RUTGERS

THE STATE UNIVERSITY OF NEW JERSEY

The Analysis and Prediction of Fiscal Distress in Local Governments: Using Statistical Methods and Machine Learning Algorithms

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Financial distress of local governments

- According to the Census Bureau, local governments are defined as
  - General purpose: cities and counties
  - Special-purpose: school districts, water authorities and other narrowly-defined municipalities
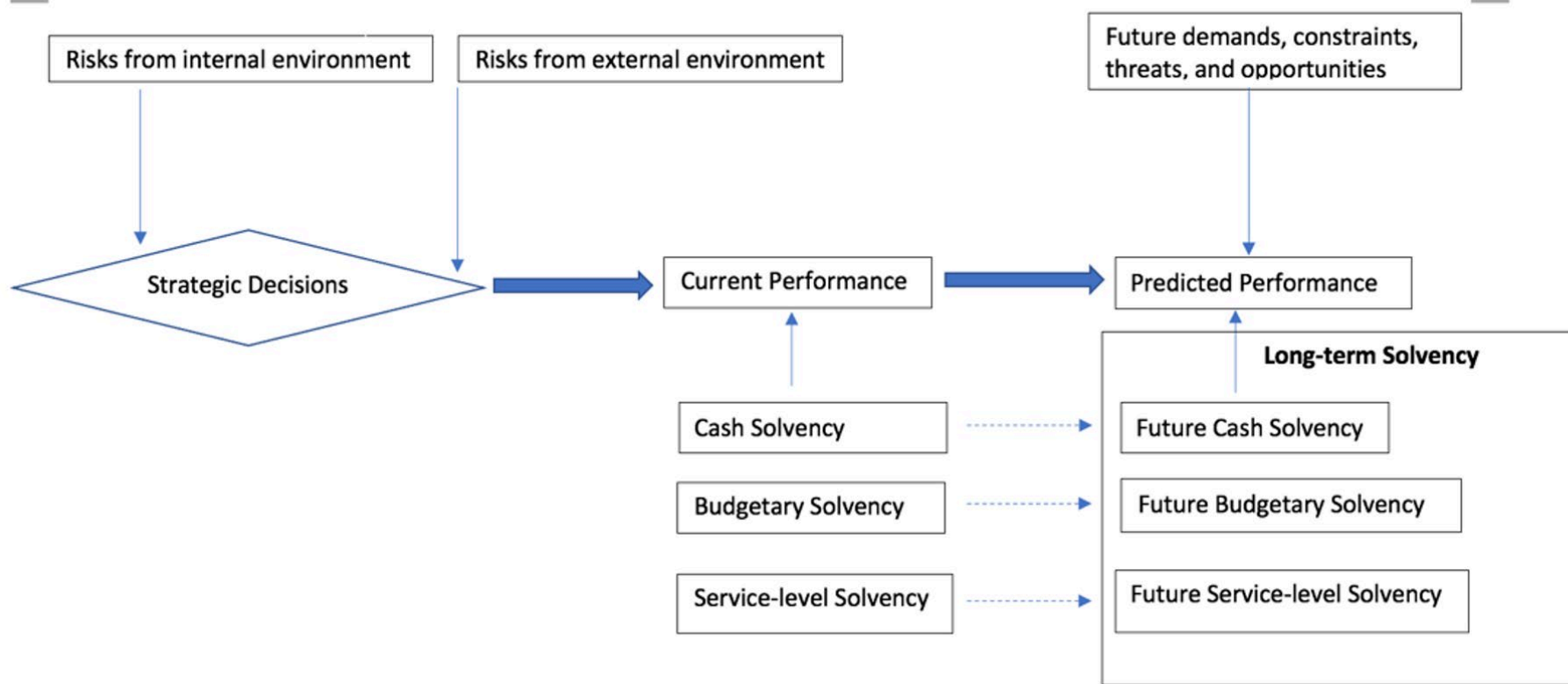
- Consequences of bankruptcy protection
  - High cost of professionals
  - High property tax bill and low pension benefits for citizens
  - Lost population and reputation damage
  - Impaired access to the capital markets

Figure 3. The Fiscal Status Assessment Framework

$$\text{FiscalHealth}_{i,t} = \beta_0 + \text{Long-Term Solvency}_{i,t-1} + \text{Cash Solvency}_{i,t-1} + \text{Budgetary Solvency}_{i,t-1} + \text{Service-Level Solvency}_{i,t-1} + \text{Revenue Structure}_{i,t-1} + \text{Controls} + \varepsilon_{i,t-1} \tag{1}$$

$$\text{FiscalDistress}_{i,t} = \beta_0 + \text{Long-Term Solvency}_{i,t-1} + \text{Cash Solvency}_{i,t-1} + \text{Budgetary Solvency}_{i,t-1} + \text{Service-Level Solvency}_{i,t-1} + \text{Revenue Structure}_{i,t-1} + \text{Controls} + \varepsilon_{i,t-1} \tag{2}$$

Research Question 1 (1/2)

- examining relevant determinants of the fiscal status of municipalities

- Fiscal status as

❑ Magnitude of Fiscal Stability

❑ Net position of Governmental Activities (GA)

- Fiscal Distress as

❑ technical insolvency (YES or No)

❑ Negative net position of Governmental Activities (GA) by (Fischer & Prachyl, 2020)

Research Question 1 (2/2)

- Main Findings
  - ❑ Unrestricted net asset of governmental activities and the revenue-to-expense ratio of business-type activities are significantly associated with a municipality's fiscal status

Measures of Financial Condition	Var.	Indicators	Formula
Long-run Solvency	L1	Unrestricted Net Asset	Unrestricted Net Position / Total Revenue
	L2	Capital Asset Condition	Accumulated Depreciation / (Current Year's Depreciable Capital Assets + Prior Year's Depreciable Capital Assets)
	L3	Net Asset Fluctuation	Change in Net Position / Total Revenues
	L4	Bonded Debt per Capita	General Bonded Debt (GA) / Population in the Current Year
	L5	Unfunded Liabilities in GA	(Net OPEB + Net Pension Liability) / Total Liabilities in GA
	L6	Unfunded Liabilities in BTA	(Net OPEB + Net Pension Liability) / Total Liabilities in BTA
Cash Solvency	C1	Current Ratio	Current Assets / Current Liabilities
Budgetary Solvency	B1	GA Interperiod Equity	GA's Net Revenues / GA's Total Expenses
	B2	BTA Self-Sufficiency	BTA's Service Charge Revenues / BTA's Total Expense
	B3	Revenue Dispersion	Non-Tax Revenue Sources / Total Revenue
	B4	Intergovernmental Revenue Ratio	Intergovernmental Revenues / General Fund Revenue
	B5	General Fund Balance	General Fund Balance / General Fund Revenue

Research Question 2

- investigating the impact of state legislation of Chapter 9 on the fiscal status of municipalities

12 states authorizing Chapter 9[1]	12 states conditionally authorizing Chapter 9[2]	Three states with limited authorization	Two states prohibiting Chapter 9	21 states with unclear authorization
ALABAMA (AL)	CALIFORNIA (CA)	COLORADO (CO): Legislation specifically authorizes special taxing districts to file a petition under Chapter 9, "any insolvent taxing district is hereby authorized to file a petition authorized by federal bankruptcy law and to take any action necessary or proper to carry out the plan filed with said petition…" (CRS § 37-32-102 (Drainage and Irrigation District)).	Iowa (IA): While Iowa typically forbids Chapter 9 filings (Ia. Code Ann. § 76.16), exceptions are made for insolvency due to non-insured debt (Ia. Code Ann. § 76.16A).	ALASKA (AK)
ARIZONA (AZ)	CONNECTICUT (CT)			DELAWARE (DE)
				HAWAII (HI)
ARKANSAS (AR)	FLORIDA (FL)			INDIANA (IN)
				KANSAS (KS)
IDAHO (ID)	KENTUCKY (KY)			MAINE (ME)
				MARYLAND (MD)
MINNESOTA (MN)	LOUISIANA (LA)	OREGON (OR): Legislation permits Irrigation and Drainage Districts to file a petition under Chapter 9 (Or. Rev. Stat. § 548.705).		MASSACHUSETTS (MA)
				MISSISSIPPI (MS)
MISSOURI (MO)	MICHIGAN (MI)			NEBRASKA (NE)
				NEW HAMPSHIRE (NH)
MONTANA (MT)	NEW JERSEY (NJ)			NEW MEXICO (NM)
				NORTH DAKOTA (ND)
NEBRASKA (NE)	NORTH CAROLINA (NC)			SOUTH DAKOTA (SD)
				TENNESSEE (TN)
OKLAHOMA (OK)	NEW YORK (NY)		Georgia (GA): Ga. Code Ann. § 36-80-5	UTAH (UT)
				VERMONT (VT)
SOUTH CAROLINA (SC)	OHIO (OH)	ILLINOIS (IL): Legislation specifically grants authorization exclusively to the Illinois Power Agency (20 Ill. Comp. Stat. Ann. 3855/1-20(b)(15)).		VIRGINIA (VA)
				WEST VIRGINIA (WV)
TEXAS (TX)	PENNSYLVANIA (PA)			WISCONSIN (WI)
WASHINGTON	RHODE ISLAND			WYOMING (WY)

Research Question 3

- predicting municipalities with fiscal distress in an imbalanced dataset

Model Performance (1/2)

Roughly Balanced Bagging emerges as the optimal classifier for predicting financial distress in this imbalanced dataset, followed by Logistic Regression

Table 10. Results of Research Question 3 - Performance Analysis of Classification Models

Panel A: Overall Model Performance (N=1,112)

Classification Model	Precision (%)	Recall (%)	Specificity (%)	Accuracy (%)	F1 Score (%)
Logistic Regression	72.73%	44.44%	98.54%	94.17%	55.17%
XGBClassifier	54.55%	33.33%	97.56%	92.38%	41.38%
RUSBoost	42.86%	66.67%	92.20%	90.13%	52.17%
C4.5 Decision Tree	53.85%	38.89%	97.07%	92.38%	45.16%
Exactly Balanced Bagging	40.63%	72.22%	90.73%	89.24%	52.00%
Roughly Balanced Bagging	80.00%	44.44%	99.02%	94.62%	57.14%

Model Performance (2/2)

Panel A. Undersampling the Majority (# Class 1 in training set =62)

Classification Model	Precision (%)	Recall (%)	Specificity (%)	Accuracy (%)	F1 Score (%)
XGBClassifier	33.33%	77.78%	86.34%	85.65%	46.67%
RUSBoost	33.33%	83.33%	0.8537	85.20%	47.62%
C4.5 Decision Tree	25.45%	77.78%	80.00%	80.00%	38.36%
Exactly Balanced Bagging	32.56%	77.78%	85.85%	85.20%	45.90%
Roughly Balanced Bagging	29.17%	77.78%	83.41%	82.96%	42.42%

Panel B. Tuning Sampling Ratio (# Class 1 in training set =62)

Classification Model	Optimal Sampling Ratio	True Positive	False Negative	Precision (%)	Recall (%)	F1 Score (%)
XGBClassifier	0.23	12	6	63%	67%	65%
RUSBoost	0.34	15	3	43%	83%	57%
C4.5 Decision Tree	0.36	10	8	50%	56%	53%
Exactly Balanced Bagging	0.12	15	3	39%	83%	54%
Roughly Balanced Bagging	0.47	14	4	48%	78%	60%

Main Findings & Contributions

- Contribution
  - ❑ Examining various indicators to understand the level of financial status of municipalities
  - ❑ Providing useful insights to practitioners who are interested in municipal fiscal distress
  - ❑ offering an effective way to predict fiscal distress in imbalanced datasets