The effects of bailouts and soft budget constraints on the environment

Joel Wood*

Centre for Environmental Studies

Fraser Institute

Published Online by *Environmental & Resource Economics*: August 2012

Abstract

This paper investigates the effects of financial relief programs, commonly referred to as 'bailouts', on pollution. A partial equilibrium soft budget constraint model of the firm is developed to identify the effect of bailouts on the emission decisions of firms. The results from the model indicate that the expectation of bailouts increases *ex ante* emissions. A more stringent emissions tax is required to achieve the same level of emissions if bailouts are available than if bailouts are not available; however, a tradable permit system will maintain the same emissions level if bailouts are available as when bailouts are not available.

Keywords: bailouts, moral hazard, pollution, soft budget constraints, uncertainty; **JEL:** Q58, H23, P31

---

*Corresponding author. Email: joel.wood@fraserinstitute.org. I would like to thank Ross McKitrick, John Livernois, Asha Sadanand, Alistair Munro, and two anonymous referees for their helpful comments. This research was conducted during Ph.D. studies at the University of Guelph and does not necessarily reflect the opinions or views of the Fraser Institute. All errors are my own.

1 Introduction

The global recession due to the 2007-2008 financial crisis resulted in unprecedented levels of stimulus spending by governments around the world. The widespread availability of government funded financial relief to private firms (e.g., the North American auto bailouts, the Canadian Economic Action Plan, etc.) suggests that the concept of the soft budget constraint remains very relevant to economists. The effect of bailouts and soft budget constraints on production input use is well documented in the economics literature; however, the effect of bailouts and soft budget constraints on firm emissions has not been investigated.

The concept of the soft budget constraint was first developed by Kornai (1979, 1986) to help explain why centrally planned economies and transitioning economies are characterized by shortage. Kornai observed that firms under central planning often excessively demand production inputs. He attributed this to the fact that losses were generally recouped through transfers, i.e., bailouts, from a supporting organization[1] (in most cases the state). This topic was extensively explored in the economics of reform and transition literature, notably by Dewatripont and Maskin (1995), Desai and Olofsgard (2006), and Lin and Li (2008). Kornai, Maskin and Roland (2003) provide a thorough review of the soft budget constraint literature.

Although soft budget constraints are most frequently associated with transitioning and centrally planned economies, it is entirely plausible that they also can occur in capitalist economies, though at a lower frequency. Recent history has shown that there are political avenues available to firms in capitalist economies to secure financial relief [2] when facing negative profit situations.

[1] Hence the term "soft budget constraint". on the other hand, if the budget constraint were "hard", the firm would either refinance through the credit market or face insolvency

[2] A bailout can be anything that helps the dependent organization, for example, negotiable subsidies, firm-dependent tax rates, leniently enforced credit contracts, toleration of unreliable

Goldfeld and Quandt (1988, 1990, 1992, 1993), Magee and Quandt (1994), Prell (1996), and Robinson and Torvik (2006) provide soft budget constraint models that are applicable to both firms in planned economies and firms in capitalist economies.

Pollution is an example of a negative externality that warrants government intervention when transaction costs are large. Environmental economics provides guidance to policy makers on how to solve these problems efficiently. However, given that bailouts are available in capitalist economies, it is conceivable that polluting firms may have soft budget constraints. For this reason it is important to know the effect of the soft budget constraint on the marginal abatement cost curve of the firm when imposing or adjusting environmental regulations.

The soft budget constraint literature provides a strong indication of what will occur to input use when bailouts are available; firms with a risk of negative profit outcomes will use more inputs when bailouts are available than when bailouts are not available. However, there is nothing in the literature concerning the effects of the soft budget constraint on firm emissions. The aim of this paper is to develop a soft budget constraint model that accords well with the soft budget constraint literature and the environmental economics literature. This model will inform policy makers by identifying the effect of the soft budget constraint on firm emissions, and any resulting effects on the marginal abatement cost curve.

Section 2 presents a general model and investigates the effect of bailouts and soft budget constraints on firm emissions. Section 3 provides a discussion of potential policy implications that can be drawn from the results. Section 4 concludes the paper.

---

debt servicce, or soft administrative prices.

2 The Model

The model considers a single, risk neutral firm that produces a single output using an input, x. The model is based on the models developed in the series of soft-budget constraint papers by Goldfeld and Quandt (1988, 1990, 1992, 1993). Diverging from Goldfeld and Quandt, the production process results in emissions, e as a by-product. Emissions are assumed to be a function of the amount of input, x and the amount of abatement technology, a. Mathematically, emissions are represented as a convex function $e(x, a)$, with $e_x > 0$, $e_a < 0$, $e_{xx} > 0$, and $e_{aa} > 0$. That is, emissions are increasing in the amount of input used at an increasing rate, and emissions are decreasing in abatement at a diminishing rate. Kohn (1986) provides evidence that the relationship between inputs and emissions is u-shaped (when holding abatement constant); however, assuming emissions to be convex-increasing is reasonable since a large firm (one able to secure a bailout) can be expected to operate on the increasing part of the curve. The assumption that emissions are convex-decreasing in abatement is a relatively standard assumption used, for example, by Antweiler (2003), McKitrick (1999) among others.

To produce output the firm has a production function, $f(x, e(x, a))$ that is strictly concave.[3] Emissions are treated as an input to the production process for analytic convenience. This is also done by Copeland and Taylor (2004). Each unit of abatement technology has a price, $w^a > 0$. The price of x is represented as $w^x > 0$. Emissions regulation is added to the model by assuming that firms face a tax, t for each unit of emissions that they release.[4]

The firm faces revenue uncertainty, which can be thought of as either price uncertainty or production uncertainty. Operating revenue is given by $R =$

[3] i.e., $f_{xx} + f_{ex} + f_e e_{xx} + f_{ee} e_x^2 < 0$, $f_{ee} e_a^2 + f_e e_{aa} < 0$, and $\left(f_{xx} + f_{ex} + f_e e_{xx} + f_{ee} e_x^2\right)\left(f_{ee} e_a^2 + f_e e_{aa}\right) - \left(f_{ex} e_a + f_{ee} e_x e_a + f_e e_{ax}\right)^2$

[4] The implications for emissions permit trading are discussed in Section 3.

$pf(x,e(x,a))\theta$ where p is the output price and θ is a continuous random variable with $E(\theta) = 1$. Consistent with the Goldfeld and Quandt models, the firm is assumed to be a price-taker. This obviously will not cover all types of firms that recieve bailouts since many firms that receive bailouts probably hold some degree of market power. However, the price-taking assumption is relevant to firms receiving bailouts who face an uncertain world price for their products, e.g., the government bailouts of the Hibernia offshore oil project (Marshall, 2001) and the Skeena pulp and paper mill (Skeena, 1999) in Canada. The probability density function of θ is represented by $g(\theta)$ on the domain $\theta \in [\underline{\theta}, \bar{\theta})$ where $\underline{\theta} > 0$. The firm chooses x and a before the realized value of θ is revealed. Operating profit is as follows:

$$\bar{\pi} = pf(x,e(x,a))\theta - w^x x - w^a a - te(x,a). \tag{1}$$

The break-even level of θ is defined as θ_0, which can be found by setting operating profit (equation (1)) equal to zero and solving for θ_0.

$$\theta_0(x,a) = \frac{w^x x + w^a a + te(x,a)}{pf(x,e(x,a))} \tag{2}$$

If $\overline{\pi} < 0$, (i.e., $\theta < \theta_0$) then the firm receives a bailout, $b(\overline{\pi})$, with probability $s \in [0,1]$. If $s = 0$, then bailouts are not possible. And if $s = 1$, then bailouts are certain. For simplicity suppose that the bailout is full compensation of realized negative profit, i.e.,

$$b(\overline{\pi}) = \begin{cases} 0, & \text{if } \theta \geq \theta_0 \\ -\overline{\pi}, & \text{if } \theta < \theta_0 \end{cases} \tag{3}$$

Assuming that the firm cannot influence s is a large simplification. A more realistic case would involve s being a function of lobbying effort by the firm and the unpredictability of the political system (i.e., randomness). However, the results in this paper using an exogenous s are similar to those with lobbying effort when $\theta \sim N(0, \sigma^2)$ and the production function is homogeneous of degree k (see Goldfeld and Quandt (1988)). To focus on isolating the effect of bailouts on e, I will assume that s is exogenous. Now that the bailout function has been defined, expected profit can be represented with the following expression

$$\pi = \begin{cases} \bar{\pi}, & \text{if } \theta \geq \theta_0 \\ (1-s)\bar{\pi}, & \text{if } \theta < \theta_0 \end{cases} \tag{4}$$

Assuming that the firm is risk neutral and maximizes expected profit, the firm's problem can be written as

$$\begin{aligned} \max_{x,a} E(\pi) =& pf(x, e(x,a)) - w^x x - w^a a - te(x,a) \\ & - \int_{\underline{\theta}}^{\theta_0(x,a)} s[pf(x, e(x,a))\theta - w^x x - w^a a - te(x,a)]g(\theta)d\theta. \end{aligned} \tag{5}$$

The resulting first-order conditions for a maximum can be written as

$$f_x + f_e e_x - \left(\frac{w^x + te_x}{p}\right)\frac{\phi_2}{\phi_1} = 0 \tag{6}$$

$$f_e e_a - \left(\frac{w^a + te_a}{p}\right)\frac{\phi_2}{\phi_1} = 0 \tag{7}$$

where $\phi_1 = [1 - s\int_{-\infty}^{\theta_0(x,a)} \theta g(\theta)d\theta]$ and $\phi_2 = [1 - s\int_{-\infty}^{\theta_0(x,a)} g(\theta)d\theta]$.

Lemma 1. *If $s > 0$, then $\frac{\phi_2}{\phi_1} < 1$ for all x and e.*

Proof. Suppose that $\phi_2/\phi_1 \geq 1$.This implies that $\phi_2 \geq \phi_1$, which in turn implies by definition that the following must be true:

$$1 - s\int_{\underline{\theta}}^{\theta_0} g(\theta)d\theta \geq 1 - s\int_{\underline{\theta}}^{\theta_0} \theta g(\theta)d\theta$$

$$\Rightarrow 1 \leq \frac{\int_{\underline{\theta}}^{\theta_0} \theta g(\theta)d\theta}{\int_{\underline{\theta}}^{\theta_0} g(\theta)d\theta}$$

The right-hand side is the conditional mean of θ when θ is less than θ_0. However, this conditional mean of θ must be less than one since the unconditional mean of θ was normalized to one in the model, thus we have a contradiction. Therefore it must be that $\phi_2/\phi_1 < 1$ for all x and e when $s > 0$. □

Let $\langle \hat{x}, \hat{a} \rangle$ denote the solution to equations (6) and (7). In an effort for conciseness, the second order conditions for a maximum are not presented, but are available from the author upon request. The second order conditions are set to restrict the matrix of second derivatives of the objective function to be negative definite, therefore, ensuring that the solution $\langle \hat{x}, \hat{a} \rangle$ represents a unique maximum for the case when bailouts are available (i.e., $s > 0$).

Now considering the case when bailouts are not available (i.e., $s = 0$), the first-order conditions are the following

$$f_x + f_e e_x - \left(\frac{w^x + te_x}{p} \right) = 0 \tag{8}$$

$$f_e e_a - \left(\frac{w^a + te_a}{p} \right) = 0 \tag{9}$$

Let $\langle x^*, a^* \rangle$ denote the solution to equations (8) and (9). The second order conditions in the $s = 0$ case are satisfied if the second order conditions in the $s > 0$ case are satisfied. Hence, the solution $\langle x^*, a^* \rangle$ represents a unique maximum for the $s = 0$ case.

Proposition 1. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and the marginal effectiveness of abatement equipment is independent of x or increases as x increases ($e_{ax} \geq 0$), then it must be true that $\hat{x} > x^*$ and $\hat{a} < a^*$.*

Proof. For notational simplicity, let F_x represent $f_x + f_e e_x$, and F_a represent $f_e e_a$. Given Lemma 1, $\phi_2/\phi_1 < 1$ for all x and a. So for notational simplicity let $\phi_2/\phi_1 = k < 1$. For further simplicity, p is normalized to one. First, equations (6) and (8) both contain the function F_x. The firm is a profit maximizer, implying that to have a maximum, F_{xx} must be < 0 ($F_{xx} < 0$ globally if $-(f_{xx} + f_{ee}e_x^2 + f_e e_{xx}) > f_{ex}e_x$ for all x and a). Figure 1 has F_x graphed with x on the horizontal axis when $F_{xx} = f_{xx} + f_{ex}e_x + f_e e_{xx} + f_{ee}e_x^2 < 0$. The equations differ with the terms $kw^x + kte_x$ when $s > 0$, and $w^x + te_x$ when $s = 0$. These functions are also graphed in Figure 1. If $F_{xa} = F_{ax} = f_{xe}e_a + f_e e_{xa} + f_{ee}e_x e_a = 0$ and $e_{ax} = e_{xa} = 0$, it is clear from Figure 1 that $\hat{x_0} > x^*$.

Now considering equations (7) and (9) both contain the function F_a. Figure 2 has F_a graphed with a on the horizontal axis, with $F_{aa} < 0$ ($F_{aa} < 0$ globally if $-f_{ee}e_a > f_e e_{aa}$ for all x and a). The equations differ with the terms $kw^a + kte_a$ when $s > 0$, and $w^a + te_a$ when $s = 0$. $e_a \to 0$ as $a \to \infty$, therefore $kw^a + kte_a \to kw^a$ as $a \to \infty$. $e_a \to 0$ as $a \to \infty$, therefore $kw^a + kte_a \to w^a$ as $a \to \infty$. These functions are graphed in Figure 2, $kw^a + kte_a$ is above $w^a + te_a$ until a_0 (where $kw^a + kte_a = w^a + te_a = 0$). If $F_{xa} = F_{ax} = f_{xe}e_a + f_e e_{xa} + f_{ee}e_x e_a = 0$ and $e_{ax} = e_{xa} = 0$, it is clear from Figure 2 that $\hat{a_0} < a^*$.

Now imposing the restrictions that $F_{xa} = F_{ax} = f_{xe}e_a + f_e e_{xa} + f_{ee}e_x e_a < 0$ and $e_{ax} = e_{xa} > 0$. As shown in Figure 1, $F_{xa} < 0$ ensures that F_x shifts out as a decreases. If $e_{xa} > 0$, then a decrease in a will shift $kw^x + kte_x$ down, as shown in Figure 1. Given these these two conditions, it is clear that $\hat{x_1}$ is indeed greater than x^*.

As shown in Figure 2, $F_{ax} < 0$ ensures that F_a shifts down as x increases. And ff $e_{ax} > 0$, then an increase in x increases kte_a, shifting the $kw^a + kte_a$ curve up. It is clear from Figure 2 that $\hat{a_1} < a^*$.

Therefore, if $e_{ax} \geq 0$, $e_{xa} \geq 0$ and $F_{xa} = F_{ax} = f_{xe}e_a + f_e e_{xa} + f_{ee}e_x e_a < 0$, then $\hat{x} > x^*$ and $\hat{a} < a^*$. □

Proposition 2. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and the marginal effectiveness of abatement equipment is independent of x or increases as x increases ($e_{ax} \geq 0$), then it must be true that $\hat{e} > e^*$.*

Proof. Follows directly from Proposition 1 and the properties of $e(x, a)$. □

Given the stated assumptions, Propositions 1 and 2 show that emissions will be higher when bailouts are available if $e_{ax} = e_{xa}$ is greater than or equal to zero. However, there is nothing in the environmental economics literature suggesting that the emission cross-effects (i.e. $e_{ax} = e_{xa}$) are indeed positive. For example, if the emissions function had a functional form of $e(x, a) = g(x)/h(a)$ that satisfies the standard assumptions of $e_x > 0$, $e_{xx} > 0$, $e_a < 0$ and $e_{aa} > 0$, then $e_{xa} = e_{ax}$ must be negative or else the assumption that $e_a < 0$ is violated. The following propositions consider the case when $e_{xa} = e_{ax} < 0$.

Proposition 3. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and the marginal effectiveness of abatement equipment decreases as x increases ($e_{ax} < 0$), and $\hat{x}$ is less than or equal to x^*, then $\hat{a}$ must be strictly less than a^*.*

Proof. For $F_{xa} = F_{ax} \leq 0$, if $\hat{x} \leq x^*$, then $kw^x + kte_x(x^*, \hat{a}) \geq w^x + te_x(x^*, a^*)$. This can be rearranged as

$$ke_x(x^*, \hat{a}) - e_x(x^*, a^*) \geq \frac{w^x[1-k]}{t}.$$

The above equation implies that $e_x(x^*, \hat{a}) - e_x(x^*, a^*) > 0$ since $k < 1$. It follows that if $e_{xa} = e_{ax} < 0$, then $\hat{a} < a^*$ since $e_{xx} > 0$. □

Proposition 4. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and the marginal effectiveness of abatement equipment decreases as x increases ($e_{ax} < 0$), and $\hat{a}$ is greater than or equal to a^*, then $\hat{x}$ must be strictly greater than x^*.*

Proof. Looking at Figure 3, it is clear that $kw^a + kte_a(x^*, a)$ is greater than $w^a + te_a(x^*, a)$ for all $a < a^*$. If $F_{xa} = F_{ax} \leq 0$, it is also clear from Figure 3 that for any $\hat{a} \geq a^*$, $w^a + te_a(x^*, a)$ is greater than $kw^a + kte_a(\hat{x}, a)$. Therefore, $kw^a + kte_a(x^*, a)$ must be greater than $kw^a + kte_a(\hat{x}, a)$ for all $a \geq a^*$, implying that $e_a(x^*, \hat{a}) > e_a(\hat{x}, \hat{a})$. This inequality implies that $\hat{x}$ must be strictly greater than x^* if $e_{ax} < 0$. □

Proposition 5. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and the marginal effectiveness of abatement equipment decreases as x increases ($e_{ax} < 0$), and the marginal productivity of x and the marginal increase in emissions from x diminish rapidly enough and increase rapidly enough respectively (i.e., $0 > kte_{xa} > F_{xx} - kte_{xx}$), then it must be true that $\hat{x}$ is strictly greater than x^*.*

Proof. Suppose that a possible solution to equations (6) and (7) is given by $\langle \hat{x} = x^*, \hat{a} \rangle$, Proposition 3 shows that $\hat{a} < a^*$ if $e_{xa} = e_{ax} < 0$ and $F_{xa} = F_{ax} \leq 0$. Now consider that equation (6) evaluated at $\langle x^*, a^* \rangle$ yields $F_x(x^*, a^*) - kw^x - kte_x(x^*, a^*) < 0$. For it to be optimal for the firm to hold x constant while decreasing a, $F_{xx} - kte_{xx}$ must be larger than kte_{xa}. Therefore, if $F_{xx} - kte_{xx} < kte_{xa} < 0$, then $\hat{x}$ must be strictly greater than x^*. □

Proposition 6. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and the marginal effectiveness of abatement* *equipment decreases as x increases ($e_{ax} < 0$), and $F_{aa} - kte_{aa} > -kte_{ax} > 0$ then it must be true that $\hat{a}$ is strictly less than a^*.*

Proof. Suppose that a possible solution to equations (6) and (7) is given by $\langle \hat{x}, \hat{a} = a^* \rangle$, Proposition 4 shows that $\hat{x} > x^*$ if $e_{xa} = e_{ax} < 0$ and $F_{xa} = F_{ax} \leq 0$. Now consider that equation (7) evaluated at $\langle x^*, a^* \rangle$ yields $F_a(x^*, a^*) - kw^x - kte_x(x^*, a^*) < 0$. For it to be optimal for the firm to hold a constant while increasing x, $F_{aa} - kte_{aa}$ must be less than kte_{xa}. Therefore, if $F_{aa} - kte_{aa} > -kte_{ax} > 0$ then $\hat{a}$ must be strictly less than a^*. □

Proposition 7. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and the marginal effectiveness of abatement equipment decreases as x increases ($e_{ax} < 0$), and $0 > kte_{xa} > F_{xx} - kte_{xx}$, and $F_{aa} - kte_{aa} > -kte_{ax} > 0$ then it must be true that $\hat{e} > e^*$.*

Proof. Follows from Propositions 3, 4, 5, and 6 and the properties of $e(x, a)$. □

Under certain assumptions about the relationship between x and a, Propositions 1 to 6 suggest that when bailouts are available the firm increases input use and decreases the amount of abatement technology implemented. An intuitive explanation of this result is as follows. Under revenue uncertainty, the firm may end up with positive profit or negative profit depending on the state of the world. Increased input-use and increased emissions (lower abatement) bring higher profit in good states and reduced profit or increased losses in bad states. Thus, when bailouts are available the firm undertakes riskier behaviour (increases x and decreases a) because it knows that it may be bailed out if the bad states occur.

What occurs when pollution is unregulated (i.e., $t = 0$) is relatively obvious given the existing soft-budget constraint literature and is addressed in the following proposition.

Proposition 8. *If emissions are unregulated ($t = 0$), then the firm implements no abatement technology ($\hat{a} = a^* = 0$), uses more inputs ($\hat{x} > x^*$), and releases more emissions ($\hat{e} > e^*$) when bailouts are available then when bailouts are not available.*

Proof. When $t = 0$, the $\left(\frac{w^a + te_a}{p}\right)\frac{\phi_2}{\phi_1} > 0$ term from equation (7) becomes $\left(\frac{w^a}{p}\right)\frac{\phi_2}{\phi_1} > 0$. However, $f_e e_a < 0$ since a is restricted to being greater than or equal to zero, and thus equation (7) cannot hold. The firm wants to choose $a < 0$, but the best it can do is choose $\hat{a} = 0$. Similarly, when bailouts are not available and $t = 0$, the term $(w^a - te_a)/p$ from equation (9) becomes w^a/p, and the firm chooses $a^* = 0$. Equations (6) and (8) remain the same, but with $\hat{a} = a^* = 0$ there are no cross partial derivatives to worry about, and it is clear from Figures 1 and 2 that $\hat{x} > x^*$. It easily follows that $\hat{e} > e^*$. □

Proposition 8 shows that in the absence of emissions regulation, emissions will be higher when bailouts are available. This result does not rely on any of the additional assumptions made in Propositions 2 and 7. Propositions 2, 7, and 8 can be used to infer the effects of soft budget constraints on marginal abatement cost (MAC) curves.

Corollary 1. *If the marginal product of x is independent of or negatively affected by increases in a ($F_{xa} \leq 0$), and $0 > kte_{xa} > F_{xx} - kte_{xx}$, and $F_{aa} - kte_{aa} > -kte_{ax} > 0$, then the MAC curve when bailouts are available is everywhere above the MAC curve when bailouts are not available.*

Proof. Follows easily from Propositions 2, 7, and 8. Illustrated in Figure 4. □

3 Policy Implications

Considering Corollary 1 and Figure 4, the soft budget constraint should result in an outward shift of the MAC curve. For policy makers working in a world where bailouts are available, when initially implementing emissions regulations the availability of bailouts would be expected not to pose any difficulties since the regulator will estimate MAC_1 when setting the tax rate. The potential difficulty posed to regulators is in situations where emissions regulation is already in place when bailouts are initially not available (e.g., the emissions tax t is set equal to t_0) and then an exogenous shock occurs to make bailouts now available (e.g., an unexpected change in the ruling government). The firm's marginal abatement cost curve would be expected to shift out in this situation as depicted in Figure 4. To achieve the original level of environmental quality, the regulator must increase the emissions tax to $t_1 > t_0$ in response to the increased availability of financial relief.

The implications are different under an emissions permit trading system where the regulator sets the total amount of emissions permits. In this case, the level of environmental quality is fixed, and therefore when the exogenous shock occurs the permit price automatically adjusts from t_0 to t_1. There is no need for the regulator to take further action if their goal is to maintain the original level of environmental quality.

However, the efficient level of environmental quality may change if bailouts are suddenly possible. Given that the firm's, and the aggregate, MAC curve shifts out now that bailouts are possible, if there is no change in the marginal damage function, then the efficient level of emissions will be higher when bailouts are possible than when bailouts are not possible. This is true regardless of whether emissions are controlled through taxation or tradable permits. Assuming no change in the marginal damage function, the regulator must, depending on which system they are using, increase the tax from t^*_{opt} to $\hat{t}_{opt}$ or increase the total number of permits from e^*_{opt} to $\hat{e}_{opt}$, as depicted in Figure 5. In otherwords, the exogenous introduction of bailouts results in an original environmental tax

(t^*_{opt}) that is too lenient ($\hat{e}_1 > \hat{e}_{opt}$) or a permit price ($\hat{p}_1$) that is too stringent ($e^*_{opt} < \hat{e}_{opt}$).

4 Conclusion

This paper proposes a soft budget constraint model that bridges the soft budget constraint literature and the environmental economics literature. The model developed provides results concerning emissions and regulatory stringency that are important for public policy. In the absence of emissions regulation, the expectation of bailouts increases *ex ante* emissions. The results also suggest that if emissions regulation is held constant, in most cases, the firm will emit more emissions when bailouts are available than when bailouts are unavailable. The availability of bailouts causes the marginal abatement cost curve of the firm to shift out, requiring a more stringent emissions tax in order to obtain the original level of environmental quality; however, the original level of emissions is maintained with a tradable permit system. The results suggest that policy-makers need to be conscious of the interactions between seemingly independent policies. In particular, if additional financial relief programs are implemented, then policy-makers may need to adjust existing emissions regulations to take into account changes in firm behaviour resulting from the new policies.

References

Antweiler, Werner (2003). How Effective is Green Regulatory Threat? American Economic Review 93: 436-441.

Copeland, Brian, Taylor, M. Scott, (2005). Trade, Growth, and the Environment. Journal of Economic Literature 42: 7-71.

Desai, Raj M., Olofsgard, Anders, (2006). The political advantage of soft budget constraints. European Journal of Political Economy 22: 370-387.

Dewatripont, Mathias, Maskin, Eric, (1995). Credit and efficiency in centralized and decentralized economies. Review of Economic Studies 62: 541-555.

Goldfeld, Stephen M., Quandt, Richard E., (1988). Budget constraints, bailouts, and the firm under central planning. Journal of Comparative Economics 12: 502-520.

Goldfeld, Stephen M., Quandt, Richard E., (1990). Output targets, the soft budget constraint and the firm under central planning. Journal of Economic Behaviour and Organization 14: 205-222.

Goldfeld, Stephen M., Quandt, Richard E., (1992). Effects of bailouts, taxes, and risk-aversion on the enterprise. Journal of Comparative Economics 16: 150-167.

Goldfeld, Stephen M., Quandt, Richard E., (1993). Uncertainty, bailouts, and the Kornai effect. Economics Letters 41: 113-119.

Kohn, Robert E. (1986). The Rate of Emissions and the optimal Scale of the Polluting Firm. Canadian Journal of Economics 19: 574-581.

Kornai, Janos, (1979). Resource-constrained versus demand-constrained systems. Econometrica 47: 801-819.

Kornai, Janos, (1986). The soft budget constraint. Kyklos 39: 3-30.

Kornai, Janos, Maskin, Eric, Roland, Gerard, (2003). Understanding the soft budget constraint. Journal of Economic Literature 41: 1095-1136.

Lin, Justin Y., Li, Zhiyun, (2008). Policy burden, privatization and soft budget constraint. Journal of Comparative Economics 36: 90-102.

Magee, Karen L., Quandt, Richard E., (1994). The Kornai effect with partial bailouts and taxes. Economic Planning 27: 27-38.

Marshall, Dale (2001). Should BC lift the offshore oil moratorium? Canadian Centre for Policy Alternatives.

McKitrick, Ross (1999). A Derivation of the Marginal Abatement Cost Curve. Journal of Environmental Economics and Management 37: 306-314.

Prell, Mark A., (1996). The two Kornai effects. Journal of Comparative Economics 22: 267-276.

Robinson, James A., Torvik, Ragnar, (2006). A political economy theory of the soft budget constraint. NBER Working Paper 12133.

Skeena gets funding to restart pulp mill (1999). Pulp & Paper 73: 21.

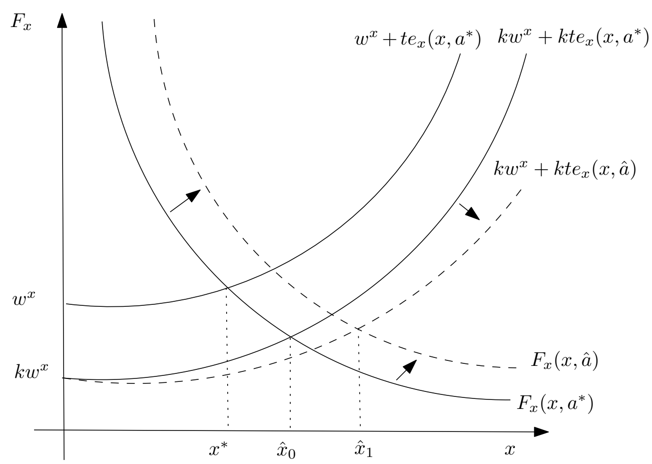

Figure 1: Proposition 1

Notes: F_x is the first portion of equations (6) and (8), and it is assumed that $F_{xx} = f_{xx} + f_{ex}e_x + f_e e_{xx} + f_{ee}e_x^2 < 0$. $w^x + te_x$ and $kw^x + kte_x$ are the second portions of equations (8) and (6) respectively. The actual curve of $kw^x + kte_x$ may look different than the one represented in this graph because k depends on x, but it is clearly everywhere below $w^x + te_x$ due to Lemma 1.$\hat{x}_o$ is the outcome when cross-effects are zero. $\hat{x}_1$ is the outcome when a decreases if $F_{xa} < 0$ and $e_{xa} > 0$.

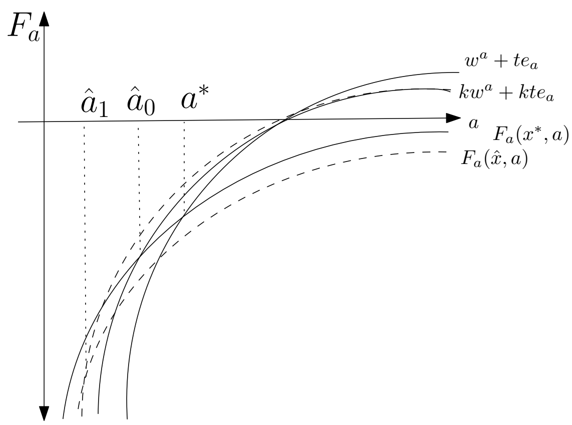

Figure 2: Proposition 1

Notes: F_a is the first portion of equations (7) and (9) with the assumption that $F_{aa} = f_{ee}e_a^2 + f_e e_{aa} < 0$. The $w^a + te_a$ and $kw^a + kte_a$ curves are from the second portions of equations (9) and (7) respectively. Even though k depends on a, we know from Lemma 1 that the $kw^a + kte_a$ curve is above $w^a + te_a$ when the terms are negative and below when the terms are positive. The dashed lines represent what occurs when x increases and $F_{ax} < 0$ and $e_{ax} > 0$.

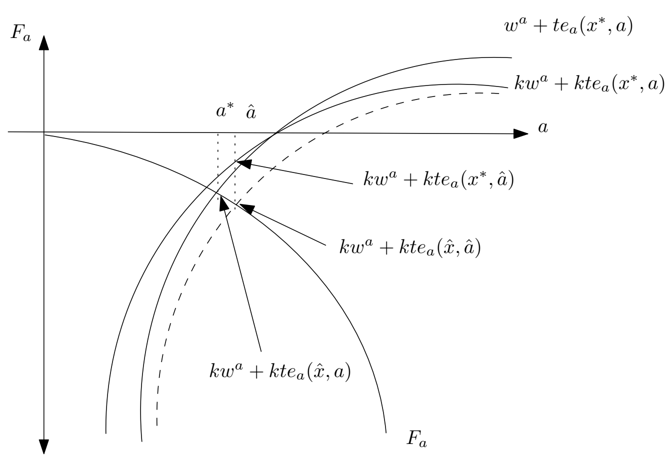

Figure 3: Proposition 4

Notes: This graph depicts the situation when $\hat{a} \geq a^*$. For $\hat{a} \geq a^*$ to occur when $F_{ax} = 0$ and $e_{ax} < 0$, $\hat{x}$ must be greater than x^*.

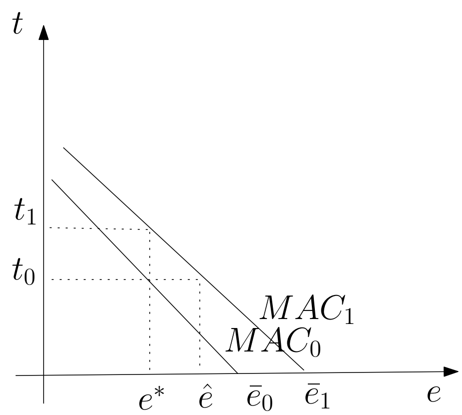

Figure 4: Corollary 1

Notes: MAC_0 is the marginal abatement cost curve when bailouts are not available, and MAC_1 is the marginal abatement cost curve when bailouts are available.This graph also shows the increased tax rate required to hold emissions constant.

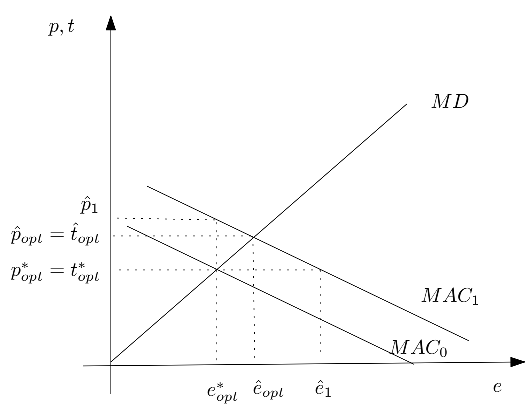

Figure 5: Policy Implications

Notes: For the purposes of this figure the MAC curves can be thought of as aggregate marginal abatement cost curves. MD is marginal damages from emissions. The emissions tax is represented by t, and the permit price is represented by p. $\langle e^*_{opt}, p^*_{opt} = t^*_{opt} \rangle$ is the efficient emissions level and policy when bailouts are not available. $\langle e^*_{opt}, \hat{p}_1 \rangle$ is the emissions level and permit price when bailouts become possible. $\langle \hat{e}_1, t^*_{opt} \rangle$ is the emissions level and tax when bailouts become possible. $\langle \hat{e}_{opt}, \hat{p}_{opt} = \hat{t}_{opt} \rangle$ is the efficient emissions level and policy when bailouts become possible.