ACCOUNTING FOR SOCIAL COSTS ASSOCIATED WITH RESALE PRICE MAINTENANCE

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Resale price maintenance (RPM) can provide a positive or negative effect on social welfare. The evaluation depends on many factors, such as whether a high-demand or low-demand state exists, storage/holding costs, and disposal costs. A number of articles addressing the welfare effects of RPM conclude they enhance social welfare. Disposal costs for manufactured products are real and increasingly accounted for in firm costs, and are an essential issue in environmental economics. This article examines the case for RPM with disposal costs. When not incorporated into firm profits, RPM may be welfare reducing. (*JEL* D42, D62, D81)

I. INTRODUCTION

Resale price maintenance (RPM) agreements may be welfare enhancing, yet are under increasing legal pressure. RPM agreements are one mechanism by which an upstream firm can control downstream prices. In the face of uncertain demand, firms that cannot guarantee repurchase of product in a low demand state will find that retail prices fluctuate with demand, leading to lower profits than might be obtained under less open regimes. An upstream firm might offer to repurchase, at cost, any product in a retailer's inventory that is unsold at the price the upstream firm wishes to set. Obviously an upstream producer must be concerned with how demand fluctuations will affect price when considering the construction of capacity.

Without the possibility of using RPM, firms will choose production and, by extension, capacity based on expected profits, with price changes dictated by fluctuating demand. Firms utilizing RPM will choose capacity to maximize profits by weighing the possibility of high production in high-demand states and restricting sales in low-demand states to ensure a higher price. This low-demand state decision would leave excess production or inventory. A retailer would be disinclined to maintain high prices if forced to pay for unsold product. In order to prevent lower prices in the low-demand state, the firm must buy back excess product or, in some other manner, convince retailers not to lower the price. This creates the question of what to do with the excess—dispose or store. In this article we examine the effect of choosing the disposal process in an RPM-tolerant environment.

The net effect of making RPM illegal, as demonstrated in Flath and Nariu (2000), is likely to be welfare reducing. However, what to do with excess production, occurring in low-demand states and leading to inventory disposal problems, was not considered. Their results indicate gains in both consumer surplus and profits in the high-demand state relative to the flexible price (no RPM allowed) choice. In a flexible price regime, the firm sees low prices in a low-demand state, with the possibility of a price equal to zero and excess production. These gains are mitigated by losses, due to higher prices in the low-demand state, which would have been obtained in the flexible price environment. Flath and Nariu (2000) use a simple linear demand model to demonstrate that if used under the conditions where a firm would prefer to operate with

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ABBREVIATION

RPM: Resale Price Maintenance

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RPM, then it improves social welfare to allow RPM. Their model assumes that repurchased or returned products are disposed of at no cost. While a zero disposal cost may have been consistent with firm conditions up through the 1960s, current law in most developed countries requires firms to dispose of waste and excess inventory in a manner consistent with societal norms and prices.

We build a model, based on Flath and Nariu (2000), that incorporates disposal costs of excess production. We then show how failure to internalize the externality associated with "free" disposal reduces and may eliminate the social gains from RPM. We follow this result by incorporating disposal costs directly into the profit function of the firm and examining welfare effects of RPM. Next we examine the effects of disposal costs in an RPM-tolerant regime using an alternative form of demand uncertainty.

Disposal costs should reflect social costs associated with toxicity, bulk, etc. Disposal costs may reflect either governmental or private market activity. In either case, the marginal cost of disposal should reflect societal costs. Disposing of toxic, long-lived products is likely to cost more than disposal of a product that biodegrades easily. The size of the product or weight may be an important consideration as well. For a space-constrained country, such as Japan, a larger product should, ceteris paribus, have a higher disposal cost per unit than a smaller product.

II. LITERATURE

"Demand Uncertainty, Inventories, and Resale Price Maintenance" by Deneckere et al. (1996) provides a theoretical explanation of how both manufacturers and society may benefit from the use of RPM. They use a niche market approach with square demand to describe the consumer environment. They address the issue of why manufacturers wish to prevent retailers from offering their products at discounted prices. For example, when prices drop, quantity demanded increases, perhaps considerably; however, prices may decrease to a level where total revenue would actually decrease. They show that even though social welfare may increase with the use of RPM or similar wholesaler controls, consumers are often likely to have lower welfare. While they include a discussion of potential costs at various stages, these do not influence their results, largely because the costs are set to zero.

In "Demand Uncertainty and Price Maintenance: Markdowns as Destructive Competition," Deneckere et al. (1997) consider the theory of "destructive competition." They show that unfettered competition can actually be welfare diminishing. The model used is one of a perfectly competitive retail market and monopolistic wholesaler. In the RPM case, the wholesaler sets two prices: wholesale and minimum resale. Demand is square, as with their earlier model. Again, unsold inventories are estimated to have no scrap value. Inventory holdings are a driving concern for the wholesaler. They concluded that with the use of RPM, imposing a retail price floor may benefit the manufacturer and even produce a greater consumer surplus when compared to market clearing competition.

Jullien and Rey (2000) look at a variety of scenarios, in a Deneckere et al. structure, where RPM can have either a positive or negative effect on social welfare. They focus on the possibility of collusive behavior when RPM is possible. The authors conclude that, in a collusive environment, RPM reduces welfare by aiding firms in detecting deviation from such an agreement and increasing their ability to punish the participants. Their analysis was conducted in an oligopoly, where there is a strong incentive for collusive behavior among firms.

Flath and Nariu (2000), using a linear demand model, determined the conditions under which firms would prefer to use RPM. They showed that RPM is welfare enhancing, in their specific model, when the wholesaler prefers RPM to flex pricing. Production costs were explicitly considered in the decision process. Our article expands on this model by including disposal costs of unsold inventory. This may be considered as a negative scrap value approach.

The Flath and Nariu (2000) modeling approach, using a simple linear demand model, is attractive for two reasons. First, using linear demand allows for relatively simple solutions to be found. Second, parameters in the linear model are easier to find an empirical value for, leading to ease of empirical testing. The Deneckere et al. modeling approach allows for broader understanding since it is more general on the demand side. This is offset by the absence of a significant role for costs in there model. Further, the difficulty in finding useful empirical parameters to test in the general case makes their model less suited for empirical testing. RPM in the current context is of interest in the political/economic policy arena. Given this arena, ease of analysis and empirical testing possibilities suggest the simplified demand model with costs considered is the appropriate modeling technique to employ.

III. BASIC MODEL OF RPM: DEMAND SLOPE DIFFERENCES

We use the linear demand form of Flath and Nariu (2000). There are two possible states of demand, with common intercept Y. With probability θ, demand is high, leading to demand slope $-b_{\mathrm{H}}$. With probability $(1-\theta)$, demand is low, leading to demand slope b_{L}, where $b_{\mathrm{L}} > b_{\mathrm{H}}$. Thus we have price equals

$$p_{\mathrm{H}} = Y - b_{\mathrm{H}}x_{\mathrm{H}}, \quad \text{with probability } \theta$$

$$p_{\mathrm{L}} = Y - b_{\mathrm{L}}x_{\mathrm{L}}, \quad \text{with probability} = 1-\theta,$$

where x_{H} is the amount sold in the high-demand state and x_{L} is the amount sold in the low-demand state when these quantities are different. In the event that the quantities in both states are the same, $x_{\mathrm{H}} = x_{\mathrm{L}} = x_{\mathrm{F}}$, where x_{F} is the "flex price" quantity. Assume a risk-neutral manufacturer that must choose capacity and produce before the state of demand is known. The firm is a monopoly producer selling to a competitive downstream retail market. The firm's marginal costs of production are equal to c. The firm maximizes expected profit,

$$\begin{aligned} (1) \qquad \pi = {} & \theta(Y - b_H x_H)x_H + (1-\theta) \\ & \times (Y - b_L x_L)x_L - cQ \\ & \text{s.t. } x_H \le Q, \text{ and } x_H \le Q, \end{aligned}$$

with no cost to disposal (Flath and Nariu, 2000) and

$$\begin{aligned} (2) \qquad \pi = {} & \theta[(Y - b_H x_{Hd})x_{Hd} + d(Q - x_{Hd})] \\ & + (1-\theta)[(Y - b_L x_{Ld})x_{Ld} \\ & - d(Q - x_{Ld})] - cQ \\ & \text{s.t. } x_{Hd} \le Q, \text{ and } x_{Hd} \le Q, \end{aligned}$$

where d is the linear disposal cost.

Solving for Equation (1) gives Q^*

$$\begin{aligned} & (Y - c/\theta)/2b_H = x_H^* \ge x_L^* = Y/2b_L, \\ & \quad \text{if } (b_L - b_H)/b_L \ge c/(Y\theta) \\ & (Y - c)/(2[b_L(1-\theta) + b_H\theta]) \\ & \quad = x_H^* = x_L^* = x_F, \\ & \qquad \text{if } (b_L - b_H)/b_L < c/(Y\theta). \end{aligned}$$

Solving for Equation (2) gives Q_d^*, where the subscript d indicates the incorporation of disposal costs directly into firm and societal objective functions:

$$\begin{aligned} & (Y - c/\theta - ((1-\theta)/\theta)d)/2b_H \\ & \quad = x_{Hd}^* \ge x_{Ld}^* = (Y + d)/2b_L, \\ & \qquad \text{if } (b_L - b_H)/b_L \ge (c + d)/(\theta(Y + d)) \\ & (Y - c)/(2[b_L(1-\theta) + b_H\theta]) \\ & \quad = x_{Hd}^* = x_{Ld}^* = x_{Fd}, \\ & \qquad \text{if } (b_L - b_H)/b_L < (c + d)/(\theta(Y + d)). \end{aligned}$$

The second solutions for Q^* and Q_d^* are effectively the no-RPM regime, or what may be called "flex pricing," since the price is allowed to fluctuate with demand. There are fewer values for b_L and b_H for which RPM will be preferred by the firm, since $(c + d)/(\theta(Y + d)) > c/(Y\theta)$, so long as $Y > c$. This more restrictive condition limits the general usefulness of RPM to firms. RPM is preferred by firms when demand variation is high. When firms must pay disposal costs, the political concern over RPM may be ameliorated by efficient use of environmental law.

In addition to a reduction in the frequency of RPM regime choice, firms take less advantage of RPM in the sense that $x_H > x_{Hd}$ and $x_{Ld} > x_L$. That is, firms reduce capacity because they are concerned with disposal costs. This effectively reduces the possibility of social welfare gains when demand is not highly volatile. Also, $x_{Fd} = x_F$, so that when RPM is not chosen, there is no change in the level of production that would occur without disposal costs being internalized. In other words, the possibility of disposal costs does not affect firm capacity choice when no RPM is used or when it is not advantageous for the firm to use.

The welfare gains and losses associated with RPM can generally be divided into two

FIGURE 1

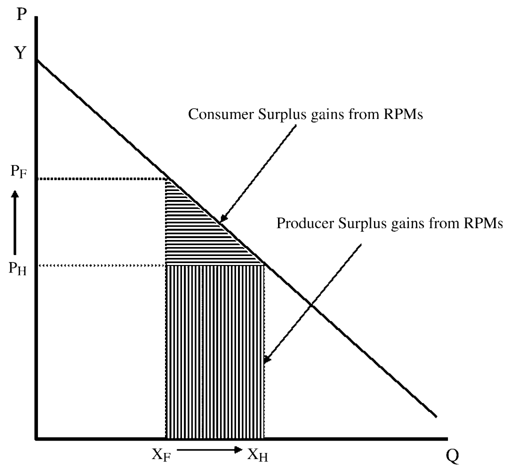
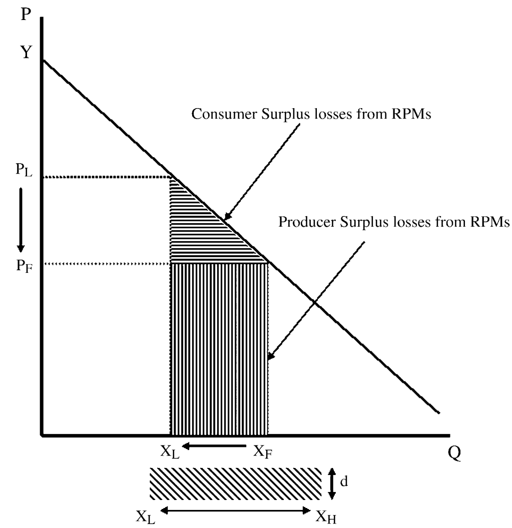


FIGURE 2



parts as shown in Figures 1 and 2. The gains come from increased production and lower prices in the high-demand state using RPM compared to the flex price environment. The losses are associated with the reduction in production/sales and higher prices in the low-demand state that occur under RPM relative to the flex price environment. Thus an important consideration in welfare effects is the quantity difference: $x_H - x_F$ and $x_F - x_L$ versus $x_{Hd} - x_{Fd}$ and $x_{Fd} - x_{Ld}$. We know that, in any RPM case, since x_{Hd} is less than x_H and x_{Fd} is equal to x_F, the gains are smaller with imposed disposal costs than when they are ignored. The effect on $x_F - x_L$ is the same: losses are likely to be smaller since production of x_L is less. Both quantity differences and price differences are smaller, thus overall gains to the firm and society under RPM are smaller than was the case of enhanced welfare under RPM with "free" disposal costs.

Flath and Nariu's (2000) welfare comparisons between RPM and flex price regimes did not account for disposal costs. Following Flath and Nariu, we examine welfare under the conditions where RPM is binding for the firm, that is, $(b_L - b_H)/b_L \geq (c + d)/(\theta(Y + d))$, and price in the low-demand state is nonnegative, that is, $\frac{1}{2}+\frac{1}{2}((c+(1-\theta))/\theta Y \geq (b_L - b_H)/b_L$.[1] If disposal costs, an unaccounted for externality, are included in their welfare calculations, the term $(1 - \theta)d(x_H - x_L)$ is subtracted from the RPM welfare gains they show to be positive when the firm prefers RPM to flex pricing and the price in the low-demand state is nonnegative. Including this term, Flath and Nariu's welfare changes for RPM should have been

$$\begin{aligned}\Delta W = {} & \theta b_H(x_H - x_F)^2/2 \\ & - (1-\theta)b_L(x_H - x_F)/2 \\ & - \theta P_H(x_H - x_F) - (1-\theta)P_{FL}(x_F - x_L) \\ & - c(x_H - x_F) - (1-\theta)d(x_H - x_L) > 0.\end{aligned}$$

Ignoring $(1-\theta)d(x_H - x_L)$ and making proper substitutions reduces this expression to a statement of the constraint conditions on RPM (see Appendix A). As a result, welfare is enhanced with RPM when firms observe a reason to use RPM. However, introducing disposal costs, as appropriate, into this statement of welfare shows that, in some conditions where RPM is used, welfare may be lower than originally predicted—in the region where the firm only slightly prefers RPM to flex pricing. In some cases the use of RPM will lead to reduced welfare relative to the flex price case if firms are

1. If, in the low-demand state under flex pricing, the price goes to zero, the firm will prefer to focus only on the high-demand state and will choose $x_{Fd} = x_{Hd} = (Y - c/\theta - ((1-\theta)/\theta)d)/2b_H$. This leads to a price greater than zero in the low-demand state if $\frac{1}{2} + \frac{1}{2}((c + (1-\theta))/\theta Y \geq (b_L - b_H)/b_L$.

allowed to ignore disposal costs. This is true of large values for d.

Using the results of Equation (2) as opposed to Equation (1) and solving the welfare conditions leads to the same type of result as obtained by Flath and Nariu (2000). Although RPM will be preferred by firms in fewer situations, when firms do choose to use this and price is nonnegative in the low-demand state, RPM is welfare enhancing as well as profit improving.

IV. BASIC MODEL OF RPM: DEMAND INTERCEPT DIFFERENCES

Linear demand differences can be modeled with different slopes, as above, or as having different intercepts. In this section we drive the firm behavior and welfare effects of possible RPM use where demand differences are defined by different intercepts.

$$(3)\quad E\pi = \theta[Y_H - bx_{YHd})x_{YHd} - d(Q - x_{YHd})] + (1-\theta)[(Y_L - bx_{YLd})x_{YLd} - d(Q - x_{YLd})] - cQ,$$

where the subscript Y indicates the model where demand differs by intercept as opposed to slope coefficient. This leads to solutions

$$\begin{aligned} Q^*_{Yd} &= (Y_H - c/\theta - ((1-\theta)/\theta)d)/2b \\ &= x^*_{YHd} \geq x^*_{YLd} = (Y_L + d)/2b, \\ &\quad \text{if } Y_H - Y_L \geq (c+d)/\theta \\ &= (\theta Y_H + (1-\theta)Y_L - c)/2b = x^*_{YHd} \\ &= x^*_{YLd} = x_{YFd}, \quad \text{if } Y_H - Y_L < (c+d)/\theta. \end{aligned}$$

As with the differing slope case, our welfare evaluations pertain to situations where RPM is binding on the firm and price in the low intercept is nonnegative. The first condition is satisfied when $Y_H - Y_L \geq (c+d)/\theta$. If, in the low intercept situation $c/\theta \leq Y_H - (1+\theta)Y_L$, the firm will choose to produce for the high-demand state, that is, $x_{YHd} = (Y_H - c/\theta - ((1-\theta)/\theta)d)/2b$. This will lead to a positive price in the low-demand provided $(1/\theta)(c + (1-\theta)d) \geq Y_H - 2Y_L$.

Under these conditions welfare changes are similar to those obtained when demand differs in slope, in that they are derived from the same type of changes in consumer surplus and profits. With some effort (see Appendix B) it can be shown that, under this demand specification, welfare is enhanced if firms are allowed to use RPM.

V. CONCLUSION

We used a linear demand model with production and disposal costs to examine the effect of RPM on profits and social welfare. While the linear model is fairly specific, it does allow for relatively easy empirical testing and is generally easier to solve and explain as compared to a more generalized demand model. From a policy perspective, this simpler model allows greater intuitive explanation and the incorporation of additional variables such as costs.

The inclusion of disposal costs in the firm's objective function reduces the gains, as well as the losses, associated with RPM. In the original formulation, firms chose capacity and produced more than they would have if disposal costs were internalized. This meant that relatively large amounts were disposed of in the low-demand state. While this would lead to generally lower prices on the market in the case of high demand, thus giving the appearance of welfare gains, the failure to include the real costs of disposal overstate the welfare gains and lead to further loses due to excessive production. As is typical with negative externalities, overall welfare losses may occur if the externality is not considered.

By pushing disposal costs into the firm's profit function, RPM is less likely to be preferred by firms, mitigating the frequency of appeal to legal action. What is apparent is that the results obtained by Flath and Nariu (2000) are very much dependent on disposal costs. The appropriate disposal cost will naturally depend on the product under consideration. These considerations imply that only certain types of products, those with a low or zero cost of disposal, are likely to see RPM providing welfare increases, because firms may decide to avoid disposal costs. Thus the argument against banning RPM is less strong if disposal costs are part of the firm's profit considerations. If consumers and society are concerned with RPM, the proper action would seem to be a careful examination of environmental law rather than intervention in markets.

Direct public policy implications of this article are concerned with both industrial and environmental policy. Many major countries—the United States, Canada (see the 1985 Competition Act, Section VI), and the European Union—are concerned with the use of RPM by firms. Generally RPM is believed to be counter to the interests of society. We contribute to the literature that gives conditional support to allowing RPM, as opposed to following the current political direction of forbidding it. We stipulate, however, that the positive effects of RPM may be overstated and indeed may be nonexistent if disposal costs are not well established. RPM, by its nature, creates waste product. If this waste product is not adequately considered, allowing RPM may lead to social loss when firms choose to use RPM. Therefore, in a legal environment that allows RPM, well-developed markets for disposal are essential.

Future research in this line will move in two directions. Suppose that there is some foreign, or world, perfectly competitive market available that the firm may sell its excess to. The firm then may choose to dispose of the excess or sell it into this alternate market at price P_W. Another possibility is to consider the firm as playing this game infinitely many times. The firm, rather than disposing of the product, can hold it as inventory; thus incurring a storage cost. At first glance, this appears to be a Markov process for production and inventory, with some optimal amount of expected inventory on hand at any given period.

APPENDIX A

Proof of welfare improvement under RPM when disposal costs are incorporated into firm profits and demand differs by slope. By definition, at equilibrium the following equalities hold:

$$\text{(A1)} \qquad P_{FH} - P_H = b_H(X_{Hd} - X_{Fd}),$$

where P_{FH} is price under flex price production and high demand, and P_H is price under RPM when demand is high;

$$\text{(A2)} \qquad P_L - P_{FL} = b_L(X_{Fd} - X_{Ld}),$$

where P_L is price under RPM when demand is low and P_{FL} is price under flex price production when demand is low;

$$\text{(A3)} \qquad (1-\theta)b_L(X_{Fd} - X_{Ld}) = \theta b_H((X_{Hd} - X_{Fd}).$$

The difference in welfare between RPM and flex price can be written as

$$\begin{aligned}\Delta W = &\frac{1}{2}\,\theta(P_{FH} - P_H)(x_{Hd} - x_{Fd}) + \theta P_H(x_{Hd} - x_{Fd})\\ &- \frac{1}{2}\,(1-\theta)(P_L - P_{FL})(x_{Fd} - x_{Ld})\\ &- (1-\theta)P_{FL}(x_{Fd} - x_{Ld}) - c(x_{Hd} - x_{Fd})\\ &- d(1-\theta)(x_{Hd} - x_{Ld}).\end{aligned}$$

Replacing P_i with the appropriate form ($P_i = Y - b_i x_i$), using Equations (A1)–(A3) yields

$$\begin{aligned}\Delta W = &\frac{1}{2}\,\theta b_H(x_{Hd} - x_{Fd})^2 + \theta(Y - b_H x_{Hd})(x_{Hd} - x_{Fd})\\ &- \frac{1}{2}\,\theta b_H(x_{Hd} - x_{Fd})(x_{Fd} - x_{Ld})\\ &- \theta(b_H/b_L)(Y - b_L x_{Fd})(x_{Hd} - x_{Fd})\\ &- c(x_{Hd} - x_{Fd}) - d(1-\theta)(x_{Hd} - x_{Ld}).\end{aligned}$$

Dividing through by $(x_{Hd} - X_{Fd})$ and gathering terms on θb_H yields

$$\begin{aligned}\frac{\Delta W}{(x_{Hd} - x_{Fd})} = &\,\theta b_H\left[-\frac{1}{2}(x_{Hd} - x_{Fd}) - \frac{1}{2}\,(x_{Fd} - x_{Ld})\right]\\ &+ \theta Y\left[\frac{b_L - b_H}{b_L}\right] - c - d(1-\theta)\frac{(x_{Hd} - x_{Ld})}{(x_{Hd} - x_{Fd})}.\end{aligned}$$

Obviously $x_{Hd} - x_{Ld} = x_{Hd} - x_{Fd} + x_{Fd} - x_{Ld}$. Using this we can break the disposal cost term into parts and use Equation (A3) to obtain:

$$\begin{aligned}\frac{\Delta W}{(x_{Hd} - x_{Fd})} = &-\theta b_H\,\frac{1}{2}\,(x_{Hd} - x_{Ld})\\ &+ \theta Y\left[\frac{b_L - b_H}{b_L}\right] - c\\ &- (1-\theta)d \;-\frac{\theta d b_H}{b_L}.\end{aligned}$$

Using the equilibrium values for x_{Hd} and x_{Ld} and dividing through by Y, we get

$$\begin{aligned}\frac{\Delta W}{Y(x_{Hd} - x_{Fd})} = &-\frac{3(1-\theta)d}{4Y} - \frac{3\theta d b_H}{4b_L\,Y}\\ &- \frac{3\theta b_H}{4b_L} + \frac{3\theta Y \;-\; 3c}{4Y}.\end{aligned}$$

If welfare increases with the use of RPM, this term is positive.

The above equation reduces to

$$\frac{b_L - b_H}{b_L} \geq \frac{d + c}{(Y + d)\theta},$$

which is simply the result of the first-order conditions when RPM is used.

APPENDIX B

Proof of welfare improvement under RPM when disposal costs are incorporated into firm profits and demand differs by intercept. By definition, at equilibrium the following equalities hold:

(B1) $$P_{YFH} - P_{YH} = b(X_{YHd} - X_{YFd}),$$

where P_{YFH} is price under flex price production and high demand, and P_H is price under RPM when demand is high;

(B2) $$P_{YL} - P_{YFL} = b(X_{YFd} - X_{YLd}),$$

where P_L is price under RPM when demand is low and P_{FL} is price under flex price production when demand is low;

(B3) $$(1-\theta)(X_{YFd} - X_{YLd}) = \theta(X_{YHd} - X_{YFd}).$$

The difference in welfare between RPM and flex price can be written as (d subscripts have been dropped)

$$\begin{aligned}\Delta W &= \frac{1}{2}\theta\,(P_{YFH} - P_{YH})(x_{YH} - x_{YF})\\ &+ \theta P_{YH}(x_{YH} - x_{YF})\\ &- \frac{1}{2}(1-\theta)(P_{YL} - P_{YFL})(x_{YF} - x_{YL})\\ &- (1-\theta)P_{YFL}(x_{YF} - x_{YL})\\ &- c(x_{YH} - x_{YF})\\ &- d(1-\theta)(x_{YH} - x_{YL}).\end{aligned}$$

Obviously $x_{YH} - x_{YL} = x_{YH} - x_{YF} + x_{YF} - x_{YL}$ using this and substituting in Equations (B2) and (B3):

$$\begin{aligned}\Delta W &= \frac{1}{2}\theta\,(x_{YH} - x_{YF})^2\\ &+ \theta P_{YH}(x_{YH} - x_{YF})\\ &- \frac{1}{2}(1-\theta)b(x_{YF} - x_{YL})^2\\ &- (1-\theta)P_{YFL}(x_{YF} - x_{YL})\\ &- c(x_{YH} - x_{YF}) - d(1-\theta)(x_{YH} - x_{YF})\\ &- d(1-\theta)(x_{YF} - x_{YL}).\end{aligned}$$

Using Equation (B3), dividing through by $(x_{YH} - X_{YF})$, and gathering terms yields

$$\frac{\Delta W}{x_{YH} - x_{YF}} = -\,\theta\frac{1}{2}b(x_{YH} - x_{YL}) + \theta(Y_H - Y_L) - (c+d).$$

Using the equilibrium values for x_{YH} and x_{YL}, we get

$$\frac{\Delta W}{x_{YH} - x_{YF}} = \theta\frac{3}{4}(Y_H - Y_L) - \frac{3}{4}(c+d).$$

If welfare increases with the use of RPM, this term is positive:

$$\frac{\Delta W}{x_{YH} - x_{YF}} = \theta\frac{3}{4}(Y_H - Y_L) - \frac{3}{4}(c+d) \geq 0.$$

The above equation reduces to

$$Y_H - Y_L \geq (c+d)/\theta,$$

which is simply the result of the first-order conditions when RPM is used.

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