Forecasting foregone uranium severance tax revenue

[Redacted]

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Forecast purpose

In July of 2020, the Wyoming legislature passed a bill to lower severance taxes on exported uranium. This was done to help the ailing Wyoming industry, but at what cost to the budget? The goal of this forecast is to consider the losses for the state of Wyoming, given the new policy, in effect until December 31, 2026.

Uranium is predominantly used to generate electricity in nuclear reactors. First, I forecast the world price of uranium, taking into consideration the domestic production of electricity from nuclear sources. Using those projections, I model a simple price-taking firm using Wyoming's known mining capacity as limits on how much the firm may produce. The estimated budget losses are projected through 2026.

Methodology and model

Estimated loss for the fiscal years 2020-2022 to the state's general fund and budgetary reserve account are $500,000 and $1,000,000, respectively (Richards; 2019). The new taxation policy in bill SF0085 continues until Dec 31, 2026, whereafter all uranium severance taxes will be 4% *SF0085 - Uranium taxation rates* (2020). The graduated severance tax rates are given in table 1.

Table 1: Uranium severance tax rates

Price/pound	Tax rate
Less than $30.00	0%
$30.00 to $36.67	1%
$36.68 to $43.34	2%
$43.35 to $50.00	3%
$50.01 to $60.00	4%
$60.01 or more	5%

A loss of $1.5 million over two years at a 4% rate equals about $37.5 million in statewide uranium revenue over those two years, or about $1.56 million in revenue per month. At the average price for that period, we can deduce a total anticipated production of around 1.6 million pounds, or around 67,000 pounds per month.

An estimate from 2015 places the cost to mine one pound of uranium (including taxes, in 2015 US$) in Wyoming at $31.26 (WNN; 2015). For the modeling component, this number is adjusted into 2021 US$ (and taken pre-tax), and used to represent the number below which the firm will produce zero pounds of uranium. State production has a combined annual capacity of 7.5 million pounds and another two uranium mines on standby with a shared annual capacity of 1.675 million pounds (EIA; 2021a). I will assume that the firm has access to only the 7.5 million annual-pound capacity. The firm faces convex costs and can produce between zero and 7.5 million pounds per year, or 625,000 pounds per month.

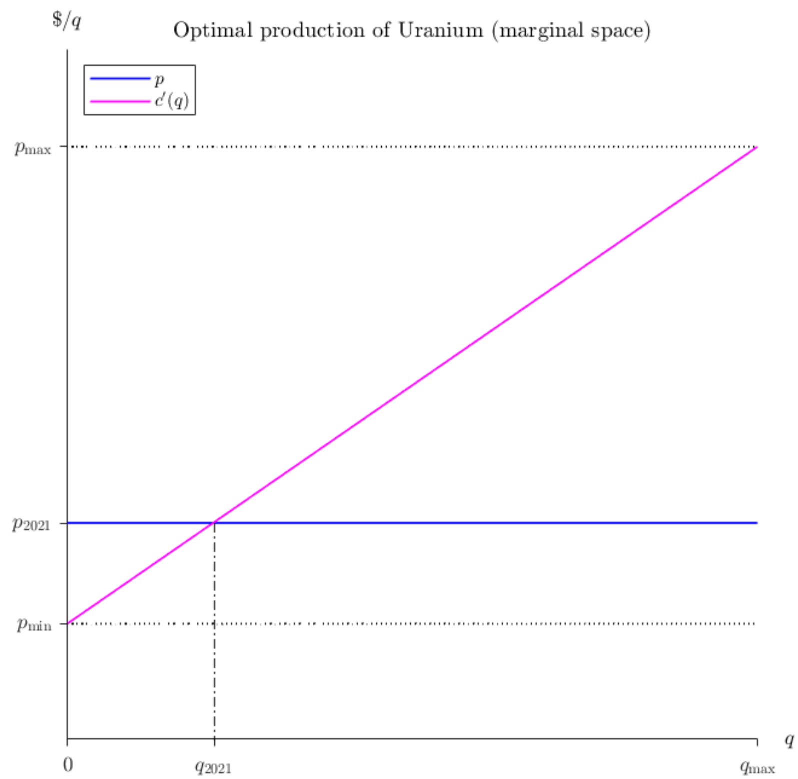

Figure 1: Price-taking firm choosing where to produce (graph shown in marginal space).

Reiterating the assumptions about the firm below, I use

$$\pi = pq - c(q),$$

where c is a standard convex cost function:

$$c'(q) > 0,$$

$$c''(q) > 0.$$

The firm is an optimizer, and quantity q is chosen to satisfy

$$\frac{\partial \pi}{\partial q} = p - c'(q) = 0.$$

Using the previously mentioned values to calibrate the model, the firm will produce

$$q = \frac{p - 26}{3.3 \times 10^{-6}}$$

pounds of uranium, given the market price p.

The goal of this forecast is to consider the losses for the state of Wyoming, given the new policy. The new taxation policy in bill SF0085 continues until Jan 1, 2026, whereafter all uranium severance taxes will be 4% *SF0085 - Uranium taxation rates* (2020).

To predict budgetary shortfalls requires prediction of the price of uranium through the period where the new legislative mandate applies, through the end of 2026. I use a dataset that describes the monthly global price of uranium from 1990 to 2021, taken from FRED (FRED; 2021b). This data is shown in figure 2. Uranium price was converted from nominal to real (2021) by using the monthly CPI, also from FRED (FRED; 2021a). Included in the analysis is domestic electricity generated by nuclear fuel in gigawatt hours (GWh) taken from the EIA (EIA; 2021b).

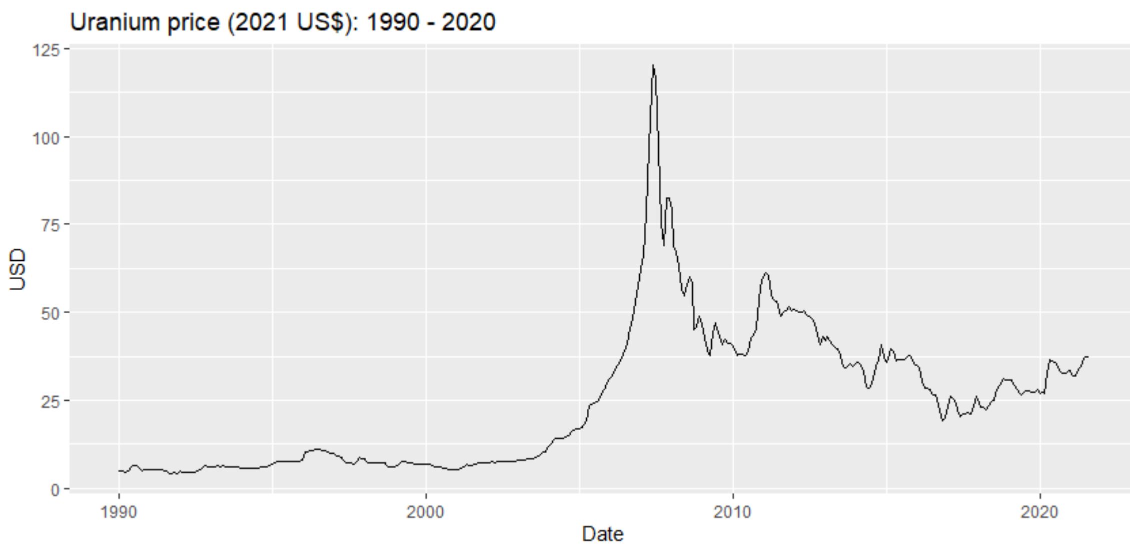

Figure 2: uranium price in 2021 US$ (1990-2021).

Table 2: Nuclear-generated electricity summary

Metric	GWh
Min	38516
25%	57072
Median	62947
Mean	62007
75%	68108
Max	74649

I use an ARIMA model to forecast the next 64 months of electricity generated from nuclear energy. There are seasonal fluctuations which can affect demand, and therefore market price. The best fitting model is an ARIMA(0,1,4)(0,1,1)$_{12}$. In backshift notation, this is

$$(1 - B)(1 - B^{12})y_t = (1 + \theta_1 B + \theta_2 B^2 + \theta_3 B^3 + \theta_4 B^4)(1 - \Theta_1 B^{12})\varepsilon_t,$$

and the forecast values are given in orange, as seen in figure 3.

The next step is to use a dynamic ARIMA model to predict uranium price, while accounting for future nuclear electricity production. Figure 4 shows the projected price of uranium,

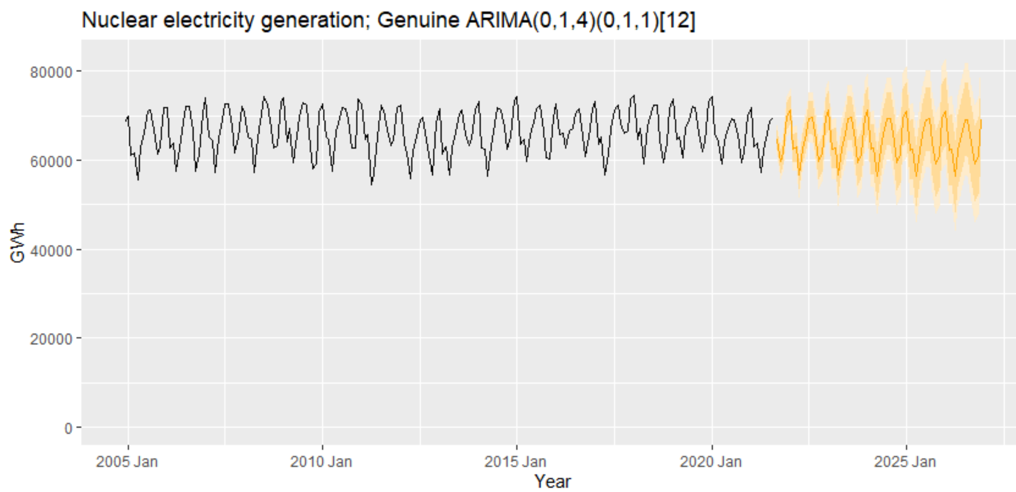

Figure 3: Historical domestic electricity generated from nuclear power. The orange represents the forecast values of electricity production required to forecast the uranium price.

which shows seasonality. The best-fitting model is ARIMA(1,0,2)$(2,1,0)_{12}$. In backshift notation, the ARIMA errors are given by

$$(1 - \phi_1 B)(1 - B^{12})(1 - \Phi_1 B^{12} - \Phi_2 B^{24})\eta_t = (1 + \theta_1 B + \theta_2 B^2)\varepsilon_t.$$

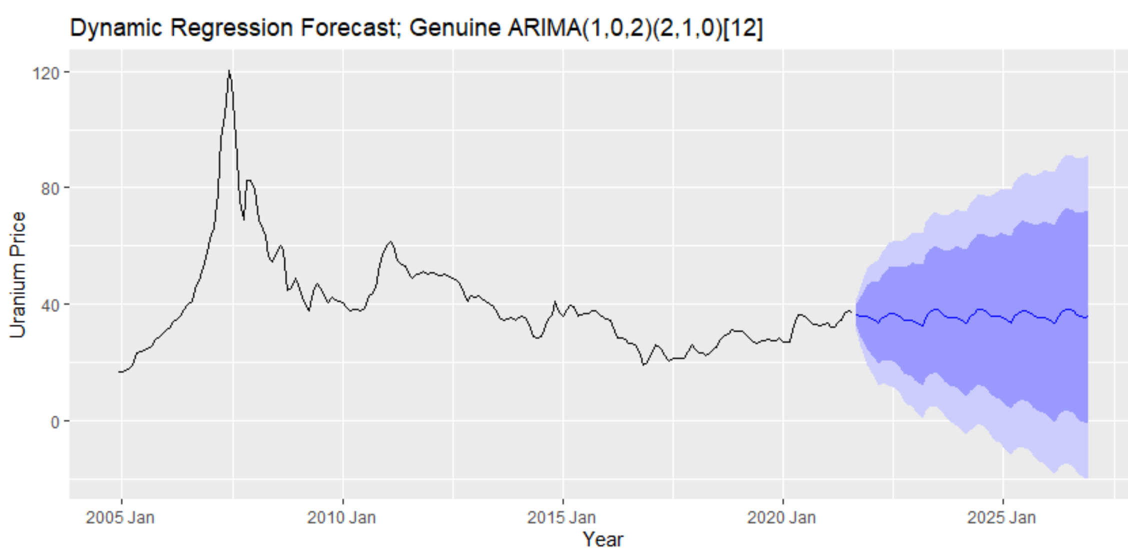

Figure 4: Forecast uranium price, used to determine quantity produced and severance tax applied.

Results

Using the forecasted values of uranium price, we can estimate expected severance tax revenues. We know the firm's optimal production choice q for any given price p, and can therefore calculate the tax collected per month. Moreover, if the counterfactual world is one where there would have been a flat 4% severance tax, we can also construct a measure of budgetary shortfall. Interestingly, the seasonality in the projected uranium price causes the severance tax rate under the new proposal to oscillate between 1% and 2%. The monthly budgetary shortfall is given in figure 5 (and assumes the new schedule of severance taxes is marginal). The total cumulative budgetary shortfall expected from the final data-point at August 2021 through December 2026 is roughly \$5.7 million.

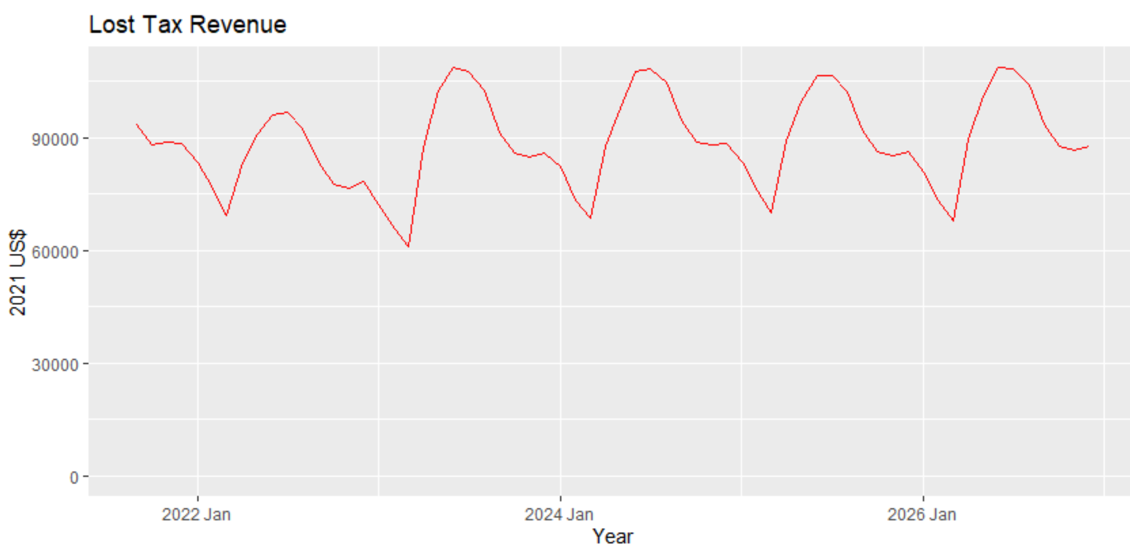

Figure 5: Monthly foregone tax revenue under the new severance tax schedule.

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