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Dichotomous Choice between a Hybrid and an all-Electric Car: A Capital Budgeting Analysis

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Abstract

In the financial pathway to a sustainable economy, the dichotomous choice between a hybrid car and an all-electric car is an inevitable transitional step. We first use the Toyota Prius and the Nissan Leaf to conduct capital-budgeting base-case analyses using the various traditional techniques. We next delve deeper into the decision-making process by conducting a sensitivity analysis on pairs of variables that have policy implications.

The case

The financial pathway to green manifests itself as a dichotomous and mutually-exclusive choice between a hybrid car which entails fossil fuel directly and an all-electric car which doesn't. This exercise frames the decision-making process into a typical mutually-exclusive capital budgeting analysis. We choose Toyota Prius as the hybrid and the Nissan Leaf as the all-electric car.

In August 2015, a Toyota Prius lists at $26,985 as its manufacturer suggested retail price. The corresponding retail price for the Nissan Leaf lists at $29,010.

The Prius has a city-highway combined efficiency of 50 miles per gallon. For the base-case analysis, let's assume a gas price at $3.00 per gallon. This will result in a mileage efficiency of 6 ¢/mile.

The Leaf has an efficiency of 5.4 miles/kWh.[1] For base-case analysis, let's assume electricity supply at a price of 12 ¢/kWh. This will result in a mileage efficiency of 2.2222 ¢/mile.[2]

For simplicity of analysis, let's assume the a driver who needs to drive 12,000 miles a year or 1,000 miles a month for work, school, and other transportation needs. Let's further assume the driver faces an auto loan's interest rate of 3% per year or .25% per month.

To do: We first perform a base-case analysis using the data provided or assumed so far.

Q1: Calculate the monthly cash flows for purchasing and operating the Prius for 10 years.

Q2: Calculate the monthly cash flows for purchasing and operating the Leaf for 10 years.

Q3: From the monthly cash flows in the previous two questions, derive the *incremental* cash flows of purchasing the more expensive Leaf over the less-expensive Prius for 10 years.

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1 We obtain the 5.4 miles per kWh statistic from http://insideevs.com/long-term-nissan-leaf-mileageusage-review-once-around-the-sun/.

2 The 2.2222 cents per mile number is consistent with Sharon Terlep's article in *The Wall Street Journal*, August 12, 2009, where she reported the Chevrolet Volt's lithium-ion battery pack can deliver a range of 40 miles before it needs recharging at 88 cents per charge. The Leaf has a range of 84 miles per full charge. We did not choose the Volt because the Volt is not an all-electric car with its fossil-fuel internal combustion engine backup propulsion.

Q4: From the incremental cash flows established in Q3 above, find the following capital-budgeting measures.

i. undiscounted payback in years;
ii. discounted payback in years;
iii. net present value, NPV, in $;
iv. internal rate of return, IRR, in %
v. profitability index
vi. modified internal rate of return, MIRR, in %. Use reinvestment rate of 1% per annum or .08333% per month.

Next, we perform 2-variable sensitivity analyses over ranges of plausible values for the two variables by calculating the discount payback which is simply the number of years it entails to breakeven the extra $2,025 upfront payment for the all-electric Nissan Leaf. For the Prius, we choose gas price as the variable for a range of 2.00 $/gallon to 6.00 $/gallon over a 50-¢ increment. For the Leaf, we choose three variables, namely the interest rate from 0% to 6% per year, electric supply rate from 8 ¢/kWh to 16 ¢/kWh, and tax credit for buying the electric car from $0 (the base-case analysis above) to $2,000 at $500 increment. Beware of the #NUM! output when applying the Excel's Data, What-if Analysis, Data Table mode. They are not spurious output but do have their own significant economic interpretation. Those who need help with the Data Table function in Excel, please refer to the Appendix where a similar numerical example was presented as an illustration.

We expect three output tables as follow:

		Gas price, $/gallon								
		2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
Interest rate, % p.a.	0									
	1									
	2									
	3									
	4									
	5									
	6									

Table 1: Discounted payback, in years, of an all-electric Leaf over the hybrid Prius at various gas prices and various auto loan interest rates.

		Gas price, $/gallon								
		2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
Electricity rate, ¢/kWh	8									
	9									
	10									
	11									
	12									
	13									
	14									
	15									
	16									

Table 2: Discounted payback, in years, of an all-electric Leaf over the hybrid Prius at various gas prices and various electricity supply charge rates.

		Gas price, $/gallon								
		2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
Tax credit for electric car, $	0									
	500									
	1500									
	2000									
	2025									

Table 3: Discounted payback, in years of an all-electric Leaf over the hybrid Prius at various gas prices and various tax credit levels.

Q5: What does the output #NUM! mean financially in Table 1 if you change the price spread from $2,025 to $4,000? Use numbers to justify your answer.

Now, change the price spread back to $2,025 before answer the following questions.

Q6: From Table 1, make two *ceteris paribus* statements on the discounted payback on each variable. Then, make another combined statement on discounted payback's trend based on both variables.

Q7: From Table 2, make two ceteris paribus statements on the discounted payback on each variable. Then, make another combined statement on discounted payback's trend based on both variables.

Q8: From Table 3, make two ceteris paribus statements on the discounted payback on each variable. Then, make another combined statement on discounted payback's trend based on both variables.

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Appendix

We illustrate the use of Excel's Data Table function to generate a 2-variable sensitivity analysis for a saver who plans to amass $1million by depositing $x monthly into an account that earns y% per year. We let x assume the domain values of 250, 500, 750, and 1,000. We let y take the domain values of 3%, 6%, 9%, and 12% per year.

	A	B	C	D	E	F	G	H
1	FV	1000000		40.065	0.03	0.06	0.09	0.12
2	Mthly deposit, x, in $	500		250	80.030	50.869	38.298	31.101
3	Ann int rate, y, in %	0.06		500	59.800	40.065	30.922	25.498
4	Years needed for $1m	40.065		750	48.939	34.033	26.743	22.299
5				1000	41.811	29.937	23.868	20.082

Entries in Excel spreadsheet are:

All contents in column A, cells B1 through B3, E1 through H1, and D2 through D5 are manually input. In cell B4, enter **=nper(B3/12,-B2,0,B1,0)/12**. In cell D1, enter **=B4**. Next, we **select cells D1 through H5** which are now highlighted. Next, we click the "**Data**" tab on top row of the spreadsheet, followed by "**What-if Analysis**," and "**Data Table**" sequentially. This will cause a window to pop up where we will enter **B3** for "Row input cell," and **B2** for "Column input cell." Clicking the **Ok** icon in the pop-up window will yield all the outputs in cells E2 through H5. These are the results for the number of years the saver needs to amass $1m at the corresponding interest rate and monthly deposit. For example, at 6% per year, and 500 $/month deposit, the saver needs 40.065 years to amass $1m. Using the Texas Instruments BA II Plus Professional financial calculator for verification, we'll enter I/Y = 6/12 = .5; PMT = -500; FV=1,000,000; CPT N = 480.777 months = 40.065 years which is exactly the answer in cells B4, D1 and F3.