

Using Confidence Intervals to Minimize Forecasting Error

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Motivation

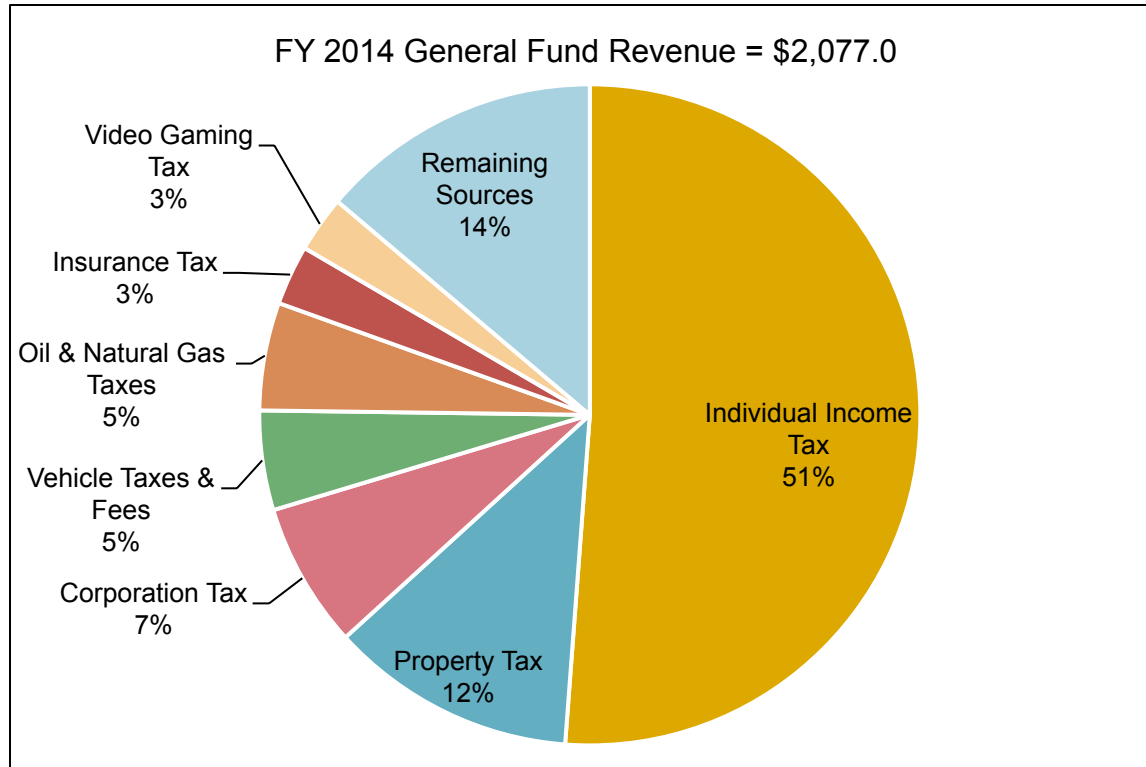
- ▶ In past years there have been numerous requests from the Legislature for standard error analysis of corporation income tax.

Objectives

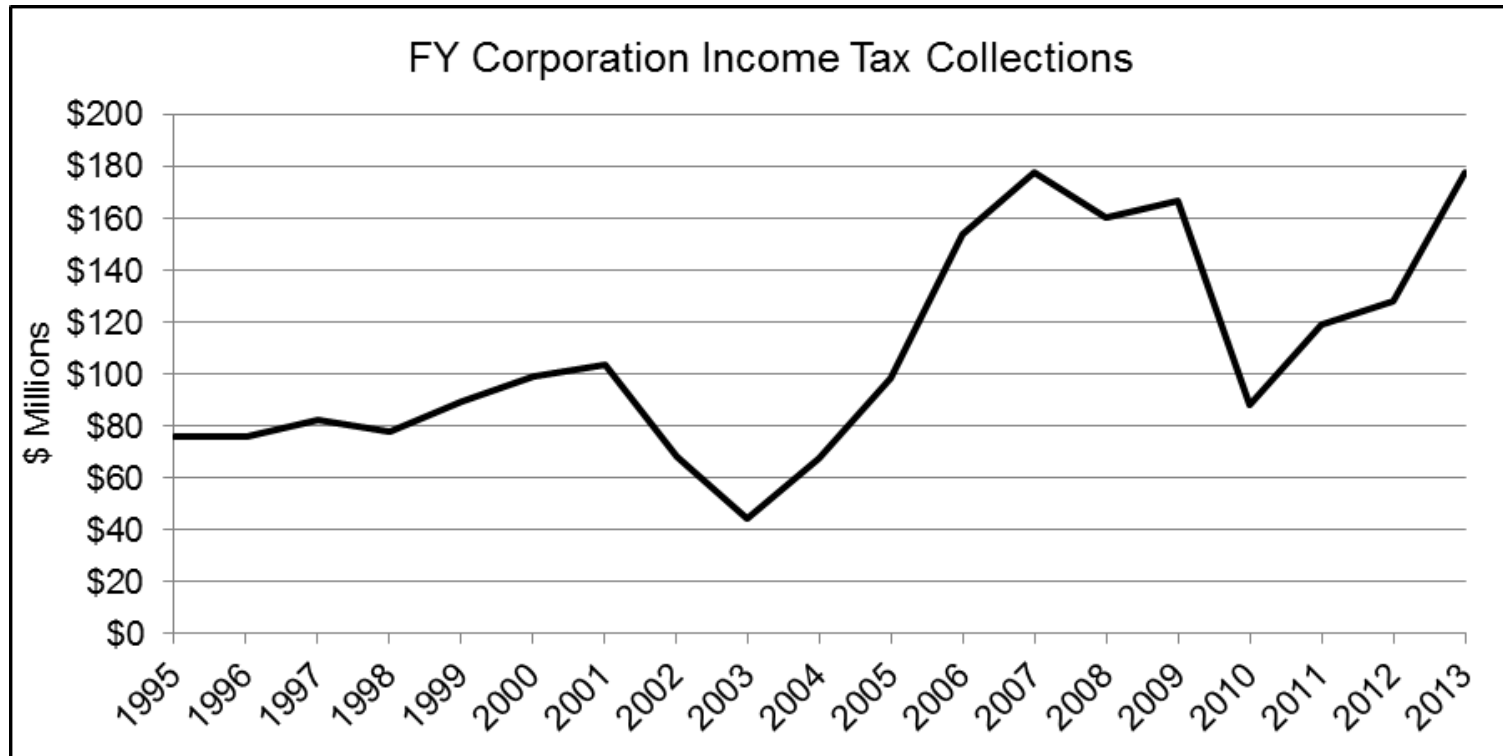
- ▶ Select economic variables that model past revenue well.
- ▶ Select economic variables that IHS consistently predicts well.
- ▶ Place some level of certainty on a revenue estimate.
- ▶ This will allow for comparison of models that use IHS economic forecasts as the main predictors.

Background:

FY 2014=\$2,077 million



Volatility of Corporation Tax



Sources of Forecasting Error

- ▶ Taxpayer Behavior
 - Montana law allows corporations to carry back current year losses for three years, and carry forward losses for up to seven years.
- ▶ Reliance on a limited number of large taxpayers.
- ▶ Random Error
- ▶ Inherent error of IHS variables used for modeling.

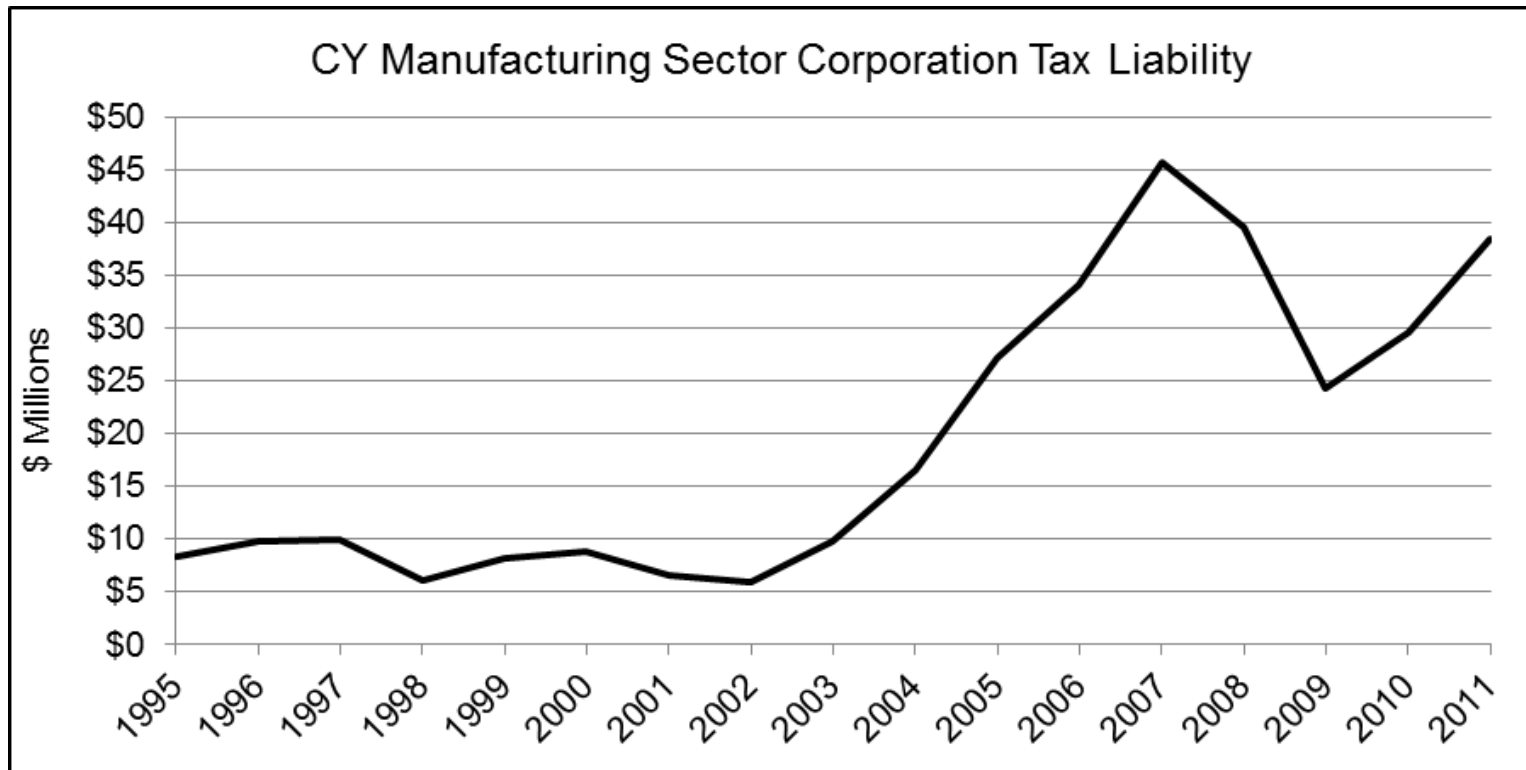
Forecast Methodology

- ▶ Corporation tax liabilities are divided into numerous sectors.
- ▶ These sectors include, but are not limited to, mining, manufacturing, retail trade, and financial sectors.
- ▶ IHS economic variables are used to model each sector individually.
- ▶ Sector estimates are combined to form a final revenue estimate for corporation tax liability.

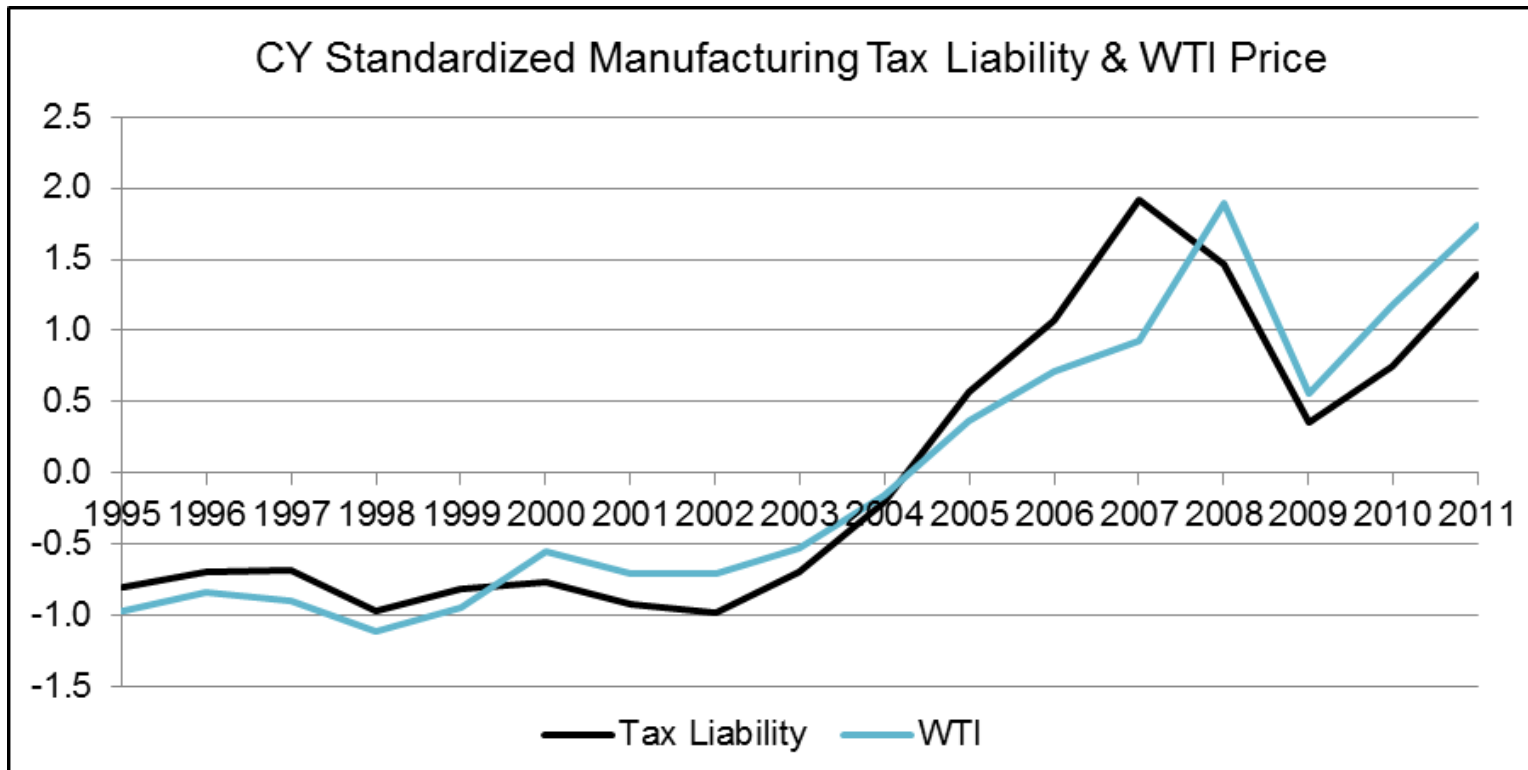
Study Sector-by-Sector Error

$$\epsilon (\text{error}) = \text{actual value} - \text{estimate} / \text{actual value}$$

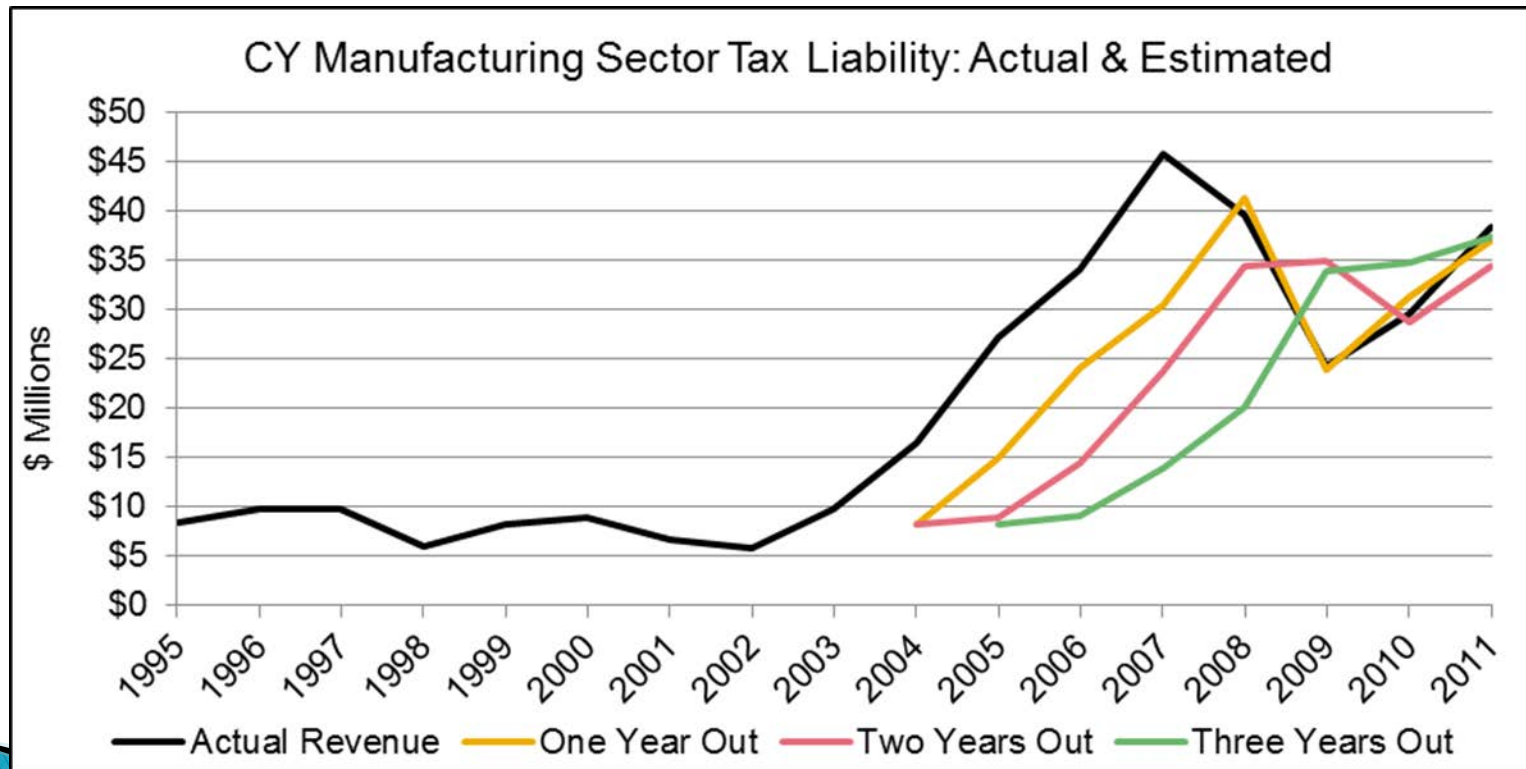
Example: Manufacturing Sector



WTI Price Fits Historical Data Well...



...but how well do IHS forecasts of WTI predict manufacturing tax liability?



Actuals vs. Estimates

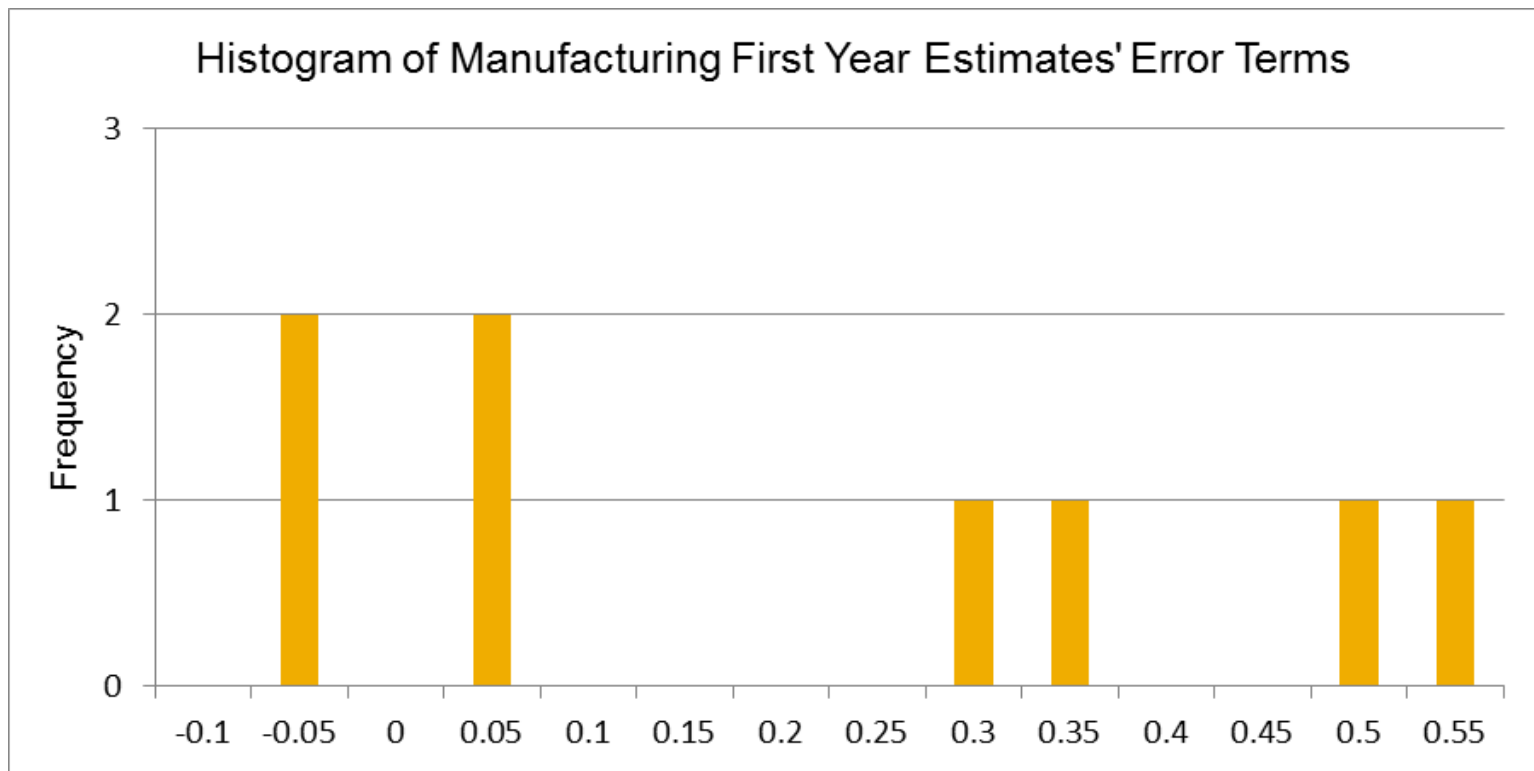
Error Term by Year of Estimate			
CY	First Year	Second Year	Third Year
2004	50%	50%	N/A
2005	45%	67%	70%
2006	29%	57%	73%
2007	33%	48%	70%
2008	-5%	13%	49%
2009	1%	-44%	-40%
2010	-6%	3%	-17%
2011	4%	11%	3%

Statistical Theory

- ▶ A confidence interval for the individual errors would require that their distribution be known.
- ▶ With such a small sample, confidence in the true distribution is small.

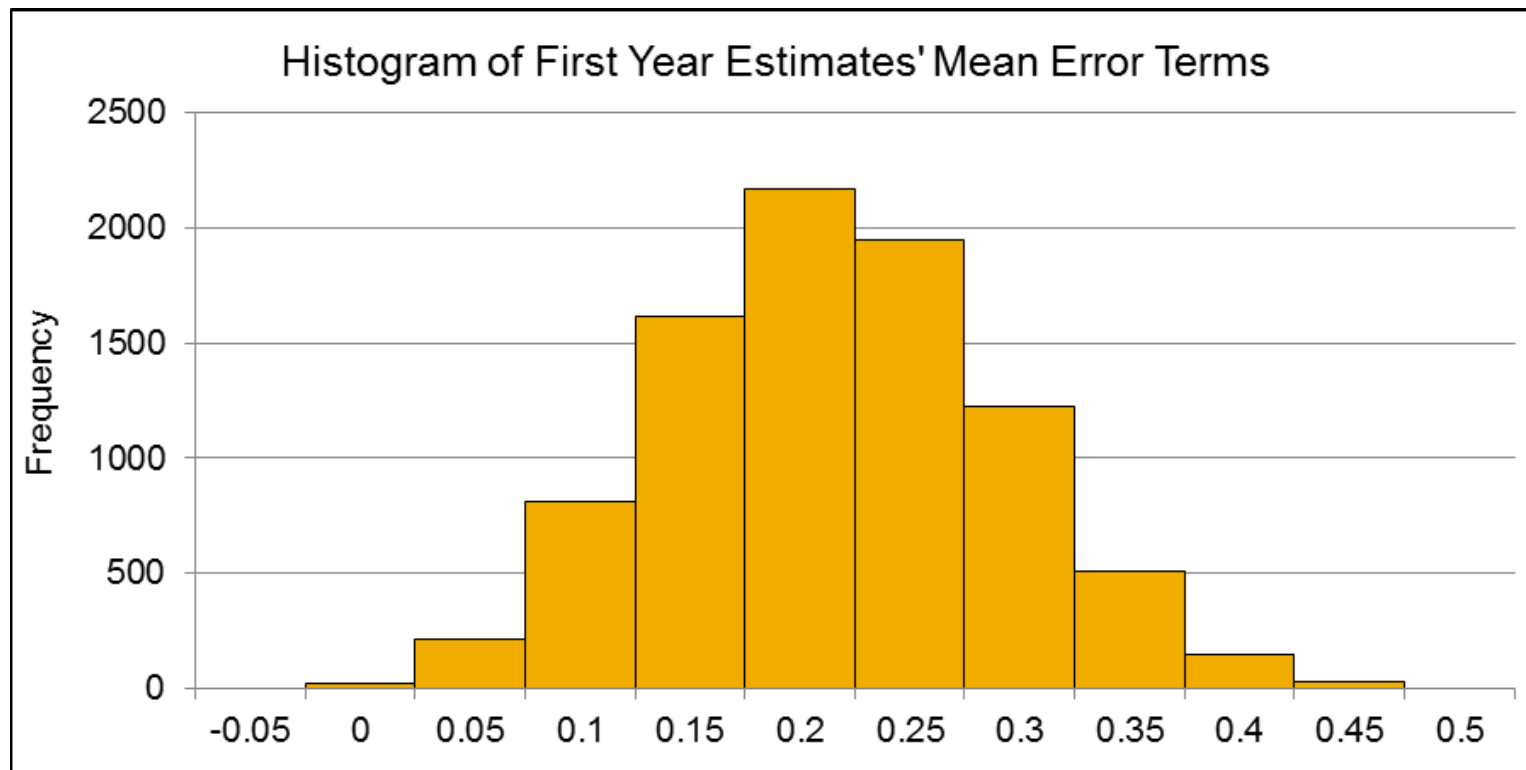
Error Summary and Distribution

Summary Statistics of Manufacturing Tax Liability Error Term by Estimate Year			
Statistic	First Year	Second Year	Third Year
Mean	19%	26%	30%
Standard Deviation	23%	37%	47%



Bootstrap Sample Mean

Summary Statistics of Manufacturing Tax Liability Average Error Term by Estimate Year			
Statistic	First Year	Second Year	Third Year
Mean Error	19%	26%	30%
Standard Error	8%	12%	16%



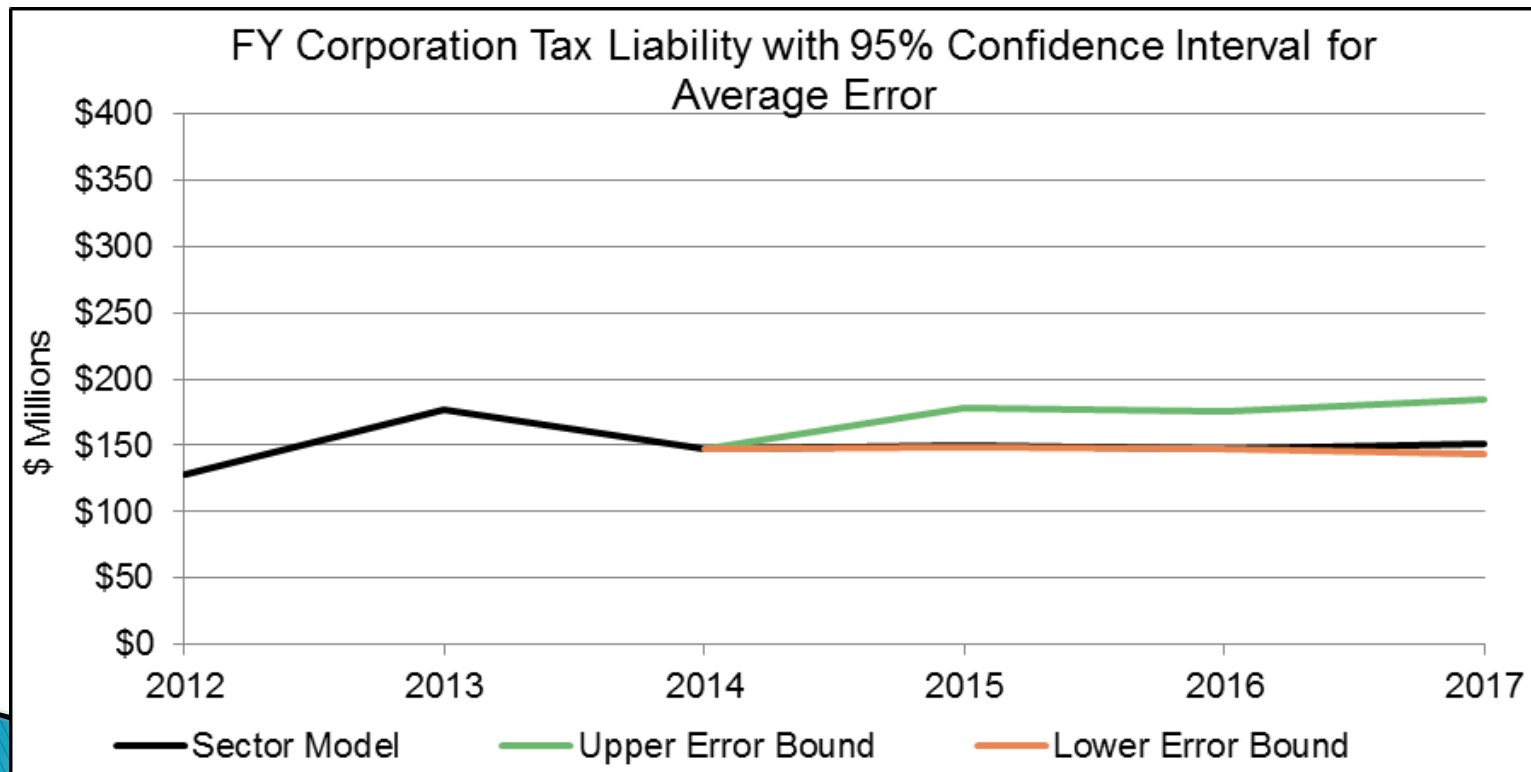
Aggregate Results

CY Corporation Income Tax Liability						
95% Confidence Intervals for the Aggregate Average Error Term of the Sector-Based Estimate (\$ Millions)						
		Mean Error	t-Statistic		Standard Error	Interval
First Year Error Bound	=	\$15.1	± 2.365	×	\$6.7	= [-\$0.8,\$30.9]
Second Year Error Bound	=	\$13.3	± 2.450	×	\$9.3	= [-\$9.6,\$36.1]
Third Year Error Bound	=	\$10.2	± 2.571	×	\$12.2	= [-\$21.2,\$41.6]

CY Corporation Income Tax Liability				
95% Confidence Intervals for the Sector-Based Estimate's Average Error (\$ Millions)				
Estimate Year	Estimate	Lower Bound	Upper Bound	% Range
2015	\$135.0	\$134.2	\$165.9	24%
2016	\$139.2	\$129.6	\$175.3	33%
2017	\$145.3	\$124.1	\$186.9	43%

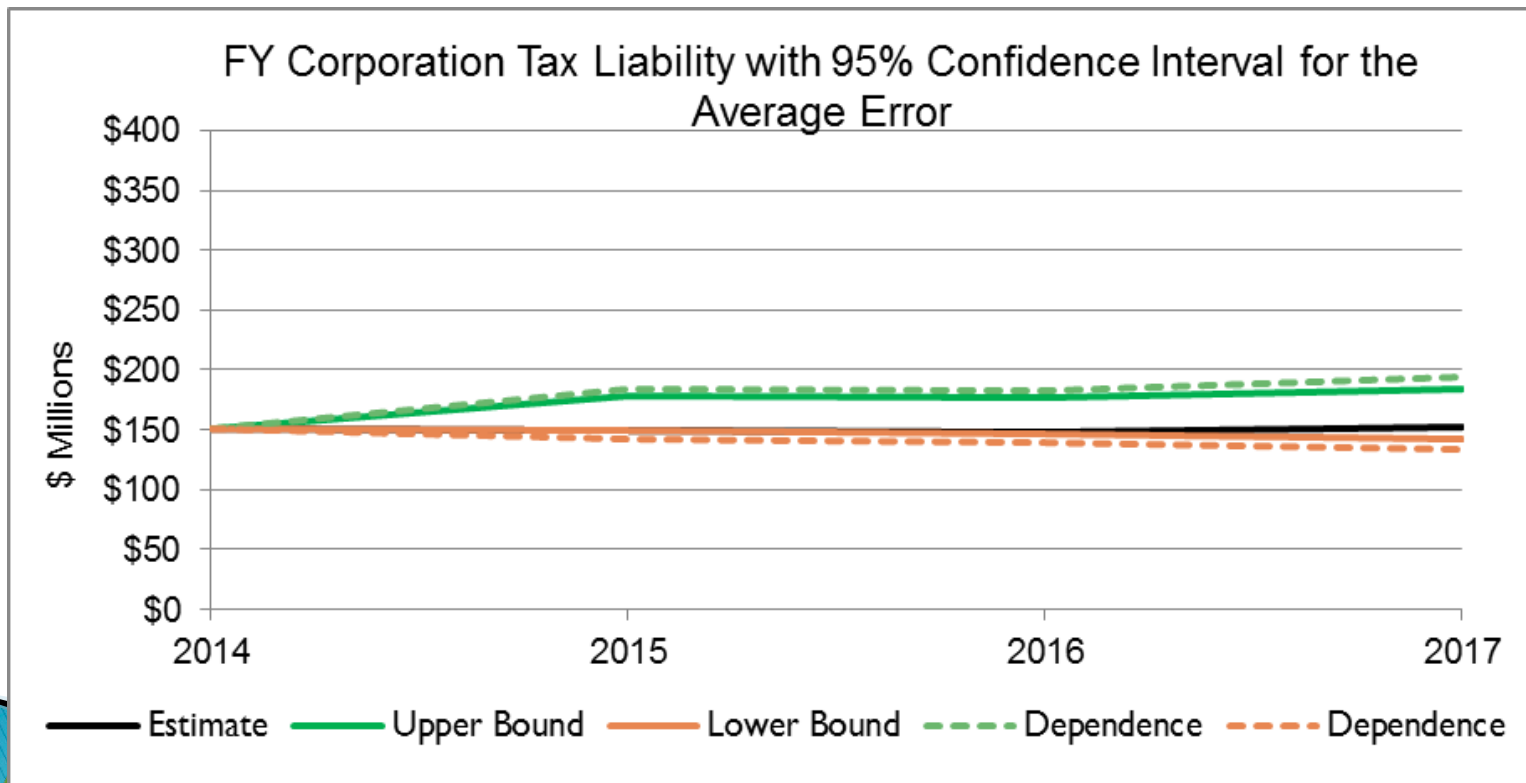
Fiscal Year Results

FY Corporation Income Tax Liability Using 95% Confidence Intervals for the Sector-Based Estimate's Average Error (\$ Millions)				
Estimate Year	Estimate	Lower Bound	Upper Bound	% Range
2015	\$149.7	\$149.0	\$177.7	19%
2016	\$147.9	\$147.2	\$176.2	20%
2017	\$151.7	\$142.9	\$184.8	28%



Are the Variables Independent?

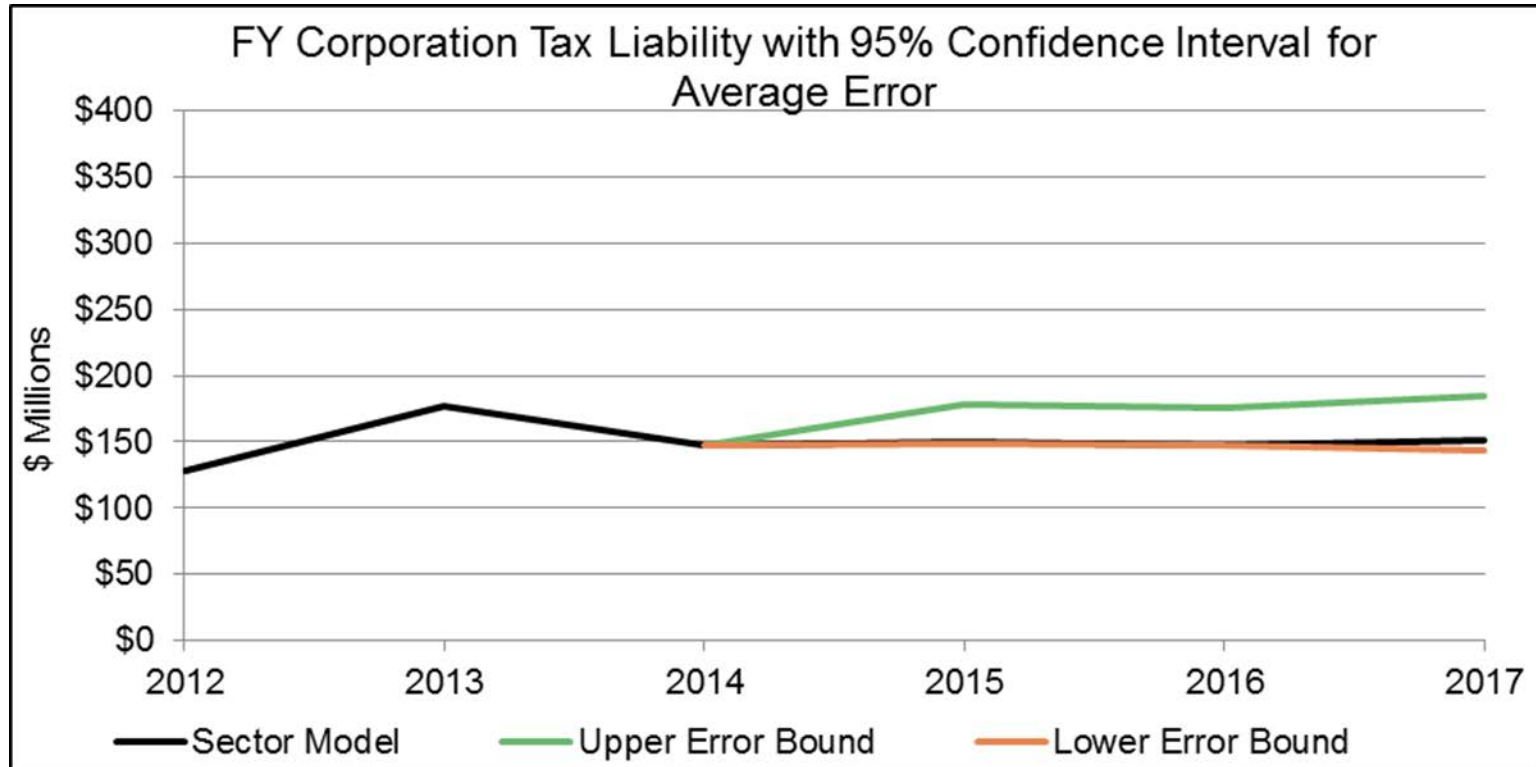
FY Corporation Income Tax Liability 95% Confidence Intervals for the Sector-Based Error Assuming Partial Dependence (\$ Millions)				
Estimate Year	Estimate	Lower Bound	Upper Bound	% Range
2015	\$149.7	\$142.0	\$184.7	29%
2016	\$147.9	\$140.0	\$183.3	29%
2017	\$151.7	\$133.9	\$193.9	40%



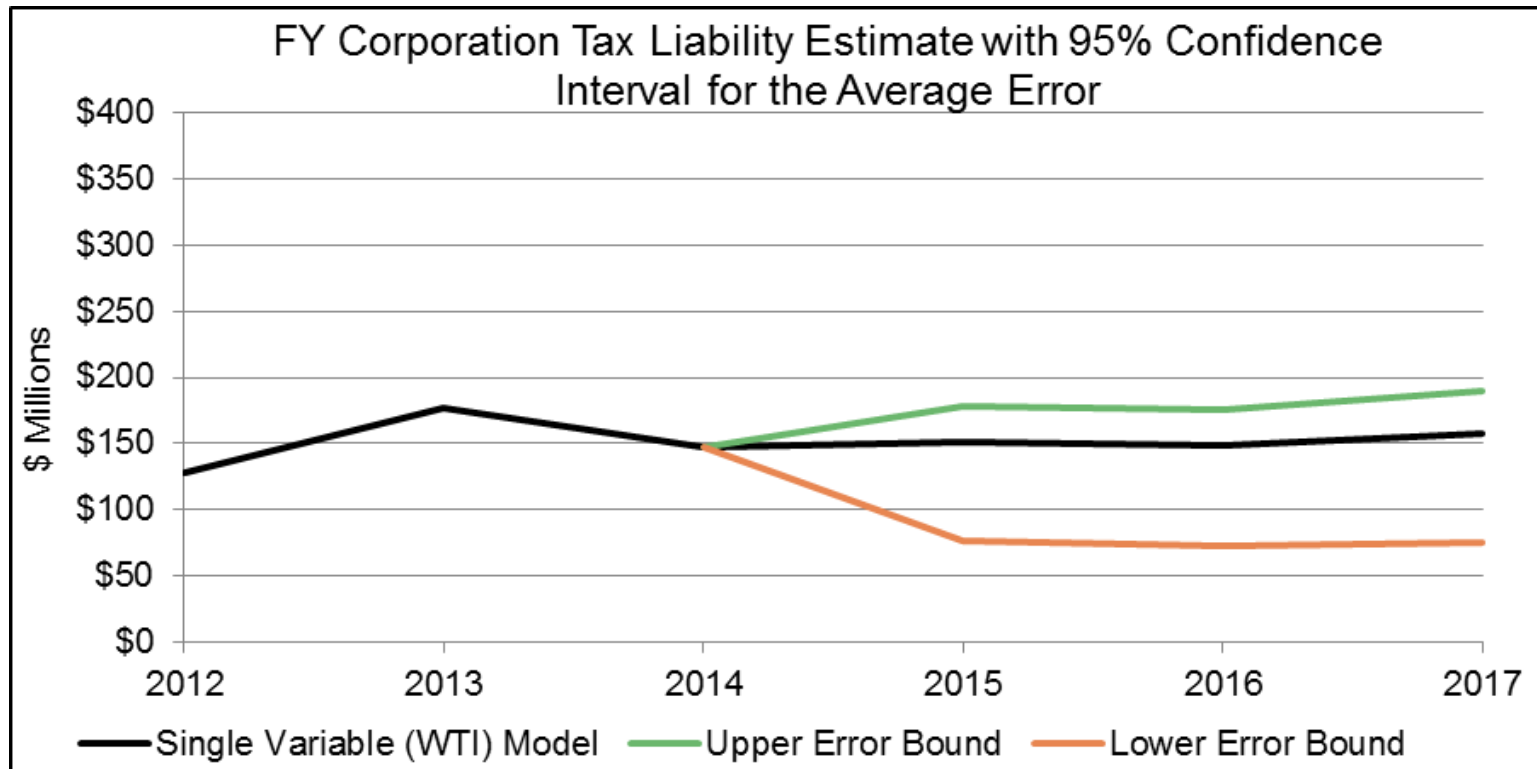
Results

- ▶ Adjusted corporation sector liability models to minimize future error bounds.
- ▶ Produced an aggregate estimate and corresponding error bounds for the sector-specific model.
- ▶ Calculated error bounds associated with alternative models.
- ▶ Allows for comparison of forecasts that use economic forecasts as the main predictors.

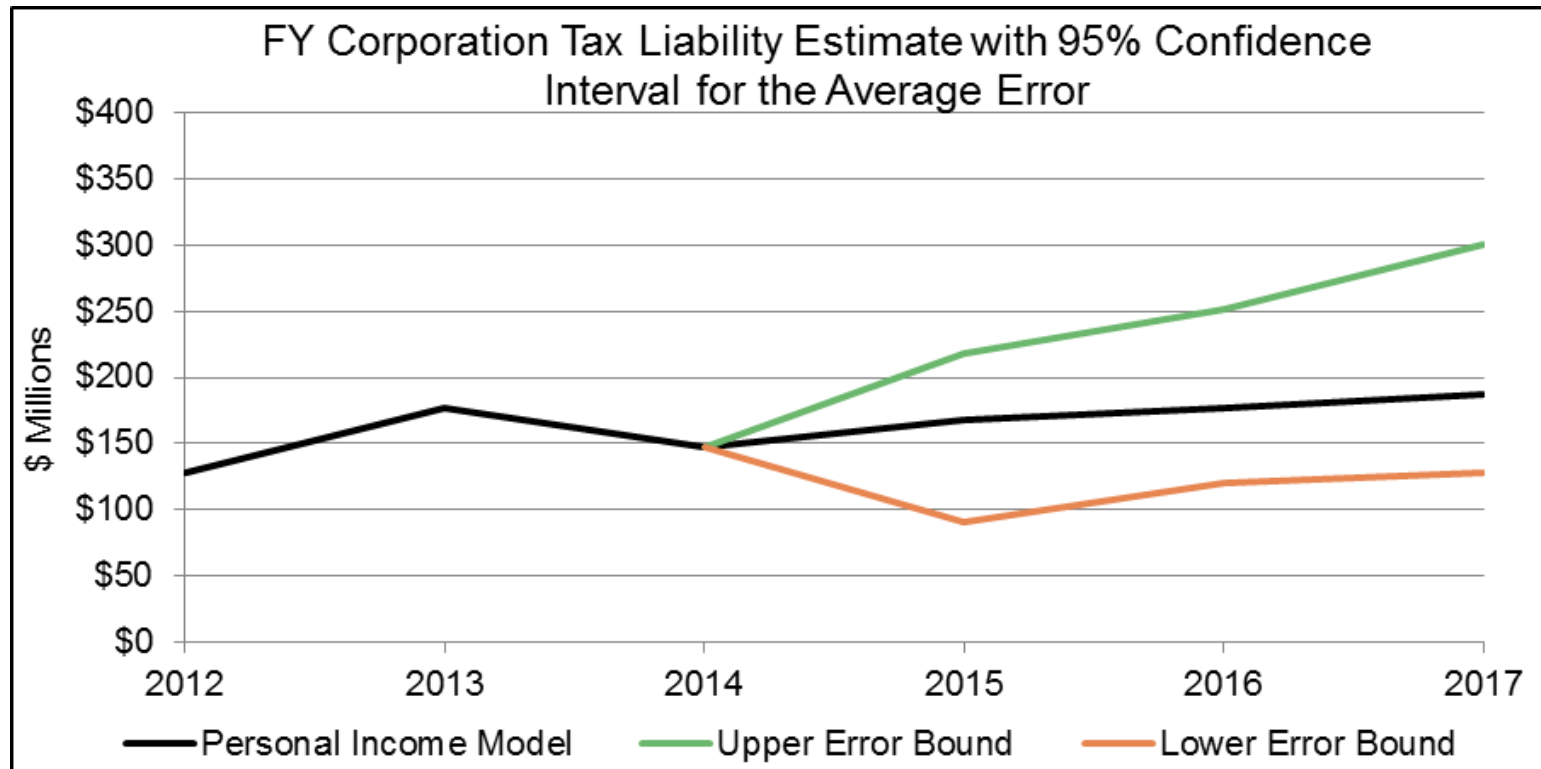
Sector-Based Model



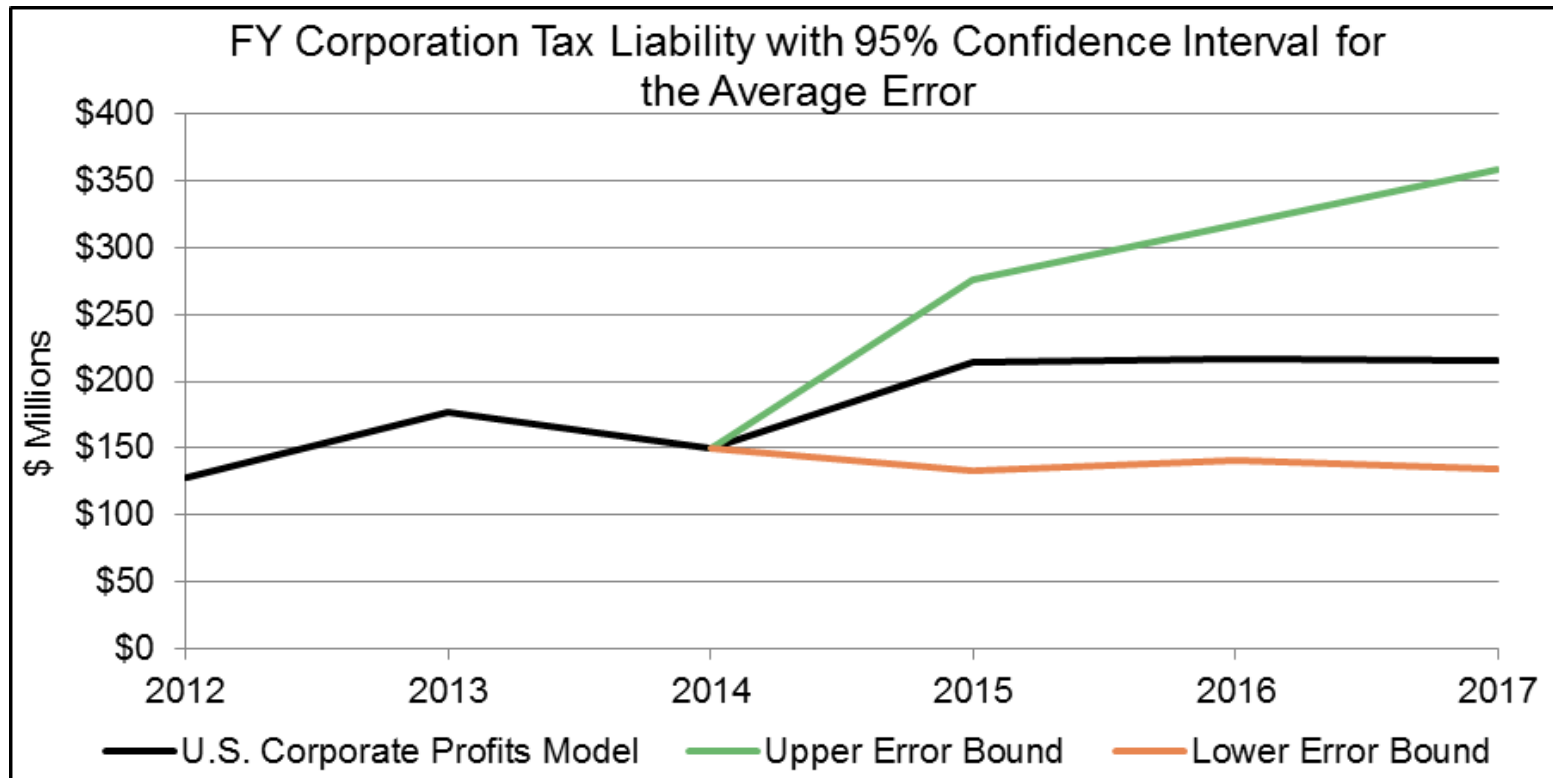
Single Variable Model: WTI



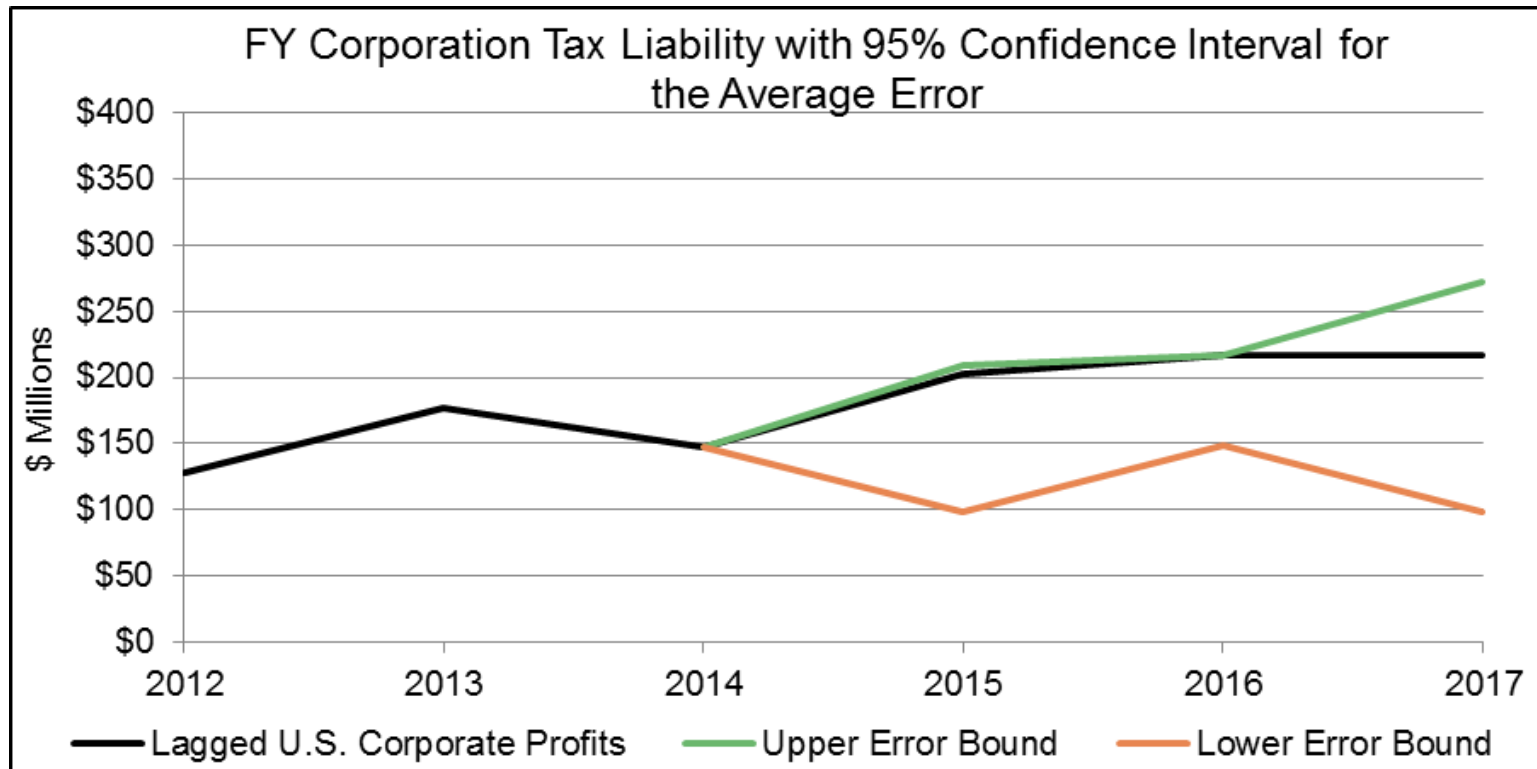
Single Variable Model: Personal Income



Single Variable Model: US Corporate Profits



Lagged Corporate Profits Model



Future Work

- ▶ Continue peer–review process.
- ▶ Incorporate relevant suggestions.
- ▶ Apply methodology to other large or volatile revenue sources.