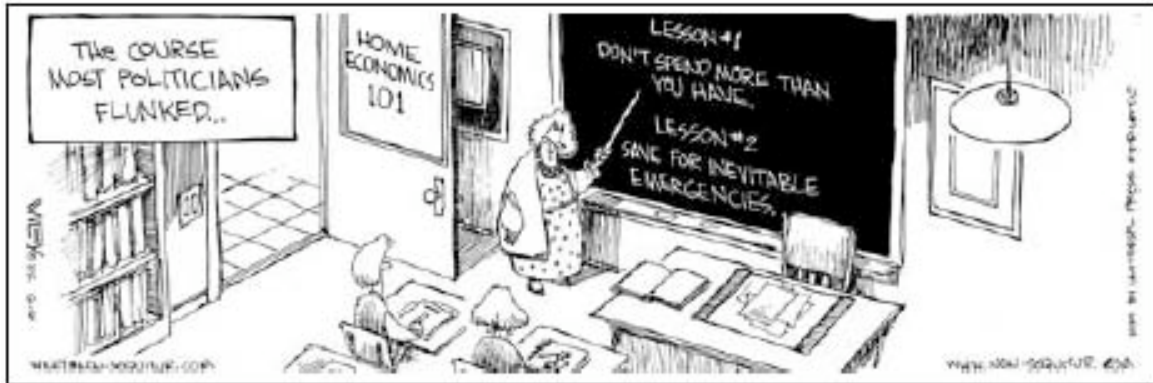


**STATE FISCAL MANAGEMENT:
WHAT PRACTITIONERS CAN LEARN FROM RISK MANAGEMENT THEORY¹**



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Abstract

In recent years, scholars have developed new financial tools that could help state governments cope more effectively with problems of structural balance and cyclical imbalance: Monte Carlo simulation, present value cash flow analysis, target budgeting, portfolio analysis, macroeconomic hedging, optimal cash balance models, etc. In this essay, we explain these tools and show how they fit together. For the most part, we rely on Oregon examples for expository purposes, but make every effort to show where and how our home state is idiosyncratic.

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STATE FISCAL MANAGEMENT: WHAT PRACTITIONERS CAN LEARN FROM RISK MANAGEMENT THEORY

At some level of generality, all entities face the same fiscal problems: solvency, liquidity, and resource allocation. For governments, solvency is largely a matter of structural balance; liquidity a matter of cyclical imbalance; and resource allocation a matter of the intimate details of taxing, spending and borrowing. Because state governments in America impose strict borrowing restrictions upon themselves and cannot print money, their fiscal problems are somewhat *sui generis*. For state governments, the devil lies less in the details than in an inability to prevent or prepare adequately for imbalances resulting from the vicissitudes of the business cycle.

In recent years, scholars have developed new financial tools for the management of risk that could help state governments cope more effectively with the fiscal problems they face. In this essay, we explain these tools and show how they fit together. For the most part, we rely on Oregon examples for expository purposes, but make every effort to show where and how our home state is idiosyncratic.

Business Cycles

An understanding of the problem of state fiscal balance begins with the dynamics of business cycles. Figure 1 illustrates the basic phases of business cycles: expansion, peak (or boom), contraction, and recessionary trough. In reality, the durations of business cycles are irregular and their magnitudes vary, as shown in Figure 2. A second reality is that, despite cyclical swings, real output has grown at a fairly steady rate in the United States, as is also shown in figure 2, and in most other industrial nations as well.

Figure 1: Hypothetical Business Cycle Dynamics

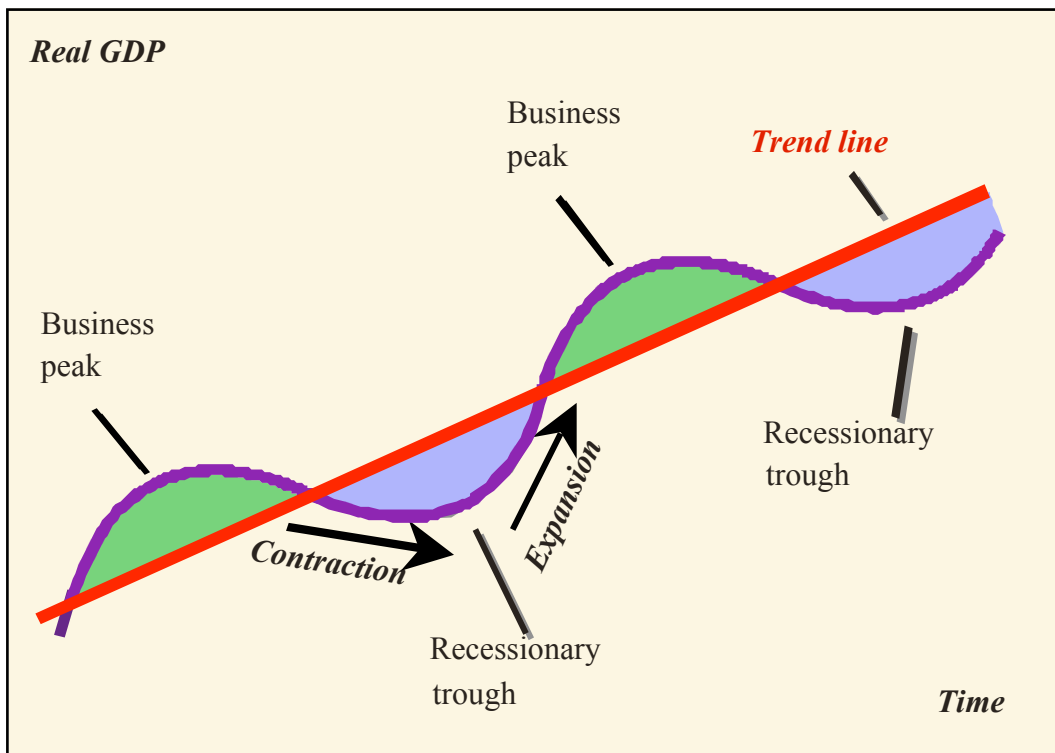
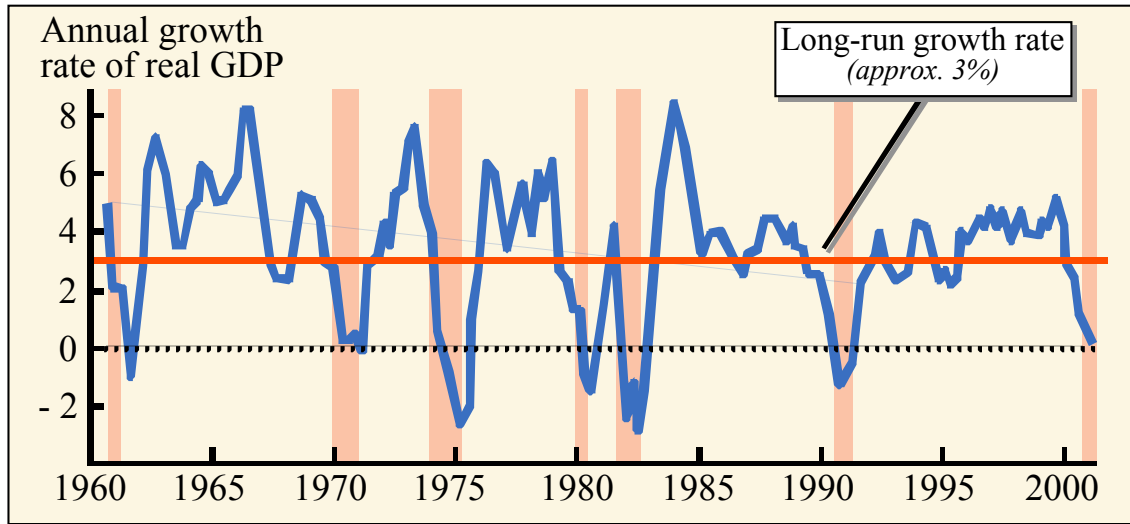


Figure 2: Real Business Cycles in the United States



Source: *Economic Report of the President, various issues.*

Cash deficits occur when outlays exceed revenues. They can have two components: a structural component and a cyclical component. The federal government defines a structural deficit as having insufficient revenues to meet current obligations when the economy is at full employment, which typically occurs during the expansionary phase of the business cycle. A cyclical deficit is a shortfall due to the business cycle, typically during the contraction phase of the cycle. This distinction is important because governments can compensate for cyclical revenue shortfalls in a variety of ways, but they can fix real structural deficits only by permanent reductions in outlays or permanent increases in taxes.

Unfortunately, the federal definition of structural deficits will not work for state governments, which must balance their budgets on an annual (or biennial) basis. Indeed, there is no generally accepted definition of the term for state governments. Regardless, there is a substantial body of literature purporting to show that this state or that one has a structural deficit. Of course, many of these works are little more than exercises in question begging. They implicitly define a structural deficit as not having enough money to meet current needs in the context of a plea for more taxes (Brown & Reading 2005). Others (Reshovsky 2002, Watkins & Smith 2003, Hirsch & Mitchell 2002, 2003) distinguish between structural deficits and cyclical deficits, more or less, as we do here, but compute the former in terms of data series that run from trough to peak for obligations and from trough to trough or even peak to trough for revenue. In recent years, these extrapolations have usually produced substantial gaps and are often arguments for more taxes or for different ones. If the current expansion continues a few more years, it is a safe bet that there will be a rash of extrapolations of this sort presented on behalf of tax cuts and/or spending increases.

For our more general purpose, the best definition of structural balance is sufficient revenue to meet a state's fiscal obligations over the course of the business cycle; under a structural deficit, revenue would be insufficient. This definition implies that state

governments could achieve balance, at least in theory, by offsetting revenue shortfalls at the troughs of business cycles with revenue windfalls at their peaks. That is: they could offset cyclical deficits with cyclical surpluses. Much of this essay is concerned with putting this rather simple idea into practice.

Structural balance

It is not easy to say whether a state has achieved structural balance by our definition. One straightforward way to do so is to measure revenues and expenditures peak-to-peak (or trough-to-trough) in constant dollars, subtracting the one from the other. To do so, we need only data on revenues and outlays, a mechanism to date recessions, and a satisfactory price deflator. We can use job growth to time recessions and the national consumer price index (CPI) to convert nominal own-source revenues and outlays to constant 2000 dollars. Doing so, tells us that in Oregon, for example, real tax revenues (before refunds) exceeded spending by \$1.4 billion, measured peak to peak and \$.17 trough to trough, which suggests that Oregon probably does not have a structural deficit.²

However, what we really want to know is whether revenue is growing faster than spending over the long term and the conventional approach to measuring fiscal balance does not answer that question. The difficulty is that these are all non-stationary variables. Everything – gross state product (GSP), population, and inflation –, not just spending and revenue, has a structural component. Moreover, as we have noted, the durations of business cycles are irregular and their magnitudes vary. These variations are largely (although not entirely) random. This further complicates matters, as does the fact that it is hard to distinguish secular growth from cyclical expansion. Moreover, we are primarily concerned about the future, not the past.

One widely used forecasting tool in financial analysis is Monte Carlo simulation. In this instance, we can use it to determine whether state revenue is growing faster than outlays by treating both state revenue and expenditure growth as Wiener processes with drift. A Wiener process (also called Brownian motion) is a discrete-time, continuous-state stochastic process with three distinguishing properties. First, it is a Markov process. This means that the probability distribution of future values of the process depends only on its initial/current value. Second, a Wiener process has independent increments. Third, the variance of the change in a Wiener process grows linearly with its time horizon. In this analysis, the degree of drift measure answers our question. If it is positive, the state is in long-term balance. If it is negative, it is not – it has a structural deficit.

Implicitly, this approach assumes that variance in the process is essentially random noise. Clearly, that is not the case. Public officials make all kinds of taxing and spending decisions with the goal of matching revenue and spending in mind. What this analysis does is allow us to separate the problem of structural balance from the problem of cyclical (and random) imbalance. If a state has structurally balanced budget, it can focus on the problem of managing cyclical and random variations in cash flows. If it is structurally out of balance, it must fix that problem first.

² As a practical matter, Oregon has an expenditure limitation measure called the kicker, which requires the state to return unanticipated revenues (those not included in the biennial balanced budget enacted by the legislature) to taxpayers. Consequently, Oregon returned \$1.1 billion in 2000 dollars to taxpayers over the course of the last business cycle, leaving it nearly \$1.4 billion in the hole at the trough of the last recession. See Thompson & Green 2004.

To estimate the mean and standard deviations of the increments in revenue and spending, we used the year-on-year increases/decreases in Oregon revenue and spending for 1977-2003,³ scaled by the Bureau of Economic Analysis's recently released comprehensive revision of gross state product estimates for 1977-2002 and its new accelerated estimates for 2003. Then we ran a series of simulations, setting both revenue and outlays initially equal to \$5 billion, and computed the resulting patterns of surpluses/deficits. Typical results are shown in Figure 3. The red line shows average drift, which implies that, on average, revenues are growing four percent faster than outlays. The blue lines represent the standard deviation of the sum of the two processes. We calculated these values by running the simulation 225 times and computing the means and standard deviations from the resulting final values.



Figure 3: Monte Carlo Simulation of Oregon's Net Revenues

This analysis shows that the State of Oregon almost certainly does not have a structural deficit. Actually, any other result would have been surprising. Oregon relies on progressive individual and corporate income taxes for ninety percent of its general-fund revenue. Both have high long-term income elasticities, especially the personal income tax (Bruce, Fox, & Tuttle 2004; Sobel & Holcombe 1996). This means that Oregon's revenues should grow faster than state product and, very likely, state spending as well. This is not necessarily the case in other states, which tend to rely more heavily on income-inelastic revenues (transactions, retail sales, state property taxes, or sin taxes).

³ Although we have Oregon state revenue and spending data from 1950 on, the data, especially the spending data, from earlier than 1977 are neither consistent nor very reliable.

Present-value analysis is a second tool that is widely used in financial analysis. This tool can also be brought to bear on the question of structural balance. From a present-value perspective, structural balance means that the present value of a state's projected revenues plus its net assets (assets minus liabilities), are equal to or greater than the present value of its projected operating outlays. Recently, Bruce Baker, Daniel Besendorfer, and Laurence J. Kotlikoff (2002) used this method to assess the structural balance of all 50 states. They started with average 1999 state tax payments and benefits received by citizens in each age and gender category, which they estimated from the Current Population Survey and the Consumer Expenditure Survey. Then they projected these averages into the future using a labor-productivity growth rate of 1.5 percent per annum. Next, they multiplied year- and state-specific age-gender population estimates from the 2001 Social Security Administration's projection of the total U.S. population by age and gender, by projected average revenues and expenditures by age and gender in that year to forecast total state revenues and expenditures for each future year. Finally, they calculated the present values of net cash flows using a 3 percent real discount rate. They found that imbalances ranged from a positive 48 percent of the present value of projected expenditures in Alaska to negative 19 percent in Vermont.

We think that present value analysis is a powerful tool for the assessment of structural balance. Moreover, we are highly impressed by the approach used by Baker, Besendorfer, and Kotlikoff to estimate a state's future cash flows. Frankly, however, we are somewhat mystified their reported results. They report that the present value of Oregon's projected net cash flows is negative by a very wide margin. We have tried to replicate their results, using their methodology, as we understand it. Unfortunately, we find that Oregon's projected net cash flows are positive by an equally large margin. Moreover, our results are very robust to changes in assumptions about productivity and discount rates as well as changes in demographic assumptions. This means one of two things. Either there is a large discrepancy between the spending and tax data reported in the 1999 U.S. Census Bureau's State Government Finances survey of receipts, expenditures, and debt, which Baker, Besendorfer, and Kotlikoff used to establish baseline state revenue, outlay, and net-asset positions for their projections, and the figures reported in Oregon's Consolidated Annual Financial Report, which we used, or one of us has made an error in transcription or calculation.⁴

Cyclical Imbalance

The toughest fiscal challenge state officials face is preventing and/or preparing for cyclical imbalance. Fortunately, researchers have learned a lot in the past decade about how to and how not to prevent cyclical imbalance and how to and how not to prepare for imbalance. In her magisterial review of the literature on state budgeting and finance, Irene Rubin wrote (2005: 47-8, 65):

Much of the literature on state-level budgeting follows the states' adaptation to and responses to cycles of boom and bust in the economy, including prevention (building up reserve funds that can be used in time of recession), temporizing (using delaying tactics to tide the state over until the economy improves), and balancing (increasing revenue

⁴ We think we know who made the error, but we've been wrong before.

and/or decreasing spending). ... What would be useful here is an index of prevention of and perhaps a second and related one of preparation for recessions.

We think Irene has it right, with one *caveat*. Imbalances are not the result of recessions, but of cyclical and random changes in revenues *and* outlays. It is necessary to deal with expansion as well as contraction to achieve fiscal stability.

Donald Schunk and Douglas Woodward (2005, see also Cornia, Nelson, & Wilko 2004) argue, for example, that the solution to the problem of cyclical imbalance at the state level lies in stabilizing spending growth through target budgeting. They imply that rapid and sustained revenue growth tends to encourage unsustainable tax cuts/spending increases. When recession strikes, state governments engage in a variety of expedients, many of them quite wasteful, to cope with the emergency. As long as the recession is fresh in the minds of public officials, their control of the purse strings remains tight (Ralph Thomas and Andrew Garber, "Gregoire: Let's Stick to a Budget," *Seattle Times*. Wednesday, January 11, 2006: A1). Gradually, however, funds accumulate and the need to spend becomes overriding (T.R. Reid, "Revenue Is Starting to Burn Holes in States' Pockets: Fiscal Posture Turns Around," *Washington Post*. Wednesday, December 21, 2005: Page A2). In some booms, state officials are swept away by the irrational exuberance of the times, funding massive infrastructure investments called forth by the elusive vista of permanent prosperity. Indeed, unsustainable state spending inspired by the length and magnitude of the Clinton era boom offers a neat, albeit probably specious, answer to how the relatively mild and short-lived 2001 recession could have led to such big fiscal problems for the states (Boyd 2000; but see Vasché and Williams 2005).

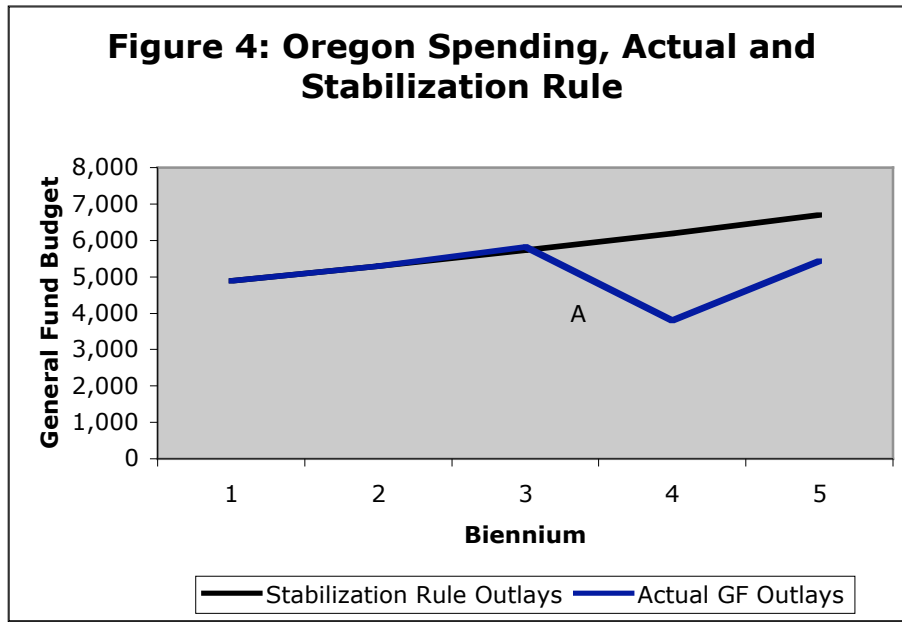
Schunk and Woodward propose a spending rule in which state spending is allowed to increase no faster than the sum of population growth, plus inflation, plus one percent real growth. Revenue in excess of this amount would be partly diverted to a stabilization (or "rainy day") fund, with the rest returned to the taxpayers. They then tested this model using aggregate spending and revenue data from the 50 states for the period 1992-2002. They found that, with a modest portion of surplus revenues partially invested in a rainy-day fund, their spending rule resulted in "stable growth of state budgets throughout the recession and sluggish recovery of the early 2000s."

Looking at California and South Carolina individually, they obtained similar results. California diverged from a sustainable path as early as 1996 or 1997, but would have been fine if it had merely practiced a little spending restraint over the next four or five years. South Carolina would have survived intact had it followed their rule, but it would have needed to put a higher portion of its surplus revenues into a rainy day fund than California and that fund would have been almost completely depleted by 2004. They conclude (Schunk & Woodward 2005: 119):

This spending rule has the effect of forcing fiscal discipline on state governments, not for the purpose of cutting the size government but for the explicit goal of providing stability over the business cycle. This stability is a virtue because it provides a benchmark for state budget writers. It is a rule that governs how much money can be spent while still leaving it up to the discretion of lawmakers to decide how to allocate these funds.

Alas, when we applied Schunk and Woodward's spending rule to the Oregon case, it had no effect whatsoever on the consequent instability. Figure 4 shows that, during the first three biennia of the decade, actual spending tracked allowable expenditures under their

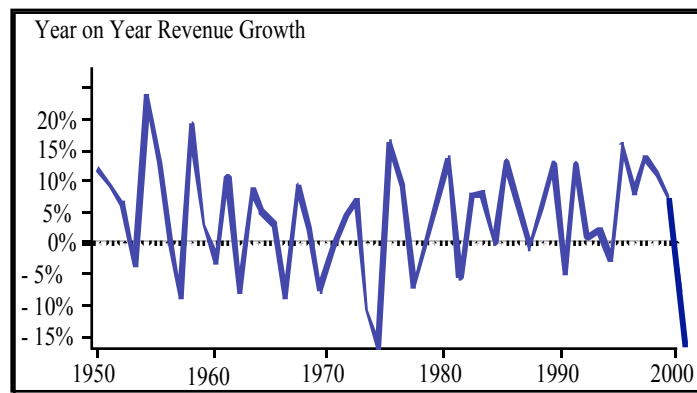
stabilization rule almost perfectly. Then, actual spending fell below the stabilization rule – way below – and stayed there. Nevertheless, this result is perfectly consistent with their analysis. Oregon has long had a legislatively enacted expenditure limit that is almost identical to Schunk and Woodward’s spending rule. The difference is that in Oregon we sent all of the surplus revenues back to the taxpayers – almost none was set aside for a rainy day. When the rainy day came, we had no money.



Reducing Revenue Volatility with Tax Portfolios

Even where state spending is on a stable, sustainable growth path, public officials must still deal with the problem of revenue volatility. The problem is starkly illustrated by Figure 5, which shows year on year changes in real revenue growth in Oregon from 1950-2000. During that period, real revenue growth was between 3.5 and 4 percent per annum (nominal revenue growth rate for the whole period was almost nine percent). Revenue volatility (the standard deviation or σ of year-on-year revenue increments) was a whopping 7.6 percent (13.4 percent for nominal revenues).

Figure 5: Real Revenue Growth, Oregon 1950-2000



The state of Oregon is probably an extreme case. Once upon a time, tax specialists would have attributed its revenue volatility entirely to a high-growth, income-elastic tax base. The traditional view held that there was an inherent trade-off between revenue growth and stability (Groves & Kahn 1952). According to this perspective, income-elastic tax bases tended to grow faster than income, but fluctuations in income over the business cycle caused them to be unstable. In the mean time, empirical analysis has conclusively demonstrated that this is not necessarily the case. Income taxes are not necessarily more volatile or faster growing than broad-based consumption taxes; corporate income taxes grow more slowly than personal income taxes and are more volatile; even some specific excises, like motor fuel taxes, are fast growing and some are quite volatile (Gentry & Ladd 1994, Sobel & Holcombe 1996, Otsuka & Braun 1999, Bruce, Fox, and & 2004, Dye & Merriman 2004). Indeed, Donald Bruce, William Fox, and M. H. Tuttle (2004; see also Fox 2003) show that the composition of the tax base, rate structures, and elements of administration can have a bigger effects on growth and volatility than tax type. For example, state policymakers can often significantly lower the volatility of revenue from broad based taxes without adversely affecting revenue growth simply by eliminating exemptions or equalizing marginal rates.

So, if income taxes are not inherently more unstable than other tax types and if Oregon’s income tax revenues are no more volatile than the average of state income tax revenues and less volatile than income taxes in many other states, what makes it exceptional, an extreme case? Here, the rather surprising answer is its heavy reliance on a single tax type – corporate and personal income taxes. Diversification of tax types can reduce revenue volatility and most states rely on a portfolio of tax types.

How does diversification of tax portfolios work? The answer is that portfolio volatility is a function of the covariance or correlation, ρ , of its component revenue sources (White 1983; Gentry & Ladd 1994).⁵ Table 1, which shows two equally weighted revenue sources, the income tax and the alcohol tax, say, illustrates this basic idea.

Table 1: An Illustrative, Two-Tax Portfolio

	<i>Prob.</i>	<i>Income</i>	<i>Alcohol</i>	<i>Portfolio</i>
Recession	0.10	-22.0%	8,0%	-7.0%
Below Average	0.20	-2.0	4.0	1.0
Average	0.40	10.0	0.0	5.0
Above Average	0.20	18.0	-4	7.0
Boom	0.10	30.0	-8.0	11.0
Expected Growth		8.0	0	4.0

Lacking further information about the economy in the coming year, we would assume that the likelihood of each of the five possible states that could occur was equal to its historical rate of occurrence or frequency. For each revenue source, these states are associated with an average year-on-year growth rate. With this information, we can calculate the expected growth and volatility, σ , of each of the revenue sources and of the

⁵ This is, of course, merely a special application of ideas formulated in corporate finance having to do with risk and return, see Markowitz 1952; Sharpe 1964; Lintner 1965.

portfolio as a whole. Expected growth is the weighted average of the growth rates (summed over the possible states of nature), or four percent. In contrast, the volatility of the portfolio, $\sigma_p = 3.1$ percent, is much less than the volatility of either the income tax (13.4 percent) or the income and alcohol taxes combined (8.9 percent). It is less even, than the volatility of the alcohol tax alone (4.4 percent).⁶

Some of the more remarkable implications of portfolio theory are:

- Average volatility will usually be reduced by adding tax sources, except where the two taxes are perfectly covariant, $r = +1.0$.
- A two tax portfolio could in theory be combined to eliminate revenue volatility completely, but only if $r = -1.0$ and the two taxes were weighted equally.
- In general, tax sources have $r \leq 0.65$, so adding taxes to the portfolio tends to reduce but not eliminate volatility.
- Only if we look only at efficient tax portfolios is there a necessary tradeoff between stability and growth. Moreover, it is possible to construct an efficient growth frontier, showing this tradeoff (see figure 6). All one needs is information on the covariance of the growth rates of each of the different tax types and designs that obtain in the different states,
- Moreover, by taking advantage of homemade leverage, it is theoretically possible to identify an efficient linear combination of growth rates and volatilities ranging from zero volatility, to a state's optimal volatility at its current growth rate and beyond.⁷

Figure 6 illustrates our efforts to apply these notions to Oregon. The point denoted OR shows the growth and volatility of Oregon's actual tax portfolio. The other points stand for various tax types as reported by Gentry and Ladd (1994), Sobel and Holcombe (1996, 1997), Otsuka and Braun (1999), Bruce, Fox, and Tuttle (2004), and Dye and Merriman (2004). Then, by making some heroic assumptions, we identified all reasonable combinations of revenue sources and feasible weights that would give Oregon the same real rate of revenue growth that it currently enjoys, about four percent. Finally, we estimated the portfolio volatility (σ_p) for each combination and set of weights and located the minimum. According to our analysis, tax portfolio diversification could reduce Oregon's revenue volatility (σ) by more than forty percent (from 7.6 to 4.4 percent), without substantially reducing revenue growth. This point is denoted PE.

The problem with this solution is that, while it would significantly reduce revenue volatility, it would do so at the expense of tax fairness. Shifting from Oregon's existing tax portfolio to the efficient portfolio would reduce the cross-sectional income elasticity

⁶ In the illustrative example, the two tax-types are equally weighted, i.e., they produced the same revenue last year. Unequal weights complicate this calculation. Consequently, we use information about the covariance (ρ) of the components of the portfolio to calculate portfolio standard deviations. If, for example, the more stable tax source A had a weight of .3 and a σ of .2, the less stable tax source B a weight of .7 and a σ of .4, and their ρ was .4, then:

$$\begin{aligned} \sigma_p &= \sqrt{W_A^2 \sigma_A^2 + (1 - W_A)^2 \sigma_B^2 + 2W_A(1 - W_A) \rho_{AB} \sigma_A \sigma_B} \\ &= \sqrt{0.3^2(0.2^2) + 0.7^2(0.4^2) + 2(0.3)(0.7)(0.4)(0.2)(0.4)} \\ &= 0.309 \end{aligned}$$

⁷ In the zero volatility case, the state would invest all of its tax revenue at the risk free rate and spend only a fixed proportion of the corpus. Figuring out the right rules for managing a state's endowment is a trivial problem analytically. It's not all clear to us how a state would actually get from here to there, however

of Oregon's tax structure 25-35 percent, converting it from moderately progressive to slightly regressive. This result did not really catch us unaware, since the efficient tax portfolio included sales taxes and greatly increased liquor and motor fuel taxes, but not corporate income taxes, and cut personal income tax rates in half.⁸

Following the approach formulated by William Gentry and Helen Ladd (1994), we replicated our search for efficient tax portfolios, this time constraining the weighted average of our synthetic portfolios to cross-sectional income elasticities equal to or greater than 1.25, the mean of Oregon's current tax portfolio, as well as its current rate of revenue growth. Unfortunately, a portfolio that would be both efficient and equally fair, would not significantly reduce tax volatility. This point is denoted PEF in Figure 6.⁹

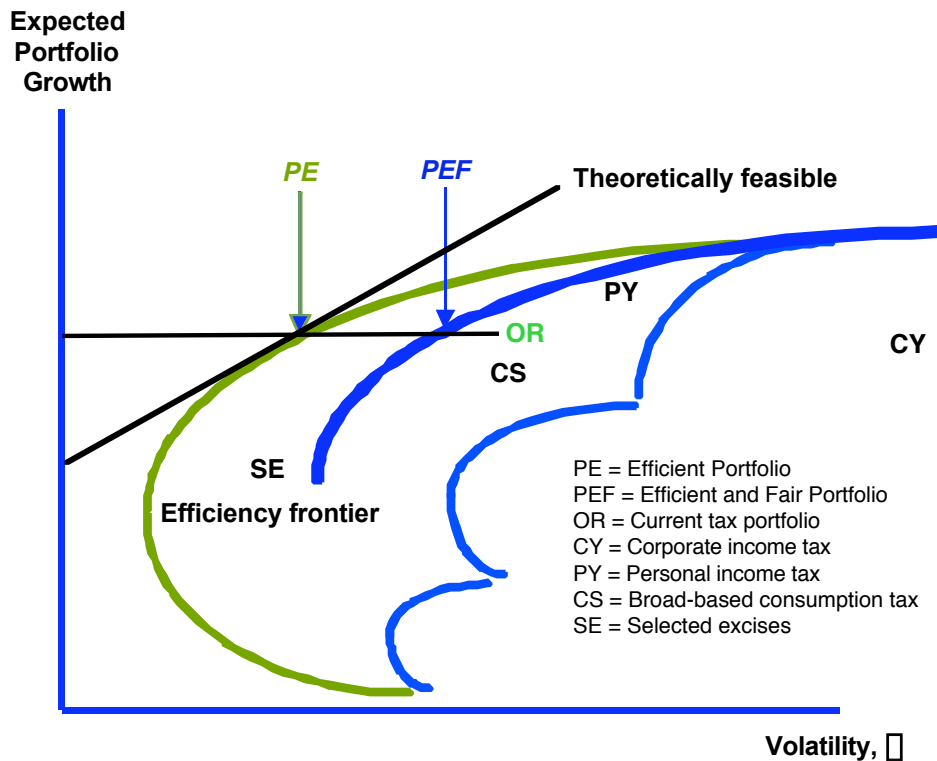


Figure 6: Feasible and Efficient Tax Portfolios

Using Futures and Options Contracts to Hedge against Revenue Volatility

There is a second approach based on a similar logic that could be used to reduce revenue volatility: using financial derivatives to hedge financial risk (Swidler, Buttimer, & Shaw, 1999). What we have just said, at least implicitly, is that portfolio strategies can

⁸ This tax portfolio is nevertheless quite attractive on several dimensions. Because it would entail substantially lower marginal deadweight losses than Oregon's current tax portfolio, it would also be allocatively more efficient than Oregon's existing tax portfolio. See Diewert, Lawrence, & Thompson 1998.

⁹ One of our former student collaborators, Katie Crocker, who now works for the CDC in Atlanta as a Presidential Management Fellow, noted, when she read what we had written, that it should be possible to design a broad-based consumption tax, e.g., say a value-added tax with direct income-contingent rebates to taxpayers, that would be as progressive as Oregon's personal income tax. She is, of course, correct. This means that the theoretically feasible efficient frontier is probably much closer to the efficiency frontier than shown in Figure 6. Unfortunately, Figure 6 reflects only the tax types actually employed by the states and not what might be theoretically possible.

effectively address the problem of unsystematic revenue volatility. Revenue volatility, however, has two components: an unsystematic component that can be diversified away through the construction of appropriate tax/revenue portfolios and a systematic component that varies directly with macroeconomic aggregates that cannot be diversified away. In finance, the standard measure of systematic risk is *beta* (β), which is mathematically equivalent to the long-run revenue elasticities we have used here. Hedging strategies are addressed primarily to systematic revenue volatility.

Two kinds of financial derivatives can be used to hedge systematic revenue volatility: futures and options contracts. A futures contract is an exchange-traded obligation in which the payoff is the difference between the price of a financial asset – a commodity or an index – at the beginning (futures price) and the end of the contract (delivery price). When the price of the contract increases, the buyer is credited with the profit and the seller with the loss; when it decreases, the seller is credited with the profit and the buyer the loss. As Cristoph Hinkelmann and Steve Swidler (2005: 129) observe: “A futures contract is therefore a zero sum game in which the profits of one party equal the losses of the counterparty.” Hence, using futures contracts to hedge revenue flows means sacrificing higher than expected revenue flows, and not just avoiding revenue shortfalls. Nevertheless, it follows that a state could fully stabilize revenue growth by *selling* futures contracts on financial assets – if the underlying asset values were sufficiently covariant with the state’s revenue flows ($\beta = +1.0$).¹⁰

If, however, states want only to protect themselves against revenue shortfalls (keeping high revenue flows for themselves), they must purchase put options on the covariant financial asset. A *put* gives the buyer the right, but not the obligation, to *sell* the underlying financial asset for a fixed price, called the strike price. Of course, a state would exercise its option to sell the asset only if its spot price fell below its strike price. Unfortunately, options aren’t free. States would have to pay hefty premiums to purchase enough put options to provide meaningful insurance against unwanted revenue shortfalls.

The rub in using futures or options contracts to hedge state revenues lies in finding a financial asset that would be sufficiently covariant with state revenue to provide a good hedge. In one of the earliest explorations of this issue, James Overdahl (1986) argued that commodity prices were likely to be highly correlated with state revenue flows and that existing derivatives traded on the New York Mercantile Exchange or the Chicago Board of Trade could be used to hedge general revenue flows. For examples, Iowa could sell corn futures and Texas oil futures to hedge revenues. Subsequent empirical analysis shows, however, that Overdahl was overly optimistic. Existing commodities futures markets provide few if any useful opportunities for states to hedge general revenues (Hinkelmann & Swidler 2004).

¹⁰ This could be accomplished in theory by selling futures contracts on state revenue, but problems of moral hazard and, perhaps, adverse selection would probably make the design and operation of such markets prohibitively costly. In practice, Oregon’s treasury refunded much of the state’s debt a few years ago with variable rate bonds precisely because of the inverse correlation between interest rates and state revenue flows. In recent months, most new and refinance issues have been at fixed rates, however, as the treasury and the bond advisory council have been under considerable external pressure “to lock in low rates.” Of course, all Oregon state debt issues feature a call provision (which gives the issuer the right but not the obligation to buy them back at a fixed price).

Currently, thanks largely to Yale professor Robert Shiller (2003), there is a movement afoot to create hedging instruments based on aggregate macroeconomic indicators. Goldman Sachs and Deutsche Bank already offer derivatives on nonfarm payroll and initial jobless claims. Futures and options based on indices such as gross national product or personal income will probably soon follow. None of these indices would represent a perfect hedge (a one-for-one offset for gains or losses). Nevertheless, according to Hinkelmann and Swidler, derivatives based on personal income (either futures or put options) could reduce revenue shortfalls by at least 60 percent in about twenty states, including New York, Ohio, Pennsylvania, and Massachusetts (Hinkelmann & Swidler 2004, 2005). Oregon is not one of the twenty, but it could still reduce year-on-year shortfalls by 40 percent or thereabout through macroeconomic hedging. The main drawback to this risk management strategy (aside from the fact that these derivative instruments do not now exist) would be the size of the premiums Oregon would have to pay if it wished only to insure itself against revenue losses. These are conservatively estimated to cost between \$180 and \$240 million a year.

Self-Insurance against Revenue Volatility

Self-insurance is usually the best available alternative to buying insurance. Given the issue at hand, creating and maintaining state rainy day funds is a kind of self-insurance. The problems here are, first, estimating the size of the rainy day fund needed to avoid significant expenditure reductions or tax increases during future downturns and, second, formulating a contribution or savings rate rule to follow to achieve the desired fund size.

Conceptually, assessing the adequacy of rainy-day funds of various sizes is an optimal cash balance or inventory problem (Baumol, 1952; Archer, 1966; Miller & Orr, 1966; Gates & Thompson, 1988).¹¹ One first estimates the mean and distribution of expected revenue shortfalls using the kind of Monte Carlo simulation we described earlier. Then, to assess the relationship between the size of the cash balance and the probability of an unredressed revenue shortfall, one calculates the average probability of shortfall, given cash balances of various sizes. The probability of an unredressed revenue shortfall and the size of cash balances should be inversely correlated, with changes in the probability of revenue shortfalls decreasing at a decreasing rate as rainy day funds are increased.

In an early, although quite sophisticated, study of this problem, Richard Pollock and Jack Suyderhoud (1986) estimated the minimum cash balance needed to achieve fiscal stability using quarterly Indiana data. They concluded that a beginning cash balance equal to 13 percent of 1983 outlays would have met the state's liquidity requirement 59 out of 60 quarters during the 1969-1983 period. They also found that withdrawals from the fund would have been required in 31 out of 59 quarters during this period. John and Leo Navin (1997) used a similar method to estimate the optimal cash balance for Ohio

¹¹ In their analysis of Utah's rainy day fund, Gary Cornia and R.D. Nelson (2003) utilize a value at risk (VAR) model rather than an inventory model. VAR identifies the worst loss over a target horizon, with a given level of confidence, and as such is widely used in the risk management literature. Cornia and Nelson used this approach because the software for it was readily available and because they wanted to develop a measure of risk over the business cycle for Utah's unique tax structure. Analytically speaking, however, what they did is not significantly different from what we describe here. But by decomposing the variance in Utah's cash flows into systematic and unsystematic components, their work more than any other inspired our attempt to show how a variety of risk management tools fit together to address the revenue volatility problem and by analogy other public sector risk management problems as well.

using data for the period 1985 to 1995. They found that, to avoid disruptive expenditure reductions or tax increases, Ohio's fund needed to be about the same size. David Sjoquist (1998) found that Georgia needed a rainy day fund of over 27 percent to achieve fiscal stability. In what is easily the most comprehensive analysis of state rainy day funds, although now somewhat dated, Randy Holcombe and R.. Sobel (1997; Sobel and Holcombe 1996) calculated the cash balance each state would have needed to weather the 1989-1992 recession. They found that the average state needed a cash balance of 30-percent of 1988 expenditures; many, however, could have made do with five-percent or less while others needed more than fifty.

In a more recent study, Gary Wagner and Erick Elder (2004) used a Markov-switching model to estimate real per-capita personal income for each state during booms and busts, as well as the probability of switching from economic expansion to contraction and back again. Based on these results (together with the assumption that state revenues vary directly with personal income), they computed the savings rate needed during good times to buffer state governments against unrequited revenue shortfalls during bad ones. They found that, to provide a ninety percent buffer against cash shortfalls, the required contribution rate was 1.87 percent of revenue on average. Ten states needed contribution rates of less than one percent of revenues, with Kansas requiring none. Eight states needed contribution rates of more than three percent of revenue, with Wyoming topping the list at 4.50 percent.

According to Wagner and Elder, Oregon is one of the states that must contribute more than three percent of general fund revenues (i.e., more than \$150 million) each year to reduce the probability of a revenue shortfall to one in ten. To explore this relationship, we replicated their analysis using the data and Monte Carlo Simulation described above (see Figure 3). In this instance, we assumed an annual contribution to a cash reserve of \$X, leaving the amount as a variable for user manipulation.¹² Each period, our model replenished the cash balance by a fixed amount, \$X, and depleted the cash balance to redress shortfalls when they occurred, until the reserve was exhausted. We then calculated the average probability of an unredressed revenue shortfall in 225 trials of 100 simulations given annual contributions to cash balances ranging from zero to \$.5 billion, increased in \$10 million increments.

As expected, we found that the probability of a revenue shortfall and the size of contributions were inversely correlated. With a zero contribution, the probability of a budget shortfall was 0.5. As the size of the annual contribution increased, the probability of a shortfall decreased. Over a range of contributions from \$0-\$80 million, the relationship was approximately linear and small incremental increases in the size of contributions generated relatively large decreases in the probability of a shortfall. However, diminishing returns set in as the size of the cash balance was further increased.¹³ Consequently, these results suggest that Oregon would experience

¹² An earlier version of this analysis was reported in Gates *et al.* 2005. The analytic problems we reported in that study have been addressed in this analysis.

¹³ For annual contributions to rainy day funds over the range of \$80 million to \$.5 billion, the best-fit relationship between unredressed budget shortfalls and cash balances was:

$$y = 0.3439e^{[0.0012x]}$$

unredressed shortfalls only once every 5 years *on average*, if it were to contribute \$80 to \$100 million (2000 dollars) each year to a rainy day fund. Reducing the probability to one in ten would require contributions of more than \$200 million and to one in twenty more than \$400 million.

For Oregon, reducing the probability of a revenue shortfall to one in five using put options would have cost almost twice as much as self-insurance through contributions to a rainy day fund, perhaps more. This represents big savings in terms of premiums avoided. Nevertheless, it might well be the case that some combination of derivatives and savings would be even better. We would also caution that the evidence is quite strong that rainy day funds that are not governed by strict deposit and withdrawal rules, usually fail to deliver on their promised benefits (Wagner 2004).

Participation in a Self-Insurance Pool as a Means of Insuring against Revenue Volatility

The recognition that most states failed to adopt adequate contribution and withdrawal rules for their rainy day funds led Holcombe and Sobel (1997) to suggest that the states establish a self-insurance pool that would operate independently of its members.¹⁴ An arm's length relationship would reduce local state pressure to spend cash reserves whenever they reached significant levels. Holcombe and Sobel further noted that clear rules governing contributions and withdrawals would improve state credit ratings and, thereby, reduce capital financing costs for states. Finally, they noted that by pooling their funds, the states could significantly reduce the amount of money each would have to contribute to achieve a given level of revenue stability. Based on their calculations, participation in a self-insurance pool would be fifteen percent less costly than self-insurance.

This last conclusion follows from treating the determination of cash balances as an inventory problem. The standard formulation of this problem under uncertainty holds that the minimum inventory needed to avoid shortages a given percentage of the time is a function of the square root of the size of the cash pool. Holcombe and Sobel did not rest their argument on this formulation alone, however. Their conclusions reflected a careful analysis of the covariance of the revenue yields of various tax types with macroeconomic aggregates, which showed that the collective or pooled state variance was substantially less than the sum of the individual states.

Based upon this finding, Richard Mattoon (2003, 2004) of the Federal Reserve Bank of Chicago designed a national state rainy day fund modeled on the unemployment compensation trust fund, a widely used countercyclical risk management tool. Mattoon

where y is the average probability of an unredressed budget shortfall and x is the size of the contribution in millions. This formula accounts for 98.22 percent of the variance in the relationship. Solving for x yields the following estimation:

$$x = \frac{\ln\left(\frac{y}{0.3439}\right)}{0.0012}$$

¹⁴ Mattoon (2003: 18) argues that "a quasi-governmental agency created by the states would be the logical organization to administer the fund. The agency would need to be autonomous enough to enforce rainy day fund rules and to have sufficient expertise to adjust rainy day fund structure to reflect emerging conditions. If specific experience ratings were created to reflect state revenue and expenditure volatility, the agency would need to have the staff expertise to calculate annual experience ratings. The agency would need to function as an independent third party administrator."

proposed the creation of an experience ratings system that would trigger differential fund contributions for each state and permit borrowing from the national fund, with borrowing states charged interest for the use of their funds. Mattoon also simulated fund performance under differing rules governing contributions and withdrawals. Unfortunately, his simulations show that it would be much easier to devise rules for operating the fund once it was capitalized, than capitalizing it in the first place. Moreover, even if the self-insurance fund had been fully capitalized and operated according to his rules, Mattoon concluded (2003: 19):

Twenty-two states would have exhausted their rainy day funds over this period with the state of California accounting for nearly 56% of the rainy day fund deficit. However, absent any other budget actions such as spending cuts or tax increases, the existence of the fund would have covered 74% of the cumulative deficit for the states. In addition, it should be remembered that rainy day funds should not cover structural state deficits. Recent state fiscal experience suggests that many states have experienced structural rather than cyclical deficits that will require revenue and expenditure actions in addition to tapping rainy day funds.

Conclusions

There are no free lunches in finance. Coping with a deficit, even a cyclical one can be painful. However, the risk management tools discussed here – Monte Carlo simulation, present value cash flow analysis, target budgeting, portfolio analysis, hedging, self-insurance, and self-insurance pools – are far less costly than are some of the expedients traditionally employed by states – shifting financial obligations to other jurisdictions, borrowing from enterprise and trust funds,¹⁵ deferring scheduled maintenance or the failure to replace worn-out or obsolete equipment, etc. States should make use of them all. Moreover, they can be applied to a wide array of public sector problems, especially when making guarantees and mitigating risks remains a major function of government. They ought to be part of the standard repertoire of all public sector managers and not just financial managers.

If public officials were trusted to use these tools, it might make sense to go a little bit further. The pursuit of ever more stable revenues leads to exponentially increasing costs, regardless of the tool or tools used, although choosing the right mix of tools can slow the rate of increase. Assuming public officials have achieved structural balance, stabilized expenditure growth, and taken appropriate steps to dampen revenue volatility, shouldn't they be allowed to borrow? Beyond some point, one year in twenty, say, or even one in ten, borrowing is cheaper than the alternatives.

Besides, from the citizen's perspective counter-cyclical borrowing is simply the other side of counter-cyclical savings. In both cases, the state would spend less or tax more in boom times in order to spend more or tax less during busts. The difference to taxpayers is largely a matter of timing, to save the state must take their money before it is needed (or keep it when it's not needed) and invest it until a shortfall occurs. Hence, taxpayers must either save less, borrow more, or defer consumption. In contrast, when the state borrows to meet cyclical needs, taxpayers do not have to reduce personal savings or increase personal debt until repayment of the state's debt is due. Arguably, borrowing is better for taxpayers because they can invest their savings more profitably than can the state and

¹⁵ Some of the costs of borrowing from trust funds are explored in Hansen & Thompson 2005.

because the state can borrow much cheaply than can they. It is also a lot easier to figure out how much a state needs to borrow than it is to figure out how much to hedge or self-insure.

There is one further consideration, not all states have equally strict rules against borrowing. Most require the enactment of a balanced budget, but in many, if a shortfall subsequently occurs, public officials are free to borrow to redress the difference (Hou & Smith 2005). In Oregon, it has happened more than once that the legislature has balanced the budget by enacting tax increases that will be predictably rejected by the voters in the next scheduled election (Thompson & Green 2004).¹⁶ The state then made up part of the difference through borrowing. One doesn't have to believe that this was the result of a cynical conspiracy to believe that it would have been better for all concerned if state officials had honestly confronted the prospect of borrowing from the outset.

¹⁶ This note will probably be of interest only to fellow Oregonians, but enacting new taxes, which are annulled by popular referenda, also has the effect of relaxing the kicker, since only revenue collections in excess of the amounts budgeted (forecast) must be returned to taxpayers.

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