The Use of Econometric and Time Series Methods in Health Care Forecasting

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Office of the Assistant Deputy Under Secretary for Health
U.S. Department of Veterans Affairs

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George Washington University
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Health Care Forecasting

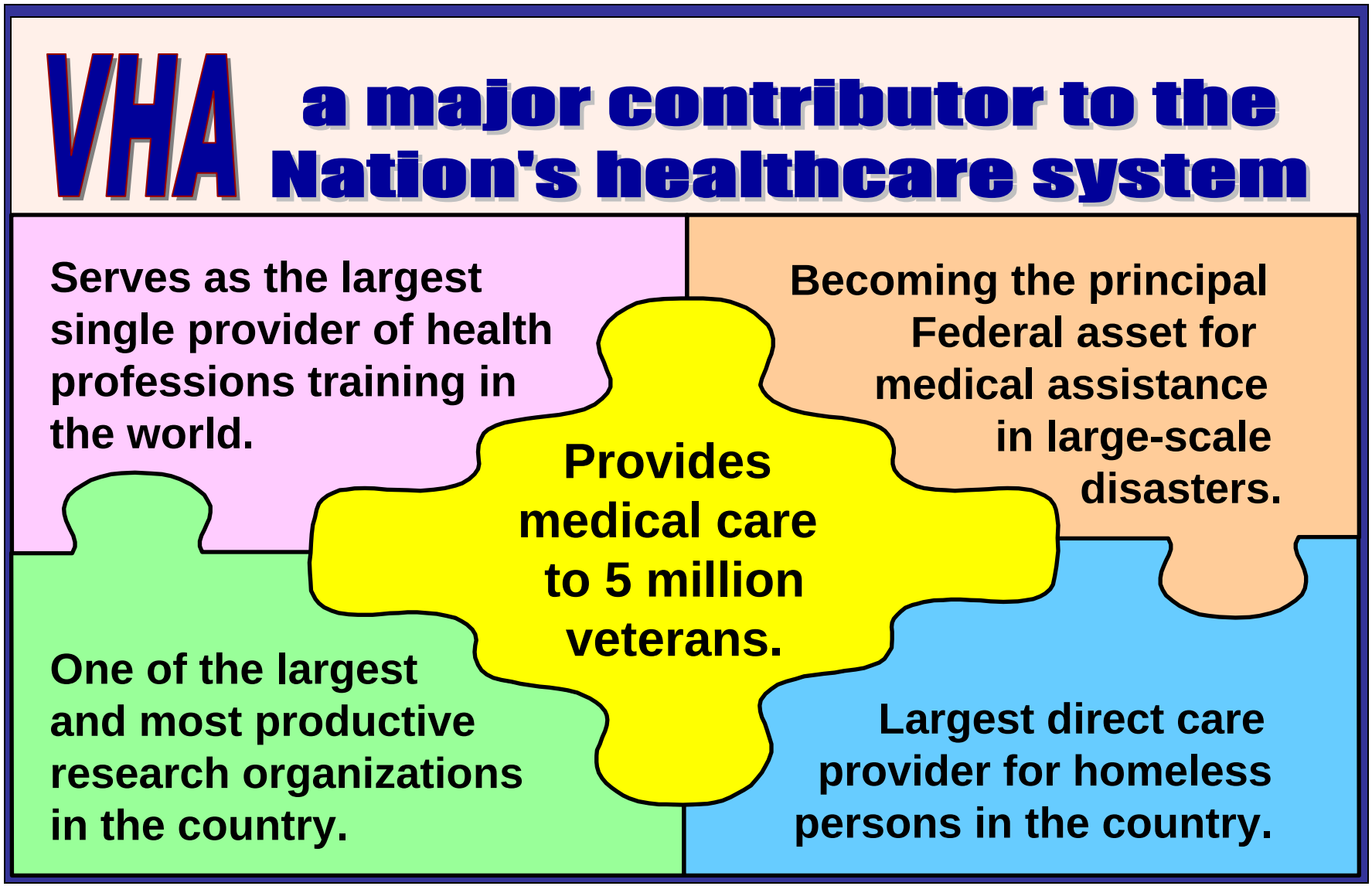
Question 1: To what extent can time series forecasting or econometric techniques be used to predict demand for VA health care services?

Question 2: What are some of the forecasting issues or problems specific to predicting demand for VA health care (effective demand=utilization)?

Question 3: How might critical complexities be built into VA health care forecasting models?

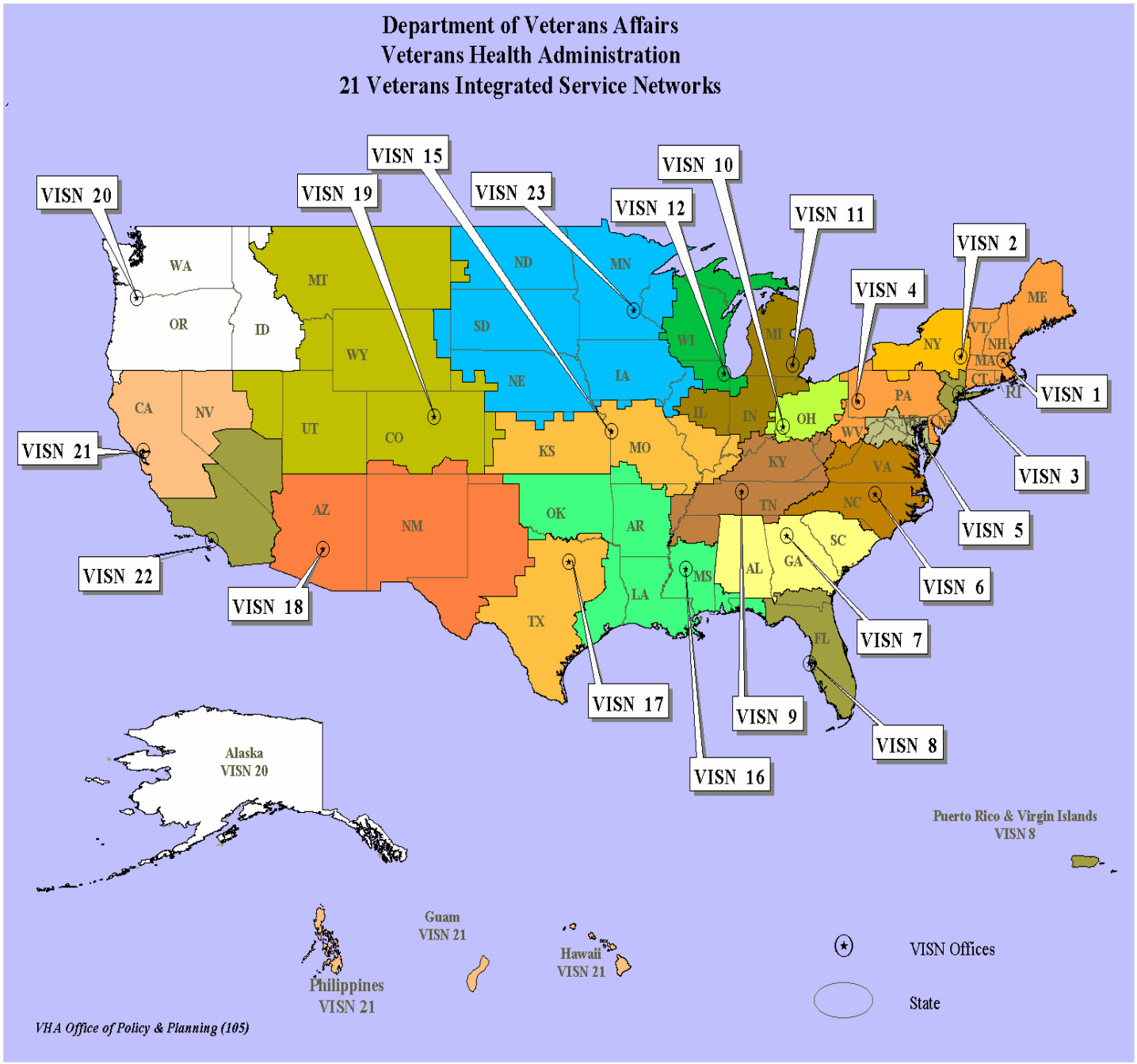
Health Care Forecasting

Veterans Health Administration Snapshot


VHA
a major contributor to the Nation's healthcare system
Serves as the largest single provider of health professions training in the world.
Becoming the principal Federal asset for medical assistance in large-scale disasters.
Provides medical care to 5 million veterans.
One of the largest and most productive research organizations in the country.
Largest direct care provider for homeless persons in the country.

Veterans Health Administration Snapshot

- VHA is the largest single provider of health professions training in the world
- About 70% of all physicians in the U.S. have had some of their training with VHA
- A significant percentage of all other health care professionals in the U.S. have also had at least some of their training with VHA
- There are some 26 million living veterans; some 7 million of them are enrolled for VHA health care; and some 5 million are patients actively using VA health care services
- The VHA annual medical care budget is some $30B


Department of Veterans Affairs
Veterans Health Administration
21 Veterans Integrated Service Networks
VISN 20
VISN 15
VISN 19
VISN 23
VISN 10
VISN 12
VISN 11
VISN 2
VISN 4
VISN 1
VISN 3
VISN 5
VISN 6
VISN 7
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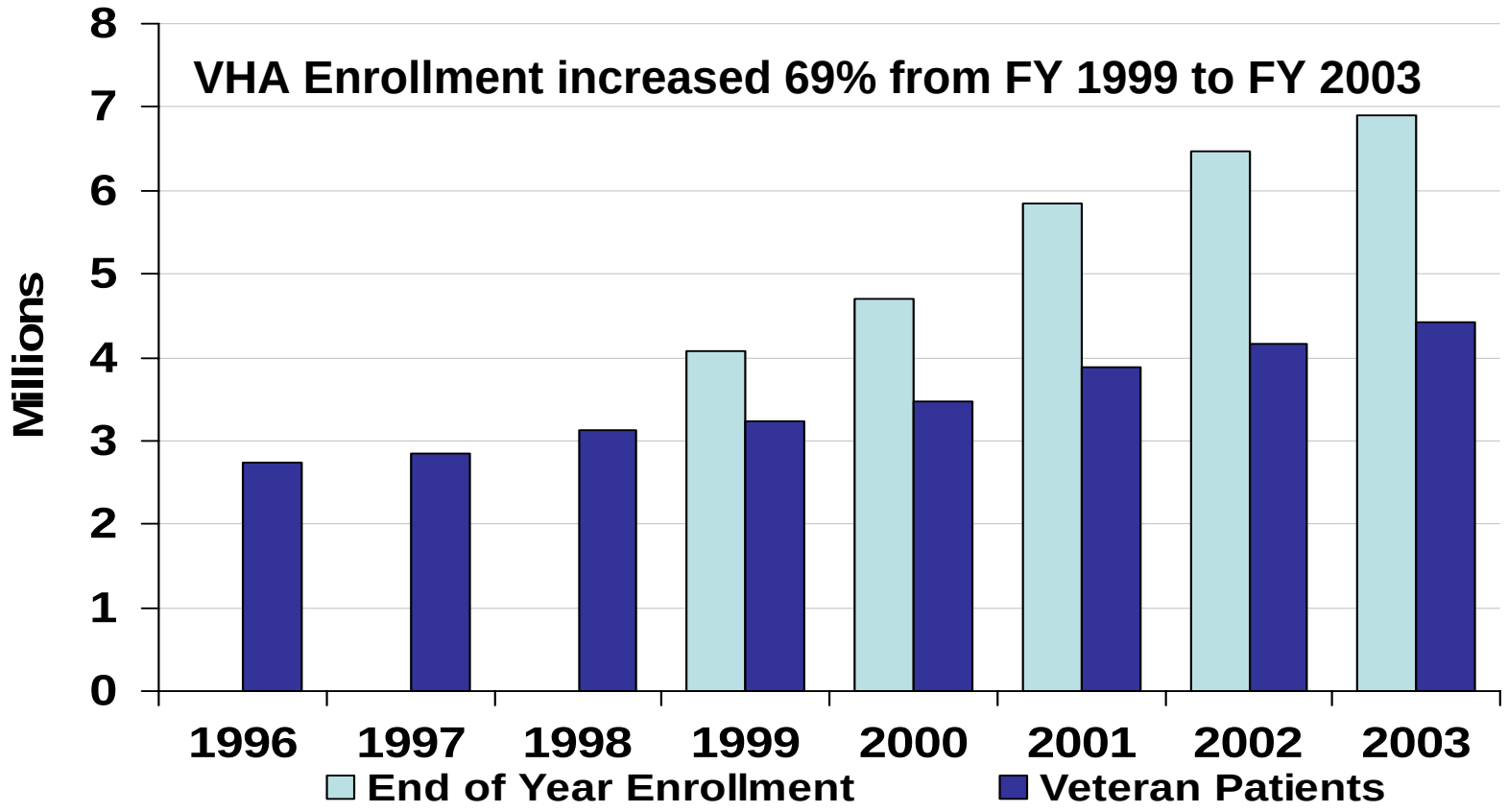
NJ
MD
DE
Alaska
VISN 20
Puerto Rico & Virgin Islands
VISN 8
Guam
VISN 21
Hawaii
VISN 21
Philippines
VISN 21
VISN Offices
State
VHA Office of Policy & Planning (105)

Veterans Health Administration Snapshot

- 21 Veterans Integrated Service Networks (VISNs)
- 158 Hospitals
- 854 Outpatient Units (including CBOCs)
- 686 Community Based Outpatient Clinics
- 132 VA Nursing Homes
- 206 Readjustment Counseling Centers
- 42 Residential Rehabilitation Treatment Centers

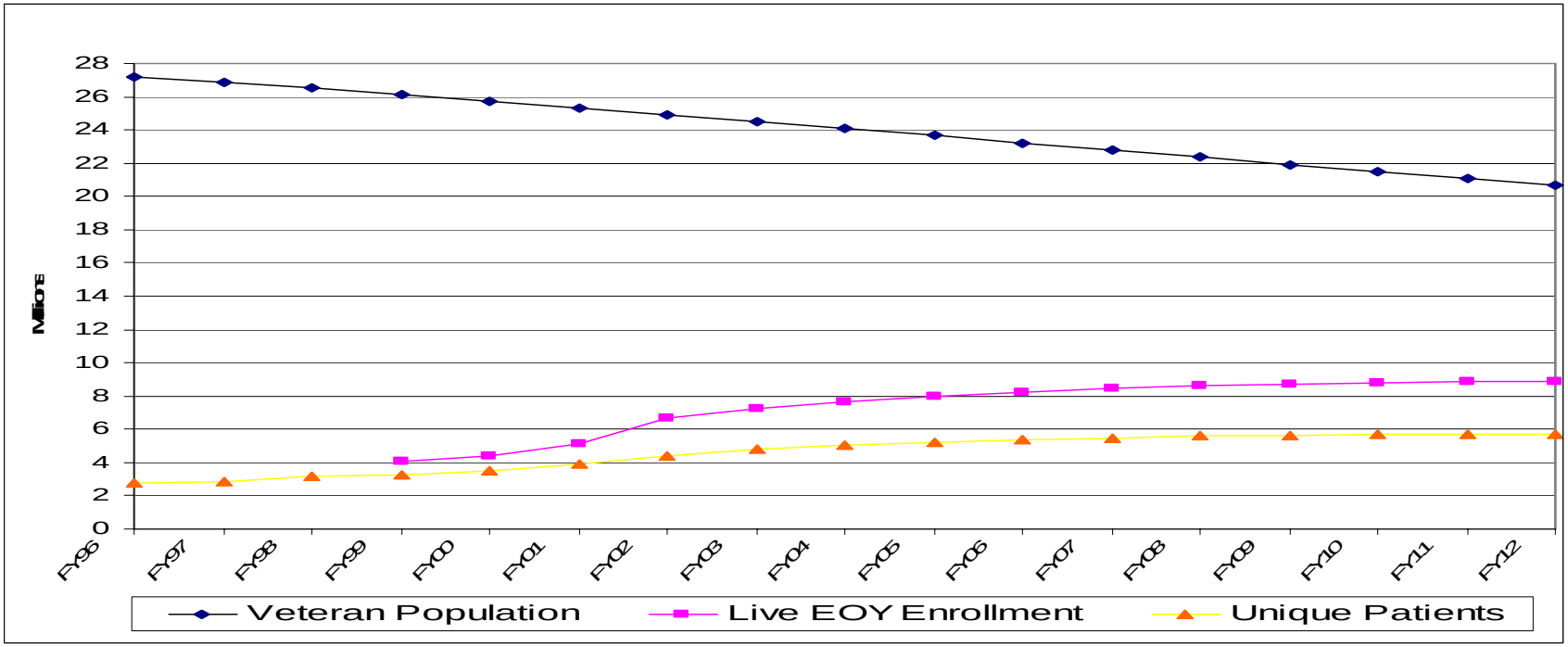
Veterans Health Administration Snapshot

Unprecedented Growth



Veterans Health Administration Snapshot

Veteran Population, VA Health Care Enrollees, and VA Patients: Fiscal Years 1996 to 2012



Sources: VA, Office of the Actuary, and Veterans Health Care Administration.

Veterans Health Administration Snapshot

Challenges
Of the Last Few Years

- Growing enrollment exhausting VA's marginal capacity to provide care
- Wait lists and waiting times
- Aging veteran population
- Rising cost of health care
- Securing resources for a discretionary program in a tight Federal budget climate is difficult
- Modeling: to predict enrollment, patients, expenditures
- Need model–based budget and policy scenarios, decisions, planning

Health Care Forecasting

Some Current VA Models

Some Current VA Models

Veterans Actuarial Model

"Vet Pop 2001 Adjusted to Census 2000" (or "Vet Pop 2001 Adj")

- "Vet Pop 2001 Adj" revises and updates earlier veteran population projection models
- Reflects impact of Census 2000 veteran data, released May 2002
- New baseline of April 2000; with projections forward from baseline and as of September 30, 2000 – September 30, 2030
- Projections by state, age, sex, period of military service
- National level detail by VA disability status, degree of disability, and officer/enlisted status
- Projections by counties and Veterans Integrated Service Networks (VISNs), by age and sex

Some Current VA Models

VAM3, From VA Office of the Actuary, Summer 2004

- It will model future eligibility for various benefits (e.g., VA compensation and pension and VA health care priority group).
- It will be based on detailed Census 2000 data, rather than adjustments as in Vet Pop 2001 Adj, with enhanced methods and updates from administrative data and other data sources.

Some Current VA Models

VA Enrollee Health Care Projection Model

- A Health Care Services Demand Model
- Projects utilization and expenditures for the enrolled veteran population
- Based on private sector benchmarks that have been adjusted for the characteristics of the enrollee population and the VA health care delivery system
- Provides detailed projections for 50 health care service categories
- Combines the knowledge and capabilities of VA and a respected private sector health care actuarial firm, Milliman USA with CACI, Inc

Some Current VA Models

HSR&D type models
e.g., Ann Hendricks, et al

Some Current VA Models

ISSUES

- Much of the big health care and demographic modeling that is done in VA and else where is either actuarial or proportional modeling, or modeling individual choice, but not time series based
- Such models often involve great complexity and expense, but those should not be the major reasons for buy-in
- How do errors get compounded in proportional models
- Are adjustments timely, reasonable, correct, done in the right order, etc.

Some Current VA Models

ISSUES

- Macroeconomics/Microeconomics views
- Assumptions
  - TS assumes that macro factors are already accounted for in the data
- Need for Feasibility Analysis

Health Care Forecasting

Feasibility Analysis

Feasibility Analysis

Feasibility Analysis: feasibility of using time series, econometric techniques, for forecasting health care demand (effective demand=utilization)

- Impact upon ST budget vs. LT capital planning needs
- Can save lots of money short-term if ST forecasting model has smaller errors than LT proportional model

- Start simple
- Build on what works
- Address complexity

Feasibility Analysis

- Types of Time Series Data
  - Micro
  - Industry
  - Macro
  - Finance
  - Demographics
  - Other
- Forecasting Techniques (General)
- Forecasting Methods (Specific)
- Software

Health Care Forecasting

Forecasting Techniques

Forecasting Techniques

How to choose the right forecasting technique

References

Chambers JC, Mullick, SK, Smith D, *How to Choose the Right Forecasting Technique*, Harvard Business Review, July-August 1971

Wesley G, Young P, *Forecasting as a Tool for Oversight*, Proceedings of the 1993 Federal Forecasters Conference, http://www.federalforecasters.org

Forecasting Techniques

Delphi Method- expert panel interviews and re-ineterviews

Market Research- questionnaires, surveys, time series of market variables over time

Historical Analysis- analysis of similar new product releases/growth, patterns

Moving Average- each point is the arithmetic or weighted average of a number of consecutive points in a series

Exponential Smoothing- Like MA, but more recent points have greater weights

B-J ARIMA- Exp'l smoothing is a special case of B-J; assigns smaller errors to history than other models

X-12- an update of Census X-11; decomposes time series (trend, cycle, seasonal, irregular); predicts turning points and time to special events

Regression Model: estimates an equation using LS; relationships analyzed statistically

Econometric Model- a system of interdependent regression equations that describes economic sales/profits; parameters estimated simultaneously

Leading Indicator- a TS of an economic activity whose behavior precedes movement of another TS

Selected Forecasting Techniques		
Qualitative	Quantitative	
Delphi Method	Time Series/Proj'n	Causal Modeling
Market Research	Exp'l Smoothing	Regression
Visionary Forecast	B-J ARIMA	Econometric
Historical Analogy	Moving Averages	Input/Output
Scenario	Seasonality (X-12)	Diffusion Index
Contextual Maps	Trend Proj'n	Leading Indicator
Monitoring		Life-Cycle An'l's

Health Care Forecasting

Framework for Modeling

Framework for Modeling

- Need to address Short-term (ST), Mid-Term (MT), Long-Term (LT) issues, concerns
- Different type of forecasting models for different time horizons
  - electrical power load - minutes or hours
  - nuclear power plants – decades
- ST forecasting models are more reliable if quantitative, statistical, such as sales, inventory
- LT forecasting models are often more reliable if econometric or judgmental, such as large-scale models of the economy

Framework for Modeling

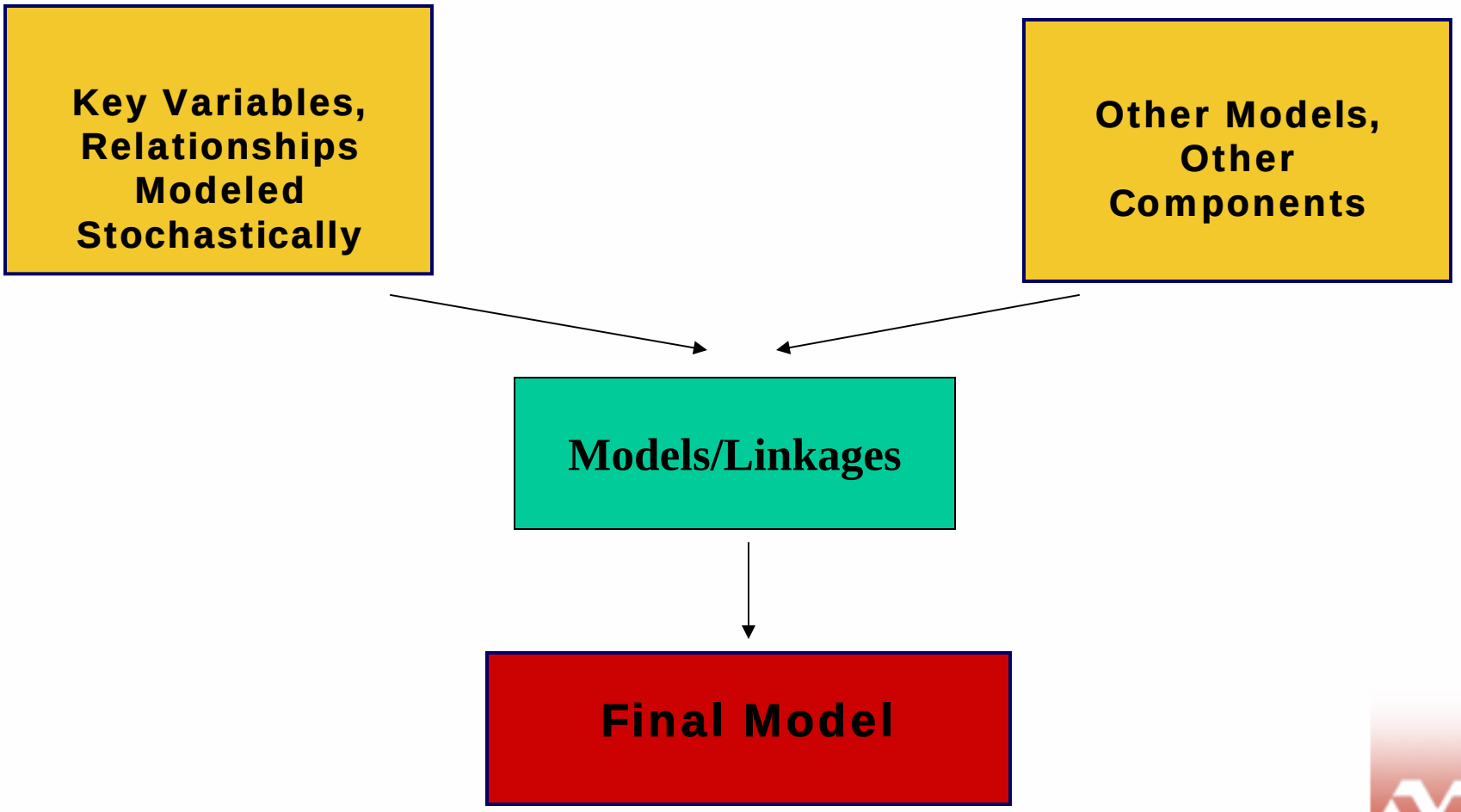
Construct different models for different parts

of the process

- A simple short-term stochastic model may be better for departmental budgeting than a more complicated proportional model constructed for long-term capital planning
- Model key variables/relationships stochastically; then other models of various types might be developed to incorporate various complexities
- ST/MT/LT models can be linked in a unified framework

"Triangulation" – reconciliation of methods, approaches

Framework for Modeling



Framework for Modeling

- Literature searches (Ageline, Medline, PubMed, FFC Proceedings, Harvard Business Review, forecasting and business journals, etc.)
- Methods reviews
- Software reviews (Forecast Pro, E-Views, SAS ETS, etc.) – Airline Model (airline passenger growth
- Expert discussions
- FFC/GWU Brown Bag Seminar
- Consultations, Collaborations
- “Triangulation” of methods, approaches

Health Care Forecasting

Rick's Slides

PURPOSE:

- DESCRIBE CURRENT SITUATION
- DISCUSS CURRENT THINKING
- COMMENTS AND SUGGESTIONS

CURRENT SITUATION

- Congress and VA/VHA Senior Management: Annual forecasts of enrollees and patients for 20 years
- Provided by actuarial contractor
- Contractor applies a detailed “chain-ratio” type forecasting model based on a detailed understanding of the VHA business

CONTRACTOR RESULTS

FISCAL YEAR	ENROLLEES ACTUAL	ENROLLEES FORECAST	ERROR	PATIENTS ACTUAL	PATIENTS FORECAST	ERROR
2001				3,843,832	3,607,845	**(235,987) (6.14%)**
2002	6,788,780	6,627,913	**(160,867) (2.37%)**	4,246,084	4,317,127	**71,043 (1.67%)**
2003	7,186,644	7,350,999	**164,355 (2.29%)**	4,493,503	4,673,503	**180,000 (4.01%)**
2004		7,632,416			4,701,689	

CONTRACTOR APPROACH

- Based on a chain ratio type approach that relates causal variables to a dependent variable with increasingly more detail.
- The approach demonstrates both a comprehensive and detailed conceptual understanding of the business and its drivers.

CONTRACTOR APPROACH: KEY ISSUES

- Quickly describing the model, other than in broad terms, is difficult due the the level of detail.
- Will more powerful statistical techniques that are conceptually simpler and more sensitive do a better job of short term forecasting?
- Will the ratios used in the Contractor model pick up longer term cyclical trends?
- What approaches are available for forecasting 5, 10, 15, etc years into the future?

SHORT TERM FORECASTING CURRENT THINKING

- CASE STUDY (1985): At GE the VP of the Electric Motors Business Requested short term (1 yr) forecast of motor sales.
- THE BUSINESS: Sells electric motors that range in size from fractional horsepower to over 1000s of horsepower. They're sold to manufacturers of toothbrushes and large turbine generators.

FORECASTING STRATEGIES

1. To reduce variation in the data on Motor Sales, sales were segmented by end user. For example smaller electric motors are sold to compressor, blower and fan OEMs. These OEMs are impacted by a different sent of economic factors than other smaller or lager OEMs serving different end markets

FORECASTING STRATEGIES

2. Short term forecasting techniques were characterized as:
   - Chain ratio
   - Econometric (forecasting sales based on the relationship of sales to controllable and/or uncontrollable variables; these were mostly macro-economic variables as opposed to variables describing individual decisions.
   - Time Series (forecast sales based on past sales)

APPROACH

	PARAMETER ESTIMATION	
TECHNIQUE	OLS	SEARCH
TIME SERIES		
State Space		
Box Jenkins		
Moving Avg.		
Etc		
ECONOMETRIC		
Stepwise		
Stepwise + modeling error term		

Approximately 60 qtrs. of sales data. Forecast using a hold out sample of 4 qtrs. Select best model and forecast 4 qtrs. into the future.

RESULTS: THE DATA

Compressor, Blower, Fan Sales ($000)

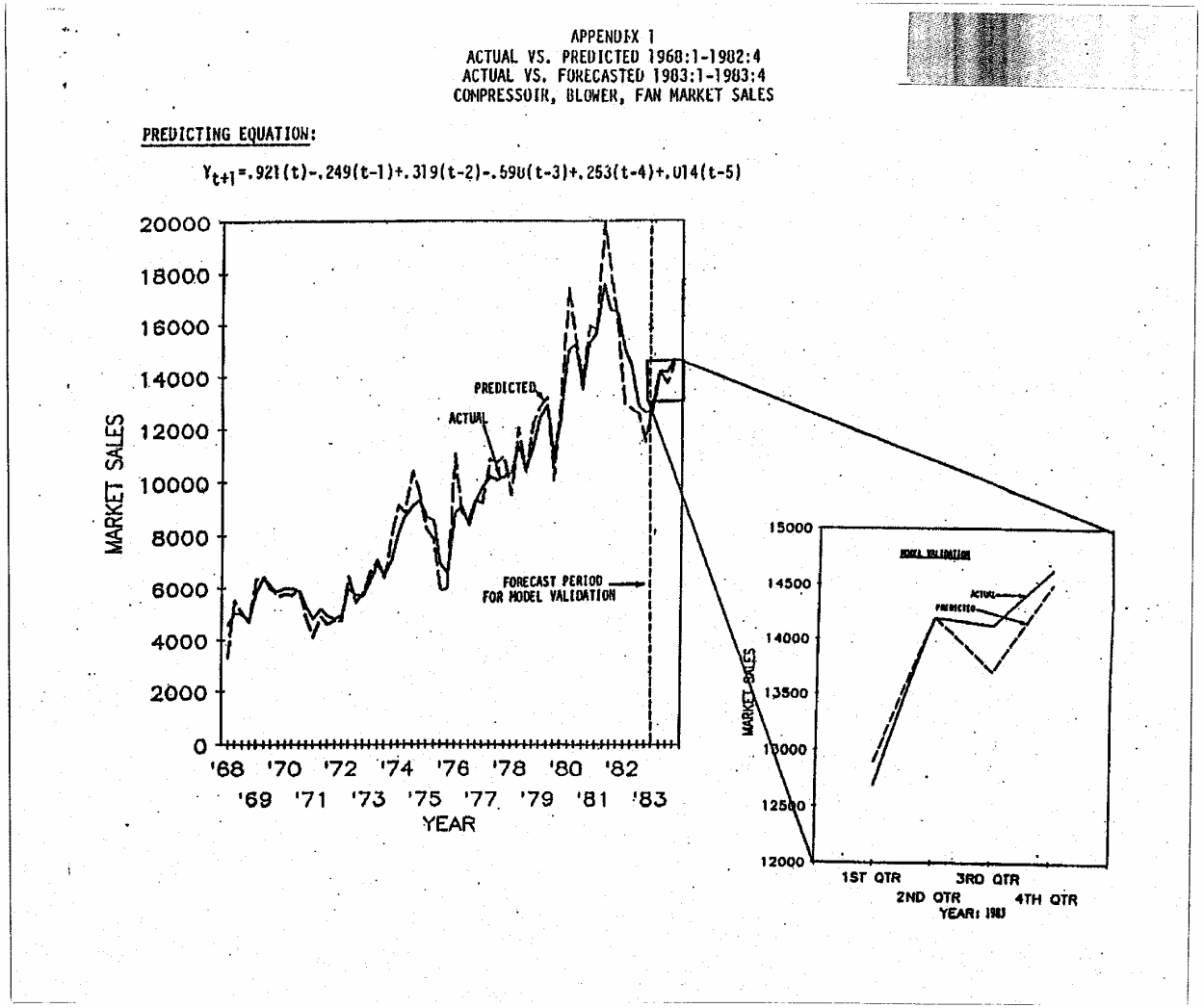
Yr:Qtr	Actual	Forecast	Error $% (Total)	MAPE
83:1	$12,693	$12,895	+$202	1.60%
83:2	14,192	14,195	+3	.02%
83:3	14,124	13,698	-426	3.01%
83:4	14,625	14,485	-140	.95%
Total	$55,634	$55,273	-$361	1.39%

MCS forecasted sales for 1984:3 - 1985:4

Compressor, Blower, Fan Sales ($000)

Yr:Qtr	Forecast
85:1	$13,937
85:2	14,899
85:3	14,526
85:4	14,852
Total	$58,214

RESULTS: GRAPHICAL



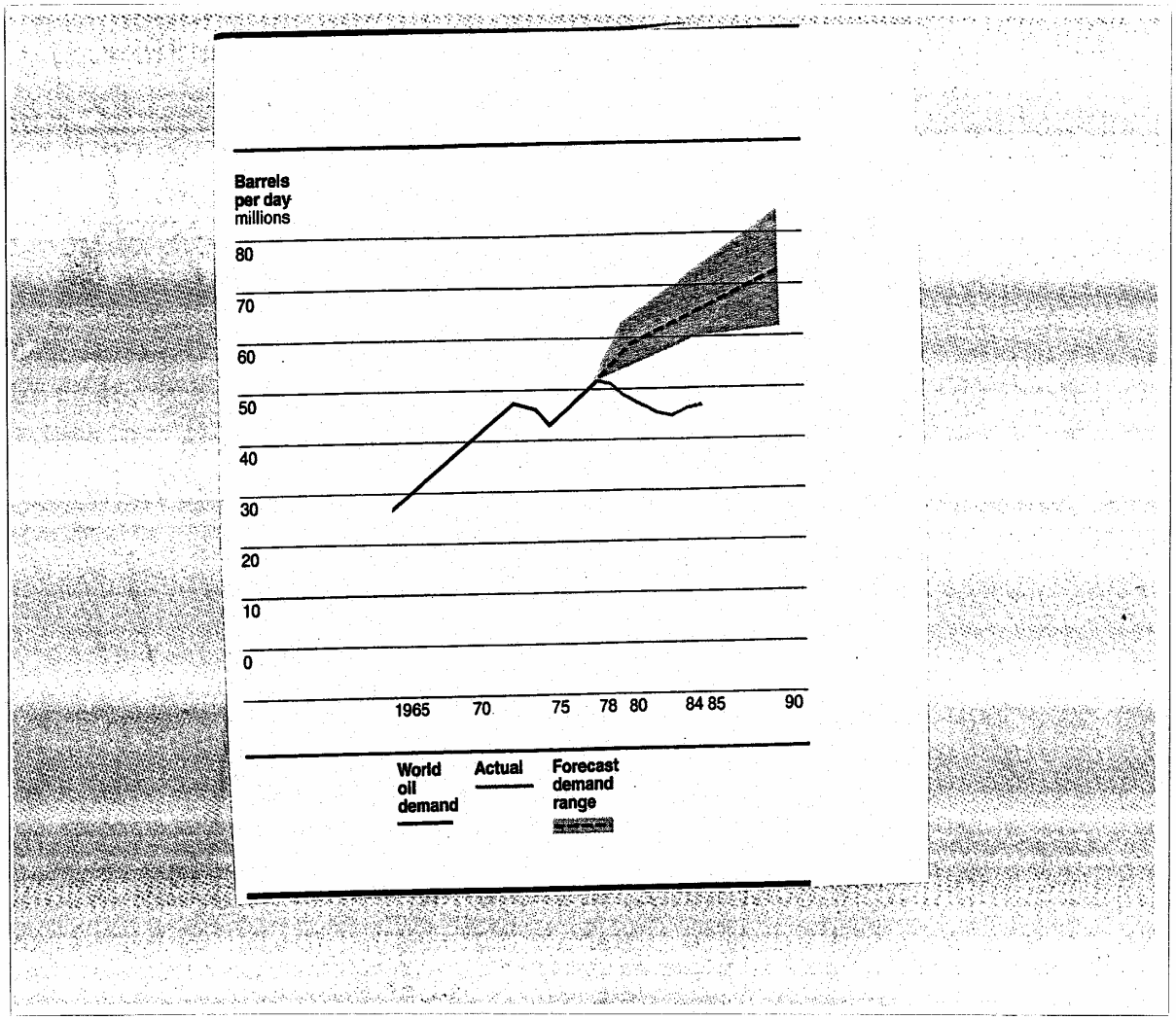
LONG TERM FORECASTING:

CURRENT THINKING

LONG TERM FORECASTING: CASE STUDY

- **CASE STUDY**: In the 1960s and early 1970s Royal Dutch Shell developed a scenario based planning/forecasting concept. (Harvard Business Review article, published Sept-Oct 1985 "Scenarios: Uncharted Waters" pg 72.)
- **RESULTS:** Shell was able to forecast the extent and timing of the 1973 and 1981 world oil disruptions.

COMPILATION OF VARIOUS OIL FORECASTS FOR THE RELEVANT PERIOD OF TIME



CASE STUDY (cont.)

- There focus was to quantify trends in the effects of uncontrollable variables on the world supply and demand for oil to the year 2000.
- They defined the key players: supplying countries, companies and consuming countries.
- For example utilizing country experts 15 year forecasts were made for each oil supplying country's oil reserves and their need and ability to spend oil income productively. Key measured concepts included
  - Production motivation
  - Take motivation
  - Absorptive capacity

CASE STUDY (cont.)

- Oil consuming countries growth in imports were analyzed; including
  - Oil demand by market class
  - Implications for high oil prices for each nations balance of payments and inflation
  - Possible reactions of governments to high oil prices
  - Construction of refinery, marine and market facilities.

Health Care Forecasting

Health Care Forecasting Methods

Health Care Forecasting Methods

- Some FFC papers are relevant to the discussion: FFC Proceedings 1988-2003
- See http://www.federalforecasters.org
- See 1992 FFC Proceedings, Session: Developments in Forecasting

Health Care Forecasting Methods

- Use univariate time series forecast methods to forecast patients one or two years, say, at the national level, and see how good or bad the forecast is
- How might a successful simple forecasting model be extended to include a variety of complexities

Health Care Forecasting Methods

- John J. Hisnanick, *Forecasting the Demand for Inpatient Services for Specific Chronic Conditions* (Journal of Medical Systems, Vol. 18, No.1, 1994)
- John J. Hisnanick, *Using an ARIMA Model in an Unconventional Setting: Forecasting the Demand for Inpatient Hospital Services*, FFC Proceedings, 1992, award winner in Best Paper competition

Health Care Forecasting Methods

- Modeling methods proven in forecasting gross national product, crop yields, and livestock production are, in many cases appropriate to the issue of addressing demand for health care services.

- Traditional econometric models along with univariate time series methods such as Box-Jenkins Auto-Regressive Integrated Moving Average (ARIMA) models have considerable appeal to predicting future hospital or outpatient care usage.

- These methods also allow for statistical testing of model accuracy and validity.

- There is considerable potential for incorporating conceptual complexity, explanatory detail, and variance minimization into health care related forecasts based on traditional econometric and time series methods.

Health Care Forecasting Methods

- Time Series
  - Composed of three parts: a trend component, a seasonal or cyclical component, and an irregular or random component
  - Stationarity – invariance with respect to time; fluctuations centered around a mean
- Univariate time series method: Box-Jenkins Auto-Regressive Integrated Moving Average (ARIMA)
- The Forecasting Process – 6 Steps:
  - Define the forecasting problem
  - Collect and prepare the data
  - Select and apply a forecasting method
  - Review and adjust the preliminary forecast
  - Track forecast accuracy
  - Update the forecast

Health Care Forecasting Methods

Within the context of our discussion, a univariate time series

- has a specific temporal ordering
- is assumed to be generated by a stochastic process with a structure that can be characterized and described as such
- is composed of three parts: a trend component, a seasonal or cyclical component, and an irregular or random component
- the trend component represents the long-run movement in the time series
- the seasonal component repeats itself over some time period
- the irregular or random component reflects non-systematic movements that occur in the series

Developing a forecasting model that accounts for these effects can be quite involved but not impossible

Health Care Forecasting Methods

One major question before selecting a model: is the time series stationary?

Stationarity: an important characteristic of a stochastic process, implying the time series is invariant with respect to time, and wanders more or less uniformly about some fixed level (mean).

Ways to assess stationarity:

- Look at a graph of the time series
- Look at a plot of the auto-correlation function (ACF) to see how the series is correlated to itself over time
- A non-stationary series can be made stationary by differencing and relating to the ACF; the number of times differenced is the “order of homogeneity”

Health Care Forecasting Methods

ARIMA Models

- Auto-Regressive Integrated Moving Average (ARIMA)
- A time series forecasting model can be autoregressive in form (a function of previous values of the series), or moving average in form (a function of previous error values from forecasting, i.e., the moving average terms), or both (ARMA). If the original series is also re-created from a differenced series (by a process of integration involving summation in the typical discrete environment) and one or more of the differences of the time series are include in the model, then the model is an ARIMA model.

Health Care Forecasting Methods

Complexities

Some complexities health care demand modelers often want to think about (see, e.g., James Fries papers).

- Compression of morbidity (disability postponed, compressed into fewer years late in life) vs. (healthier lifestyles increasing morbidity and health expenditures late in life by increasing the number of years with chronic illness and disability)
- Compression of mortality (a given proportion of deaths occurs in a shorter age interval than before)
- Aging; veteran population aging as a group faster than general population; and prone to chronicity
- Transitions in disability
- Policy changes or impact of legislation
- Medicare/Medicaid reforms
- Geographic variation; socioeconomics, demographics
- Health care markets; they are local, vary widely, and are largely non-VA

Health Care Forecasting Methods

Before we go more into what we're doing or have done, let's discuss software …

Health Care Forecasting

Software

Software

- Software packages
  - ForecastPro
    - ForecastPro Standard
    - ForecastPro XE
    - ForecastPro Unlimited
  - E-Views
    - E-Views Full Version
    - E-Views Student version
  - SAS Economic Time Series (SAS/ETS)

Software

- Free Fore
- Stata
- Statistica
- DecisionPro

Software

M-3 Competition

- Forecasting accuracy studies; can help reduce costs, provide better customer service
- M-3 Competition: held in 1997; sponsored by International Journal of Forecasting; 26 different approaches examined (19 academic forecasters and 7 commercial software packages) in preparing 3003 forecasts based on historic demand data; compared a range of forecasting techniques across a 3003 sample time series; accuracy was measured using a range of measures on a "holdout set"
- Experts provided the forecasts for their areas of expertise
- Forecasts were evaluated and compared with other experts as well as some simple methods/benchmarks
- *The M-3 Competition: Results, Conclusions, Implications*, Spyros Makridakis, Michele Hibon, International Journal of Forecasting 16 (2000) 452-476

Software

ForecastPro

- The most accurate for MAPE, all data, in M-3
- Expert model selection, with prompts for model improvements
- Expert model selection based on state space models; person who wrote the program did dissertation on state space models
- Forecast XE's **Expert Selection** feature is the heart of this application and the most useful feature for nonstatistician users. This exceptionally easy-to-use option works the same way an actual statistical analyst would, performing a series of statistical tests, interpreting the results, performing additional tests if necessary, and making recommendations based on the findings.

Software

ForecastPro

- **Expert Selection** begins by analyzing the data. Once that analysis is completed, it generates an audit trail -- a report that shows the various mathematical methods the program has applied to the data, what the level of error is likely to be, the final choice of statistical modeling method, and the forecasted results.
- Once the audit trail is complete, you can switch to a graphical view of the forecast. The graphed data appears as a line chart with clearly differentiated lines for historical data, projected data, and upper and lower confidence levels. The user can define the confidence levels, which are meant to give an acceptable range of deviation. They indicate the probable best-and worst-case scenarios in the event that your actual results deviate from the projection.
- You can test the accuracy of your projection model by creating a "holdout." In a holdout, the user gives Forecast just a subset of the total data set and asks the product to project for the data that was held back. In this way you could coax the program into calculating "projections" that could then be compared to the actual results of the same period. A graph would clearly display actual performance vs. what Forecast Pro would have predicted for that period of time. This excellent feature allows users to test their data models. If Forecast's projection differed wildly from the actual results, you would know that some hidden causality, such as a labor strike, needed to be built into the data model.

Software

M-3 Competition Conclusion:

Statistically sophisticated or complex methods do not produce more accurate forecasts than simpler ones (although they can better fit a model to the available historical data).

Health Care Forecasting

Initial VHA Forecasts

Initial VHA Forecasts

- Use univariate time series forecast methods to forecast patients one or two years, say, at the national level, and see how good or bad the forecast is
- How might a successful simple forecasting model be extended to include a variety of complexities

- Outline some of Carl's work
  - monthly patient data
  - books, literature, software reviews
  - ForecastPro Class
  - Macro data
  - Etc.

Health Care Forecasting

More Forecasting Methods

More Forecasting Methods

- Box-Jenkins Auto-Regressive Integrated Moving Average (ARIMA)models
- Atheoretical, non-model, quantitative forecasts
- Naïve extrapolative procedures vs. more formal models
- Allows the data to drive the model
- Characteristcis of the data (ACS, PACF, etc.)
- Multiple techniques: judgment, scenarios, etc.
- Combine forecasts?

More Forecasting Methods

- Structural Models: Harvey Model (Harvey and Peters, 1990)
- Harvey Models are a general class of models that handle trend and seasonality and can be represented in state space form.
- Automation of model selection, expert systems
- Univariate models (Box-Jenkins)- back to regression
- Forecasts with limited comprehension vs. forecasts with violated assumptions
- Harvey Model: combines time series and structural models
- Similar to Cointegration Techniques
- E.G., P. Young FFC papers

More Forecasting Methods

- Geographic Variation
- Single equation time series of regression?
- Usually do not use interrelationships across geographic areas
- Each area is treated as a separate equation independent of the others
- Thus, differences in economic and demographic variables across geographic areas are also ignored
- Neural networks, based on clustering algorithms may exploit geographic interrelationships
- But they are “black box”, no explicit model
- Neural networks are very general and complementary to stochastic methods
- E.G., Arababi, et al, FFC paper

More Forecasting Methods

Long-Term Forecasts

- Mega Trends
- Analogies
- Scenarios
- Etc. (Delphi methods, etc.)

More Forecasting Methods

The Future of Forecasting Methods

- Combining ST and LT forecasts……..
- E.G., see Joutz FFC papers

More Forecasting Methods

The Future of Forecasting Methods (Cont'd)

- Cointegration Techniques
- Error Correction Models (ECM)
- Short-Run vs. Long-Run Models
  - Short-Run: demand as a function of seasonal or relatively rapid changes
  - Long-Run: demand as a function of relatively slow changes, like demographics, or income
  - Unified (merged) models vs. separate models
- ECM framework (short-run/long-run, as subsets of unified)
- E.G., see Joutz FFC papers

Health Care Forecasting

Forecast Evaluation

Forecast Evaluation

How good is the method?

Are the forecasts biased?

Is one method better than another?

Does one forecast contain info not available in another?

(See Stekler, FFC)

Health Care Forecasting

Where Next

Health Care Forecasting Methods

Where Next?

Feasibility Analysis

Health Care Forecasting

Selected Bibliography

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Health Care Forecasting

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