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Gun Buybacks and Firm Behavior: Do Buyback Programs Really Reduce the Number of Guns?

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Abstract: We suppose that guns or firearms are subject to an anticipated future buyback program undertaken by the government. A simple linear demand durable-goods monopoly model is then analyzed where the durable-good manufactured is a firearm that lasts for two-periods. The model is calibrated so that buyers are indifferent between selling (participating in the buyback program) or holding the gun in the future period. This allows us to focus solely on the firm's behavior. We find, among other things, that if the firm *can* credibly commit to its current buyers the anticipated buyback has no impact on the future stock of guns. In this case, the firm simply increases its production of new firearms after the buyback, and offsets all the units collected and destroyed by the government. However, in contrast, we show that if the seller *cannot* commit to these buyers, the future stock is indeed reduced (but by only one-half of the buyback program level). Thus, any anticipated (repeated) buyback's impact on future stock levels of firearms depends critically on the commit ability of the durable-goods manufacturer, independent of the buyers' reselling and arbitrage activities. Moreover, regardless of commitment ability, the model suggests the imperfectly competitive firms may, at least partially, counteract the buyback program, making any governmental buyback less effective at reducing future firearm stocks than expected.

JEL classifications: L3, D4

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1. Introduction

Gun buyback programs have become a relatively common phenomena around the world, and the United States in particular.[1] Indeed, a large number of major U.S. cities have offered gun buybacks in recent years (e.g., Boston, Buffalo, Chicago, Cleveland, Detroit, Louisville, Miami, Tampa, St. Louis, and Washington, D.C., (see Welch (2008)). This raises interesting questions about the behavior of the economic agents (buyers and producers) involved in gun sales. The conventional wisdom is that these buybacks are an effective means to decrease the circulating stock of firearms and thus, reduce gun violence.

Recently, however, this "conventional wisdom" has been challenged in both the popular press and economic arenas. For example, the popular press has, of late, often characterized these buyback programs as being largely ineffective "feel good" policies that have little to no impact on the stock of firearms and related gun crime (e.g., Los Angeles Times (May 12 2009), Welch (March

[1] Examples of recent gun buyback programs outside the U.S in the past decade, include Argentina and Brazil, among many others (see Valente (2008)).

17, 2008)). Similarly, the effectiveness of these buyback programs has been questioned recently on both theoretical and empirical grounds in the economics literature.

On the empirical side, there are a number of analyses that raise doubts about the effectiveness of governmental gun buybacks, particularly the large Australian buyback of 1996-1997. The Australian buyback was one of the largest buyback programs in history and ultimately involved the repurchase of some 600,000 firearms.[2] The stated purpose of this buyback was to reduce the stock of circulating firearms by approximately $1/5^{th}$ by repurchasing the used guns at the market price. A number of empirical studies have examined the impact of this buyback, with most recent being Lee and Suardi (2010) and Leigh and Neill (June 2010). Lee and Suardi, as well as a number of previous authors, conclude the buyback has had little to no effect on firearms related deaths in Australia. However, Leigh and Neill argue that when panel (cross-sectional and time-varying) data is used, there is a significant drop in firearm suicide rates in Australia due to the buyback (although the relationship between gun homicides rates and buybacks is more ambiguous). Hence, the empirical evidence is somewhat mixed which, of course, begs the theoretical question: why might these buyback programs not be as effective as originally thought?

In terms of theoretical economic models, in perfectly competitive market durable-goods framework, Mullin (2001) argues that circulating stock of firearms may not be decreased by gun buybacks. Indeed, Mullin shows that anticipated buybacks might actually *increase* the circulating stocks of guns due to buyers' arbitrage activities. Mullin argues that anticipated buybacks likely will increase "the willingness of consumers to buy, hold, and later resell" the durable firearm. This provides one theoretical rationale for the ineffectiveness of gun buybacks. One aspect, however, that is lacking in this existing economic analysis on gun buybacks, is the so-called "durable-goods problem" or "Coase conjecture" found in *imperfectly* competitive durable-goods markets. In other words, what impact does an anticipated future buyback likely have on a durable-goods (firearms) *producer's* behavior?

Coase (1972) was the first to argue that rational buyers would likely expect a monopolistic seller to decrease the durable-goods future price since these buyers would hold the existing stock, not the firm. In other words, the resulting capital loss on the existing units (circulating stock of durables) as the future price is decreased (output increased) is borne by buyers and not the firm. Consequently, a monopoly seller would have little interest in taking these capital losses into account in its future decisions. As Coase notes, however, given rational buyers, there will effectively be an expectational constraint placed on the firm. In effect, the firm will be forced to price the durable good closer to its marginal cost (the Coase conjecture) *unless* the firm can credibly convince its customers it will not decrease future prices of the durable at their expense. A number of subsequent authors (e.g. Bulow (1982, 1986), Butz (1990), Goering and Pippenger (2002)) have confirmed that unless the seller can credibly commit to buyers in some fashion, buyers' rational expectations will indeed constrain the durable-goods producer.[3] In summary, in these imperfectly competitive durable-goods frameworks, the ability of the firm to commit to buyers (that it will not decrease future prices to their detriment) has a large impact on the actual outcomes the models predict.

Although there are examples of quasi-monopoly firearms markets, such as the U.S. military's assault rifle M16 manufactured exclusively by Colt and its licensees, this is not typical. Firearms markets are more commonly thought to be imperfectly competitive durable-goods markets dominated by a relatively small number of major producers with a number of smaller "fringe"

[2] Note, however, the buyback program was only one part of the National Firearms Agreement (NFA) of 1996-1997. The NFA made sweeping changes in other areas of gun ownership in Australia, such as, restrictions on the types of firearms allowed. Thus, it is difficult to untangle the impact of the buyback program from the other provisions included in the NFA.

[3] See Waldman (2003) for a survey of the durable-goods literature and the Coase conjecture.

firms. For example, Smith&Wesson, Colt, Beretta, Taurus, Glock, and Ruger are all major players in the U.S. handgun market, while companies like Springfield Armory, Para Ordnance, and Dan Wesson are smaller handgun manufacturer's selling in the U.S. Unfortunately, the modeling of these types of imperfectly competitive durable-goods markets is extremely complicated due to the strategic aspects of the rival firms inside a dynamic framework (see Waldman (2003)). Thus, durable-goods imperfectly competitive markets are most often stylized and analyzed using a dynamic monopoly model. This is, in fact, the approach we take in this paper.

We build on the extant durable-goods models, and analyze the impact of an anticipated government firearms buyback on a durable-goods monopolist's time path of output. In particular, in a simple two-period setting, we parameterize the government's gun buyback amount in terms of the number of units of the used firearms sold back to the government and subsequently destroyed. The model is normalized so that firearms buyers are indifferent between participating in the government buyback program or holding the gun in the future period. The monopoly simplification allows us to focus on the buyback programs impact, given the commitment ability of the firearms manufacture with its potential buyers.

We find, among other things, that if the firm *can* credibly commit to current buyers, the anticipated buyback has no impact on the future stock of guns. In this case, the firm simply increases firearms productions to offset all the units collected and destroyed by the government. In other words, the governmental buyback is completely counteracted by the firm through its production of additional new guns, implying no net reduction in the stock of guns in the future. However, in contrast, we show that if the seller *cannot* commit to these buyers, the future stock is reduced (but by only one-half of the buyback program level given our linear demand assumption). Thus, any anticipated (repeated) buyback's impact on future stock levels of firearms depends critically on the commit ability of the durable-goods manufacturer, independent of the buyers' reselling (arbitrage) activities. However, regardless of the firm's commitment ability, our analysis suggests the imperfectly competitive firms will likely counteract the buyback program to some extent through increased future production. Consequently, governmental buybacks may be less effective than expected at reducing circulating stocks of firearms. Our model provides yet another theoretical rationale for the ineffectiveness of gun buybacks.

In addition, our model suggests that even if the buybacks are successful in temporarily decreasing the stock of firearms, this will *increase* the manufacturer's profits. Buybacks will decrease the used stock of guns on the secondary market. Consequently, the competition the firm faces on the sale of its new firearms declines. In other words, the monopolist does not have to deal with competition from all its own surviving durable units since some of these guns are bought by the government and destroyed.[4]

2. Durable-Goods Model with Anticipated Gun Buybacks

As discussed in the previous section, we suppose that firearms are manufactured by a monopolist over a two-period horizon (for an analysis of the basic two-period monopoly durable goods framework see Bulow (1982, 1986)). In particular, the firm can select its output levels q_t in each period. Since guns are usually extremely durable, we also suppose every firearm produced in the first period remains for service or use in the second period. In other words, we are assuming

[4] This would suggest that firearms producers might actually favor such governmental buybacks or engage in buybacks themselves. Indeed, recently SIG-Sauer ran in its own buyback program in Chicago and actually paid a higher price for the guns than the city's own official police run buyback program (see Gwinn (2009)).

that guns are perfectly durable.[5] This indicates, the total stock of durable firearms available for use in period one is $Q_1 = q_1$ and in period two it is $Q_2 = q_1 + q_2$, ignoring any government buybacks in the second period. However, with buybacks, the actual stock of firearms available for use in period two is the cumulative production, *less* what the government buys back and destroys: $x \geq 0$. This implies the actually stock in period two is $Q_2 = q_1 + q_2 - x$. For tractability we also assume the inverse service or periodic demand for output is simply linear in the stock of durable firearms, i.e., $p_t = a - bQ_t$.[6]

If we let $\beta \in [0,1]$ represent the one-period discount factor, we can now construct the selling price of a firearm in the first period. The asset or sales price of the firearm is the same as any other durable goods, namely the discounted stream of rental or service prices which is given by (1):

$$p_1^s = p_1 + \beta p_2^e = a - bq_1 + \beta(a - b(q_1 + q_2 - x)) \qquad (1)$$

As noted, if $x \geq 0$ as the amount of period one (used) firearms that are purchased back through the anticipated government program at the beginning of the second period and destroyed, it indicates that $p_2^e = a - b(q_1 + q_2 - x)$ is the expected service price in period two. Equation (1) indicates consumers will purchase a durable unit in period one given their rational expectations about the service price in period two. This, of course, begs the question about timing and arbitrage possibilities of the government's buyback program.

As stated, we are assuming in (1) that the government's anticipated (announced) buyback in the second period occurs *before* any production occurs, i.e., before the firm's choice of q_2. This implies that only old guns (durable period one output) are eligible for the buyback and not new production q_2. This is roughly consistent with most government buybacks where the firearms targeted are old or used firearms and not new production of the assembly line (e.g., see Welch (2008)). Secondly, since the used durable stock is entirely held by buyers at the beginning of period two (guns are only sold and not leased in period one), only consumers are allowed to participate in the buyback program which also is consistent with most real-world buybacks. Effectively, our assumption eliminates the possibility of the manufacturing firm participating directly in the buyback by either producing new guns in period two and then immediately selling them to the government, or by leasing the guns in the first period and then selling these used units to the government in period two. However, on the other hand, we need to ensure that the buyers of the guns have an incentive to participate directly in the buyback program even if the firm cannot.

Note that the owner of a used firearm, in terms of arbitrage or selling possibilities, can either: 1) sell the unit to the government through the buyback program at the beginning of the second period for say r_2 or 2) hold the unit and resell it in the secondary private market for used durables at the expected price p_2^e. If we treat this durable unit simply as a pure asset, the gun buyer or owner will choose the alternative that maximizes their return. To avoid this confounding factor (which has already been extensively examined by Mullin (2001) in a perfectly competitive model), we normalize the government buyback price in period two r_2 such that it equals the expected price

[5] However, we can relax this assumption, i.e., allow for deprecation of the durable good, without impacting our main results.

[6] Although a more general demand specification will not likely impact the overall conclusion that the durable-goods manufacturer will offset some of the government's buyback units, it certainly changes the magnitude of these effects as we note in following section.

p_2^e.[7] Consequently, the period one buyers (used firearm owners) are indifferent between selling (participating in the buyback program) or simply holding the gun in the second period for private use.[8] This effectively parameterizes the government buyback amount *x* and indicates it does indeed represent the number of units of the used durable sold back to the government and subsequently destroyed (i.e., removed from the circulating stock in the second period). Moreover, we can now focus exclusively on the imperfectly competitive durable-goods firm's likely response to the future anticipated buyback level *x* independent of any buyer arbitrage behaviour.

Before we can analyze the monopolist's profit maximizing response to the anticipated buyback, we need to specify the firm's cost, which we do by assuming a constant marginal production cost of output in each period as $c_1 > 0$ and $c_2 > 0$, respectively.[9] Although we are assuming a simple constant returns technology, we do allow that these manufacturing costs maybe different in each period. This cost specification and our sales price in (1) now allow us to form the monopolist's discounted profits of selling firearms given the buyback program. The firm's objective function is shown in (2):

$$\begin{aligned}\pi &= (p_1^s - c_1)q_1 + \beta(p_2^e - c_2)q_2 \\ &= (p_1 + \beta p_2^e - c_1)q_1 + \beta(p_2^e - c_2)q_2 \\ &= \big(a - bq_1 + \beta(a - b(q_1 + q_2 - x)) - c_1\big)q_1 + \beta(a - b(q_1 + q_2 - x) - c_2)q_2\end{aligned} \tag{2}$$

Remembering here that we have assumed buyers are indifferent between participating in the gun buyback program or holding the gun in the second period for private use, i.e., $r_2 = p_2^e$.

Although the firm always seeks to maximize (2), it is effectively constrained by current buyers' expectations about the future price p_2^e (as Coase (1972) notes). A selling durable-goods monopolist faces a potential commitment problem with its rational period-one buyers, and therefore

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[7] If, however, we suppose $r_2 > p_2^e$, the anticipated buyback would likely have a similar consumer arbitrage effect as found by Mullin. In this case, there would an incentive for period one buyers to increase their gun purchases since they can sell the used guns (to the government) for a higher price than they would be able in the absence of the buyback. This would tend to increase the number of guns purchased in period one. This suggests that any anticipated buybacks would be even less effective (at decreasing gun stocks) than what we found in this paper where we assume $r_2 = p_2^e$. Note also that, if $r_2 < p_2^e$, the buyback would be completely ineffective in our framework, since used gun owners can receive higher prices in period two by selling the firearm in the private market at p_2^e rather than to the government at r_2. It is also worth mentioning that our assumption is $r_2 = p_2^e$ is consistent with the Australian NFA gun buyback where the used firearms were bought back at market prices (eventually reducing the stock of circulating firearms by approximately 1/5th).

[8] Note that although the buyback price r_2 is normalized here such that $r_2 = p_2^e$, it still is true that the government buyback price is *less* than the price of a new durable firearm purchased in *period one* ($r_2 < p_1^s$). This is consistent with actual gun buybacks. For example, Mullin (2001) notes buybacks have averaged about $41 paid for used firearms, which is less than the cost of a new firearm. Similarly, in Argentina, Valente (2008) notes the buyback prices ranged from $34 to $150 for the firearms and their associated ammunition.

[9] We further suppose that these marginal production costs are less than the demand choke price *a* (to ensure positive output in both periods), i.e., $a > c_1$ and $a > c_2$.

must maximize (2) *subject to* their expectations. First-period buyers rationally expect the firm to re-maximize in period two. However, the surviving durable period one units q_1 are owned by buyers and *not* the firm in period two. Consequently, a monopolistic seller has little incentive to take these durable units into account in its future re-maximization decision. This indicates the capital loss on the existing stock of durables, will be borne by period one buyers (the future owners), as the firm sells future units and decreases the market price. Unless the monopolist can credibly commit to buyers it will take their capital loss into account in its future behavior, the expected price in future p_2^e is impacted by the buyers' rational expectations.[10] In other words, we seek the dynamically consistent (sub-game perfect) solution to our durable-goods buyback model. Hence, in the final (second) period, the first period buyers rationally recognize the selling firm without commitment power will simply maximize (3):

$$\pi_2 = \beta(a - b(q_1 + q_2 - x) - c_2)q_2 \tag{3}$$

Thus, unless the firm can credibly convince or commit to these buyers (that it will take their capital loss on the period one units they still hold into account), it will maximize (3) and *not* the discounted portion of (2) (which equals $\beta((q_1 + q_2)(a - b(q_1 + q_2 - x)) - c_2 q_2)$). This creates a dichotomy between the committed and uncommitted sellers case.

We explore both cases in the next two sections to ascertain the likely impact of an anticipated governmental buyback of firearms. In other words, what is the impact of gun buybacks on the firm behavior in terms of the future stock of guns, in both committed and uncommitted sales markets?

3. Uncommitted Gun Sales with Anticipated Buybacks

We first suppose that it is difficult or costly for the firm to credibly commit to the period one buyers of its durable firearm. Hence, rational buyers will recognize the firm will maximize (3) when the second period production is chosen. To ensure our resulting solution is dynamically consistent (sub-game perfect) we solve the model in reverse order. The maximization of (3) with respect to second period output q_2, gives:

$$q_2 = \frac{a - c_2 + bx - bq_1}{2b} \tag{4}$$

It is immediately apparent from (4), that the profit-maximizing firm's future output of guns q_2 is *increased* by the buyback level *x*. Hence, the firm simply offsets some of the destroyed buyback units *x* through new production. However, we need to fully solve the model to ascertain the complete impact of the gun buyback program on the circulating stock ($Q_2 = q_1 + q_2 - x$) of firearms in period two.

Since rational buyers know that (4) is optimal for the seller in period two, they will take this into account in their period one buying behavior. Hence, (4) becomes a constraint on the firm's maximization in the first period. Even though the seller wishes to maximize (2), is constrained by

[10] As many previous authors have noted, a variety of mechanisms exist to allow the firm to credibly commit. For example, capacity constraints, best-price provisions, and forward marketing contracting immediately come to mind (see Butz (1990), Goering (1992, 1997), Goering and Pippenger (2002), Waldman (2003), Morita and Waldman (2004) for further discussion of this commitment issue and the associated commitment mechanisms).

(4). Substituting (4) into (2), differentiating with respect to first period output q_1, and solving gives the optimal period one output:[11]

$$q_1 = \frac{2(a - c_1 + \beta c_2)}{b(4+\beta)} \tag{5}$$

Equation (5) indicates that an uncommitted seller of durable firearms does *not* wish to alter its current output, even though it anticipates the future government buyback *x*. Substituting (4) and (5) into the stock equation $Q_2 = q_1 + q_2 - x$, and simplifying gives:

$$Q_2 = q_1 + q_2 - x = \frac{(6+\beta)a - 2c_1 - (4-\beta)c_2}{2b(4+\beta)} - \frac{1}{2}x \tag{6}$$

Equation (6) simply confirms what we already know from (4) and (5), namely the buyback amount is partially offset by the monopoly seller with new period two production of guns. Given our linear demand assumption, the actual circulating stock in period two is only decreased by *one-half* the amount of the guns purchased and destroyed by the government. This gives:

Proposition one: *In a market where the seller of durable firearms cannot commit to current buyers, the future stock of guns is reduced in equilibrium, but by only one-half of the government buyback level given linear demand.*

This proposition indicates that any anticipated buyback of guns will likely be less effective at reducing the stock in an imperfectly competitive market, simply due to the firm's own profit-maximizing incentives to sell new firearms.12 In other words, the firm may, in the wake of the government purchase and destruction of guns, simply increase its production to satisfy the residual demand for these firearms and offset *x* at least partially. In a sense, the government is helping to reduce the firm's commitment problem with period one buyers, by removing the some of the used stock of guns.[13] The selling uncommitted firm will optimally respond by increasing its production by $\frac{1}{2}x$, given our linearity assumption.

Interestingly, we show in the next section that the firm response (of increased production) is heightened if the seller can credibly commit to its current buyers. Indeed, we show that a committed seller may, in fact, offset completely the governments buyback amount *x* through new production in the future period, rendering the buyback completely ineffective.

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[11] Second-order conditions are satisfied in all our solutions.

[12] As noted in the previous section, our assumption of a linear service demand, as well as constant marginal production costs, undoubtedly impacts the magnitude of our result here. In particular, with a more general (non-linear) demand, although the future stock of guns would still tend to be reduced, it would not be reduced by precisely one-half the buyback amount.

[13] This suggests that the buyback program will *enhance* the firm's profit. In other words, as the buyback amount *x* increases, it tends to *increase* the firm's profit (which presumably is a unintended consequence of the governmental buyback program). In this particular case, of an uncommitted selling firm, it is easy to show that:

$$\frac{\partial \pi^*}{\partial x} = \frac{(a - c_2 + bx)}{2} > 0 .$$

Intuitively, the buyback decreases the used stock of guns in the secondary market, effectively decreasing the competition the firm faces on the sale of its new guns in period two.

4. Committed Gun Sales with Anticipated Buybacks

In this section, we suppose, the firm can credibly commit to current period one buyers that it will take into account capital losses borne by buyers as the firm increases output (decreases price) in period two. As noted in the previous section, with committed sales, the optimal sales solution can usually be calculated by simply differentiating (2) with respect to the output levels in each period.

This implies that the firm simply commits to take into account in its period two maximization *all* durable period one units that remain for use in the second period (which is q_1, given we have assumed perfect durability). However, given the existence of the government buyback amount *x*, the remaining units held by period one buyers in period two is actually only $q_1 - x$. Effectively, the buyback program decreases the number of units that are available for use in period two as noted earlier. In other words, in our setting, there is a dichotomy between the number of physically surviving units (based on their "built-in" durability), which is q_1, and the actual number of units still in circulation $q_1 - x$ in period two. This dichotomy is *not* present in the standard durable-goods model.

This dichotomy indicates that the firms may be able to commit to different levels of output (say $q_1 - x$ or q_1). We suppose that the firm can credibly commit to the number of actual units still in circulation and used by owners after the buyback is completed, which is $q_1 - x$. This seems to be the most reasonable assumption, since buyers would likely *not* believe that the firm would take into account in its profit-maximization in period two, those firearms *x* already purchased and destroyed by the government's buyback. Hence, we assume the firm can commit on the remaining units held by private buyers in period two $q_1 - x$, rather than the total number of period one durable units manufactured q_1.[14] With this assumption the firm would maximize (7) with respect to second period output q_2:

$$\pi_2 = \beta((q_1 + q_2 - x)(a - b(q_1 + q_2 - x)) - c_2 q_2) \qquad (7)$$

Comparing (7) with the uncommitted seller's profits in (3), we see that in this case the seller is indeed taking into account the value of guns previously sold to customers but still in circulation after the buyback $q_1 - x$. Hence, this term appears in the firm's objective function in (7), but not in (3). This maximization yields:

$$q_2 = \frac{a - c_2}{2b} + x - q_1 \qquad (8)$$

in this committed selling case. From (8), it appears, that the committed firearms seller will optimally wish to keep the stock at the same level *regardless* of the government buyback amount *x*. That is, equation (8) suggests that that if the seller that can credibly commit to period one buyers that it will take into account their units still in circulation after the buyback ($q_1 - x$), it will simply

[14] However, it does raise interesting questions about the firm's ability and desire to commit to *all* the units produced q_1, which includes units bought back by the government and destroyed. If the firm could credibly convince buyers it will take into account these units held and destroyed by the government, it effectively changes its objective function into that of a pure renting durable goods producer that is allowed to directly participate in the government buyback program in period two. The firm would, in effect, be able to simultaneously sell its used rental units to the government directly through the buyback or to period two private buyers as it wished in this case.

increase its production in the second period to *fully* offset *x*. This implies an anticipated governmental buyback will have no impact on the circulating stock of guns in period two: $(Q_2 = q_1 + q_2 - x)$.

To show that this is indeed the case we, as in the previous uncommitted sales section III, fully solve the model by differentiating the discounted profit function in (2) with respect to period one production q_1, given that q_2 is determined now by (8) and not (4) as in the previous uncommitted sales case. This maximization gives:

$$q_1 = \frac{(a - c_1 + \beta c_2)}{2b} \qquad (9)$$

As in the uncommitted selling case equation (5), equation (9) still indicates that a committed seller of durable firearms does *not* wish alter its current output. Hence, even though it anticipates the future government buyback *x*, it does not optimally alter current output, only future period two output are changed (8) and (9) show.

Once again, by simply substituting (8) and (9) into the circulating period two stock equation $Q_2 = q_1 + q_2 - x$, we obtain:

$$Q_2 = q_1 + q_2 - x = \frac{a - c_2}{2b} \qquad (10)$$

Equation (10) shows that in this committed case the gun buyback has no impact on the stock of circulating firearms in period two Q_2. The firm simply offsets, unit-by-unit, any old output destroyed by the government through new period two production. This confirms what we already suspected from equation (8), i.e., the buyback amount is *completely* offset by the new production of guns in period two in this case.

Proposition two: *In a market where the seller of durable firearms can credibly commit to current buyers, an anticipated governmental gun has no impact on the future stock of guns in circulation. Hence, an anticipated governmental buyback is completely ineffective at reducing the future stock of firearms when the monopolistic seller can commit to its current customers.*

Among other things, proposition one and two indicate that any anticipated or repeated buyback's impact on future stock levels of firearms likely depends critically on the commitment ability of the durable-goods firearms manufacturer.[15] This "production effect" is independent of, and in addition to, any impact of buyers' reselling or arbitrage activities (see Mullin (2001)). Furthermore, regardless of the firm's commitment ability, our analysis (propositions one and two) suggest, imperfectly competitive firms will likely, at least partially, counteract any gun buyback program. Hence, any governmental gun buyback may well be less effective at reducing future firearm stocks than expected.

[15] Although our propositions are game theoretic in nature, in may be possible to empirical evaluate and test them by using the firm's use of commitment mechanisms as a proxy for the firm's commitment ability (e.g., best price guarantees as in Butz (1990)).

Finally, it is worth noting that once again (see footnote 13), any buyback will tend to enhance the committed gun sellers profit.[16] Hence, as the government increases its buyback amount *x*, it once again has the unintended consequence of *increasing* the gun seller's profit.

5. Concluding Remarks

In this paper we explore the effectiveness of gun buybacks in reducing the circulating stock of durable firearms. Indeed, there have been a number of economic studies that raise doubts about the effectiveness of governmental gun buybacks (e.g., Lee and Suardi (2010)). However, the vast majority of these studies are empirical in nature and seemingly little attention has been paid to the theoretical economic implications of gun buybacks (Mullin's (2001) is an exception). In particular, to our knowledge, there has been no analysis of an imperfectly competitive durable-goods firm's likely production response to such buybacks. Our current examination sheds light on the expected behavior of a monopolistic firearms producer that faces a future buyback program.

Since guns are typically a very durable good, we utilize a standard two-period durable-goods monopoly framework where guns are assumed to be perfectly durable. The buyback program in period two is also assumed to be known to all participants. In this setting, our analysis suggests that the imperfectly competitive firm may simply increase future production of firearms to offset those units purchased and destroyed by the government. Consequently, gun buyback programs may be much less effective at reducing the circulating stock of firearms than previously thought in imperfectly competitive markets.

In particular, we find that the effectiveness of these buyback programs in reducing the circulation stock depends critically on the ability, or lack thereof, of the firm to credibly commit to current buyers about its future pricing behavior. Indeed, if the firm can credibly convince period one buyers it will take into account (in its future maximization) the value of these units still held by buyers, the firm will *completely* offset the destroyed buyback units with newly manufactured guns in the future period. On the other hand, if the firm cannot commit to its customers, we find that, given our linear demand assumption, the future circulating stock of guns is decreased but by only *one-half* the buyback amount. Thus, in both examined cases, the buyback program is less effective at reducing the circulating stock of firearms than one may expect. Additionally, in both cases, the ineffectiveness of these gun buybacks is likely heightened when one includes buyers' arbitrage activities (which we have abstracted from here), as in Mullin's (2001). In this sense, our analysis is complementary to Mullin's, since both analyzes raise serious theoretical concerns about the "conventional wisdom" that buybacks are an effective means to reduce the circulating stock of firearms and related gun violence.

Finally, our model suggests that even if the buybacks temporarily decrease gun stocks, the firm actually receives a profit *enhancement* by this. The simple logic here is that buybacks decrease

[16] Note even though in both cases profits tend to be enhanced by the buyback amount *x*, the impact of the buyback (as one would expect) is different in each case. In the committed case we can show that:

$$\frac{\partial \pi^*}{\partial x} = \frac{(a - c_2)}{2} > 0 .$$

As footnote (13) indicates, this profit enhancing effect is less than in the uncommitted case ($\frac{\partial \pi^*}{\partial x} = \frac{(a - c_2 + bx)}{2} > 0$). This is because the buyback effectively decreases the uncommitted seller's commitment problem (since less period one units remain in service after the buyback); consequently, it has higher profit potential in this case. This "commitment effect" of the gun buyback is, of course, an irrelevant point in the committed sales case.

the secondary (used) stock of durable guns, which, in turn decreases the effective competition the firm faces on the sale of its new guns. As is well known, a durable-goods monopoly faces dynamic competition with its own surviving durable units and the buyback and destruction of these used guns simply helps mitigate this problem and increases the firm's profit.

In terms of future research avenues, first, our analysis has suggested that commitment ability in imperfectly competitive firearms markets is likely an important factor (on the effectiveness of gun buybacks in reducing the number of firearms in circulation). Consequently, this raises the question about the type of commitment and mechanisms that a profit-maximizing firm wishes to utilize. For example, would any of the "standard" commitment mechanisms, such as best-price provisions, still work in the face of governmental buybacks? What exactly does the seller wish to commit to, i.e., all period one units manufactured including those bought and destroyed by the government, or just those that remain in actual circulation in the future period? Secondly, by stylizing imperfect competitive market as a pure monopoly, we have clearly removed any strategic interaction among rival firms. What is the impact of an anticipated future buyback on the firm's behavior when they face rivals? Finally, the durability of the firearms was exogenously specified in our model (perfectly durable) since firearms tend to be very durable. However, in a more general setting, obviously, product durability may be endogenously determined. What impact does durability choice have upon the ultimate effectiveness of any buyback program? These all are interesting questions about the effectiveness of buybacks in imperfectly competitive markets, which are left for future research.

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