Modeling the D.C. Economy, Revenues, and Debt Service Obligations

November 13, 2019

A Methodology Report by District Economics Group

Office of the District of Columbia Auditor

Kathleen Patterson, District of Columbia Auditor
www.dcauditor.org

November 13, 2019

The Hon. Phil Mendelson
Chairman
Council of the District of Columbia
1350 Pennsylvania Avenue N.W.
Washington, DC 20004

Dear Chairman Mendelson:

As you know, the D.C. Auditor's signature is required each time the District of Columbia goes to the bond market to borrow money. The D.C. Official Code, § 1-206.03 (b)(1) states that the D.C. Auditor must certify the accuracy of the Chief Financial Officer's (OCFO) revenue estimate as follows:

> *No general obligation bonds… or Treasury capital project loans shall be issued during any fiscal year in an amount which would cause the amount of principal and interest required to be paid both serially and into a sinking fund in any fiscal year on the aggregate amounts of all outstanding general obligation bonds and such Treasury loans, to exceed 17% of the District revenues… which the Mayor estimates,* ***and the District of Columbia Auditor certifies****, will be credited to the District during the fiscal year in which the bonds will be issued…*

To comply with this requirement, the Office of the D.C. Auditor (ODCA) issued three revenue reports in FY 2019 certifying that the OCFO revenue estimate, at the time of certification, appeared to be sufficiently supported and achievable. Each report included staff analyses on the District's revenues and interviews with representatives of the Stephen S. Fuller Institute at George Mason University.

This year we determined to take a more robust approach to the ODCA role and contracted with the District Economics Group (DEG) to design and build a revenue forecasting model that will serve as an independent assessment for future certifications. DEG founder Michael Udell and consultant economist Diane Lim lead the firm's work on the forecasting model. What follows is a report on the methodology and assumptions used to develop the revenue forecasting model for ODCA.

We anticipate the model will be used for the first time later this year in conjunction with the issuance of Income Tax Secured Revenue Bonds. It is our intention to use this forecasting model for revenue certifications for several years then reassess and possibly contract with another firm to assist us in meeting ODCA's revenue certification responsibility to be consistent with best practices in public and private sector auditing. My thanks to Chief Financial Officer Jeffrey S. DeWitt and Deputy CFO and Chief Economist Fitzroy Lee for providing DEG with current and historical revenue data.

An important bottom line in the work reflected here is that this independent assessment produced annual forecasts of the District Gross Domestic Product that, while not identical, are very similar to those of the OCFO. We also identify an issue ripe for discussion going forward, which is whether it would be advisable to capture in a single data point the total amount of bond pledges made against income tax revenues for income tax secured bonds, tax increment financing, and other financial instruments used.

I hope the ongoing independent assessment of the District's revenues will be of value to the D.C. Council as well as to the CFO and others in the executive branch, and to District residents.

Sincerely yours,

Kathleen Patterson
District of Columbia Auditor

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Modeling the D.C. Economy, Revenues, and Debt Service Obligations: A Methodology Report for the Office of the D.C. Auditor

District Economics Group
October 2019

Executive Summary

District Economics Group (DEG) constructed a revenue forecasting model for the Office of the District of Columbia Auditor (ODCA) to assist in fulfilling responsibilities the ODCA has pursuant to D.C. Code § 1-206.03(b)(1) to certify that bond obligations will not exceed the District's 17% debt limit cap. In assisting ODCA, DEG created:

- A detailed revenue table similar to Table 1 of the Revenue Estimates reports prepared by the Office of the Chief Financial Officer (OCFO) as part of their certification to the Mayor of fiscal year revenue estimates.
- A detailed bond and revenue note funding table reflecting the D.C. Governments' payment obligations through time.
- A general macro-economic forecast of key parameters of the D.C. economy.

This methodology report describes the models DEG has developed for ODCA and the sources of data employed. Our findings observed and discussed in our methodology report are as follows:

- Our primary conclusion is that our annual forecasts of D.C. GDP are similar to that of the Office of the OCFO.
- A $1 billion decline in D.C. Gross Domestic Product (GDP) results in, on average, a $60 million decline in D.C. general fund revenue.
- D.C. general fund revenues are projected to grow annually at approximately 4.1% while population growth is projected to grow annually at approximately 1.0%.
- D.C. revenue projections show an increasing amount of revenue dedicated to special purpose revenue funds.
- Payments of principal and interest subject to the 17% limitation for ODCA certification are projected to grow from 9.39% to 9.6% if historic patterns of borrowing are maintained through 2049.
- D.C. does not use income tax revenues to fund special purpose revenue funds. Income tax revenues are used as obligations or pledges on certain bond issuances. We could find no accounting of the total of these bond pledges, all of which appear to be pledges against income tax revenues, in the D.C. government documents reviewed. This could lead to a distorted view of D.C.'s fiscal capacity.

Introduction

District Economics Group (DEG) was asked to design and build a revenue forecasting/projection model of the D.C. economy and budget outlook for the Office of the District of Columbia Auditor (ODCA), to provide a regular and independent assessment to support ODCA's role of certifying the revenue adequacy of D.C. government finances pursuant to § 1-206.03(b)(1) of the D.C. Official Code. This report documents the methodology and assumptions that went into the revenue forecasting model that DEG built for the ODCA. The revenue forecasting model will provide source-by-source details of each revenue stream and the extent of each revenue stream's dedication to programs in the D.C. government budget, on a frequency as needed by the Auditor in support of the certifications and will be continually improved as new data become available.

Objective

Our modeling approach in building a revenue forecasting model for the ODCA uses historical economic and fiscal revenue data to parameterize the relationships between economic measures and revenue levels that can then be applied to long-term economic forecasts to determine the implied long-term revenue outlook. The model uses annual D.C. economy and fiscal revenue measures as inputs and provides annual forecasts of fiscal revenues necessary for the D.C. Auditor's certifications. The forecasted revenue amounts form the basis for a test of the ratio of annual amount of principal and interest due on certain bonds to the amount of certain revenues, which cannot exceed 17% as noted in D.C. Code § 1-206.03(b)(1) of the D.C. Code.

As with all revenue forecasts based on historical data a key assumption is that observed past relationships between the economy and revenues will persist into the future. It is a challenge to know how accurate this assumption is—i.e., how much the future will behave like the past. As is well understood, the U.S. economy performance was much stronger in years prior to the great recession than since and how a model accounts for this difference can significantly impact forecasts. (See the three rightmost columns in Table 2 for an example of the D.C. economy) The wide variation in the historical data leads us to emphasize the range of forecast values of the D.C. economy instead of making point estimates. In the graphs of D.C. revenues that follow we illustrate these ranges with blue shading.

The specific methodological decisions and steps applied in building our revenue model and forecast are described in this report—the order of which corresponds to the order of our presentation to ODCA staff on September 5 (See the presentation deck in Appendix A).

Gathering historical economic and financial/budget data

The Office of the Chief Financial Officer (OCFO) kindly provided us historical (Fiscal Year (FY) 2002 - 2018) D.C. revenues by source. In addition, we gathered historical demographic and economic variables for both D.C. and the US extending back to 1997. Of note, the 17% debt limitation was established in the Home Rule Charter (§ 1-206.03(b)(1)). In 2009, local law (L17-360) established a 12% cap on borrowing (§47-335.02).

Understanding and forecasting the D.C. economy

We tested the historical data patterns for D.C. demographic and economic variables that could be related to historical revenue levels. These included population and age profiles among other variables. With annual-frequency historical data, it turns out that movements in D.C. GDP are best explained by (previous) movements in D.C. GDP along with movements in nationwide GDP and adding other variables did not improve the fit. In the models and graphs that follow we describe the confidence range of our GDP forecast based on the statistical significance of the estimated coefficients, and we compare our forecast to that of the OCFO forecast.

Our primary conclusion is that our annual forecasts of D.C. GDP are similar to that of the OCFO.

Forecast model specifications

Due to the strong correlations in year-over-year values of GDP and fiscal revenues, we fit an ARIMA model (auto-regressive integrated moving average) to the historical time-series to forecast future values. This model is used to forecast annual D.C. GDP (based upon a log transformation of D.C. GDP). See slides 3-7 in Appendix A.

ARIMA models relate a current period value of a variable such as the D.C. GDP to three operations on prior period values of the same variable. Thus, ARIMA models are described as ARIMA(x,y,z). The first of these operators is the auto-regressive parameter which identifies the number of time lags of the variable of interest to include, the second operator identifies the degree of differencing between prior period values of the variable, and the third operator identifies the moving average component indicating whether the error term from the prior time period model estimate should be included .

Forecasting D.C. Gross Domestic Product

After testing various model specifications for D.C. GDP, an ARIMA(0,2,1) model specification fit best. This model specification uses the following operations on D.C. GDP:

- The auto-regressive parameter is 0 which means this model uses no time lags of D.C. GDP.
- The degree of differencing is 2 indicating that the log of D.C. GDP series is differenced twice in the model to achieve stationarity (a necessary statistical property for estimation).

- The moving average component is 1. This means that the error term from the previous time period is included in the model.

In addition to fitting the ARIMA structure, additional regressors were tested in each of the models that follow.

- For the model of the log of D.C. GDP, the log of U.S. GDP is used as an extra regressor in the ARIMA(0,2,1) model.
- The model output shows the coefficient on the log of U.S. GDP regressor and the coefficient on the previous period's model error term represented by "ma1".
    - For graphical presentation, we convert the model outputs to forecast D.C. GDP in its nominal value form rather than in log form and plot them in Chart 1 below.
- Other D.C. specific regressors tested but failed to show any significance in the ARIMA model were the log of D.C. population and log of D.C. unemployment.
- Table 1 shows the model parameter estimates, the ARIMA specification, and the Akaike Information Criterion (AIC) which is a goodness of fit measure. The lower the value of the AIC the better is the model fit to the data.

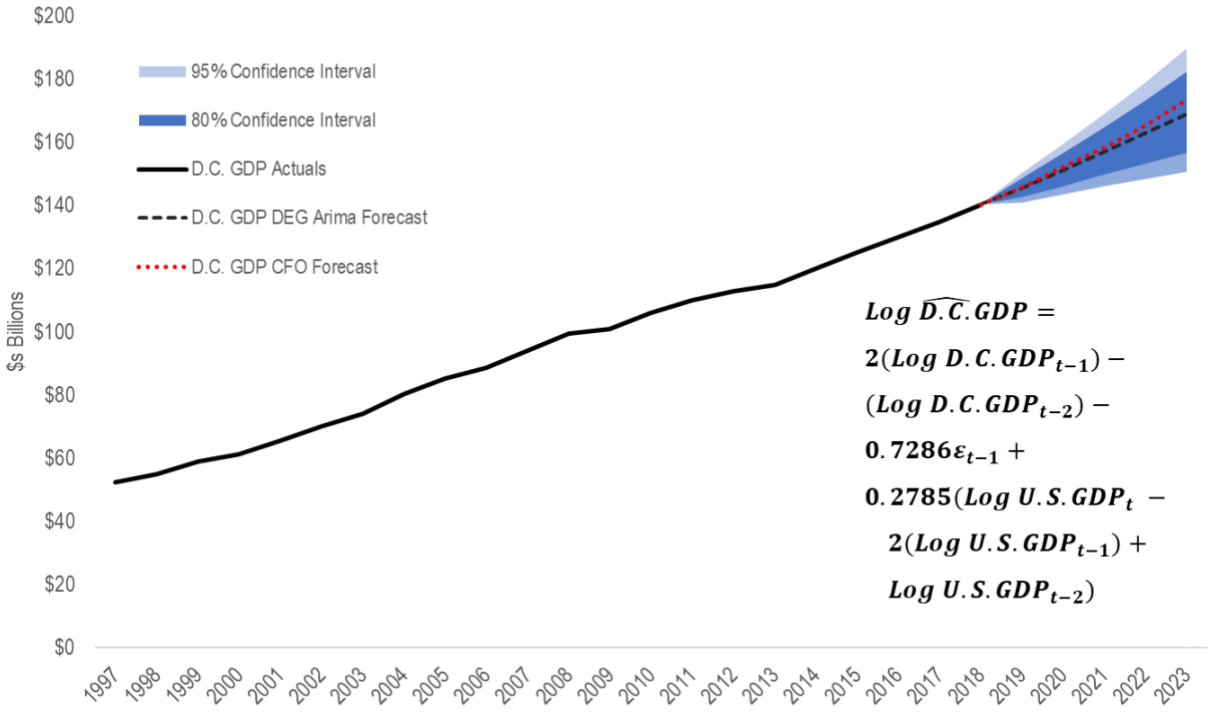
Table 1. Log of D.C. GDP ARIMA(0,2,1) Model
Regression with ARIMA(0,2,1) errors

coefficients:

	ma1	Log of U.S. GDP
	-0.7286	0.2785
s.e.	0.1580	0.1849
t statistic	-4.6114	1.5062

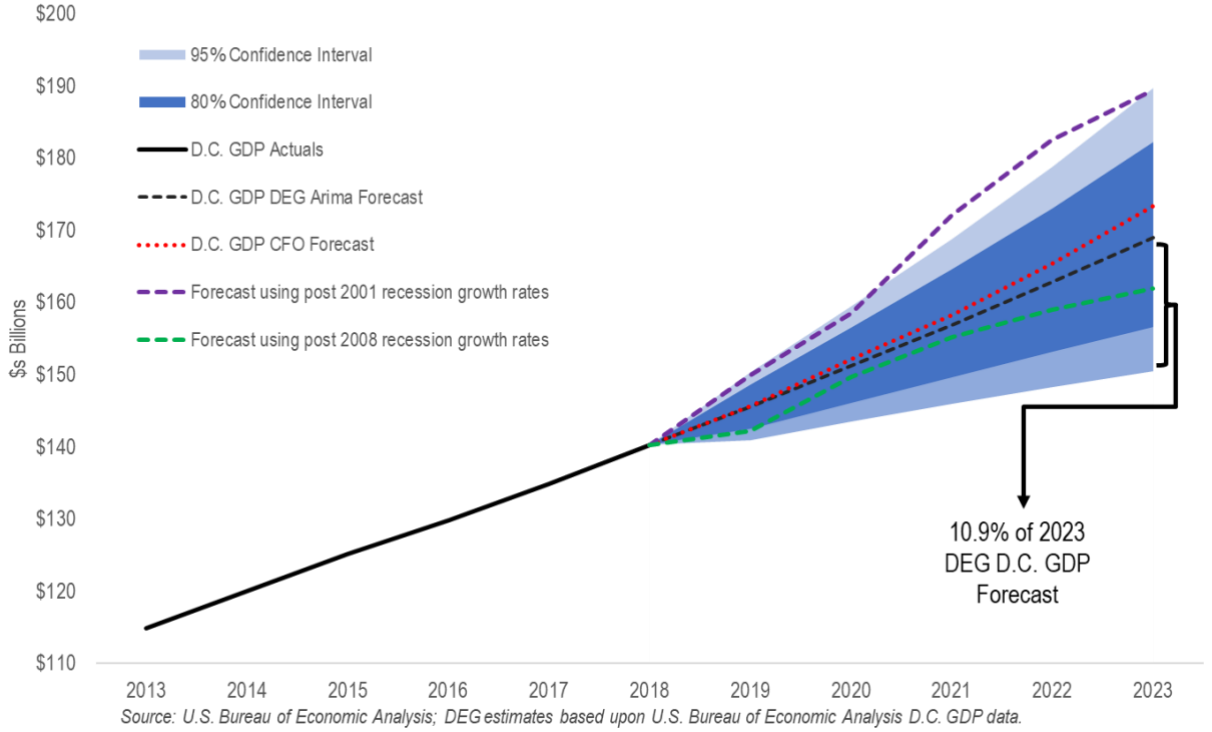
sigma^2 estimated as 0.0002757
log likelihood=54.42
AIC=-102.85 AICc=-101.35

Chart 1. D.C. GDP Forecast 2019-2023



Source: U.S. Bureau of Economic Analysis; DEG estimates based upon U.S. Bureau of Economic Analysis D.C. GDP data.

Chart 2. D.C. GDP Forecast 2019-2023



Source: U.S. Bureau of Economic Analysis; DEG estimates based upon U.S. Bureau of Economic Analysis D.C. GDP data.

In Charts 1 and 2 above, historical annual D.C. GDP is shown for years up through 2018, and forecasted D.C. GDP for 2019-23. Chart 2 focuses only on the most recent period and tightens the vertical scale to get a more detailed look. The black dashed line shows DEG's GDP forecast, and the blue shaded regions show the 80% and 95% confidence intervals associated with our forecast. (The better the statistical fit of an estimated equation to the data it describes, the narrower the confidence range will be.) The OCFO's forecast of D.C. GDP is the red dotted line, showing that the forecasts are similar.

Our models use historical data spanning the 2001 and 2008 recessions and our estimates, shown as dashed-black-lines use model parameters from the entire time period. The estimated equations are sensitive to the periods of historical data on which they are based. To illustrate the sensitivity, we include forecasts of D.C. GDP using growth rates only from the post-2001 recession (stronger/faster recovery) and growth rates only from the post-2008 Great Recession (weaker/slower recovery). Were we to forecast D.C. GDP for the 2019 through 2023 period based upon the growth in D.C. GDP prior to the Great Recession, the forecasted amounts would be above and outside of the shaded blue areas of our forecast indicating a significant departure from the estimates shown with the dashed-black-line. The dollar amounts of D.C. GDP from Chart 2 above are shown in Table 2 below. While our best estimate of D.C. GDP for 2023 is $169.0 billion, the estimate would be $189.4 billion based upon post-2001 recession growth rates but only $162.0 billion if based upon post-2008 Great Recession growth rates. Our best estimates for the D.C. GDP are quite similar with the OCFO estimates.

Table 2. DEG D.C. GDP Forecasts ($ billions)

Year	D.C. GDP DEG ARIMA Forecast	Low 80%	High 80%	Low 95%	High 95%	D.C. GDP CFO Forecast	Forecast using post 2001 recession growth rates	Forecast using post 2008 recession growth rates
2018	$140.3	$140.3	$140.3	$140.3	$140.3	$140.3	$140.3	$140.3
2019	$145.6	$142.5	$148.7	$140.9	$150.4	$145.6	$149.9	$142.3
2020	$151.2	$146.1	$156.5	$143.5	$159.4	$152.1	$158.5	$149.6
2021	$156.9	$149.6	$164.6	$145.9	$168.8	$158.3	$172.2	$155.2
2022	$162.8	$153.1	$173.1	$148.3	$178.8	$165.4	$182.5	$159.0
2023	$169.0	$156.7	$182.3	$150.5	$189.7	$173.4	$189.4	$162.0

Source: Office of the Chief Financial Officer; DEG estimates based upon U.S. Bureau of Economic Analysis D.C. GDP data.

Forecasting D.C. Revenues

For each year in the historical time series, we relate D.C. revenue levels by source to D.C. GDP and use the estimated relationship to forecast revenues going forward (applying forecasted D.C. GDP to the projection period).

The data provided by the OCFO report D.C. revenues by eight different categories: Property, sales and excise, income, gross receipts, other taxes, non-tax, special purpose, and lottery.

After examining the historical patterns for these revenue sources, we decided to combine the non-tax, special purpose, and lottery revenues into a single category for estimation because the

sum of all three presented a more stable historical series from which to forecast. As a result, we estimate six revenue groups. Interestingly, each group exhibits stable shares of GDP after the Great Recession:

- **Property** accounted for 30.7% of total revenues in 2018.
- **Income** accounted for 30.5% of total revenues in 2018.
- **Sales and excise** accounted for 18.4% of total revenues in 2018.
- **Gross receipts** accounted for 4.2% of total revenues in 2018.
- **Other taxes** accounted for 5.9% of total revenues in 2018.
- **Non-tax, special purpose and lottery** accounted for 10.3% of total revenues in 2018.

These six groups of D.C. revenues are forecasted using ARIMA models with D.C. GDP as an additional regressor when it improved the model fit.

Property tax model: An ARIMA(0,1,1) model with property tax revenues as the dependent variable and nominal D.C. GDP as an additional regressor was the best fit.

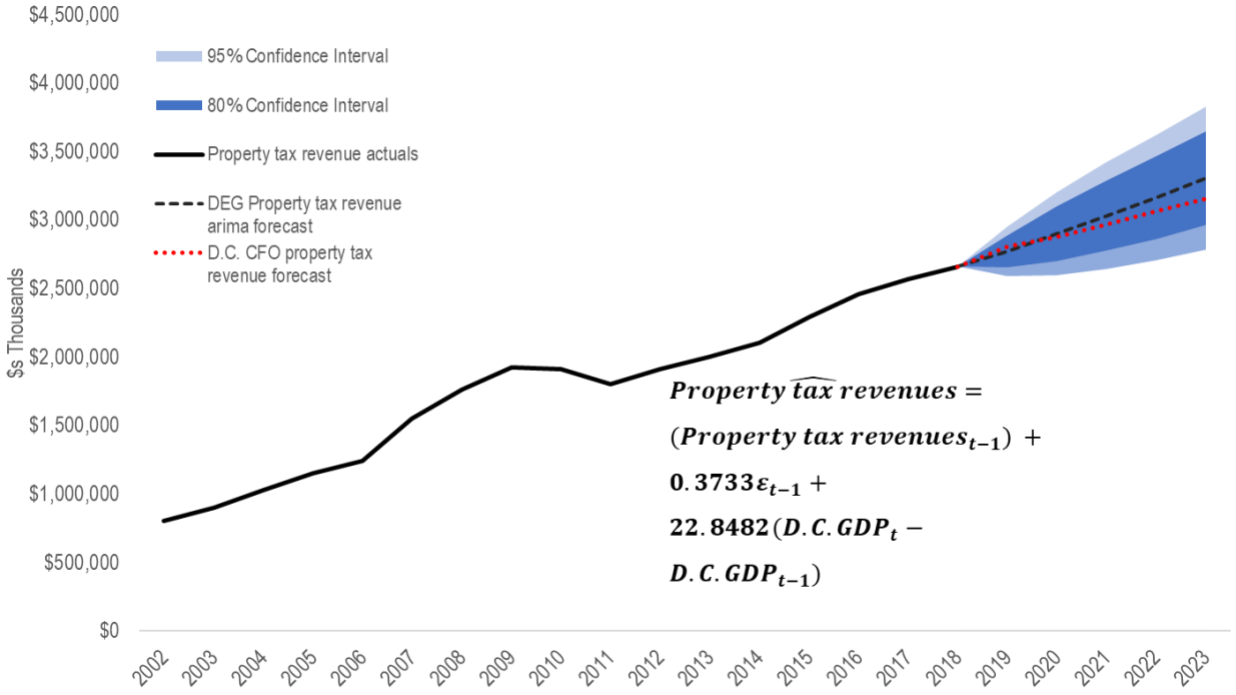
Table 3. Property tax revenue ARIMA(0,1,1) Model
Regression with ARIMA(0,1,1) errors

coefficients:

	ma1	D.C. GDP
	0.373	22.8482
s.e.	0.2573	6.2745
t statistic	1.4508	3.6414

sigma^2 estimated as 8.258e+09
log likelihood=-204.39
AIC=414.77 AICc=416.77

Chart 3. D.C. Property Tax Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

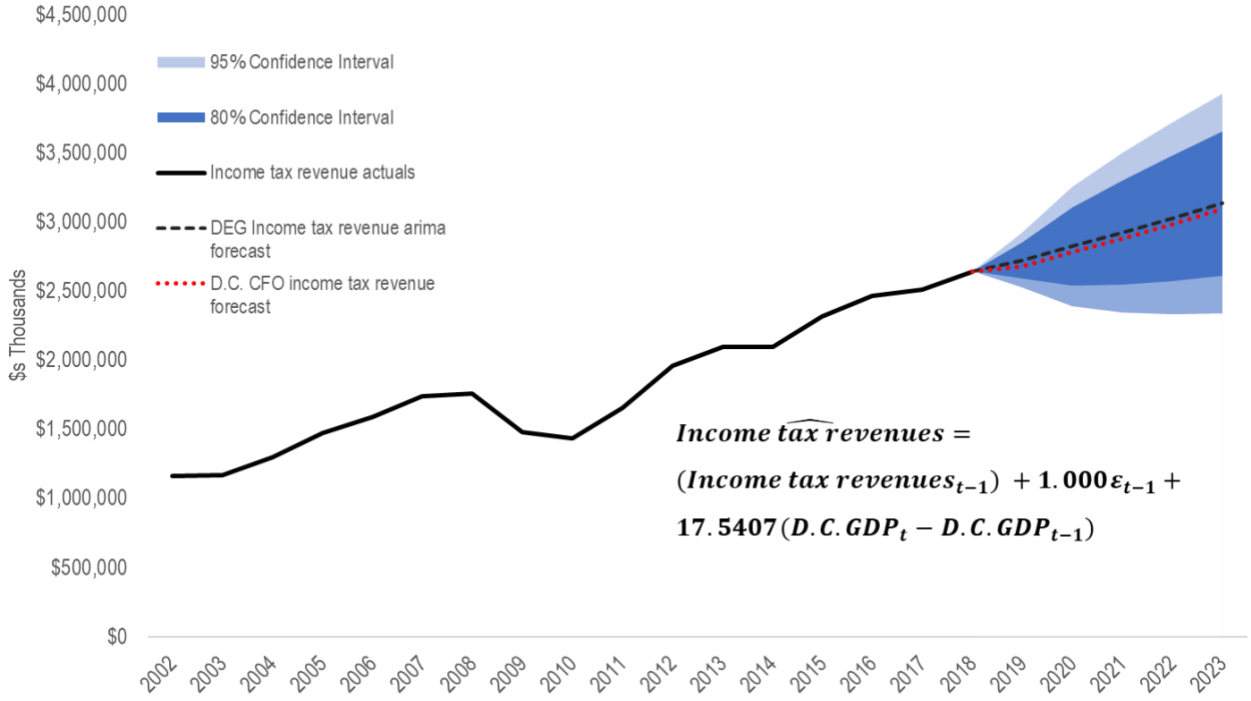
Income tax model: An ARIMA(0,1,1) model with income tax revenues as the dependent variable and nominal D.C. GDP as an additional regressor was the best fit.

Table 4. Income tax revenue ARIMA(0,1,1) Model
Regression with ARIMA(0,1,1) errors

coefficients:		
	ma1	D.C. GDP
	1.000	17.5407
s.e.	0.3446	7.094
t statistic	2.9019	2.4726

sigma^2 estimated as 9.655e+09
log likelihood=-206.98
AIC=419.95 AICc=421.95

Chart 4. D.C. Income Tax Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Sales and excise tax model: An ARIMA(0,1,0) model with sales and excise tax revenues as the dependent variable and nominal D.C. GDP as an additional regressor was the best fit. ARIMA(0,1,0) models are a special category known as "random walk" models because the current period D.C. sales and excise tax revenues are a function of the full amount of prior period sales and excise tax revenues. However, the significant contribution of D.C. GDP to forecasting sales and excise tax revenues improves this model beyond a pure random walk.

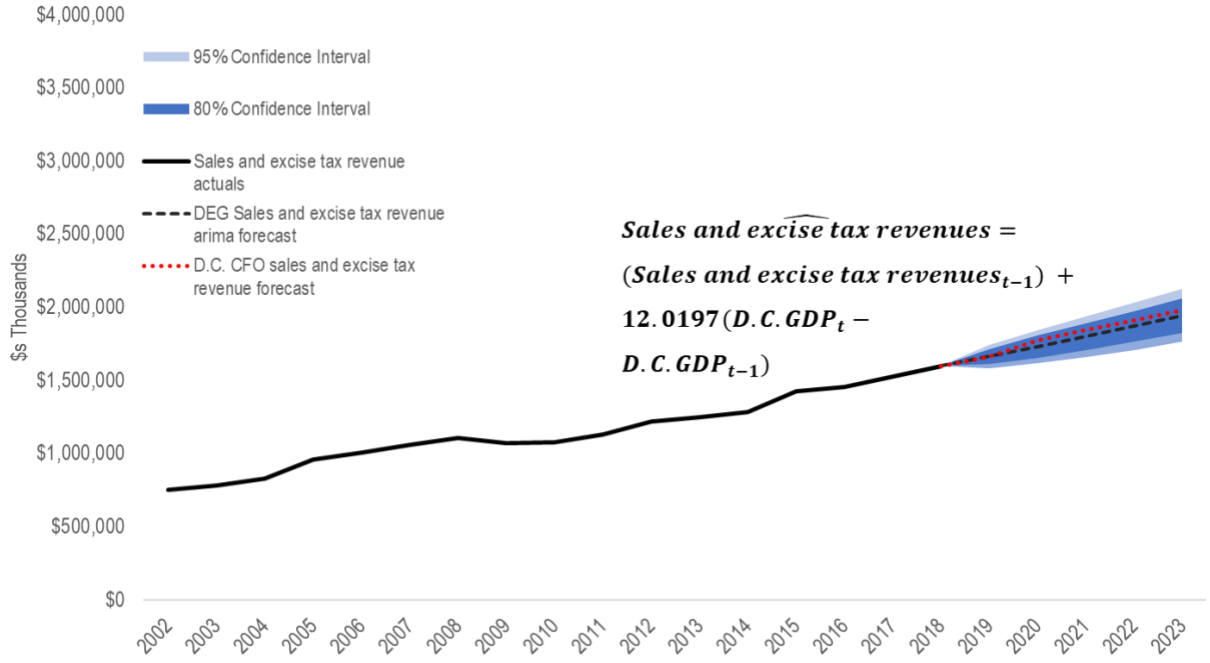
Table 5. Sales and excise tax revenue ARIMA(0,1,0) Model
Regression with ARIMA(0,1,0) errors

coefficients:

	D.C. GDP
	12.0197
s.e.	2.1591
t statistic	5.5670

sigma^2 estimated as 1.674e+09
log likelihood=-192.09
AIC=388.19 AICc=389.11

Chart 5. D.C. Sales and Excise Tax Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Gross receipts model: An ARIMA(1,2,1) model with gross receipts revenues as the dependent variable was the best fit. Adding Nominal D.C. GDP to the model did not improve the fit. The relatively wide error bands around the estimates cannot be readily viewed in the basic Chart 6 so in Chart 7 we expand the detail to more easily view. The wide forecast error bounds comport with the large Akaike Information Criteria (AIC) of 338.66 at the bottom of Table 6. The dip in the CFO office forecast on Chart 7 is due to their accounting for recent tax law changes, which is an issue we will address later in this report.

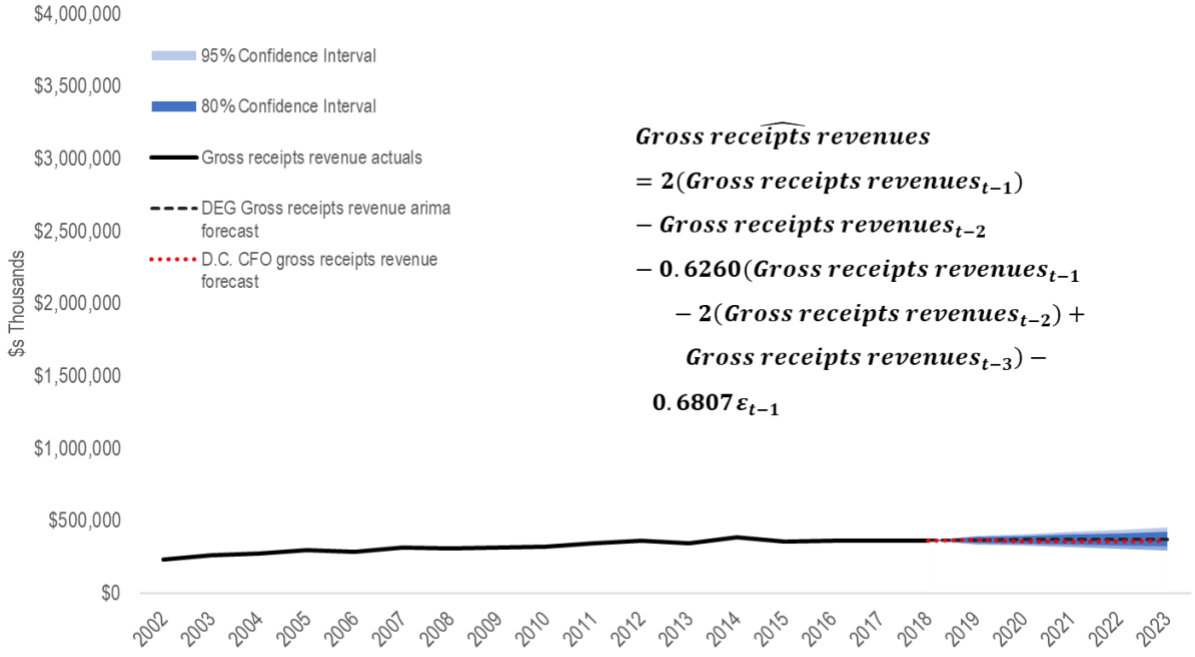
Table 6. Gross receipts revenue ARIMA(1,2,1) Model
Regression with ARIMA(1,2,1) errors

coefficients:

	ar1	ma1
	-0.6260	-0.6807
s.e.	0.2002	0.2261
t statistic	-3.1273	-3.0106

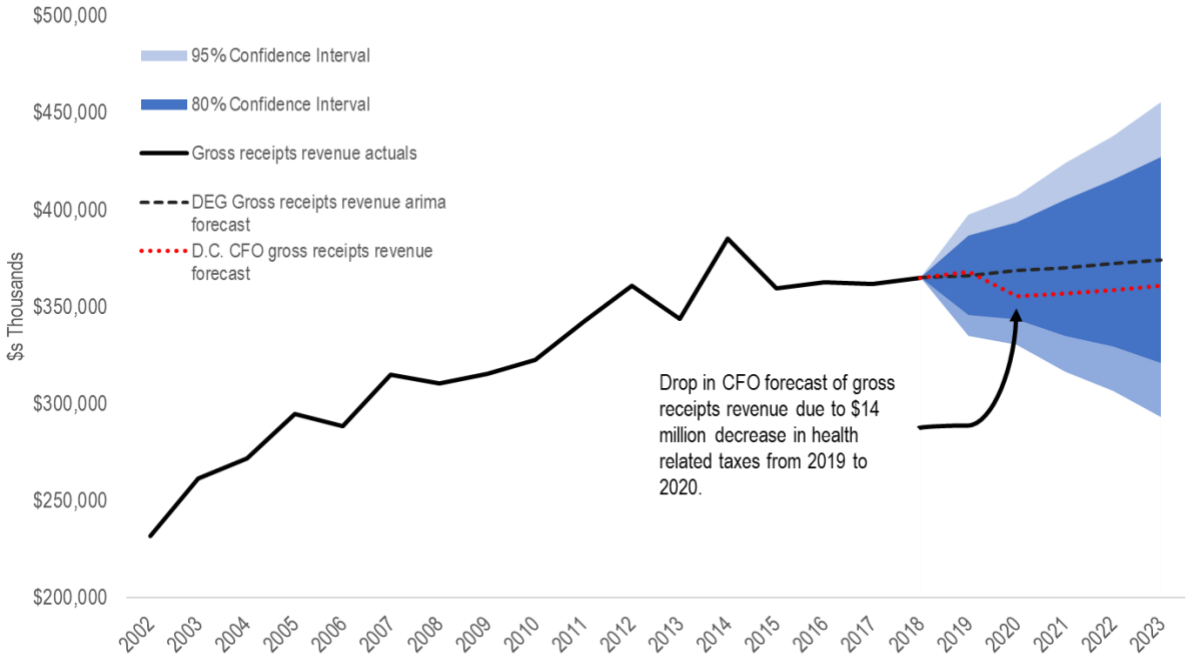
sigma^2 estimated as 2.56e+08
log likelihood=-166.33
AIC=338.66 AICc=340.84

Chart 6. D.C. Gross Receipts Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Chart 7. D.C. Gross Receipts Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

"Other taxes" model: An ARIMA(0,2,1) model with other taxes revenue as the dependent variable was the best fit. Adding Nominal D.C. GDP to the model did not improve the fit. As with

the gross receipts tax model, we show two charts with Chart 9 showing the expanded view of the wide error ranges around the 2019 through 2023 estimates. Chart 9 also shows a slight dip in the OCFO forecast of other taxes for 2019 and 2020 because that office accounts for the timing of tax law changes in their forecasts while the estimates presented here do not. Chart 7 also shows a slight dip in the dashed red line of the OCFO forecast for the same reason. In subsequent revisions of these models we will include recently enacted legislative changes that would impact revenue forecasts based upon revenue estimates from the OCFO.

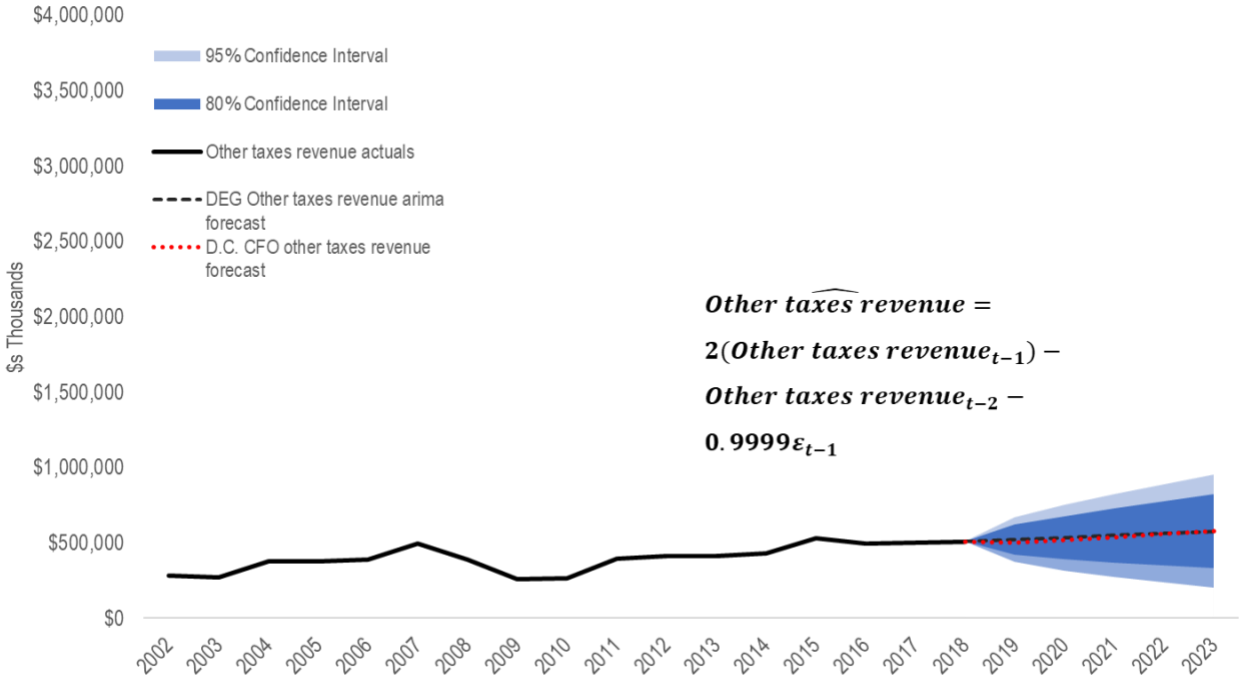
Table 7. Other taxes revenue ARIMA(0,2,1) Model
Regression with ARIMA(0,2,1) errors

coefficients:

	ma1
	-0.9999
s.e.	0.1854
t statistic	-5.3932

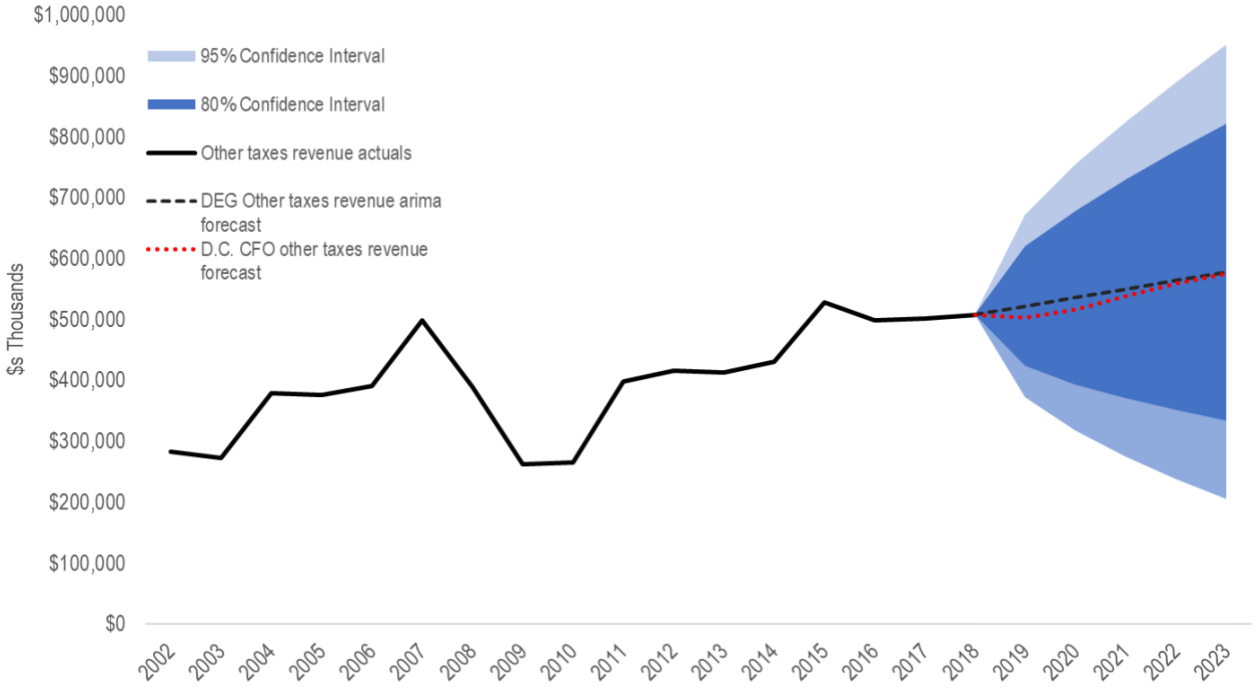
sigma^2 estimated as 5.512e+09
log likelihood=-190.38
AIC=384.76 AICc=385.76

Chart 8. D.C. Other Taxes Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Chart 9. D.C. Other Taxes Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

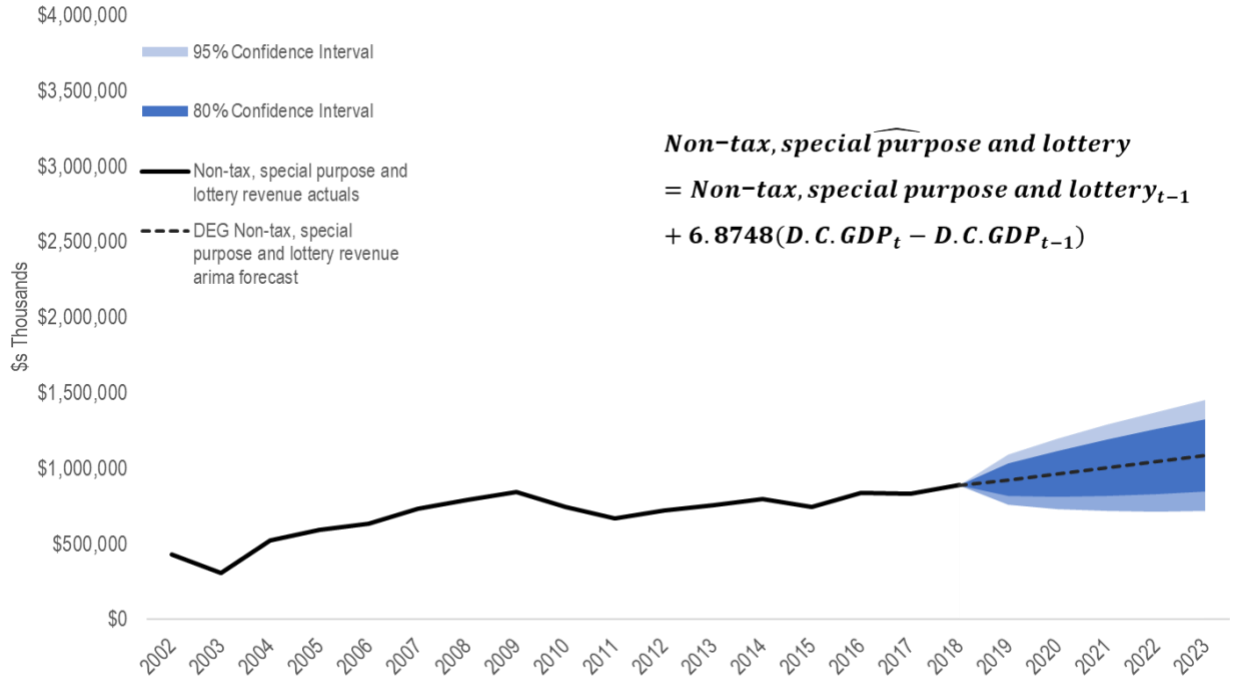
Non-tax, special purpose, and lottery revenue model: A random walk ARIMA(0,1,0) model with the annual sum of non-tax, special purpose and lottery revenues is the best fit.

Table 8. Non-tax, special purpose and lottery revenue ARIMA(0,1,0) Model
Regression with ARIMA(0,1,0) errors

coefficients:	D.C. GDP
	6.8748
s.e.	4.4217
t statistic	1.5548

sigma^2 estimated as 7.021e+09
log likelihood=-203.56
AIC=411.13 AICc=412.05

Chart 10. D.C. Non-tax, Special Purpose and Lottery Revenue Forecast 2019-2023

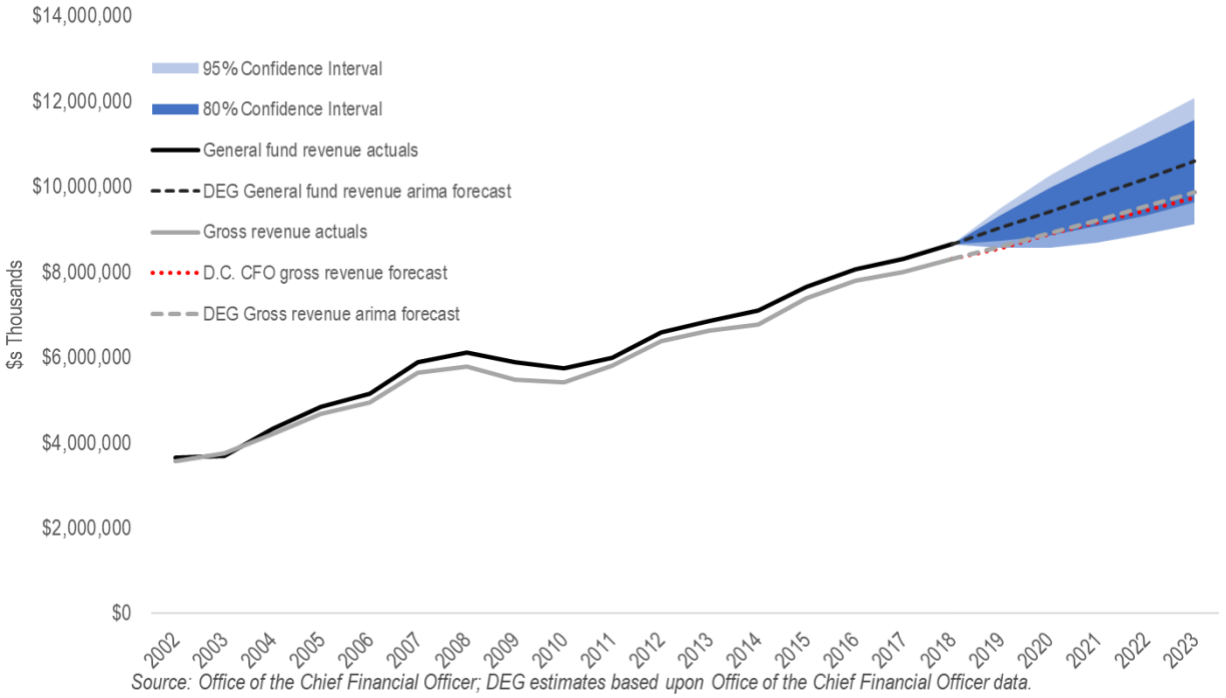


Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

General revenue

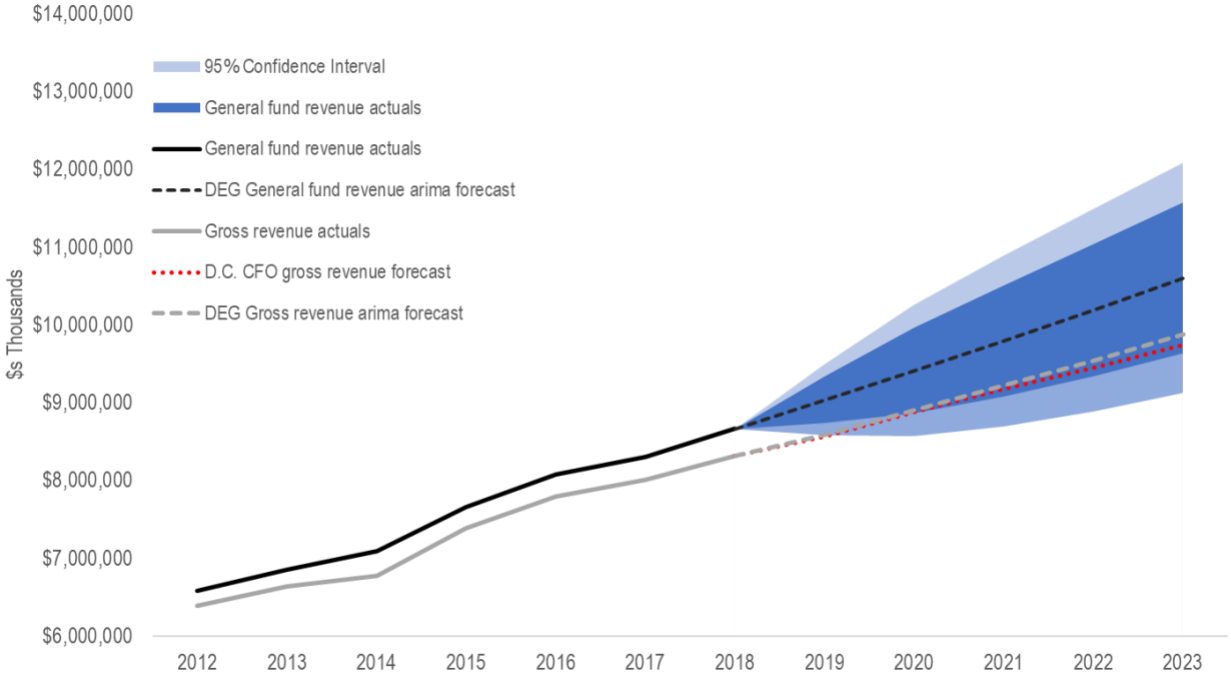
By summing up the various revenue components above, we can compare our forecast for "general revenue" with the OCFO's forecast for "gross revenue" (net of special purpose revenue) shown below in Charts 11 and 12. General revenue is a larger measure of the sum of all of the revenue sources because it includes revenues that have been dedicated to special purpose funds (referred to as dedicated revenues). Gross revenue is equal to general revenue less these amounts dedicated to special funds. From time to time the D.C. government will create special purpose funds to address particular city issues and dedicate portions from various revenue sources (other than income tax) to these activities. We forecast both general revenue and gross revenues. As with our forecasts of the specific revenue sources, the gross revenue forecast is very similar to the OCFO forecast (see the Chart 12 grey and red dashed lines).

Chart 11. D.C. General Fund Revenue Forecast and Gross Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.
Note: Gross revenue = General fund revenue – special purpose revenue

Chart 12. D.C. General Fund Revenue Forecast and Gross Revenue Forecast 2019-2023

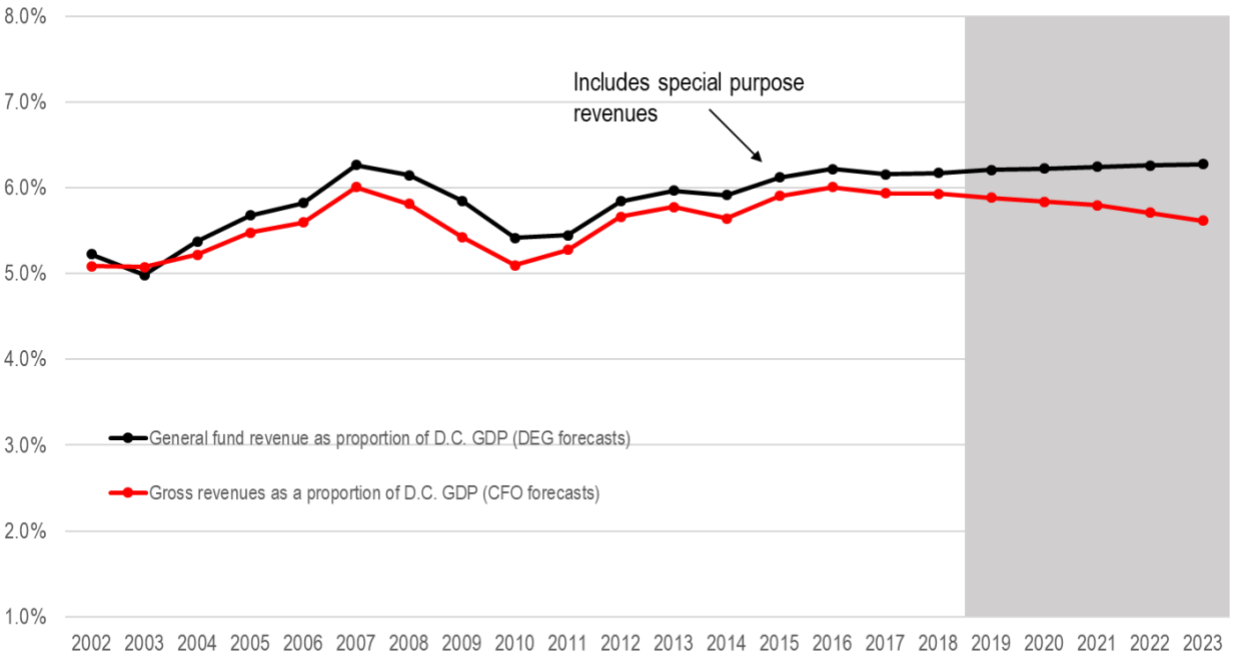


Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.
Note: Gross revenue = General fund revenue – special purpose revenue

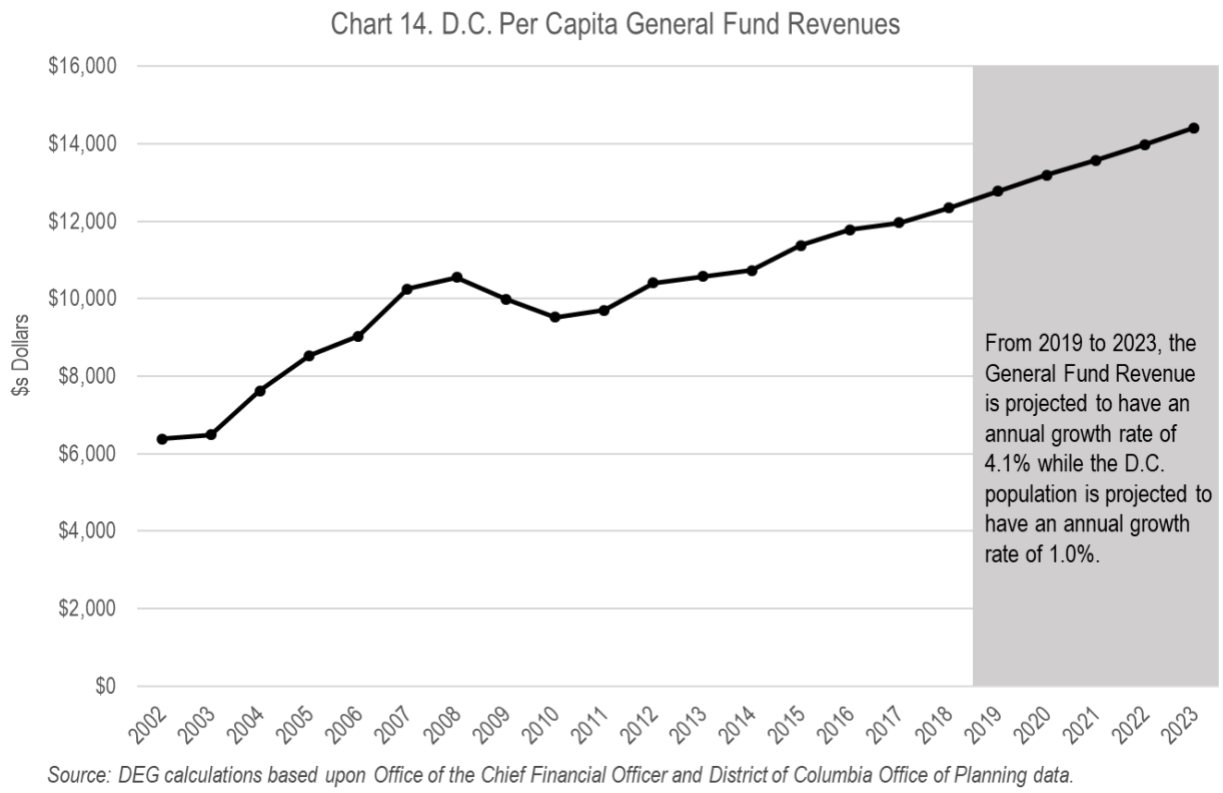
Observations and analysis of trends in D.C. revenue

Charts 13 and 14 below relate the level of historical and projected general revenues to the size of the D.C. economy (GDP) and population. In particular, Chart 13 shows that the divergence between the black line for general revenues projected and the red line for gross revenues projected is due to an increasing claim on general revenues by special purpose funds. Chart 14 shows that nominal amounts of forecasted revenues per-capita will continue to grow in the 2019 through 2023 forecast period.

Chart 13. DEG Forecasted General Fund Total Revenue as a Proportion of GDP



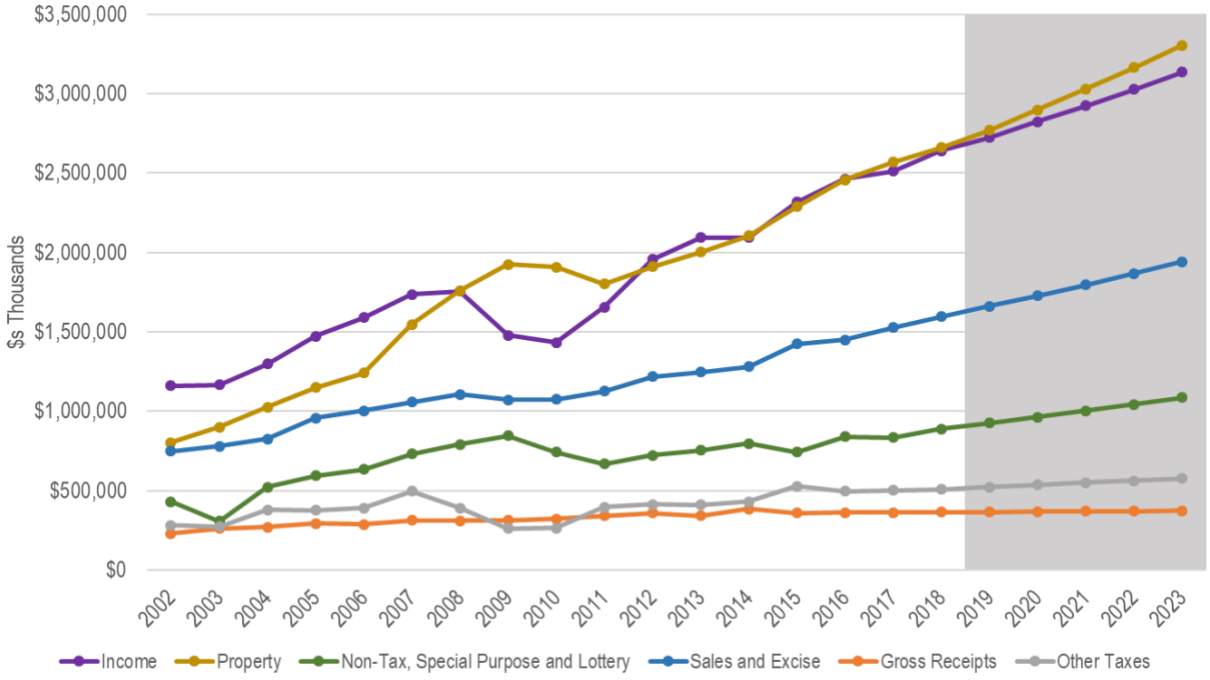
Source: DEG calculations based upon Office of the Chief Financial Officer and U.S. Bureau of Economic Analysis data.
Note: Gross revenue = General fund revenue – special purpose revenue



Source: DEG calculations based upon Office of the Chief Financial Officer and District of Columbia Office of Planning data.

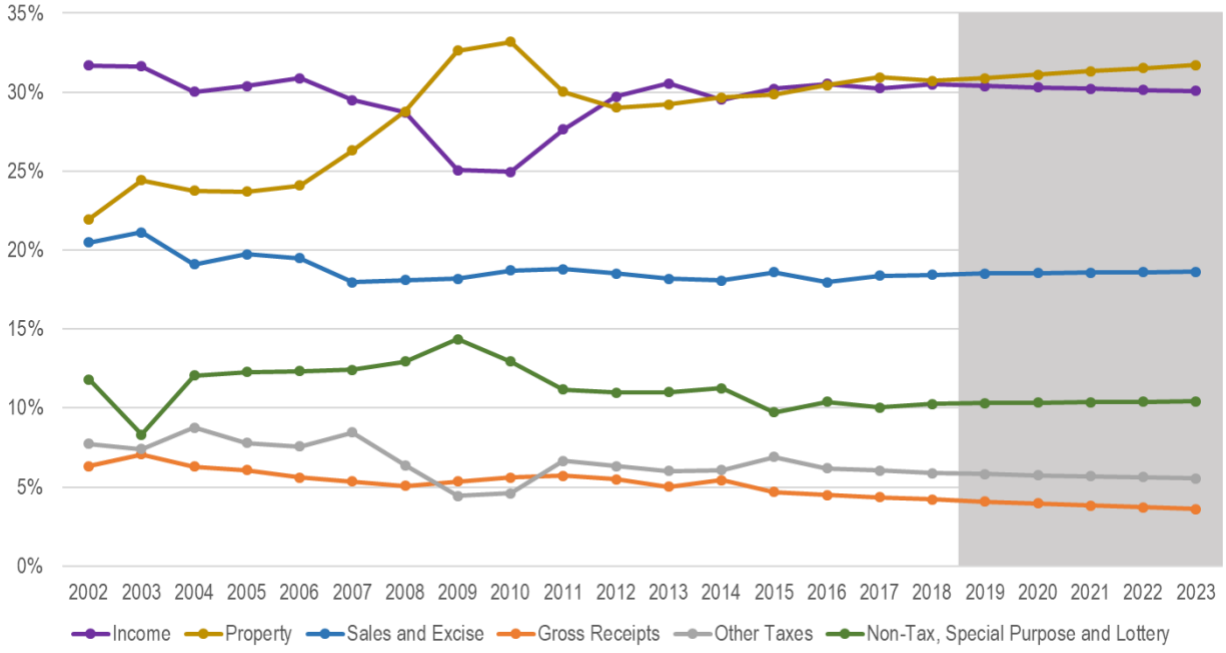
Since 2015 there appears to be a stabilization in the shares of revenue sources as shown in Charts 15 and 16:

Chart 15: D.C. General Fund Revenue Broken Down by Revenue Stream



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Chart 16. Are Shares of D.C. General Fund Revenue Harmonizing?



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Dedicated revenues

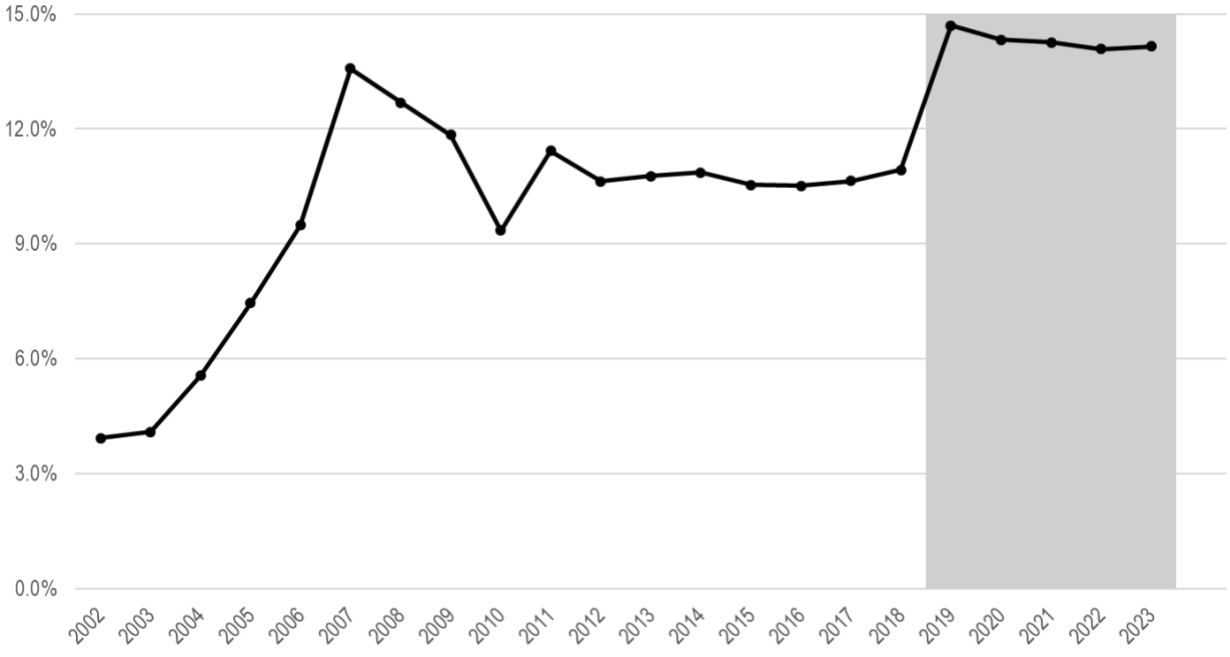
Dedicated revenues are revenues committed by law to support particular programs and activities. Fifteen funds received revenues from dedicated taxes in 2018 including the Hospital Fund, Highway Trust Fund, and Healthy Schools Fund. Note that there are no dedicated revenues from income taxes.

Table 9. Dedicated Taxes by Type of Revenue		2018	2019
Property	Gross Revenues	$2,659,241	$2,803,742
	Net of Dedicated Taxes	$2,613,898	$2,752,325
	Percentage Dedicated	1.7%	1.8%
Sales and Excise	Gross Revenues	$1,597,405	$1,661,371
	Net of Dedicated Taxes	$1,283,924	$1,124,514
	Percentage Dedicated	19.6%	32.3%
Gross receipts	Gross Revenues	$365,129	$368,251
	Net of Dedicated Taxes	$234,388	$244,182
	Percentage Dedicated	35.8%	33.7%
Other taxes	Gross Revenues	$507,976	$503,198
	Net of Dedicated Taxes	$436,997	$431,288
	Percentage Dedicated	14.0%	14.3%
Total	Gross Revenues	$5,129,752	$5,336,561
	Net of Dedicated Taxes	$4,569,207	$4,552,310
	Percentage Dedicated	10.9%	14.7%

Source: Office of the Chief Financial Officer, Table S-1E FY 2018 D.C. CAFR.

Chart 17 below shows that as a share of revenue source, dedicated portions of revenues have gone up recently, particularly for sales and excise taxes (see also Table 9 above).

Chart 17. Dedicated Revenues as Percentage of Source Revenues (Property, Gross Receipts, Sales and Excise, Other Taxes, D.C. CFO)



Source: Office of the Chief Financial Officer.

The Role of Recently-Enacted Legislation

The ARIMA models specified to forecast the sources of revenues for the D.C. government are by design abstractions from a detailed accounting of the many factors that determine the particular revenue levels. While the models comport well with the historical levels of the revenue sources and provide forecasts similar to the OCFO, they do not account for year-to-year fluctuations of small amounts that may be the result of legislative changes.

We created a historical series of enacted legislative changes to examine the importance of annual legislative changes separately from economic factors. The large number of legislative changes each year and the relatively few economic data points used in our models (18 data points for 2002 through 2018 annual data) leave too few data points and too many legislative changes to account for within our model to date. (Slides 31-33 in the presentation deck; Tables 10 and 11 below). What our revenue forecasts capture is an average trend of the overall relationship between the economy and revenues during the estimation period, which includes an average effect of the fluctuations and growth in the economy and the average effect of legislative changes over the same historical period. As Tables 10 and 11 below show, there is a great deal of variation from one year to the next in the frequency and impact on receipts from legislative changes. This year-over-year variation is not captured in the first version of our revenue models but will be in subsequent revisions by adding atop our forecast revenue estimates of current period legislative changes. The red dashed lines in Charts 7 and 9 above

show examples of the impact from specific legislative changes to other taxes revenue for 2019 and 2020 that are not included in our current forecasts but are included in the OCFO forecasts.

Tables 10 and 11 show that, on average, legislation enacted during a business cycle recovery results in revenue reductions (2004 through 2008 and 2013 through 2017) while legislation enacted during the business cycle decline result in revenue increases (2003, 2009 through 2012, and 2018 and 2019). Table 11 also shows that over time the mix of revenues has moved away from more volatile sources such as income and property taxes and towards more stable sources such as sales and excise and gross receipts taxes.

Table 10. Count of Tax Changes (Including Dedicating Funds) by Type and Positive/Negative Net Gross Revenue Impact in Effective Fiscal Year

FY Effective	Property	Sales and Excise	Income	Gross Receipts	Other Taxes	Total
2002	0	0	0	0	1	1
2003	2	3	4	2	6	17
2004	2	0	1	0	0	3
2005	2	4	2	4	2	14
2006	5	2	4	2	0	13
2007	1	0	1	0	4	6
2008	3	1	4	0	0	8
2009	4	1	1	3	2	11
2010	2	5	2	1	0	10
2011	2	2	3	4	0	11
2012	2	6	3	1	0	12
2013	1	3	1	0	0	5
2014	1	3	1	0	0	5
2015	2	4	5	3	0	14
2016	1	5	10	2	1	19
2017	1	2	3	2	0	8
2018	1	3	2	2	3	11
2019	2	3	1	3	1	10
Total	34	47	48	29	20	178

Source: 2018 D.C. Tax Facts from the Office of the Chief Financial Officer.

Table 11: Positive/Negative Gross Revenue Impact of Tax Changes in $s (Net of Dedicated Taxes) by Type and Fiscal Year Effective

FY Effective	Property	Sales and Excise	Income	Gross Receipts	Other Taxes	Total
2002	-	-	-	-	-	-
2003	$70,900,000	$18,050,000	$24,800,000	$15,300,000	$22,794,000	$151,844,000
2004	$27,585,000	-	$28,700,000	-	-	$56,285,000
2005	$9,547,000	$4,262,000	$24,146,475	$18,000,000	$89,525,000	$145,480,475
2006	$56,472,000	$29,988,000	$70,000,000	-	-	$156,460,000
2007	$17,100,000	-	$64,000,000	-	$60,557,000	$20,543,000
2008	$32,570,000	-	$17,819,000	-	-	$50,389,000
2009	$16,200,000	$12,530,000	$1,870,000	$13,005,000	$8,000,000	$15,465,000
2010	$8,756,000	$35,526,000	$5,200,000	-	-	$31,970,000
2011	$3,182,918	-	$41,830,000	$4,747,000	-	$49,759,918
2012	$43,456,000	$28,915,000	$20,620,000		-	$92,991,000
2013	$1,217,431	$17,758,000	$17,084,000	-	-	$543,431
2014	$844,688	$20,540,000	$10,937,383	-	-	$32,322,071
2015	$3,759,073	$16,200,000	$43,941,000	$28,751,244	-	$2,748,829
2016	$247,376	$17,582,000	$18,359,000	-	$6,194,000	$7,218,376
2017	$595,827	-	$26,490,000	-	-	$27,085,827
2018	$753,600	$6,128,000	$28,410,000	-	$8,893,000	$24,891,400
2019	$39,615,000	$34,997,000	$14,475,000	$23,018,000	$6,460,000	$118,565,000
Total	$18,494,077	$132,896,000	$188,011,858	$66,821,244	$6,801,000	$13,589,691

Source: 2018 D.C. Tax Facts from the Office of the Chief Financial Officer.

The Impact of an Economic Shock on D.C. Revenues

Because our revenue forecasts rely on the close relationship between GDP and revenue levels, we can simulate the effect of a future economic recession on projected revenue levels. The effects of recessions of various magnitudes on the D.C. revenue forecasts are shown in Slides 34-38 of the presentation deck and Tables 12-14 below. The only complete history of a recession or business cycle downturn in our data is the Great Recession of 2008. We use the historical impact of the Great Recession on GDP to examine how an economic downturn might impact D.C. government tax revenues. Two economic downturns of differing sizes are modeled by reducing the forecasted D.C. GDP annual growth rate in 2020. After 2020, the GDP growth rates return to the baseline D.C. GDP annual growth rates, but do not include a period during which GDP annual growth rates speed up, or "catch up" to where the economy would have been had the downturn not occurred.

During the Great Recession, the D.C. GDP annual growth rate slowed by 75.7% from 5.86% in 2008 to 1.42% in 2009. In the first scenario, an economic downturn in 2020 is modeled as a 75.7% reduction in forecasted growth of D.C. GDP. This amounts to a $4.3 billion reduction in D.C. GDP in 2020.

In the second scenario, an economic downturn in 2020 is modeled to be half the size of the Great Recession, which implies that the D.C. GDP annual growth rate from 2019 to 2020 decreases by 37.85%. This amounts to a $2.15 billion reduction in D.C. GDP in 2020. Table 12 shows the D.C. GDP during the 2019 through 2023 forecast period for these two events.

These two economic downturns are used to project the various revenue streams and consider how shocks of varying sizes affect D.C. general fund revenue. These scenarios are selected for ease of illustration and are not based upon a projection of the likelihood or magnitude of a future recession. Table 13 shows the impact of the two economic downturn scenarios on the various sources of revenues. Because the effect of the D.C. GDP varies between revenue sources, the impact is not uniform.

For example, in our models both the gross receipts tax and the other taxes revenues categories are not sensitive to changes in D.C. GDP and as a result show no change to an economic downturn. On the other hand, property taxes are quite sensitive to changes in D.C. GDP and register a significant drop in revenues.

A bottom line on the "revenue elasticity" of D.C. general revenues to a recessionary shock to the D.C. economy according to the DEG/ODCA revenue forecast model: A **$1 billion** decline in D.C. GDP results in an approximate **$60 million** decrease in D.C. general fund revenue.

Table 12. DEG D.C. GDP forecasts with and without 2020 shock to the economy followed by return to baseline D.C. GDP growth rates in 2021 ($ Billions)

	No shock		Shock same magnitude as Great Recession in 2020		Shock half the size of the Great Recession in 2020	
Year	DEG D.C. GDP forecast	Annual growth rate	DEG D.C. GDP forecast	Annual growth rate	DEG D.C. GDP forecast	Annual growth rate
2019	$145.6	3.77%	$145.6	3.77%	$145.6	3.77%
2020	$151.2	3.88%	$146.9	0.92%	$149.0	2.34%
2021	$156.9	3.77%	$152.4	3.77%	$154.6	3.77%
2022	$162.8	3.76%	$158.2	3.76%	$160.4	3.76%
2023	$169.0	3.79%	$164.2	3.79%	$166.5	3.79%

Source: DEG estimates based upon U.S. Bureau of Economic Analysis D.C. GDP data.

Table 13. Effect of shock equal in magnitude to the Great Recession on revenue streams

		2019	2020	2021	2022	2023
Income	DEG forecast without shock	$2,724,180	$2,823,192	$2,923,224	$3,026,685	$3,134,847
	DEG forecast with shock	$2,724,180	$2,747,558	$2,844,738	$2,945,248	$3,050,327
	Difference	$0	-$75,634	-$78,486	-$81,436	-$84,521
Property	DEG forecast without shock	$2,770,306	$2,899,277	$3,029,577	$3,164,342	$3,305,233
	DEG forecast with shock	$2,770,306	$2,800,758	$2,927,343	$3,058,265	$3,195,138
	Difference	$0	-$98,519	-$102,234	-$106,077	-$110,095
Sales and excise	DEG forecast without shock	$1,660,975	$1,728,822	$1,797,369	$1,868,264	$1,942,382
	DEG forecast with shock	$1,660,975	$1,676,995	$1,743,587	$1,812,460	$1,884,464
	Difference	$0	-$51,827	-$53,782	-$55,804	-$57,917
Gross receipts	DEG forecast without shock	$366,178	$368,670	$370,258	$372,412	$374,212
	DEG forecast with shock	$366,178	$368,670	$370,258	$372,412	$374,212
	Difference	$0	$0	$0	$0	$0
Other taxes	DEG forecast without shock	$522,028	$536,080	$550,132	$564,184	$578,236
	DEG forecast with shock	$522,028	$536,080	$550,132	$564,184	$578,236
	Difference	$0	$0	$0	$0	$0
Non-tax, special purpose revenue and lottery	DEG forecast without shock	$925,073	$963,879	$1,003,085	$1,043,634	$1,086,027
	DEG forecast with shock	$925,073	$934,235	$972,323	$1,011,717	$1,052,900
	Difference	$0	-$29,643	-$30,761	-$31,918	-$33,126
Total	DEG forecast without shock	$8,968,741	$9,319,919	$9,673,645	$10,039,521	$10,420,936
	DEG forecast with shock	$8,968,741	$9,064,295	$9,408,381	$9,764,286	$10,135,277
	Difference	$0	-$255,624	-$265,264	-$275,235	-$285,659

Source: DEG estimates based upon Office of the Chief Financial Officer data.

Table 14. Effect of shock half the size of Great Recession on revenue streams

		2019	2020	2021	2022	2023
Income	DEG forecast without shock	$2,724,180	$2,823,192	$2,923,224	$3,026,685	$3,134,847
	DEG forecast with shock	$2,724,180	$2,784,003	$2,882,558	$2,984,489	$3,091,054
	Difference	$0	-$39,189	-$40,667	-$42,195	-$43,793
Property	DEG forecast without shock	$2,770,306	$2,899,277	$3,029,577	$3,164,342	$3,305,233
	DEG forecast with shock	$2,770,306	$2,848,230	$2,976,606	$3,109,380	$3,248,188
	Difference	$0	-$51,046	-$52,971	-$54,963	-$57,044
Sales and excise	DEG forecast without shock	$1,660,975	$1,728,822	$1,797,369	$1,868,264	$1,942,382
	DEG forecast with shock	$1,660,975	$1,701,968	$1,769,502	$1,839,350	$1,912,373
	Difference	$0	-$26,854	-$27,866	-$28,914	-$30,009
Gross receipts	DEG forecast without shock	$366,178	$368,670	$370,258	$372,412	$374,212
	DEG forecast with shock	$366,178	$368,670	$370,258	$372,412	$374,212
	Difference	$0	$0	$0	$0	$0
Other taxes	DEG forecast without shock	$522,028	$536,080	$550,132	$564,184	$578,236
	DEG forecast with shock	$522,028	$536,080	$550,132	$564,184	$578,236
	Difference	$0	$0	$0	$0	$0
Non-tax, special purpose revenue, and lottery	DEG forecast without shock	$925,073	$963,879	$1,003,085	$1,043,634	$1,086,027
	DEG forecast with shock	$925,073	$948,519	$987,146	$1,027,097	$1,068,863
	Difference	$0	-$15,359	-$15,939	-$16,538	-$17,164
Total	DEG forecast without shock	$8,968,741	$9,319,919	$9,673,645	$10,039,521	$10,420,936
	DEG forecast with shock	$8,968,741	$9,187,471	$9,536,202	$9,896,911	$10,272,925
	Difference	$0	-$132,448	-$137,443	-$142,609	-$148,010

Source: DEG estimates based upon Office of the Chief Financial Officer data.

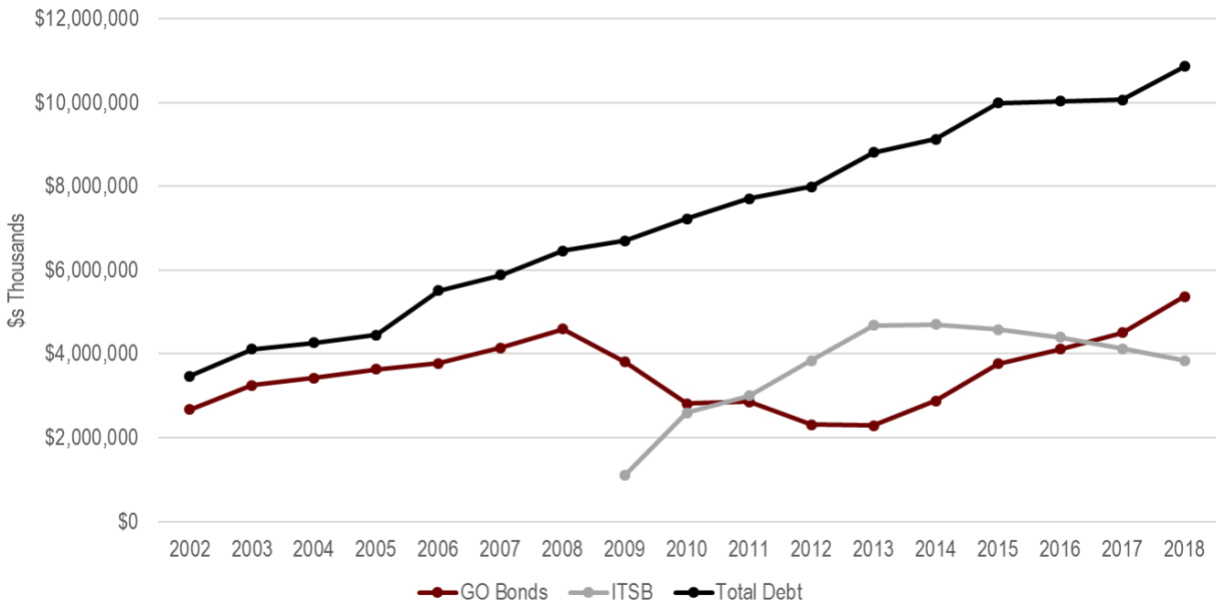
We are currently evaluating alternative approaches towards modeling economic downturns and other shocks to the economy. Among these will be a D.C. specific analysis of the channels of response to various D.C. revenues to an economic downturn and the pace of recovery, consideration of the impact of federal government shutdowns, major weather events, and the sensitivity to the progressivity of the tax structure. It is generally understood in public finance

that the steeper the progressivity of the tax system will result in greater revenue volatility with economic fluctuations.

D.C. Government Bonds

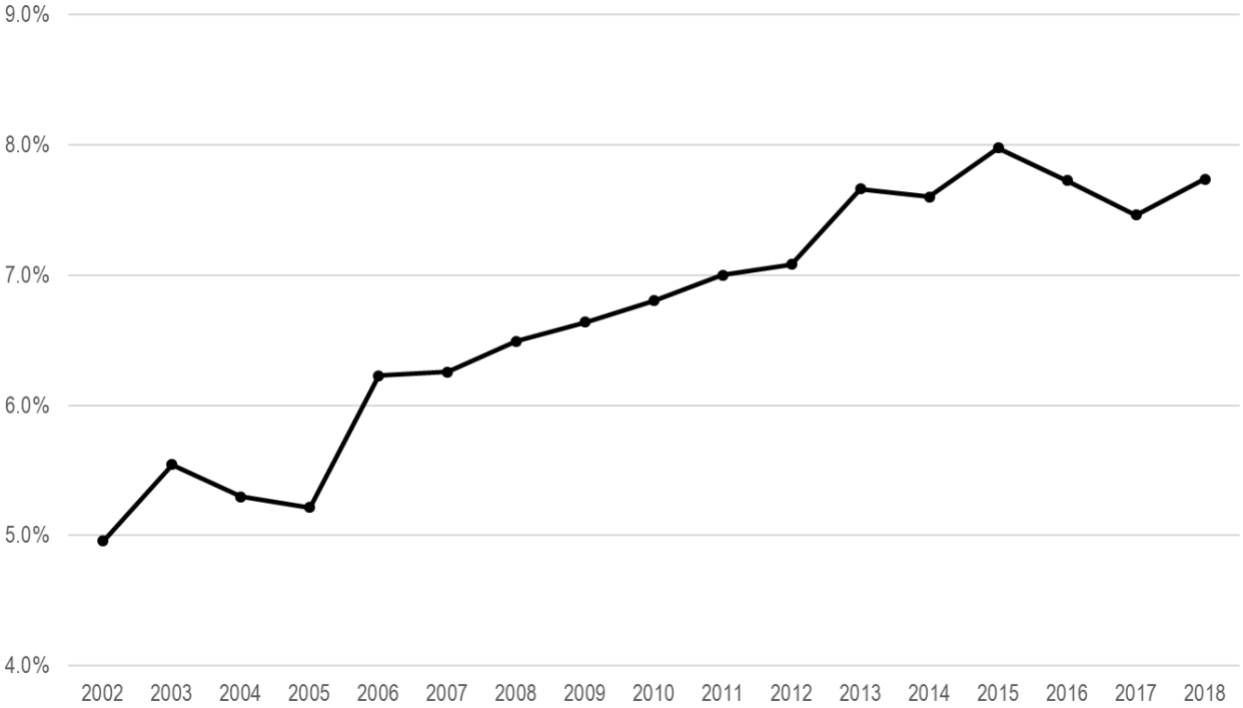
Chart 18 below shows the total amount of debt outstanding through 2018, and Chart 19 shows this outstanding debt as a growing share of D.C. GDP. Outstanding debt has been increasing over time and as a share of D.C. GDP. Note, however, that the rate of growth from 2002 onward appears to be steady and did not accelerate as a result of the Great Recession of 2008.

Chart 18. Total Debt Outstanding on GO, ITSB, TIF, QZAB, Ballpark, HPTF, PILOT, GARVEE and Tobacco Bonds (Plus Bond Anticipation Notes, Capital Leases and Certificates of Participation)



Source: Exhibit S-3C and Table N7-1 from FY 2018 D.C. CAFR.

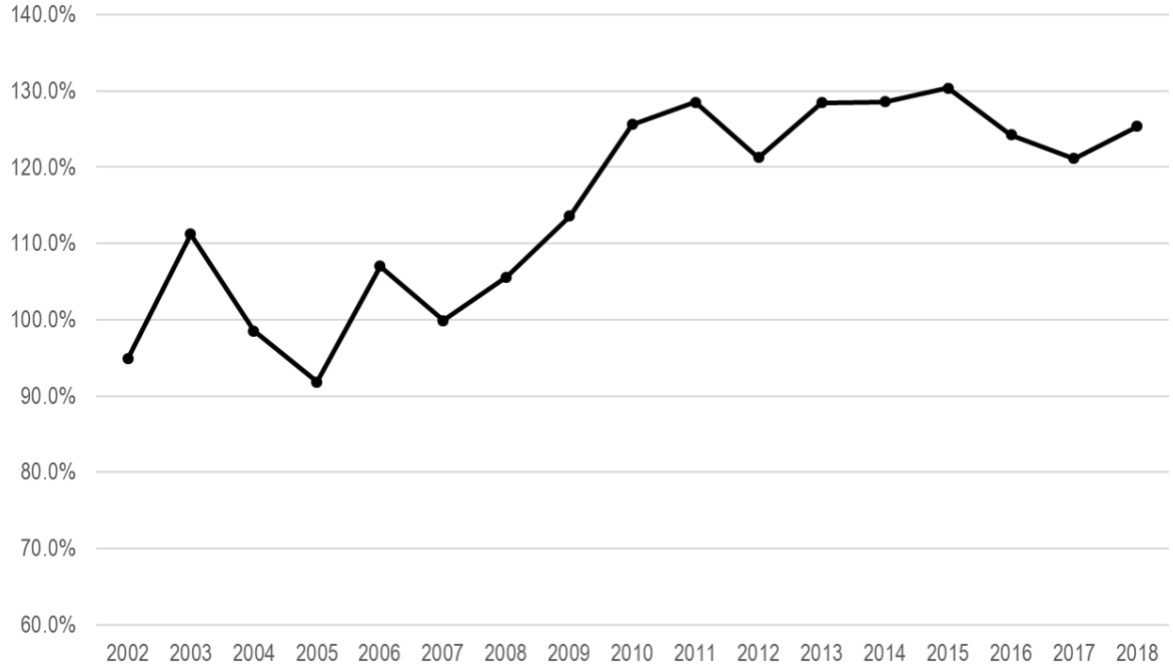
Chart 19. Total Debt as a Percentage of D.C. GDP



Source: DEG calculations based upon Office of the Chief Financial Officer and Bureau of Economic Analysis data.

However, Chart 20 below show that since the Great Recession the ratio of D.C. government debt to general fund revenue has increased by approximately 20%. We caution against a quick judgement concerning this growth as there may be reasonable economic justifications for such an increase. For example, D.C. taxing capacity may, at the same time, have increased more quickly than debt, or it may be that with record low bond market rates a higher debt-to-revenue ratio can be justified. We do not opine on this issue here.

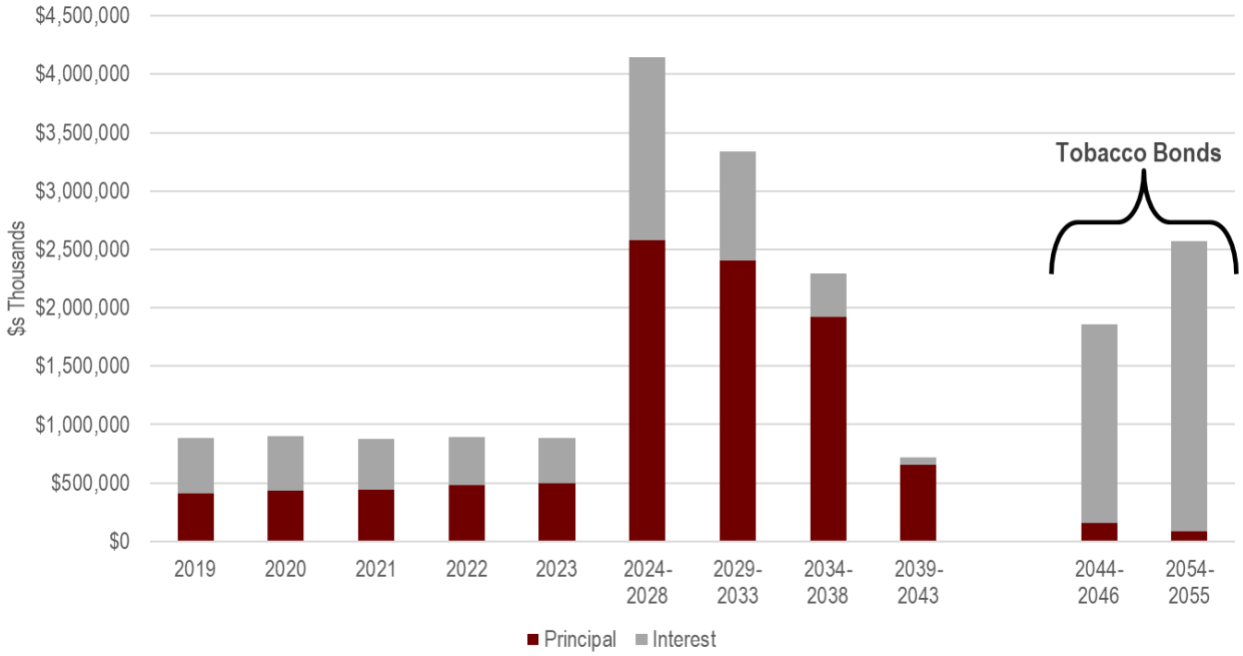
Chart 20. Total Debt as a Percentage of D.C. General Fund Revenue



Source: DEG calculations based upon Office of the Chief Financial Officer data.

Chart 21 below show the long-run annual principal and interest obligations that need to be funded through the D.C. budget in each year through 2023, and then every five years afterwards. These payment obligations for principal and interest on outstanding debt do not grow during the current 2019 through 2023 budget period and are just under $1 billion annually. This chart does not include principal and interest payments on new debt that has yet to be issued, however. The exceptional amounts of interest payment relative to principal payment for the tobacco bonds is likely due the long-duration (often 30 years) and a key feature of the 1998 Tobacco Master Settlement Agreement in which payments will be made *in perpetuity* by the major tobacco companies to the 46 states and the District of Columbia based upon annual cigarette consumption. In contrast, most of the other D.C. government bonds would be of short-term duration less than 10 years.

Chart 21. Principal and Interest Payments on GO, ITSB, TIF, QZAB, Ballpark, HPTF, PILOT, GARVEE and Tobacco Bonds As of September 30, 2018



Source: Office of the Chief Financial Officer, Table N7-1 FY 2018 D.C. CAFR.

Pledged Income Tax Revenues

The D.C. government does not use income tax revenues to fund special purpose funds. However, certain bonds issued by the D.C. government do include obligations, or pledges, on the part of the D.C. government to maintain an amount of income tax revenue sufficient to cover a multiple of the amount of principal and interest due. This multiple is typically between 1.5 and 2 times the amount of principal and interest due. Both Income Tax Secured Bonds, or ITSBs, and Tax Increment Financing Bonds, or TIF bonds, appear to include these income tax revenue pledges on coverage of principal and interest payments in their underlying bond documents. ITSBs are secured by and paid solely from the individual income tax and the business franchise tax. TIF bonds pledge future sales tax and real property tax increments.

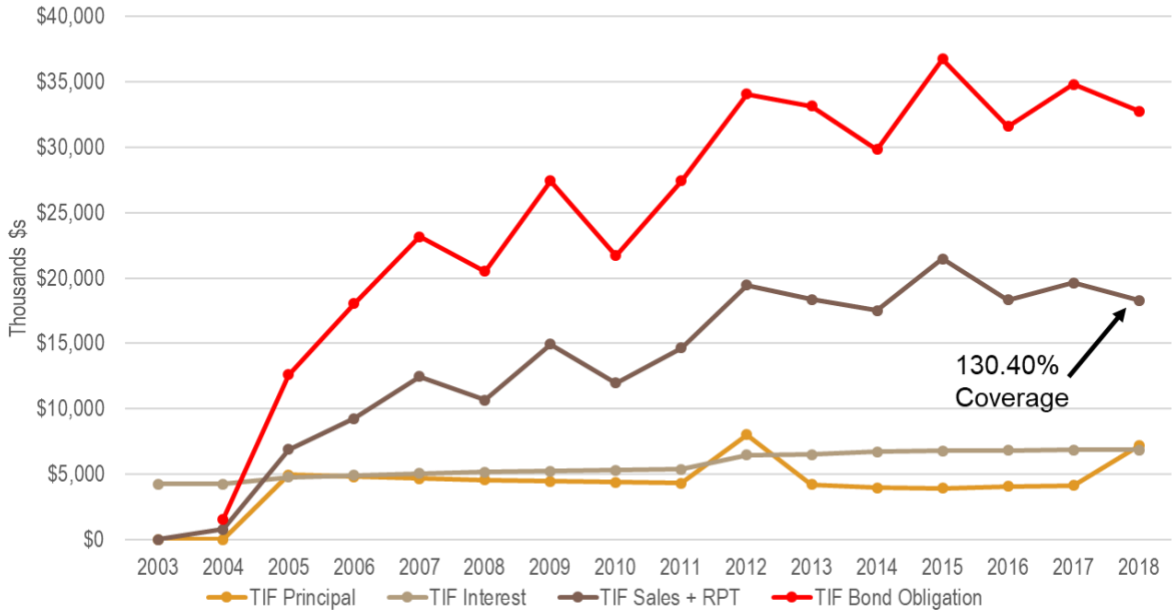
We could find no accounting of the total of these bond pledges, all of which appear to be pledges against income tax revenues, in the D.C. government documents.

TIF bond obligations typically include a pledge of revenues between 1.5 and 2 times the outstanding debt service for property tax and sales tax increments in each bond year. Some ITSB bond tests stipulate that the Maximum Annual Debt Service coverage of outstanding bonds be at least 2 times based solely on withholding revenues (also a part of Bond Non-Impairment Covenants). We have not examined each of the bond issuance summary documents to measure the totality of pledges against income tax revenues, but observe that

currently there is no measure of the total amount of these bond pledges against income tax revenues in the D.C. government documents we have examined.

For tax increment financing bonds one reason for this lack of accounting of income tax pledged amounts could be that the gross amounts issued are not very large. In 2018 principal and interest payments for ITSB bonds totaled approximately $10 million out of a total of all bond principal and interest payments of approximately $700 million (see Chart 25). Chart 22 below shows the outstanding TIF bond obligation through 2018.

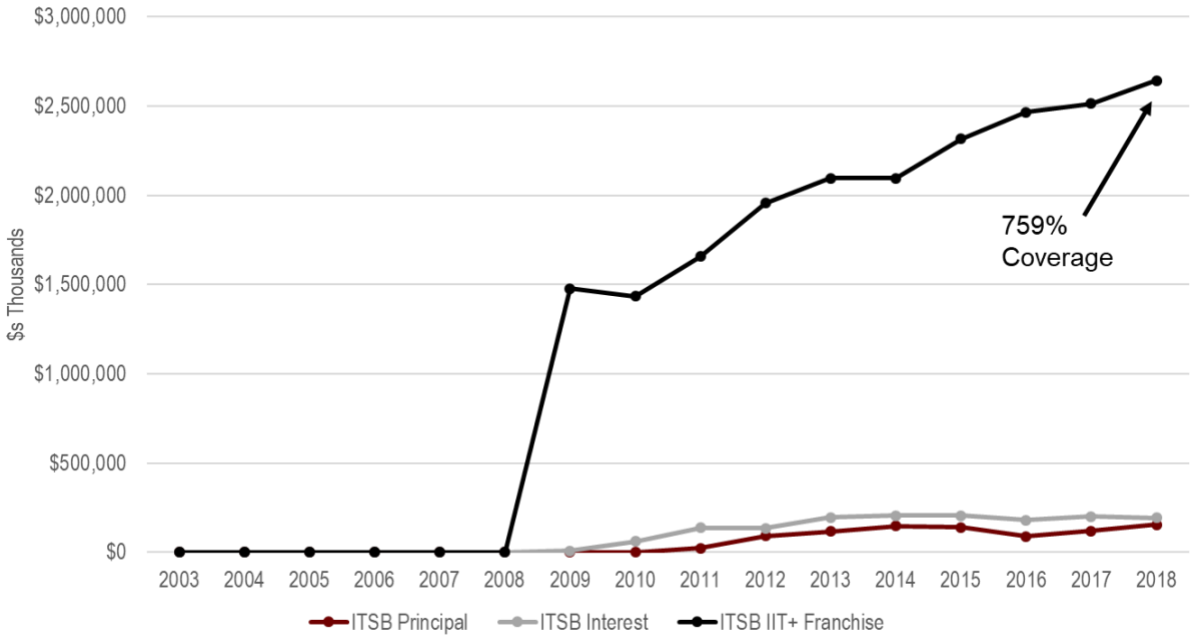
Chart 22. Estimated Bond Obligation Amount and Pledged Real Property (RPT) and Sales Tax Revenues for Tax Increment Financing Bonds (Pledged Revenues are a Small Portion of Total Sales and Property Revenues, D.C. CFO)



Source: Exhibit S-3B from FY 2018 D.C. CAFR.

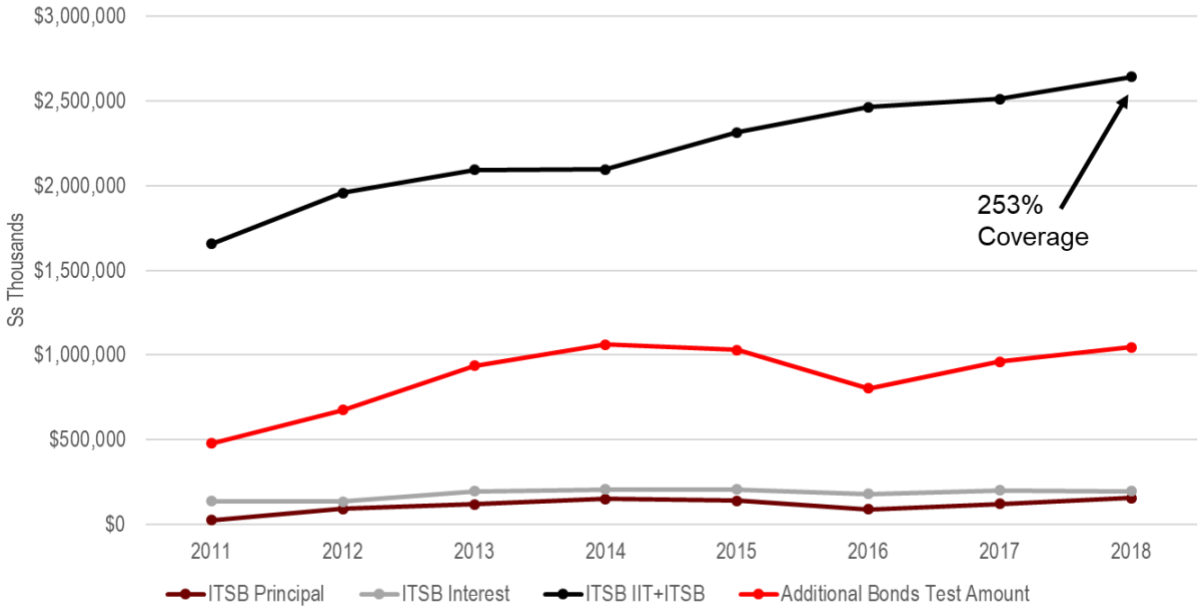
Charts 23 and 24 below examine how ignoring bond pledges might distort a view of the D.C. government's fiscal capacity. Chart 23 shows that what would appear to be a 759% coverage of 2018 principal and interest payments on ITSB bond payments is somewhat less once the estimated (by DEG) principal and interest pledged amounts in the bond issuance documents are accounted for. The red line on Chart 24 shows an estimate of the pledged amount for principal and interest, and the coverage rate on this pledged amount is 253% rather than 759%. This is an issue for further evaluation.

Chart 23. Pledged Income Tax Revenues for Income Tax Secured Revenue Bonds in $ thousands of nominal dollars (**All Income Tax Revenues Pledged**, D.C. CFO)



Source: Exhibit S-3B from FY 2018 D.C. CAFR.

Chart 24. Pledged Income Tax Revenues for Income Tax Secured Revenue Bonds, Estimated Additional Bonds Test Amount, in $ thousands of nominal dollars (**All Income Tax Revenues Pledged**, D.C. CFO)



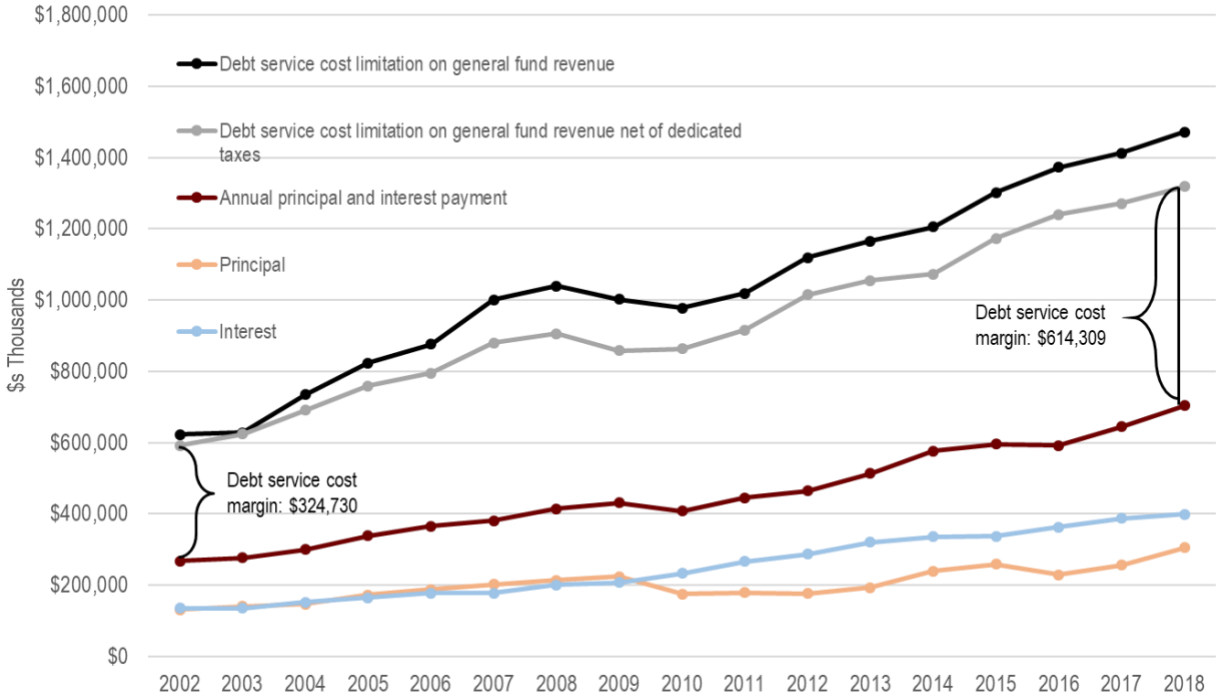
Source: Exhibit S-3B from FY 2018 D.C. CAFR.

The 17% Debt Limitation

The D.C. Auditor is required to certify that the aggregate amount of certain outstanding bond obligations of the District of Columbia will not exceed 17% of District revenues. Chart 25 below provides historical details of the components of the data necessary for this certification. The bottom two lines show the amounts of principal (in pink) and interest (in blue) to be paid each year that are subject to the test. These amounts are summed and shown as the maroon line. The amounts of principal and interest become the numerator of the test statistic that determines the percentage of outstanding bond obligations as a portion of District revenues. The grey line shows the amounts of general fund revenue to be used in the denominator of the test statistic. By forming the ratio of principal and interest payments to District revenues, this statistic must be less than 17% for the D.C. Auditor to provide certification that a new bond issue will be in compliance.

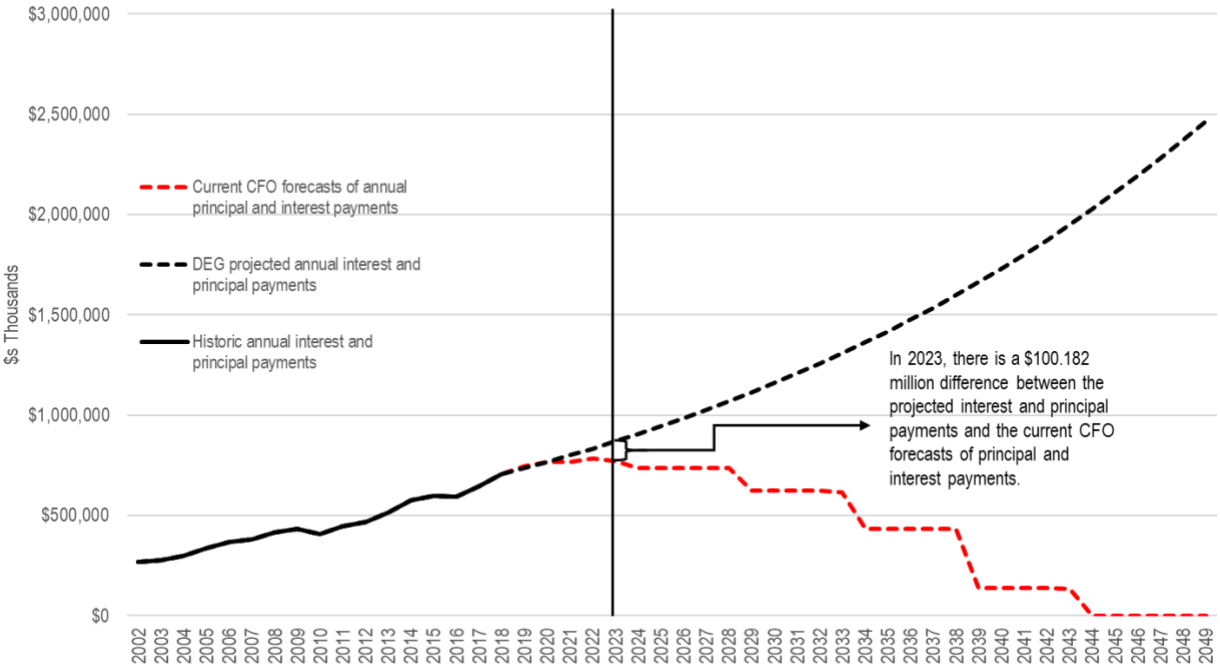
While it is the normal course of business for the D.C. government to issue bonds each year, budget analysis documents typically do not include projections of future bond issues. To provide some intuition for how much additional debt could be accomodated by the D.C. government in any year to remain at the historical level of the test statistic, which has been between 9% and 10%, we forecast the historical levels of annual principal and interest amounts and compare them to the current projected principal and interest amounts over the coming years. These amounts are shown as the solid black line for historical and dashed black line for projected on Chart 26 below. The red line then shows the amount of principal and interest projected by the OCFO that is currently obligated to be paid ***as if no additional debt would be issued.*** The gap between the dashed black line and the dashed red line shows the amount, measured on the Y-axis of the chart, of new principal and interest obligations that would maintain the D.C. government at its historic level of between 9% and 10% for the test statistic. For example, by 2023, an additional $100.182 million of bond obligation of interest and principal could be incurred. This chart can provide a useful tool to gauge how new debt issues will impact the D.C. Auditor's certifications.

Chart 25. Principal and Interest Payments Due with FY Debt Service Limitation



Source: Exhibit S-3D from FY 2018 D.C. CAFR.

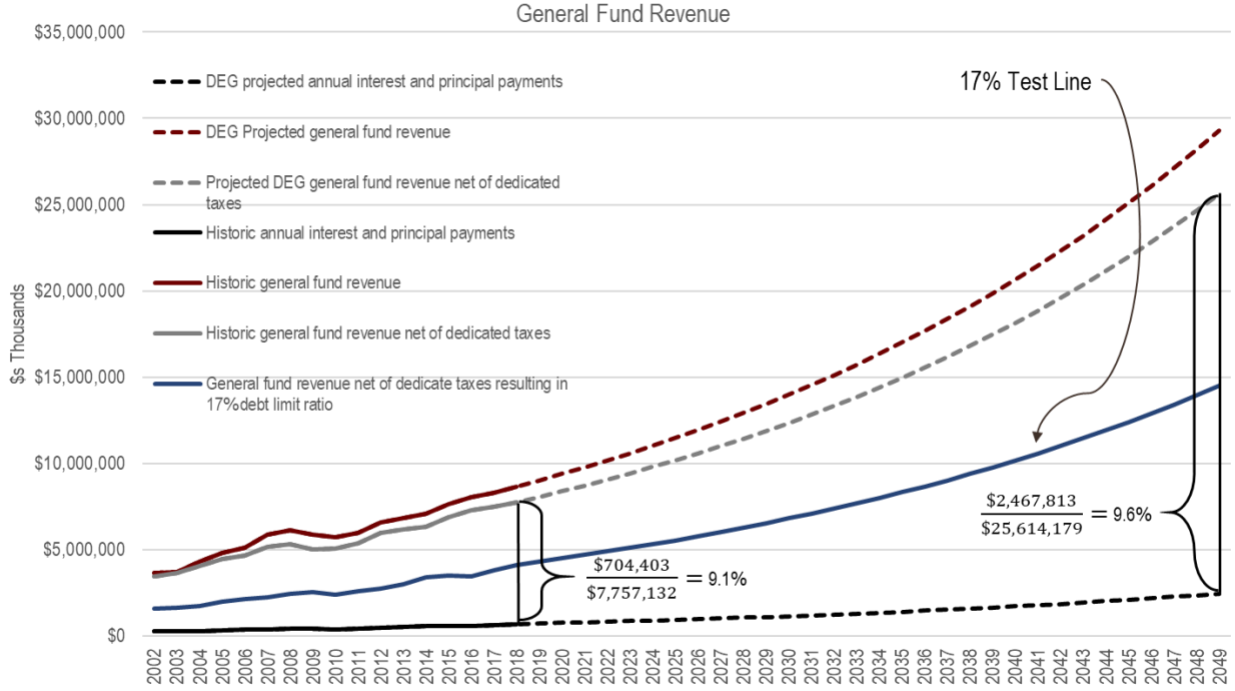
Chart 26. Historical and Projected Annual Principal and Interest Payments Applicable to 17% Debt Limit



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Chart 27 below shows the test statistic calculation for 2018, as 9.1%, and for 2049, as 9.6%. The bottom solid and dashed black line is actually the same solid and dashed line from Chart 26 above. It is placed on a chart with a larger scale to also show our projections of general fund revenues, the dashed maroon line, and gross revenues, the dashed grey line. The test statistic is calculated as the amount from the black line divided by the amount from the grey line. Further, we have placed a blue line on the graph to show the "headroom" between the current path of the test statistic and how much additional principal and interest payments could be incurred before reaching the 17% test threshold.

Chart 27. Historic and Projected Annual Principal and Interest Payments Applicable to 17% Debt Limit and General Fund Revenue



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

D.C. Auditor Certification Table

Finally, to pull each of the revenue forecast and bond principal and payment amounts together for the purpose of the D.C. Auditor's certification, we create an expanded version of Figure 1 from the D.C. Auditor's Certification of Fiscal Year 2019 Total Local Source, General Fund Revenue Estimate (Net of Dedicated Taxes) in Support of General Obligation Commercial Paper Bond Anticipation Notes, (Series 2019) from May 29, 2019, below. This table uses our forecasted revenue amounts in the first column, adjusts these amounts for recently enacted legislation in the second column and totals these amounts for the purpose of calculating the test statistic, which cannot exceed 17%, in the far right column.

Figure 1. FY 2019 Total Local Source, General Fund Revenue Estimate (Net of Dedicated Taxes) DEG Estimate dated September 6, 2019

Revenue Source	DEG 2019 Total Local Source, General Fund Revenue Estimate (Net of Dedicated Taxes)	FY2019 Tax Changes Full-Year Revenue Effect	Total
Property Taxes	$2,718,890	$39,615	$2,758,505
Sales Taxes	$1,124,119	$34,997	$1,159,116
Income Taxes	$2,724,180	$14,475	$2,738,655
Gross Receipts Taxes	$242,110	$23,018	$265,128
Other Taxes	$450,118	$6,460	$456,578
Total Taxes	$7,259,417	$118,565	$7,377,982
Total Non-Tax and Lottery Revenues	$546,338		
Total Local Source, General Fund Revenue Estimate	$7,805,755	$118,565	$7,924,320

Principal and interest from:	2019 Principal and Interest Payments	GO Bond and Income Tax Revenue Bond Debt Service
General Obligation, ITSB, QZAB, Housing Production Trust and 225 Virginia Ave, LLC	$744,462	9.39%
+ PILOT	$762,808	9.63%
+ TIF	$774,616	9.78%

Source: DEG estimates of revenues and CFO estimates of principal and interest payments.

District Economics Group

Michael Udell

Managing Member, District Economics Group, LLC

Office: (202) 408 6235 Cell: (408) 562 6479 michael.udell@districteconomics.com

Diane Lim

Consultant, District Economics Group, LLC

Cell: (703) 470 1357 diane.lim@districteconomics.com

Matthew Fellows

Data Analytics Manager, District Economics Group, LLC

Office: (202) 480 2785 Cell: (603) 233 2189 matthew.fellows@districteconomics.com

Danielle Sockin

Analyst, District Economics Group, LLC

Office: (202) 408 6232 Cell: (845) 709 5361 danielle.sockin@districteconomics.com

District Economics Group

101 Constitution Ave. NW, Suite 675 East, Washington, D.C. 20001

Fax: (202) 289 6600

www.districteconomics.com

Appendix A

Presentation Deck of District Economic Group Model Discussion

DEG Model Discussion with the Office of the DC Auditor

Washington, D.C.

5 September, 2019

DISTRICT ECONOMICS GROUP

Table of Contents

DC GDP Forecast with Log of DC GDP

- An ARIMA model (auto-regressive integrated moving average), is a commonly used statistical method for time series forecasting. This model is used to forecast annual DC GDP (based upon a log transformation of DC GDP).
- After testing various model specifications, an ARIMA(0,2,1) model specification is chosen. This model specification uses the following…
  - The auto-regressive parameter is 0 which means this model uses no time lags of the dependent variable.
  - The degree of differencing is 2 indicating that the log of DC GDP series is differenced twice in the model to achieve stationarity.
  - The moving average component is 1. This means that the error term from the previous time period is included in the model.
- Log of US GDP is used as an extra regressor in the ARIMA(0,2,1) model.

DC GDP Forecast with Log DC GDP

- Below is the model output for an Arima(0,2,1) model with log of DC GDP as the dependent variable and log of US GDP as an additional regressor.
  - The model output shows the coefficient on the log of US GDP regressor and the coefficient on the previous period's model error term represented by ma1.
- Additional DC specific regressors were tested in the ARIMA model including log of DC population and log of DC unemployment, but these variables statistically reduced the goodness of fit of the model.

Table 1. Log of DC GDP ARIMA(0,2,1) Model
Regression with ARIMA(0,2,1) errors

coefficients:

	ma1	Log of US GDP
	-0.7286	0.2785
s.e.	0.1580	0.1849
t statistic	-4.6114	1.5062

sigma^2 estimated as 0.0002757
log likelihood=54.42
AIC=-102.85 AICc=-101.35

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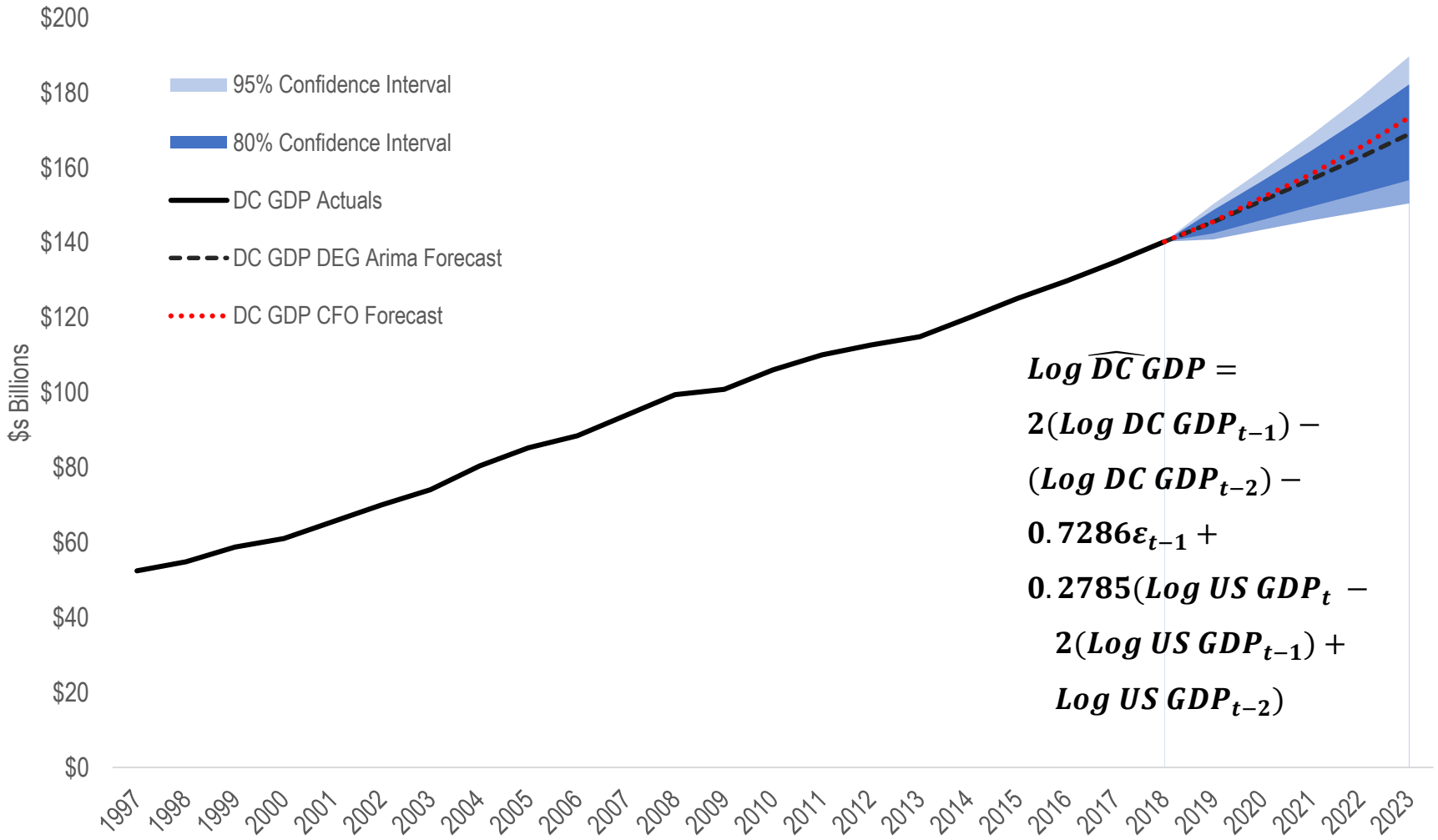
DC GDP Forecast with Log DC GDP

Chart 1. DC GDP Forecast 2019-2023

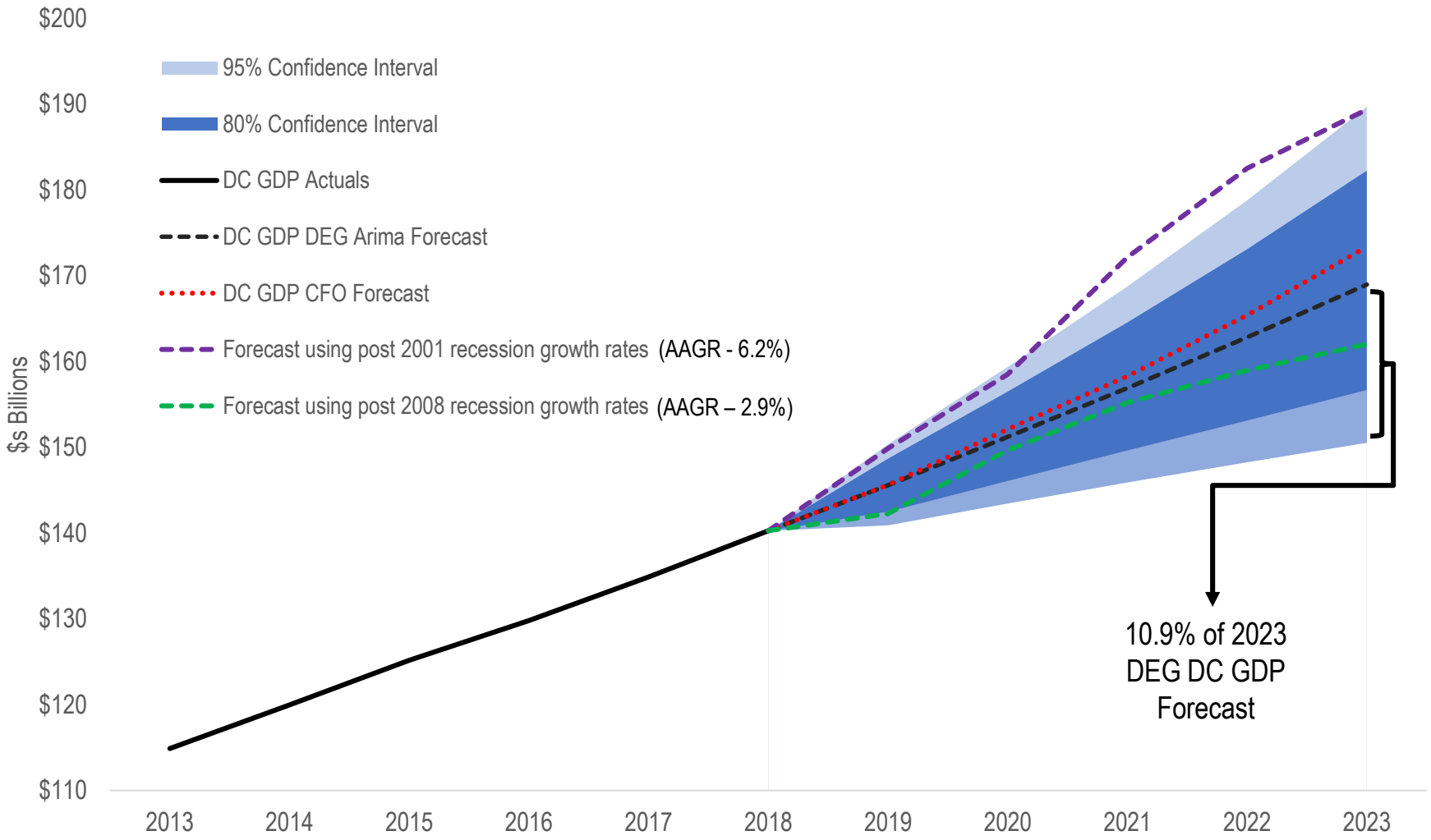


$$\widehat{Log\ DC\ GDP} = 2(Log\ DC\ GDP_{t-1}) - (Log\ DC\ GDP_{t-2}) - 0.7286\varepsilon_{t-1} + 0.2785(Log\ US\ GDP_t - 2(Log\ US\ GDP_{t-1}) + Log\ US\ GDP_{t-2})$$

Source: U.S. Bureau of Economic Analysis; DEG estimates based upon U.S. Bureau of Economic Analysis DC GDP data.

DC GDP Forecast with Log DC GDP

Chart 2. DC GDP Forecast 2019-2023



Source: U.S. Bureau of Economic Analysis; DEG estimates based upon U.S. Bureau of Economic Analysis DC GDP data.

DC GDP Forecast with Log DC GDP

Table 2. DEG DC GDP Forecasts ($ billions)

Year	DC GDP DEG ARIMA Forecast	Low 80%	High 80%	Low 95%	High 95%	DC GDP CFO Forecast	Forecast using post 2001 recession growth rates	Forecast using post 2008 recession growth rates
2018	$140.3	$140.3	$140.3	$140.3	$140.3	$140.3	$140.3	$140.3
2019	$145.6	$142.5	$148.7	$140.9	$150.4	$145.6	$149.9	$142.3
2020	$151.2	$146.1	$156.5	$143.5	$159.4	$152.1	$158.5	$149.6
2021	$156.9	$149.6	$164.6	$145.9	$168.8	$158.3	$172.2	$155.2
2022	$162.8	$153.1	$173.1	$148.3	$178.8	$165.4	$182.5	$159.0
2023	$169.0	$156.7	$182.3	$150.5	$189.7	$173.4	$189.4	$162.0

Source: Office of the Chief Financial Officer; DEG estimates based upon U.S. Bureau of Economic Analysis DC GDP data.

Forecasting Revenue

- Data provided by the DC CFO breaks down DC revenues into seven different categories: Property, sales & excise, income, gross receipts, other tax, nontax, special purpose and lottery.
- These seven categories were placed into six groups by combining the nontax, special purpose, and lottery revenues. Each group exhibits stable shares of GDP after the Great Recession:
  - Property – accounted for 30.7% of total revenues in 2018.
  - Income – accounted for 30.5% of total revenues in 2018.
  - Sales & excise – accounted for 18.4% of total revenues in 2018.
  - Gross receipts – accounted for 4.2% of total revenues in 2018.
  - Other tax – accounted for 5.9% of total revenues in 2018.
  - Nontax, special purpose and lottery – accounted for 10.3% of total revenues in 2018.
- These six groups of DC revenues are forecasted using ARIMA models with DC GDP as an additional regressor.

Forecasting Revenue – Property

- Below is the model output for an ARIMA(0,1,1) model with property tax revenues as the dependent variable and nominal DC GDP as an additional regressor.

Table 3. Property tax revenue ARIMA(0,1,1) Model
Regression with ARIMA(0,1,1) errors

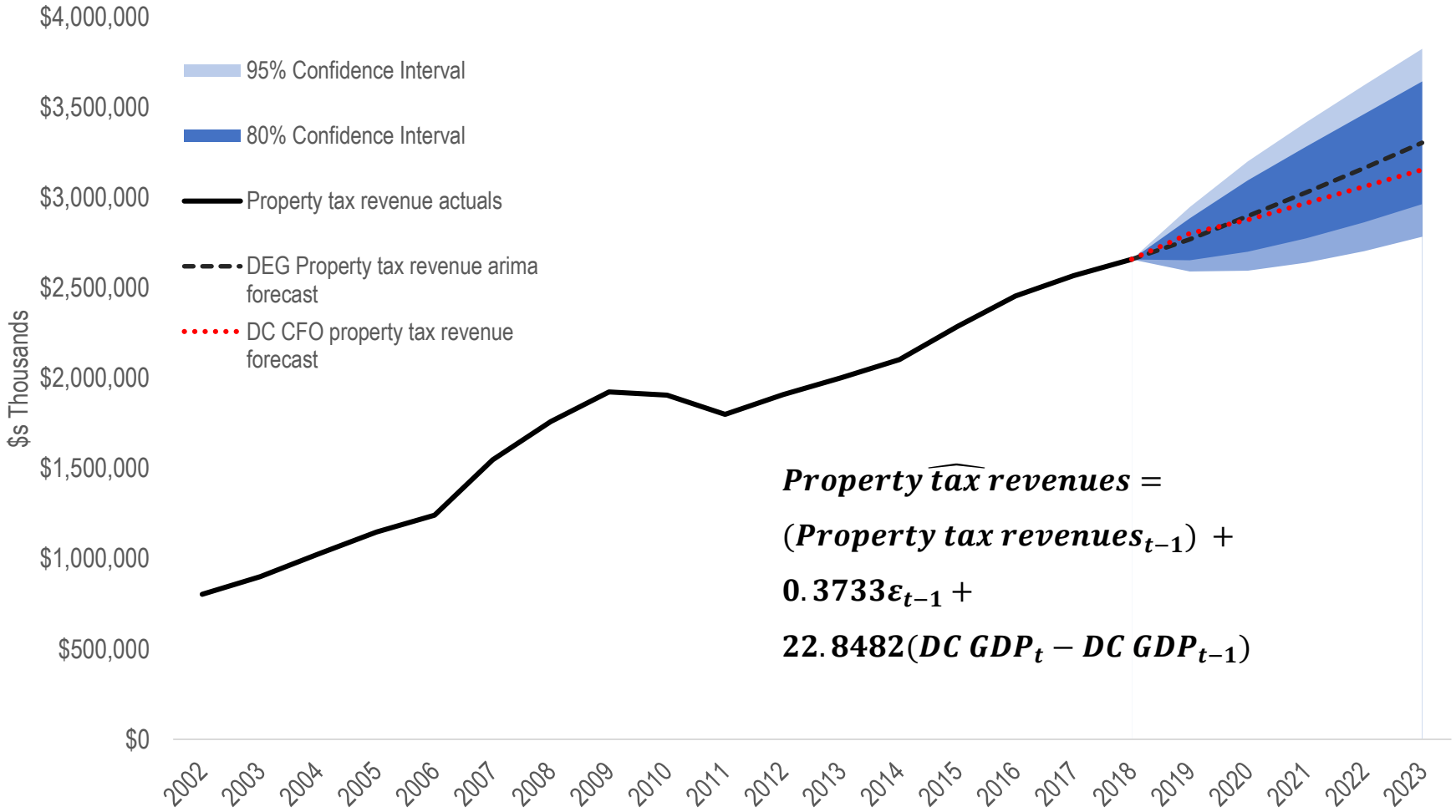
coefficients:

	ma1	DC GDP
	0.373	22.8482
s.e.	0.2573	6.2745
t statistic	1.4508	3.6414

sigma^2 estimated as 8.258e+09
log likelihood=-204.39
AIC=414.77 AICc=416.77

Forecasting Revenue – Property

Chart 3. DC Property Tax Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Forecasting Revenue – Income

- Below is the model output for an ARIMA(0,1,1) model with income tax revenues as the dependent variable and nominal DC GDP as an additional regressor.

Table 4. Income tax revenue ARIMA(0,1,1) Model
Regression with ARIMA(0,1,1) errors

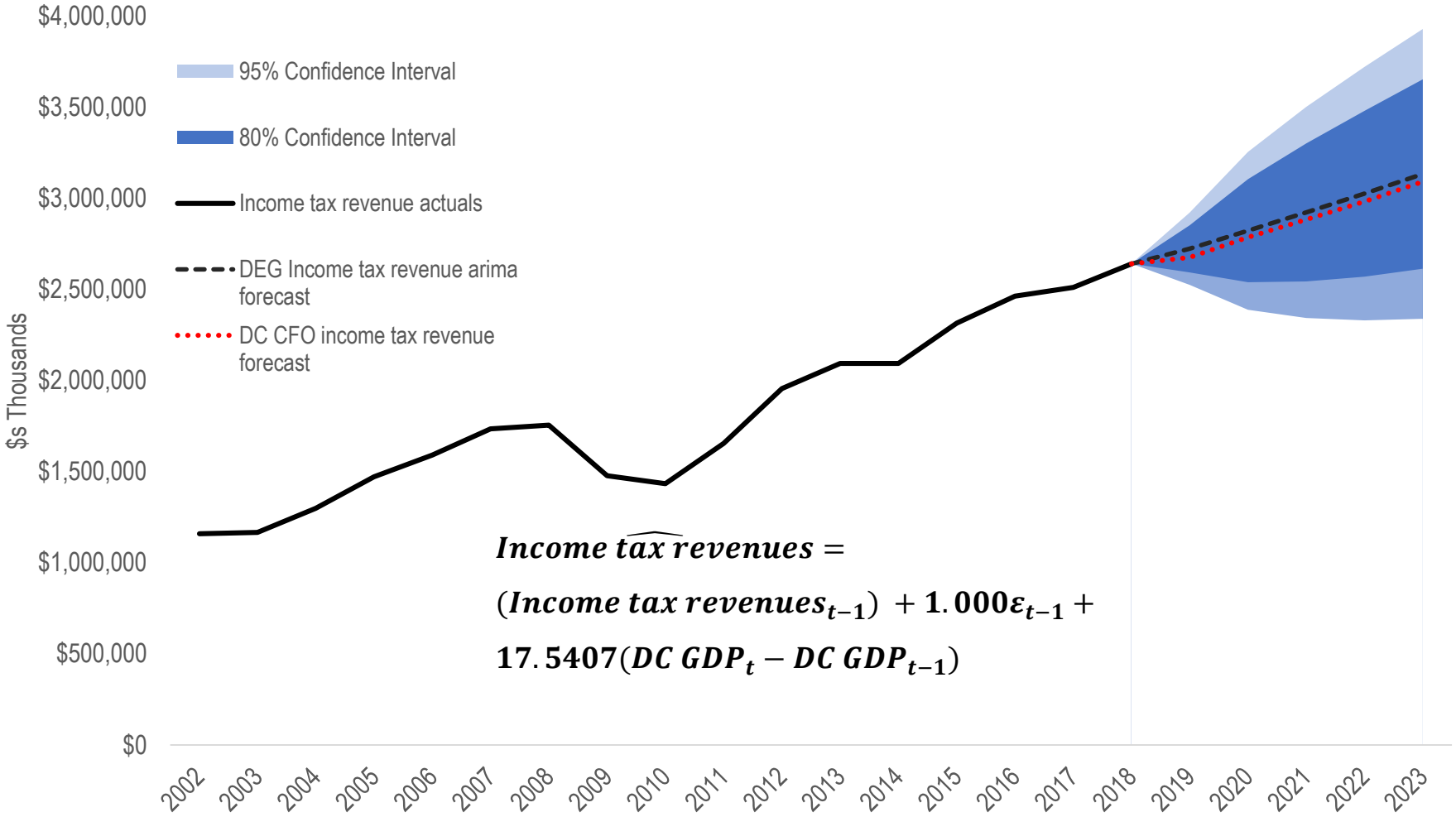
coefficients:

	ma1	DC GDP
	1.000	17.5407
s.e.	0.3446	7.094
t statistic	2.9019	2.4726

sigma^2 estimated as 9.655e+09
log likelihood=-206.98
AIC=419.95 AICc=421.95

Forecasting Revenue – Income

Chart 4. DC Income Tax Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Forecasting Revenue – Sales and Excise

- Below is the model output for an ARIMA(0,1,0) model with sales and excise tax revenues as the dependent variable and nominal DC GDP as an additional regressor.

Table 5. Sales and excise tax revenue ARIMA(0,1,0) Model

Regression with ARIMA(0,1,0) errors

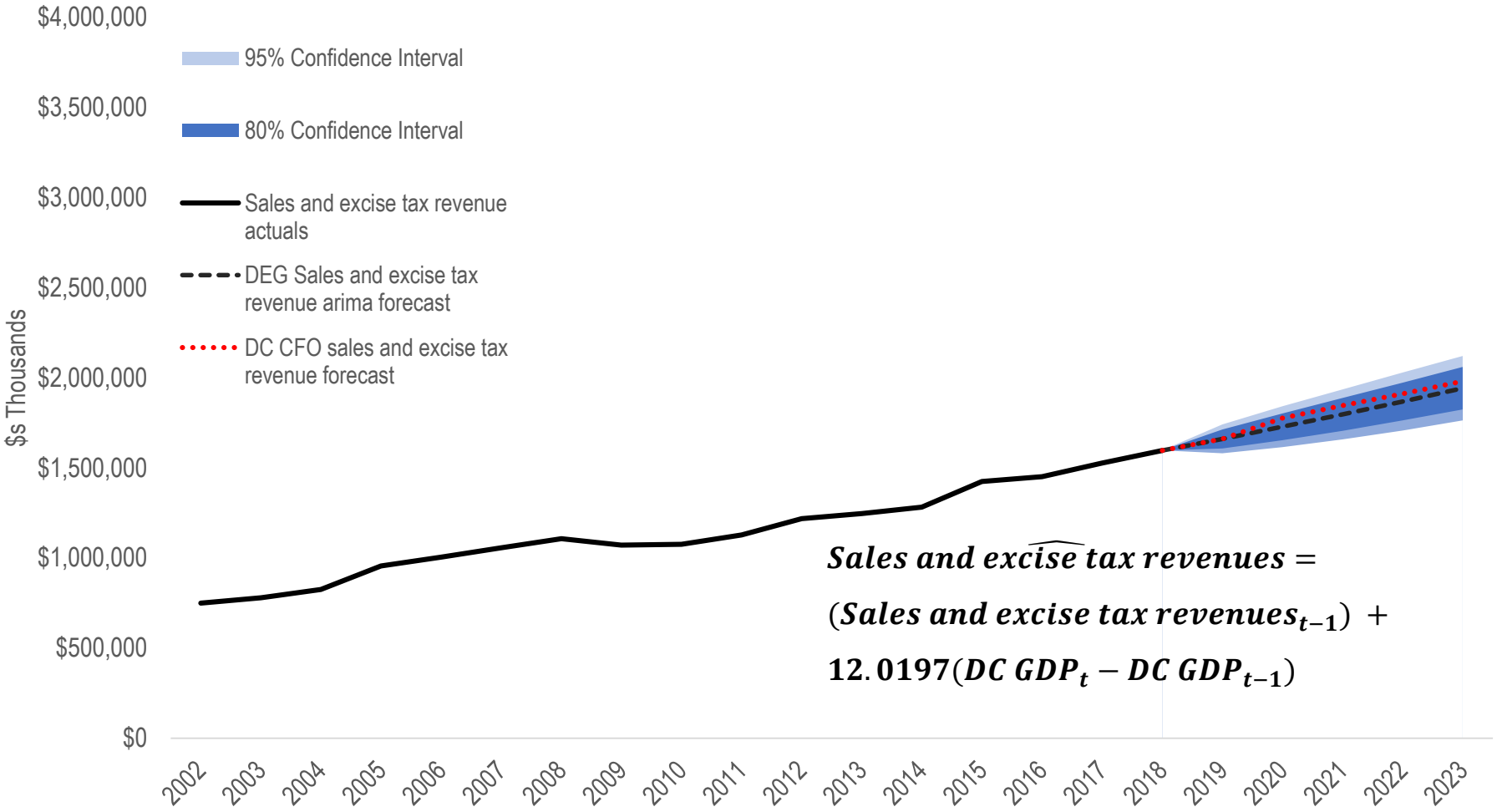
coefficients:

	DC GDP
	12.0197
s.e.	2.1591
t statistic	5.5670

sigma^2 estimated as 1.674e+09
log likelihood=-192.09
AIC=388.19 AICc=389.11

Forecasting Revenue – Sales and Excise

Chart 5. DC Sales and Excise Tax Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Forecasting Revenue – Gross Receipts

- Below is the model output for an ARIMA(1,2,1) model with gross receipts revenues as the dependent variable.
  - Adding Nominal DC GDP to the Arima model does not improve the fit of the model.

Table 6. Gross receipts revenue ARIMA(1,2,1) Model
Regression with ARIMA(1,2,1) errors

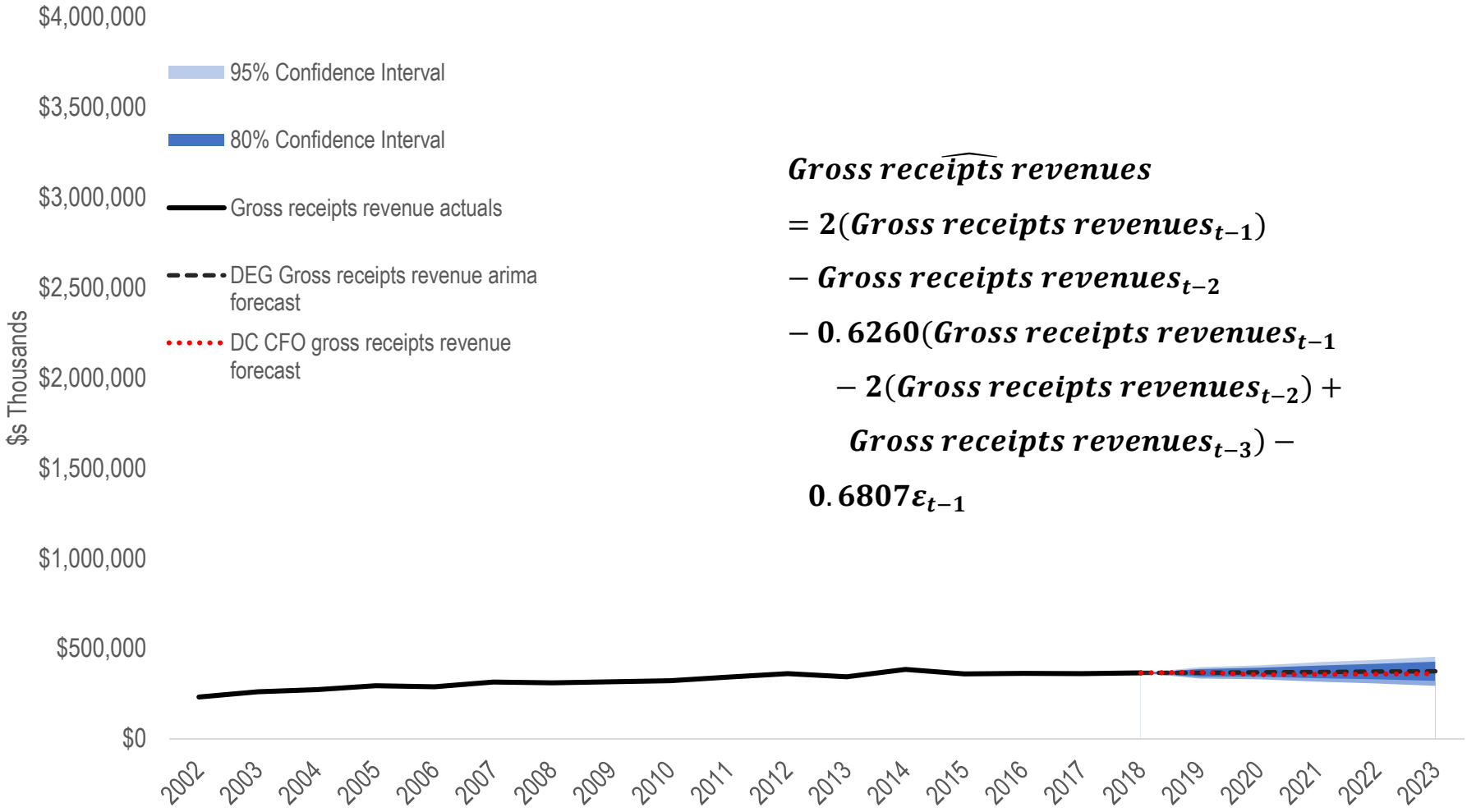
coefficients:

	ar1	ma1
	-0.6260	-0.6807
s.e.	0.2002	0.2261
t statistic	-3.1273	-3.0106

sigma^2 estimated as 2.56e+08
log likelihood=-166.33
AIC=338.66 AICc=340.84

Forecasting Revenue – Gross Receipts

Chart 6. DC Gross Receipts Revenue Forecast 2019-2023

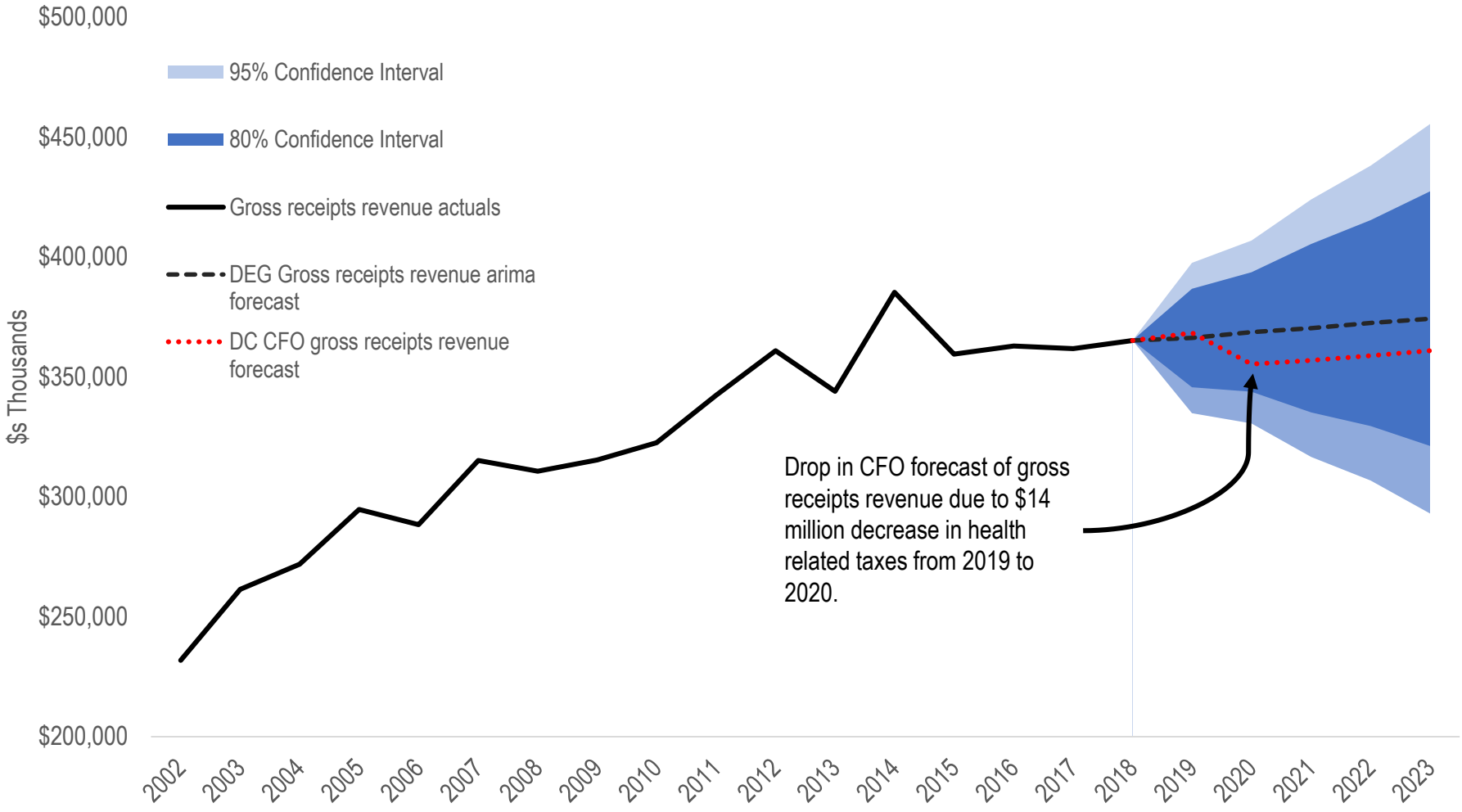


$$\widehat{\textbf{Gross receipts revenues}} = 2(\textbf{Gross receipts revenues}_{t-1}) - \textbf{Gross receipts revenues}_{t-2} - 0.6260(\textbf{Gross receipts revenues}_{t-1} - 2(\textbf{Gross receipts revenues}_{t-2}) + \textbf{Gross receipts revenues}_{t-3}) - 0.6807\varepsilon_{t-1}$$

Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Forecasting Revenue – Gross Receipts

Chart 7. DC Gross Receipts Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

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Forecasting Revenue – Other Tax

- Below is the model output for an Arima(0,2,1) model with other tax revenues as the dependent variable.
  - Adding Nominal DC GDP to the Arima model does not improve the fit of the model.

Table 7. Other tax revenue ARIMA(0,2,1) Model
Regression with ARIMA(0,2,1) errors

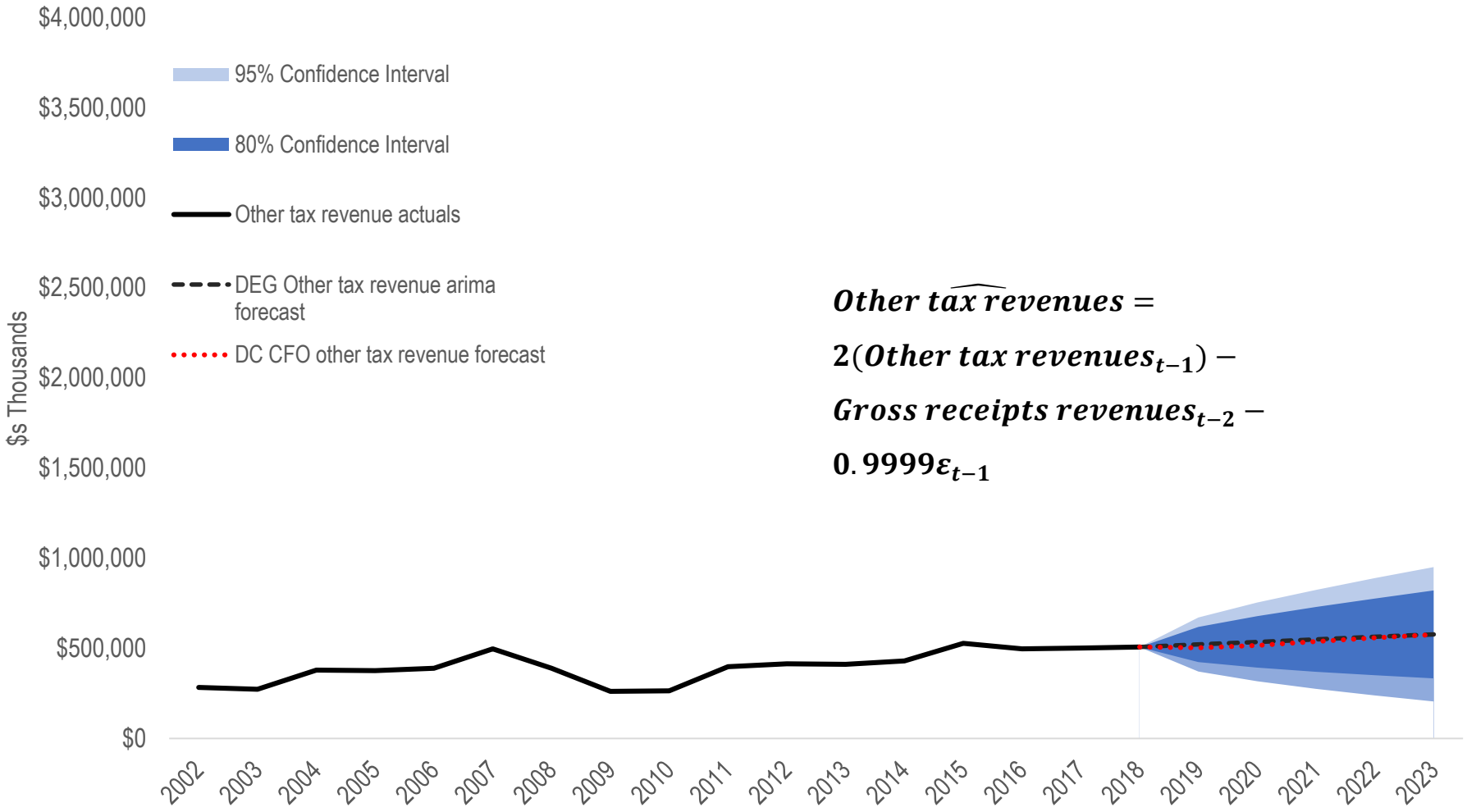
coefficients:

	ma1
	-0.9999
s.e.	0.1854
t statistic	-5.3932

sigma^2 estimated as 5.512e+09
log likelihood=-190.38
AIC=384.76 AICc=385.76

Forecasting Revenue – Other Tax

Chart 8. DC Other Tax Revenue Forecast 2019-2023

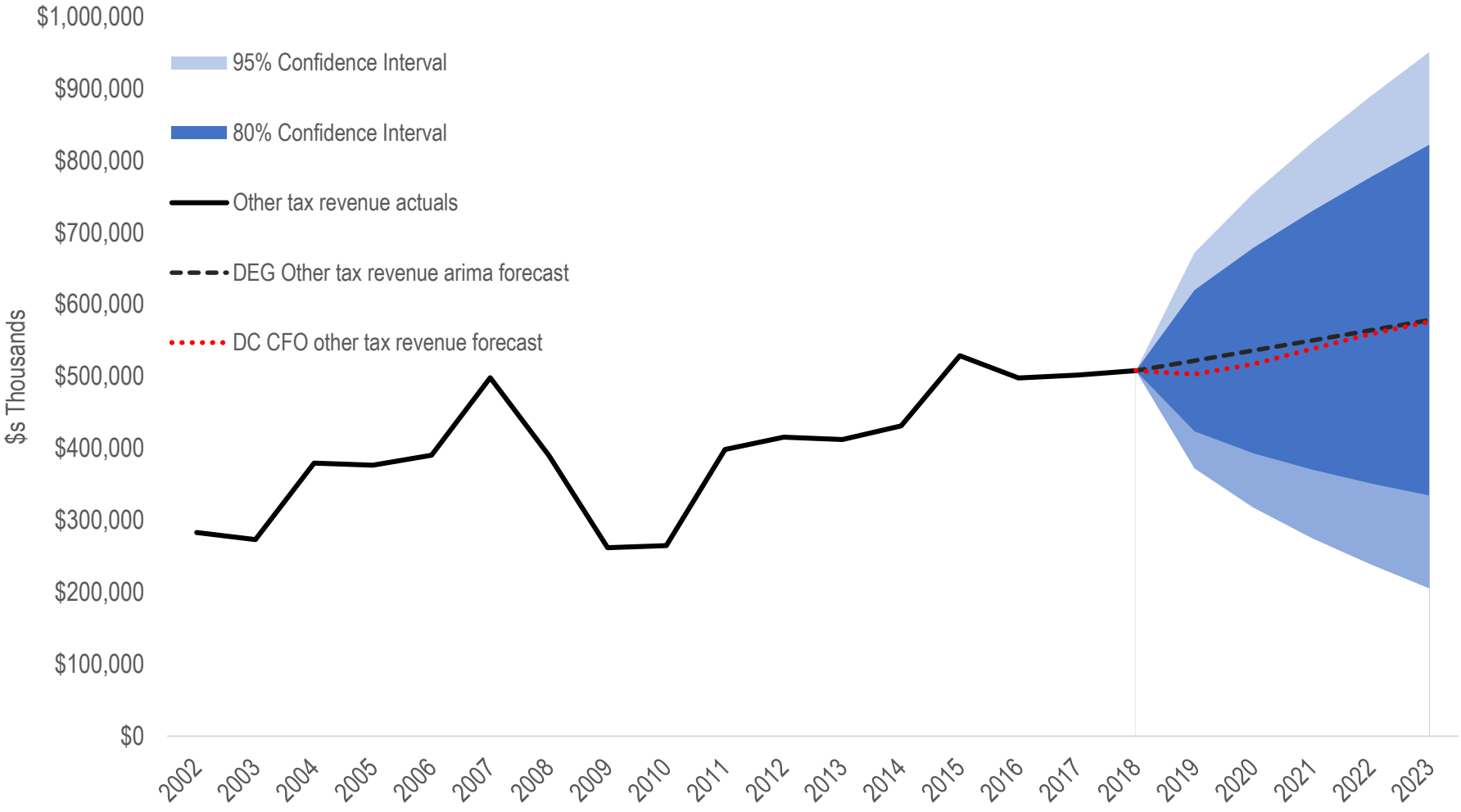


$$\widehat{Other\ tax\ revenues} = 2(Other\ tax\ revenues_{t-1}) - Gross\ receipts\ revenues_{t-2} - 0.9999\varepsilon_{t-1}$$

Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Forecasting Revenue – Other Tax

Chart 9. DC Other Tax Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

Forecasting Revenue – Nontax, Special Purpose and Lottery

- Below is the model output for an ARIMA(0,1,0) model with the annual sum of nontax, special purpose and lottery revenues as the dependent variable.

Table 8. Nontax, special purpose and lottery revenue ARIMA(0,1,0) Model
Regression with ARIMA(0,1,0) errors

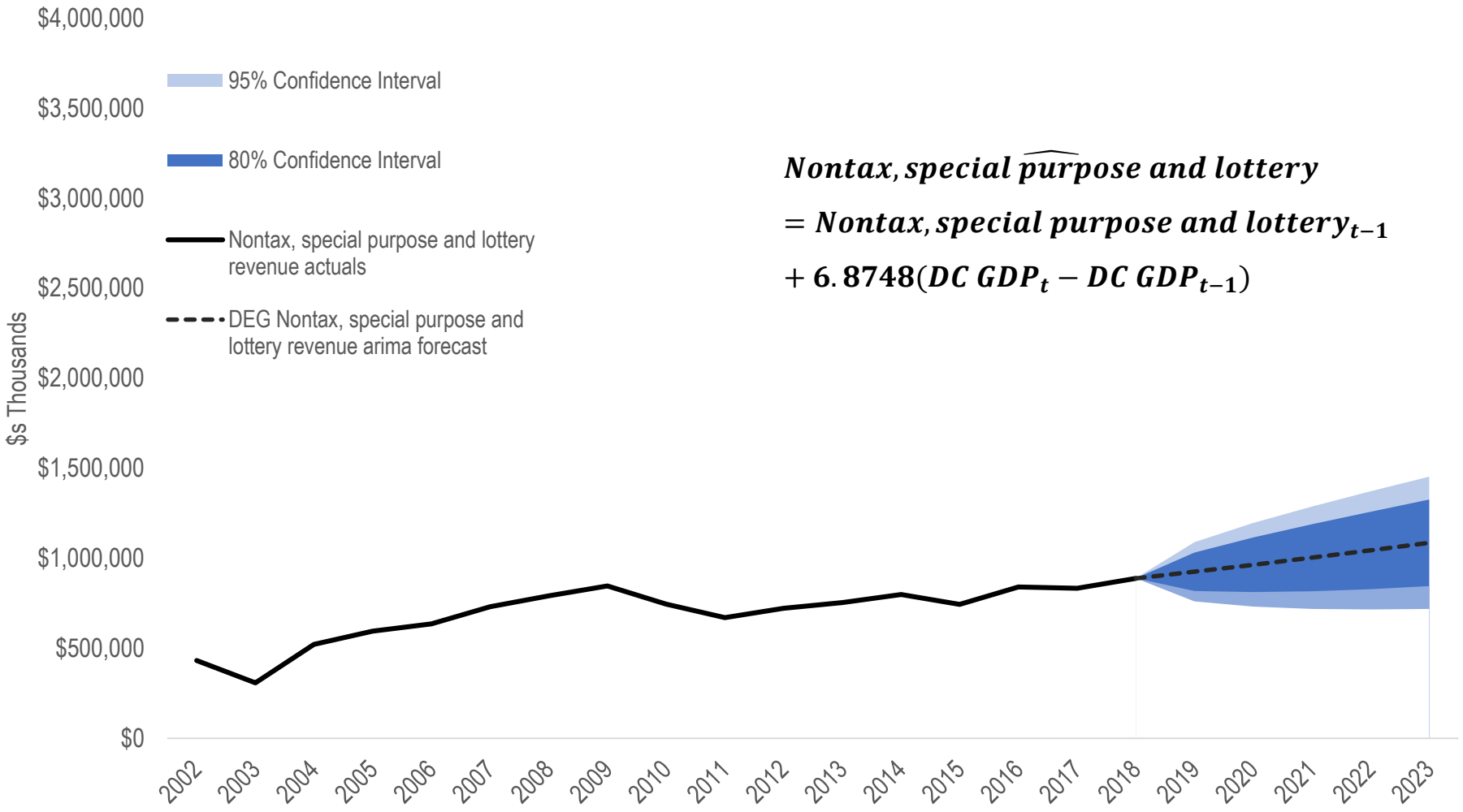
coefficients:

	DC GDP
	6.8748
s.e.	4.4217
t statistic	1.5548

sigma^2 estimated as 7.021e+09
log likelihood=-203.56
AIC=411.13 AICc=412.05

Forecasting Revenue – Nontax, Special Purpose and Lottery

Chart 10. DC Nontax, Special Purpose and Lottery Revenue Forecast 2019-2023



$$\widehat{Nontax, special\ purpose\ and\ lottery} = Nontax, special\ purpose\ and\ lottery_{t-1} + 6.8748(DC\ GDP_t - DC\ GDP_{t-1})$$

Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

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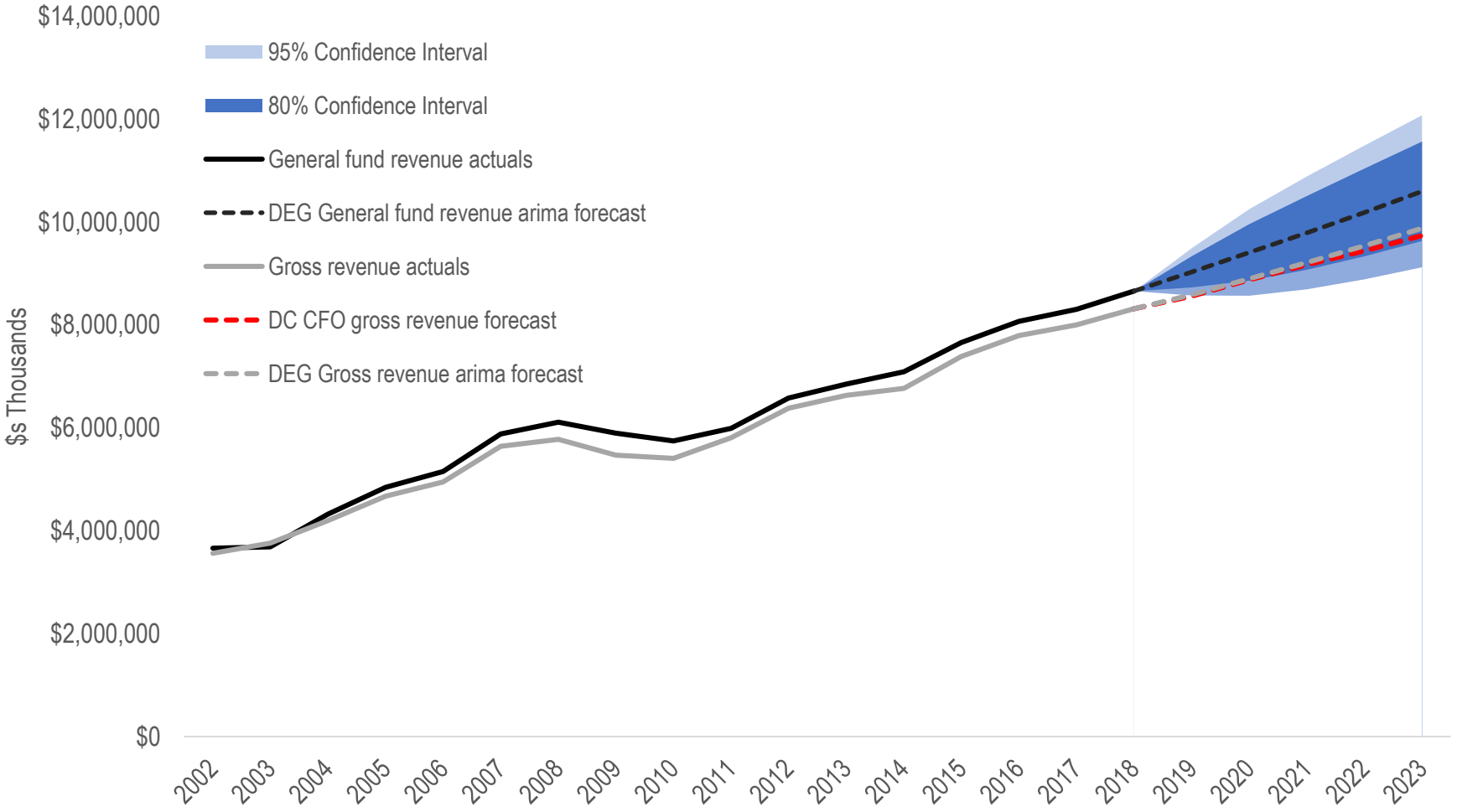
Forecasting Revenue – General Fund Revenue

Chart 11. DC General Fund Revenue Forecast and Gross Revenue Forecast 2019-2023



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.
Note: Gross revenue = General fund revenue – special purpose fund revenue

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Tax Changes by Type and Effective Fiscal Year

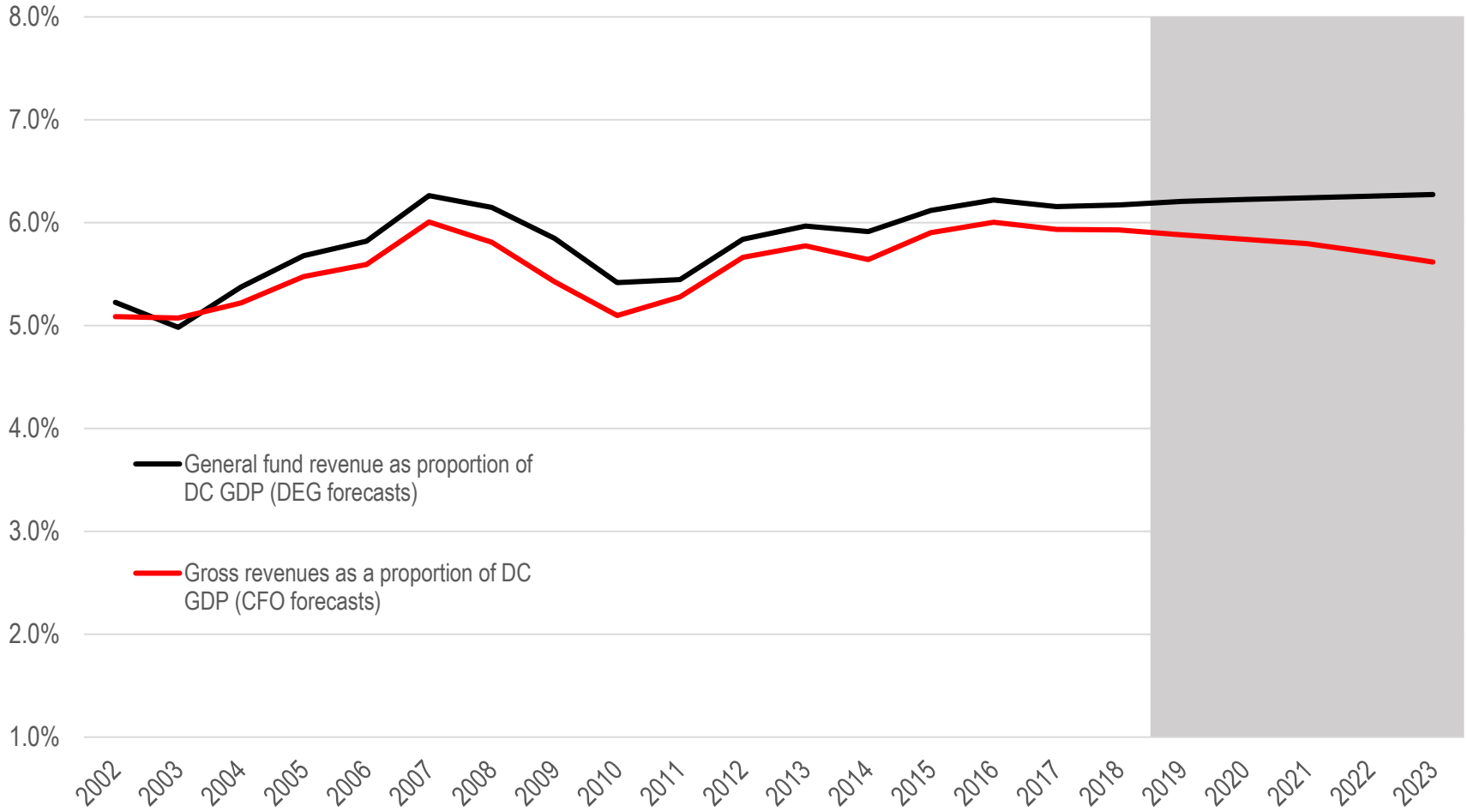
Table 9. Count of Tax Changes by Type and Effective Fiscal Year

FY Effective	Property	Sales and Excise	Income	Gross Receipts	Other Tax	Total
2002	0	0	0	0	1	1
2003	2	3	4	2	6	17
2004	2	0	1	0	0	3
2005	2	4	2	4	2	14
2006	5	2	4	2	0	13
2007	1	0	1	0	4	6
2008	3	1	4	0	0	8
2009	4	1	1	3	2	11
2010	2	5	2	1	0	10
2011	2	2	3	4	0	11
2012	2	6	3	1	0	12
2013	1	3	1	0	0	5
2014	1	3	1	0	0	5
2015	2	4	5	3	0	14
2016	1	5	10	2	1	19
2017	1	2	3	2	0	8
2018	1	3	2	2	3	11
2019	2	3	1	3	1	10
Total	34	47	48	29	20	178

Source: 2018 D.C. Tax Facts from the Office of the Chief Financial Officer.

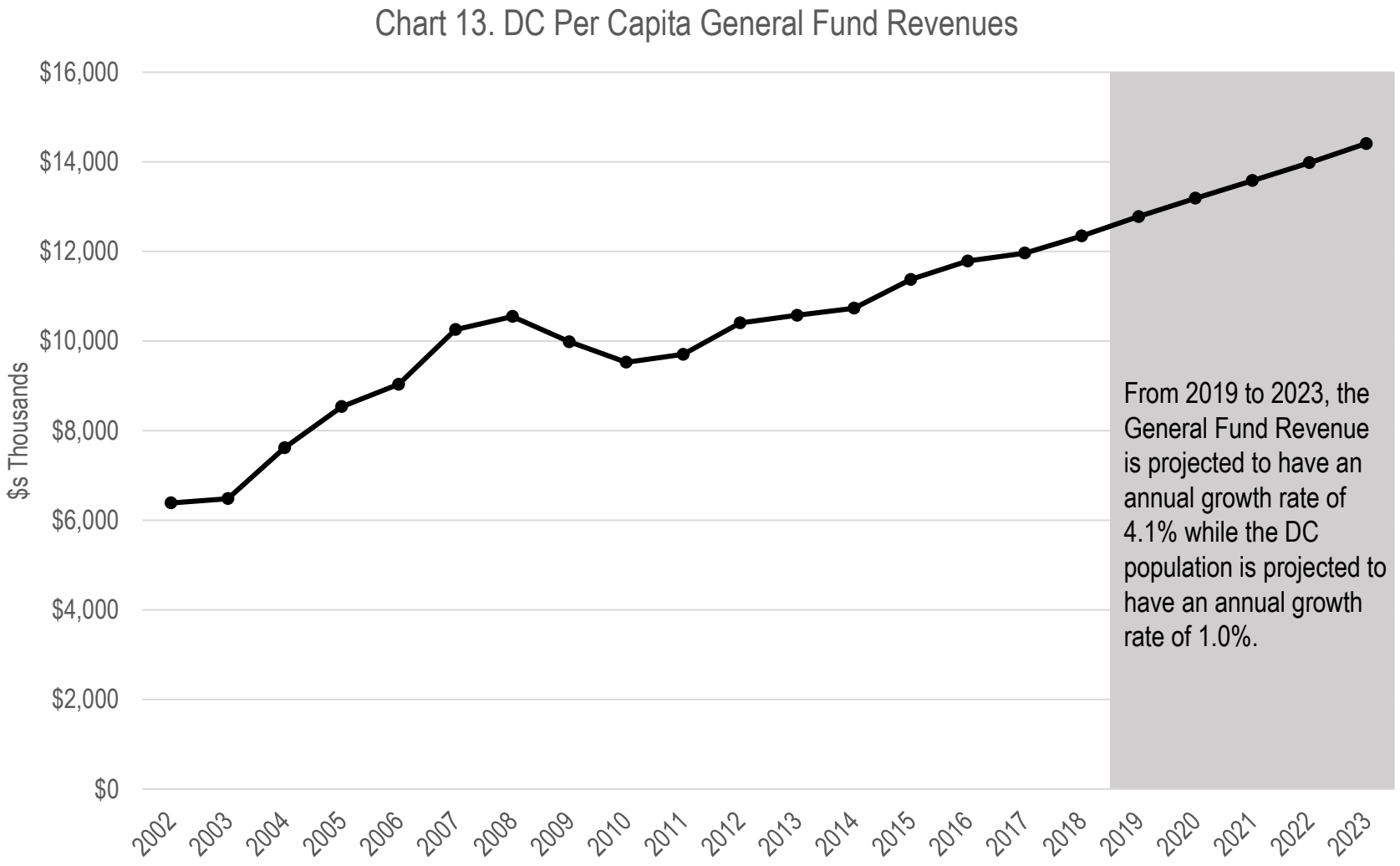
DC GDP and General Fund Revenue

Chart 12. General Fund Revenue and Gross Revenue as a Proportion of DC GDP



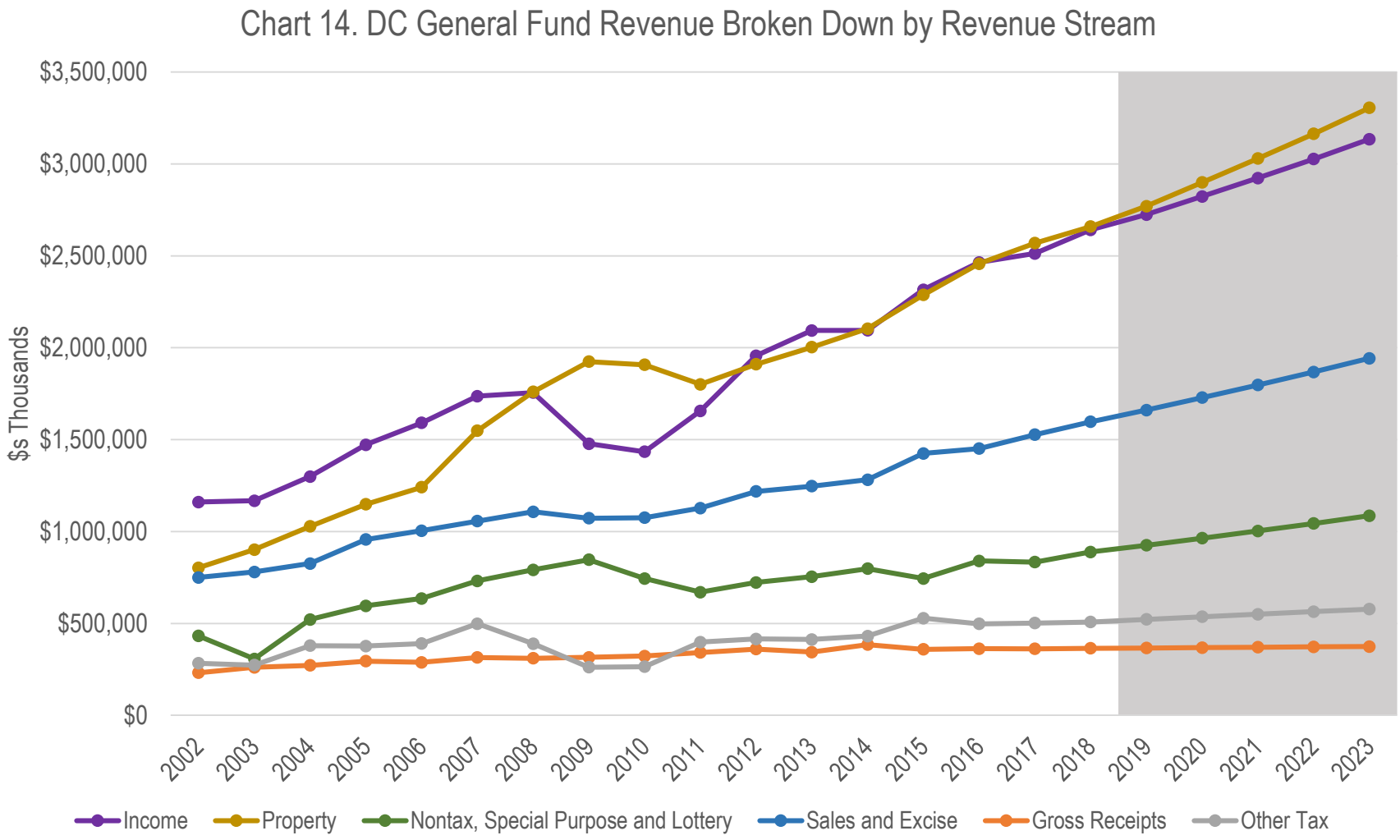
Source: DEG calculations based upon Office of the Chief Financial Officer and U.S. Bureau of Economic Analysis data.
Note: Gross revenue = General fund revenue – special purpose fund revenue

DC GDP and General Fund Revenue



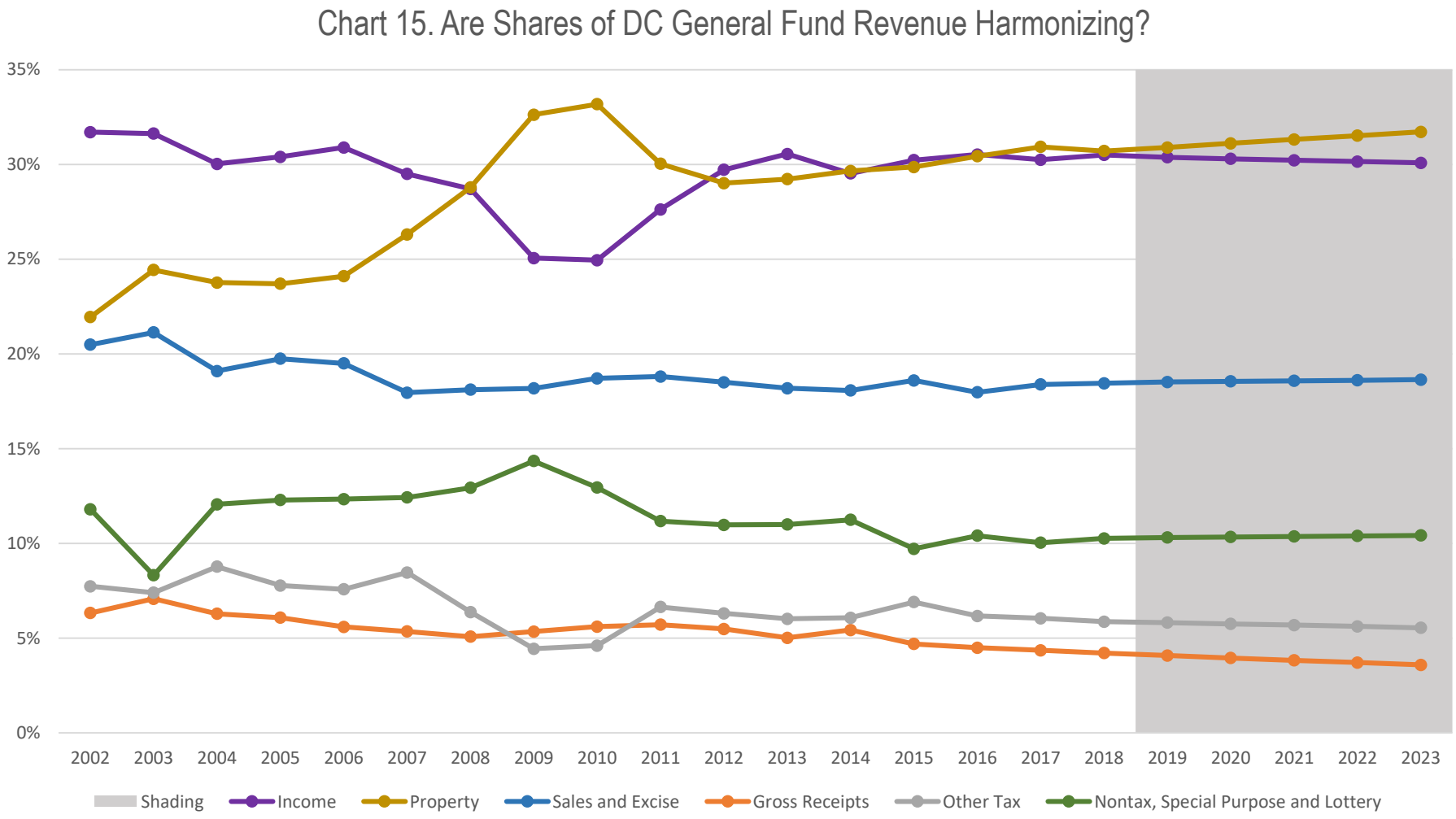
Source: DEG calculations based upon Office of the Chief Financial Officer and District of Columbia Office of Planning data.

DC Revenues by Type



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

DC Revenues by Type



DC Dedicated Revenues

- Dedicated taxes are revenues earmarked to support particular programs and activities as required by law.
  - Dedicated taxes are not available for general budgeting and are earmarked from Property, Sales and Excise, Gross Receipts, and Other tax revenues; Income tax revenues are not dedicated.
- In 2018, there were 15 dedicated taxes allocating revenue to Funds such as the Hospital Fund, Highway Trust Fund, and Healthy Schools Fund.

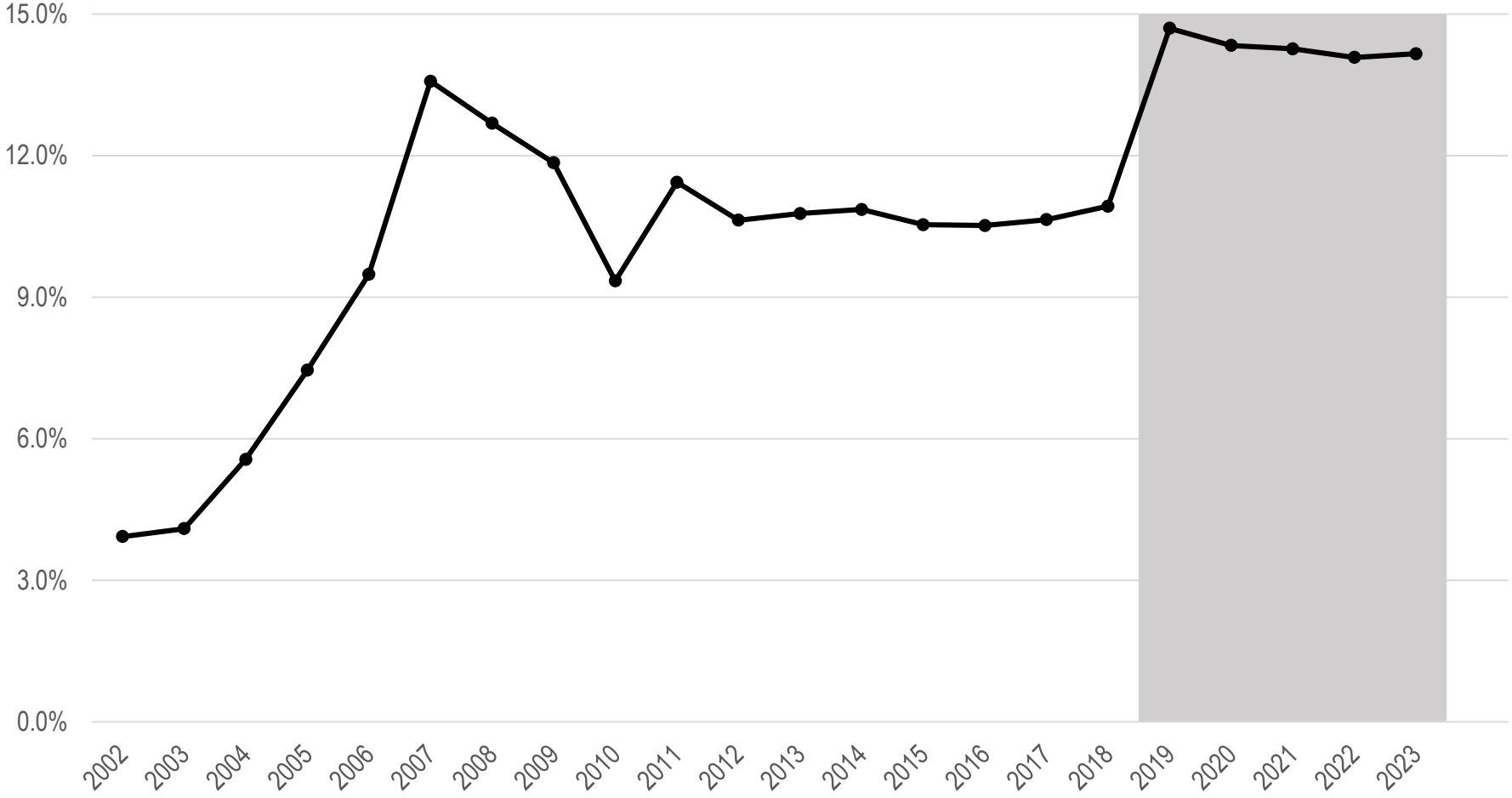
Table 10. Dedicated Taxes by Type of Revenue, 2018 and 2019

Property	Gross Revenues	$2,659,241	$2,803,742
	Net of Dedicated Taxes	$2,613,898	$2,752,325
	Percentage Dedicated	1.7%	1.83%
Sales and Excise	Gross Revenues	$1,597,405	$1,661,371
	Net of Dedicated Taxes	$1,283,924	$1,124,514
	Percentage Dedicated	19.6%	32.3%
Gross receipts	Gross Revenues	$365,129	$368,251
	Net of Dedicated Taxes	$234,388	$244,182
	Percentage Dedicated	35.8%	33.7%
Other tax	Gross Revenues	$507,976	$503,198
	Net of Dedicated Taxes	$436,997	$431,288
	Percentage Dedicated	14.0%	14.3%
Total	Gross Revenues	$5,129,752	$5,336,561
	Net of Dedicated Taxes	$4,569,207	$4,552,310
	Percentage Dedicated	10.9%	14.7%

Source: Office of the Chief Financial Officer, Table S-1E FY 2018 DC CAFR.

DC Dedicated Revenues

Chart 16. Dedicated Revenues as Percentage of Source Revenues (Property, Gross Receipts, Sales & Excise, Other Tax, DC CFO)



Source: Office of the Chief Financial Officer.

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Forecasting Revenue with 2020 Shock to the Economy

- Two recessions of differing sizes are modeled by changing the forecasted DC GDP annual growth rate in 2020 as a recession. After 2020, the GDP growth rates return to the baseline DC GDP annual growth rates.
  - During the Great Recession, the DC GDP annual growth rate slowed from 5.86% in 2008 to 1.42% in 2009. The DC GDP growth rate decreased from 2008 to 2009 by 75.7%.
    - In the first scenario, a 2020 recession in 2020 is modeled to be the same magnitude as the Great Recession, so the DC GDP annual growth rate from 2019 to 2020 is decreased by 75.7%.
    - In the second scenario, the recession in 2020 is modeled to be half the size of the Great recession which implies that the DC GDP annual growth rate from 2019 to 2020 decreases by 37.85%.
  - These two recession scenarios are used to project the various revenue streams and to see how shocks of varying sizes affect DC general fund revenue.
    - These scenarios are selected for ease of illustration and are not based upon any projection of the likelihood or magnitude of a future recession.

Forecasting Revenue with 2020 Shock to the Economy

Table 11. DEG DC GDP forecasts with and without 2020 shock to the economy followed by return to baseline DC GDP growth rates in 2021 ($ Billions)

	No shock		Shock same magnitude as Great Recession in 2020		Shock half the size of the Great Recession in 2020	
Year	DEG DC GDP forecast	Annual growth rate	DEG DC GDP forecast	Annual growth rate	DEG DC GDP forecast	Annual growth rate
2019	$145.6	3.77%	$145.6	3.77%	$145.6	3.77%
2020	$151.2	3.88%	$146.9	0.92%	$149.0	2.34%
2021	$156.9	3.77%	$152.4	3.77%	$154.6	3.77%
2022	$162.8	3.76%	$158.2	3.76%	$160.4	3.76%
2023	$169.0	3.79%	$164.2	3.79%	$166.5	3.79%

Source: DEG estimates based upon U.S. Bureau of Economic Analysis DC GDP data.

Forecasting Revenue with 2020 Shock to the Economy

A $1 billion decline in DC GDP results in a $59.283 million decrease in DC general fund revenue.

Forecasting Revenue with 2020 Shock to the Economy

Table 12. Effect of shock equal in magnitude to the Great Recession on revenue streams

		2019	2020	2021	2022	2023
Income	DEG forecast without shock	$2,724,180	$2,823,192	$2,923,224	$3,026,685	$3,134,847
	DEG forecast with shock	$2,724,180	$2,747,558	$2,844,738	$2,945,248	$3,050,327
	Difference	$0	-$75,634	-$78,486	-$81,436	-$84,521
Property	DEG forecast without shock	$2,770,306	$2,899,277	$3,029,577	$3,164,342	$3,305,233
	DEG forecast with shock	$2,770,306	$2,800,758	$2,927,343	$3,058,265	$3,195,138
	Difference	$0	-$98,519	-$102,234	-$106,077	-$110,095
Sales and excise	DEG forecast without shock	$1,660,975	$1,728,822	$1,797,369	$1,868,264	$1,942,382
	DEG forecast with shock	$1,660,975	$1,676,995	$1,743,587	$1,812,460	$1,884,464
	Difference	$0	-$51,827	-$53,782	-$55,804	-$57,917
Gross receipts	DEG forecast without shock	$366,178	$368,670	$370,258	$372,412	$374,212
	DEG forecast with shock	$366,178	$368,670	$370,258	$372,412	$374,212
	Difference	$0	$0	$0	$0	$0
Other tax	DEG forecast without shock	$522,028	$536,080	$550,132	$564,184	$578,236
	DEG forecast with shock	$522,028	$536,080	$550,132	$564,184	$578,236
	Difference	$0	$0	$0	$0	$0
Nontax, special purpose fund revenue and lottery	DEG forecast without shock	$925,073	$963,879	$1,003,085	$1,043,634	$1,086,027
	DEG forecast with shock	$925,073	$934,235	$972,323	$1,011,717	$1,052,900
	Difference	$0	-$29,643	-$30,761	-$31,918	-$33,126
Total	DEG forecast without shock	$8,968,741	$9,319,919	$9,673,645	$10,039,521	$10,420,936
	DEG forecast with shock	$8,968,741	$9,064,295	$9,408,381	$9,764,286	$10,135,277
	Difference	$0	-$255,624	-$265,264	-$275,235	-$285,659

Source: DEG estimates based upon Office of the Chief Financial Officer data.

Forecasting Revenue with 2020 Shock to the Economy

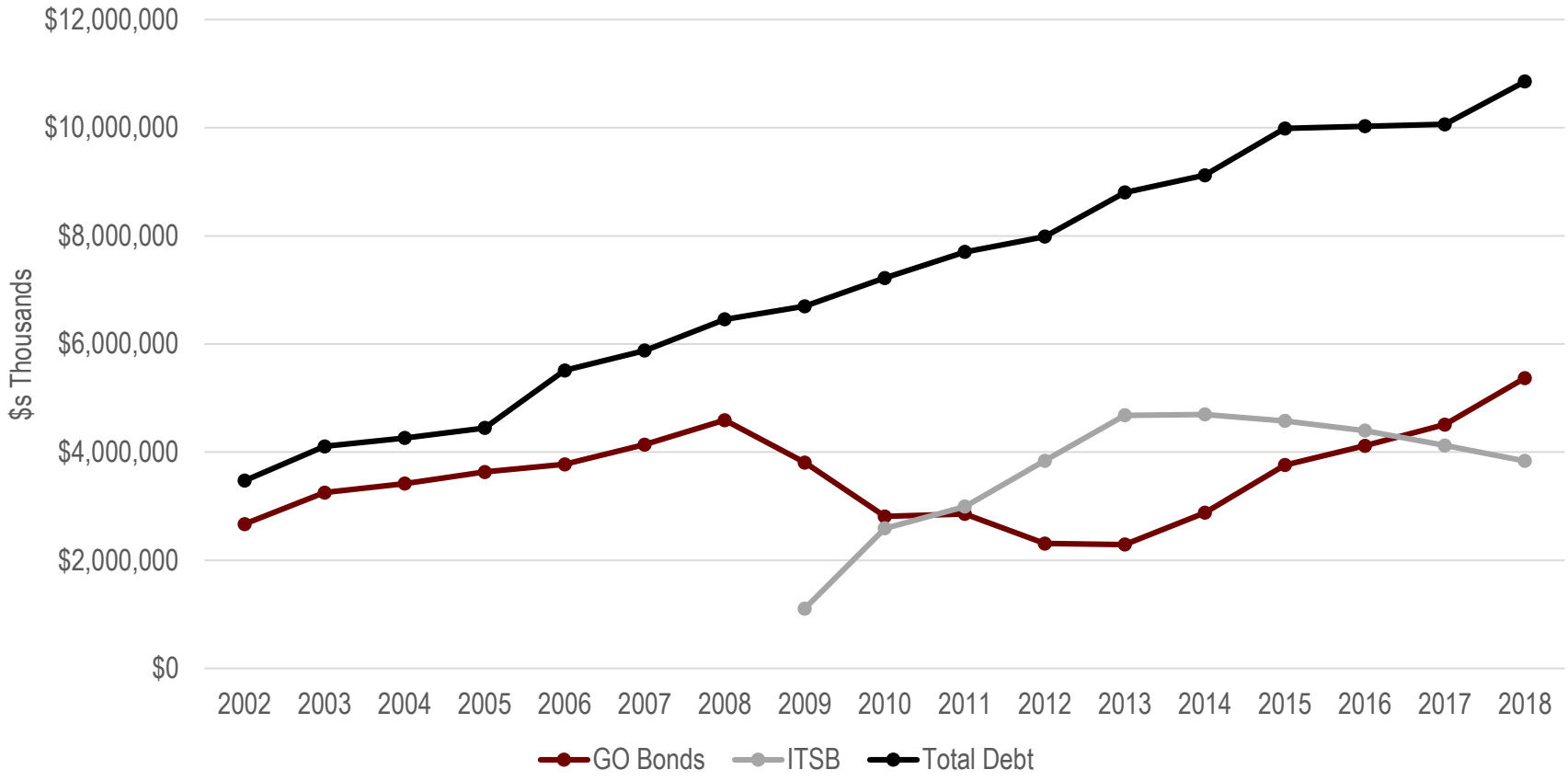
Table 13. Effect of shock half the size of Great Recession on revenue streams

		2019	2020	2021	2022	2023
Income	DEG forecast without shock	$2,724,180	$2,823,192	$2,923,224	$3,026,685	$3,134,847
	DEG forecast with shock	$2,724,180	$2,784,003	$2,882,558	$2,984,489	$3,091,054
	Difference	$0	-$39,189	-$40,667	-$42,195	-$43,793
Property	DEG forecast without shock	$2,770,306	$2,899,277	$3,029,577	$3,164,342	$3,305,233
	DEG forecast with shock	$2,770,306	$2,848,230	$2,976,606	$3,109,380	$3,248,188
	Difference	$0	-$51,046	-$52,971	-$54,963	-$57,044
Sales and excise	DEG forecast without shock	$1,660,975	$1,728,822	$1,797,369	$1,868,264	$1,942,382
	DEG forecast with shock	$1,660,975	$1,701,968	$1,769,502	$1,839,350	$1,912,373
	Difference	$0	-$26,854	-$27,866	-$28,914	-$30,009
Gross receipts	DEG forecast without shock	$366,178	$368,670	$370,258	$372,412	$374,212
	DEG forecast with shock	$366,178	$368,670	$370,258	$372,412	$374,212
	Difference	$0	$0	$0	$0	$0
Other tax	DEG forecast without shock	$522,028	$536,080	$550,132	$564,184	$578,236
	DEG forecast with shock	$522,028	$536,080	$550,132	$564,184	$578,236
	Difference	$0	$0	$0	$0	$0
Nontax, special purpose fund revenue, and lottery	DEG forecast without shock	$925,073	$963,879	$1,003,085	$1,043,634	$1,086,027
	DEG forecast with shock	$925,073	$948,519	$987,146	$1,027,097	$1,068,863
	Difference	$0	-$15,359	-$15,939	-$16,538	-$17,164
Total	DEG forecast without shock	$8,968,741	$9,319,919	$9,673,645	$10,039,521	$10,420,936
	DEG forecast with shock	$8,968,741	$9,187,471	$9,536,202	$9,896,911	$10,272,925
	Difference	$0	-$132,448	-$137,443	-$142,609	-$148,010

Source: DEG estimates based upon Office of the Chief Financial Officer data.

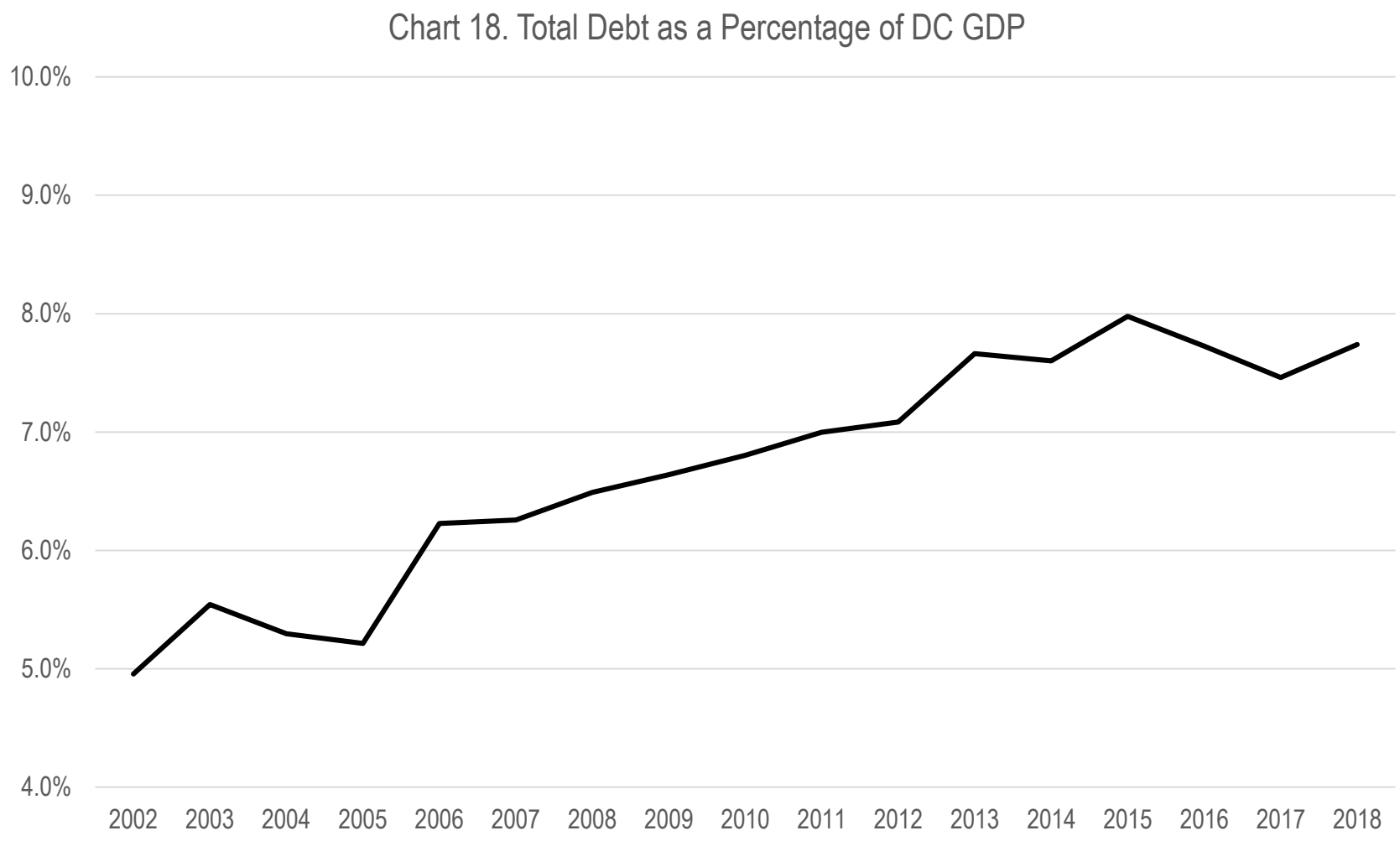
DC Total Debt Outstanding Through 2018

Chart 17. Total Debt Outstanding on GO, ITSB, TIF, QZAB, Ballpark, HPTF, PILOT, GARVEE and Tobacco Bonds (Plus Bond Anticipation Notes, Capital Leases and Certificates of Participation)



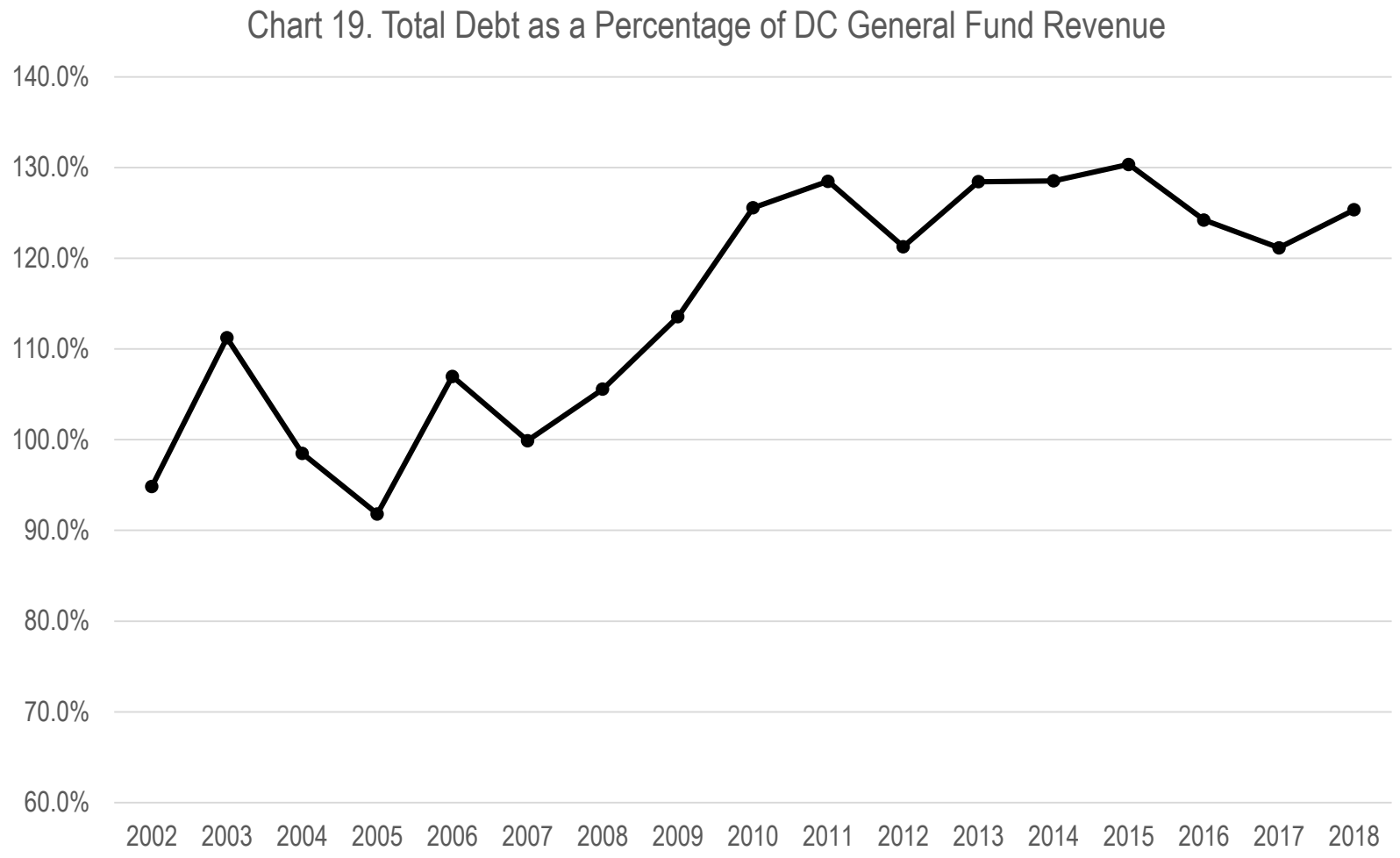
Source: Exhibit S-3C and Table N7-1 from FY 2018 DC CAFR.

Total Debt to DC GDP Ratio



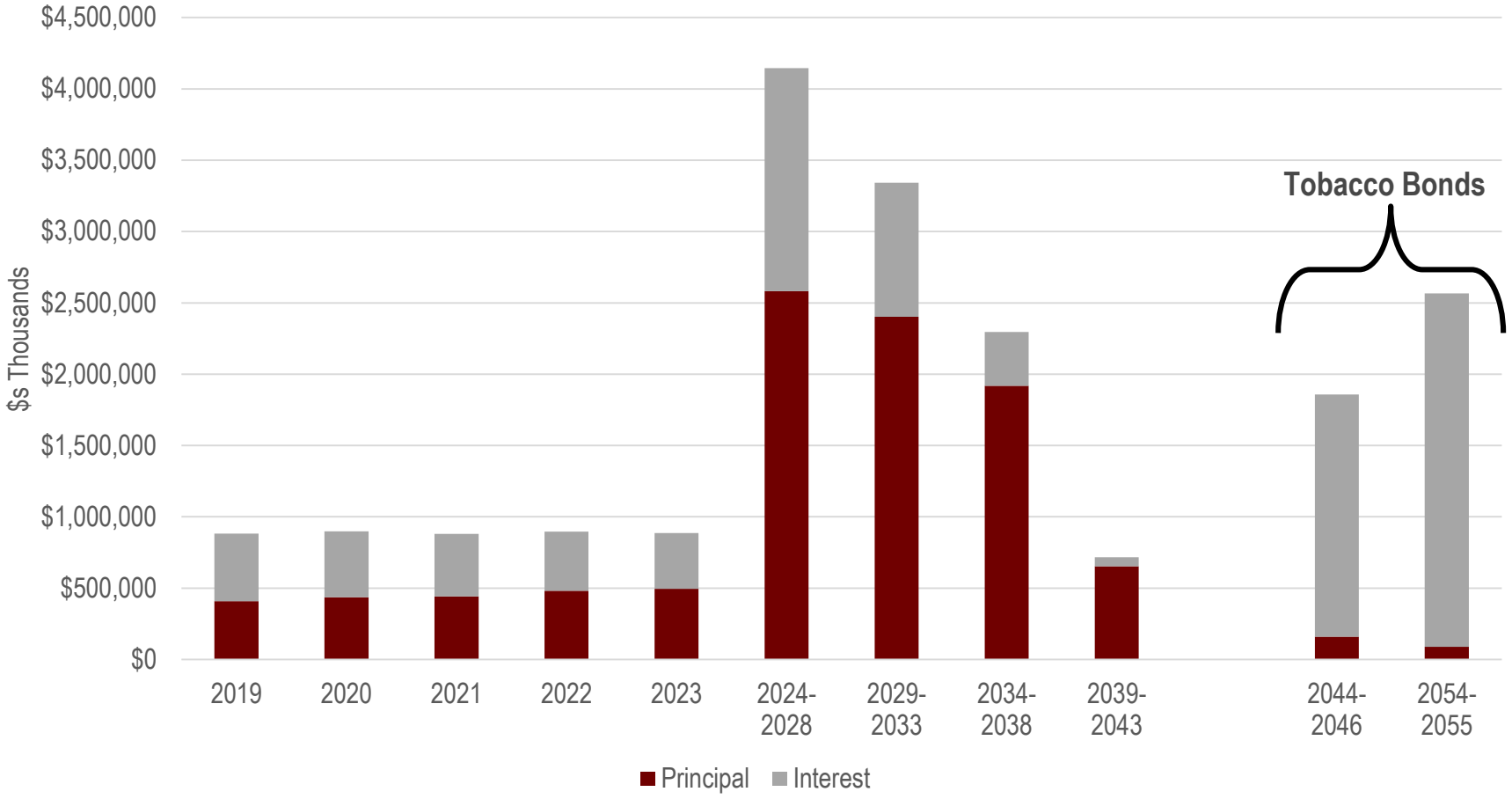
Source: DEG calculations based upon Office of the Chief Financial Officer and Bureau of Economic Analysis data.

Total Debt to DC General Fund Revenue Ratio



DC Principal and Interest Payments Through 2055

Chart 20. Principal and Interest Payments on GO, ITSB, TIF, QZAB, Ballpark, HPTF, PILOT, GARVEE and Tobacco Bonds As of September 30, 2018



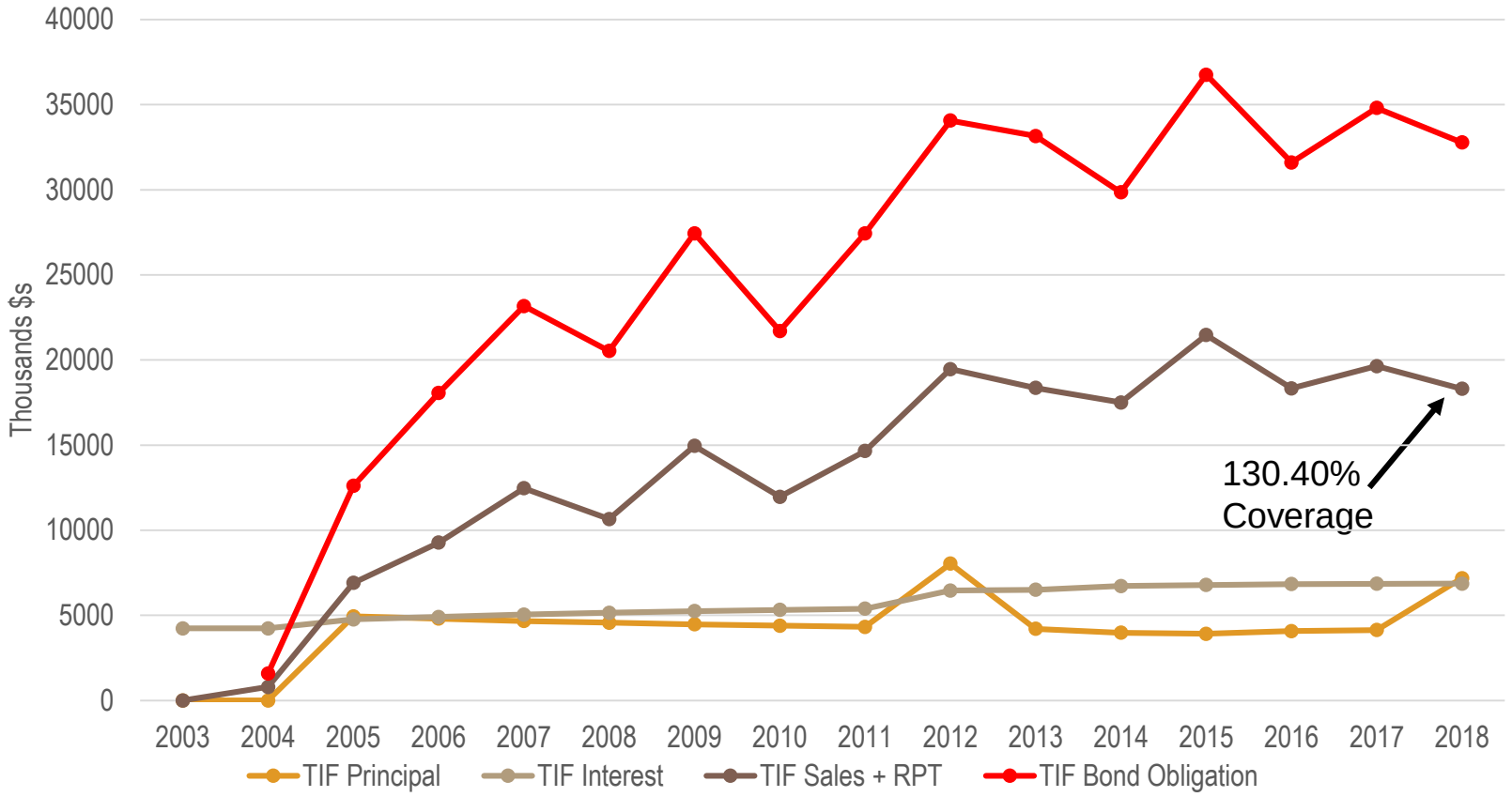
Source: Office of the Chief Financial Officer, Table N7-1 FY 2018 DC CAFR.

Pledged Revenues

- Income Tax Secured Revenue Bonds (ITSB) and Tax Increment Financing Bonds (TIF) use tax revenues for repayment
  - ITSB are secured by and paid solely from the individual income tax and the business franchise tax.
  - TIF bonds pledge future sales tax and real property tax increments
- Bond issuances specify multiples of debt service (principal and interest) to be maintained as coverage, which must be upheld before and after additional debt is issued
  - TIF bond obligation: pledged revenues of 1.5x and 2.0x the outstanding debt service are to be maintained for property tax and sales tax increments, respectively, in each bond year
  - ITSB Additional Bonds Test stipulates that:
    - Maximum Annual Debt Service coverage of outstanding bonds by historical pledged revenues in 12 consecutive months of the prior 15 must equal to at least 2.0x based solely on withholding revenues (also a part of Bond Non-Impairment Covenants)
    - Pledged revenue must be at least 3x Maximum Annual Debt Service

DC TIF Bond Pledged Revenue

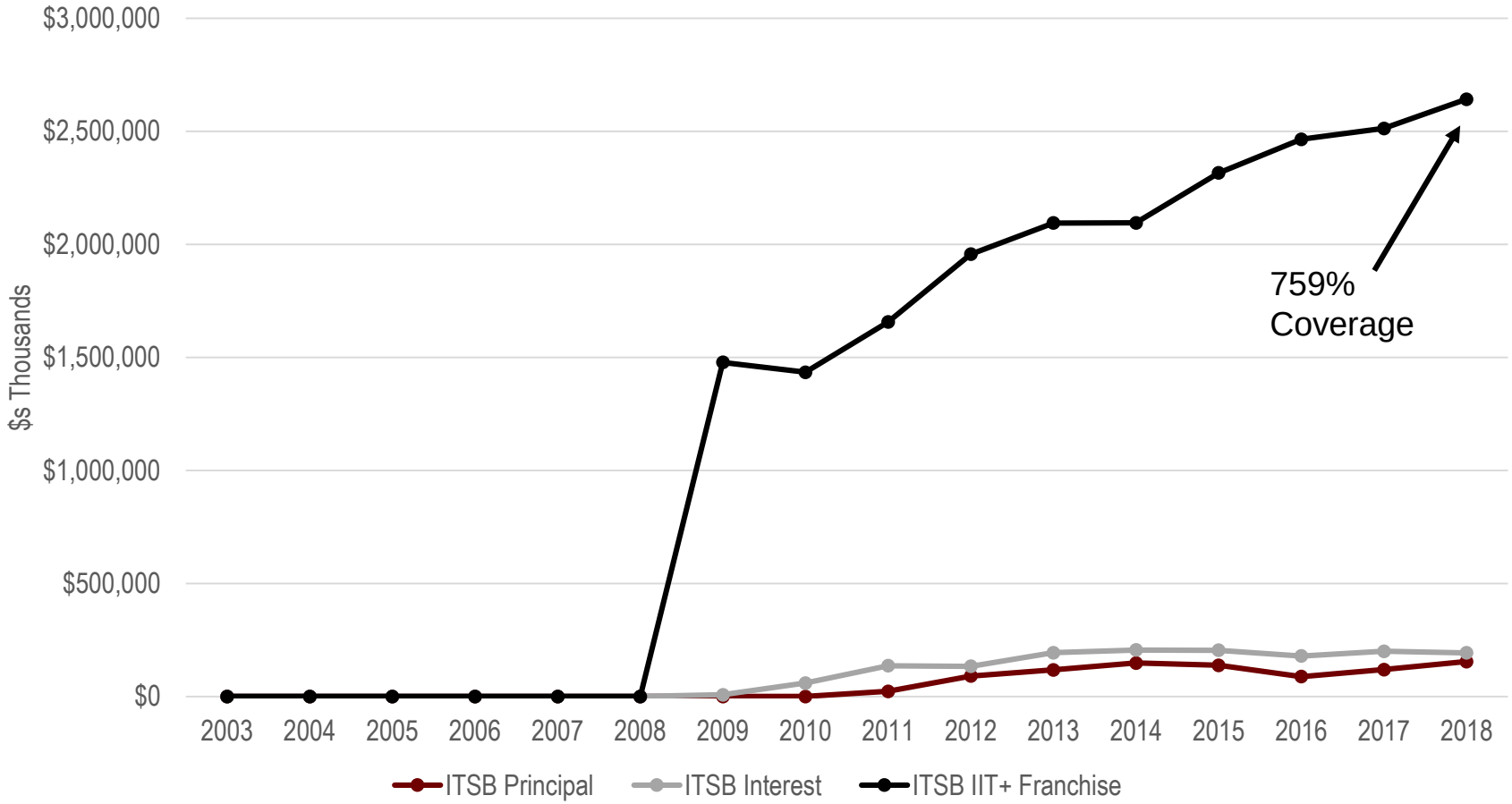
Chart 21. Estimated Bond Obligation Amount and Pledged Real Property (RPT) and Sales Tax Revenues for Tax Increment Financing Bonds (Pledged Revenues are a Small Portion of Total Sales and Property Revenues, DC CFO)



Source: Exhibit S-3B from FY 2018 DC CAFR.

DC ITSB Bond Pledged Revenue

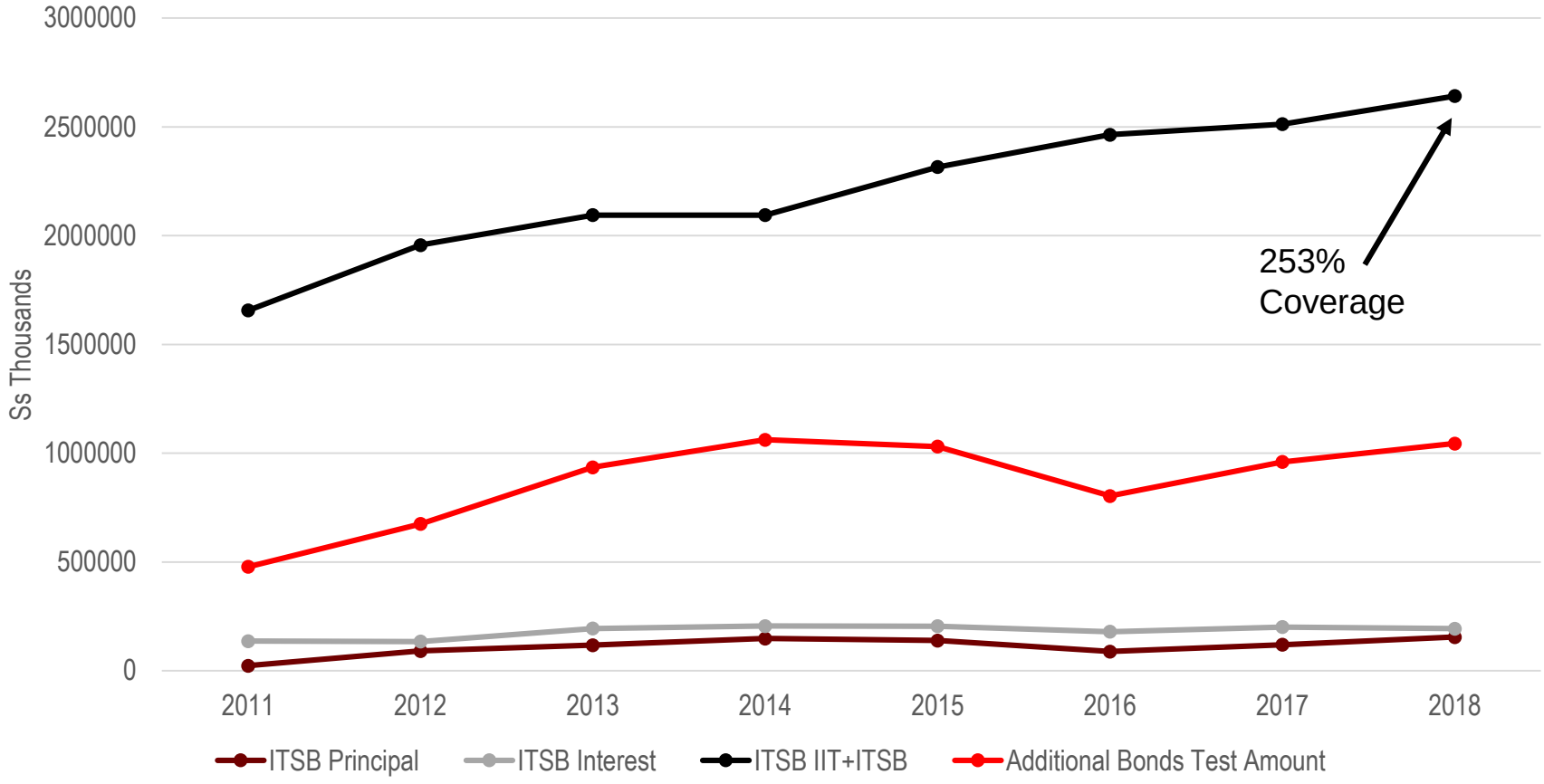
Chart 22. Pledged Income Tax Revenues for Income Tax Secured Revenue Bonds in $ thousands of nominal dollars (**All Income Tax Revenues Pledged**, DC CFO)



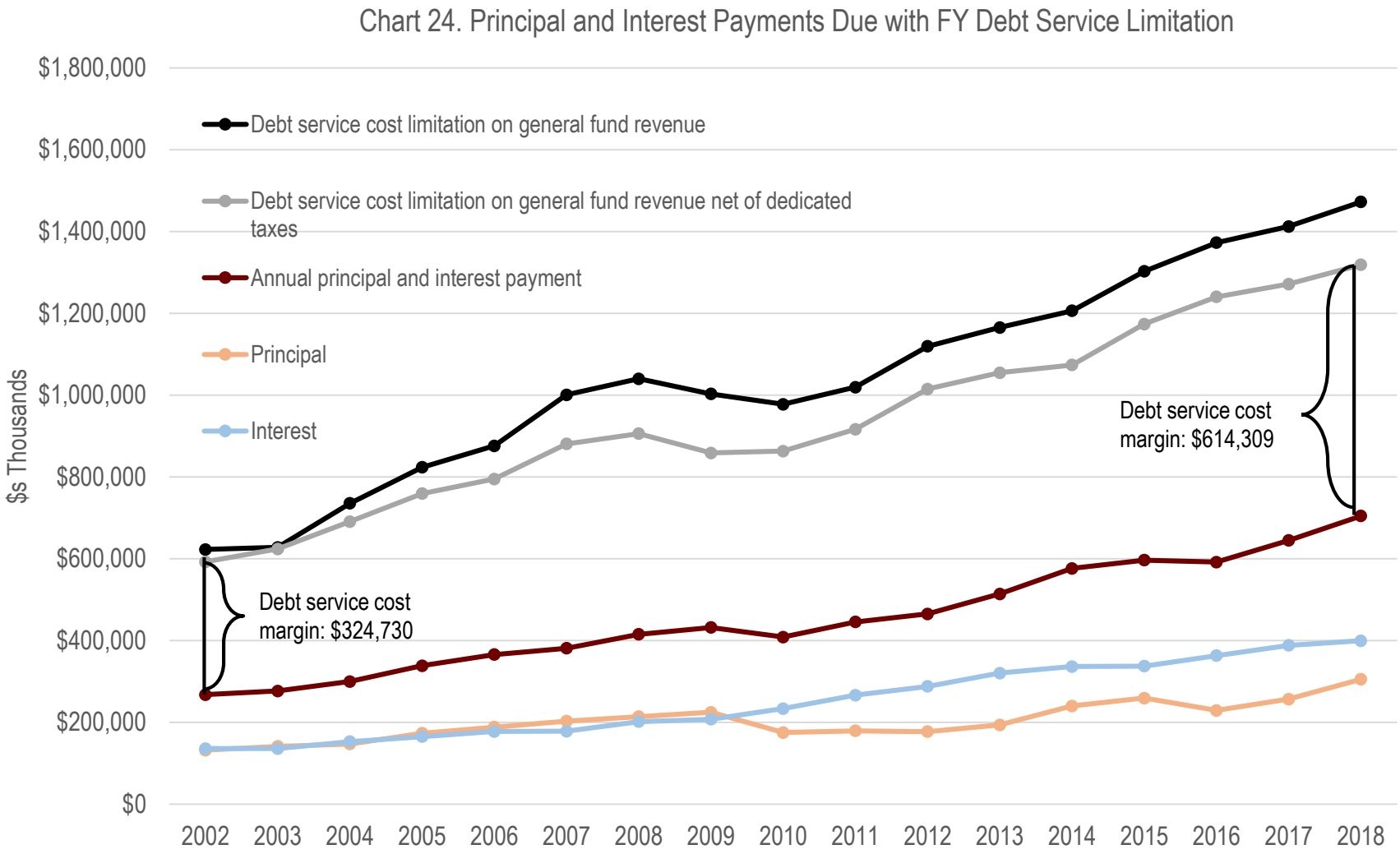
Source: Exhibit S-3B from FY 2018 DC CAFR.

DC ITSB Bond Pledged Revenue

Chart 23. Pledged Income Tax Revenues for Income Tax Secured Revenue Bonds, Estimated Additional Bonds Test Amount, in $ thousands of nominal dollars (**All Income Tax Revenues Pledged**, DC CFO)



DC Auditor Debt Limitation



Source: Exhibit S-3D from FY 2018 DC CAFR.

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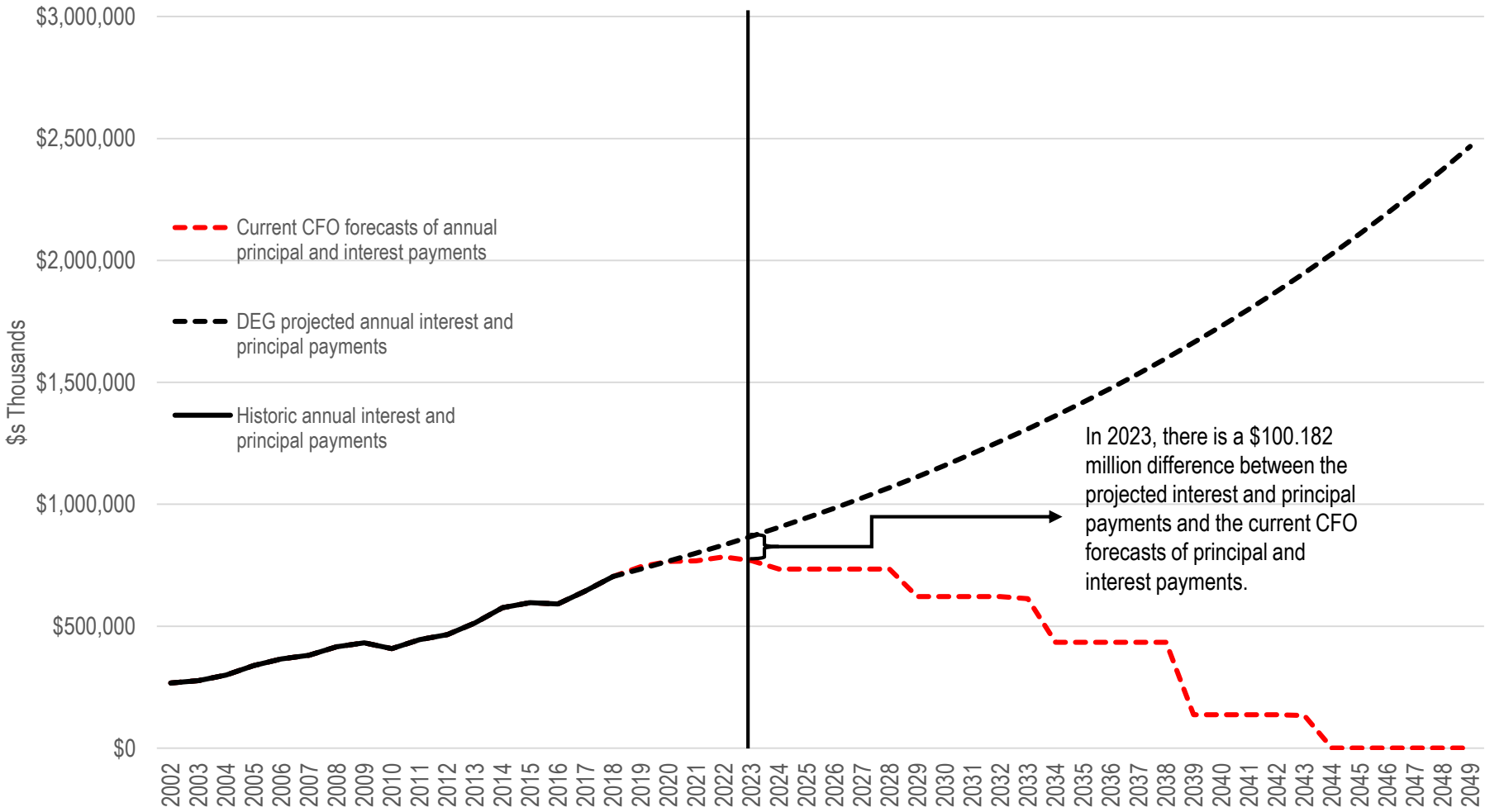
Long-Run Projections of Revenues and Debt

Chart 25. Historical and Projected Annual Principal and Interest Payments Applicable to 17% Debt Limit



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

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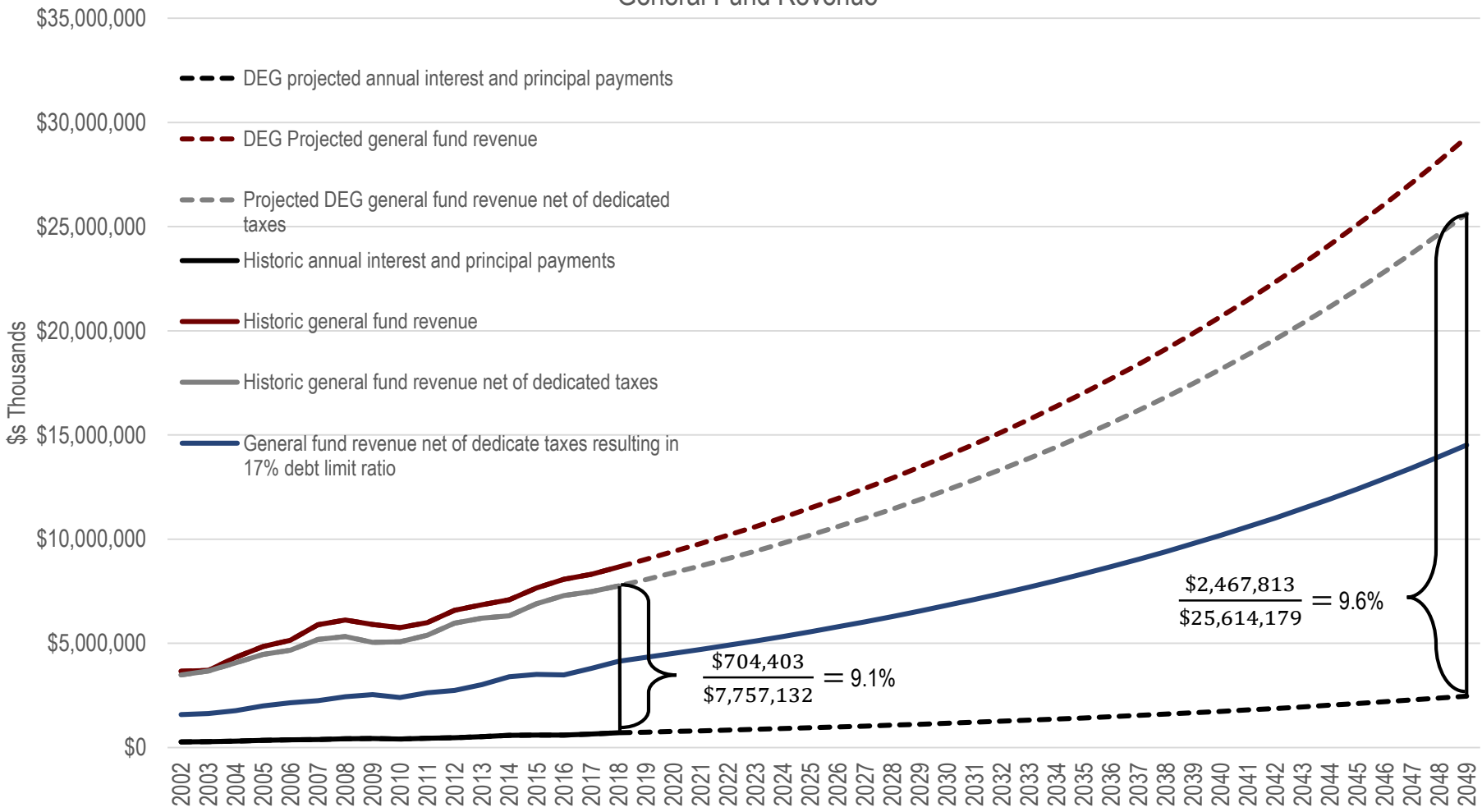
Long-Run Projections of Revenues and Debt

Chart 26. Historic and Projected Annual Principal and Interest Payments Applicable to 17% Debt Limit and General Fund Revenue



Source: Office of the Chief Financial Officer; DEG estimates based upon Office of the Chief Financial Officer data.

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Tables for D.C. Auditor Certifications

Figure 1. FY 2019 Total Local Source, General Fund Revenue Estimate (Net of Dedicated Taxes) DEG Estimate dated September 6, 2019

Revenue Source	DEG 2019 Total Local Source, General Fund Revenue Estimate (Net of Dedicated Taxes)
Property Taxes	$2,718,890
Sales Taxes	$1,124,119
Income Taxes	$2,724,180
Gross Receipts Taxes	$242,110
Other Taxes	$450,118
Total Taxes	$7,259,417
Total Non-Tax and Lottery Revenues	$546,338
Total Local Source, General Fund Revenue Estimate	$7,805,755

Principal and interest from:	2019 Principal and Interest Payments	GO Bond and Income Tax Revenue Bond Debt Service
General Obligation, ITSB, QZAB, Housing Production Trust and 225 Virginia Ave, LLC	$744,462	9.54%
+ PILOT	$762,808	9.77%
+ TIF	$774,616	9.92%

Source: DEG estimates of revenues and CFO estimates of principal and interest payments.

Appendix: Contact information

Michael Udell

Managing Member, District Economics Group, LLC

Office: (202) 408 6235 Cell: (408) 562 6479 michael.udell@districteconomics.com

Diane Lim

Consultant, District Economics Group, LLC

Cell: (703) 470 1357 diane.lim@districteconomics.com

Matthew Fellows

Data Analytics Manager, District Economics Group, LLC

Office: (202) 480 2785 Cell: (603) 233 2189 matthew.fellows@districteconomics.com

Danielle Sockin

Analyst, District Economics Group, LLC

Office: (202) 408 6232 Cell: (845) 709 5361 danielle.sockin@districteconomics.com

About ODCA

The mission of the Office of the District of Columbia Auditor (ODCA) is to support the Council of the District of Columbia by making sound recommendations that improve the effectiveness, efficiency, and accountability of the District government.

To fulfill our mission, we conduct performance audits, non-audit reviews, and revenue certifications. The residents of the District of Columbia are one of our primary customers and we strive to keep the residents of the District of Columbia informed on how their government is operating and how their tax money is being spent.

Office of the District of Columbia Auditor
717 14th Street N.W.
Suite 900
Washington, DC 20005

Call us: 202-727-3600
Email us: odca.mail@dc.gov
Tweet us: https://twitter.com/ODCA_DC
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