EXCESS COST MODEL FOR SPECIAL EDUCATION STUDENTS IN CONNECTICUT DOCUMENTATION

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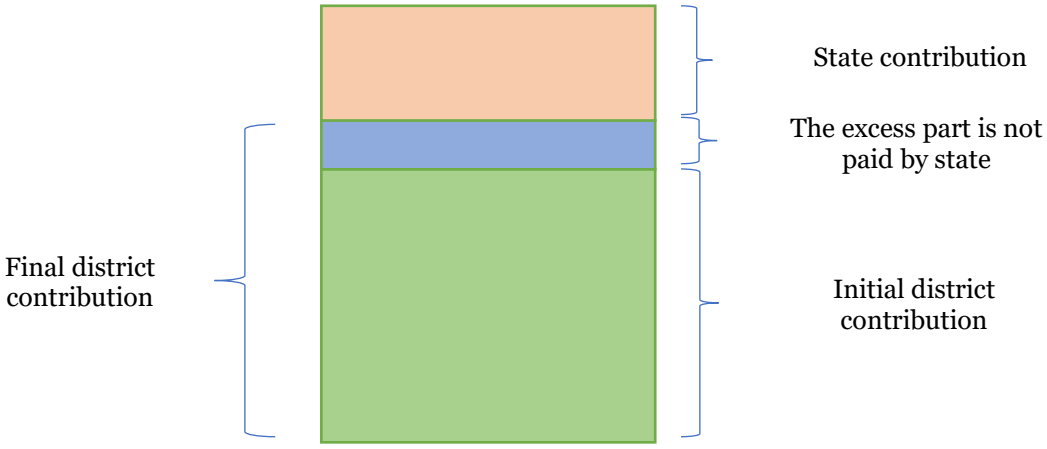
1. EXECUTIVE SUMMARY

In the state of Connecticut, students who require special education services may usually incur a large amount of costs. This model mainly focuses on the special education students whose costs are more than 4.5 times the state's average education cost level based on previous years (4.5μ), and we denote it by excess cost. (Note that the name of 'excess cost' could be confusing, it is not the excess part that is above 4.5μ, but the total cost incurred by a special education student). The total excess cost for special education students usually can be separated into two parts: the part covered by school districts and the part by the state (we will call them 'district contribution' and 'state contribution' respectively in this documentation). Typically, every school district will make a payment for each special education student who is incurring excess costs (i.e. students whose total special education (SPED) costs exceed 4.5μ) at the beginning of the year to form an 'initial district contribution'. At the end of the year, when the actual excess costs for the district are billed and we will know what that amount is, the state will cover a percentage of the portion above 4.5μ.The portion of SPED costs above 4.5μ that is not covered by the state will also be covered by the school district. So, at the end of a year, we will have 'final district contribution' and 'state contribution' to cover all the excess costs. The following graph shows the various components of a student's excess costs. For more calculation details, please refer to section 3.2 CALCULATION OF FINAL DISTRICT CONTRIBUTION.



This model aims to decide how much should the school district contribute at the beginning of the year (initial district contribution) so that it can help school districts to better manage their budget in special education excess costs. We can understand the goal of this model from the following two dimensions: the state level and the district level.

- For the state level, we need to make sure the amount collected by every district every year plus the state contributions can cover the whole state special education excess costs.
- For the district level, we try to make sure that the district contributions for every year are smooth and relatively steady, not so fluctuating

At first, we used a method called Experience Weighted Average Cost Contribution to adjust next year's district contribution based in this year's total excess costs for each district. However, the results turned out to be very fluctuating and increasing or decreasing significantly year by year due to the volatility of excess costs at the school district level. The annual experience rating just created a one-year lag in the fluctuation, but did not smooth the fluctuation.

Credibility Weighted Contribution Technique

In order to reduce the volatility and guarantee smoother annual excess costs per student at the school district level, we applied an actuarial technique called Credibility Method. The Credibility Method can smooth an individual district's contribution by considering both the district mean contribution and the whole state mean contribution from previous years. By doing this, we have obtained a much smoother and acceptable pattern of annual excess cost contribution at the school district level. For the next part, we will explain more details about our Credibility Method.

2. INPUT AND OUTPUT DATA

2.1 INPUT DATA

In this model, the input data are based on a total of 219 different school districts from 2010 to 2017. A1 illustrative description of each input item we used is shown in the following table:

Input Data Name	Description	Value
numECST	The number of special education students that incur excess costs for one specific school district in a year	4
EC	Total excess cost for one specific school district in a year	437,760
EC.perST	Average excess cost (per student) for one specific school district in a year (i.e. EC / numECST)	109,440
Cont.Dist	Total final school district contribution for one specific school district in a year	360,761
Cont.Dist.perST	Average district contribution (per student) for one specific school district in a year (i.e. Cont.Dist / numECST)	90,190
ContS	Total state contribution in a year	138,751,390.96

Percent	The capped percentage that the state will contribute for the excess part	72.8%

2.2 OUTPUT DATA

Our output data for this model is the initial district contribution, and this result will provide a guidance for school districts to decide how much they should pay at the beginning of a year that will be sufficient to cover this year's excess costs.

3. ASSUMPTIONS

In this section, we will list some assumptions that we used in the model calculations.

3.1 DISTRIBUTION OF STATE CONTRIBUTION

The state contribution is expressed as an aggregate number in the state level in our model. So we assume that every special education students that incurs excess costs will receive the same amount of state contribution, that is:

$$\text{State Contribution per District per Student} = \frac{\text{Total State Contribution}}{\text{Total Number of SPEC excess cost Students in State}}$$

3.2 CALCULATION OF FINAL DISTRICT CONTRIBUTION

The raw data does not contain 'Final District Contribution' that we used in this model, so we use the following technique to calculate it, for every district:

$$\begin{aligned}\text{District Actual cost} &= \text{Initial District Contribution} + (1 - \text{Capped Percentage}) \\ &\quad * (\text{Total Excess Costs} - \text{Initial Contribution})\end{aligned}$$

3.3 INFLATION FACTOR

There are two sets of inflation factors. One is used for the constant state contributions, the second one is used for the adjusted state contributions.

Inflation factor are inputs, which can be changed manually to make sure the ending co-op surplus fund every year is positive.

4. METHODOLOGY-CREDIBILITY WEIGHTED CONTRIBUTION METHOD

4.1 CREDIBILITY WEIGHTED CONTRIBUTION METHOD

We choose data from 2010 to 2013 as training data to predict the initial contribution for every district in 2014. The number of training years is fixed as 4 years. (i.e. if we predict the district contributions in 2015, we use historical data from 2011 to 2014.) The formula to calculate the initial district contributions is shown as follows assuming n years in the training data set:

$$\begin{aligned}&\text{Initial Contribution for District i in } (n+1)\text{st year}\\&\quad = (\text{Credibility Factor for District i in } n+1 \text{ year}\\&\quad * \text{ Average Final Contribution for District i over last n years}\\&\quad + (1 - \text{Credibility Factor for District i in } n+1 \text{ year})\\&\quad * \text{Industry Average Contribution over last n years}) * (1 + \text{Inflation Factor})^n\end{aligned}$$

Consider a simple example with 10 school districts and 3 years of training data. To calculate the credibility factor for each of the 10 districts and determine the coming year's contribution, we need to:

Calculate the average actual excess costs for each of 10 districts over the last 3 years, which denote by $\bar{x}1, \bar{x}2 \ldots \bar{x}10$.

Calculate the variance of the 10 averages which we denote by VHM.

For each of the 10 districts, calculate the standard deviation of actual excess costs over the past 3 years, which we denote by $\sigma 1, \sigma 2 \ldots \sigma 10$ The variance is the square of the standard deviation

Calculate the average of the 10 variances, which we denote by EPV.

Calculate the ratio of EPV over VHM, which we denote by k.

Calculate the total number of excess cost students for each of 10 districts over last 3 years, which we denote by m1, m2 …m10.

$$\text{Credibility Factor for District i in 2013} = \frac{m_i}{m_i + k}$$

4.2 TRIGGER

Based on the current performance of our new model, we found that for several specific districts, modeled contributions are always larger than the actual costs from 2014 to 2017. In this circumstance, it seems a little bit unfair to those districts who actually don't need to make that much budgets.

Therefore, we set up a trigger mechanism. For a specific district, if both of the its latest two years' modeled contributions are larger than its actual costs, then for this year's prediction, we ignore the credibility theory and just use the average of last two years' actual costs times the related inflation factor to do the following calculation:

$$District\ Contribution_{i,t} = \frac{Actual\ Cost_{i,t-1} + Actual\ Cost_{i,t-2}}{2} * (1 + Inflation\ Factor_t)$$

Where $i = 1, 2, \cdots, 219$; And $t = 2016, 2017$.

4.3 SURPLUS ADJUSTMENT

In this model, we introduce two very important funds: Risk Capital and Co-op Surplus Fund to help us maintain solvency and manage the surplus of district modeled contribution. We will explain the functionalities of these two funds and the mechanism of surplus adjustment which is based on Risk Capital and Co-op Surplus Fund.

4.3.1 RISK CAPITAL

The functionality of Risk Capital in this excess cost model is very similar to "Reserve" in Actuarial Science. Risk Capital can only be touched if the total contribution collected from district and state cannot cover the actual total excess cost (for more details, please refer to Section 0). At this time, the deficit part will be covered by the Risk Capital and hence the balance of Risk Capital will decrease. In order to bring it back to the required level, additional charges will be made on next year's district contributions. We will explain how to arrange these in surplus adjustment. Note that appropriate development factor was set when calculating district modeled contribution to avoid the depletion of Risk Capital.

For the required level of Risk Capital, we defined:

$$\text{Beginning Risk Capital}_t = 1\% * \text{Total Actual Excess Cost}_{t-1}$$

$$\begin{aligned}\text{Ending Risk Capital}_t &= 1\% * \text{Total Actual Excess Cost}_t \\ &= \text{Beginning Risk Capital}_{t+1}\end{aligned}$$

4.3.2 CO-OP SURPLUS FUND

There are two kinds of Co-op Surplus Fund every year. One is Beginning Co-op Surplus Fund, another one is Ending Co-op Surplus Fund. The Beginning Co-op Surplus Fund is the part of the Surplus Fund that does not fund to the districts, which will be accumulated to the same year's Ending Co-op Surplus Fund. The Ending Co-op Surplus Fund is basically the remaining contributions that the Co-op collected after paying the total actual excess cost plus the Beginning Co-op Surplus Fund. The increase in the Risk Capital (which is an expense) will also be calculated in Ending Co-op Surplus Fund and lower the balance. As a result, the balance of Ending Co-op Surplus Fund could be negative. The balance of Ending Co-op Surplus Fund will directly reflect on next year's modeled contribution, we will discuss this part on Section 0.

The formula of calculating the balance of Ending Co-op Surplus Fund is given as follows:

$$\begin{aligned}\text{Ending Co} - \text{op Surplus Fund}_t &= \text{Total District Modeled Contribution before Surplus Adjustment}_t \\ &+ \text{Total State Contribution}_t - \text{Total Actual Excess Cost}_t \\ &- (\text{Ending Risk Capital}_t - \text{Beginning Risk Capital}_t) \\ &+ \text{Begining Co} - \text{op Surplus Fund}_t\end{aligned}$$

4.3.3 SURPLUS ADJUSTMENT

According to the balance of Ending Co-op Surplus Fund, certain adjustments will be made to the modeled contribution after trigger in district level. The contribution after surplus adjustment is the final contribution that the Co-op need to collect from districts.

If the balance of Ending Co-op Surplus Fund is positive

In this case, it means that the Co-op have surplus on contribution collected so that they can reduce the amount of next year's contribution collected from district. Such reduction is the surplus adjustment. However, not every district will get a discount on their contribution. In this model, we looked at districts' last year's contributions and actual excess costs. If one district has higher contribution than actual excess cost, then it will be marked as a district with "good" performance. Otherwise it will be marked as "bad" performance. In the meantime, we also captured how much higher is the contribution than excess cost for district with "good" performance. That is because the surplus distributed back to district is proportional to the excess part of contribution to excess cost.

For example, suppose we have a total of three districts and the balance of Co-op Surplus Fund is $1 million. The other information is listed in the following table:

District	No. of SPED Students	Last year's final contribution (per student, after trigger & surplus adjustment)	Last year's actual excess cost (in total)
1	3	40,000	200,000

2	8	70,000	400,000
3	5	100,000	300,000

Based on our rules, District 2 and 3 are two districts with "good" performance. And the excess of contributions to actual excess costs are calculated as follows:

$$\text{District 2:} \quad 8 * 70{,}000 - 400{,}000 = 160{,}000$$

$$\text{District 3:} \quad 5 * 100{,}000 - 300{,}000 = 200{,}000$$

As a result, the surplus to be distributed to these two districts are:

$$\text{District 2:} \quad 1{,}000{,}000 * \frac{160{,}000}{360{,}000} = 444{,}444.44$$

$$\text{District 3:} \quad 1{,}000{,}000 * \frac{200{,}000}{360{,}000} = 555{,}555.56$$

It means that, in the next year, the total contribution to be collected from District 2 and 3 can be reduced by $444,444.44 and $555,555.56 respectively.

If the balance of Co-op Surplus Fund is negative

In this case, the district with "bad" performance will be charged additional amounts on their next year's contribution. The calculation and logic are very similar to the previous case. Note that the adjustment amounts for districts with "bad" performance are proportional to their shortage part of contributions to actual excess costs.

Modeled Contributions for every district should not be negative. If a district has more refund than its contribution, then, its Modeled Contribution becomes zero. And the part of fund that does not refund that that district will be put to next year's Beginning Co-op Surplus Fund.

5. TESTING RESULTS

We did the solvency test, overall feasibility test and district volatility test to verify the goodness of the model. We used the historical state contributions to run all the tests for the first time. After that, we used the adjusted state contributions to do the same tests for comparison. The adjusted method is shown as below:

State Contribution this year = State Contribution last year *(1+ State Contribution Increase Factor this year)

Since 2013 is the initial year, the state contribution in 2013 is still the historical data.

To do the tests, we used 4% every year as the State Contribution Increase Factors, 3%,4%, 5.5%, 5.5% as the inflation factors for constant state contribution tests and 2.5%, 3%, 3.15%,3.225% as the inflation factors for adjusted state contribution tests from 2014 to 2017.

5.1 SOLVENCY TEST

- Historical State Contribution

Using historical state contributions, the Ending Co-op Surplus Funds are positive from 2014 to 2017, which means the overall state contribution and overall district contribution are enough to cover the total excess cost from 2014 to 2017.

	2014	2015	2016	2017
Ending Co-op Surplus Fund	19,626,022	446,744	2,105,240	2,519,396

- Adjusted State Contribution

The Ending Co-op Surplus Funds are also positive from 2014 to 2017 after adjusting the state contributions.

	2014	2015	2016	2017

Ending Co-op Surplus Fund	13,638,492	354,772	642,074	1,290

5.2 OVERALL FEASIBILITY TEST

- Historical State Contribution

The overall historical average actual cost (73,720) is slightly lower than overall average modeled contribution (74,671) and 62% of districts' average modeled contribution are higher than their average historical actual cost.

- Adjusted State Contribution

After adjusting the state contributions, the overall average modeled contribution will drop to 71,185, which is less than the overall historical average actual cost (73,720). 15% of districts' average modeled contribution are higher than their average historical actual cost.

5.3 DISTRICT VOLATILITY TEST

- Historical State Contribution

Using the historical state contributions, 66% of districts have higher standard deviation of modeled contribution than standard deviation of actual cost.

- Adjusted State Contribution

Using the adjusted state contributions, 42% of districts have higher standard deviation of modeled contribution than standard deviation of actual cost.