Modeling Volatility in Public Funding for Higher Education

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Abstract

A substantial body of literature has examined the factors related to levels of public funding of higher education and the factors related to changes in public funding of higher education over the last few decades (Lacy et al., 2017; Tandberg et al., 2017; Li, 2017; Delaney, 2016; Abbott, 2016; Toutkoushian and Hillman, 2012). Volatility in funding has not been examined in as much detail. Volatility, understood as the extent to which funding changes from one year to the next, can be detrimental to institutions of higher education in a number of ways. Institutions that face higher levels of volatility will be unable to plan effectively. Institutions facing volatility may also seek out alternative sources of revenue, including higher tuition rates or more out-of-state enrollments (Jaquette and Curs, 2015; Cheslock and Gianneschi, 2008a). Increasing prices in this way could hurt student enrollment over the long term (Delaney, 2014). In addition, institutions that face high levels of volatility may face difficulty in hiring and retaining personnel, as lack of knowledge about future levels of funding makes planning for staffing levels difficult, if not impossible.

In this study we seek to establish which institutional- and state-level factors are associated with higher levels of volatility in higher education funding. Our theoretical framework, derived from earlier work in this area will focus on four broad areas that can drive volatility in funding: economic conditions, political characteristics, institutional factors, and state-level governance and finance structures. We find that economic factors are closely associated with volatility, and that two-year institutions experience substantially higher levels of volatility than four-year institutions.
Modeling Volatility in Public Funding for Higher Education

According to data from the State Higher Education Executive Officers (SHEEO), the combined spending of all of the US states on public higher education in 2000 was approximately $78.1 billion. By 2012, states’ collective spending dropped in real terms to approximately $69.5 billion; following a high watermark in 2008, when states collectively spent approximately $83.2 billion in constant 2012 dollars on public higher education (SHEEO, 2016). The rapid change in spending levels over this short time period, including a nearly $13.7 billion drop in spending since 2008, has resulted in an extremely unpredictable environment for institutions.

The destabilization of state support for colleges is also evident over a longer period of time. In 1990, average state appropriation per FTE was $8,688 in constant 2012 dollars; by 2015 this figure had fallen to $6,966 – a decline of $1,722 per FTE or approximately 20 percent. However, the story has not been one of consistent disinvestment. Instead the pattern of funding has been volatile. Over this time period, the high watermark was reached in 2001 with a funding level of $9,120 per FTE and 2012 was the low point with funding levels at $6,177 per FTE. Between 2001 and 2012, there was a $2,943, or a nearly 32 percent, decrease in spending per FTE. Volatility in state support for higher education combined with uneven increases in enrollments has resulted in an unpredictable, but generally declining, long-term trend in state spending per student.

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Volatility in funding has not been examined in as much detail. Volatility, understood as the extent to which funding changes from one year to the next, can be detrimental to institutions of higher education in a number of ways. Institutions that face higher levels of volatility will be unable to plan effectively. Institutions facing volatility may also seek out alternative sources of revenue, including higher tuition rates or more out-of-state enrollments (Jaquette and Curs, 2015; Cheslock and Gianneschi, 2008a). Increasing prices in this way could hurt student enrollment over the long term (Delaney, 2014). In addition, institutions that face high levels of volatility may face difficulty in hiring and retaining personnel, as lack of knowledge about future levels of funding makes planning for staffing levels difficult, if not impossible (Delaney, 2016; Massy, 2016).

In this study we seek to establish which institutional- and state-level factors are associated with higher levels of volatility in higher education funding. Volatility in state appropriations is defined as the extent to which state appropriations change from year to year for a given public institution of higher education (Fatas & Mihov, 2013).

Our paper provides a contribution to the literature on higher education funding by establishing which factors may be associated with volatility. Policy implications include both identifying which institutions are at high risk of volatile funding levels and establishing which institutional- or state-level governance structure might best limit volatility.

Background
A considerable literature has explored both variation across time and differences across states in state funding for higher education.

A key recent study that explores variation in state funding for higher education over time suggests that a crucial factor leading to decreased state appropriations to higher education is the increasing cost of Medicaid (Kane, Orszag, and Gunter, 2003). Kane et al. (2003) find that a one dollar increase in spending for Medicaid is associated with a six cent decrease to higher education spending. Medicaid spending between 1988 and 1998 explain 80 percent of the decline in higher education appropriations. In a related analysis, they find that states have taken longer to return to pre-recession levels of higher education funding since the 1990s.

During the Great Recession, states put in place unprecedented cuts to spending for higher education, prompting subsequent tuition increases. Barr and Turner (2013) analyze changes within higher education in the wake of the Great Recession. They find that during this period of high unemployment individuals were more likely to pursue a college degree. Enrollment increased the most for community colleges (32%), public four-year institutions (27.4%), and for-profit institutions (30%). With a decreased tax base and increased demand for social services, states cut appropriations to higher education by 17 percent from the 2007 to 2011 academic years. Institutions raised tuition rates in response. However, some of the cost to students was offset by increased federal aid in the form of Pell grants and tax credits (Barr and Turner, 2013).
Further studies into the relationship between state and federal aid for higher education reinforce this finding. Bettinger and Williams (2013) find that prior to the Great Recession, state and federal aid were generally positively correlated. This correlation has reversed since the mid-1990s. Whereas state appropriations have remained procyclical with unemployment, Pell grants now increase when unemployment decreases. This suggests a fiscal federalism model in which the federal and state budgets are strategically coordinated to offset budget cuts, although it is unlikely in practice that actual coordination occurs.

The method states use to appropriate funds to higher education has also shifted. Bhatt et al. (2011) find that states increase earmark spending on higher education when they decrease funding from the general fund. For every $1000 increase in earmarked revenue per student, the general fund for higher education is predicted to decrease by 11.3 percent.

Within state appropriations, McLendon et al. (2014) find that states have increased the amount of merit aid while decreasing funding for need based aid. States with Republican government and higher wealth are more likely to demonstrate this trend. Merit aid is disproportionately allocated to higher income students.

Doyle (2007) updated Hansen and Weisbrod’s study using data from 1996 and the results confirmed that low income students continue to receive the lowest subsidies and middle income students receive the greatest subsidies. Doyle questions Hansen and Weisbrod’s assumption that policymakers do not realize that this is a regressive system. Doyle finds that policymakers appropriate less money
for higher education as inequality increases. This suggests that the policymakers are passing benefits to their middle class constituents, even though this distribution process exacerbates the decreased educational opportunity for low income students.

As states decrease funding to higher education, the burden is increasingly passed through to students in the form of higher tuition. Webber (2017) finds that when states decrease funding per student by $1000, students pay $257 more annually on average. This trend has accelerated since the Great Recession. Prior to 2000, the pass through rates was 10.3 percent, but it has since increased to 31.8 percent.

States budgets use higher education as a “balance wheel,” increasing appropriations in prosperous economies, but disproportionately decreasing appropriations during economic downturns (Hovey 1999). Delaney and Doyle’s (2011) research supports this model using state level data from 1985 to 2004. Compared to other budget categories, higher education is subject to larger cuts and gains. The balance wheel pattern is indicative of volatility, but this volatility follows a discernable, patterned relationship with economic conditions.

Few studies have measured the volatility state appropriations to higher education. Lacy, et al. (2017), explain the state-level political characteristics that make funding more or less volatile. Using a two-way fixed effects model, they regress volatility of appropriations to higher education on governor appointed SHEEO and SHEEO recommended budget. Results indicate that appropriations are more volatile when the governor appoints the SHEEO (.129, p=.034) and when the
SHEEO does not recommend the budget. Other factors that make significantly increased volatile appropriations to higher education include partisan change in gubernatorial control (.060, p=.013), state higher education appropriations per capita (.003, p=.001), and median household income (.005, p=.002). Legislative professionalism (-.286, p=.110) and divided partisan control of state government (-.030, p=.012) had a negative influence on volatility. They also find that volatility in appropriations increases the budget cycle after state revenues experience volatility. This study does not take into account institutional factors that may influence volatility, though it does find that increased enrollment decreased volatility. Our study differs from the Lacy et al. study by focusing on institutions as the unit of analysis, and specifically emphasizing the role of volatility in other economic conditions as the source.

Li (2017) finds that higher education appropriations exhibit a pattern of punctuated equilibrium, meaning there are periods of stasis punctuated by large budget cuts or increases. While measuring punctuated equilibrium is conceptually different from volatility, budget punctuations are instances of volatility. Using an event history analysis, the predictors of large state budget cuts (greater than 14%) to higher education were: changes in the unemployment rate, changes in tax revenue, a unified Democratic or Republican government, interest group density, and the existence of a merit aid program.

Outside the field of higher education, there is a body of literature that has refined the methods for measuring volatility and factors that contribute to state-level economic volatility. Overall, state growth rates have declined since the 1970s,
but there is significant variation between states. Crain (2003) finds that higher income states experience higher volatility than low income states.

Crain also finds a significant positive relationship between volatility in tax revenue and volatility in spending. State tax revenues sources vary in volatility, so the type of taxes that a state relies on can contribute to volatility of economic growth. For example, sales taxes are more volatile than income tax (Crain, 2003). Similarly, corporate taxes are highly volatile because they are easily impacted by national macroeconomic trends (Cornia and Nelson, 2010). States that rely on volatile sources are likely experience volatility in growth (Cornia and Nelson, 2010).

In response to unexpected fiscal shocks, Poterba (1994) finds that states recuperate deficits through spending cuts and raising taxes. However, many states are unable to make large tax adjustments due to tax and expenditure limitations (TELs). When these states do have the opportunity to raise taxes, Staley (2016) finds that states compensate for previous deficiencies with major tax increases, which creates a pattern of volatility. States with more stringent TELs have greater revenue volatility ($5.75 higher fluctuation per capita for states with medium stringent TELs). Direct democracy (60.64), legislative professionalism (28.43), and state unemployment (2.52) are also related with higher volatility.

While these studies focus on state level differences, Ramey and Ramey (1995) provide evidence on an international level that countries that experience more volatility experience less economic growth. The correlation of growth and volatility is measured as the mean and standard deviation of per capita annual growth rates for each country. This negative relationship persists when controlling
for country specific growth including: the investment fraction of the GDP, initial log GDP per capita, initial human capital, and the average growth rate of the population. The analysis is replicated to include forecasting variables that account for predictable changes in growth. Results indicate that countries with higher innovation variances have lower growth rates. These relationships are not affected when controlling for investment share of GDP, contradicting previous theories about investment, volatility, and growth.

In the study that follows a structure most similar to ours, Fatas and Mihov (2013) model the impact of volatility in government spending on economic growth for a panel of countries for the years 1960-2007. Their measure of volatility in government spending forms the basis for our measure of volatility in state appropriates. The authors use the country-specific residuals from a regression of the log of real government consumption spending on country-level GDP. They reason that variations from this relationship constitute volatility in government spending. The standard deviation of these country-specific residuals forms the basis for the independent variable in their study, which they then use to model overall growth during the time period 1960-2007. They find that countries with high levels of volatility exhibit low levels of growth (Fatas and Mirov, 2013).

Our primary contribution to this literature is to provide a refined analytic approach which considers institution-specific volatility, instead of considering only state-level volatility as Lacy et al. do in their study. In addition, we provide evidence regarding how variability in state-level economic, governance, and political factors may impact volatility at the institutional level.
**Theory and Model Specification**

In this section, we describe our measures of volatility and provide hypothesized relationships between key state characteristics and volatility at the institutional level. We suggest three possible measures of volatility, two of which will be used in this analysis.

### Periodicity and Term

There are two important decisions to be made about modeling volatility in any time series before choosing a method. First, what periodicity will be used, and second, over what term. For instance, stock prices can be measured at minute intervals, daily intervals, weekly and so on. Similarly, the volatility of an index can be measured over the course of a month, a year, or a decade, among many other possibilities. We can only use years as our period, and given that we have so few years (29) for any single institution, we must use the full term as the basis for our measure of volatility, instead of subdividing into smaller subsets of the data. Time series models, including ARCH and GARCH, would be inappropriate for this data, as the number of periods is too few.

### Mean Volatility

The simplest possible measure of volatility would be to measure the standard deviation in log appropriations:

$$\sigma_{mean} = var(y_{lst})$$

Figure 1 shows how this measure would work with a subset of institutions. As the figure shows, this measure ignores the more-or-less common secular pattern in funding for all institutions—during this time period, funding increased for nearly all...
of the public institutions in our dataset over time. The institution in the subset that is ranked as having the highest level of volatility—Black Hawk College—also has the strongest linear growth in funding over time. In contrast, Moore County Community College shows the lowest amount of volatility, but also has the flattest linear time trend in the subset.

**Volatility Around Secular Trend**

In our judgment, using variation around the mean would be inappropriate given the strong linear time trend in the data. We instead use variation around the secular trend. A standard model of appropriations in a given year $t$ for an institution $i$ in state $s$ is as follows:

$$y_{ist} = \beta_0(i) + \beta_1(i)t + \epsilon_{ist}$$

This model assumes that state funding for the institution is a function of enrollment measured as full time equivalent enrollment and time. We estimate this model separately for all 1,063 institutions in the dataset. We use the standard deviations of the residuals from this regression as the basis for our first specification, which we refer to as the “trend only” specification. Figure 2 shows how this measure would work with a subset of institutions.

**Volatility Around Secular Trend Plus Enrollment**

Most of the institutions in our dataset experienced substantial enrollment growth over the time period 1987-2015. Because of common use of enrollment-based formula funding for higher education in the 1980s and 1990s, we expect that institutional leaders and other administrators anticipated that funding would grow
as a linear function of enrollment growth, and that deviations from this trend would also be experienced as funding volatility. In our second specification, we estimate a similar model to the above, but also include a covariate for full time equivalent enrollment.

\[ y_{ist} = \beta_0 + \beta_1 t + \beta_2 fte_t + \epsilon_{ist} \]

As with the previous specification, we use the standard deviation from the residuals as the basis for our dependent variable. We refer to this specification as the “Trend plus enrollment” results. Figure 3 shows how this measure would work with a subset of institutions.

**Volatility Around State-Level Trends**

It may not be appropriate to model these results separately at the institutional level, as the most important impact of volatility may not be deviations from the individual institution’s own history but instated deviations from a common state trend. In a second set of specifications, we model deviations from the time and enrollment levels at the state as opposed to the institutional level. State funding is likely to change over time differently from one state to another. Some states may be rapidly increasing their funding controlling for enrollment, while in other states the relationship between funding increases and the secular trend may be flat or even negative. This argues for a model of the form:

\[ y_{ist} = \beta_0 + \beta_1(s) t + \beta_2(s) fte_{ist} + \epsilon_{ist} \]

Where the coefficients \( \beta_1(s) \) and \( \beta_2(s) \) are allowed to vary at the state level. This implies a separate set of coefficients for the effect of time and enrollment on state level spending for every state. The resulting estimates provide a separate
function for every state and sector. The intuition here is that within each state and each sector there is a common trend that establishes the extent to which institutional leaders can expect that state and local appropriations will increase or decrease as a function of both enrollment and time.

In our approach, we are interested in the variance of the residuals from the above regression as a separate parameter, $\text{var}(e_{ist})$. This variation expresses the extent to which individual institutions vary from their state-sector specific trends over time. If state spending on institutions varies from the state-sector specific trends considerably over the time period in our sample, then we take that as evidence of volatility relative to state-level trends.

**Modeling Volatility**

In our models, we are interested in the extent to which the standard deviation of the error term varies as a function of state and institution level characteristics:

$$\sqrt{\text{var}(e_{ist})} \equiv \sigma_s = \psi + \gamma_1 z_s + \mu_s$$

Where $z_s$ is a series of covariates measuring state-level characteristics. These include economic, political, and higher education governance characteristics of the state. We describe each of these in detail in the next section.

**Data**

In this section, we describe the data for our project. This data was compiled from a series of different sources. The data cover the years 1987-2015 for all states, with the exception of Colorado, which was excluded from the analysis due to funding changes which substantially altered patterns of appropriations in the state,
and make estimates of volatility unreliable. These funding changes included steep cuts to higher education as part of the taxpayer bill of rights (TABOR) and a switch to funding which follows students and does not go directly to campuses (Archibald & Feldman, 2008).

**Dependent Variable**

Our dependent variables are based on the variable state and local appropriations as reported by the Delta Cost Project in their data. We use both state and local appropriations as several states—particularly California and Illinois—provide their state revenues effectively through local entities. We collapse this variable to the level of the reporting institution to avoid any possible parent/child reporting conflicts (for a more complete discussion of this issue see Jaquette and Parra, 2016).

For the unit-specific variation, we run a separate regression for every institution in the dataset, regressing state and local appropriations on the year, and then in a separate specification the year and the log of full time equivalent enrollment. For the state specific residuals, we run a separate regression for every state, then calculate the standard deviation of the residuals from the state-level equation separately for each institution. Institutions that experience more deviations from the state-level trends will show more volatility than those institutions that more closely follow the state trend.

**Independent Variables**

We include two measures of the state economy: state-level unemployment and state-level median family income, both averaged at the state-level over the time
period in the study (U.S. Bureau of the Census, 2018). We expect that states with lower unemployment and higher levels of income will be able to make a more stable investment in higher education. In separate specifications we also include the standard deviation of unemployment and family income as measures of the volatility of the economic environment in the state during the time period in the study (US Bureau of Labor Statistics, 2018).

We expect that partisanship at the state level may impact volatility in state funding. In particular, institutions in states that experience considerable volatility in partisan representation may also experience funding shocks. We include measures of the proportion of all state legislators that are Democrats and in a separate specification the standard deviation of this measure over time (Klarner, 2003; Klarner 2013).

Statewide governance arrangements are thought to moderate possible funding shocks (McLendon, et. al., 2014). Governance arrangements that help state policymakers to understand budgeting needs and help institutional leaders to better comprehend state funding constraints should be in a position to moderate funding swings. We use a five part measure of governance, based on McGuiness (1997) defined as follows:

*Planning agency*: a statewide agency that has some coordination capacity, but no authority to regulate campuses.

*“Weak” coordinating board*: a board that has some authority over issues like program review, articulation, and campus locations, but does not have the ability to review and approve institutional budgets before passing them on to the state.
“Strong” coordinating board: a board that has the same broad portfolio of responsibilities as a weak coordinating board but also has the ability to review and approve institutional budgets before passing them on to the state.

Governing board for four-year institutions: the state has established a single governing board for all four-year institutions in the state. The state may also have a single board for all two-year institutions in the state, but this is not necessary for our definition.

Governing board for all institutions: the state has a single governing board for all institutions.

We use measures of governance arrangements at the beginning of the term—1987. We do this as we expect the impact of governance changes to be relatively slow moving, and because very few states experienced changes in governance during this time.

Last, we expect that community colleges will experience wider swings in funding than their four-year peers, even after controlling for enrollment changes. We expect this as community colleges generally have less powerful constituencies, with generally less ability to lobby and to influence decision makers than their four-year peers.

Results

We begin by summarizing our various measures of volatility. We then provide estimates from our OLS models, estimating the association between various covariates and volatility in funding.

Descriptive Results
Our first measure of volatility is mean-level variation. A ranking for all 50 states on average institutional-level mean volatility is shown in Table 1. As the table shows, high-growth states like Nevada, New Mexico, and Arizona all rank highly on this measure. While these states have experienced substantial variation around mean funding during this time period, that variation has been almost entirely due to growth. State with the lowest levels of volatility according to this measure include Rhode Island, South Carolina, and Kentucky, all of which are relatively low-growth states.

Table 2 shows state-level averages for institutional-level trend volatility. This measures the extent to which each institution's funding deviates from its own linear trend—or line of best fit—during the time period of the study. Florida, North Dakota, and Georgia all show the highest levels of variation around the trend. Vermont, Maine and South Dakota all show low levels of variation. While this measure does capture some states that have experienced wide swings in funding, it also includes states that have experienced substantial enrollment growth or decline during this time period.

Our last and preferred measures is volatility around the linear trend and enrollment, which we show in Table 3. According to this measure, Kansas, Illinois, and Minnesota have experienced the highest levels of volatility during this time period. Other states with high levels of volatility include Georgia, Massachusetts, and Florida. According to this measure, the states with the lowest levels of volatility include Maine, Alaska, and Vermont. Several of the states measured as most volatile according to this measure have experienced multiple cuts of more than 10 percent
in funding, while none of the states ranked as having low volatility have experienced cuts this large. It appears that this last measure better captures what is generally thought of as volatility—much more or less funding than anticipated from the state.

**Model Results**

Table 4 includes our results for a regression for our institution-specific results. The dependent variable in Table 4 is the standard deviation of the residuals from the 1,066 regressions, one for each institution. In columns 1 and 2, the dependent variable is the standard residual of the residuals from a regression of log state and local appropriations on the linear time trend. In columns 3 and 4, the dependent variable is the standard deviation of the residuals from a regression of log state and local appropriations on the linear time trend and full-time equivalent enrollment.

In column 1 of Table 4, we show results where the key economic and political covariates are measured as their mean during the time period of the study. The results show that institutions in states with higher levels of unemployment experienced significantly more volatility in funding. The coefficient for mean unemployment is 1.155, with a 95 percent confidence interval bounded by [.05,2.26]. In column 1, as with all of our other specifications, two-year institutions are shown as having significantly higher volatility than four-year institutions, with a coefficient of 2.9 bounded by a confidence interval of [.77,4.02]. None of the other results from Column 1 are significant.

In column 2 of Table 4, we show estimates where key economic and political covariates are measured as standard deviations as opposed to means. In these
specifications, we seek to find whether volatility in economic or political conditions is associated with volatility in state funding for higher education. We find that volatility in both unemployment and income are associated with increased volatility in state and local appropriations for higher education. The coefficient for unemployment is 2.9, with a confidence interval that goes from [.67,5.16]. Similarly, the coefficient for income is positive and statistically significant, indicating that institutions in states that experienced large changes in income also experienced large changes in state and local appropriations for higher education.

Columns 3 and 4 use deviations from the time and enrollment trends as the basis of their measures of volatility. As with the previous estimates, higher mean unemployment is associated with higher levels of volatility according to this measure. Institutions in states where income and unemployment varied during this time period had wider swings in funding as well, mirroring the patterns found in Column 3. In these specifications, the indicator for two-year institution remains positive and statistically significant, meaning that community colleges had substantially higher volatility in funding than four-year institutions.

In Table 5, we show results for institutional-level variation around state-level trends. The structure of table 5 is the same as table 4, with variation from linear trend only in columns 1 and 2 and variation from linear trends plus enrollment in columns 3 and 4. Measuring variation from state-level trends yields some different results, particularly with respect to political variables. According to the results in Table 5, institutions in states with more variation in legislative representation showed more variation in state and local appropriations. The results in Table 5 also
differ from the institution-specific results in that the coefficient for two-year institutions is not statistically significant.

In columns 1 and 2 of Table 5, we provide estimates that show a statistically significant relationship between governance arrangements and variation from the state-level mean. In particular, institutions in states with a centralized governing board show higher levels of variation from the state-level time trends, as shown in column 1. These results do not also appear when measuring variation from state-level time and enrollment trends in columns 3 and 4.

**Summary of Results**

We find that economic conditions are associated with higher levels of volatility. In particular, state-level unemployment shows a consistent relationship with volatility, when measured both in terms of mean and variance. Institutions in states with higher levels of changes in political representation show higher levels of variance from state-level trends in our results. Differing governance arrangements show some level of association with one of our measures of volatility, but in general we show no clear relationship between governance arrangements on volatility in spending. Public two-year institutions generally appear to have substantially higher variation from institution-specific trends, but not from state-level trends.

**Limitations**

Our primary concern remains with the various measures of volatility. In particular, this kind of regression on residuals approach, while widely used, has proven problematic in other domains. We are concerned about the two sources of variation in our residuals – one is the level of volatility in state spending, the other is
idiosyncratic variation from the regression line. In future work, multilevel modeling can be used to directly model variance. Second, additional covariates could be included in our model specifications, including the extent to which the states show the ability to plan for fiscal downturns.

**Conclusions**

As noted earlier, our primary contribution in this paper is to provide a series of possible measures of volatility and to evaluate their effectiveness in measuring variation in state funding at the institutional-level. We conclude that volatility should be measured relative to both a linear time trend and enrollment levels. Our preferred estimates of the association of various covariates with these measures reveal several important findings. Volatility in state funding for higher education appears to be closely related to volatility in state level economic factors. We find no observable relationship between volatility in state funding and either direct measures of political partisanship or measures of variation in political partisanship. State-level higher education governance arrangements similarly do not appear to be associated with volatility in state spending, but two-year institutions generally experience much more volatility.

While we offer no specific policy recommendations, our results can be used to help set the context for volatility in state spending at the state level. Based on past experience, states that have experienced high levels of volatility in the past can expect to experience similar levels of economic volatility in the future. These states will also likely be the ones that have the largest changes in state funding. Policymakers and institutional leaders in these states should incorporate this
feature of state funding into their discussions, opening the possibility for various measures that might limit the impact of volatility on campuses. These conversations should happen before the crisis moments that occur during economic downturns. In a similar vein, policymakers should consider how to either limit volatility in funding for two-year institutions or help these institutions to prepare for future funding changes.
References


https://doi.org/10.1007/s11162-016-9432-0


Massy, W. F. (2016). Reengineering the university: How to be mission centered, market smart, and margin conscious. JHU Press.


https://doi.org/10.1177/0002716214540849


https://doi.org/10.1086/261955


https://doi.org/10.1111/pbaf.12054

https://doi.org/10.1080/00221546.2016.1243945


Table 1: Ranking of States by Mean Level Volatility

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<th>Mean Log Volatility</th>
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Table 2: Ranking of States by Trend Volatility

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Table 3: Ranking of States by Trend and Enrollment Volatility, 1987-2015

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Table 4: OLS Results, Volatility Measured as Variation from Institution-Specific Trends

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<th>Volatility: Trend+Enrollment</th>
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<td>(2)</td>
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<tr>
<td></td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>Unemployment (mean)</td>
<td>1.155**</td>
<td>1.043*</td>
</tr>
<tr>
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<td>(0.566)</td>
<td>(0.540)</td>
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<tr>
<td>Income (mean)</td>
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<td>0.024</td>
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<td>(0.060)</td>
<td>(0.057)</td>
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<tr>
<td>% Leg Democrats</td>
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<td>0.027</td>
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<td>(0.037)</td>
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<td>Unemployment (sd)</td>
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<td>2.506**</td>
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<td>(1.146)</td>
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<td>Income (sd)</td>
<td>1.117**</td>
<td>0.967**</td>
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<td>(0.482)</td>
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<td>% Leg Democrats (sd)</td>
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<td>1.726</td>
<td>2.359**</td>
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<td>(1.061)</td>
<td>(1.171)</td>
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<td>Governing Board: All</td>
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<td>(1.618)</td>
<td>(1.645)</td>
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<td>Governing Board: 4 yr</td>
<td>-1.280</td>
<td>-2.157**</td>
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<td>(1.107)</td>
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<td>Governing Board: Planning</td>
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<td>Sector: Two Year</td>
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<td>Note:</td>
<td>*p&lt;0.05</td>
<td>**p&lt;0.01</td>
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### Table 5: OLS Results, Volatility Measured as Variation from State Trend

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<td>% Leg Democrats</td>
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<td>Unemployment (sd)</td>
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<td>(1.731)</td>
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<td>Income (sd)</td>
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<td>% Leg Democrats (sd)</td>
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<td>Governing Board: All</td>
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<td>(3.196)</td>
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| Observations           | 1,066                   | 1,066                       |
|                        | 1,066                   | 1,066                       |
| R²                     | 0.037                   | 0.038                       |
|                        | 0.007                   | 0.015                       |

*Note: p<p<0.01
Notes: This figure shows the natural log of state appropriations on the y axis and years on the x axis. The blue lines indicate the mean level of appropriations over the time period in the study. The distance from actual values to the mean value form the basis for our measure of mean volatility.
Figure 2: Visualization of Trend Volatility

Notes: This figure shows the natural log of state appropriations on the y axis and years on the x axis. The blue lines indicate the regression line for an institution-specific regression of log appropriations on time. The distance from actual values to the regression form the basis for our measure of trend volatility.
Figure 3: Visualization of Funding as a Function of Enrollment

Notes: This figure shows the natural log of state appropriations on the y axis and log full time equivalent enrollment on the x axis. The blue lines indicate the regression line for an institution-specific regression of log appropriations on fte enrollment. The distance from actual values to the regression form the basis for our measure of trend+ enrollment volatility.
Endnotes:

1 In general, ARCH/GARCH models require between 50 and 100 time periods per unit. So, if revenues were measured on a monthly basis, we might be able to utilize those methods.