Will the Margin Protection Program for Dairy Producers Crowd Out Dairy Futures and Options?

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Abstract

The Margin Protection Program for Dairy Producers, created under the Agricultural Act of 2014, introduces a new margin insurance program that pays dairy producers when national income-over-feed-cost margin declines below elected coverage level. A potential side effect of the program is that it may crowd out hedging using CME dairy futures and options. We analyze this issue under the assumption that hedging and Margin Protection Program are utilized by dairy producers as a protection against catastrophic margin risks. We model such behavior using safety-first preferences where farmers minimize hedge ratio subject to probabilistic constraint on revenue falling below a critical threshold level. We use Monte Carlo simulations and accounting data on dairy cost of production in two US regions to compare the crowding-out effect on representative producers in the upper and lower Midwest. We find that the magnitude of the crowding out depends on production efficiency, market risk exposure, and the timing of the Margin Protection Program sign-up.

Keywords: dairy policy, Margin Protection Program, crowding-out, safety-first preferences

Introduction

With the volatile milk price and increasing feed costs, the U.S. dairy industry has been facing an ever growing challenge to stay at a healthy profit margin since the second half of the first decade in the 21st century. The once effective Dairy Product Price Support Program (DPPSP), formerly known as the Dairy Price Support Program, became irrelevant in this new market landscape with its lower-than-market $9.90 per hundredweight (cwt) price floor for milk[1] (see Figure 1 below). Amid concerns over stabilizing income-over-feed-cost (IOFC) margin for dairy producers, the Agriculture Act of 2014, which will be referred to as the 2014 Farm Bill in the rest of the paper, authorized USDA Farm Service Agency (FSA) to administer an insurance program that pays indemnity if a national level of IOFC margin falls below a user-selected coverage level. Formally known as the Margin Protection Program for Dairy Producers (MPP), the insurance program has the potential to become a new risk management tool for the dairy industry.

Throughout the passage of the 2014 Farm Bill, there has been considerable amount of speculation on the impact of the new margin protection program on the existing risk management practice through futures contracts traded on Chicago Mercantile Exchange (CME) (Stephenson, et al., 2014, Wolf, et al., 2013). A recent survey among dairy producers and market experts states that 10% to 50% of the trading volume on CME Class III milk contracts were placed by producers directly or through their cooperatives (Stephenson, et al., 2014). The upward sloping

[1] The DPPSP supports the milk price by purchasing a basket of dairy products whenever a product’s price falls below a threshold that reflects the $9.90 milk price based on production relationship between the milk price and the product price. The program was discontinued in 2014 when the MMP was established.

open interest curve presented in Figure 2 suggests that the interest in using Class III contracts for risk management purpose has been growing since the commodity was first introduced in 1996. Part of the reason that contributes to the growing interest is that CME is the go-to place for dairy exporters to offset their risk associated with the commitments specified in forward contracts they signed with foreign importers. For example, a long position in Class III milk contracts effectively reduces a dairy exporter's risk exposure to matters typically highly sensitive in the buyer's home country. Without CME futures contracts, dairy exporters will find themselves unable to promise a fixed export price for long period of time, therefore losing their comparative advantage to competitors in EU and New Zealand.

Figure 1 Historical milk price vs. support price

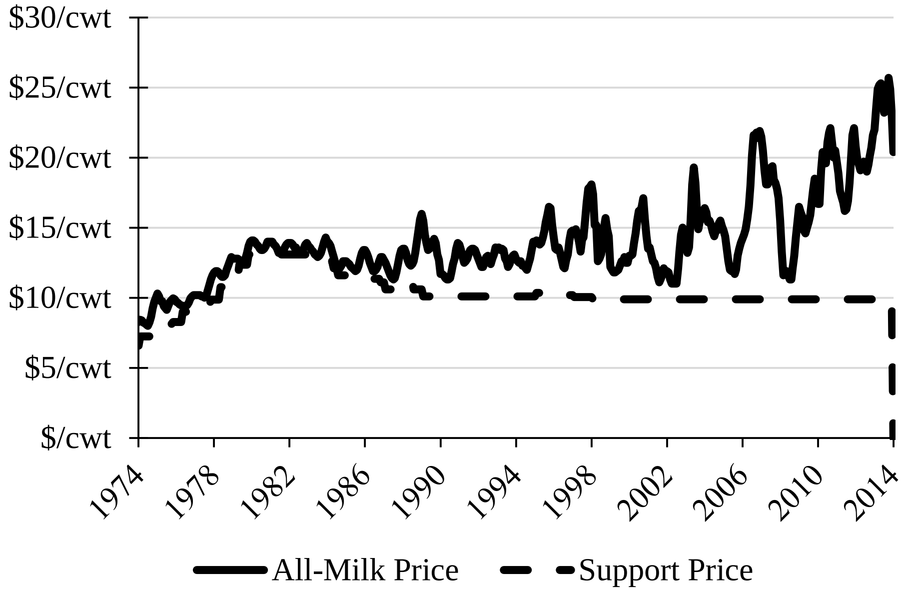
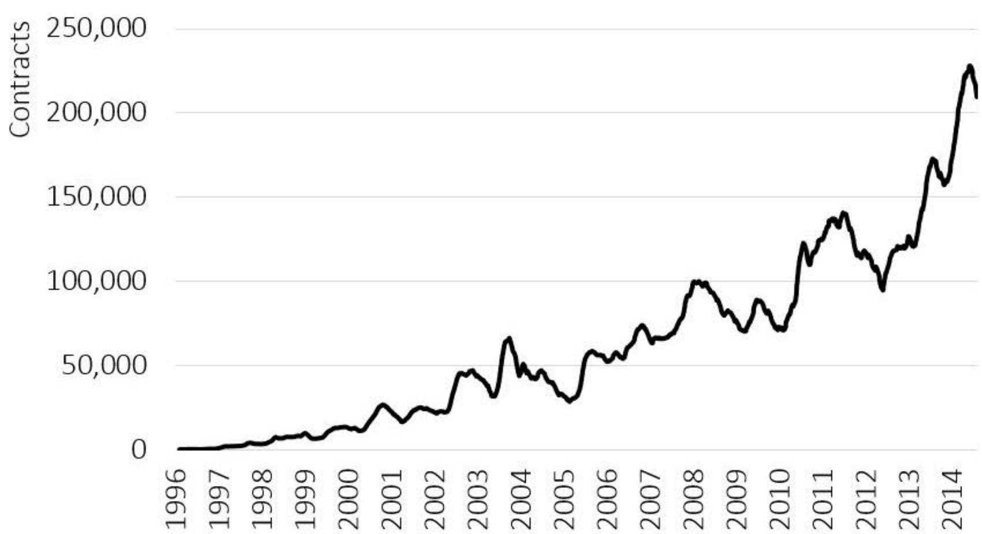


Figure 2 Class III futures and options open interest



The market concern about the MPP negatively affecting private risk management practice is founded in a historical precedent roughly five decades ago. The butter futures contract was first traded in the namesake Chicago Butter and Egg Board – the former entity of CME before 1919 – since the inception of the board. On October 1st, 1949, the DPPSP was established under the Agricultural Act of 1949. The DPPSP greatly reduced the price risk faced in dairy production and effectively sidelined butter contracts as a risk management tool for decades. The interest in butter contracts waned and the contract was ultimately delisted.

Compared to the MPP that is designed at a national level, CME futures and options contracts as risk management tools provide great flexibility. Individual producers can customize their hedging strategies using one or several contracts to fit their specific production and risk profile. Therefore, it is of vital importance to maintain trading volumes of CME contracts. However, because the MPP provides an alternative to the traditional risk management tools through CME and only allows dairy producers to participate, many dairy risk management experts believe that the MPP may reduce the use of futures for risk management purpose if producers find it provides satisfactory risk protection (Stephenson, et al., 2014). In the rest of the paper, we refer to this reduction as the "crowding-out" effect. This paper seeks to answer the question what is the magnitude of the crowding-out effect, if any, that the MPP poses to the dairy futures market.

Newton, et al. (2013a) argue that the margin protection program is not designed to be actuarially fair. An insurance program that is not actuarially fair is prone to the plague of adverse selection and moral hazard. This argument supports the heated speculation on the crowding-out effect. To take one step further on the issue, Wolf, et al. (2013) theoretically analyzed the change in hedge ratio with and without MPP under a mean-variance utility framework. Their findings confirm the existence of the crowding-out effect.

This paper adds empirical analysis to previous studies. The results of this paper support the theoretical findings in Wolf, et al. (2013). But the model in this paper is built on a set of less restricted assumptions. The empirical study of this paper is also in line with the 9-month mean-reversion theory in Bozic, et al. (2012) and suggests that MPP may better serve its purpose if the program sign-up period is further removed from the start of the coverage year. A novel dairy financial benchmark dataset utilized in this study allows us to look at the crowding-out effect by different regions, which is something that has not been done in previous studies.

The rest of the paper can be divided into several sections. The first section introduces the margin protection program and paves the way for the derivation of the theoretical model in the second section. The third section details empirical methods and documents additional assumptions regarding the characterization of the multivariate log-normal distribution. Empirical results follow in the section after. The paper concludes in the last section by reiterating key findings and discussing directions for further research.

Background: Margin Protection Program for Dairy Producers

The Margin Protection Program for Dairy Producers (MPP) in the 2014 Farm Bill allows dairy producers to protect their income-over-feed-cost (IOFC) margin against adverse market conditions. Much like a put option on the IOFC margin, the MPP is a voluntary program that pays an indemnity if a national level bi-monthly IOFC margin falls below a coverage level that a dairy producer elects to purchase. The coverage period always starts in January and ends in December of the same year. Coverage year 2015 is the first coverage year under the current authorization of the farm bill and opened its sign-up period on Sept 2nd, 2014. Subsequent coverage years (2016 - 2018) will start enrollment from July 1st to Sept 30th of the preceding year. There are four major components of the MPP: Actual Dairy Production Margin (ADPM), Production History (PH), Coverage Percentage (CP) and Coverage Level (CL).

The Actual Dairy Production Margin (ADPM) is a type of IOFC margin that equals the average milk price for all grades of milk minus the cost of three key components of feed fed to cattle. The 2014 Farm Bill states that the ADPM is calculated from the following formula:

$$
\begin{aligned}
ADPM\ (\$/\text{cwt}) = {} & All\ \ Milk\ Price\ (\$/\text{cwt}) \\
& -1.0728 \times Corn\ Price\ (\$/\text{bu}) \\
& -0.00735 \times Soybean\ Meal\ Price\ (\$/\text{ton}) \\
& -0.0137 \times Alfalfa\ Hay\ Price\ (\$/\text{ton})
\end{aligned}
\tag{1}
$$

where *All Milk Price* is the national average wholesale milk price; *Corn Price* and *Alfalfa Hay Price* are national average prices reported by National Agricultural Statistics Service (NASS); and *Soybean Meal Price* is the Dectaur-Central Illinois high protein soybean meal price reported by Agricultural Marketing Service. Though $ADPM$ can be calculated from monthly USDA data, the determination of the indemnity payment event is based on the two-month average ADPM. The two-month periods over which indemnity payment is determined start at the first two-month period of Jan/Feb and end at Nov/Dec with six in total in a coverage year. The formula implies that the ADPM is a national level IOFC margin and individual participants cannot tailor the ADPM to reflect their actual margin structure.

The Production History (PH) determines the upper bound of the amount of milk production (in pounds) that one can cover in the MPP. The PH level for coverage year 2015 equals the highest annual production of a participating producer in the calendar years of 2011, 2012 and 2013. FSA did not detail how PH may be determined in subsequent coverage years but stated in its website that future PH will adjust to reflect milk production at the time (FSA, 2014). There are other rules in place to determine PH for new dairy producers whose production history has not been 3 years old. In this paper, PH is assumed known and the determination of its value is irrelevant to the research question.

Coverage percentage (CP) is the percentage of PH that is covered in the MPP. Individual participants can elect to cover as low as 25% to as high as 90% of their PH with an increment of 5% in between. Coverage Level (CL) is the IOFC margin level that may trigger the indemnity payment if the ADPM slips below CL. It is between $4.00/cwt and $8.00/cwt in an interval of 50 cents.

Annual premium of the MPP insurance depends on the CL and PH. The premium is priced to encourage small scale producers to participate by charging them less than larger dairy farms even though both may face the same risk environment. In order to entice high participation in the program, a 25%-off discount is offered to Tier 1 premiums for all levels of CL except the $8.00/cwt coverage for the 2014 and 2015 sign-ups. Detailed premium charges can be seen in Table 1.

Table 1 MPP Premiums under different coverage level and production history

Coverage Level ($/cwt)	Tier 1 ($/cwt)	Tier 2 ($/cwt)
$4.00	$0.000	$0.000
$4.50	$0.010	$0.020
$5.00	$0.025	$0.040
$5.50	$0.040	$0.100
$6.00	$0.055	$0.155
$6.50	$0.090	$0.290
$7.00	$0.217	$0.830
$7.50	$0.300	$1.060
$8.00	$0.475	$1.360

The tier 1 rates (2nd column in Table 1) apply to the first four million pounds of the covered production. The covered production is calculated as the product of production history and coverage percentage. The tier 2 rates apply to the rest of the covered production. For example, if a producer chooses to cover 50% (CP = 50%) of its 10 million pounds PH, the covered production equals 5 million pounds. The producer will pay the tier 1 rate for 4 million pounds of milk and the tier 2 rate for the remaining 1 million pounds. The premium calculation on a per hundredweight basis can be summarized in equation (2):

$$Premium = \min\left(\frac{4\,million}{CP \cdot PH}, 1\right) \cdot R_1 + \max\left(1 - \frac{4\,million}{CP \cdot PH}, 0\right) \cdot R_2 \qquad (2)$$

where R_1 is the tier 1 rate and R_2 is the tier 2 rate. Both rates are functions of the coverage level.

Because the MPP requires a single sign-up to cover a whole calendar year, it is of dairy producer's interest to select a proper coverage level for the entire coverage period. If the dairy producer believes the profit margin will be high during the coverage period, he may choose the lowest coverage level to minimize premium payment. If the dairy producer envisions the profit margin to be low, he may opt to purchase a higher coverage level to maximize the expected net indemnity payment (indemnity minus premium).

Model Framework: Hedging alongside the MPP

Telser (1955) has proposed a “safety-first” hedging model in which the primary goal of a risk-averse producer is to keep below a chosen probability level the risk of the event in which his or her net income falls below a certain threshold. From there a long list of studies examined a variety of problems under mean-variance framework, such as Pyle and Turnovsky (1970), Ederington (1979), Anderson and Danthine (1980) and Anderson and Danthine (1981). Because the mean-variance framework considers upside risk and downside risk equally (Levy, 1974, Quirk and Saposnik, 1962, Tsiang, 1972), a second generation of risk analysis articles focused on the lower partial moments to measure hedging effectiveness. Examples of previous work on this topic include Berck and Hihn (1982), Turvey and Nayak (2003), Mattos, et al. (2008), Power and Vedenov (2010).

Because hedging with futures curbs the overall profit when the market moves in favor of the cash market where the actual sales take place, it is not always a very profitable move to fully hedge one’s production. Therefore, as long as the actions dairy producers take expose themselves under their tolerated risk level, they are willing to make a tradeoff between a locked-in profit margin with less upside potential and the opportunity to profit from favorable market environment. So it seems reasonable to assume dairy producers are seeking the lowest amount of risk protection in futures markets as long as they are comfortable with the risk they take. This assumption holds with or without MPP participation because the MPP only pays indemnity in an adverse market environment. MPP alleviates the loss dairy producers may suffer when milk price is low or feed cost is high.

Other assumptions we make for the theoretical model:

1. No production risk: the expected production turns out to be the actual production.
2. No seasonal changes in milk production: annual milk production is equally distributed to its 12 months.
3. There are only two types of producers: feed grower and feed purchaser. Feed growers grow feed on their land to meet ration needs completely. Feed purchasers buy all feed from open markets.
4. Futures contract size is perfectly divisible: one can always find an integer number of futures contracts to cover his or her production no matter the hedge ratio or production level.
5. Producers set up the hedge portfolio for the entire production in an MPP coverage year at the time they sign up for the program. There are twelve hedging portfolios targeting 12 months of the coverage year. All contracts will be held until contract expiry. Hedge for feed is at a fixed proportion to the milk output according to feed ration.

A dairy producer who seeks to find the least hedge coverage while having the risk in check solves the following problem

$$\begin{aligned} \min \quad & h \\ s.t. \quad & \Pr[revenue \leq RTL] \leq \gamma \\ & h \in [0,1] \end{aligned} \tag{3}$$

where h, the hedge ratio, is defined as the proportion of the milk production being hedged over the overall production; $\Pr[\cdot]$ denotes the probability of an catastrophic event; RTL denotes a revenue threshold level and is typically set around the variable cost of production; and γ represents the maximum risk the producer can tolerate in terms of the probability of the revenue being below the RTL. We term inequality constraint in the problem the risk constraint. Everything in the problem is deterministic except the $revenue$ term. It is subject to milk and feed price shocks. The hedge ratio is bound between 0 and 1 to eliminate over-hedging. Given that the hedge ratio is being minimized here, if the optimized hedge ratio still turned out to be greater than 1, either the risk tolerance level (γ) was unrealistically strict against the risk environment or the cost of production was too high resulting in a very large RTL.

The $revenue$ term in the risk constraint is further specified by the following formula:

$$revenue = \alpha \cdot \left(\frac{1}{6} \sum_{j=1}^{6} I_j - P^{MPP} \right) + \frac{1}{12} \left(\sum_{T=1}^{12} MI(T) \right) + h \cdot \frac{1}{12} \left(\sum_{T=1}^{12} HG(T) \right) \tag{4}$$

This formula defines the monthly average revenue on a per hundredweight basis under the assumption of no production seasonality. The three terms separated by the plus signs respectively represent the MPP net indemnity payment, the 12-month average income from milk sales and the average hedging Profit & Loss (P&L). In the formula, t denotes the date when the producer registers for the program. T represents an MPP coverage month with value 1 denoting January, value 2 denoting February and so on. $HG(T)$ defines the hedging P&L for month T's milk production. Similarly $MI(T)$ denotes the income from milk sales in month T. Furthermore, j represents a bi-monthly indemnity payment period in a coverage year. It starts with the Jan-Feb period and ends with the Nov-Dec period. I_j denotes the MPP indemnity payment made for the jth period. P^{MPP} denotes the MPP premium calculated from equation (2). Finally, α represents the coverage ratio whose sole purpose is to sale up or down the net indemnity payment to match up with the expected production level. For an MPP non-participant, α is set to zero, whereas for a participant, it is defined as

$$\alpha = \frac{CP \cdot PH}{Y}$$

where $CP \cdot PH$ calculates the covered production level and Y denotes the expected annual production.

The income from the milk sales is defined as

$$MI(T) = P_T^{Milk} - \xi \cdot \left(\omega^C P_T^C + \omega^{SM} P_T^{SM} + \omega^H P_T^H \right) \tag{5}$$

where P_T^{Milk}, P_T^C, P_T^{SM} and P_T^H are the monthly average mailbox milk price, spot corn price, spot soybean meal price and alfalfa hay price respectively. The subscript T denotes the month over which these prices are averaged. ω^C, ω^{SM}, ω^H collectively denote the feed ration (corn, soybean meal and hay) for producing one hundredweight of milk. ξ is an indicator that takes the value of 1 for feed purchaser and 0 for feed grower.

Since we do not include feed growing cost in the definition of $MI(T)$, we add it back to the right hand side of the catastrophic event inequality. In other words, we let RTL for feed growers be the feed growing cost plus other operating expenses. As for feed purchasers, since $MI(T)$

takes into account the feed purchasing cost, we leave only the operating cost net feed purchasing cost in RTL.

The hedging P&L is specified as the following:

$$HG(T) = w\Delta F_{t,T}^{DE} + (1-w)\Delta F_{t,T}^{DK} - \xi\left[\left(\omega^{C} + \omega^{H} B^{H,C}\right)\Delta F_{t,T}^{C} - \left(\omega^{SM} + \omega^{H} B^{H,SM}\right)\Delta F_{t,T}^{SM}\right] \quad (6)$$

In the above equation, $\Delta F_{t,T}^{DE}$ and $\Delta F_{t,T}^{DK}$ respectively denote the hedging P&L from a short Class III milk position of one contract and the P&L from a short Class IV milk position of the same size. The position is set up at time t and targets the production in coverage month T. Similarly, $\Delta F_{t,T}^{C}$ and $\Delta F_{t,T}^{SM}$ denote the hedging P&L from a short Corn position and a short soybean meal position respectively. The position size of each grain hedge equals the size of one contract. These positions are then resized by the terms they are multiplied with. The milk sales is cross-hedged with Class III and Class IV contracts. The size of the milk hedge is split between these two futures by the weight w. Hay is cross hedged with corn and soybean meal contracts. $B^{H,C}$ and $B^{H,SM}$ are coefficients for corn and soybean meal futures in the cross hedge. They are multiplied by the feed ration coefficient for hay ω^{H} to align with the milk production level.

The indemnity payment is modeled as a simple put option. The strike price of a put option is analogous to the MPP coverage level (CL) and the price of the underlying asset is analogous to the ADPM.

$$I_j = \max\left(CL - ADPM_j, 0\right)$$

where $ADPM_j$ is obtained by using equation (1) with monthly prices and averaging the obtained ADPM's over the two months in the jth bi-monthly period.

As discussed in the previous section, a producer may optimally choose a coverage level to maximize the expected net indemnity received from the MPP. This behavior can be model as the following optimization problem:

$$CL^{*} = \arg\max_{CL} \frac{1}{6}\sum_{j=1}^{6} E_t\left[I_j(CL)\right] - P^{MPP}(CL) \quad (7)$$

where I_j and P^{MPP} are now functions of CL; and $E_t[\cdot]$ denotes the expected value conditioned at time t that reflects a producer's belief of the market.

It is worth noting that if we view RTL and γ in the problem (3) deterministic, the probability of the catastrophic event is the cumulative distribution function of the random variable $revenue$. As a cumulative distribution function, the probability is monotonically increasing in the threshold RTL. This means the probability of a catastrophic event is higher when the cost of production is higher. The relation between the catastrophic probability and the hedge ratio depends on whether or not the hedge is "good". We define a hedge is "good" if it makes the catastrophic probability monotonically decreasing in hedge ratio. We claim that a "good" hedge makes the hedge-locked-in revenue greater than the revenue threshold. To see that, imagine a world of one commodity and no basis risk. We further simplify it to have only three possible states of the market: conducive, neutral, and adverse to cash sales with equal probability. Consider the following example in Table 2.

Table 2 Three-state hedge monotonicity example

			$h = 0.9$	$h = 0.5$	$h = 0.1$
Market	Hedge P&L	Cash Sales	Revenue Income		
Conducive	-$1	$4	$3.1	$3.5	$3.9
Neutral	$0	$3	$3.0	$3.0	$3.0
Adverse	$1	$2	$2.9	$2.5	$2.1
Cost	Hedge Outcome		Catastrophic Probability		
$RTL = 3.6$	Bad hedge		100%	100%	66.7%
$RTL = 3.2$	Bad hedge		100%	66.7%	66.7%
$RTL = 2.8$	Good hedge		0%	33.3%	33.3%
$RTL = 2.4$	Good hedge		0%	0%	33.3%

The average hedge-locked-in sales income is $3.0 in the above example. As we can see from the table, when the cost of production (RTL) is above the locked-in level, catastrophic probability decreases as the hedge ratio decreases. The opposite is true when the cost of production is below the locked-in level. Problem (3) is not defined in case of a "bad" hedge where more hedged production incurs higher probability of a catastrophic event. "Bad" hedge is not of particular interest of this study because they are not desired form of conventional risk management.

Empirical Strategy

The empirical study follows closely a method used in Newton, et al. (2013a), Newton, et al. (2013b), Bozic, et al. (2014). Their method derives market outlooks from futures and options markets, and simulates different price scenarios in line with the outlooks. The derivative markets used to derive price scenarios include the CME corn, soybean meal, Class III milk and Class IV milk markets. Once price scenarios are simulated, we calculate the optimal hedge ratios for an MPP participant ($\xi = 1$) and a non-participant ($\xi = 0$), then compare the difference in hedge ratios to measure the degree of crowding-out.

Data sources include "Understanding Dairy Markets" website [2] for mailbox milk price and futures and options close prices, USDA National Agricultural Statistics Service for other USDA prices. We also use regional aggregate accounting data from Genske Mulder & Co, LLP to study the crowding-out effect by regions. These regions are upper Midwest (IL, IN, IA, MN, ND, OH, SD, WI, MI) and lower Midwest (KS, MO, NE, OK, UT).

We estimate regression models to convert CME prices to USDA prices at national and local levels. National level prices comprise the right-hand-side of equation (1) and determine the $ADPM$ level for indemnity calculation. The local level prices are used to derive the hedge ($HG(T)$) and sales ($MI(T)$) part of equation (4). Specification of the regression models can be found in Table 5 and Table 6 in Appendix C. To align grain futures price with the USDA counterpart, we follow Newton, et al. (2013a), Newton, et al. (2013b) and Risk Management Agency (2005), and employ the following matching table. A month in the first column of Table 3

[2] Web address: http://future.aae.wisc.edu/

represents a calendar month in which a USDA price is averaged over. A month in the second or third column represents a futures contract expiration month.

Table 3 Weights on grain futures to pair with USDA price

USDA Price Month	Corn Contracts	Soybean Meal Contracts
Jan	⅔ Dec + ⅓ Mar	Jan
Feb	⅓ Dec + ⅔ Mar	½ Jan + ½ Mar
Mar	Mar	Mar
Apr	½ Mar + ½ May	½ Mar + ½ May
May	May	May
Jun	½ May + ½ Jul	½ May + ½ Jul
Jul	Jul	Jul
Aug	½ Jul + ½ Sep	Aug
Sep	Sep	Sep
Oct	⅔ Sep + ⅓ Dec	Oct
Nov	⅓ Sep + ⅔ Dec	½ Oct + ½ Dec
Dec	Dec	Dec

Milk is cross-hedged with Class III and Class IV futures contracts. We first obtain the OLS estimates for the regression model of local mailbox milk price on the terminal prices of the two futures (see Table 8). The sum of the coefficient on the futures is very close to 1[3] no matter what region it is. In light of this we split the hedged milk into two portions. The first one is covered by Class III futures while the second by Class IV futures. Because the sum of the coefficients is close to 1, we impose the constraint of the sum being 1 and re-estimate the coefficients under the same specification. This provides us an estimate of $w = 0.6863$ for upper Midwest and $w = 0.3136$ for lower Midwest. $B^{H,C}$ and $B^{H,SM}$ in equation (6) are estimated in the similar fashion but without a constraint (see cross-hedge models in Table 7). We use the absolute value of the constant coefficients in equation (1) as the estimates for the ration weights ω^C, ω^{SM} and ω^H in equation (5) and (6).

Multivariate Gaussian distribution is assumed to be the joint distribution of all futures terminal prices. We use the Spearman's rho correlation coefficient between two price shocks to populate the variance-covariance matrix parameter for the multivariate Gaussian. A price shock η_τ^T is the difference between a futures' terminal price at time T and its price quoted τ time units before T. We assume the time series $\{\eta_\tau^{T_i}\}$ with element shocks of a same commodity is autocovariance-ergodic as $i \to \infty$. In other words, autocovariance made from shocks taken over a period of τ time units regardless of contract expiration is treated as the autocovariance of a latent shock variable η_τ. Given the shock is τ time units ahead of contract expiration regardless what

[3] The sum of the OLS coefficients on milk futures is 0.0058 above 1 for upper Midwest model and 0.0126 above 1 for lower Midwest model. See Table 8 for detail.

contract it is, the ergodicity assumption implies that the new information made available in the period of τ time units before contract expiration has the same effect on determining the price movement leading to the terminal price. In other words, we assume the effect of information uncertainty is a function of the length of the time period leading to the terminal price. It has nothing to do with when the contract expires. To make the correlation coefficient matrix, we set a sequence of τ's in an increment of one month and calculate the Spearman's rho coefficient between $\left\{\eta_{\tau_j}^{T_i}\right\}$ and $\left\{\eta_{\tau_k}^{T_i}\right\}$ for the (j,k) element of the matrix. We use Table 3 to compute the weighted futures price to make sure each τ has a grain shock to match with. The correlation matrix measures intra- and inter-commodity co-movements up to 24 months before contract expiration. Appendix B explains in further detail about the data generating process.

Results: how big is the crowding-out effect?

We first calculate optimal hedge ratio as a function of production cost RTL and MPP participation ξ for a representative farm with the production history of 60 million pounds and the risk tolerance level $\gamma = 5\%$. This function is empirically determined by a heuristic algorithm. The algorithm starts off by attempting a very low cost level, for example 0. If production is free or very low, there is no need to hedge at all as long as the output is a good rather than a bad. For the same reason, the catastrophic probability shall be zero in those cases. Keeping the hedge ratio at zero, the algorithm moves up the cost level RTL until the catastrophic probability violates the risk constraint. As argued in the previous section, the catastrophic probability is monotonically decreasing in hedge ratio. Hence, increasing the hedge ratio may bring the catastrophic probability down to the risk tolerance level γ. Further attempt to lower catastrophic probability would result in a sub-optimal / higher hedge ratio. In this case, the algorithm finds an interior solution and the problem can be simplified to a root finding problem that makes the risk constraint binding. Empirically this is done by the bi-section root finding method.

We compute the optimal hedge ratio functions for hypothetical coverage years of 2008 to 2014 with 1 million simulation scenarios in each case. For each coverage year, we assume three different sign-up periods: the April, October and January sign-up. The April and October sign-up are assume to be done on the closest business day to the first day of the month in the year before the coverage year. The January sign-up is assumed to be done on the closest business day to January 1st of the coverage year. Had the MPP existed in those years, the results show what the expected effect on the hedge ratio would have been given the market condition at sign-up. Figure 5 to Figure 48[4] in Appendix C show the optimal hedge ratios at different cost levels. The downward sloping curve in black depicts the percentage change in the hedge ratios caused by MPP participation.

Several quick observations can be made from those figures. First, regardless of MPP participation, the upward-sloping optimal hedge ratio curves suggest that producers need more hedge protection when their production cost is high. Second, in most cases with optimal

[4] We only provide the October sign-up for 2008 and 2014 because of the similarity in the graphs of other sign-up periods for those two years. We also omitted charts for 2011 because they add no additional insights to what 2009, 2012 and 2013 reveal. We report complete hedge ratio charts for these three years.

coverage level at \$4.00/cwt, the difference in hedge ratio between a participant and non-participant is almost zero. This is possibly because the baseline MPP coverage provides too little protection to make a difference between the hedging portfolios. Third, the percentage drop in hedge ratios is larger at lower cost levels than that at higher ones. This suggests that highly efficient producers experience stronger crowding-out effect than their inefficient peers. As an interesting case to note, some figures, for example those for 2009 and 2012, suggest that extremely inefficient producers may need more hedge protection on top of MPP compared to the case with the same producer but in the absence of MPP. Fourth, many of the hedge ratio curves for MPP participants and some of those for non-participants do not reach to 100%. This does not mean a full hedge is an infeasible solution. The problem lies in the computational limitation of our numerical analysis. If we were to increase the number of simulation scenarios higher than 1 million, one should be able to observe the curves getting closer to 100%.

To study the actual crowding-out effect in different regions, we derived production cost from data provided by Genske Mulder & Co, LLP. Because of the model setup, the RTL level for feed growers is the sum of feed growing cost and other operating expense. The RTL level for feed purchasers is just the other operating expense. The other operating expense accounts for costs not related to feed and herd replacement. It includes, for example, equipment leases, employee benefits, insurance premium, etc. These costs are at the basis of per total annual production. It is reported this way because dairy producers are more interested in protecting average profit margin of an entire year rather than that of a single month (Bozic, et al., 2012). Occasional shocks can be smoothed out by lines of credit or cash reserves.

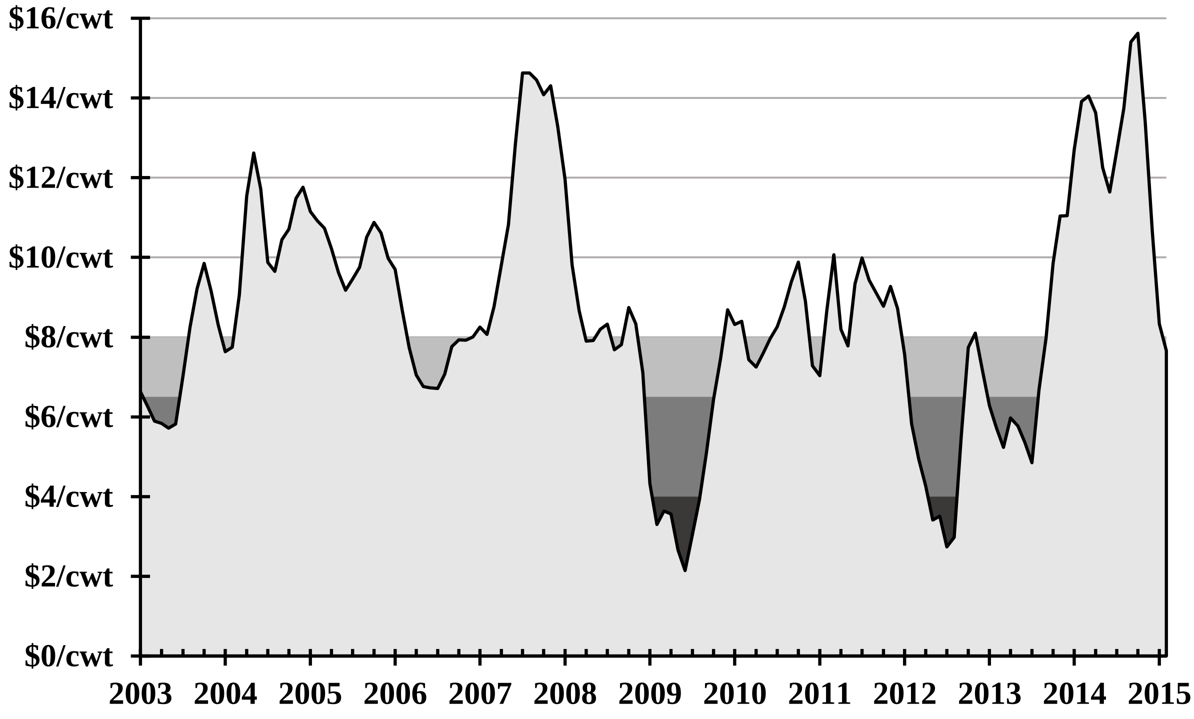
Table 4 shows the average percentage decline in hedge ratios in each region for each producer type. We can see from the table that no matter the region they are in, feed purchasers face stronger crowding-out effect than feed purchasers. Comparing between regions, we find that the crowding-out effect is more pronounced in upper Midwest than in the lower Midwest. It is also worth noting that feed growers and purchasers sit on the two sides of a market risk exposure spectrum, with the feed growers taking much less price risk than the feed purchasers. Possibly due to their higher need for risk protection, the crowding-out effect is stronger among feed purchasers. This suggests that the crowding-out effect for a producer with a different level of price risk exposure is possibly between the effect our representative grower and purchaser experience. In other words, the percentage drops of hedge ratios from a feed grower and a feed purchaser provide us the lower and upper bound measures of the crowding-out effect. But the difference in these two bounds diminishes as they get closer to the start of the coverage year. This implies that the level of risk exposure becomes irrelevant once everyone has a better grip on future market movements in the coverage year. Furthermore, comparing among different sign-up periods, one may find the crowding-out effect becomes stronger as producers register into the program earlier. But there is one exception to that conclusion. The April sign-up among growers does not increase from later sign-up. Finally, because Oct sign-up is close to the September deadline for the program registration, we use the percentage drop in hedge ratios from the Oct sign-up as a conservative measure for the crowding-out effect.

Table 4 Average percentage decline in hedge ratio

	Upper Midwest		Lower Midwest	
	Feed Grower	Feed Purchaser	Feed Grower	Feed Purchaser
Apr Sign-up	0.00%	49.79%	0.00%	25.41%
Oct Sign-up	14.89%	19.99%	12.99%	15.17%
Jan Sign-up	10.36%	10.39%	7.52%	7.52%

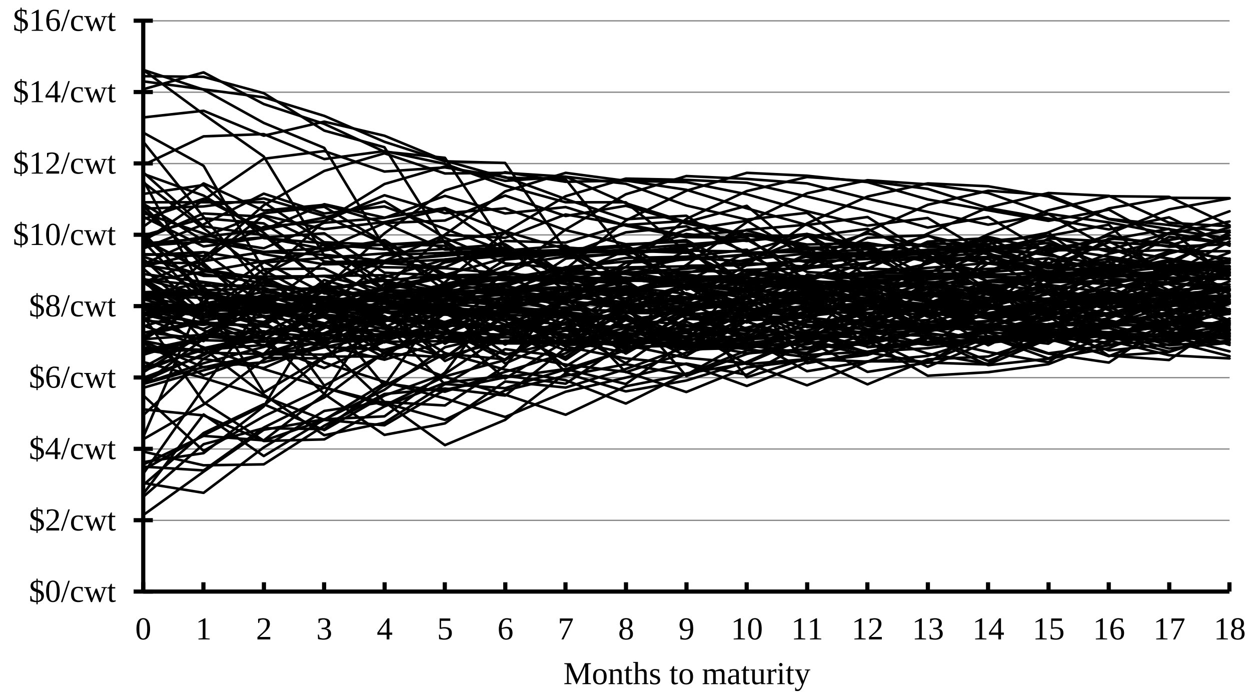
Detailed RTL level and percentage drop in hedge ratios are reported in Table 10 to Table 13. An "N/A" in those tables indicates the cost of production is too high and the hedging strategy our model utilizes cannot keep the producer's revenue above water. If producers were able to lock in at better futures prices, they might be able to cover a higher cost of production. The average percentage reduction reported in Table 4 excludes those cases with "N/A" values.

Figure 3 Realized ADPM from Jan, 2003 to Feb, 2015



The dairy industry suffered a historically low margin in 2009. As a special case study, it is worth looking at what our results show for 2009. A quick inspection of the realized ADPM in Figure 3 reveals that the ADPM profit margin reached its bottom at the end of the second quarter in 2009. Coincidentally Jan sign-up just so happened at a time when the market was trapped in the middle of the drastic margin decline. Given the market situation at the time, it is hard to believe that any bullish signal could be picked up in January, 2009. The possible bearish signal may have given rise to the highest indemnity payment ($2.30/cwt) and the lowest cash sales income across producer types and regions (see Table 9). One may question why the $8.00/cwt MPP coverage seemed ineffective in keeping the margin above the cost. Note our model optimally picks the best coverage level for each sign-up period. Any other coverage level will bring less net indemnity payment to the overall revenue. This only leaves us to suspect bad hedge is the culprit. Indeed, with the market in the middle of the downward spiral, it would be too late for any hedge that were made at that time to lock in a promising margin. Does the hedge made three months earlier fare better than the January hedge? The answer seems to be yes. Table 10 to Table 13 show that both producer types can cover their cost of production in Midwest regions.

Figure 4 Forward ADPM



Bozic, et al. (2012) point out that there exists a 9-month mean reversion in IOFC margin in the dairy industry. Figure 4 above shows the forward ADPM up to 18 months before the ADPM is realized. A forward ADPM at n months to maturity equals the ADPM calculated from the futures prices quoted n months before they mature. In Figure 4, futures prices are taken around the first day of a month. The dispersion in forward ADPM peaks at the realized level (at 0 month to maturity) and wanes its way out as it moves away from its named month. The dispersion becomes relatively stable at the 9-month mark. This fact suggests that any gap less than 9 months between the MPP sign-up and program kick-off cannot lock in a long-term average margin in the futures market. There is still plenty of room within that 9 months for the market consensus to evolve on what the coming calendar year would be like. If producers were to use market outlook embedded in futures market to speculatively choose MPP coverage level, they may find it difficult to do so once the sign-up/kick-off gap is 9 month long or more. Our results seem to suggest just that. The standard deviation of the coverage level for the April sign-up is 1.36 while the standard deviation of the coverage level for the October sign-up is 1.24. From an insurance issuer's standpoint, a diverse pool of coverage levels selected among producers is an indicator of less occurrence of the adverse gaming behavior.

Conclusion and Discussion

Our empirical results suggest that the MPP is likely to induce a crowding-out effect on the hedging practice in the futures markets. The percentage decline in hedge ratios is estimated to be within a range between 14.89% to 19.99% in upper Midwest region and 12.99% to 15.17% in the lower Midwest region. Besides the geographic locations, we find that the crowding-out effect also depends on the production efficiency, market risk exposure, and the timing of the program sign-up. More efficient producers experience more pronounced crowding-out effect. Higher market risk exposure induces a higher crowding-out effect. But the exposure matters less and less as we get closer to the coverage year. Finally, there seems to be a positive relation between the intensity of the crowding-out effect and how early one registers before the start of the coverage.

Shortcomings of the model and method in this paper call for future studies in several aspects. First, this paper assumes futures prices follow multivariate log-normal distribution. A refined distributional assumption can be made to deal with the tail dependency issue. Second, the theoretical model assumes producers hedge on the day of the MPP sign-up. This assumption may not always meet producer's risk protection need. A further study on hedging ahead of MPP sign-up period to cover variable cost is needed to fully address the issue of crowding-out effect. Finally, it is important to understand how long a gap between MPP coverage period and sign-up deadline would be in order to thwart adverse gaming and to minimize the crowding-out of private dairy risk markets.

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Appendix A: Basis models explained

The NASS all-milk price in equation (1) is the national average milk price dairy producers receive. Here we use the classified milk prices under federal marketing order to model the all-milk price. The Class I and Class II prices can be expressed by the Class III and Class IV prices in the same period and the higher of the lagged Class III or Class IV prices. This is because (a) the Class I and Class II prices are derived from the same component value formula used to derive Class III and Class IV prices and (b) the lagged term can account for the advanced pricing in Class I and Class II. See model specification in Table 5.

The problem with NASS hay price is that there is no hay futures to pair it with. A regression model of hay prices on corn, soybean meal and lagged hay prices has been used to solve the problem (Newton, et al., 2013a, Newton, et al., 2013b). This specification is justified for at least the following two reasons: (a) Competition for land to grow corn, soybean or hay makes corn and soybean meal prices relatively correlated with hay prices. (b) Some persistent unexplained factors can be dealt with by the lagged term to correct autocorrelation.

Mailbox price represents all payments received for milk sold by dairy farmers net marketing cost. It is highly correlated with Class III and Class IV milk prices that set the national minimum sales price for cheese and dry milk products. A specification developed by Gould (2014) is used here to utilize this correlation.

Appendix B: Data generating process

Let $f_{t,T}$ denote the realized price at time t of the futures contract that expires at T. Let random variable $F_{t,T}$ represent all possible terminal prices that matures at T with information available at time t. Naturally we let $F_{T,T} = f_{T,T}$ be deterministic.

The change of a commodity futures price conditioned at time t is assumed to follow geometric Brownian motion expressed by the following Wiener process (Black, 1976):

$$d(F_{t,T}) = \sigma \cdot F_{t,T} \cdot d\mathrm{W}_{\mathrm{T}}$$

where $W_T \sim N(0, \sqrt{T})$ is a Wiener process; σ is the volatility of the futures price. The solution of this stochastic differential equation is

$$\ln(F_{t,T}) = \ln(f_{t,T}) - \frac{1}{2}\sigma^2(\mathrm{T} - t) + \sigma\sqrt{T - t}Z$$[5]

where $Z \sim N(0,1)$ is a standard normal random variable. This says the price at time t of the contract that expires at T follows a log-normal marginal distribution

$$\ln(F_{t,T}) \sim N\left(\ln(f_{t,T}) - \tfrac{1}{2}\sigma^2(\mathrm{T} - t), \sigma^2(T - t)\right).$$

The volatility of a futures contract (σ^i) is estimated as the average of the implied volatilities from near-the-money call and put options. Bisection root-finding method is used to invert the trinomial tree option pricing model (Boyle, 1986) to get implied volatilities. Since prices of the contracts that expire in more than a year are needed, proper data imputation strategy is required to deal with the illiquidity of the deferred soybean meal and Class IV option contracts. For deferred soybean meal options that were not traded on a particular day, the implied volatility of the contract that expires the closest to the deferred contract is used as the imputed value. This can be justified for deeply deferred contracts are usually priced based on long-term average. For Class IV options whose price cannot be found on a particular day, if they expire before the first 3 months in the coverage year, implied volatility of the Class III option with the same expiration is used as imputed value; if they expire after the first 3 months in the coverage year, the imputation rule for soybean meal applies.

To put together a multivariate normal distribution with marginal distributions, a correlation matrix $\boldsymbol{R}$ for all possible pairs of random variables has to be determined. Define realized price shock $\eta_\tau^T = f_{T,T} - f_{t,T}$. Let $\{\hat{T}_i\}$ be a sequence of months in which Class III or Class IV contracts expire. For grain futures, $f_{t,T}$ and $f_{T,T}$ are weighted prices following Table 3. Let $\{\tau_j\}$ be a sequence of 96 τ's. These 96 τ's can be further divided into 4 groups with 24 τ's in each group. These four groups represent four futures commodities: Class III milk, Class IV milk, corn and soybean meals. Within each group, τ

[5] For an exposure to how this stochastic differential equation is solved, see Hull, J.C. 2009. *Options, Futures, and other derivatives*: Prentice-Hall Inc..

sequentially ranges from one month to 24 months. The (j, k) element in the correlation matrix equals the correlation between sequence $\left\{\eta_{\tau_j}^{\hat{T}_i}\right\}$ and $\left\{\eta_{\tau_k}^{\hat{T}_i}\right\}$. This correlation is regarded as the correlation between $\left(F_{T_1-\tau_j,T_1} - E_{T_1-\tau_j}\left[F_{T_1,T_1}\right]\right)$ and $\left(F_{T_2-\tau_k,T_2} - E_{T_2-\tau_k}\left[F_{T_2,T_2}\right]\right)$[6] for any contract expiration months T_1 and T_2. Since expectations are deterministic, it can be interpreted as the correlation between random variables $F_{T_1-\tau_j,T_1}$ and $F_{T_2-\tau_k,T_2}$. In practice, the actual correlation matrix $\boldsymbol{R}$ is determined by removing the columns and rows from the 96x96 matrix and only leaving the ones that are relevant to a particular simulation.

Because Class IV futures market was very illiquid before 2007, not all 24 contracts of Class IV futures are traded on a particular day. Contracts that expire in 1 to 4 months are more frequently traded than those deeply deferred contracts. As a matter of fact, 61 out of 127 months sampled to construct the correlation matrix contain at least one missing price for Class IV. A simple solution of excluding data before 2007 causes the correlation coefficients between any two of the rest three commodities unrealistically high due to the 2008 financial crisis and its ripple effect over a few years after. Omitting only Class IV data before 2007 while keeping the rest of the commodities over a longer period renders the correlation matrix not positive definite[7]. In a belief that deferred contracts are priced based on long term trend, missing prices on the same day are linearly extrapolated through an OLS regression model on the available data of the term structure[8]. The extrapolation method does not apply to observations that only contain no more than 4 available prices because of the information scarcity of the term structure those observations provide. This leads to the exclusion of 10 observations from the dataset that generates the correlation matrix.

The Spearman's rho is defined as the Pearson correlation coefficient of the ranked variables. For a sample set $\mathbf{H}$, let h_t^i denotes the tth observation of the ith variable. The ranked value of the sample observation h_t^i is defined as

$$r_t^i = \sum_{s \in \mathbf{H}^{\mathrm{i}}} \mathbf{1}_{h_t^i \leq s}$$

where $\mathbf{H}^{\mathrm{i}}$ is the subset of $\mathbf{H}$ with all sample values of the ith variable in it; $\mathbf{1}_A$ is the indicator function that takes the value of 1 if condition A is satisfied or takes 0 otherwise. Since the Spearman's rho only depends on the ordinal order of the observations in a sample set, any monotonically increasing transformation preserves Spearman's rho. This interesting property of Spearman's rho is crucial to preserve dependence structure among all contracts.

Finally, the data generating process can be described as the following (Press, et al., 2007):

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[6] If we believe futures price is a Martingale process, $E_t\left[F_{t,T}\right] = f_{t,T}$.

[7] The data generating process performs Cholesky decomposition of the correlation matrix. The Cholesky decomposition requires the correlation matrix to be positive definite.

[8] A term structure of a commodity is the prices of a continuous range of contract months observed on a same day. The range usually goes from the first contract that expires after the observe day to as far as the research needs or the market trades.

Let $\boldsymbol{X} = (X_1, \dots, X_i, \dots, X_M)'$ be a vector of standard-normally distributed random variables. Use Cholesky decomposition to factor Spearman's rho correlation matrix $\boldsymbol{R}$ into the lower triangular matrix $\boldsymbol{L}$ post multiplied by its transpose $\boldsymbol{L}'$:

$$\boldsymbol{R} = \boldsymbol{L} \times \boldsymbol{L}'.$$

Then $\boldsymbol{Z} = (Z_1, \dots, Z_i, \dots, Z_M)' = \boldsymbol{LX} \sim N(\boldsymbol{0}, \boldsymbol{R})$ follows multivariate normal distribution with mean zero and variance-covariance matrix $\boldsymbol{R}$. Thus the terminal prices of Class III milk, Class IV milk, corn and soybean meal follow multivariate log-normal distribution ln N $(\boldsymbol{\mu}, \boldsymbol{\Sigma R \Sigma}')$:

$$\boldsymbol{Y} = \boldsymbol{\Sigma L X} + \boldsymbol{\mu}$$

where $\boldsymbol{Y} = \left(ln\left(F_{t,T_1}\right), \dots, ln\left(F_{t,T_i}\right), \dots, ln\left(F_{t,T_M}\right)\right)'$ is an $M \times 1$ column vector of log-prices; $\boldsymbol{\Sigma}$ is a diagonal matrix with the ith diagonal entry equal to the time scaled implied volatility $\sigma_i\sqrt{T_i - t}$ for the ith contract; and $\boldsymbol{\mu}$ is a column vector of means with $\left(\ln\left(f_{t,T_i}\right) - \frac{1}{2}\sigma^2(T_i - t)\right)$ as the ith element.

It is worth noting that the correlation coefficient matrix $corr[\boldsymbol{Y}] = \boldsymbol{R}$, because any (l, k) entry in the variance-covariance matrix $\boldsymbol{\Sigma R \Sigma}'$ is equal to the product of the standard deviation of each variable multiplied by the (l, k) entry of the $\boldsymbol{R}$ matrix. Furthermore let $\boldsymbol{F}_{t,\boldsymbol{T}} = \left(F_{t,T_1}, \dots, F_{t,T_i}, \dots F_{t,T_M}\right)'$ be a column vector of prices at time t obtained by taking the exponential function on $\boldsymbol{Y}$ element by element. Because the exponential function is monotonically increasing, $corr\left[\boldsymbol{F}_{t,\boldsymbol{T}}\right] = \boldsymbol{R}$. Thus the dependence structure is preserved.

Appendix C: Additional tables and figures

Table 5 National basis models

	All milk price$_t$	NASS Corn$_t$	NASS Soybean meal$_t$	NASS Hay$_t$
Intercept	1.8548***	0.0490	-3.6946	4.3358***
	(0.0925)	(0.0622)	(3.4031)	(1.6553)
Class III$_t$	0.4235***			
	(0.0147)			
Class IV$_t$	0.2723***			
	(0.0126)			
Max(Class III$_{t-1}$, Class IV$_{t-1}$)	0.2889***			
	(0.0169)			
CME Corn$_t$		0.9250***		3.5193***
		(0.0120)		(0.5409)
CME Soybean Meal$_t$			1.0203***	-0.0184**
			(0.0102)	(0.0081)
Nass Hay$_{t-1}$				0.8935***
				(0.0213)
1st Quarter Dummy	-0.0405	0.0200	1.2473	3.1078***
	(0.0527)	(0.0619)	(2.9443)	(1.1360)
2nd Quarter Dummy	-0.4459***	0.0442	-2.3605	2.8151**
	(0.0535)	(0.0623)	(2.9626)	(1.1277)
3rd Quarter Dummy	-0.4815***	0.0191	1.7367	1.4895
	(0.0530)	(0.0622)	(2.9676)	(1.1250)
Number of observations	169	170	170	169
R^2	0.9950	0.9731	0.9840	0.9852

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 6 Regional basis models

	Upper Midwest Mailbox	Lower Midwest Mailbox	Upper Midwest NASS Corn	Lower Midwest NASS Corn	Upper Midwest NASS Hay	Lower Midwest NASS Hay
Intercept	1.8958*** (0.1856)	1.7506*** (0.2999)	-0.0138 (0.063)	0.066 (0.0604)	5.0392*** (1.4974)	3.0909*** (1.18)
Announced Class III	0.6775*** (0.0248)	0.5575*** (0.0401)				
Announced Class IV	0.3329*** (0.0237)	0.4541*** (0.0383)				
Weighted CME Corn			0.9257*** (0.0122)	0.9427*** (0.0117)	1.6983*** (0.4009)	2.7783*** (0.3552)
Weighted CME Soybean Meal					-0.0014 (0.0089)	-0.0177*** (0.006)
Lag Hay					0.9281*** (0.0228)	0.9368*** (0.0145)
1^{st} Quarter Dummy	-0.1819 (0.1134)	-0.4494** (0.1832)	0.028 (0.061)	-0.0019 (0.0584)	-2.704** (1.1281)	-1.7074* (0.919)
2^{nd} Quarter Dummy	-0.8628*** (0.1124)	-1.3392*** (0.1815)	0.0807 (0.061)	0.0468 (0.0585)	-3.6241*** (1.1352)	-0.719 (0.9308)
3^{rd} Quarter Dummy	-0.8524*** (0.1121)	-0.8022*** (0.1811)	0.0836 (0.061)	0.0085 (0.0585)	-3.6365*** (1.1629)	0.7105 (0.9306)
# of obs	167	167	167	167	167	167
R^2	0.982538433	0.95662701	0.972791699	0.975781861	0.9815	0.9912

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

See Appendix A for more explanation.

Table 7 Regional hay models

	Upper Midwest Hay Basis Model	Lower Midwest Hay Basis Model	Upper Midwest Hay Cross-hedge Model	Lower Midwest Hay Cross-hedge Model
Intercept	5.0392*** (1.4974)	3.0909*** (1.18)	29.9032 (0.7696)	31.0558 (0.7566)
Weighted CME Corn	1.6983*** (0.4009)	2.7783*** (0.3552)	5.258 (1.3613)	12.7958 (1.6528)
Weighted CME Soybean Meal	-0.0014 (0.0089)	-0.0177*** (0.006)	0.2285 (0.0225)	0.1611 (0.0274)
Lag Hay	0.9281*** (0.0228)	0.9368*** (0.0145)		
1^{st} Quarter Dummy	-2.704** (1.1281)	-1.7074* (0.919)		
2^{nd} Quarter Dummy	-3.6241*** (1.1352)	-0.719 (0.9308)		
3^{rd} Quarter Dummy	-3.6365*** (1.1629)	0.7105 (0.9306)		
# of obs	167	167	167	167
R^2	0.9815	0.9912	0.7696	0.7566

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Hay basis models convert futures prices to local hay prices for the calculation of feed cost. The cross-hedge models determine the hedging P&L for the hay hedge.

Table 8 Regional mailbox price models

	Upper Midwest Mailbox Milk Price	Lower Midwest Mailbox Milk Price
Intercept	1.4835*** (0.2068)	1.075*** (0.3087)
Announced Class III	0.6905*** (0.0306)	0.5842*** (0.0457)
Announced Class IV	0.3153*** (0.0294)	0.4284*** (0.0439)
Number of observations	167	167
R^2	0.9722	0.9409

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 9 Values of key simulation variables

Coverage Year	Sign-up	Quote Date	Optimal Coverage Level	Avg. Indemnity Payment	Avg. Simulated ADPM	MPP Premium	Average Cash Sales Income†			
							LMW Grower	LMW Purchaser	UMW Grower	UMW Purchaser
2008	Oct	10/1/2007	4.0	0.0002	10.3012	0	17.8145	9.8781	17.9413	10.2410
2008	Jan	1/2/2008	4.0	0.0004	9.6925	0	18.4408	9.3106	18.7832	9.8639
2009	Apr	4/2/2008	6.0	0.2518	8.8320	0.1476	18.8417	8.1028	19.2205	9.0145
2009	Oct	10/1/2008	6.0	0.2106	7.6996	0.1476	16.9644	7.2210	17.3906	8.0414
2009	Jan	1/2/2009	8.0	2.3013	5.6173	1.2944	13.7718	5.2107	14.0826	5.7530
2010	Apr	4/1/2009	5.0	0.0817	8.9357	0.0389	16.7562	8.1984	17.0845	8.9054
2010	Oct	10/1/2009	4.0	0.0011	8.5947	0	15.4088	8.1047	15.9232	8.6991
2010	Jan	12/31/2009	4.0	0.0024	8.5591	0	16.4557	8.2388	16.7990	8.7225
2011	Apr	4/1/2010	4.0	0.0058	8.5721	0	15.7269	7.9868	16.1542	8.6470
2011	Oct	9/30/2010	6.5	0.4981	6.7205	0.2752	15.6676	6.3011	15.9654	6.9004
2011	Jan	12/31/2010	8.0	2.0371	5.8798	1.2944	16.5248	5.5956	16.7331	6.1674
2012	Apr	4/1/2011	8.0	2.2881	5.8067	1.2944	16.6162	5.0017	17.0676	6.0265
2012	Oct	9/30/2011	6.5	0.3570	7.6120	0.2752	18.1762	6.9263	18.4220	8.0052
2012	Jan	1/3/2012	6.0	0.2186	7.3098	0.1476	18.4605	6.6559	18.7913	7.9779
2013	Apr	4/2/2012	6.5	0.6230	6.8999	0.2752	16.9682	5.9863	17.3751	7.0754
2013	Oct	10/1/2012	6.5	0.6472	6.8496	0.2752	19.5017	5.9048	19.9239	6.9510
2013	Jan	1/2/2013	4.0	0.0102	7.3891	0	19.5435	6.7725	19.8744	7.5896
2014	Apr	4/1/2013	6.0	0.2170	7.5669	0.1476	17.5907	6.6129	18.0006	7.4911
2014	Oct	10/1/2013	4.0	0.0003	9.2731	0	18.4818	8.5601	18.6789	9.0839
2014	Jan	12/31/2013	4.0	0.0000	11.0041	0	20.1142	10.4819	20.1790	10.7255

All values except dates and years are in $/cwt.

† For feed growers, the cash sales income equals milk revenue. For feed purchasers, cash sales income equals the milk sales net feed cost.

Table 10 Crowding-out effect on upper Midwest feed growers

Coverage Year	Sign-Up Month	Cost benchmark	Non-participant	Participant	% change
2008	2007 Oct	16.40	0.00%	0.00%	0.00%
2008	2008 Jan	16.40	0.00%	0.00%	0.00%
2009	2008 Apr	15.30	0.00%	0.00%	0.00%
2009	2008 Oct	15.30	0.00%	0.00%	0.00%
2009	2009 Jan	15.30	#N/A	#N/A	
2010	2009 Apr	14.96	0.00%	0.00%	0.00%
2010	2009 Oct	14.96	0.00%	0.00%	0.00%
2010	2009 Jan	14.96	0.00%	0.00%	0.00%
2011	2010 Apr	16.85	#N/A	#N/A	
2011	2010 Oct	16.85	#N/A	#N/A	
2011	2011 Jan	16.85	#N/A	#N/A	
2012	2011 Apr	18.15	#N/A	#N/A	
2012	2011 Oct	18.15	77.83%	86.39%	-10.99%
2012	2012 Jan	18.15	33.84%	19.17%	43.36%
2013	2012 Apr	19.24	#N/A	#N/A	
2013	2012 Oct	19.24	43.89%	0.00%	100.00%
2013	2013 Jan	19.24	25.76%	23.58%	8.44%
2014	2013 Apr	18.07	#N/A	#N/A	
2014	2013 Oct	18.07	26.57%	26.48%	0.31%
2014	2014 Jan	18.07	0.00%	0.00%	0.00%

Class IV contracts are not available in April 2007.

Table 11 Crowding-out effect on upper Midwest feed purchasers

Coverage Year	Sign Up Month	Cost benchmark	Non-participant	Participant	% change
2008	2007 Oct	7.84	0.00%	0.00%	0.00%
2008	2008 Jan	7.84	0.00%	0.00%	0.00%
2009	2008 Apr	7.13	23.24%	0.00%	100.00%
2009	2008 Oct	7.13	44.58%	19.16%	57.02%
2009	2009 Jan	7.13	#N/A	#N/A	
2010	2009 Apr	7.34	27.40%	15.66%	42.86%
2010	2009 Oct	7.34	0.00%	0.00%	0.00%
2010	2009 Jan	7.34	0.00%	0.00%	0.00%
2011	2010 Apr	7.56	25.32%	23.67%	6.51%
2011	2010 Oct	7.56	#N/A	#N/A	
2011	2011 Jan	7.56	#N/A	#N/A	
2012	2011 Apr	7.52	#N/A	#N/A	
2012	2011 Oct	7.52	70.93%	40.47%	42.95%
2012	2012 Jan	7.52	66.28%	38.73%	41.57%
2013	2012 Apr	7.65	#N/A	#N/A	
2013	2012 Oct	7.65	#N/A	#N/A	
2013	2013 Jan	7.65	#N/A	#N/A	
2014	2013 Apr	7.58	#N/A	#N/A	
2014	2013 Oct	7.58	0.00%	0.00%	0.00%
2014	2014 Jan	7.58	0.00%	0.00%	0.00%

Class IV contracts are not available in April 2007.

Table 12 Crowding-out effect on lower Midwest feed growers

Coverage Year	Sign-Up Month	Cost benchmark	Non-participant	Participant	% change
2008	2007 Oct	15.79	0.00%	0.00%	0.00%
2008	2008 Jan	15.79	0.00%	0.00%	0.00%
2009	2008 Apr	15.22	0.00%	0.00%	0.00%
2009	2008 Oct	15.22	0.00%	0.00%	0.00%
2009	2009 Jan	15.22	#N/A	#N/A	
2010	2009 Apr	14.66	0.00%	0.00%	0.00%
2010	2009 Oct	14.66			
2010	2009 Jan	14.66	0.00%	0.00%	0.00%
2011	2010 Apr	17.03	#N/A	#N/A	
2011	2010 Oct	17.03	#N/A	#N/A	
2011	2011 Jan	17.03	#N/A	#N/A	
2012	2011 Apr	17.68	#N/A	#N/A	
2012	2011 Oct	17.68	57.55%	48.93%	14.98%
2012	2012 Jan	17.68	16.12%	0.00%	100.00%
2013	2012 Apr	19.12	#N/A	#N/A	
2013	2012 Oct	19.12	69.57%	34.97%	49.74%
2013	2013 Jan	19.12	47.28%	45.28%	4.24%
2014	2013 Apr	17.96	#N/A	#N/A	
2014	2013 Oct	17.96	36.86%	36.78%	0.23%
2014	2014 Jan	17.96	0.00%	0.00%	0.00%

Class IV contracts are not available in April 2007.

Table 13 Crowding-out effect on lower Midwest feed purchasers

Coverage Year	Sign Up Month	Cost benchmark	Non-participant	Participant	% change
2008	2007 Oct	7.67	0.00%	0.00%	0.00%
2008	2008 Jan	7.67	0.00%	0.00%	0.00%
2009	2008 Apr	6.92	53.45%	28.21%	47.23%
2009	2008 Oct	6.92	80.90%	64.91%	19.76%
2009	2009 Jan	6.92	#N/A	#N/A	
2010	2009 Apr	7.04	46.87%	35.38%	24.52%
2010	2009 Oct	7.04	10.08%	9.69%	3.88%
2010	2009 Jan	7.04	0.00%	0.00%	0.00%
2011	2010 Apr	7.08	37.51%	35.83%	4.49%
2011	2010 Oct	7.08	#N/A	#N/A	
2011	2011 Jan	7.08	#N/A	#N/A	
2012	2011 Apr	6.34	#N/A	#N/A	
2012	2011 Oct	6.34	66.12%	31.95%	51.67%
2012	2012 Jan	6.34	76.45%	53.46%	30.07%
2013	2012 Apr	7.15	#N/A	#N/A	
2013	2012 Oct	7.15	#N/A	#N/A	
2013	2013 Jan	7.15	#N/A	#N/A	
2014	2013 Apr	7.65	#N/A	#N/A	
2014	2013 Oct	7.65	19.83%	19.72%	0.56%
2014	2014 Jan	7.65	0.00%	0.00%	0.00%

Class IV contracts are not available in April 2007.

Figure 5 Upper Midwest grower signing up on Oct, 2007 for 2008 (CL:4.0, PC:90%)

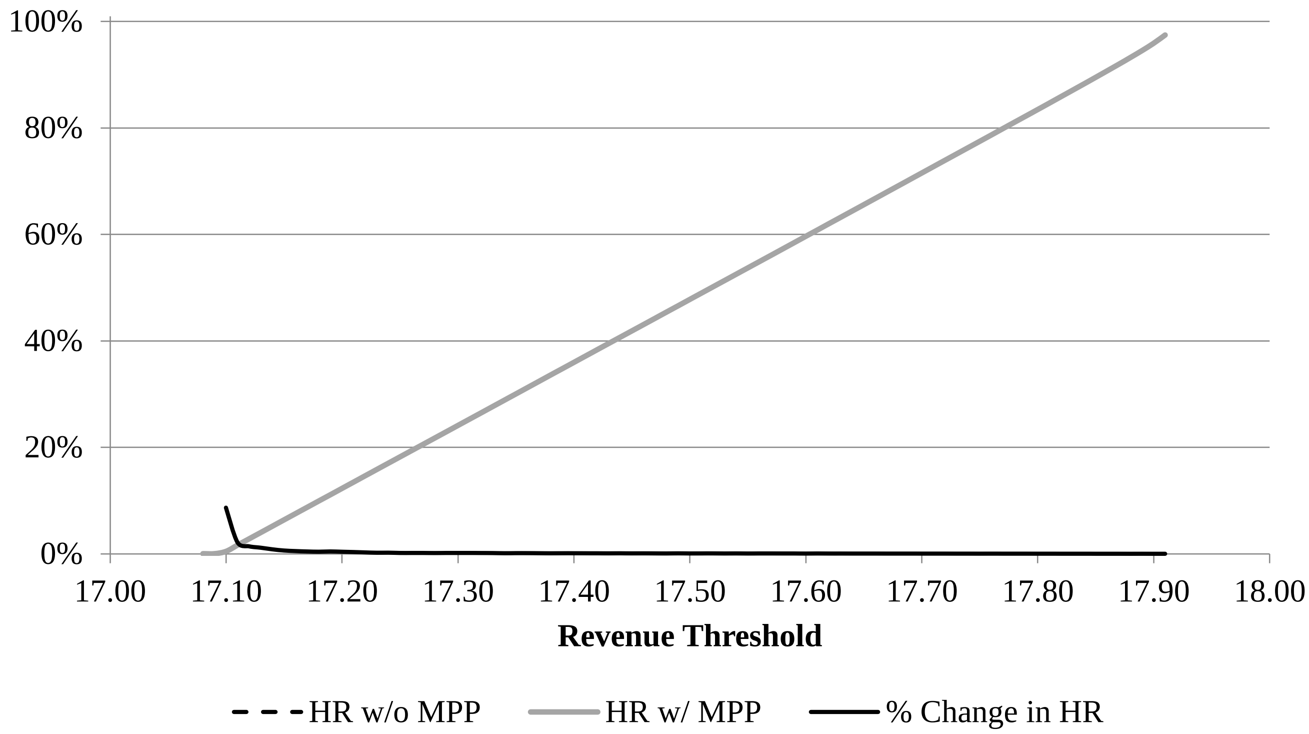

Figure 6 Lower Midwest grower signing up on Oct, 2007 for 2008 (CL:4.0 CP:90%)

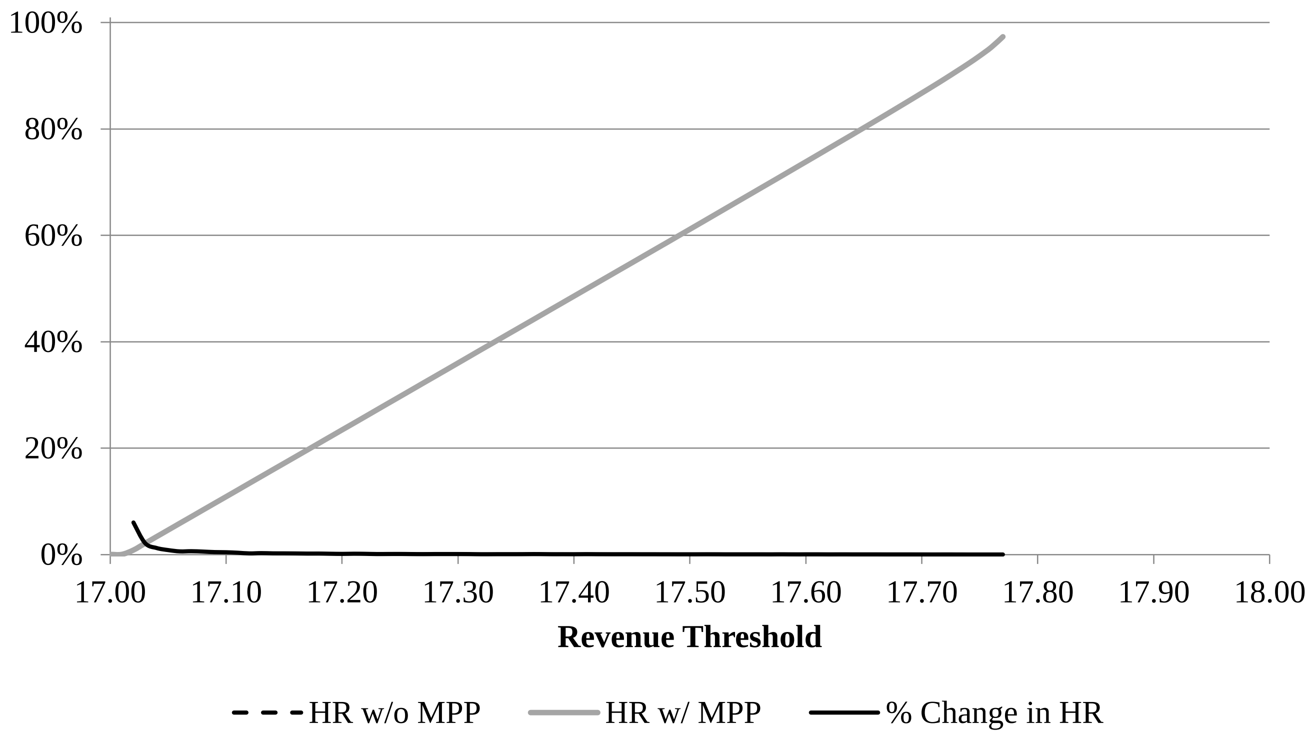

Figure 7 Upper Midwest grower signing up on Oct, 2008 for 2009 (CL:6.0 CP:90%)

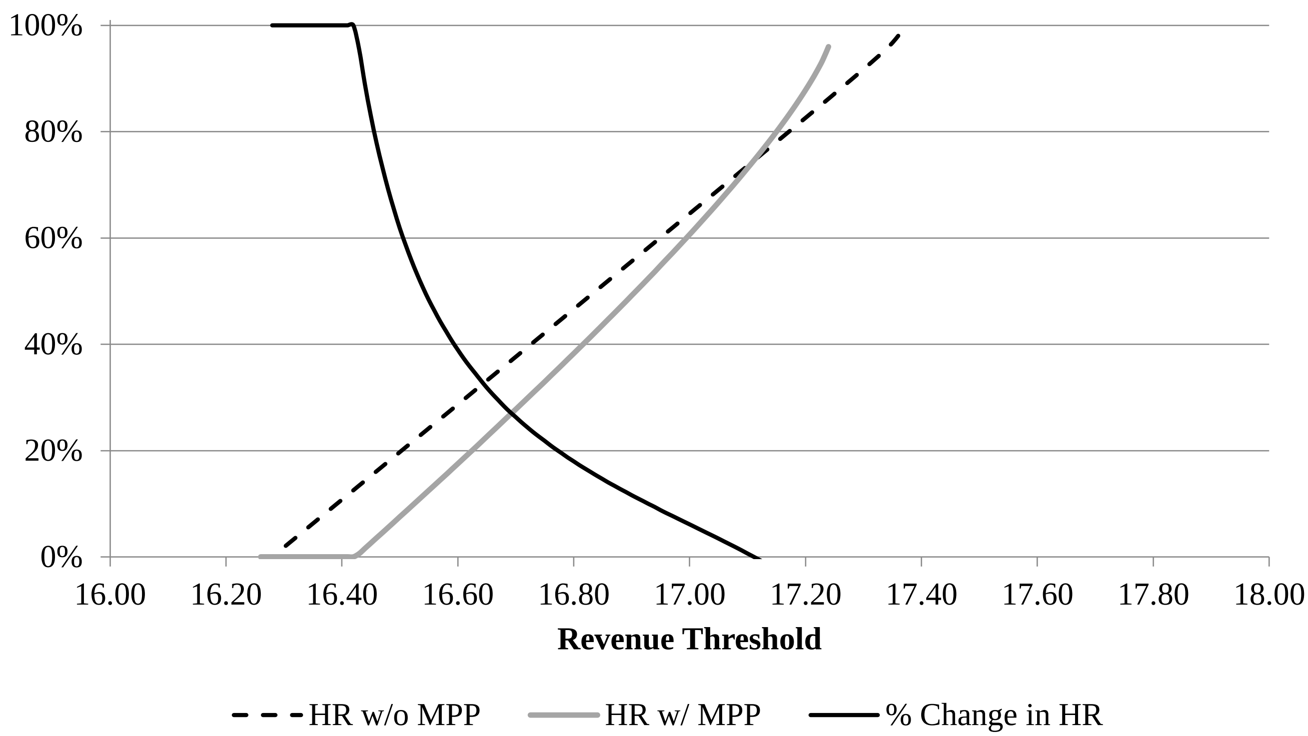

Figure 8 Lower Midwest grower signing up on Oct, 2008 for 2009 (CL:6.0 CP:90%)

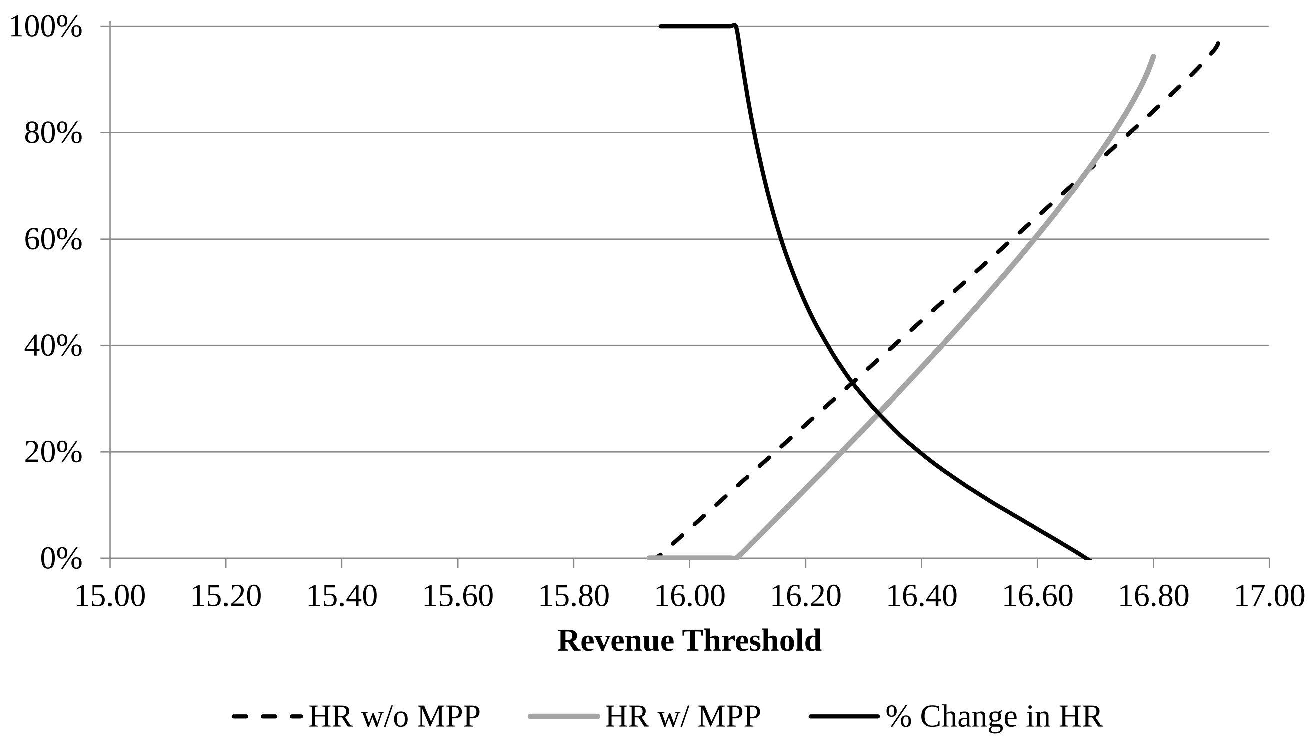

Figure 9 Upper Midwest grower signing up on Apr, 2008 for 2009 (CL:6.0 CP:90%)

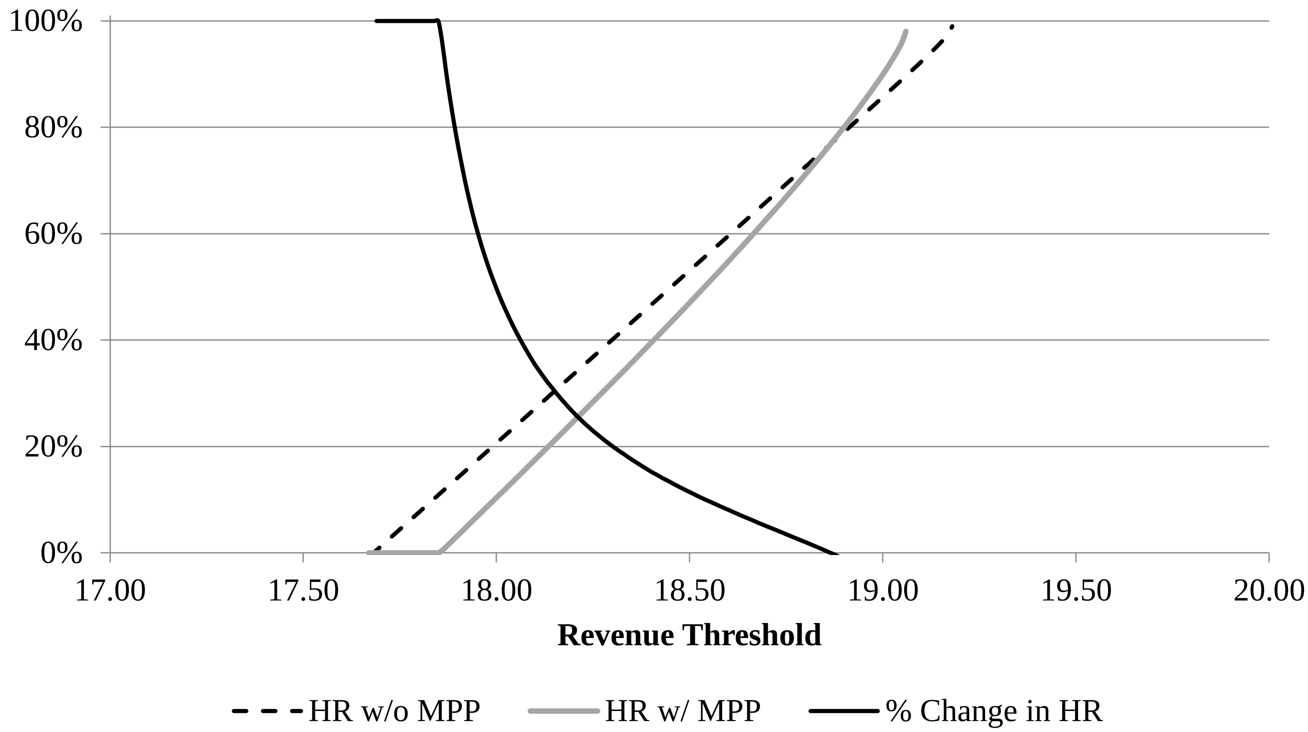

Figure 10 Lower Midwest grower signing up on Apr, 2008 for 2009 (CL:6.0 CP:90%)

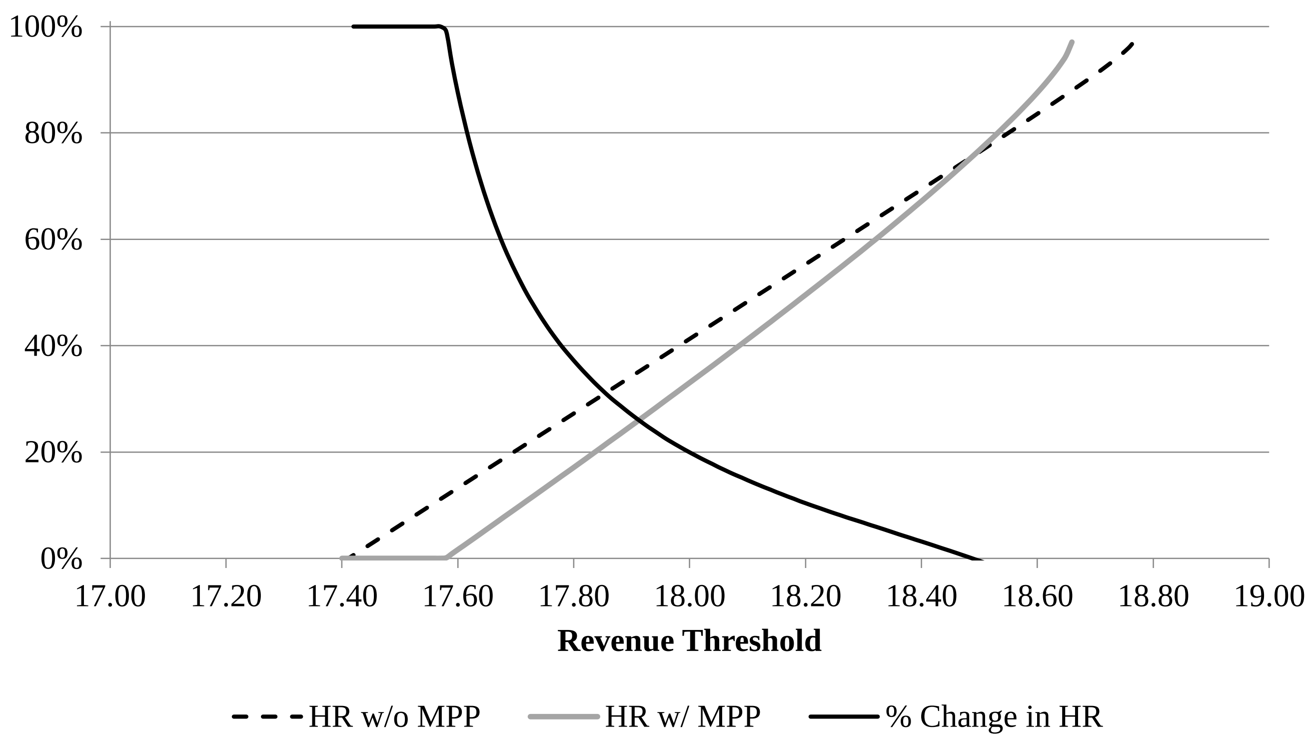

Figure 11 Upper Midwest grower signing up on Jan, 2009 for 2009 (CL:8.0 CP:90%)

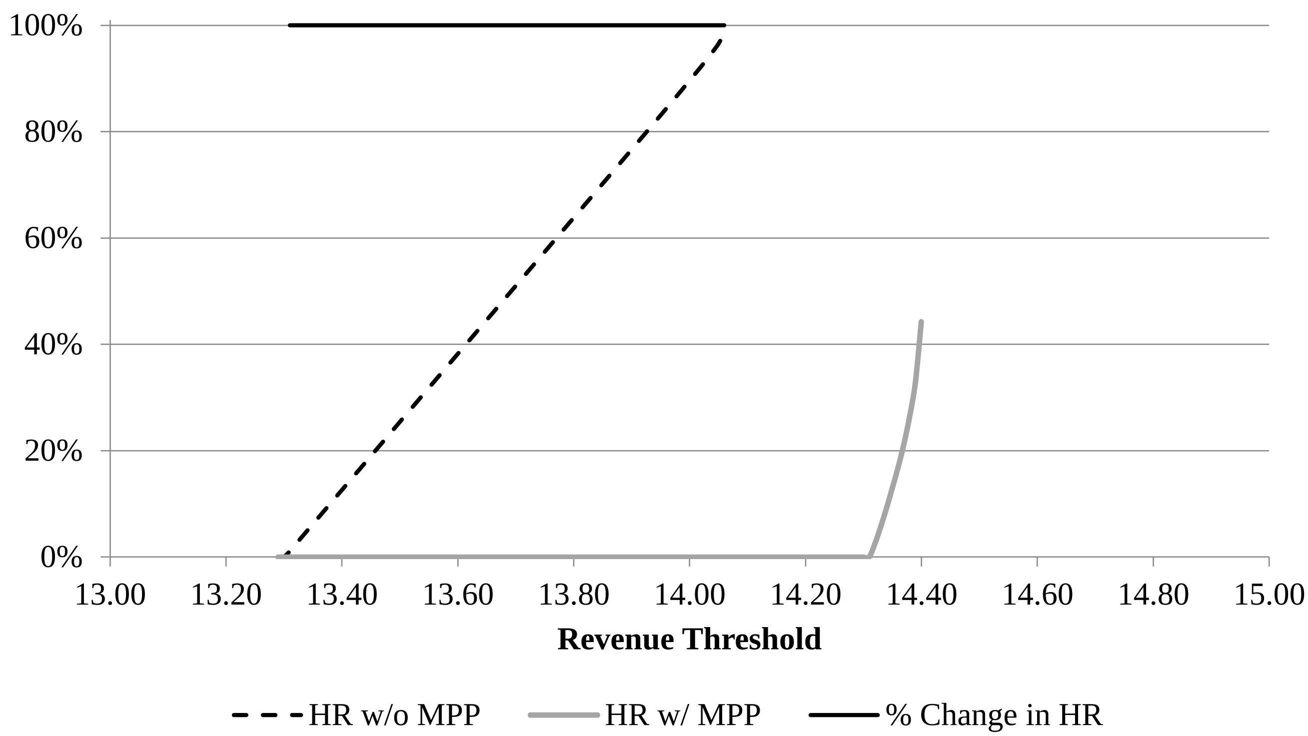

Figure 12 Lower Midwest grower signing up on Jan, 2009 for 2009 (CL:8.0 CP:90%)

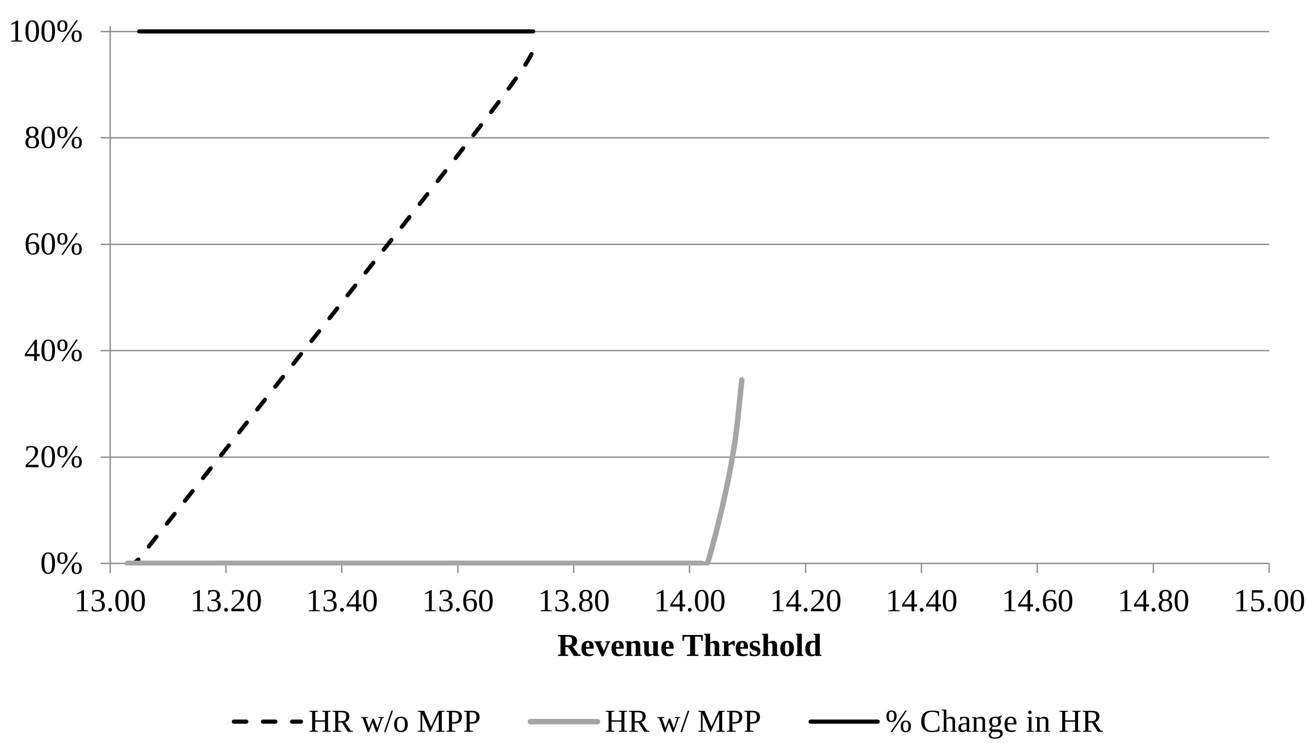

Figure 13 Upper Midwest grower signing up on Apr, 2011 for 2012 (CL:8.0 CP:90%)

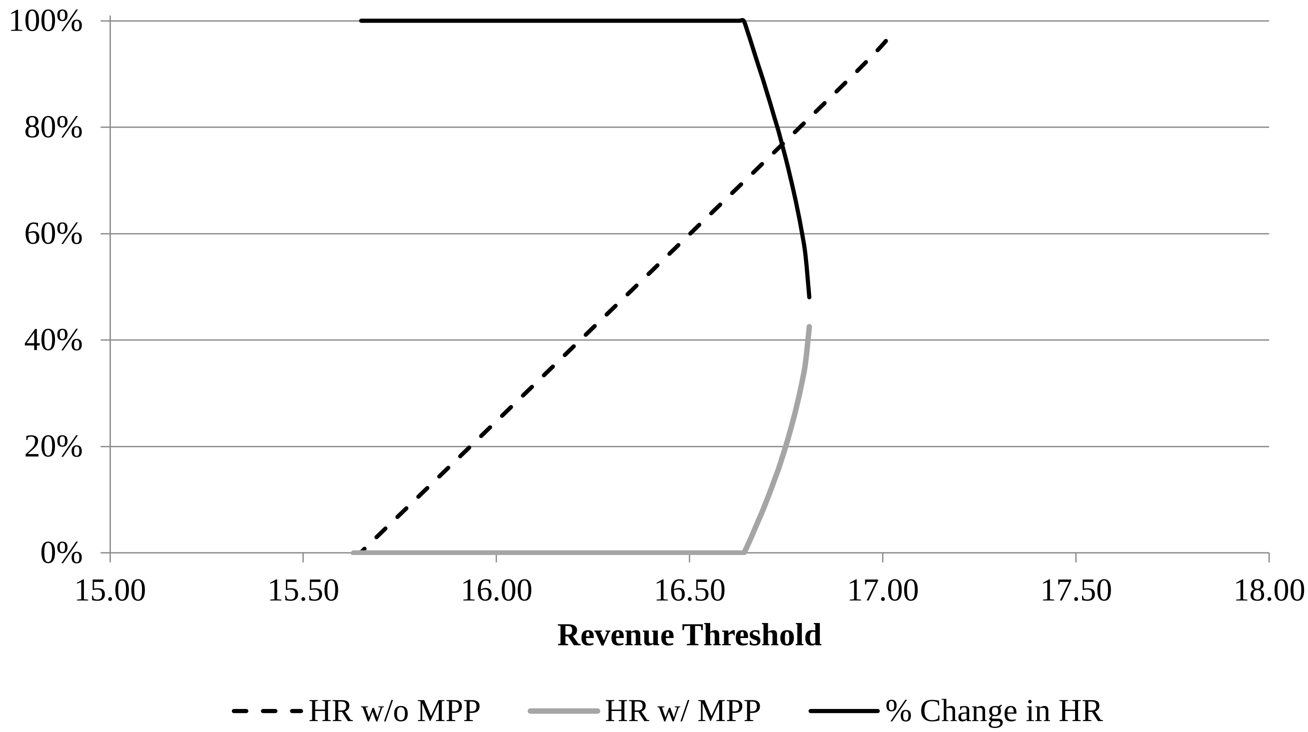

Figure 14 Lower Midwest grower signing up on Apr, 2011 for 2012 (CL:8.0 CP:90%)

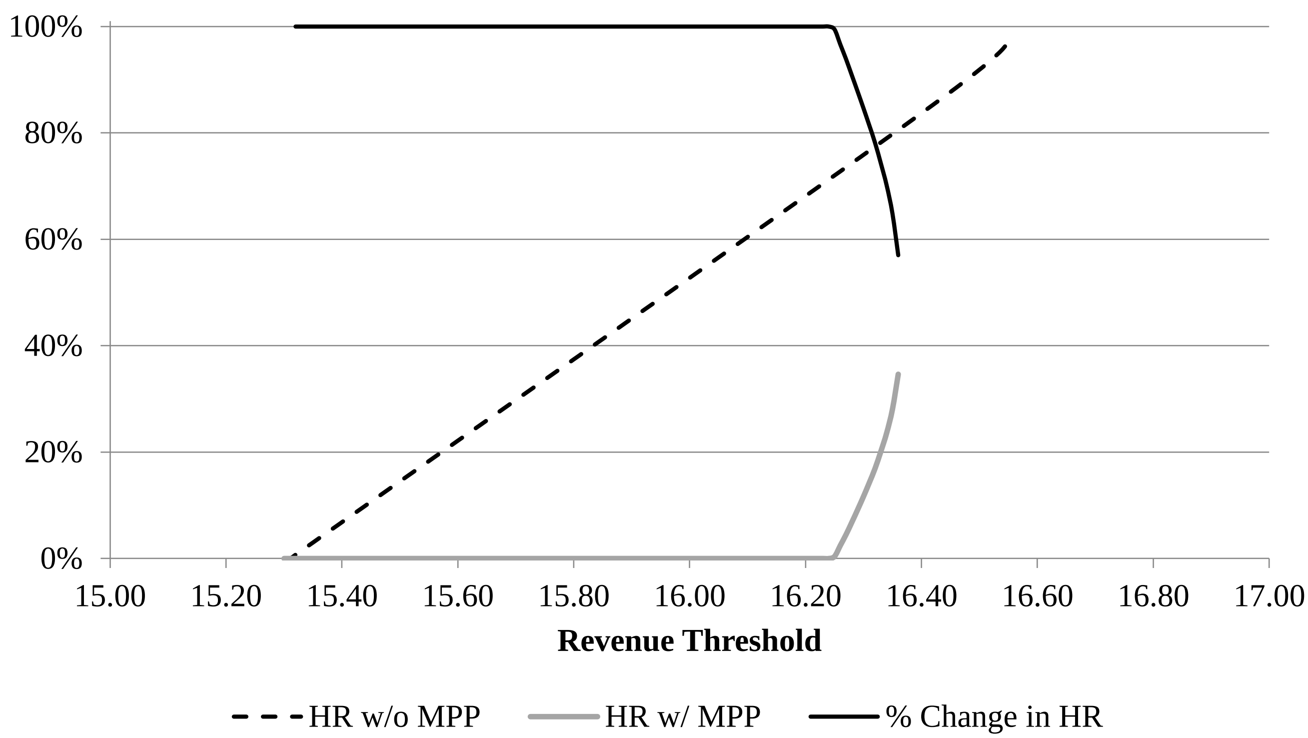

Figure 15 Upper Midwest grower signing up on Oct, 2011 for 2012 (CL:6.5 CP:90%)

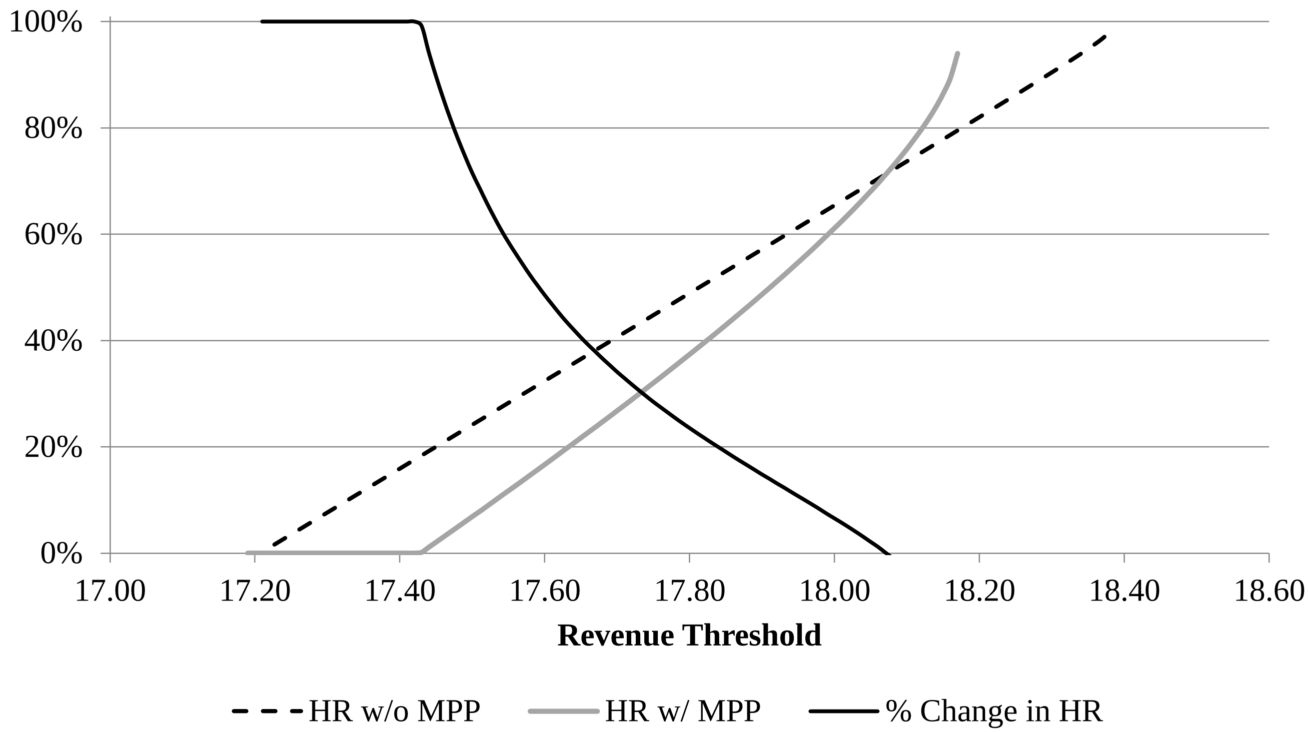

Figure 16 Lower Midwest grower signing up on Oct, 2011 for 2012 (CL:6.5 CP:90%)

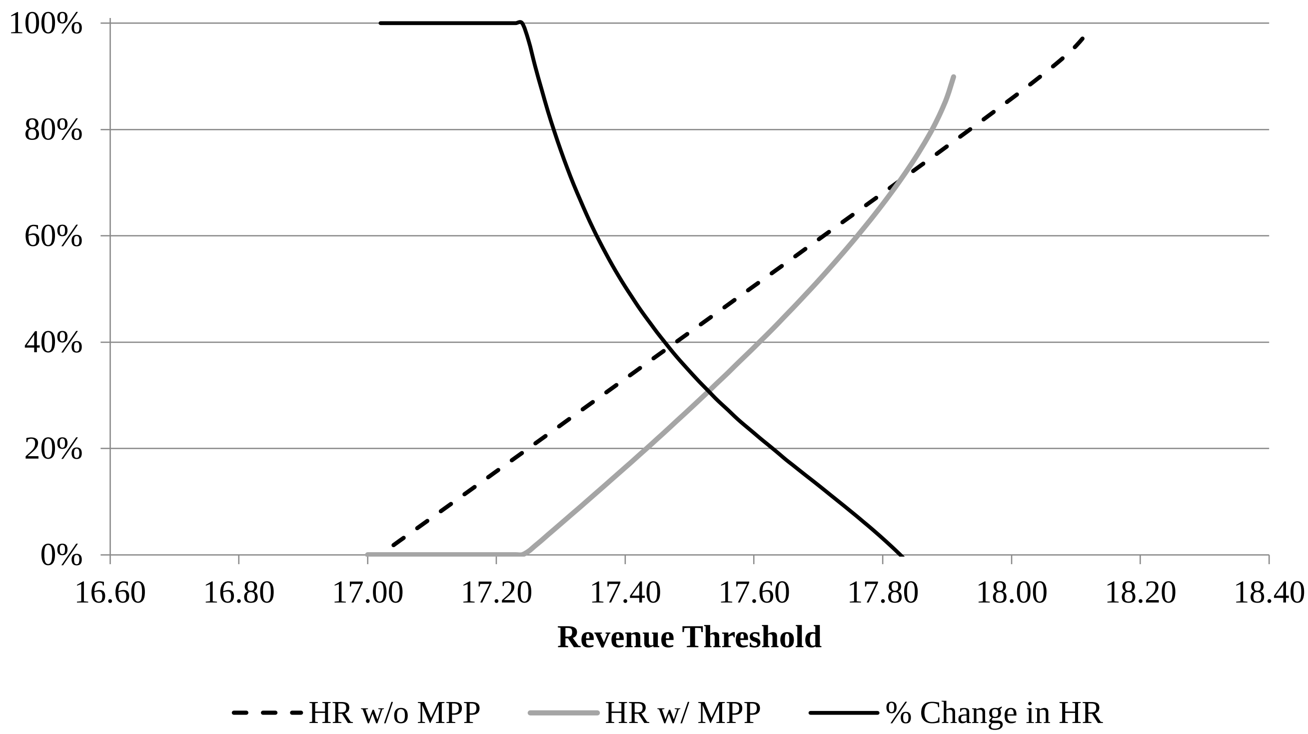

Figure 17 Upper Midwest grower signing up in Jan, 2012 for 2012 (CL:6.0 CP:90%)

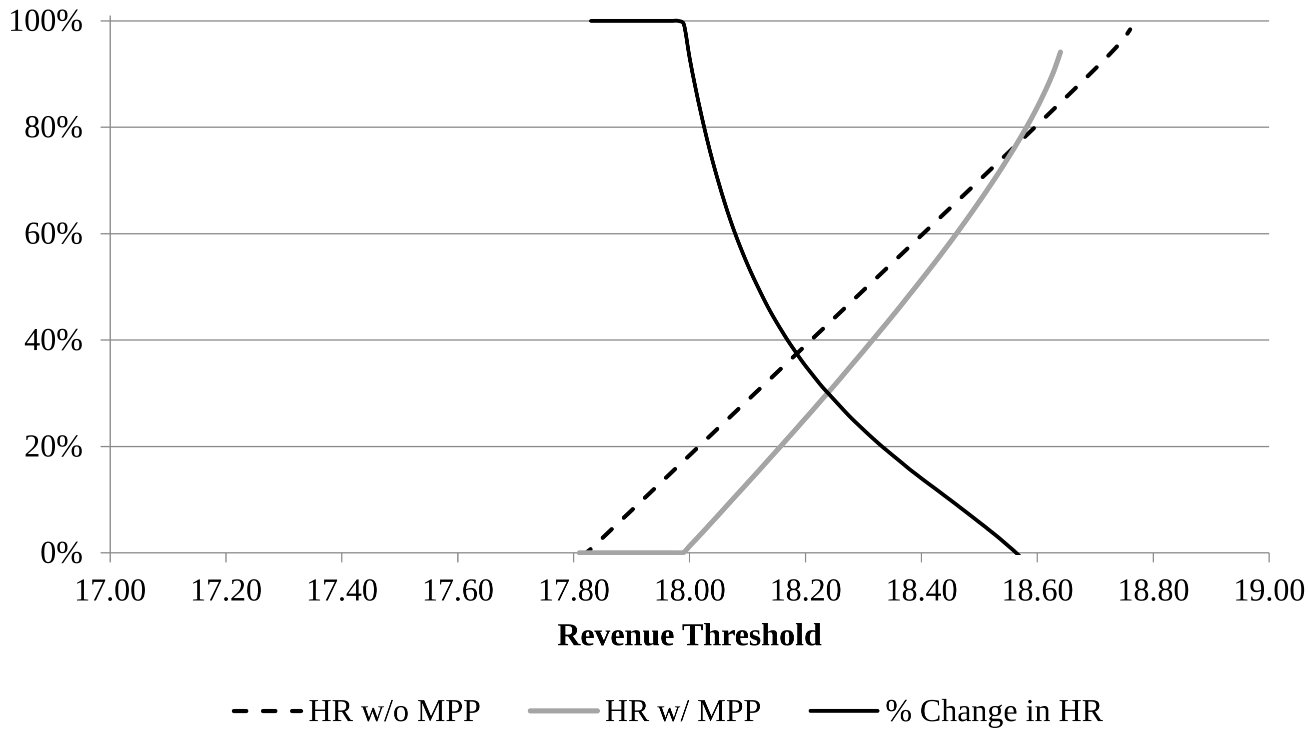

Figure 18 Lower Midwest grower signing up in Jan, 2012 for 2012 (CL:6.0 CP:90%)

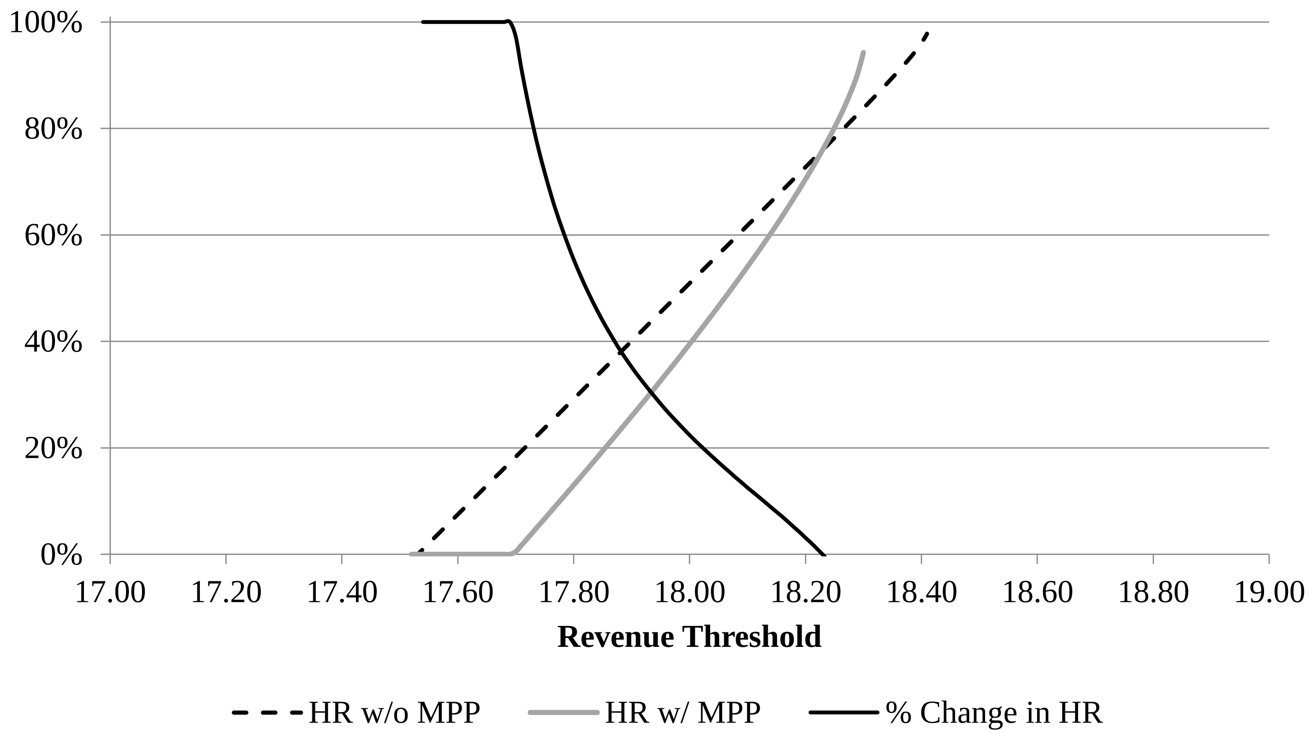

Figure 19 Upper Midwest grower signing up in Oct, 2012 for 2013 (CL:6.5 CP:90%)

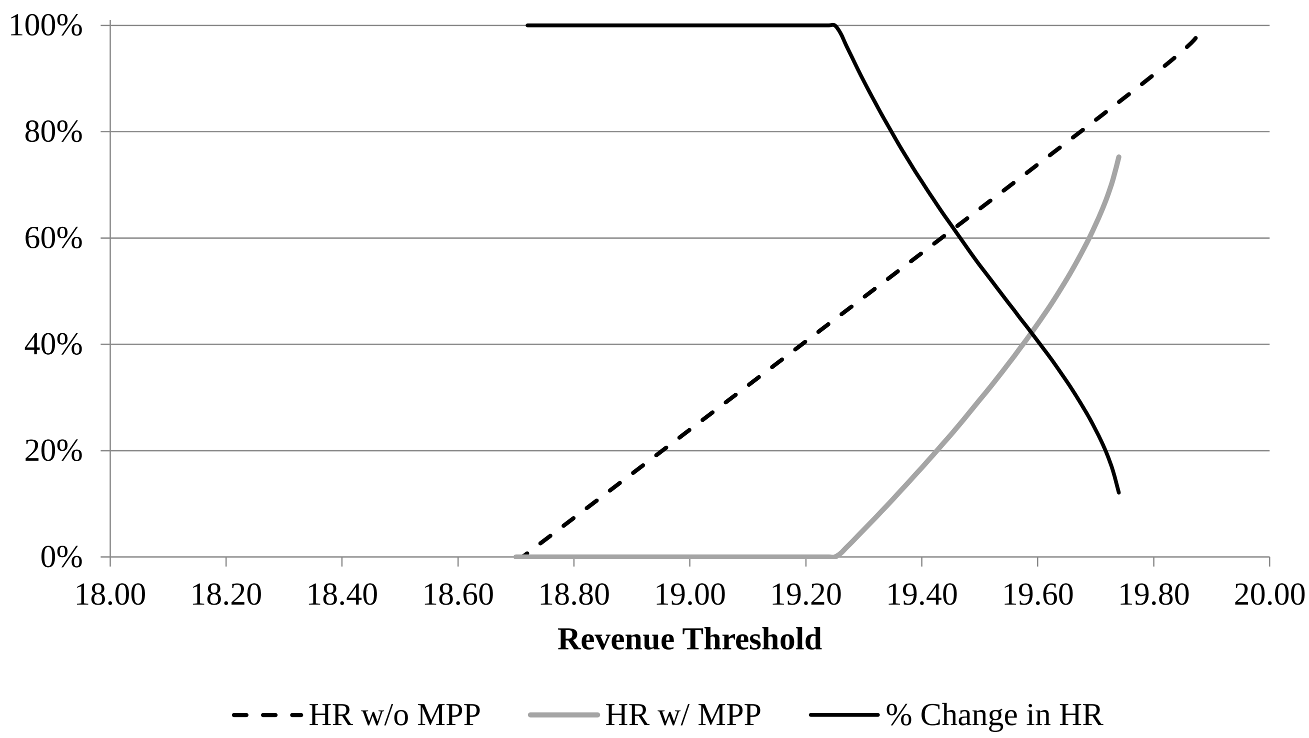

Figure 20 Lower Midwest grower signing up in Oct, 2012 for 2013 (CL:6.5 CP:90%)

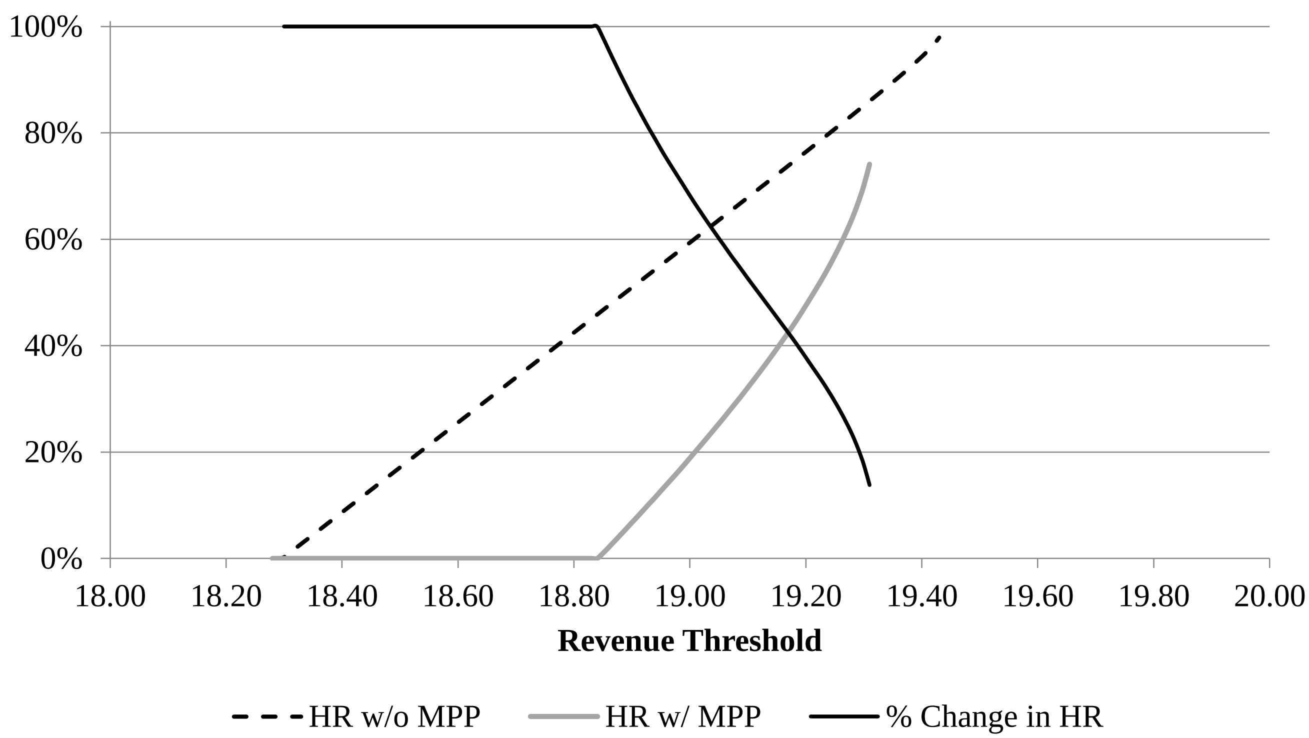

Figure 21 Upper Midwest grower signing up in Apr, 2012 for 2013 (CL:6.5 CP:90%)

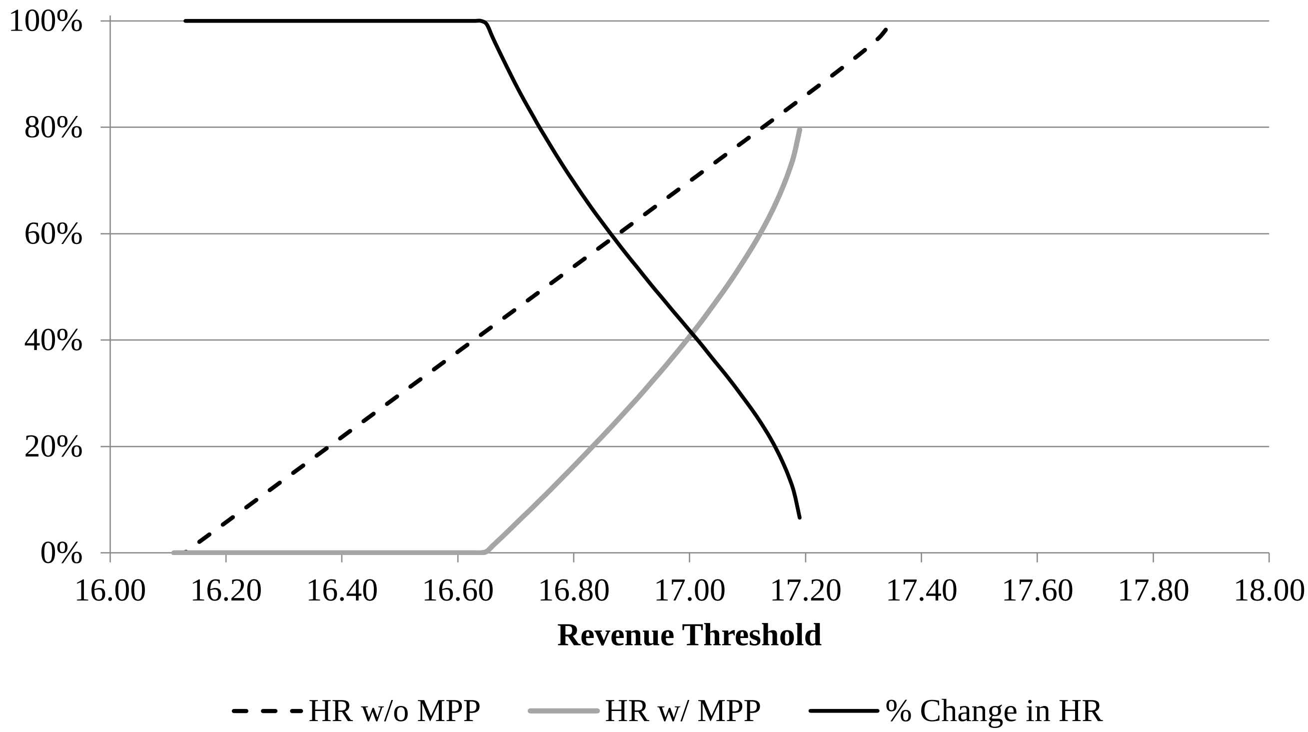

Figure 22 Lower Midwest grower signing up in Apr, 2012 for 2013 (CL:6.5 CP:90%)

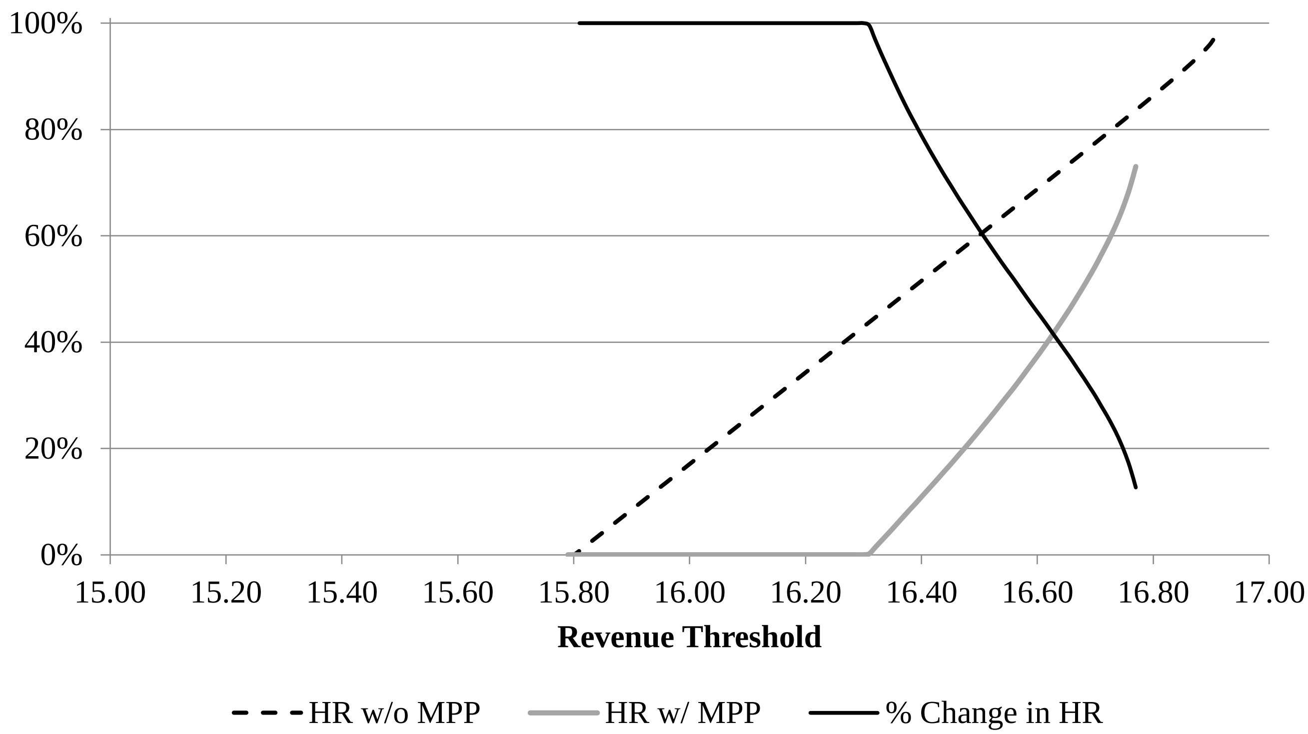

Figure 23 Upper Midwest grower signing up in Jan, 2013 for 2013 (CL:4.0 CP:90%)

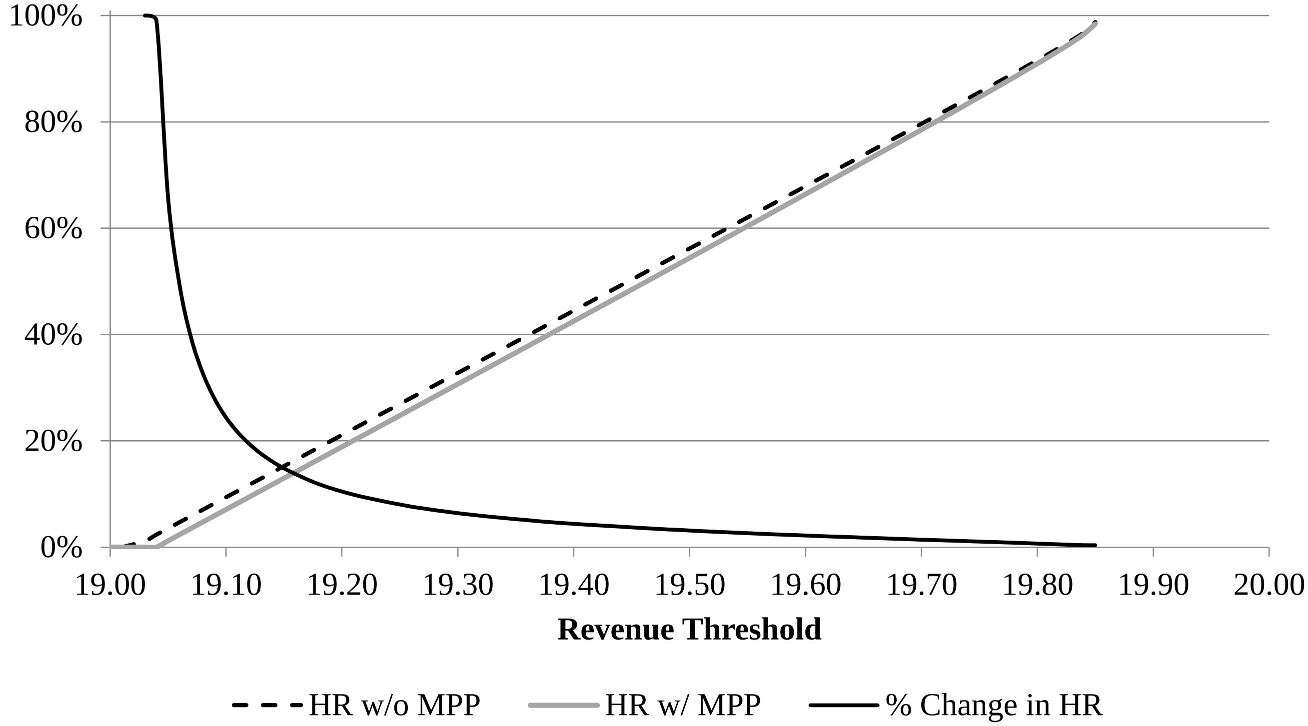

Figure 24 Lower Midwest grower signing up in Jan, 2013 for 2013 (CL:4.0 CP:90%)

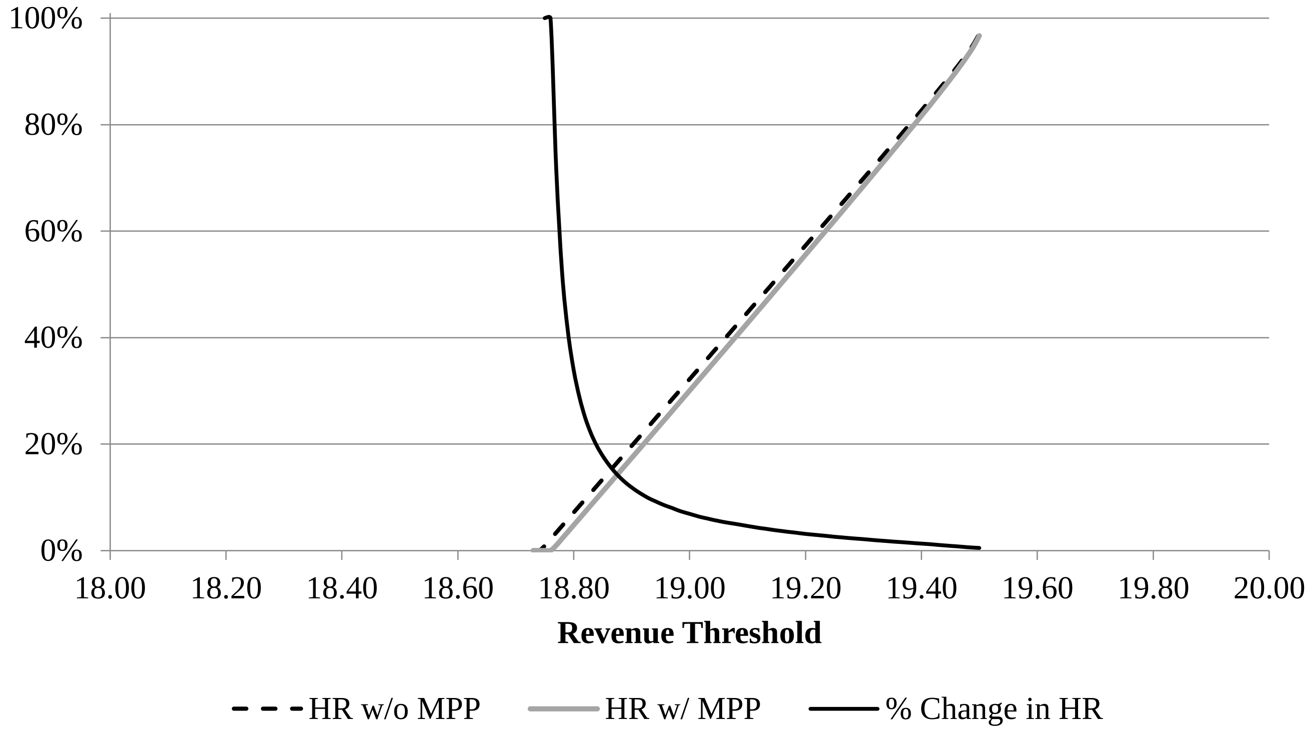

Figure 25 Upper Midwest grower signing up in Oct, 2013 for 2014 (CL:4.0 CP:90%)

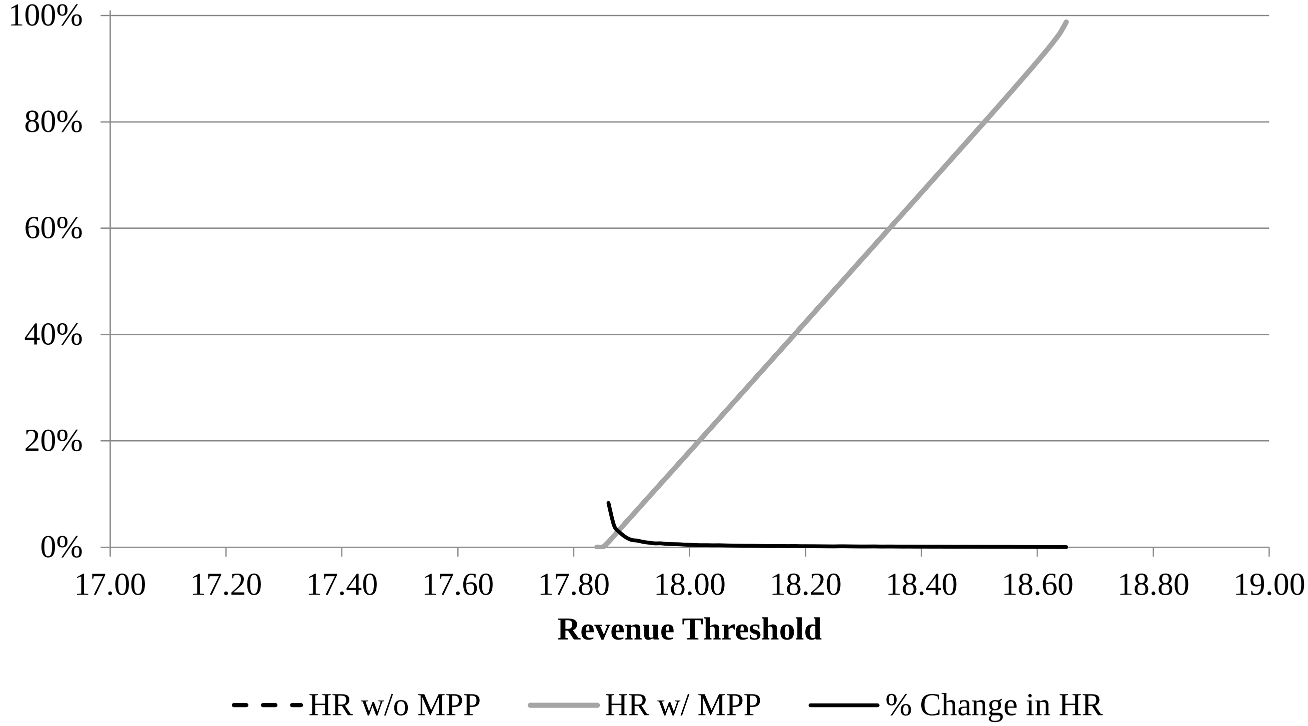

Figure 26 Lower Midwest grower signing up in Oct, 2013 for 2014 (CL:4.0 CP:90%)

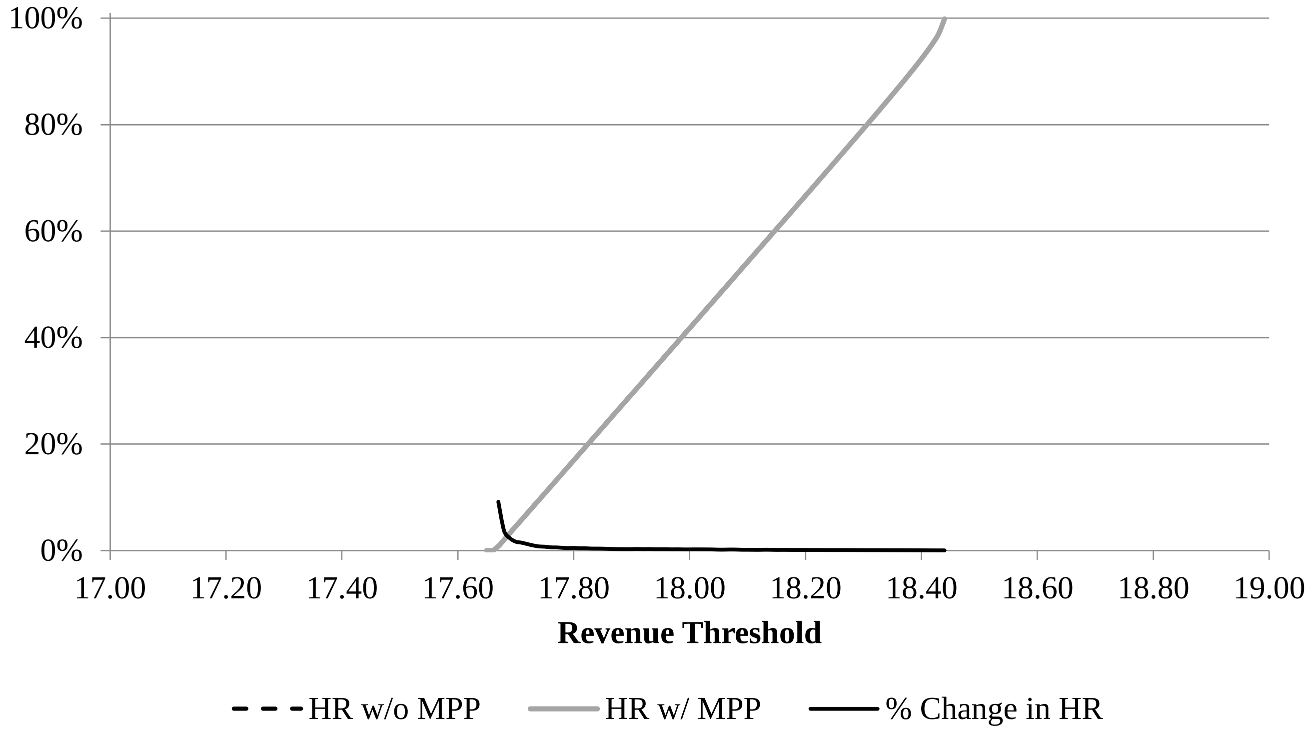

Figure 27 Upper Midwest purchaser signing up on Oct, 2007 for 2008 (CL:4.0, PC:90%)

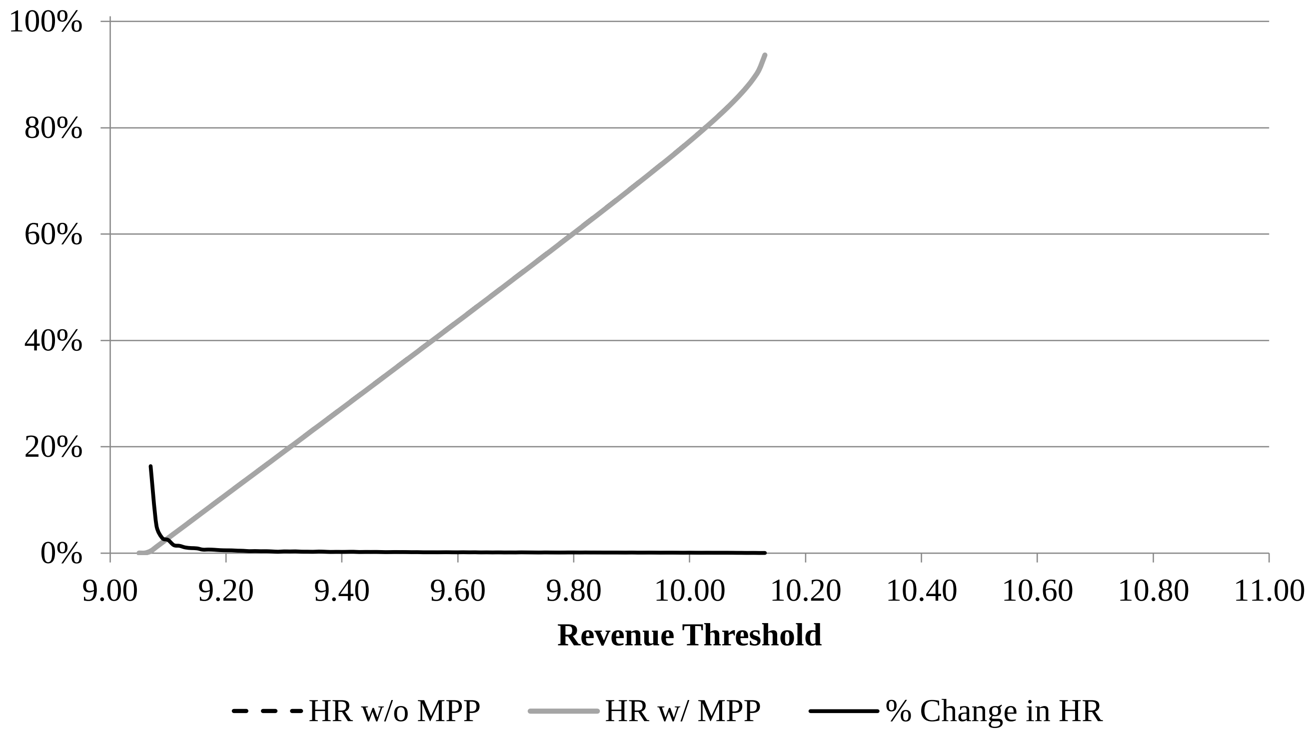

Figure 28 Lower Midwest purchaser signing up on Oct, 2007 for 2008 (CL:4.0 CP:90%)

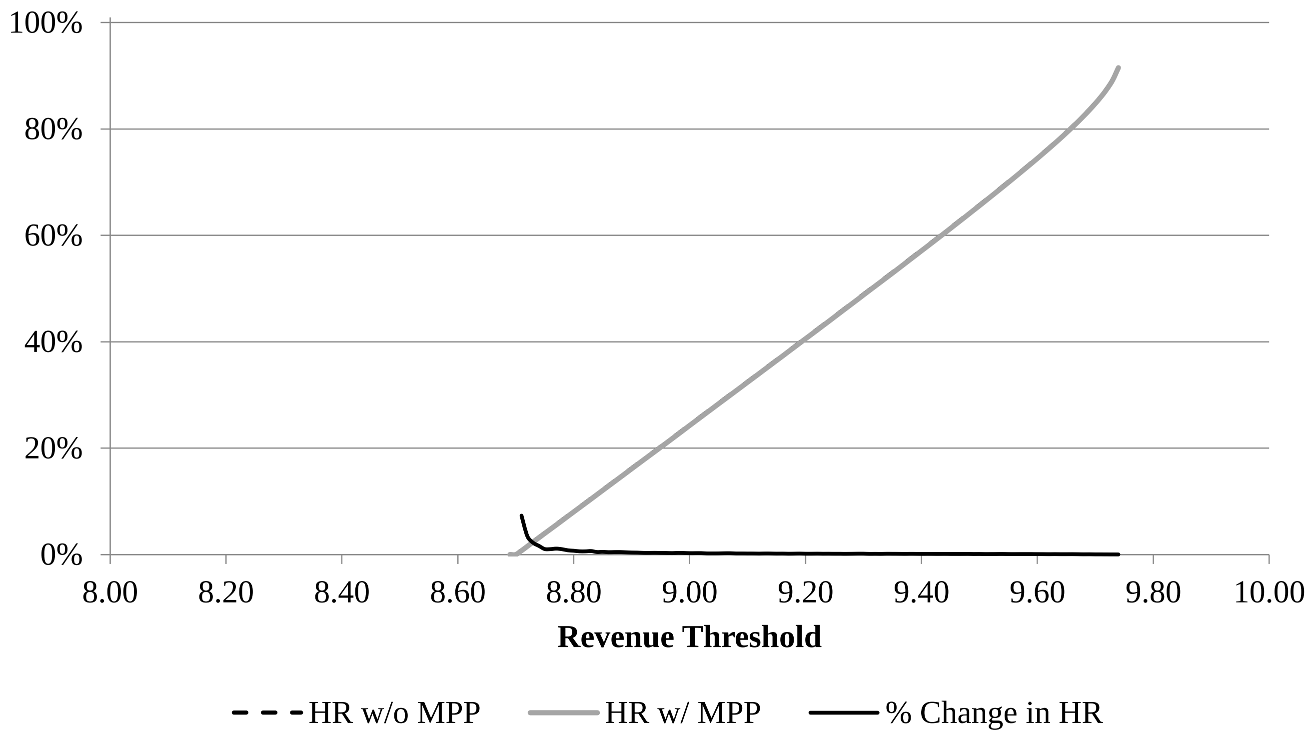

Figure 29 Upper Midwest purchaser signing up on Oct, 2008 for 2009 (CL:6.0 CP:90%)

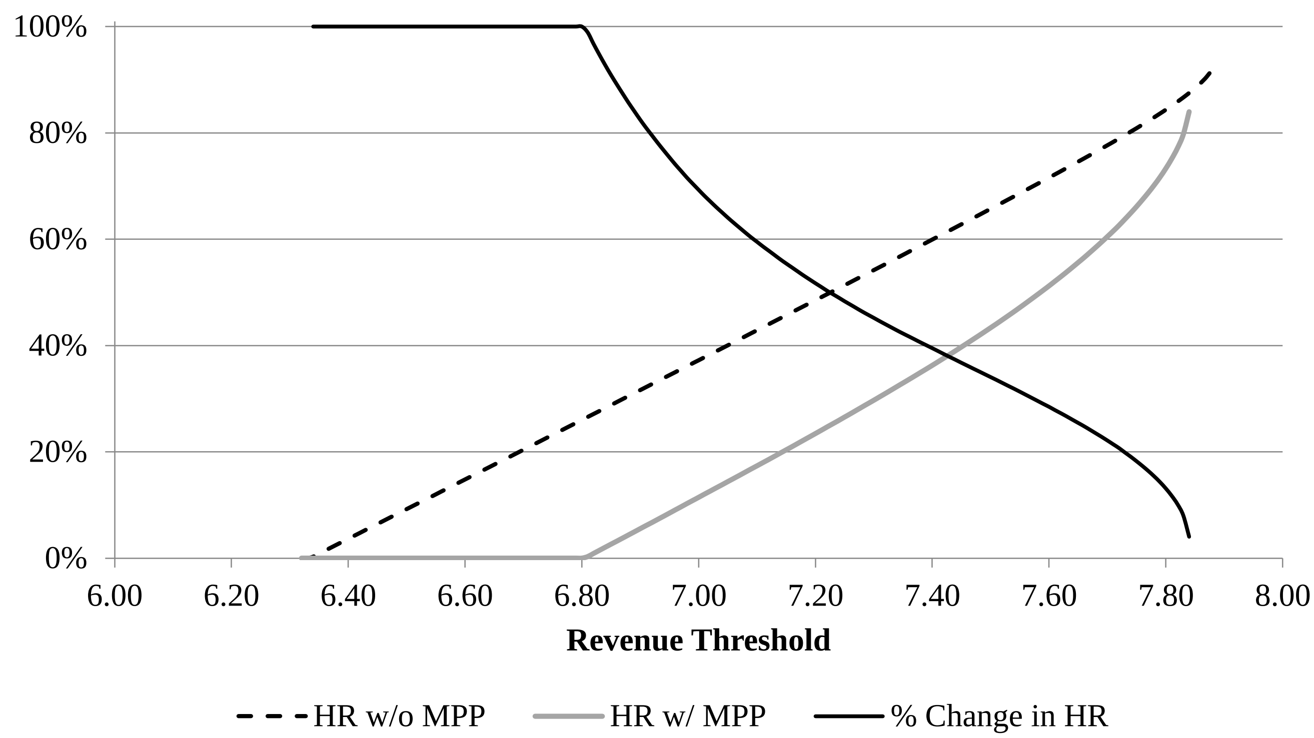

Figure 30 Lower Midwest purchaser signing up on Oct, 2008 for 2009 (CL:6.0 CP:90%)

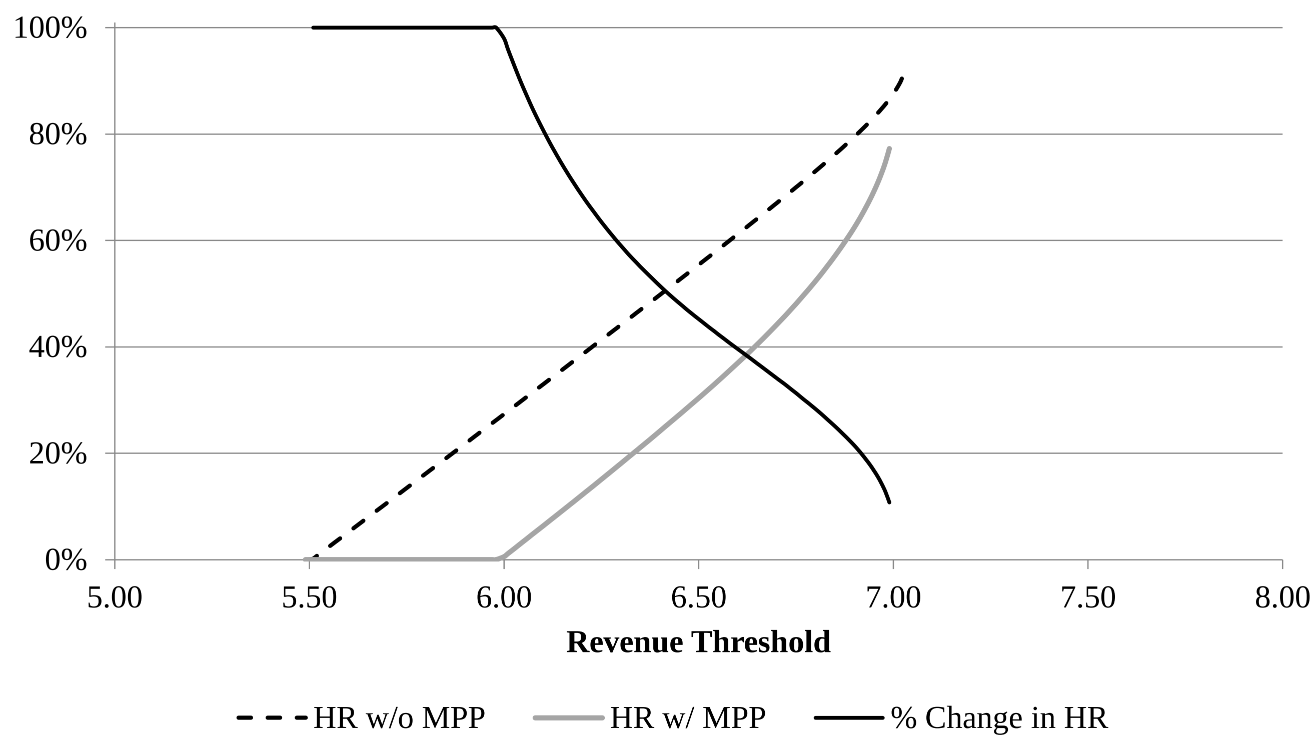

Figure 31 Upper Midwest purchaser signing up on Apr, 2008 for 2009 (CL:6.0 CP:90%)

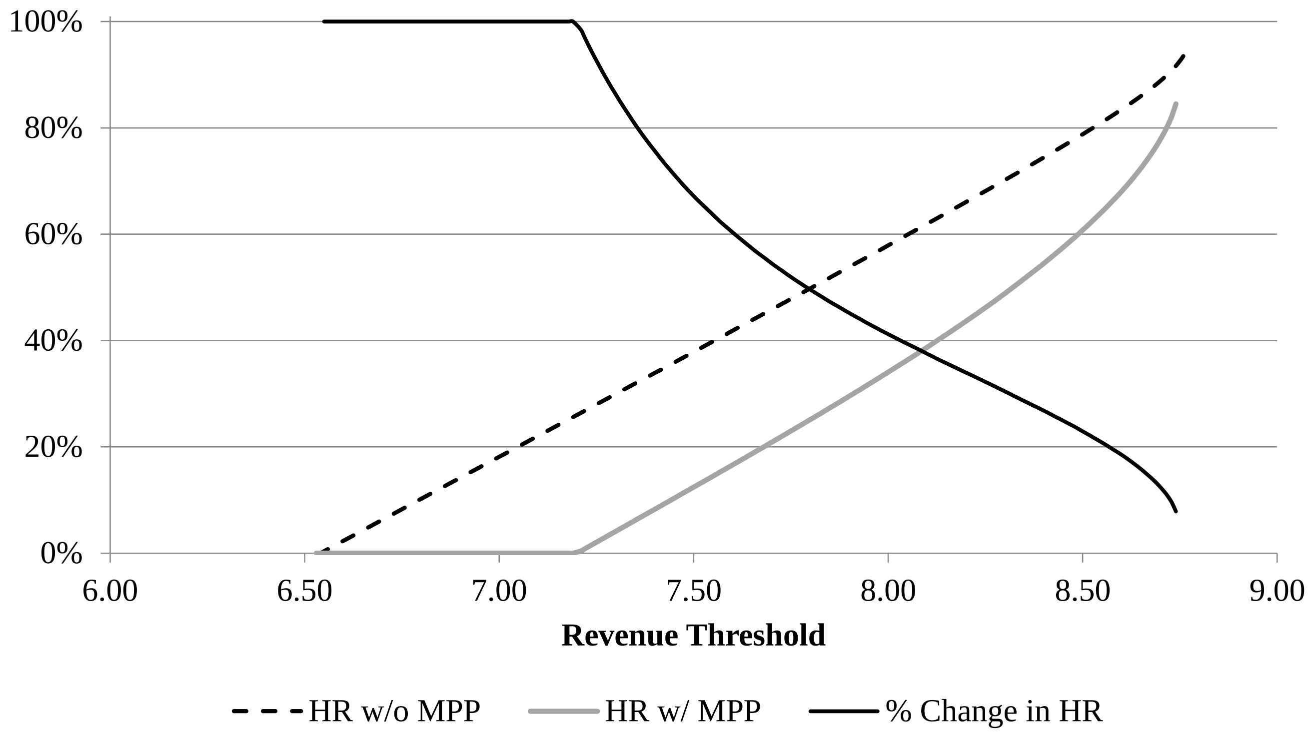

Figure 32 Lower Midwest purchaser signing up on Apr, 2008 for 2009 (CL:6.0 CP:90%)

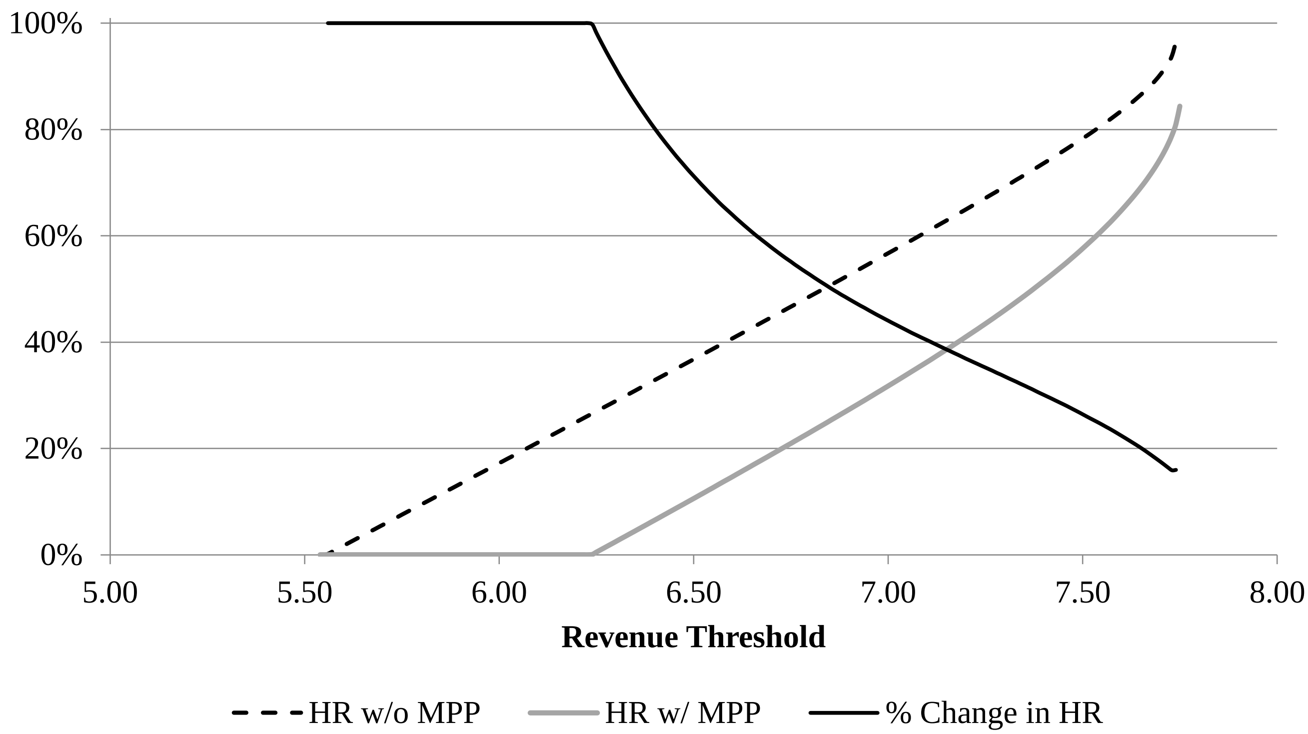

Figure 33 Upper Midwest purchaser signing up on Jan, 2009 for 2009 (CL:8.0 CP:90%)

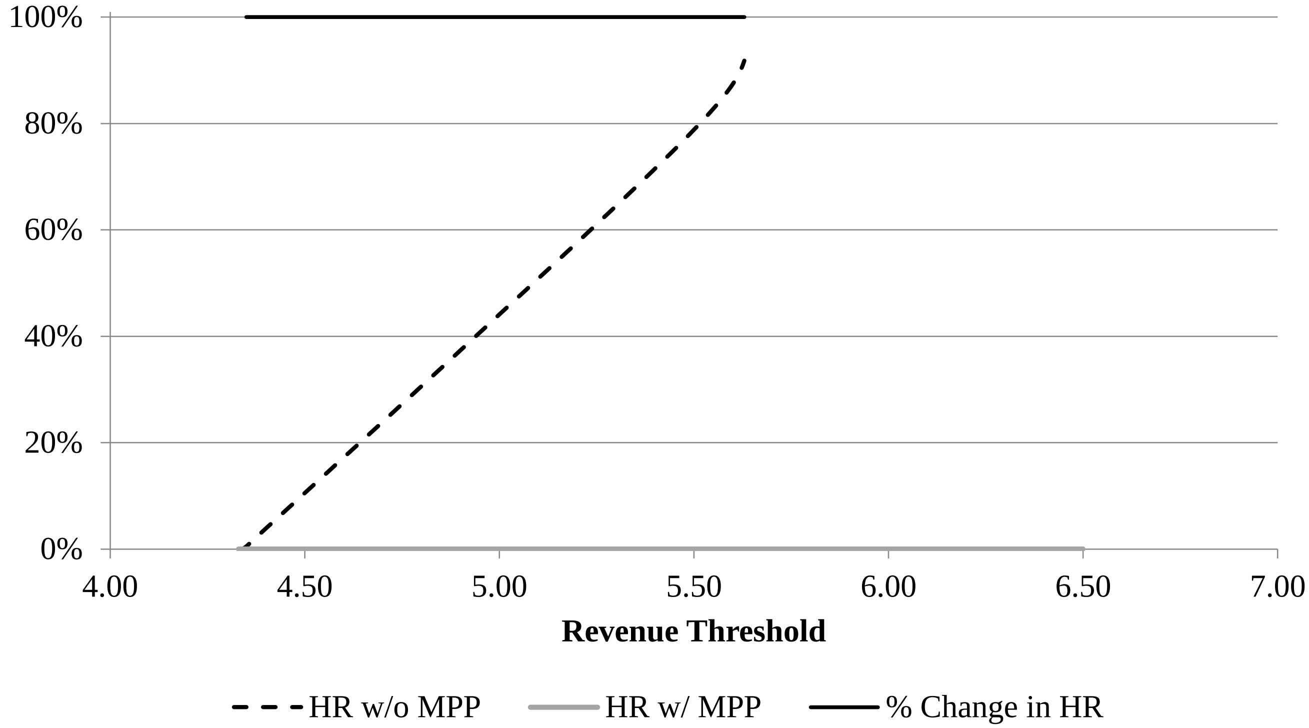

Figure 34 Lower Midwest purchaser signing up on Jan, 2009 for 2009 (CL:8.0 CP:90%)

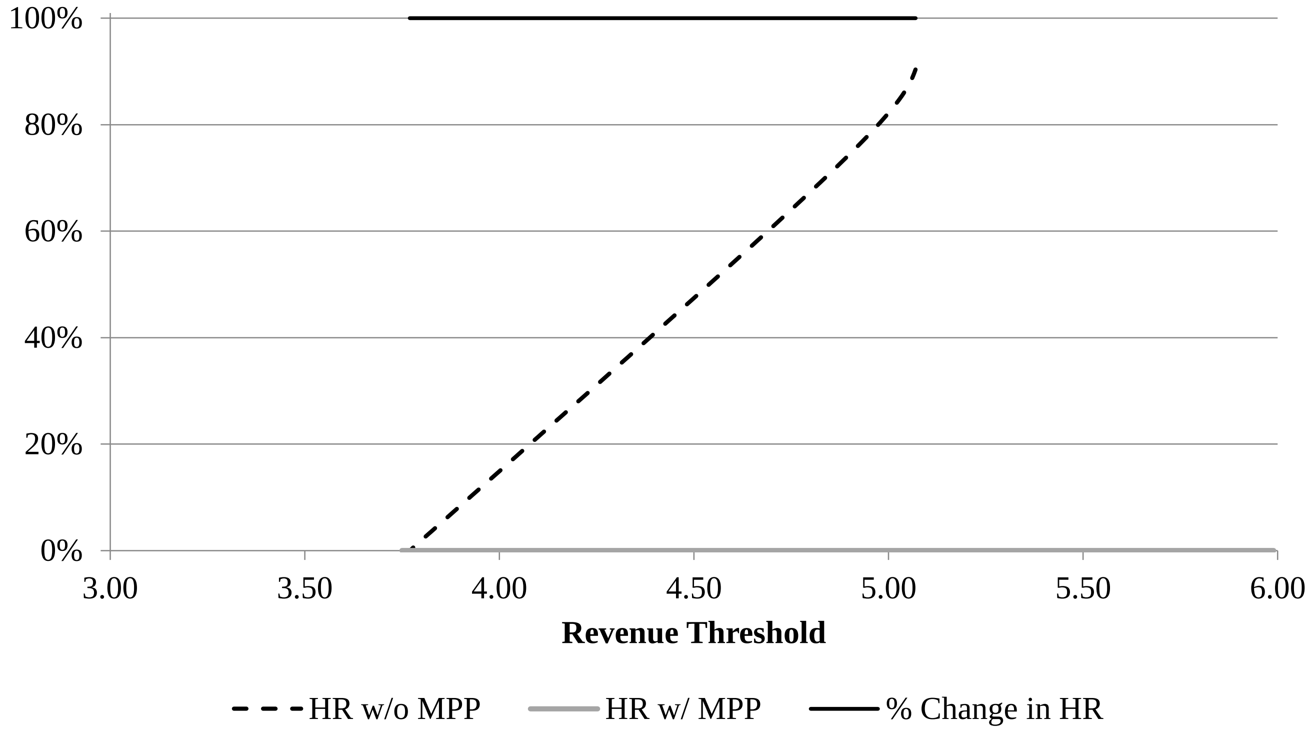

Figure 35 Upper Midwest purchaser signing up on Apr, 2011 for 2012 (CL:8.0 CP:90%)

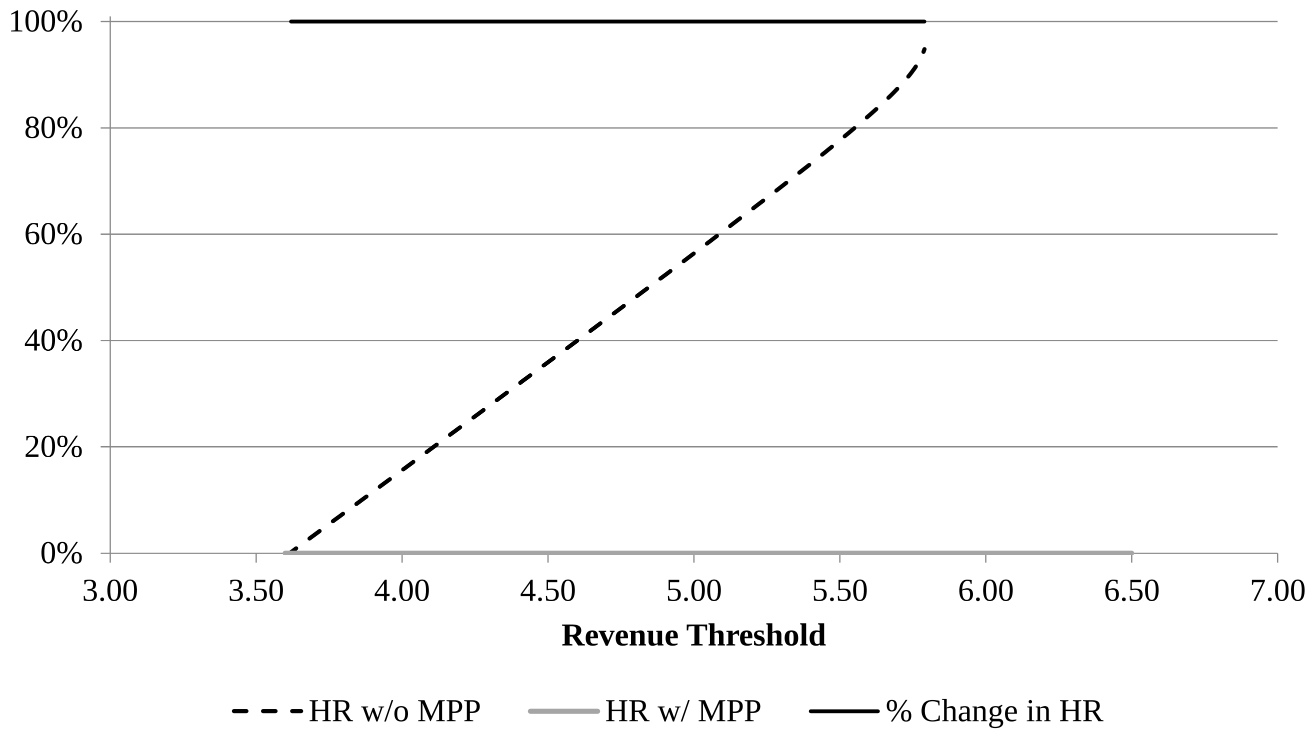

Figure 36 Lower Midwest purchaser signing up on Apr, 2011 for 2012 (CL:8.0 CP:90%)

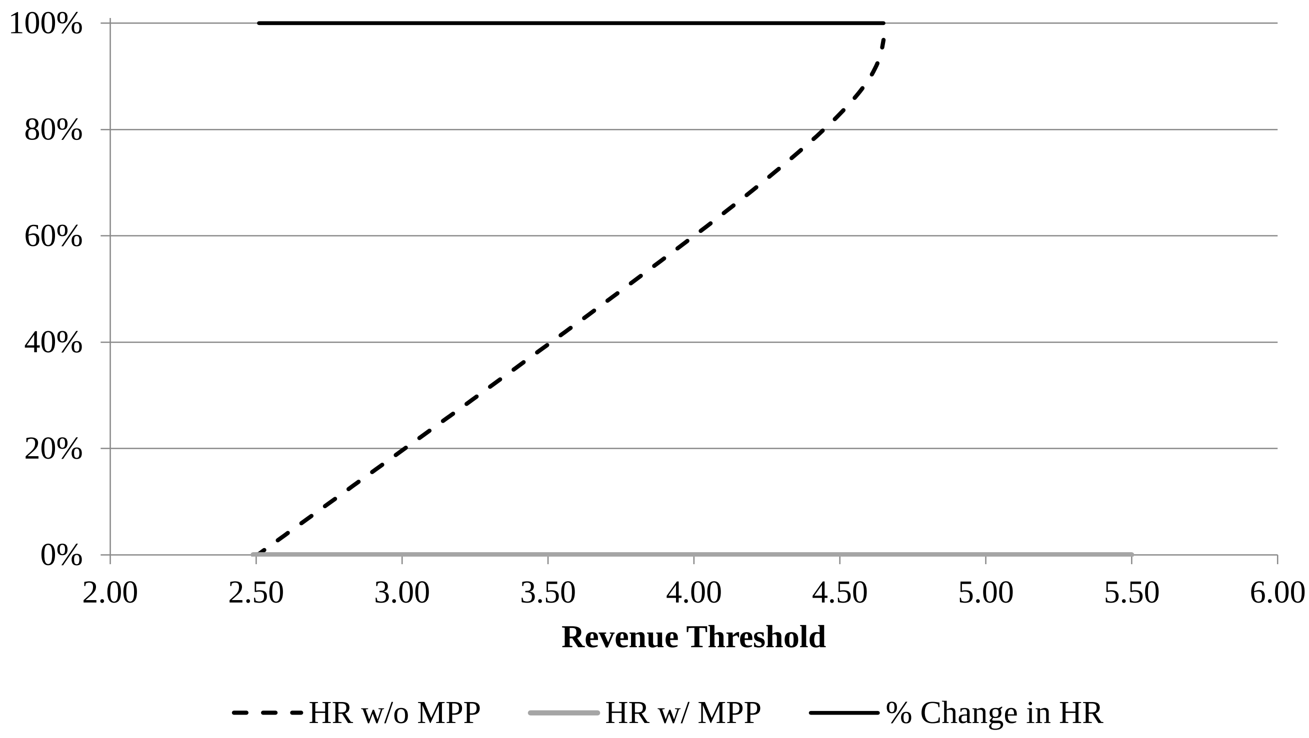

Figure 37 Upper Midwest purchaser signing up on Oct, 2011 for 2012 (CL:6.5 CP:90%)

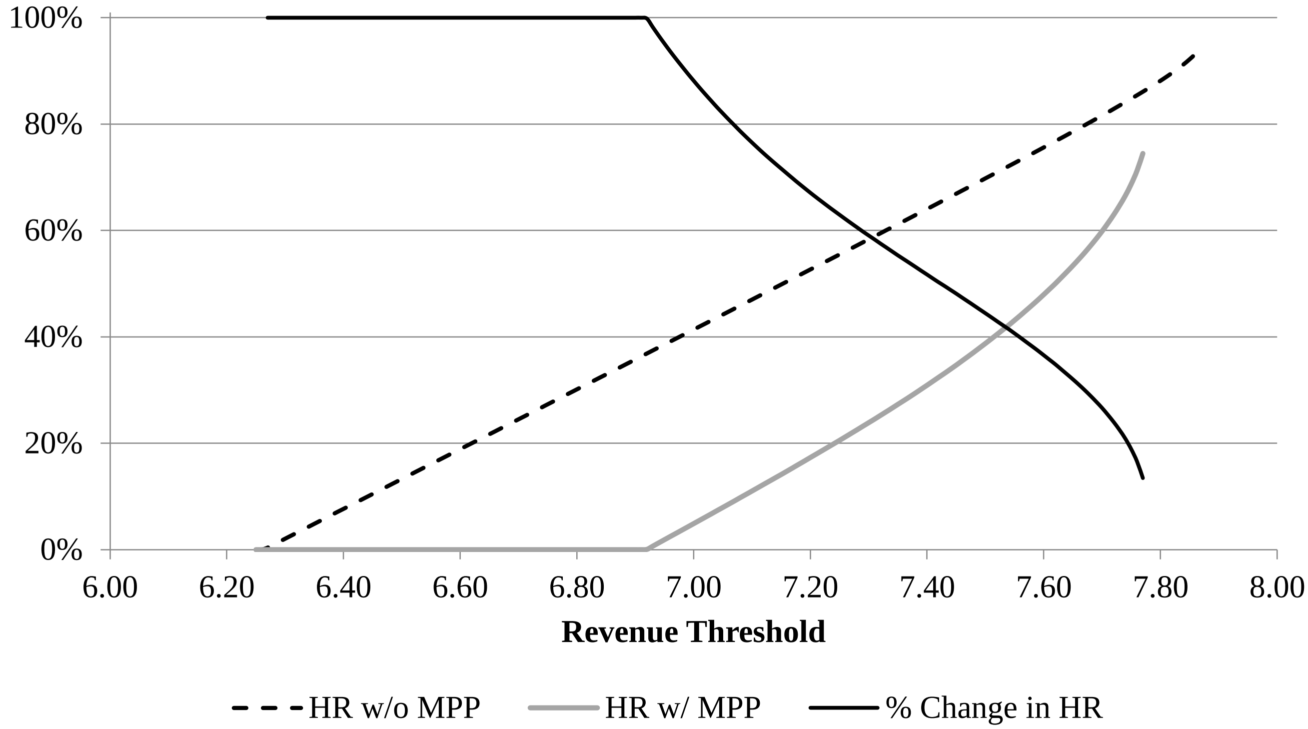

Figure 38 Lower Midwest purchaser signing up on Oct, 2011 for 2012 (CL:6.5 CP:90%)

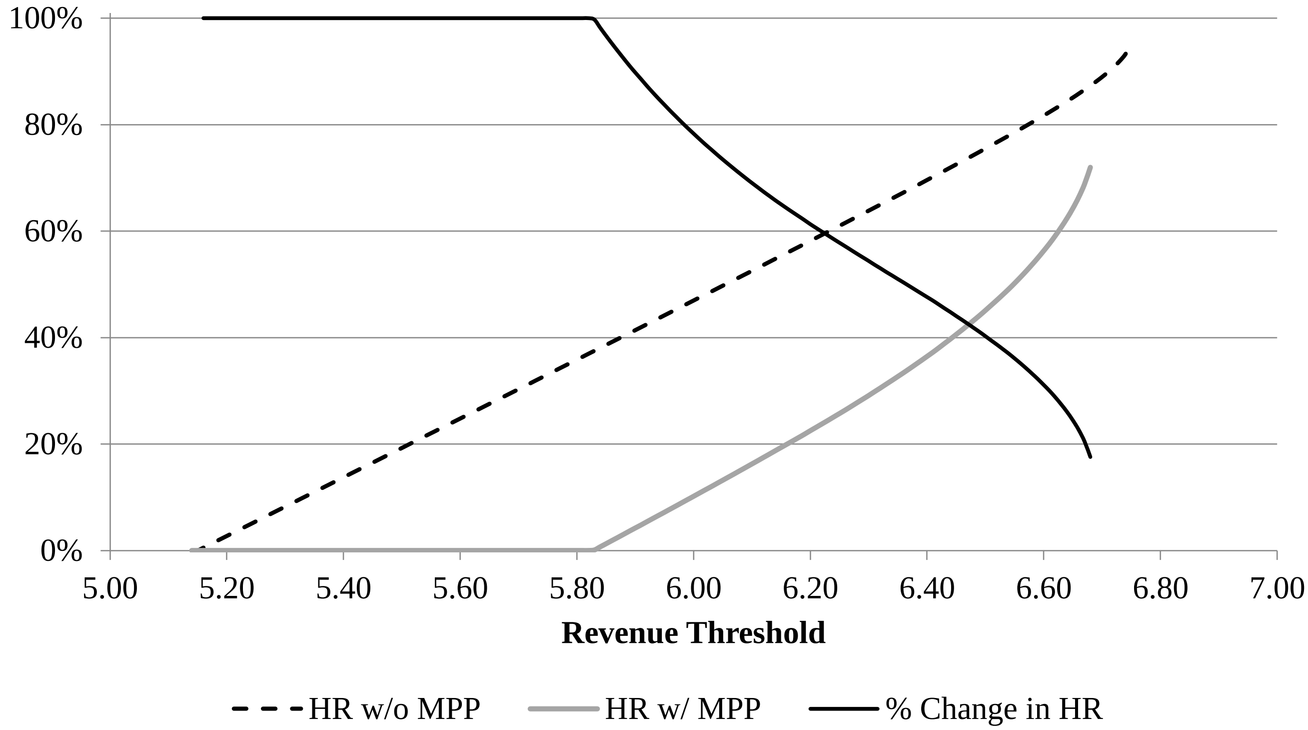

Figure 39 Upper Midwest purchaser signing up in Jan, 2012 for 2012 (CL:6.0 CP:90%)

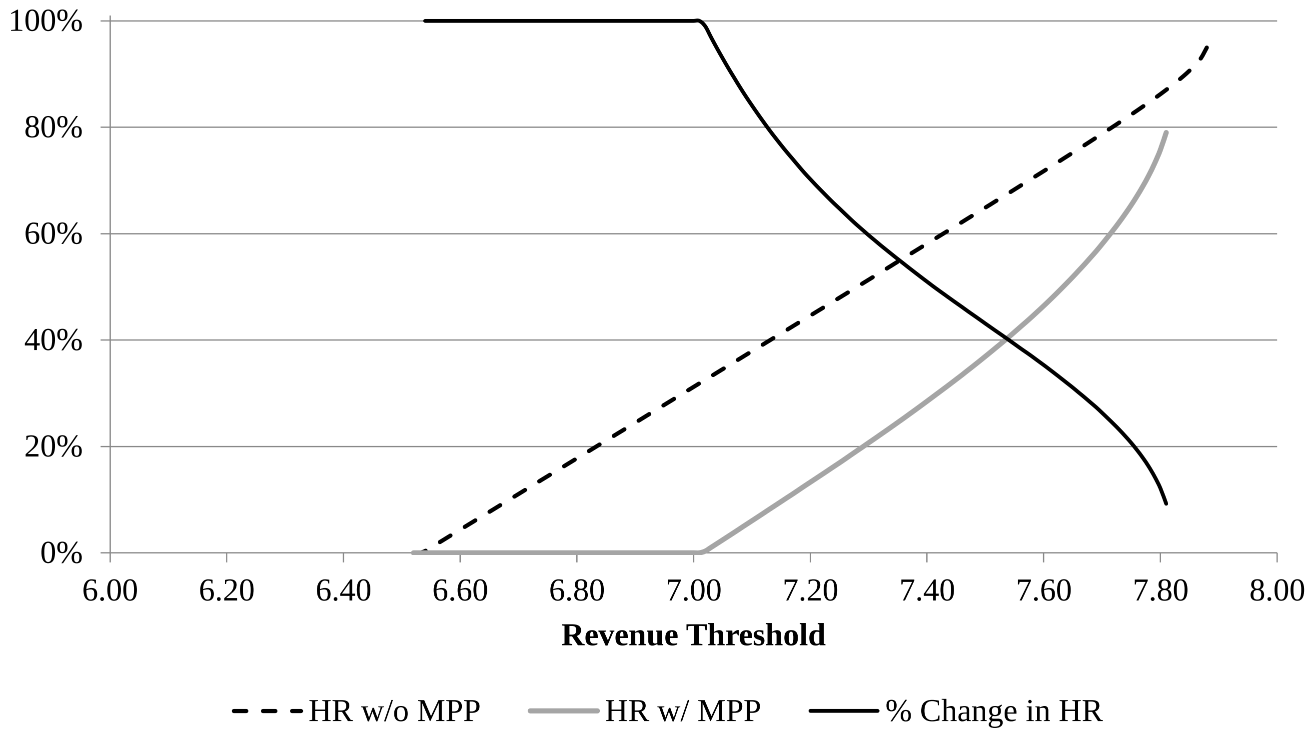

Figure 40 Lower Midwest purchaser signing up in Jan, 2012 for 2012 (CL:6.0 CP:90%)

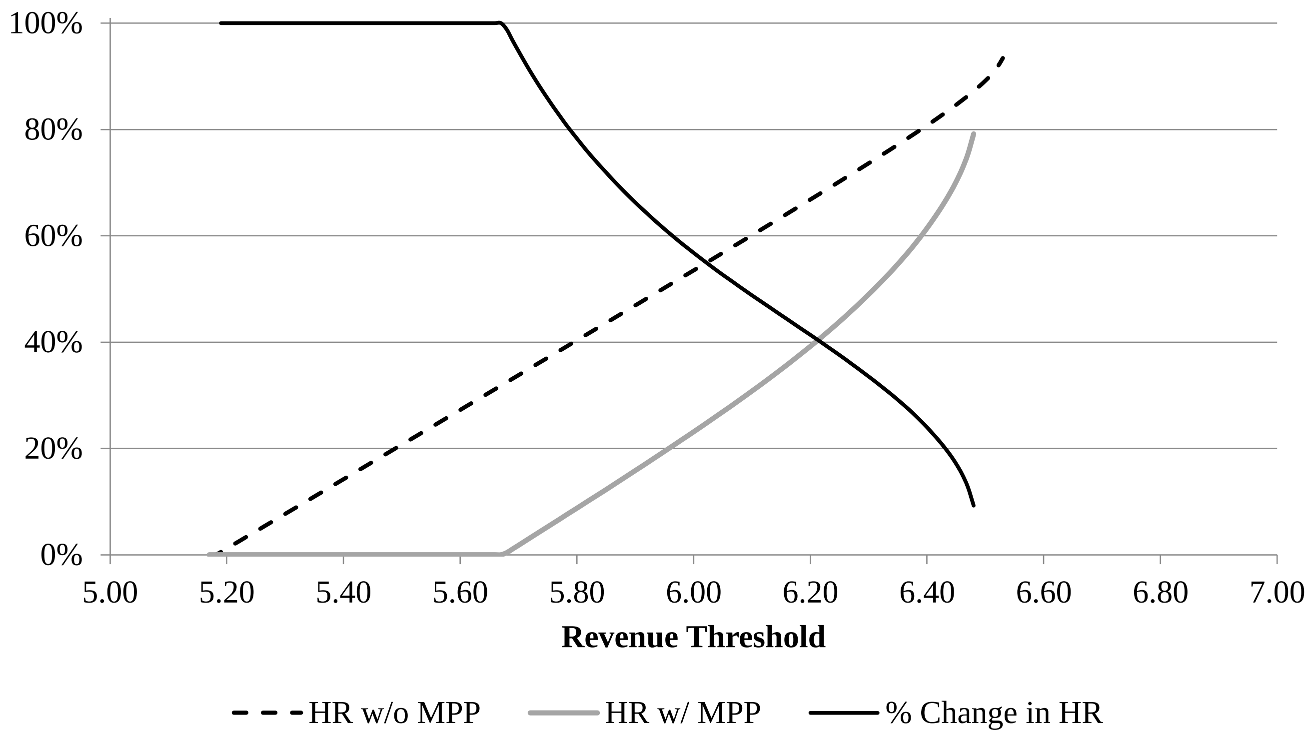

Figure 41 Upper Midwest purchaser signing up in Oct, 2012 for 2013 (CL:6.5 CP:90%)

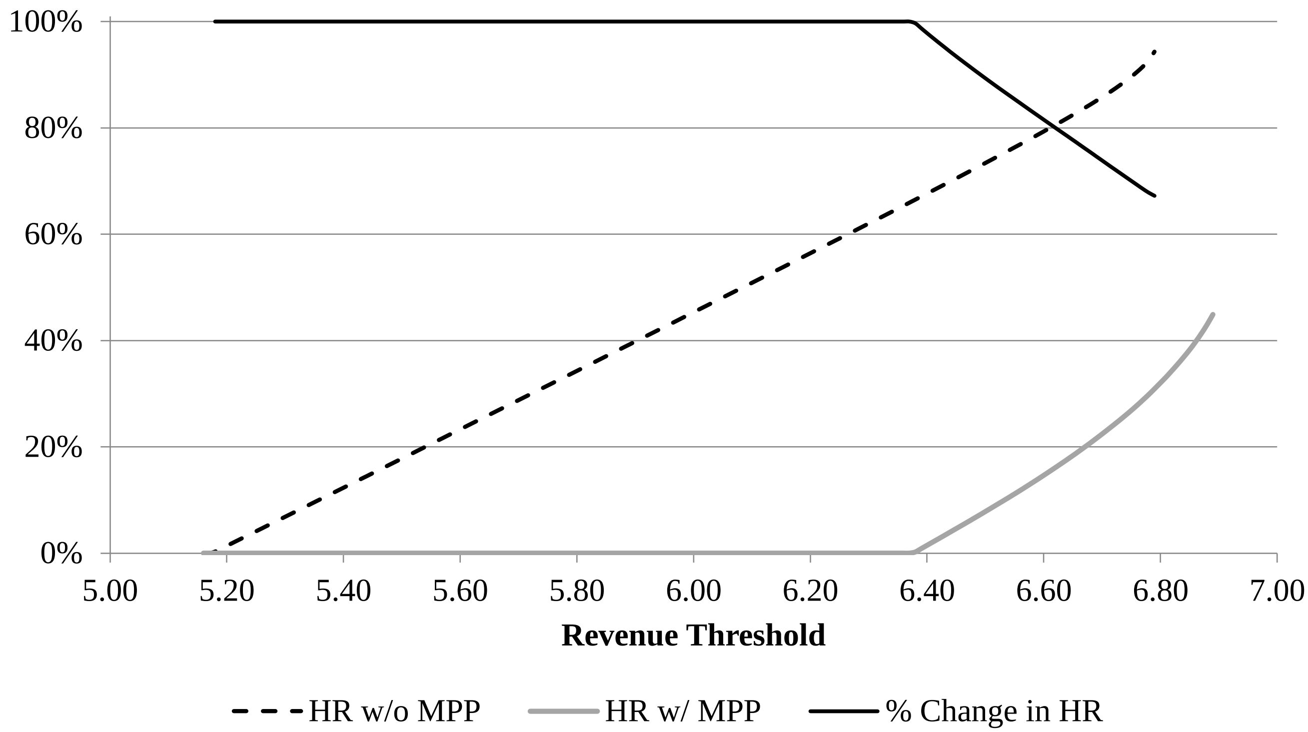

Figure 42 Lower Midwest purchaser signing up in Oct, 2012 for 2013 (CL:6.5 CP:90%)

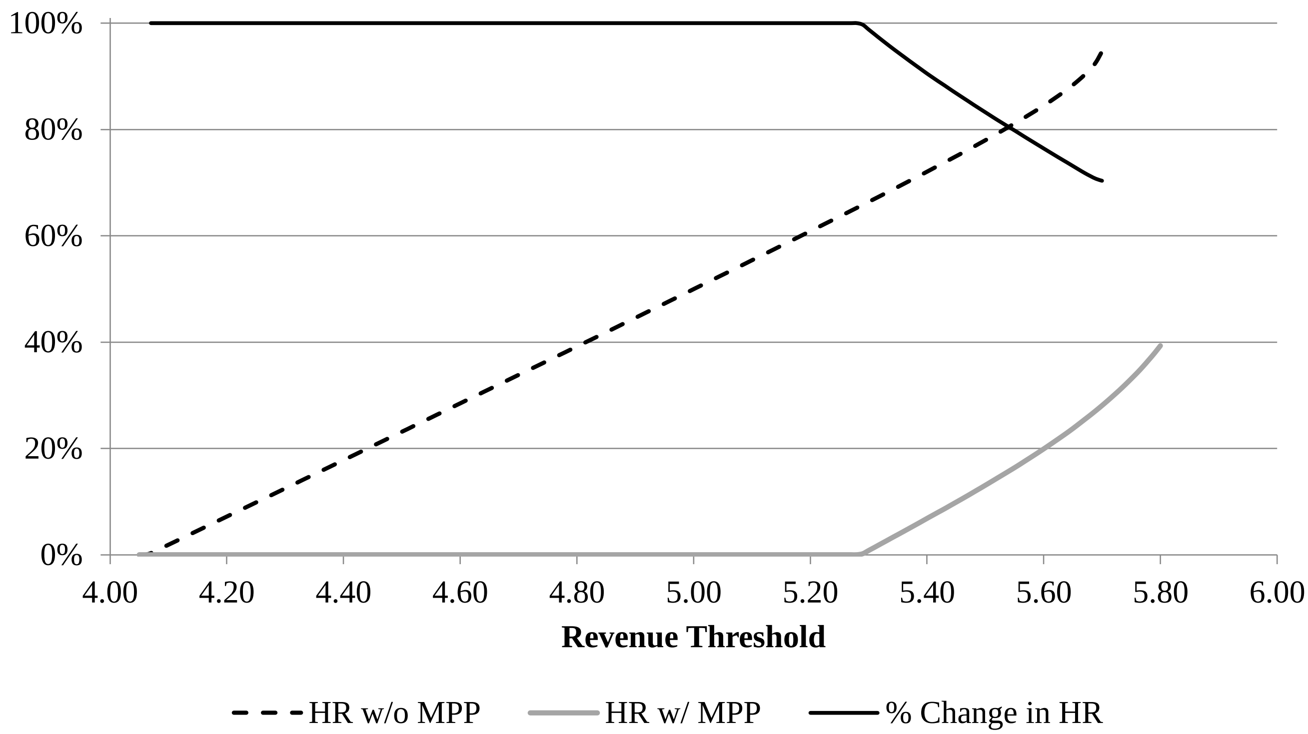

Figure 43 Upper Midwest purchaser signing up in Apr, 2012 for 2013 (CL:6.5 CP:90%)

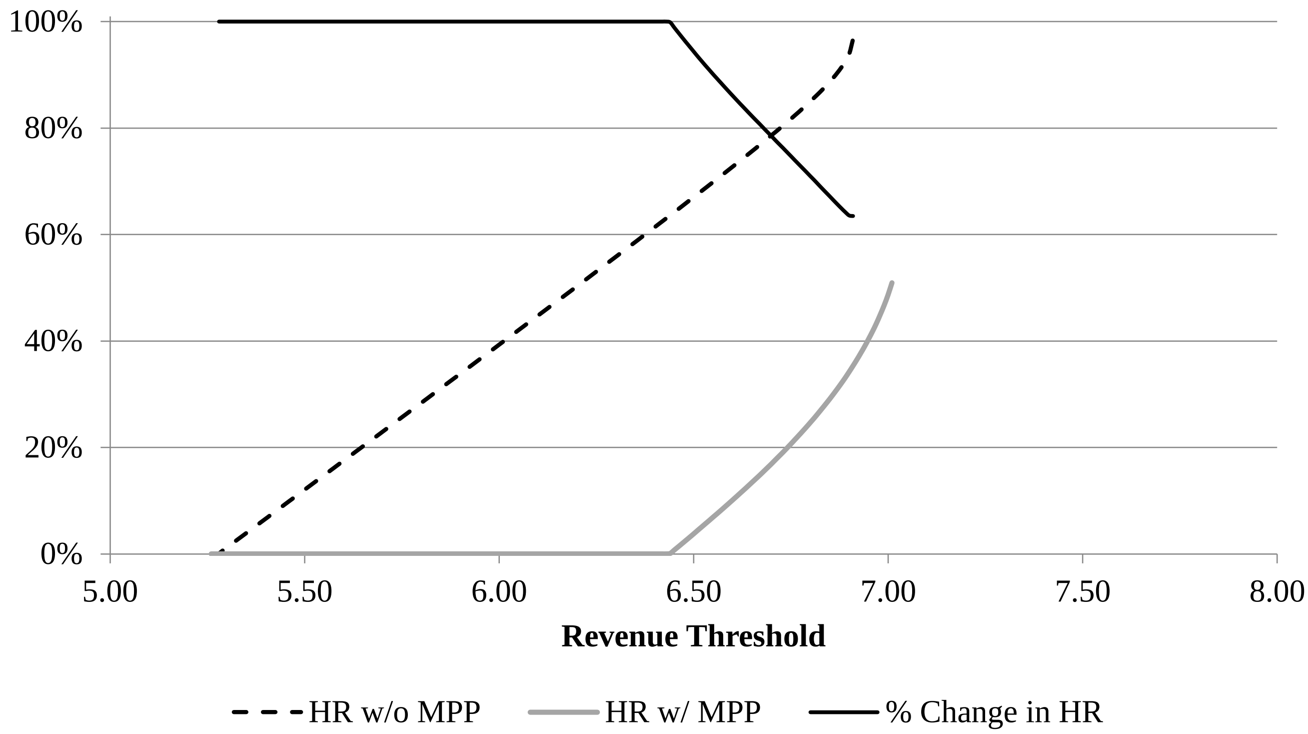

Figure 44 Lower Midwest purchaser signing up in Apr, 2012 for 2013 (CL:6.5 CP:90%)

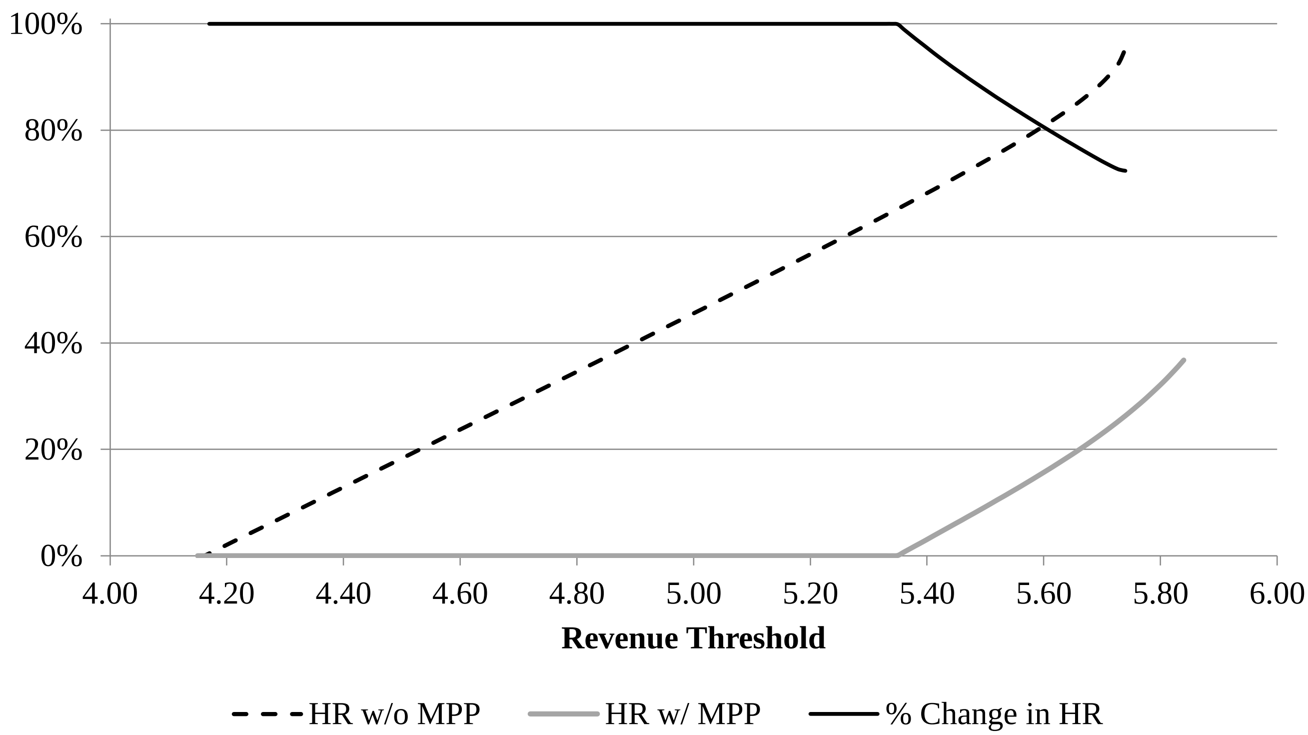

Figure 45 Upper Midwest purchaser signing up in Jan, 2013 for 2013 (CL:4.0 CP:90%)

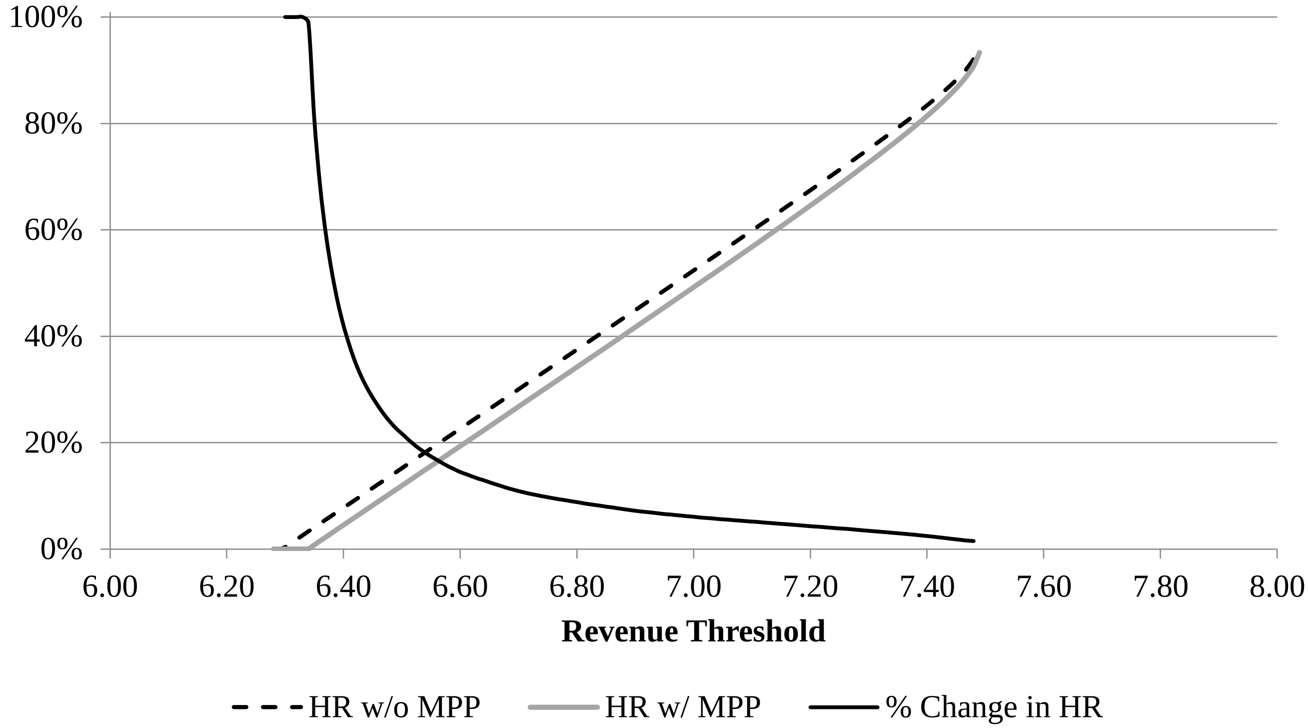

Figure 46 Lower Midwest purchaser signing up in Jan, 2013 for 2013 (CL:4.0 CP:90%)

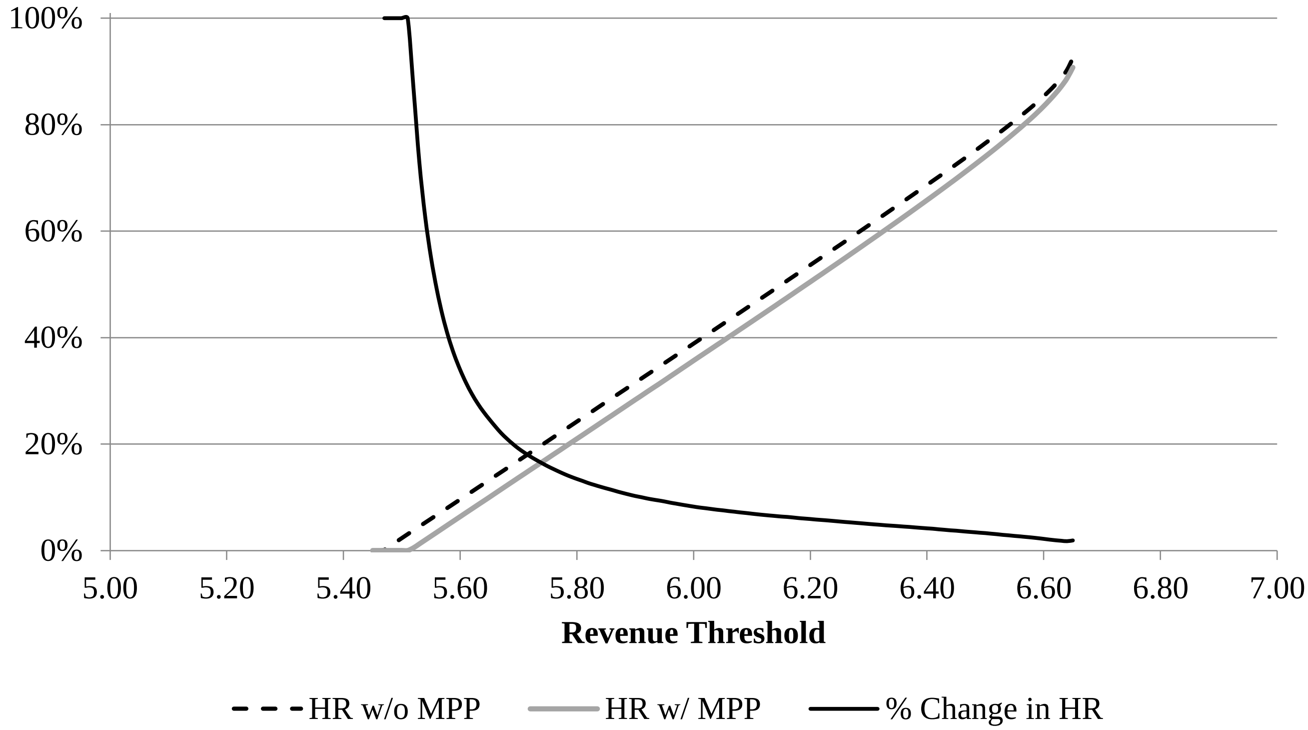

Figure 47 Upper Midwest purchaser signing up in Oct, 2013 for 2014 (CL:4.0 CP:90%)

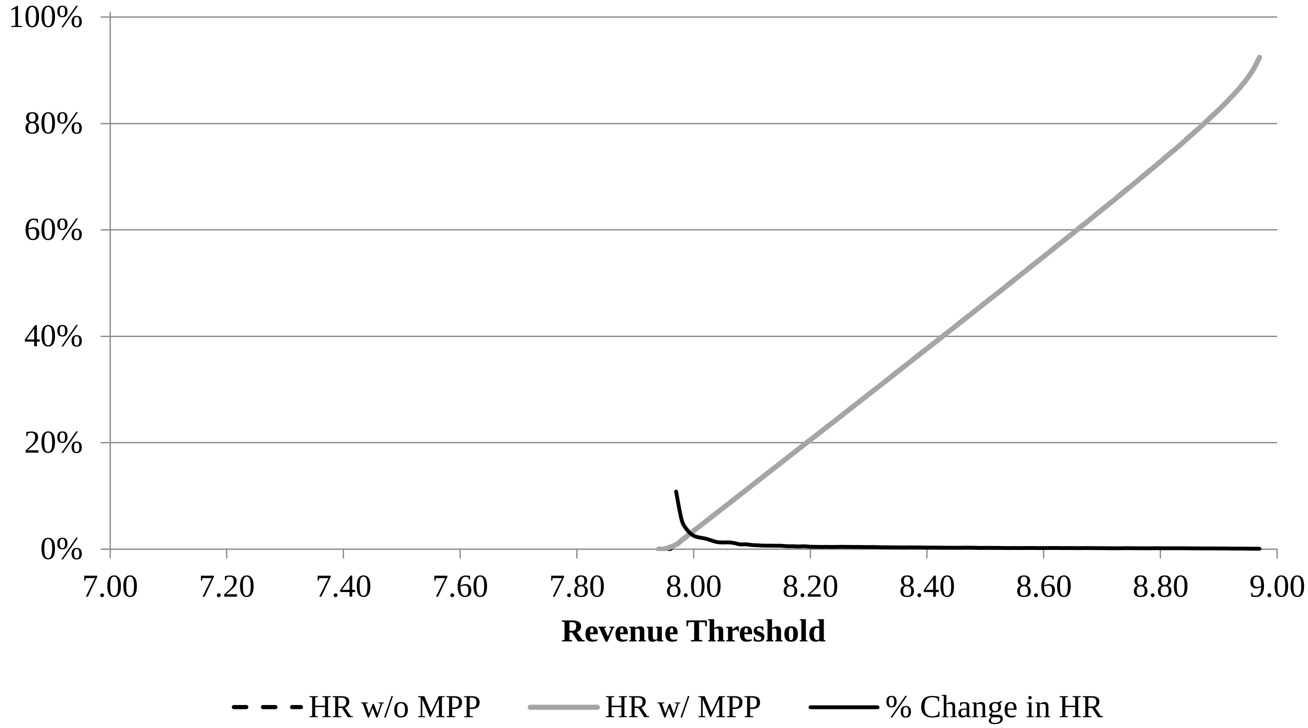

Figure 48 Lower Midwest purchaser signing up in Oct, 2013 for 2014 (CL:4.0 CP:90%)