Scale (S_Q), Pure Technical Change ($\overline{V}_T$, percent/year) and Marginal Cost of Capital ($\partial VC_{SR} / \partial K$), State Averages

	Long run		Short run		MG. COST
	SCALE	TIME	SCALE	TIME	OF CAPITAL
Alabama	-0.621	-3.31%	-0.766	-2.08%	0.460
Arizona	-0.620	-3.29%	-0.815	-1.85%	0.558
Arkansas	-0.620	-3.44%	-0.725	-2.27%	0.431
California	-0.623	-2.93%	-0.966	-1.17%	1.013
Colorado	-0.618	-3.29%	-0.786	-1.95%	0.651
Connecticut	-0.619	-3.40%	-0.764	-2.08%	0.773
Delaware	-0.616	-3.58%	-0.642	-2.61%	0.362
Florida	-0.620	-3.19%	-0.840	-1.73%	0.531
Georgia	-0.621	-3.30%	-0.766	-2.08%	0.452
Idaho	-0.619	-3.55%	-0.690	-2.42%	0.332
Illinois	-0.622	-3.14%	-0.846	-1.72%	0.459
Indiana	-0.622	-3.27%	-0.775	-2.05%	0.554
Iowa	-0.617	-3.35%	-0.746	-2.13%	0.514
Kansas	-0.622	-3.34%	-0.798	-1.95%	0.535
Kentucky	-0.621	-3.35%	-0.746	-2.18%	0.401
Louisiana	-0.621	-3.31%	-0.769	-2.07%	0.494
Maine	-0.620	-3.58%	-0.703	-2.38%	0.529
Maryland	-0.620	-3.29%	-0.797	-1.92%	0.573
Massachusetts	-0.622	-3.34%	-0.774	-2.07%	0.498
Michigan	-0.621	-3.12%	-0.846	-1.71%	0.606
Minnesota	-0.617	-3.25%	-0.779	-1.97%	0.549
Mississippi	-0.621	-3.39%	-0.768	-2.08%	0.504
Missouri	-0.623	-3.31%	-0.800	-1.95%	0.549
Montana	-0.614	-3.53%	-0.677	-2.43%	0.331
Nebraska	-0.624	-3.45%	-0.760	-2.16%	0.493
Nevada	-0.612	-3.54%	-0.687	-2.37%	0.395
New Hampshire	-0.618	-3.61%	-0.673	-2.50%	0.474
New Jersey	-0.618	-3.25%	-0.811	-1.84%	0.617
New Mexico	-0.620	-3.46%	-0.725	-2.27%	0.491
New York	-0.623	-3.10%	-0.876	-1.58%	0.587
North Carolina	-0.620	-3.26%	-0.795	-1.94%	0.656
North Dakota	-0.615	-3.52%	-0.684	-2.40%	0.350
Ohio	-0.625	-3.18%	-0.845	-1.75%	0.590
Oklahoma	-0.623	-3.33%	-0.786	-2.02%	0.592
Oregon	-0.620	-3.34%	-0.787	-1.98%	0.544
Pennsylvania	-0.620	-3.21%	-0.810	-1.87%	0.582
Rhode Island	-0.619	-3.57%	-0.709	-2.35%	0.560
South Carolina	-0.620	-3.39%	-0.737	-2.20%	0.532
South Dakota	-0.614	-3.55%	-0.672	-2.46%	0.285
Tennessee	-0.622	-3.32%	-0.768	-2.09%	0.433
Texas	-0.624	-3.09%	-0.878	-1.59%	0.679
Utah	-0.621	-3.44%	-0.736	-2.22%	0.520
Vermont	-0.616	-3.66%	-0.631	-2.67%	0.366
Virginia	-0.623	-3.28%	-0.808	-1.91%	0.709
Washington	-0.621	-3.25%	-0.802	-1.92%	0.618
West Virginia	-0.620	-3.43%	-0.735	-2.22%	0.476
Wisconsin	-0.620	-3.24%	-0.800	-1.91%	0.525
Wyoming	-0.613	-3.59%	-0.655	-2.52%	0.256

Table 13: Welfare, Economies of Scale (S_Q), Pure Technical Change ($\overline{V}_T$, percent/year) and Marginal Cost of Capital ($\partial VC_{SR} / \partial K$), State Averages

	Long run		Short run		MG. COST
	SCALE	TIME	SCALE	TIME	OF CAPITAL
Alabama	-0.762	-6.47%	-0.636	-6.66%	-0.229
Arizona	-0.813	-6.70%	-0.794	-6.31%	1.323
Arkansas	-0.798	-6.76%	-0.727	-6.68%	1.027
Connecticut	-0.805	-6.61%	-0.831	-5.87%	1.034
Florida	-0.744	-6.54%	-0.651	-6.43%	0.200
Georgia	-0.747	-6.39%	-0.619	-6.55%	-5.804
Idaho	-0.878	-6.74%	-0.909	-6.22%	1.364
Illinois	-0.721	-6.32%	-0.709	-5.56%	1.103
Iowa	-0.806	-6.62%	-0.859	-5.69%	0.982
Kentucky	-0.769	-6.62%	-0.732	-6.20%	0.840
Louisiana	-0.749	-6.44%	-0.715	-5.94%	0.698
Maine	-0.836	-6.77%	-0.785	-6.69%	1.188
Michigan	-0.728	-6.22%	-0.698	-5.62%	1.305
Mississippi	-0.771	-6.67%	-0.695	-6.54%	0.646
Missouri	-0.761	-6.71%	-0.682	-6.56%	0.993
Montana	-0.875	-6.76%	-0.935	-6.03%	1.138
Nevada	-0.890	-6.61%	-0.935	-6.04%	1.331
New Hampshire	-0.891	-6.90%	-0.904	-6.55%	2.417
New Mexico	-0.825	-6.72%	-0.826	-6.23%	0.861
North Dakota	-0.891	-6.78%	-0.927	-6.28%	1.758
Oklahoma	-0.784	-6.64%	-0.804	-5.88%	0.937
Oregon	-0.816	-6.67%	-0.790	-6.34%	2.601
Pennsylvania	-0.724	-6.40%	-0.645	-6.12%	1.280
Rhode Island	-0.842	-6.73%	-0.905	-5.86%	0.942
South Carolina	-0.792	-6.64%	-0.768	-6.21%	1.024
South Dakota	-0.878	-6.84%	-0.914	-6.29%	1.323
Tennessee	-0.763	-6.57%	-0.713	-6.22%	0.184
Texas	-0.722	-6.45%	-0.685	-5.86%	0.894
Utah	-0.850	-6.65%	-0.859	-6.20%	1.657
Vermont	-0.883	-6.84%	-0.885	-6.54%	2.336
Washington	-0.776	-6.53%	-0.788	-5.80%	1.450
West Virginia	-0.801	-6.82%	-0.760	-6.54%	0.902

Table 14: Hospitals, Economies of Scale (S_Q), Pure Technical Change ($\overline{V}_T$, percent/year) and Marginal Cost of Capital ($\partial VC_{SR} / \partial K$), State Averages

	Long run		Short run		MG. COST
	SCALE	TIME	SCALE	TIME	OF CAPITAL
Alabama	-0.915	-3.60%	-0.865	-3.02%	0.580
Arizona	-0.936	-3.45%	-0.914	-2.24%	0.601
Arkansas	-0.945	-3.04%	-0.940	-2.06%	0.565
California	-0.870	-4.81%	-0.819	-4.52%	0.376
Colorado	-0.909	-4.19%	-0.879	-3.11%	0.678
Connecticut	-0.905	-4.01%	-0.881	-3.40%	0.365
Delaware	-0.939	-3.36%	-0.921	-2.16%	0.336
Florida	-0.906	-3.72%	-0.858	-3.40%	0.332
Georgia	-0.905	-3.74%	-0.855	-3.42%	0.343
Idaho	-0.948	-3.39%	-0.957	-1.80%	0.280
Illinois	-0.886	-4.27%	-0.841	-4.06%	0.193
Indiana	-0.912	-3.60%	-0.873	-3.20%	0.342
Iowa	-0.923	-3.74%	-0.912	-2.73%	0.438
Kansas	-0.926	-3.50%	-0.906	-2.68%	0.386
Kentucky	-0.928	-3.36%	-0.905	-2.64%	0.333
Louisiana	-0.921	-3.37%	-0.900	-2.94%	0.492
Maine	-0.931	-3.54%	-0.902	-2.42%	0.326
Maryland	-0.902	-4.02%	-0.864	-3.48%	0.297
Massachusetts	-0.905	-3.73%	-0.865	-3.48%	0.315
Michigan	-0.878	-4.74%	-0.838	-4.23%	0.317
Minnesota	-0.901	-4.18%	-0.868	-3.48%	0.475
Mississippi	-0.940	-2.68%	-0.897	-2.33%	0.439
Missouri	-0.918	-3.40%	-0.873	-3.01%	0.336
Nebraska	-0.936	-3.30%	-0.915	-2.29%	0.594
Nevada	-0.935	-4.05%	-0.937	-2.05%	0.601
New Hampshire	-0.934	-3.42%	-0.906	-2.32%	0.238
New Jersey	-0.897	-3.94%	-0.846	-3.71%	0.266
New Mexico	-0.948	-3.14%	-0.936	-1.85%	0.807
New York	-0.865	-4.48%	-0.796	-4.85%	0.151
North Carolina	-0.907	-3.80%	-0.871	-3.38%	0.335
North Dakota	-0.942	-3.28%	-0.923	-2.02%	0.435
Ohio	-0.895	-3.96%	-0.846	-3.78%	0.290
Oklahoma	-0.927	-3.29%	-0.904	-2.72%	0.263
Oregon	-0.920	-3.76%	-0.894	-2.81%	0.780
Pennsylvania	-0.884	-4.12%	-0.829	-4.21%	0.237
Rhode Island	-0.932	-3.52%	-0.903	-2.37%	0.794
South Carolina	-0.920	-3.44%	-0.879	-2.90%	0.467
Tennessee	-0.922	-3.30%	-0.887	-2.92%	0.304
Texas	-0.901	-3.75%	-0.851	-3.60%	0.382
Utah	-0.943	-3.50%	-0.946	-1.99%	0.670
Vermont	-0.942	-3.37%	-0.920	-1.99%	0.332
Virginia	-0.913	-3.46%	-0.865	-3.22%	0.419
Washington	-0.914	-3.86%	-0.889	-3.03%	0.453
West Virginia	-0.945	-2.74%	-0.909	-2.10%	0.517
Wisconsin	-0.901	-4.11%	-0.857	-3.45%	0.388
Wyoming	-0.952	-3.28%	-0.947	-1.63%	0.467

Table 15: Education (Long Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	η_{KK}	σ_{LM}	σ_{LK}	σ_{MK}
Alabama	-0.364	-0.602	-0.885	0.853	0.690	1.432
Arizona	-0.353	-0.605	-0.889	0.851	0.651	1.473
Arkansas	-0.350	-0.611	-0.885	0.848	0.681	1.471
California	-0.337	-0.604	-0.897	0.855	0.542	1.650
Colorado	-0.270	-0.660	-0.896	0.822	0.620	1.902
Connecticut	-0.297	-0.651	-0.888	0.830	0.654	1.702
Delaware	-0.362	-0.599	-0.878	0.841	0.664	1.630
Florida	-0.259	-0.682	-0.888	0.807	0.720	1.761
Georgia	-0.356	-0.610	-0.882	0.850	0.685	1.455
Idaho	-0.333	-0.620	-0.887	0.833	0.690	1.558
Illinois	-0.312	-0.658	-0.874	0.829	0.742	1.502
Indiana	-0.325	-0.640	-0.882	0.841	0.705	1.537
Iowa	-0.261	-0.679	-0.895	0.827	0.667	1.796
Kansas	-0.295	-0.649	-0.894	0.838	0.646	1.804
Kentucky	-0.374	-0.609	-0.862	0.835	0.727	1.432
Louisiana	-0.360	-0.607	-0.883	0.850	0.689	1.425
Maine	-0.404	-0.531	-0.899	0.866	0.445	1.569
Maryland	-0.278	-0.654	-0.894	0.807	0.683	1.760
Massachusetts	-0.386	-0.594	-0.867	0.847	0.703	1.429
Michigan	-0.325	-0.634	-0.888	0.847	0.683	1.544
Minnesota	-0.286	-0.662	-0.890	0.834	0.676	1.726
Mississippi	-0.339	-0.616	-0.891	0.852	0.643	1.546
Missouri	-0.355	-0.603	-0.886	0.852	0.625	1.507
Montana	-0.280	-0.665	-0.886	0.810	0.708	1.705
Nebraska	-0.363	-0.577	-0.893	0.840	0.588	1.568
Nevada	-0.358	-0.588	-0.886	0.837	0.597	1.592
New Hampshire	-0.348	-0.592	-0.895	0.840	0.602	1.624
New Jersey	-0.299	-0.651	-0.882	0.842	0.573	1.880
New Mexico	-0.346	-0.600	-0.896	0.856	0.601	1.606
New York	-0.401	-0.569	-0.870	0.844	0.668	1.488
North Carolina	-0.362	-0.590	-0.894	0.858	0.617	1.508
North Dakota	-0.343	-0.609	-0.890	0.847	0.645	1.671
Ohio	-0.333	-0.624	-0.887	0.848	0.655	1.562
Oklahoma	-0.366	-0.583	-0.896	0.859	0.602	1.512
Oregon	-0.319	-0.628	-0.895	0.841	0.672	1.573
Pennsylvania	-0.372	-0.593	-0.883	0.852	0.677	1.446
Rhode Island	-0.342	-0.594	-0.897	0.839	0.583	1.664
South Carolina	-0.370	-0.585	-0.890	0.859	0.600	1.515
South Dakota	-0.352	-0.607	-0.888	0.852	0.658	1.529
Tennessee	-0.354	-0.618	-0.877	0.842	0.721	1.411
Texas	-0.345	-0.608	-0.889	0.850	0.625	1.562
Utah	-0.363	-0.580	-0.894	0.861	0.531	1.689
Vermont	-0.366	-0.555	-0.895	0.818	0.577	2.544
Virginia	-0.297	-0.648	-0.892	0.835	0.649	1.680
Washington	-0.318	-0.636	-0.893	0.845	0.688	1.540
West Virginia	-0.305	-0.645	-0.878	0.798	0.721	1.610
Wisconsin	-0.263	-0.673	-0.881	0.789	0.695	2.188
Wyoming	-0.378	-0.584	-0.883	0.851	0.670	1.497

Table 16: Welfare (Long Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	η_{KK}	σ_{LM}	σ_{LK}	σ_{MK}
Alabama	-0.353	-0.549	-0.996	0.895	-1.894	6.597
Arizona	-0.495	-0.409	-0.990	0.895	-0.195	1.887
Arkansas	-0.423	-0.451	-0.994	0.865	-1.385	4.671
Connecticut	-0.488	-0.428	-0.984	0.900	0.212	1.665
Florida	-0.433	-0.439	-0.996	0.865	-1.629	4.139
Georgia	-0.547	-0.349	-0.994	0.893	-4.017	4.007
Idaho	-0.414	-0.491	-0.987	0.889	0.353	1.947
Illinois	-0.438	-0.432	-0.986	0.850	-0.011	1.926
Iowa	-0.389	-0.496	-0.978	0.856	0.543	1.573
Kentucky	-0.495	-0.404	-0.988	0.888	-0.442	1.856
Louisiana	-0.424	-0.482	-0.988	0.892	-0.099	2.213
Maine	-0.525	-0.370	-0.996	0.893	-1.477	2.488
Michigan	-0.386	-0.472	-0.992	0.840	-0.296	2.837
Mississippi	-0.508	-0.389	-0.994	0.893	-0.519	2.229
Missouri	-0.390	-0.508	-0.994	0.890	-0.524	3.994
Montana	-0.436	-0.482	-0.980	0.895	0.415	1.458
Nevada	-0.518	-0.386	-0.989	0.895	0.195	1.532
New Hampshire	-0.477	-0.414	-0.993	0.884	-0.502	2.359
New Mexico	-0.460	-0.421	-0.988	0.867	-0.324	1.840
North Dakota	-0.480	-0.305	-0.985	0.784	-2.346	1.651
Oklahoma	-0.348	-0.561	-0.984	0.888	0.613	1.712
Oregon	-0.498	-0.402	-0.996	0.898	-1.486	2.937
Pennsylvania	-0.432	-0.410	-0.997	0.835	-2.362	5.466
Rhode Island	-0.444	-0.474	-0.974	0.888	0.651	1.425
South Carolina	-0.396	-0.503	-0.991	0.887	0.248	2.045
South Dakota	-0.467	-0.439	-0.987	0.892	0.299	1.549
Tennessee	-0.453	-0.444	-0.990	0.887	-0.901	2.100
Texas	-0.393	-0.494	-0.990	0.871	0.130	2.265
Utah	-0.448	-0.461	-0.991	0.899	-0.154	2.052
Vermont	-0.586	-0.307	-0.993	0.890	-1.008	2.124
Washington	-0.476	-0.427	-0.989	0.892	0.112	1.771
West Virginia	-0.456	-0.443	-0.991	0.889	-0.324	2.011

Table 17: Hospitals (Long Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	η_{KK}	σ_{LM}	σ_{LK}	σ_{MK}
Alabama	-2.537	-3.073	-0.973	5.755	6.985	-6.269
Arizona	-2.976	-3.027	-0.950	6.244	6.509	-3.418
Arkansas	-2.370	-3.761	-0.945	6.487	5.416	-4.419
California	-2.121	-4.002	-0.957	6.457	5.071	-5.922
Colorado	-1.912	-7.958	-0.968	10.460	4.873	-24.598
Connecticut	-2.191	-4.125	-0.927	6.814	3.999	-4.239
Delaware	-2.043	-8.440	-0.942	11.395	3.262	-10.561
Florida	-2.049	-3.340	-0.948	5.662	3.689	-4.354
Georgia	-2.287	-3.500	-0.943	6.109	3.974	-4.184
Idaho	-2.217	-5.386	-0.916	8.327	2.663	-3.761
Illinois	-2.106	-4.401	-0.940	6.950	3.059	-3.955
Indiana	-2.058	-4.159	-0.942	6.635	3.595	-4.361
Iowa	-2.100	-3.909	-0.965	6.272	4.355	-5.946
Kansas	-2.216	-4.735	-0.956	7.333	4.378	-7.717
Kentucky	-2.379	-3.409	-0.941	6.111	3.654	-2.944
Louisiana	-2.308	-3.537	-0.945	6.176	5.186	-4.631
Maine	-2.056	-4.550	-0.946	7.047	3.613	-5.116
Maryland	-2.206	0.649	-0.954	1.279	3.760	0.830
Massachusetts	-1.957	-4.850	-0.945	7.303	3.858	-5.344
Michigan	-2.110	-4.318	-0.953	6.825	4.153	-4.780
Minnesota	-2.519	-3.105	-0.954	5.862	5.659	-4.160
Mississippi	-2.620	-2.989	-0.943	5.872	4.433	-4.113
Missouri	-1.954	-6.059	-0.961	8.527	3.913	-8.890
Nebraska	-2.169	-4.514	-0.967	7.016	5.426	-6.912
Nevada	-2.479	-3.466	-0.932	6.333	4.438	-3.507
New Hampshire	-1.960	-5.158	-0.942	7.637	2.731	-4.519
New Jersey	-2.059	-4.336	-0.937	6.866	3.521	-4.483
New Mexico	-2.605	-3.321	-0.964	6.140	7.264	-6.983
New York	-1.887	-4.864	-0.944	7.240	3.321	-5.288
North Carolina	-2.236	-3.650	-0.940	6.247	3.866	-4.165
North Dakota	-2.282	-3.460	-0.955	6.010	4.322	-4.472
Ohio	-2.277	-3.898	-0.953	6.503	4.157	-4.354
Oklahoma	-2.281	-3.839	-0.941	6.500	3.303	-2.931
Oregon	-2.291	-3.715	-0.950	6.337	6.170	-6.052
Pennsylvania	-2.327	-3.520	-0.933	6.229	3.706	-3.004
Rhode Island	-2.489	-3.477	-0.969	6.169	6.454	-6.463
South Carolina	-2.326	-3.613	-0.950	6.251	5.316	-4.934
Tennessee	-2.603	-3.510	-0.924	6.543	3.785	-3.063
Texas	-2.307	-3.333	-0.962	5.857	5.320	-6.204
Utah	-2.451	-3.370	-0.956	6.078	6.228	-5.232
Vermont	-2.316	-4.378	-0.943	7.142	3.280	-3.613
Virginia	-2.398	-3.192	-0.959	5.812	5.209	-4.514
Washington	-2.135	-3.658	-0.949	6.089	4.311	-4.923
West Virginia	-2.308	-3.996	-0.944	6.677	4.340	-5.059
Wisconsin	-2.170	-3.995	-0.951	6.519	4.351	-4.964
Wyoming	-2.212	-4.701	-0.948	7.316	3.813	-7.932

Table 18: Miscellaneous (Long Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	η_{KK}	σ_{LM}	σ_{LK}	σ_{MK}
Alabama	-0.303	-0.144	-0.064	0.518	-3.420	0.403
Arizona	-0.317	-0.178	-0.084	0.543	-3.269	0.415
Arkansas	-0.299	-0.138	-0.042	0.514	-4.447	0.418
California	-0.297	-0.225	-0.431	0.568	-1.323	0.560
Colorado	-0.311	-0.254	-0.401	0.592	-0.819	0.507
Connecticut	-0.314	-0.165	-0.292	0.536	-2.068	0.541
Delaware	-0.338	-0.207	-0.299	0.567	-1.583	0.509
Florida	-0.324	-0.185	-0.306	0.558	-1.758	0.535
Georgia	-0.294	-0.151	-0.307	0.499	-2.600	0.586
Idaho	-0.341	-0.217	-0.268	0.585	-1.524	0.488
Illinois	-0.273	-0.138	-0.216	0.483	-3.424	0.527
Indiana	-0.259	-0.193	-0.444	0.496	-1.458	0.632
Iowa	-0.320	-0.171	-0.122	0.538	-2.787	0.434
Kansas	-0.307	-0.245	-0.216	0.575	-1.584	0.385
Kentucky	-0.291	-0.151	-0.355	0.491	-2.313	0.619
Louisiana	-0.280	-0.147	-0.358	0.474	-2.578	0.633
Maine	-0.293	-0.150	-0.075	0.529	-3.473	0.392
Maryland	-0.332	-0.231	-0.444	0.585	-0.785	0.589
Massachusetts	-0.219	-0.176	-0.484	0.446	-1.824	0.660
Michigan	-0.291	-0.139	-0.015	0.518	-4.172	0.375
Minnesota	-0.272	-0.220	-0.293	0.545	-1.878	0.460
Mississippi	-0.290	-0.150	-0.240	0.496	-2.562	0.528
Missouri	-0.273	-0.129	0.257	0.485	-6.857	0.249
Montana	-0.321	-0.216	-0.317	0.555	-1.683	0.543
Nebraska	-0.289	-0.256	-0.359	0.558	-0.909	0.378
Nevada	-0.349	-0.224	-0.303	0.591	-1.452	0.525
New Hampshire	-0.301	-0.179	-0.331	0.543	-1.840	0.548
New Jersey	-0.311	-0.213	-0.426	0.564	-1.269	0.596
New Mexico	-0.329	-0.196	-0.278	0.567	-1.757	0.509
New York	-0.291	-0.244	-0.613	0.532	-0.310	0.728
North Carolina	-0.304	-0.262	-0.456	0.593	-0.673	0.550
North Dakota	-0.268	-0.121	0.557	0.472	-8.543	0.072
Ohio	-0.287	-0.161	-0.245	0.506	-2.415	0.515
Oklahoma	-0.237	-0.121	0.131	0.445	-7.506	0.355
Oregon	-0.330	-0.196	-0.201	0.579	-2.156	0.449
Pennsylvania	-0.273	-0.147	-0.238	0.503	-2.829	0.510
Rhode Island	-0.325	-0.172	-0.291	0.554	-2.099	0.540
South Carolina	-0.315	-0.181	-0.459	0.534	-1.245	0.660
South Dakota	-0.312	-0.184	-0.363	0.514	-1.732	0.609
Tennessee	-0.280	-0.155	-0.362	0.492	-1.997	0.606
Texas	-0.285	-0.138	0.110	0.491	-5.050	0.327
Utah	-0.327	-0.200	-0.360	0.554	-1.388	0.577
Vermont	-0.323	-0.180	-0.065	0.572	-2.746	0.341
Virginia	-0.309	-0.250	-0.295	0.592	-1.241	0.426
Washington	-0.329	-0.176	-0.186	0.551	-2.696	0.484
West Virginia	-0.272	-0.143	-0.294	0.474	-2.558	0.575
Wisconsin	-0.271	-0.210	-0.352	0.536	-1.668	0.493
Wyoming	-0.317	-0.265	-0.408	0.549	-0.646	0.571

Table 19: Education (Short Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	σ_{LM}
Alabama	-0.329	-0.527	0.857
Arizona	-0.320	-0.532	0.852
Arkansas	-0.315	-0.536	0.851
California	-0.314	-0.537	0.851
Colorado	-0.239	-0.578	0.817
Connecticut	-0.258	-0.574	0.832
Delaware	-0.328	-0.516	0.844
Florida	-0.214	-0.595	0.809
Georgia	-0.319	-0.535	0.854
Idaho	-0.296	-0.541	0.836
Illinois	-0.261	-0.576	0.837
Indiana	-0.283	-0.561	0.845
Iowa	-0.225	-0.600	0.824
Kansas	-0.263	-0.572	0.835
Kentucky	-0.325	-0.525	0.849
Louisiana	-0.322	-0.533	0.855
Maine	-0.392	-0.468	0.860
Maryland	-0.240	-0.567	0.808
Massachusetts	-0.345	-0.511	0.857
Michigan	-0.289	-0.560	0.848
Minnesota	-0.249	-0.585	0.834
Mississippi	-0.308	-0.544	0.852
Missouri	-0.322	-0.532	0.854
Montana	-0.235	-0.579	0.814
Nebraska	-0.338	-0.501	0.839
Nevada	-0.327	-0.512	0.839
New Hampshire	-0.321	-0.517	0.838
New Jersey	-0.264	-0.577	0.841
New Mexico	-0.322	-0.531	0.853
New York	-0.366	-0.486	0.852
North Carolina	-0.335	-0.522	0.857
North Dakota	-0.312	-0.534	0.846
Ohio	-0.299	-0.551	0.849
Oklahoma	-0.342	-0.515	0.857
Oregon	-0.287	-0.553	0.840
Pennsylvania	-0.338	-0.518	0.856
Rhode Island	-0.317	-0.520	0.837
South Carolina	-0.344	-0.514	0.858
South Dakota	-0.319	-0.534	0.853
Tennessee	-0.310	-0.540	0.850
Texas	-0.313	-0.537	0.850
Utah	-0.343	-0.513	0.856
Vermont	-0.346	-0.464	0.810
Virginia	-0.262	-0.573	0.834
Washington	-0.283	-0.562	0.845
West Virginia	-0.253	-0.557	0.810
Wisconsin	-0.216	-0.576	0.792
Wyoming	-0.347	-0.507	0.854

Table 20: Welfare (Short Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	σ_{LM}
Alabama	-0.357	-0.539	0.896
Arizona	-0.499	-0.399	0.897
Arkansas	-0.428	-0.439	0.867
Connecticut	-0.489	-0.414	0.904
Florida	-0.439	-0.428	0.866
Georgia	-0.554	-0.340	0.895
Idaho	-0.415	-0.477	0.892
Illinois	-0.438	-0.417	0.855
Iowa	-0.384	-0.478	0.862
Kentucky	-0.498	-0.393	0.891
Louisiana	-0.424	-0.471	0.895
Maine	-0.532	-0.362	0.894
Michigan	-0.387	-0.456	0.844
Mississippi	-0.514	-0.380	0.895
Missouri	-0.394	-0.497	0.891
Montana	-0.431	-0.469	0.899
Nevada	-0.523	-0.375	0.898
New Hampshire	-0.483	-0.404	0.886
New Mexico	-0.462	-0.408	0.870
North Dakota	-0.499	-0.290	0.789
Oklahoma	-0.345	-0.547	0.891
Oregon	-0.504	-0.395	0.899
Pennsylvania	-0.440	-0.396	0.836
Rhode Island	-0.437	-0.457	0.894
South Carolina	-0.398	-0.491	0.889
South Dakota	-0.468	-0.427	0.895
Tennessee	-0.456	-0.434	0.890
Texas	-0.394	-0.480	0.873
Utah	-0.451	-0.451	0.901
Vermont	-0.594	-0.298	0.892
Washington	-0.479	-0.415	0.895
West Virginia	-0.458	-0.433	0.891

Table 21: Hospitals (Short Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	σ_{LM}
Alabama	-2.079	-2.786	4.865
Arizona	-2.387	-2.665	5.052
Arkansas	-1.877	-3.305	5.182
California	-1.695	-3.555	5.250
Colorado	-1.538	-7.176	8.714
Connecticut	-1.688	-3.565	5.254
Delaware	-1.588	-7.397	8.985
Florida	-1.609	-2.975	4.584
Georgia	-1.801	-3.087	4.888
Idaho	-1.670	-4.623	6.293
Illinois	-1.644	-3.864	5.508
Indiana	-1.611	-3.652	5.263
Iowa	-1.694	-3.517	5.212
Kansas	-1.772	-4.221	5.993
Kentucky	-1.875	-2.995	4.870
Louisiana	-1.826	-3.112	4.939
Maine	-1.616	-4.009	5.625
Maryland	-1.759	0.454	1.306
Massachusetts	-1.533	-4.255	5.788
Michigan	-1.676	-3.812	5.488
Minnesota	-2.023	-2.755	4.778
Mississippi	-2.075	-2.636	4.710
Missouri	-1.560	-5.402	6.962
Nebraska	-1.755	-4.043	5.798
Nevada	-1.936	-3.006	4.943
New Hampshire	-1.526	-4.535	6.061
New Jersey	-1.601	-3.785	5.386
New Mexico	-2.111	-2.978	5.088
New York	-1.471	-4.279	5.750
North Carolina	-1.754	-3.207	4.960
North Dakota	-1.825	-3.082	4.907
Ohio	-1.817	-3.454	5.272
Oklahoma	-1.795	-3.364	5.159
Oregon	-1.822	-3.281	5.104
Pennsylvania	-1.815	-3.066	4.881
Rhode Island	-2.027	-3.133	5.160
South Carolina	-1.851	-3.196	5.047
Tennessee	-2.011	-3.033	5.044
Texas	-1.862	-2.994	4.856
Utah	-1.971	-2.996	4.968
Vermont	-1.824	-3.832	5.656
Virginia	-1.933	-2.853	4.786
Washington	-1.686	-3.257	4.943
West Virginia	-1.818	-3.530	5.347
Wisconsin	-1.723	-3.534	5.257
Wyoming	-1.751	-4.180	5.932

Table 22: Miscellaneous (Short Run), Own Price Elasticities (η_{XX}) and Allen Partial Elasticities (σ_{XX}), State Averages

	η_{LL}	η_{MM}	σ_{LM}
Alabama	-0.377	-0.113	0.490
Arizona	-0.383	-0.143	0.526
Arkansas	-0.372	-0.109	0.481
California	-0.343	-0.200	0.543
Colorado	-0.357	-0.222	0.579
Connecticut	-0.384	-0.131	0.515
Delaware	-0.394	-0.167	0.561
Florida	-0.387	-0.152	0.539
Georgia	-0.372	-0.112	0.484
Idaho	-0.395	-0.181	0.576
Illinois	-0.356	-0.103	0.459
Indiana	-0.335	-0.154	0.488
Iowa	-0.389	-0.135	0.524
Kansas	-0.359	-0.210	0.568
Kentucky	-0.372	-0.109	0.481
Louisiana	-0.365	-0.101	0.467
Maine	-0.363	-0.127	0.489
Maryland	-0.382	-0.195	0.577
Massachusetts	-0.303	-0.134	0.437
Michigan	-0.364	-0.114	0.478
Minnesota	-0.331	-0.191	0.522
Mississippi	-0.371	-0.111	0.482
Missouri	-0.355	-0.098	0.453
Montana	-0.383	-0.174	0.557
Nebraska	-0.342	-0.216	0.559
Nevada	-0.399	-0.186	0.585
New Hampshire	-0.366	-0.150	0.516
New Jersey	-0.366	-0.180	0.547
New Mexico	-0.388	-0.163	0.551
New York	-0.343	-0.200	0.543
North Carolina	-0.346	-0.233	0.579
North Dakota	-0.352	-0.089	0.441
Ohio	-0.365	-0.125	0.489
Oklahoma	-0.325	-0.087	0.412
Oregon	-0.385	-0.169	0.554
Pennsylvania	-0.350	-0.119	0.469
Rhode Island	-0.389	-0.141	0.530
South Carolina	-0.383	-0.142	0.524
South Dakota	-0.387	-0.135	0.522
Tennessee	-0.363	-0.116	0.479
Texas	-0.366	-0.103	0.469
Utah	-0.391	-0.159	0.550
Vermont	-0.382	-0.156	0.538
Virginia	-0.356	-0.220	0.576
Washington	-0.393	-0.141	0.534
West Virginia	-0.359	-0.102	0.462
Wisconsin	-0.332	-0.181	0.513
Wyoming	-0.376	-0.210	0.586