

STRESS TESTING STATE BUDGETS UNDER ALTERNATIVE BUSINESS CYCLE SCENARIOS

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Introduction

Recent press releases chronicle the dire fiscal conditions faced by most states as they anticipate future budget decisions. Dadayan and Boyd (2009) report record drops in tax revenue. They describe the worst conditions for budget deliberations since 1962 when the Census Bureau first began reporting state tax revenues. If historical patterns persist, states will continue to suffer budgeting challenges even though the National Bureau of Economic Research (NBER) might officially declare that the national recession has ended. Budget challenges will be especially acute if sluggish labor markets and banking sector stress continue to retard sales and income tax revenue growth.

Garage (Forthcoming) identifies a recurrent pattern of state fiscal crises. He describes how states often raise rates or broaden tax bases during recessions in order to finance state government commitments that were made previously during more prosperous times. After the economy finally begins to grow, states gradually feel budgetary relief as tax revenues slowly recover. Eventually, the higher rates and broader bases generate significant increases in tax revenues. State budgets then expand with the greater revenue resources of boom economic conditions. These new and often larger commitments inevitably contribute to higher levels of budgetary stress once the economy again lapses into recessionary conditions. When eventual recessions reverse revenue growth and increase expenditures required by health and welfare mandates, the resulting budget deficits challenge state officials to find new revenue sources and cut expenditures.

States wisely attempt to anticipate fiscal challenges by augmenting their two-year official budgetary process with long-run planning. Because the revenue and expenditure forecasts needed for this type of analysis are very imprecise, a framework that includes the risk and uncertainty that characterize revenue and expenditure estimates can potentially improve the budgeting process. Associating revenue and expenditure estimates with probability distributions can help state legislative and executive branch officials understand the growth and uncertainty that characterizes their revenue and expenditure forecasts.

Long-run state fiscal planning first requires economic forecasts. Subsequently, expected revenues and expenditures are calculated conditional on these forecasts. This process creates a challenge because future business cycle patterns are unknown. The variety of ways revenues and expenditures react to business cycle patterns compounds with macroeconomic uncertainty. A model of revenues and expenditures that are driven by the economy allows simulations that test the robustness of given budgets to alternative business cycle patterns. These stress tests meter the effects of potential macroeconomic fluctuations on expected revenues and expenditures. By simulating a variety of potential business cycle outcomes, one can assess their impact on state budgets.

Simulation based stress tests offer state government budget management officials a very insightful tool that allows them to investigate the viability of current and proposed revenue and expenditure policies. If stress tests reveal that the status quo is not sustainable, then the proposed methodology provides a vehicle to analyze possible tax and expenditure changes. Fortunately, the stress testing models can be implemented using readily available software and data. Spreadsheet add-in simulation software generates understandable conclusions whose graphical summaries clearly communicate the implications of future state fiscal decisions.

State Budgeting Model

Holcombe and Sobel (1997) emphasize the importance of including both the expected growth rates and volatility of revenues and expenditures whenever conducting fiscal analysis. They further recommend measuring volatility relative to the business cycle. This allows state budgets to be modeled using concepts popularized by Sharpe (1963) in securities and portfolio analysis. The traditional tax elasticity can then map the business cycle into revenue and expenditure streams that are useful for budget analysis.

The three main parts of the simulation model outlined in Figure 1 include revenue and expense growth and volatility. The first part of the model gives the conditional probabilities of entering and exiting recessions. This assigns a state of the economy, expansion or recession, to each quarter in the simulation. The second part specifies the probability distributions for growth rates given the expansion/recession state of the economy. Monte Carlo simulation takes random draws from the appropriate distribution to give an economic growth rate for each quarter in the simulation. The combination of business cycle probabilities and growth rate distributions determine the average duration and amplitudes of different phases of the business cycle. The third part of the simulation maps the economic growth rates into corresponding changes for taxes and expenditure. The model thus combines structural, cyclical, and idiosyncratic components into revenue or expenditure growth rates for each quarter.

Macroeconomic Patterns and Benchmarks

The first part of the model must simulate business cycle patterns. NBER analysis describes and dates business cycle trends at the national level. Leading, coincident, and lagging indicators establish the beginning and end of expansions and recessions. Because state business cycles don't always synchronize perfectly with national patterns, an alternative is needed to compare state business cycles with each other. Fortunately, the Federal Reserve Bank of Philadelphia publishes a monthly coincident index for each of the 50 states, which provides a means for consistent macroeconomic measurement across state borders.

The Philadelphia Fed coincident indicator is useful for evaluating the potential influences on total state tax receipts and expenditures by first considering the historical growth and volatility of the US economy. The data graphed in Figure 2 give the year-over-year growth rate in the Philadelphia Fed coincident indicator for the US economy. The three recessions shown vary significantly in their severity and duration. According to NBER business cycle dating protocol, a very brief and mild recession began in July 1990

and ended in March 1991. Once vigorous growth began, the economy accelerated into the longest post World War II expansion on record.

Similarly, another brief and mild recession began March 2001 and officially ended in November 2001. In contrast to the previous business cycle, the economy did not recover rapidly after the end of the recession. In reflection of the large emphasis on labor market conditions in the Philadelphia Fed index, the graph shows that a jobless recovery continued almost two years after the recession officially ended.

The present recession that began in December 2007 is noteworthy because of its depth and length. The coincident indicators didn't fall below the previous year until a few months after the NBER's initial date. The depth of the fall is the worst since the Great Depression. Because of the prominent weighting of labor markets in the index, the coincident indicator reflects the millions of jobs that have been lost since the beginning of the recession. The depth of the decline makes economists pessimistic about the amount of time that it will take for labor markets to return to employment levels equal to those achieved during the previous expansion.

The variety of historical patterns in Figure 2 illustrates general business cycle characteristics. First, the amplitude of the rates of change in the economy varies significantly from one business cycle to the next. Second, the length of the business cycle is also variable. Third, the rates of change depend on the state of the economy, expansion or recession.

Because both revenues and expenditures are dependent on the state of the economy, a simple probability formulation is needed to simulate the state business cycle. One approach assumes that a state's economy alternates between two situations, expansion and recession. These conditional probabilities are given by:

$$\begin{aligned} \text{Probability}(x | \text{expansion}) &= \begin{cases} p_e & \text{expansion continues} \\ 1 - p_e & \text{recession begins} \end{cases} \\ \text{Probability}(x | \text{recession}) &= \begin{cases} p_r & \text{recession continues} \\ 1 - p_r & \text{recovery begins} \end{cases} \end{aligned} \quad (1)$$

If the economy is currently in an expansion, then p_e signifies the probability that the expansion will continue. Likewise, when the economy is in a recession, then p_r represents the probability that the recession will continue.

Incorporating these conditional probabilities into a simulation allows the economy to move into and out of expansions and recessions during the planning horizon chosen for the stress testing model. Once the state of the economy has been determined, then the growth rates that are conditional on the expansion or recession phase of the economy can be determined. The modeling schematic in Figure 1 shows that once the state of the economy has been determined, the next step selects a growth rate from a probability distribution for potential growth rates.

The probabilities of recession and recovery and their corresponding growth rates can be either estimated empirically from historical data or specified subjectively by experienced analysts. For those who prefer to use expert opinion to specify a subjective probability distribution (Morgan, Henrion et al. 1990), simulation software provides a convenient way for such experts to calibrate the PDF's to match their personal judgments.

In the simplest approach, the expert simply gives estimates for the worse, best, and most likely outcomes. These three parameters fully specify the triangular and PERT distributions (Vose 2008). These two distributions, which are pictured in Figure 3, represent the probability distribution functions (PDF) for economic growth rates under the condition of an economic expansion. In the illustration, the expert has judged that the growth rates are greater than the minimum of 0 percent, less than a maximum of 10 percent, and have a most likely (mode) outcome of 3 percent. As shown in the graph, the simple triangular distribution possibly allocates too much probability to the upper tail. In order to maintain simplicity but overcome this upward bias, the PERT distribution was developed (Vose 2008).

Structural, Cyclical, and Idiosyncratic Budget Factors

Both government revenues and expenditures depend on the growth rate of the state economy. As revenues increase during the expansion phase of the business cycle, the resulting core-budget surplus usually remains manageable and predictable. Often this situation allows funding for one-time projects such as capital improvements and public infrastructure investments. In contrast, during business cycle downturns, potential deficits stress budget management as government programs must be pared or eliminated. In addition, business cycle downturns generate significant expenditure demands because employment, medical care, and general welfare mandates increasingly deplete state government financial resources.

Basic financial portfolio management gives a methodological foundation for relating revenue and expenditures to the business cycle. Sharpe (1963) applies the regression concepts of explained and unexplained variance to decompose individual stock market returns into two components: systematic and unsystematic risk. The systematic risk is explainable by equity markets in general. The nonsystematic or idiosyncratic risk is specific to a given company. Brooking, Triplett, and Wells (1989) cleverly apply this framework to state tax systems as they focus on alternative measures of growth and stability. Perdue (1992) further investigates the portfolio approach by comparing and contrasting absolute versus relative risk measures.

Braun (1988) lays the groundwork for quantitatively integrating the business cycle into the proposed stress testing methodology. Holcombe and Sobel (1997) astutely establish the need "to measure variability related to the business cycle, rather than variability in general." They explain the differences between long and short run elasticities and propose estimating short run elasticities using the equation

$$r_{i,t} = \alpha_i + \beta_i y_t + \varepsilon_{i,t} \quad (2)$$

where $r_{i,t}$ and y_t are continuously compounded percentage changes in revenue (expenditures) and aggregate economic activity. The $\varepsilon_{i,t}$ are traditional disturbance terms.

The formulation in equation (2) decomposes the growth rate of a given budget item (revenues or expenditures) into three components: structural, cyclical, and idiosyncratic. The constant or α_i is the structural growth rate. This rate occurs independently from aggregate economic activity. This rate depends on factors such as demographic and political influences that cause secular trends in revenues and expenses for reasons unrelated to the business cycle.

The second or cyclical factor meters the cyclical sensitivity of each budget component to the business cycle. Potential measures for the business cycle include such macro aggregates as coincident indicators, gross state product, personal income, or total nonagricultural wages. Since β_i measures the percentage change in each revenue or expenditure source relative to the state economy's growth rate, it is an elasticity. When $\beta_i > 1$, the component is more volatile than the economy and when $\beta_i < 1$, the component is more conservative than the economy.

The third growth factor or the idiosyncratic $\varepsilon_{i,t}$ subsumes random, unpredictable events and reactions that affect revenues and expenditures. This includes geopolitical events that impact state economies but which cannot be anticipated. Because they are not predictable, this factor has an expected value of zero and the corresponding standard error of estimate is an average unexplainable deviation.

Revenue

Dadayan and Boyd (2009) describe the most recent iteration of the boom-bust pattern in state finances. Figure 2 superimposes the year over year growth rate for total state tax revenue on the business cycle graph. This diagram shows that after the 2001 recession, state revenues slowly improved because of a retarded labor market recovery. By 2005, revenues were growing by 10 percent annually. The unusually high growth rate of 2005 moderated to average growth in 2006. Revenues grew more slowly until 2009 when they plummeted by record amounts. The Bureau of Census reported a 16.6% decline in state tax revenue from the second quarter of the previous year.

State budget officials may not experience relief from the recent revenue declines for two principal reasons. First, analysis of the first two recessions shown in Figure 2 reveals that the Philadelphia Fed coincident index continues to decline beyond the NBER terminal date for the contraction. Because the coincident indicators emphasize labor markets rather than aggregate economic growth, protracted labor market weakness can continue past the official end of the recession. This suggests the possibility that tax revenues might lag behind general national economic growth. Even though many think that the national recession has ended, the anticipated weaknesses in the labor market could depress tax receipts for another two years.

The second reason for continued near term budgetary distress focuses on the first two quarters of 2009. The plummeting rate of decline in tax revenues has begun to exceed declines in state economies. This contrasts with the previous two recessions which saw revenue decline at a slower rate than the economy.

The information in Table 1 decomposes these historical revenue patterns for the period 1997- 2007 into structural, cyclical, and idiosyncratic components. As mentioned, the intercept terms gives the average structural growth in revenues during the sample period. This means that total state tax revenues average 3.2% per year, regardless of macroeconomic trends. The second shows that the state portfolio of taxes is less volatile than the economy. When the economy grows by 1%, total tax revenues only grow by 0.9% per year. In recessions, a symmetrical effect occurs since a 1% decrease in the economy only causes a 0.9% revenue decline. The combination of structural and cyclical components explains 44.6% (R-Squared) of the variation in tax revenues. This means that although the idiosyncratic component averages zero, its standard error of 2.8% accounts for random effects that are unexplainable by business cycle trends.

Expenditures

Annual revenue and expenditures are compared with the business cycle in the time series graph shown in Figure 4. Contrary to popular opinion, expenditure growth didn't match the high revenue growth rates of the recovery that began in 2002. Because timely Bureau of Census data has not yet reported outcomes beyond 2007, it is difficult to conclude whether the currently reported state budget deficits are caused by surging expenditures or solely by severely declining revenues. The data in the graph does give limited support to the conclusion that expenditures are less volatile than revenues. If this is true, then one can also conclude that deficits regularly increase during recessions and decline during expansions.

Stress test simulation models also require an analysis of historical and current expenditure trends. Similar to the variety of reactions to the business cycle manifested by tax revenues, state budget expenditures react uniquely to macroeconomic fluctuations. Application of simple regression once again gives estimates of the structural, cyclical, and idiosyncratic growth components. The interpretation of these statistics is similar to that in the revenue analysis. Unlike the revenues, expenditures are not strongly related to the business cycle. The information in Table 1 shows that only 6.1% (R-Squared) of the variation in total state tax expenditures is explainable by macroeconomic effects. On average, total state expenditures show 6.3% structural growth. State fiscal responsibilities associated with the business cycle cause expenditures to increase by approximately 0.2% whenever the economy declines in a recession. In comparison to revenue, the idiosyncratic or unexplained error is smaller than tax revenues. The simple regression result show only 1.6% as the standard error of the idiosyncratic component. These statistics give the historical benchmark needed to initiate budgetary stress tests.

Budgetary Stress Tests

In a recent *Wall Street Journal* article, Indiana Governor Mitch Daniels (2009) identifies the pressing challenges of current state government finances. He speaks of the short term focus in most state governments who face the immediate challenge of

balancing the budget. He points out the long run potential of facing a near permanent reduction in state tax revenues. He suggests that this will likely fuel a long run debate about raising taxes or reducing the size and scope of state government. Stress tests which model the interaction between the business cycle and state budget components could prove valuable in this debate.

Originally, stress tests were developed for financial management to identify weaknesses that would require management to rectify the identified risks. One possible remedy might then be to set aside enough capital to absorb potentially large losses. Sometimes, however, the size of this amount might so cripple the return on capital that alternative approaches might be necessary. Such alternatives might mean alteration of trading positions to reduce risk exposure. Such strategies would insure that the institution could ride out the turmoil. In other words, stress testing could help to guarantee the very survival of the institution.

Stress tests might serve a similar function for states who find themselves engulfed in the current budget crisis. In this case, the stress tests can help public officials ascertain if current revenues structures can support government financial commitments during a variety of future economic conditions. If the stress tests do answer such inquiries in the negative, then the simulations models can help investigate potential revenue and expenditure alteration that will allow states to meet their statutory obligations to balance their budgets.

Stress Test Simulation Results

To illustrate the potential value of stress tests, consider the following three simulations. The first, shown in Figure 5, reports the results of a model that uses the estimated total revenue and total expenditure parameters for the structural, cyclical, and idiosyncratic components given in Tables 1. In addition, the stress testing process initially assigns a 10 percent probability of a recession when the economy is in an expansion. Similarly, the probability of a recovery from a recessionary economy is 50 percent. The diagram in Figure 5 depicts the mean budget surplus\deficit, a one standard deviation interval, and a 90 percent confidence interval that are based on one thousand replications of the simulation model. Each of the iterations in the simulation starts out with the budget in balance, as legally required in most states. This stress test shows that under the above assumptions, the status quo on average will not be sustainable during the simulated 5 years or 20 individual quarters. It is true, that some of the iterations result in budget surpluses. For the majority of the simulated outcomes for the current budget parameters, however, the budget suffers a deficit.

One proposal for solving the current budget crisis is to cut expenditures. The second stress test investigates the effect of cutting the structural growth rate of expenditures from 6.3 percent to 5 percent. The result shown in Figure 6 gives state officials hope that the current tax systems coupled with such budget cuts could lead to sustainable surpluses. Although the stress test does determine a significant chance that deficits would still occur, in this case, the majority of simulated outcomes result in a budget surplus.

The third stress test scenario investigates the possibility of altering the tax system in order to fix the current budget crisis. There are many ways that the tax base and rate structure could be manipulated to generate additional revenue. One approach would be to increase the portfolio weight of a highly volatile tax in the state's revenue portfolio. For example, a state could increase rates or broaden the base for its personal income taxes. This would increase the percentage of total revenue derived from income taxes. The resulting larger weight on the personal income tax would increase the cyclical risk of the revenue portfolio. Consider the graph shown in Figure 7 which reports a simulation that increases volatility from 0.9 to 1.5, as measured by the slope coefficient. The results indicate that this strategy could also fix the current state fiscal challenges. The more volatile revenue portfolio does generate significantly more revenue and hence surpluses. The significant number of quarters in which large numbers of budget deficits occur, however, should alert government officials to the potential challenges that are inherent in the increased riskiness of the tax portfolio.

Summary and Conclusions

If the recent forecasts of dire state fiscal conditions prove true, future state legislative sessions will devote significant and painful attention to budget balancing alternatives. The short run pressure to achieve budget balance by increasing taxes or decreasing base expenditures can sometimes divert attention from the long term implications of such policy decisions. The stress testing methodology proposed in this paper can help legislative and executive branch officials anticipate the consequences of their proposals.

In addition to the situations used as illustrations in this paper, the stress testing methodology facilitates the investigation of such questions as:

- How will current and future budgets perform in alternative business cycle scenarios? For example, what if the economy enters a phase of more prolonged downturns where labor markets lag even further behind the overall growth in the economy?
- What potential future budgetary effects could occur when altering the composition of the state's portfolio of revenue sources? Such changes could result from altering the rate and/or base of current taxes. It might also include new levies on previously untaxed economic activities.
- What expenditure categories are most important in finding budget relief?
- Which business cycle, revenue, and expenditure characteristics most strongly impact the current budget situation and influence potential solutions?

As legislators and governors grapple with budgetary issues, additional questions will undoubtedly arise. The stress testing framework can help analysts investigate such issues.

Luckily, the resource requirements for implementing Monte Carlo simulations are not burdensome. Seasoned analysts possess the wisdom, experience, and intuition to offer the subjective judgments that are needed to specify the probabilities and distributions in the models. Historical data exist to estimate the structural, cyclical, and idiosyncratic

characteristics of revenue and expenditure patterns. This estimation can be completed using simple regressions or more sophisticated econometric techniques. The actual Monte Carlo simulations of revenues and expenditures are greatly facilitated by using Excel spreadsheet add-ins such as *@RISK*®.

If Indiana Governor Mitch Daniels is correct, state governments will have no choice but to reset their budgets. The longer planning horizon possible through the models proposed in this paper should allow analysts to significantly and positively influence the upcoming budgetary debates by providing insightful analysis and forecasts. Such Monte Carlo modeling might minimize the future impact of the expanding and contracting phases of the economy that cause the regular and destabilizing boom\bust cycles in state budgets.

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Table 1
Total State Revenue
Non-systematic, Systematic, and Idiosyncratic Growth Components

Total	Structural (Intercept)	Cyclical (Slope)	Systematic Risk (R-Squared)	Idiosyncratic (Regression Standard Error)
Revenue	3.2	0.9	44.6	2.8
Expenditure	6.3	-0.2	6.1	1.6

Figure 1
Simulation Overview

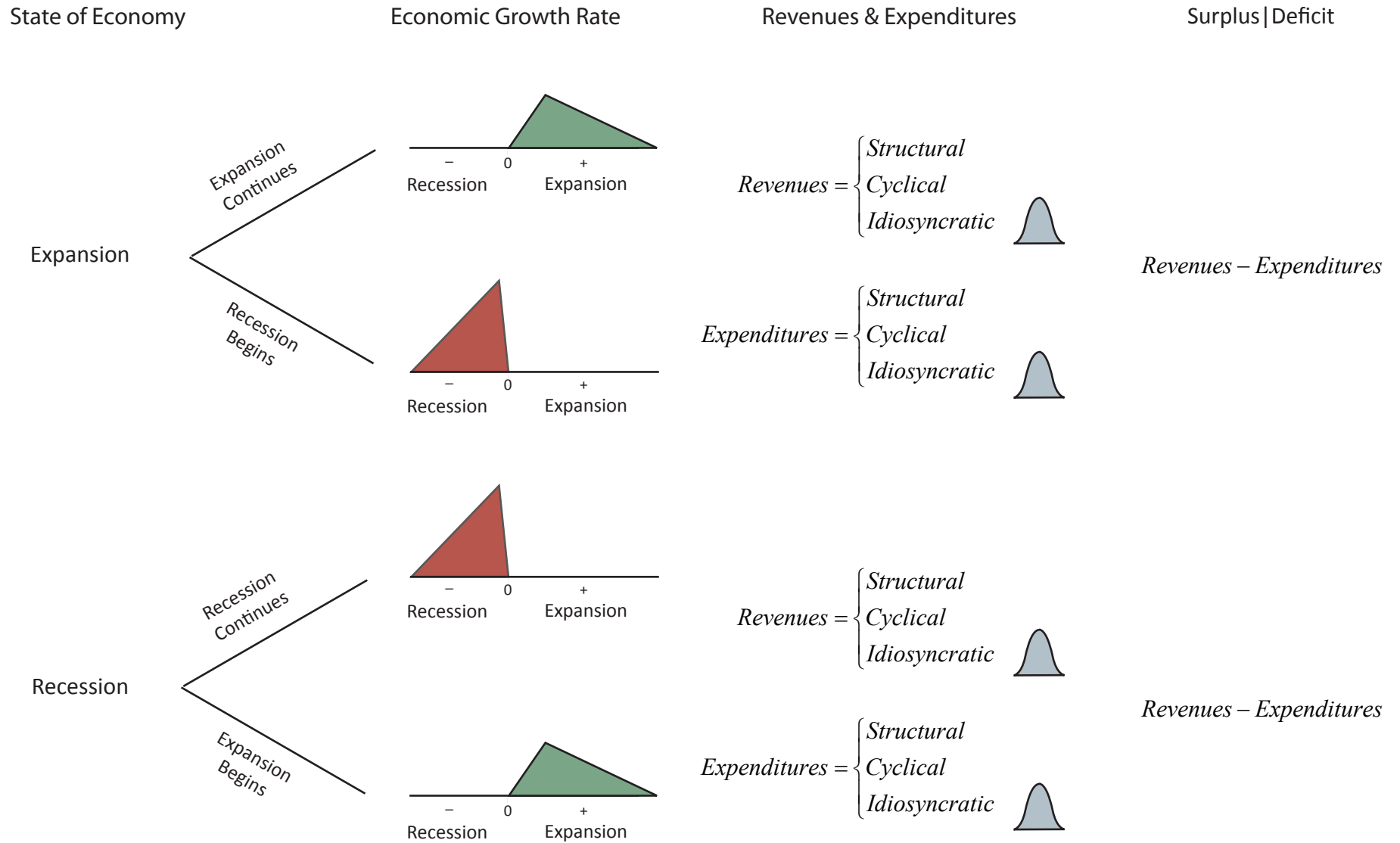


Figure 3
Possible Probability Distribution Shapes for Expansion
Triangular and PERT Distributions
Minimum = 0, Most Likely = 3, Maximum = 12

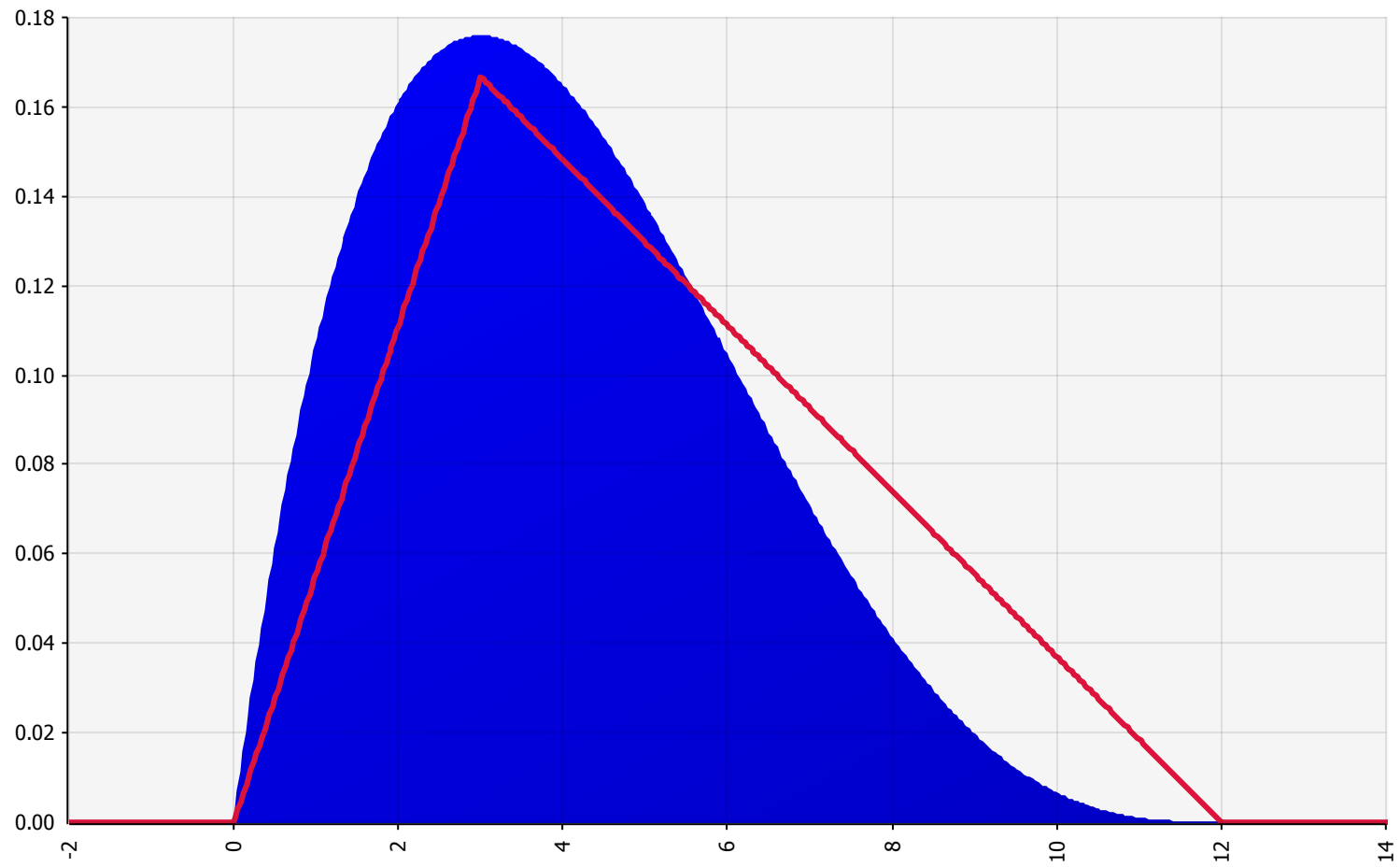


Figure 2
Total State Quarterly Tax Revenue
Year over Year Growth Rates

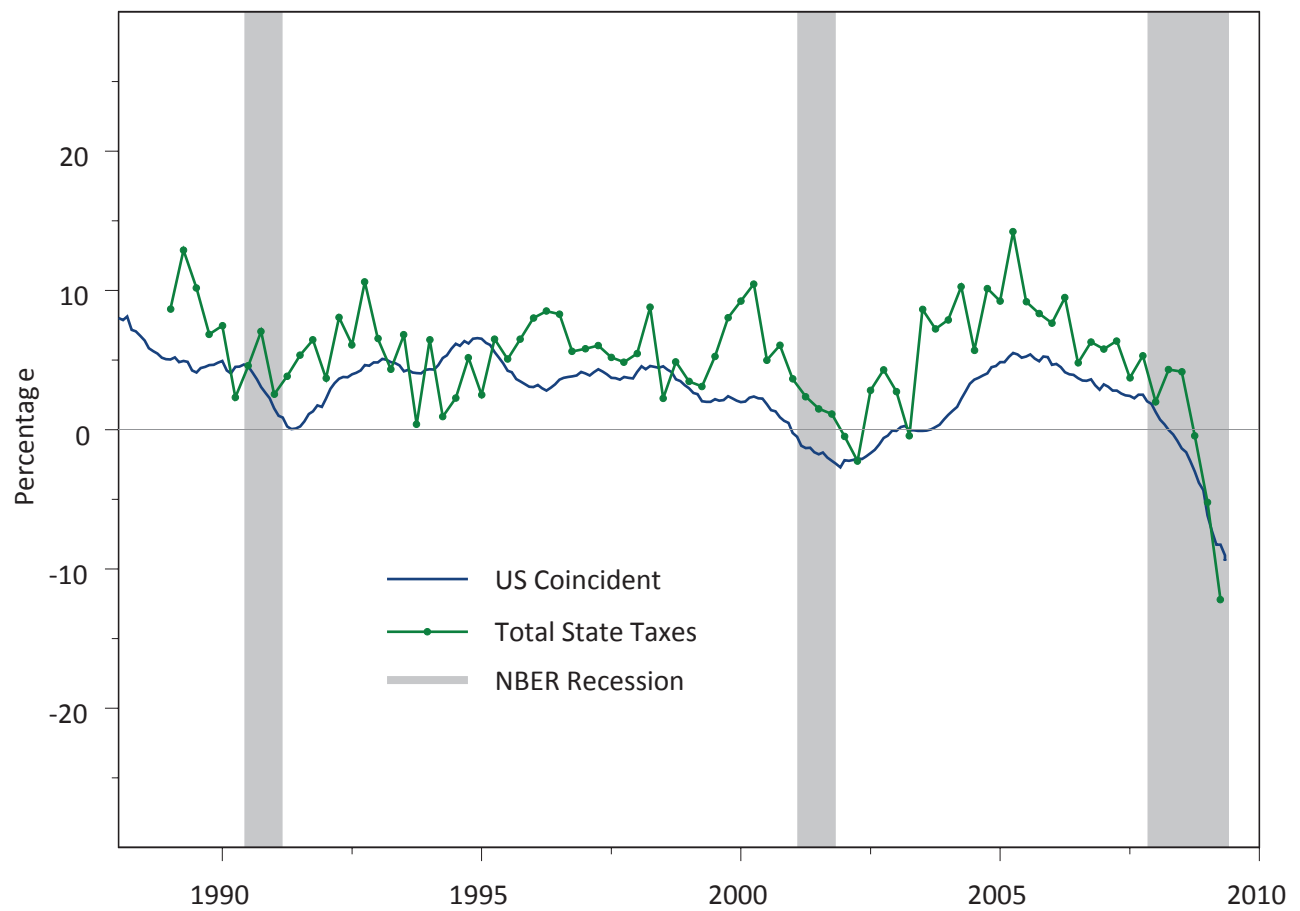


Figure 4
Total State Revenues and Expenditures
Annual Growth Rate

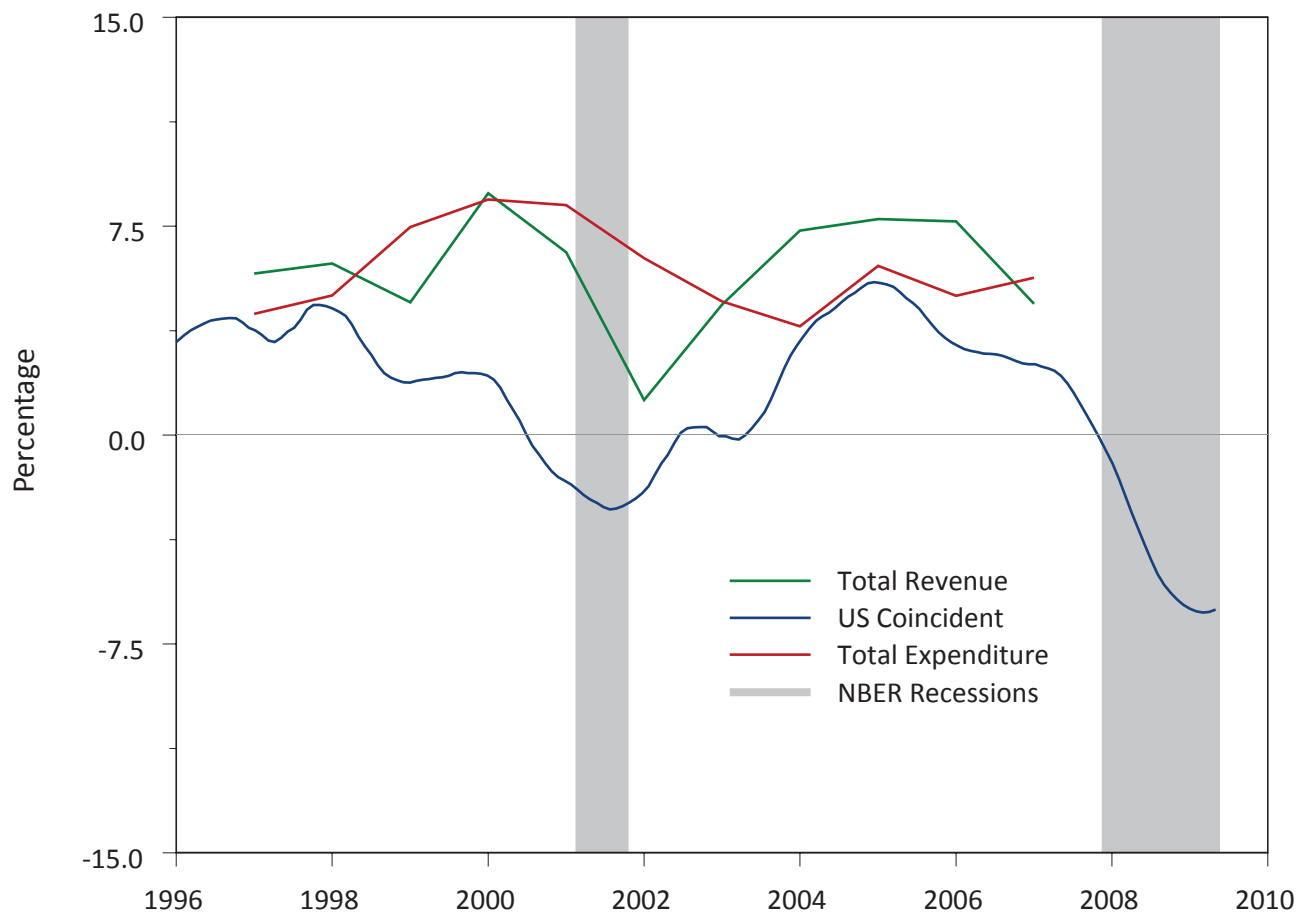


Figure 5
Budget\Surplus Stress Test
Current State Fiscal Conditions

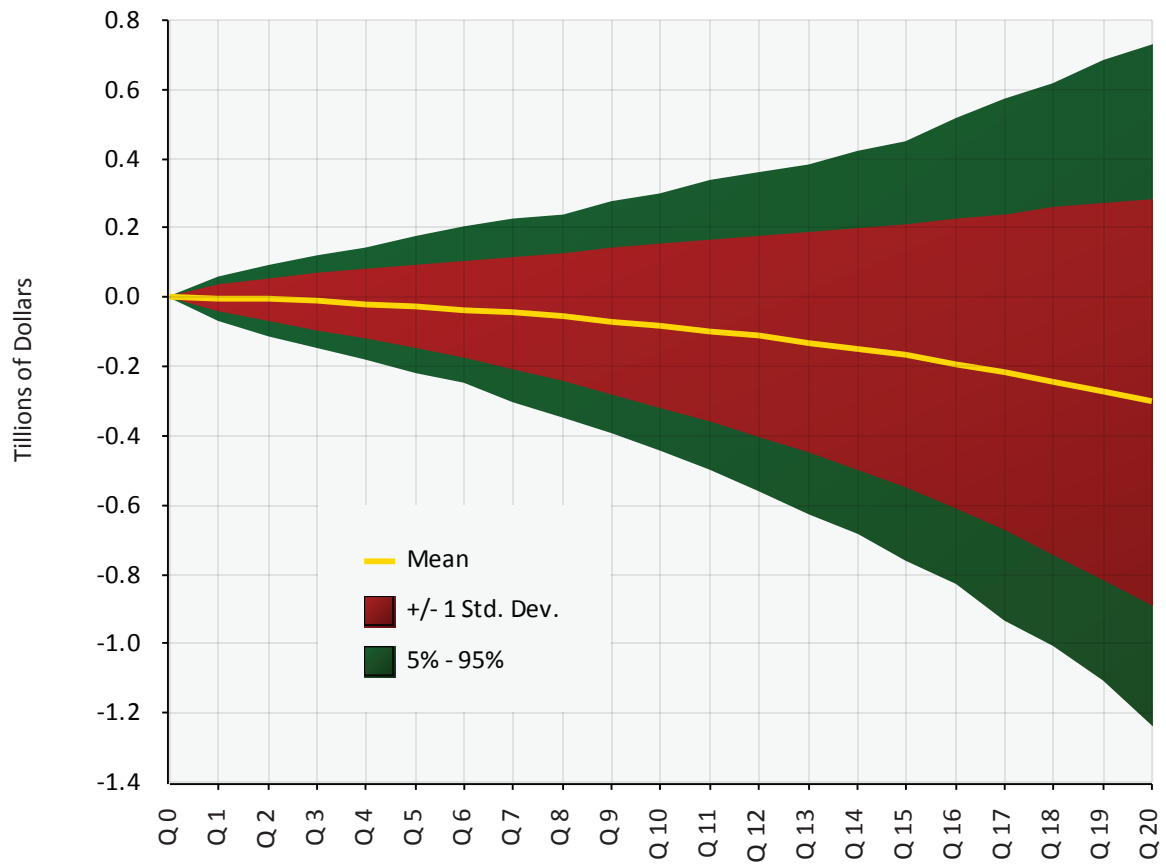


Figure 6
Budget\Surplus Stress Test
Decrease in Expenditure Non-Cyclical Growth from 6.3% to 5%

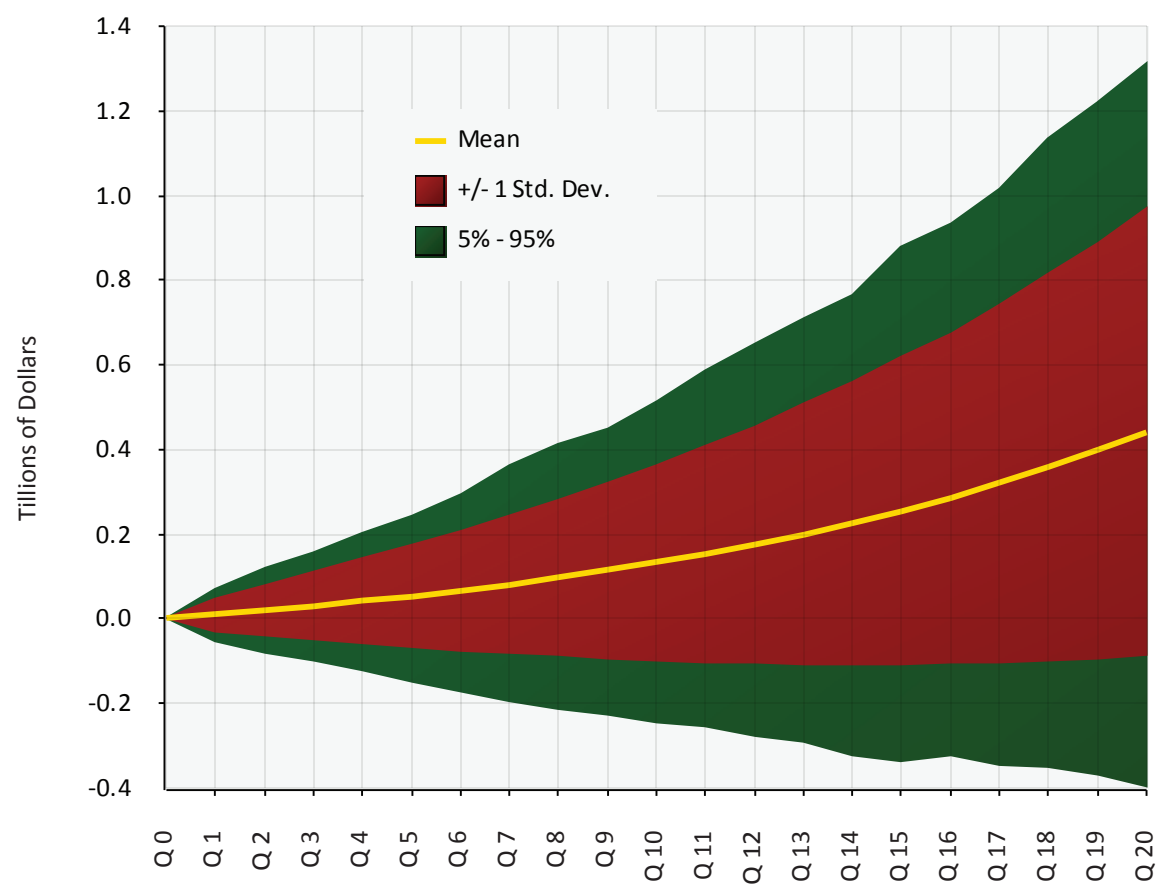


Figure 7
Budget\Surplus Stress Test
Increase in Total Revenue Volatility from 0.9 to 1.5

