Abstract

Diesel fuel is a major expense for most farmers. Diesel fuel prices do exhibit some seasonality so farmers can try to lower their fuel expenses by buying their fuel in months when prices are lower. However, purchasing fuel before it is needed results in a carrying charge to the farmer. This paper examines the optimal purchase month for diesel fuel for both spring planting and fall harvest. Both risk neutral and risk-averse farmers are considered. Higher interest rates discourage advance purchasing, but in many cases farmers would be better served by purchasing diesel in advance of use.

Seasonality of Diesel Fuel Prices

By Gregory Ibendahl

Introduction

Fuel purchases are a major expense item for all farmers. According to USDA-NASS, fuel expenses amounted to $12.3 billion in 2009. This was down from $16 billion in 2008. Fuel, as a percent of total expenses, was 5.2 percent and 4.3 percent in 2008 and 2009 respectively. Over half of the fuel expense is for diesel fuel.

To a degree, farmers can reduce the amount of fuel they use by controlling the number of trips across the field and by the technology used to grow the crop. As shown by Cleveland (1995), farmers have responded to shocks in fuel prices. In particular, the oil price increases in the mid-1970s caused farmers to become more energy efficient. However, this response is more of a long-term answer, since developing and adopting new technologies takes time. Even now, farmers are somewhat limited in what they can do as any crop production requires several trips across a field to plant and harvest.

Farmers are also limited in their ability to control diesel fuel prices. In certain instances, a farmer can get a small break in price by buying in a large enough volume. However, for the most part, farmers are price takers in regard to fuel prices.

Despite these limitations on controlling fuel expenses (at least in the short-run), farmers do have some ability to lower their fuel costs by timing when they make the fuel purchases. Diesel fuel prices exhibit some degree of seasonality which result in the diesel fuel price being lower in some months relative to other months. However, purchasing fuel before it is needed results in an interest or carrying charge for the time the fuel has been purchased but not yet used. In addition, price variability is not the same across months so a risk-adverse farmer might have preferences for purchasing fuel in certain months.

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The purpose of this study is to determine the optimal months for farmers to purchase their diesel fuel for spring planting and fall harvest by examining the seasonality in diesel fuel prices. The study assumes an interest charge for any months the fuel is purchased but not used. In addition, the study examines the variability in monthly fuel prices to determine how risk adverse producers would make fuel purchase decisions.

Data and approach

Data for this analysis comes from Energy Information Administration (EIA). The EIA has collected monthly and weekly data on oil, natural gas, gasoline, and diesel fuel for decades. The monthly series goes back to at least 1973. Their price series includes different formulations and also different regions. For this analysis, the diesel series EMD_EPD2D_PTE_NUS_DPG from 1996 through 2010 was used (15 years). The same diesel series from 1980 through 2010 was also examined for comparison. This diesel series is the monthly price of U.S. No. 2 Diesel Retail Sales by All Sellers (dollars per gallon). This data set of nominal values was then adjusted by the CPI-U index to produce a set of real values. All values were adjusted relative to December 2010 so the effect of the inflation adjustment was to raise the price of older values. Figure 1 shows the nominal and inflation-adjusted diesel prices since 1980.

Thought data from the EIA is for highway prices this did not affect the analysis for farmers. Farmers do not have to pay road taxes for their fuel but this is just a fixed amount lower than the EIA price. While Figure 1 shows diesel prices in highway prices, the analysis was conducted using average farm prices (51.4 cents lower when combining federal and average state taxes).

The second analysis step was to calculate the price seasonality. This was accomplished by running a regression with 11 dummy variables for the months February through December. January was thus the base month with the dummy variables representing a price difference relative to January.

The seasonality results are shown in Figure 2. This figure includes data for the last 15 years and also for the last 31 years. As this figure shows, diesel fuel is cheapest in January and February and the most expensive in October. Notice that this trend holds for the most recent data as well as the longer-term data series. The main difference between the shorter and longer-term series is the amount of variability. The longer-term series varies at most 10 cents from January while the shorter-term series varies up to 25 cents from January. Otherwise, the shapes of the bar graphs are similar. Diesel fuel prices tend to have two peaks, one in the spring around May and another in the fall around October. From a farmer's perspective, these are bad times to have a price spike as fuel usage is likely to be greatest at those times during spring planting and fall harvest. Thus, if farmers buy their fuel on an as-needed basis, they will likely pay more than they need to in order to cover their fuel needs. Conversely, buying fuel during other periods of the year means a farmer has an interest charge from committing funds to an expense before it is actually needed.

Results

No risk

The next step in determining the optimal month to purchase diesel fuel is to ignore price variability and just examine expected costs. In this risk neutral perspective, two cases are examined. The first applies a one percent per month interest or carrying charge for the months the fuel has been purchased but not actually used (12% annual interest rate). The second case applies a one-half percent per month charge for not using the fuel (6% annual interest rate). In both of these cases a spring use and a fall use are considered. The spring use of fuel for planting was assumed to be the month of April while the fall use of fuel for harvest was assumed to be the month of October.

It is assumed that farmers have either the storage capacity or the ability to pre-pay for fuel. On-farm storage would require the ability to store the entire amount needed for either spring or fall use. Storage of diesel fuel for up to six months should not present a fuel quality problem for most farms. Pre-paying for fuel is assumed to allow farmers to pay for fuel at the price when purchased but delay delivery until needed.

With either scenario, on-farm storage or pre-paying, a farmer is committing money to an expense before it is actually needed. Thus, there should be a carrying charge for tying up a farmer's money when the funds could be used elsewhere. This is the rationale for including a carrying charge in the analysis.

These carrying or interest charges for buying and not using fuel make buying fuel ahead of time a potentially expensive proposition. Without these charges though, farmers would always pay for all of their fuel in January (or possibly February in a longer term analysis) as this is historically the cheapest month for diesel prices. The higher the interest charge, the more likely farmers are to purchase their fuel at the time it is needed.

Table 1 lists the expected fuel costs for purchasing diesel fuel in each month for both spring planting (April use) and fall harvest (October use). The table is divided into three sections. The top section has no interest charge for buying fuel ahead of time. This section would thus be comparable to Figure 2. As discussed above, with no penalty for buying fuel before it is needed, farmers would pre-pay for all their fuel use in the upcoming year in January. The middle section lists the expected costs when there is a half-percent interest charge per month for prepaying for fuel. The bottom section lists the expected costs when there is a one percent interest charge per month for pre-paying for fuel.

With a half-percent interest rate, a purchase in January is the still the ideal purchase month for April use and also October use. However, purchasing fuel from January through April for fall use would present some problems in regards to fuel quality and also the ability to store both the requirements for spring and fall use together. In other words, purchasing too far in advance means a farmer would need nearly twice the storage capacity than when trying to store only a single season's fuel use. If we assume that fall fuel use cannot be purchased until the spring requirements are completed (April), then May would be optimal for purchase. With a one-percent interest rate, a purchase in February is the most ideal month for April and October use. If fall fuel use cannot be purchased until after April then fuel should be purchased in October.

Table 2 presents the extra costs when fuel is purchased outside of the least expensive month. As in Table 1, either a one-half or a one-percent charge is added to each month of carry. As in Table 1, there is no risk included. Notice that the penalties for purchasing outside of the ideal month for the spring are much more severe than the fall situation. In fact, purchasing fall fuel during the months April through October are relatively the same from an average cost perspective.

Risk

The previous analysis assumed that farmers were risk neutral and did not care about risk. In other words, the month that had the lowest expect cost would be optimal for them. Most individuals are risk averse however, so variability in prices would be a concern.

To model risk-averse producers, a negative exponential utility function is assumed for the producers and the Stochastic Efficiency with Respect to a Function (SERF) from Simetar is used to graph the results. The SERF method is a procedure for ranking risky alternatives based on their certainty equivalents (CE) for alternative absolute risk aversion coefficients (ARACs). The CEs for the various fuel purchase months are calculated and the results are presented in Figures 3 through 7.

Certainty equivalents (CE) are a fancy way of comparing a sure thing to something involving outcomes that are not certain. The CE represents what an individual would pay or would give up to avoid the risk. An example of this is auto insurance. A policy holder pays a fixed amount in premiums each year to have the insurance company pay out should an accident occur. Insurance companies can make money because the average cost of accidents is less than the amount of premiums paid. This difference between the expected cost of an accident and the premium is the CE (assuming the premium is the most the policy holder is willing to pay for insurance).

In each of the figures, the horizontal axis represents the degree of risk aversion. Moving further to the right means a farmer becomes more and more risk averse. While at the left hand side, where the ARAC is zero, represents a risk neutral producer. The vertical axis represents the CE in cents. The lines in the figures display the CE for the selected months at each level of risk aversion. The confidence premium (or conviction level) with which a decision maker would prefer one alternative (e.g., month to purchase fuel) over another is visually displayed in the four figures as the vertical distance between the CE lines at each level of risk.

In each of the figures, the CE is relative to a base month – the month the fuel is actually needed (either planting or harvest). Thus, Figure 3 represents the loss of utility (the certainty equivalent) relative to purchasing in April while Figure 4 represents the loss of utility relative to purchasing in October. Figures 3 and 4 are when a one percent carrying charge for pre-paying fuel is in place. Figures 5 and 6 are comparable to Figures 3 and 4 except the interest charge is lower at one-half percent per month.

A lower vertical position in the figures is better as these figures are representing the risk premium (cost as a certainty equivalent) relative to the base month. Thus points below the center horizontal line have a lower cost relative to the base month. The lower the vertical position, the bigger the savings relative to the base month. In Figure 3, a risk neutral producer would purchase in January or February when interest charges were one percent as the risk premium is lowest. This was also confirmed in the table with the lowest expected cost without risk.

Moving further to the right in Figure 3, March starts to become a better choice for fuel purchase as the producer becomes more risk adverse. This occurs about a quarter way across the figure. Eventually, December becomes the preferred purchase month when producers become very risk averse.

Figure 4 assumes that the earliest fuel can be purchased for fall is June. Otherwise, risk neutral producers would purchase earlier. In Figure 4 for fall harvest and a one percent interest rate, a risk neutral producer would purchase fuel in October right at harvest as the risk premium is lowest at the point where ARAC is zero. Quickly though, July becomes a better purchase month when the producer becomes only a little bit risk averse. With a little more risk aversion, August becomes the best month to purchase fuel.

Figures 5 and 6 represent the analysis when the interest charge is one-half percent per month. In Figure 5 for April fuel use, a risk neutral producer would purchase fuel in January or February. However, as the degree of risk aversion increases, March becomes a better month for purchasing. About half way across the figure, December again becomes the optimal month for purchase. This figure is very similar to Figure 3 except the window for purchasing in March is smaller.

In Figure 6 for October fuel use, a risk neutral producer would purchase in June or July assuming fall purchases could not start until June. If earlier purchases were possible, then January or February would be the ideal purchase month for a risk-neutral producer. However, adding just a small amount of risk aversion quickly removes February from consideration and July becomes optimal. July remains the optimal purchase month; as producers become fairly risk averse, August becomes the optimal month.

Conclusions

The higher the interest rate or carrying charge per month, the greater the likelihood that producers will purchase their fuel in the month used. With lower interest rates, producers will purchase more in advance of needing their fuel. This is because the months of April and October tend to have some of the more historically high prices.

Higher levels of risk aversion will also affect the purchase decision as January and February tend to have more price variability. For spring (April use), January and February are initially the best purchase months but March and then December become better purchase months as producers become more risk averse. For fall (October use), July and August will be the best purchase months unless fuel can be purchased in the spring. July will be the best month with lower levels of risk aversion but as producer risk aversion increases, August tends to become the best month.

The spring is more sensitive to the month of purchase than the fall, especially for more risk-neutral producers. Fall use fuel can be purchased anytime during the summer or fall with only up to a maximum six cent penalty no matter the risk level of the producer. Fuel use for spring needs to be purchased in January or February for risk neutral producers or else they will face a 14 cent penalty. This spring penalty changes very quickly and the ideal month switches quickly as the degree of risk aversion increases.

Again, this data are only general guidelines. Any particular year could be different and this analysis assumes that historical data patterns will hold in the future though world events may change these patterns. This analysis works for the purposes of a short-term solution to minimizing fuel costs and is certainly better than trying to guess when fuel prices might cheapest during the year.

References

Cleveland, Cutler J. 1995. The direct and indirect use of fossil fuels and electricity in USA agriculture, 1910-1990. *Agriculture, Ecosystems & Environment* 55 (2): 111-121.

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Table 1. Expected cost per gallon from purchasing fuel in different months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Interest Charge												
Spring or Fall use	158.6	159.5	168.0	175.2	177.0	178.9	179.3	181.5	184.3	183.2	177.1	170.5
0.5% Interest/mo.												
Spring	160.9	161.1	168.9	175.2	187.0	188.0	187.6	188.9	190.8	188.8	181.6	173.9
Fall	165.8	166.0	174.0	180.6	181.5	182.5	182.0	183.4	185.2	183.2	187.1	179.2
1.0% Interest/mo.												
Spring	163.4	162.7	169.7	175.2	197.5	197.6	196.1	196.6	197.6	194.5	186.2	177.4
Fall	173.4	172.7	180.1	186.0	186.0	186.1	184.8	185.2	186.1	183.2	197.6	188.4

Table 2. Expected extra cost from purchasing fuel in non-optimal month (no risk adjustment) (lower numbers are better)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No Interest Charge												
Spring or Fall use	0.0	0.9	9.5	16.7	18.4	20.3	20.8	23.0	25.7	24.6	18.6	12.0
0.5% Interest/mo.												
Spring	0.0	0.1	7.9	14.3	26.0	27.1	26.6	28.0	29.9	27.8	20.6	13.0
Fall	0.0	0.1	8.1	14.7	15.6	16.6	16.2	17.5	19.4	17.4	21.3	13.4
1.0% Interest/mo.												
Spring	0.7	0.0	7.0	12.6	34.8	34.9	33.5	33.9	34.9	31.8	23.5	14.8
Fall	0.7	0.0	7.5	13.3	13.4	13.4	12.1	12.5	13.4	10.5	24.9	15.7

Figure 1. Monthly diesel fuel prices

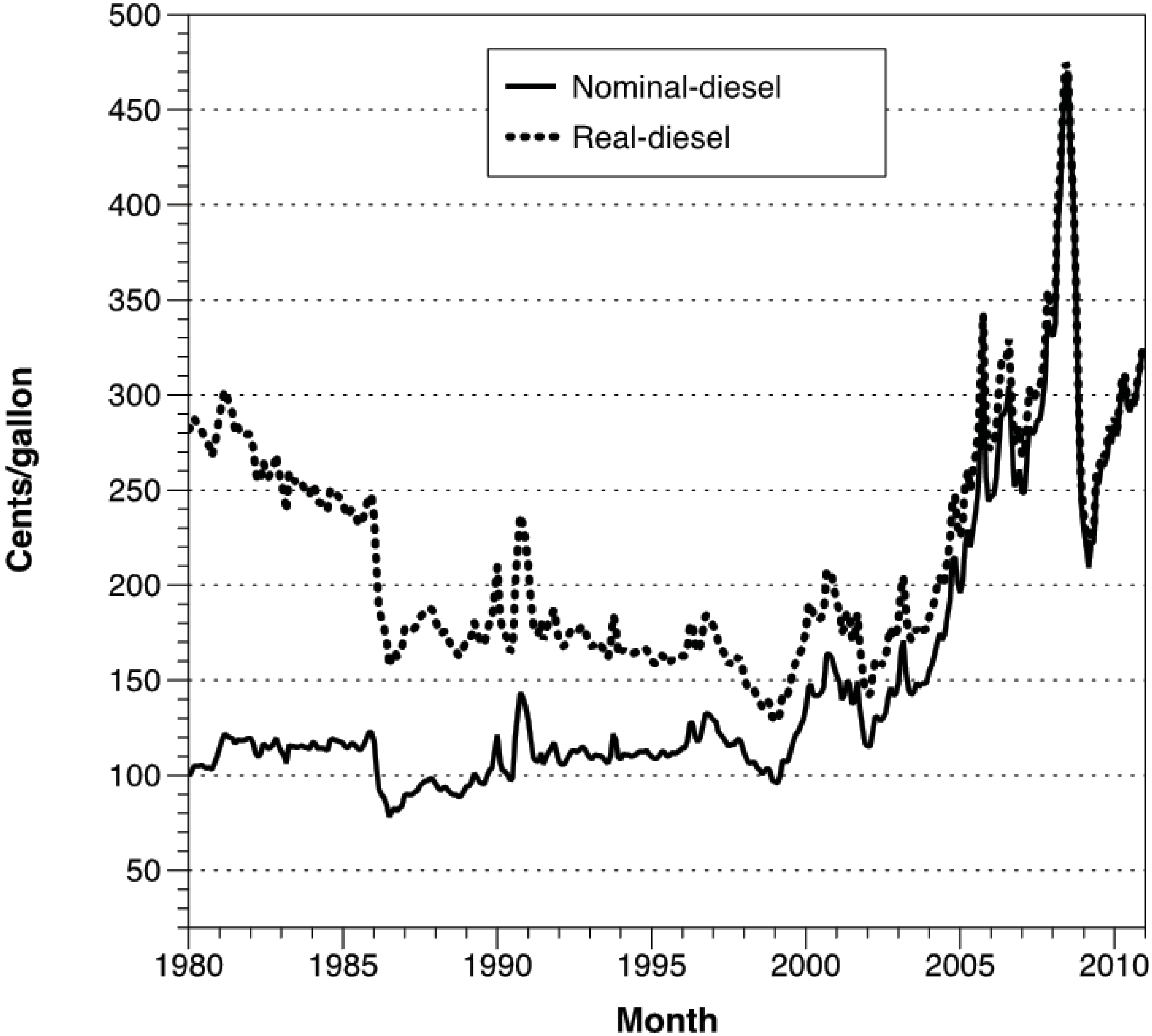

Figure 2. Monthly seasonality of diesel fuel prices

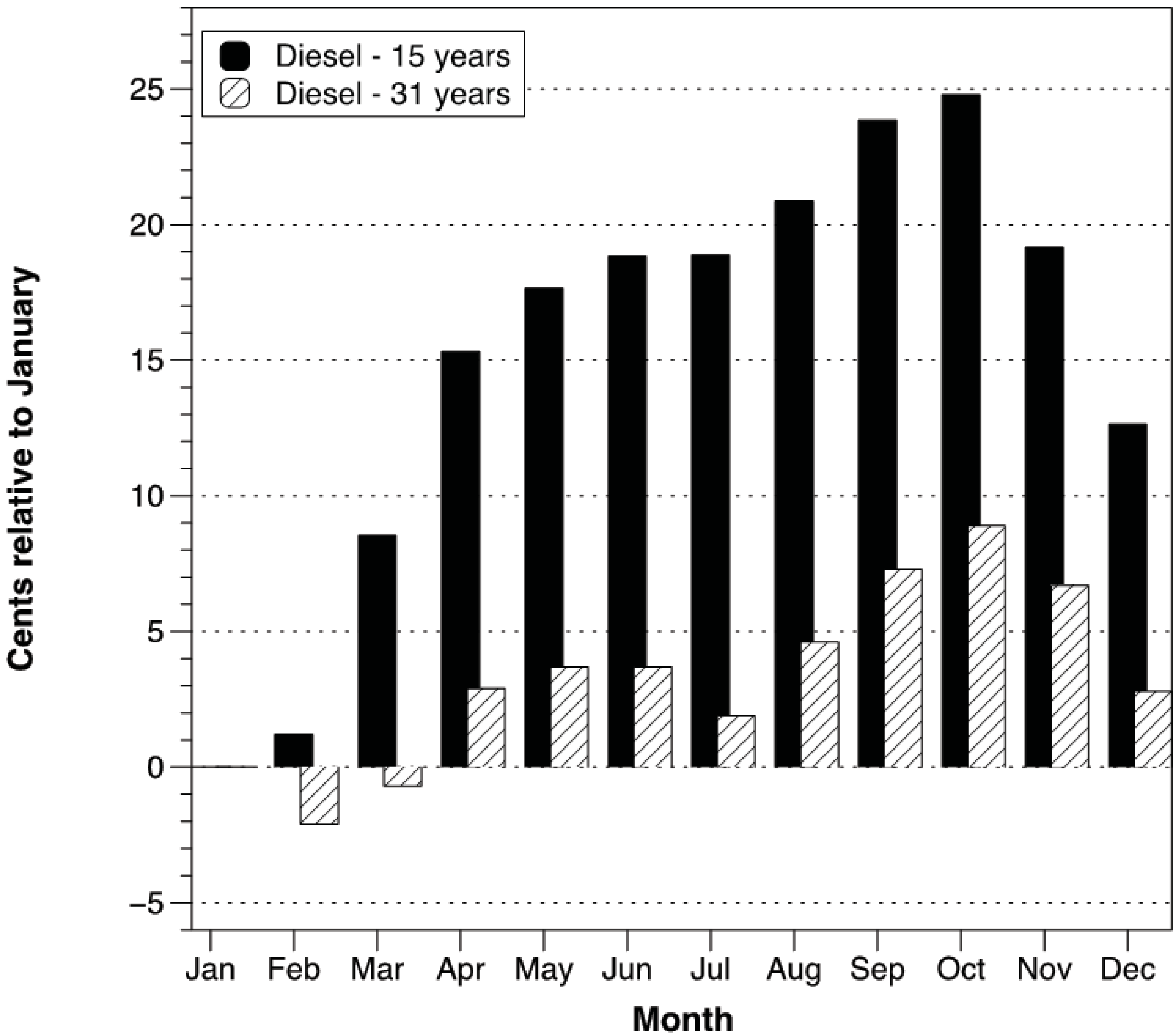

Figure 3. Certainty Equivalent relative to April – 1% Interest

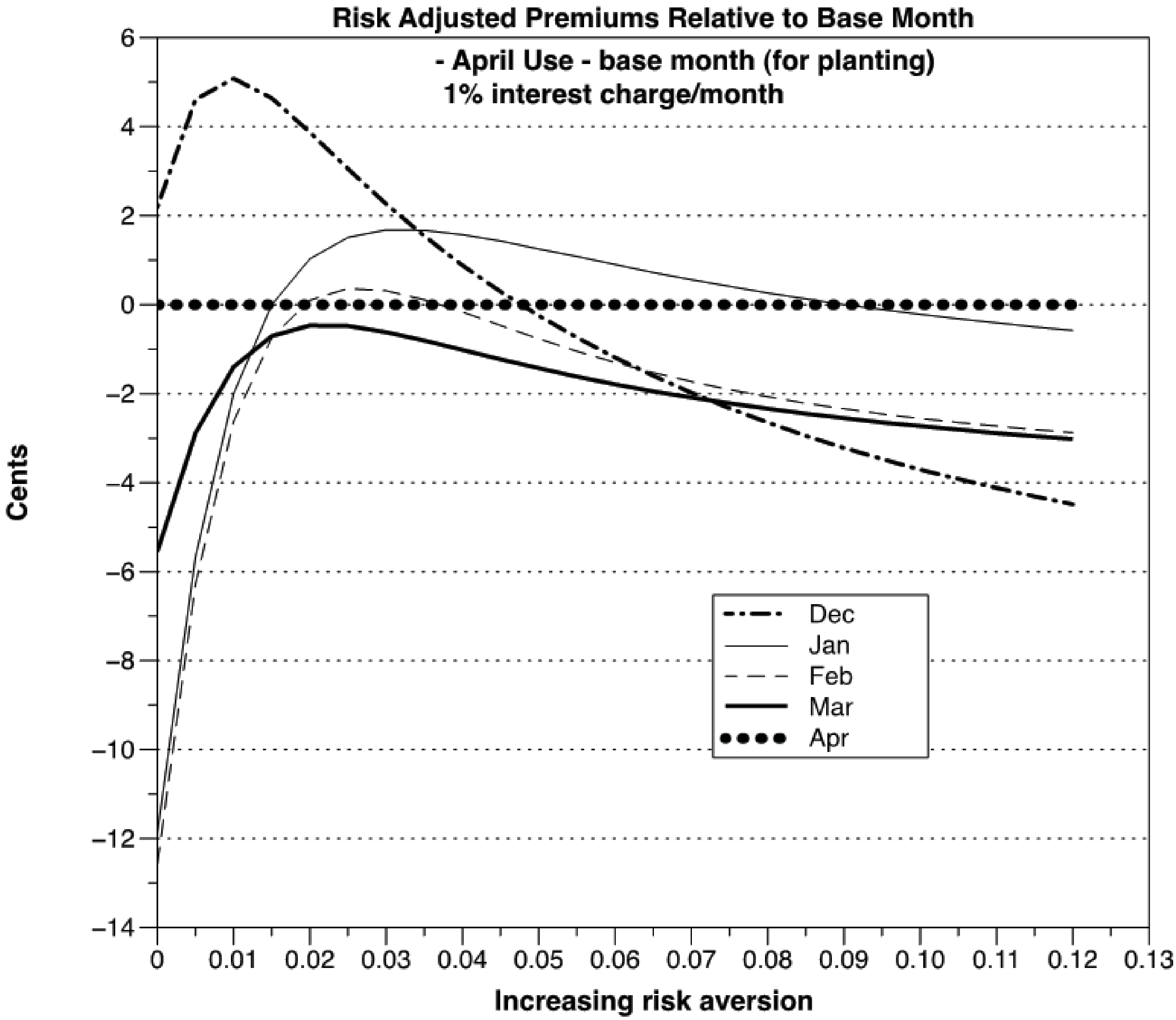

Figure 4. Certainty Equivalent relative to October – 1% Interest

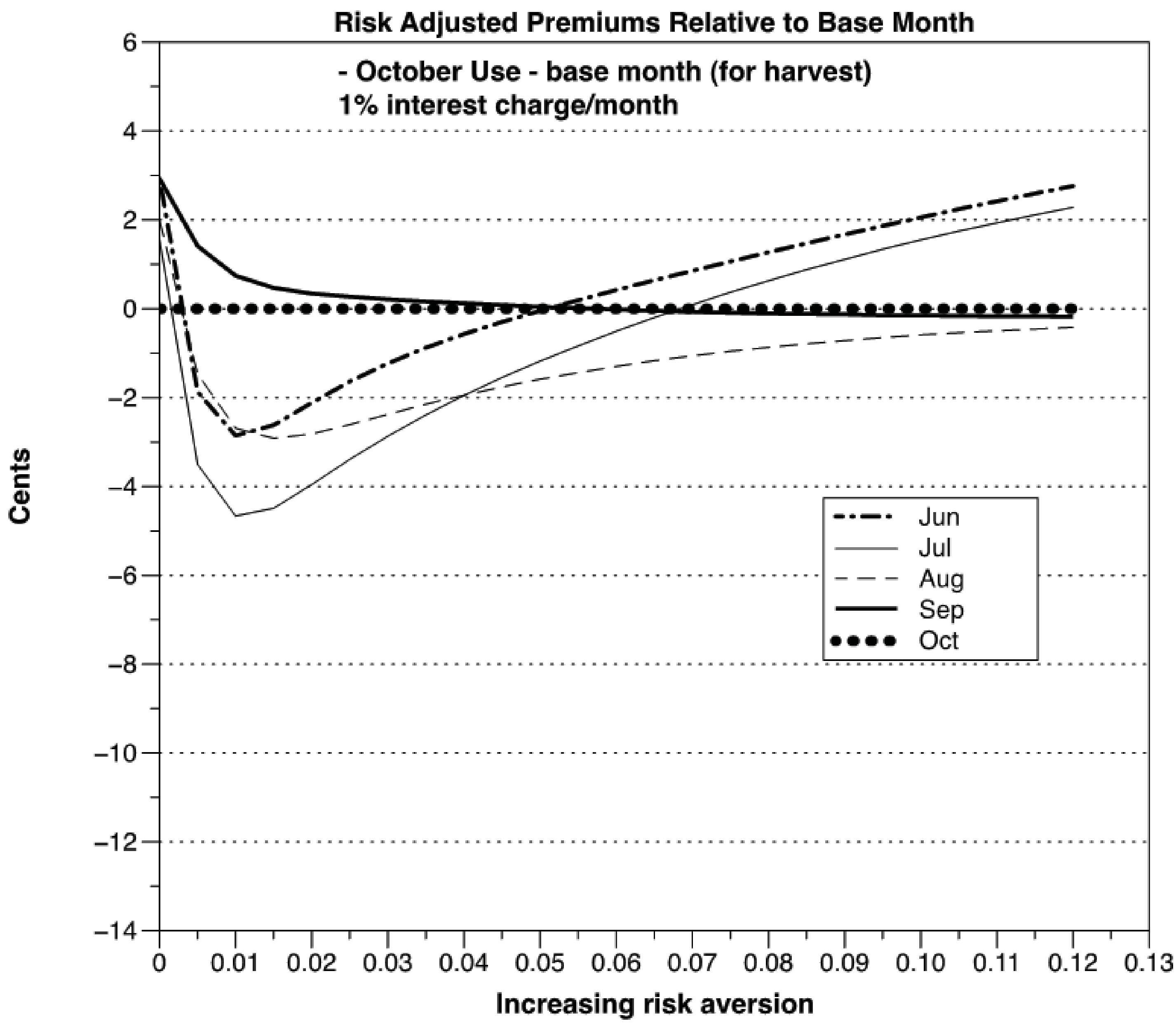

Figure 5. Certainty Equivalent relative to April – 0.5% Interest

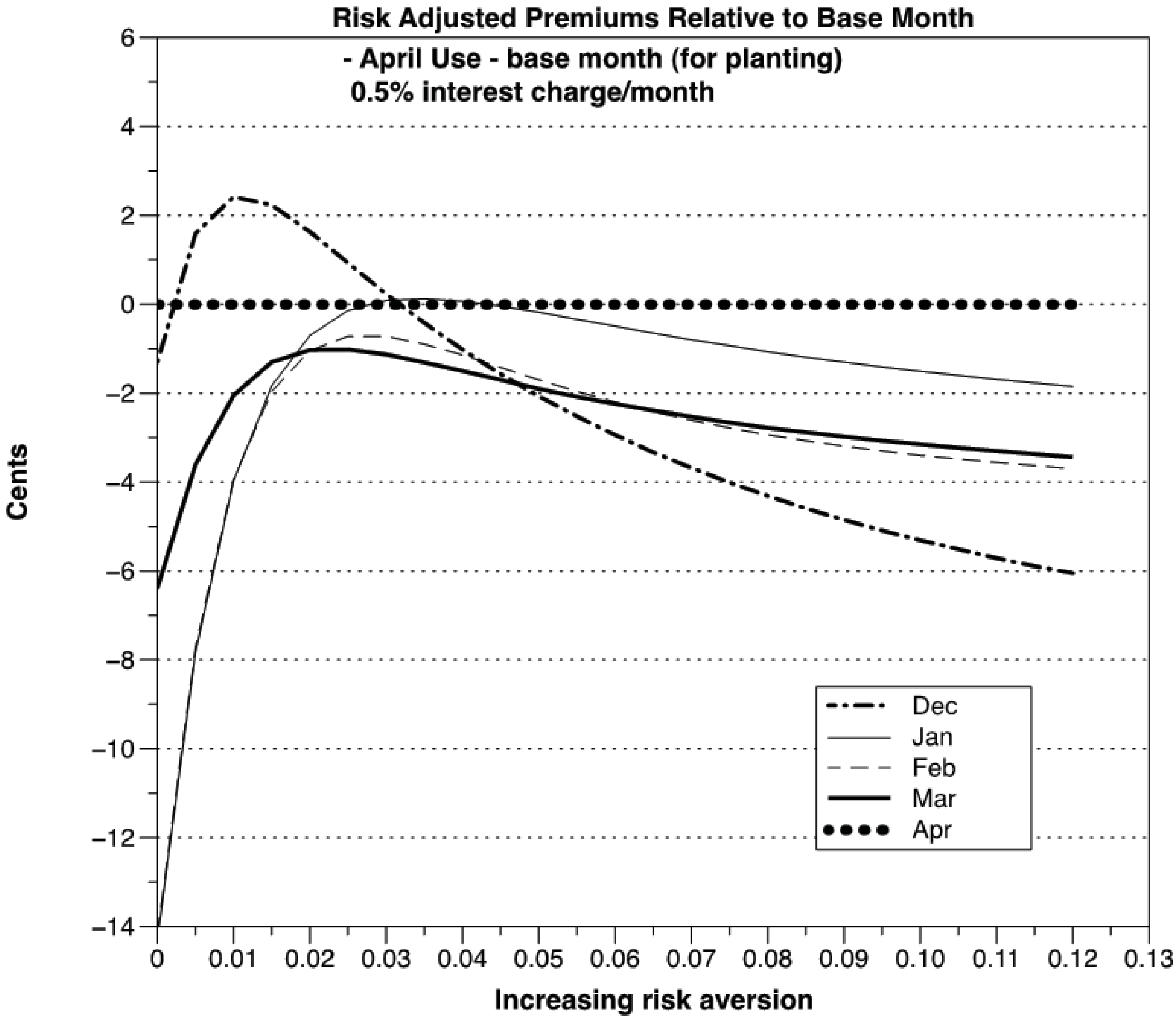

Figure 6. Certainty Equivalent relative to October – 0.5% Interest