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**A NEW VERSION OF EDGEWORTH'S TAXATION
PARADOX**

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A new version of Edgeworth's taxation paradox

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Abstract

Edgeworth's taxation paradox states that an excise tax can decrease the market price of a good. This paper presents a new version of the paradox in which a tax reduces price because it attracts entry of additional firms into the market. The paper also presents two new applications: (i) an emissions tax that leads to an increase in industry emissions (due to entry), and (ii) an interest rate cut by the central bank that reduces lending by commercial banks (due to exit). Basic principles of environmental regulation and monetary policy therefore fail under the conditions of the paradox.

Keywords: Bank lending, cost pass-through, Edgeworth's paradox, environmental regulation, market structure, taxation.

JEL classifications: D43 (imperfect competition), G21 (banks), H22 (tax incidence), Q50 (environmental economics).

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1 Introduction

Can a unit tax on a product decrease its price? Standard economic analysis suggests that the answer is no. However, Edgeworth (1925) showed that, under certain conditions, a multi-product monopolist may indeed respond to a tax on one of its goods by reducing price: “When the supply of two or more correlated commodities — such as the carriage of passengers by rail first class or third class — is in the hands of a single monopolist, a tax on one of the articles — e.g., a percentage of first class fares — may prove advantageous to the consumers as a whole... The fares for *all* classes might be reduced” (p. 139). This result has become known as Edgeworth’s taxation paradox.¹

The intuition for the result is that — in contrast to a single-product setting — the price of the other (untaxed) good need not remain unchanged. In particular, the price of the other good may decrease, which, under conditions of complementarity, can exert downward pressure on the price of the taxed good to the extent that both prices end up falling in response to the tax.

Edgeworth’s surprising result prompted contributions by several distinguished economists. Hotelling (1932) showed that price-reducing taxes can also obtain under perfect competition with substitute goods and diseconomies of scope in production; see also Bailey (1954). Vickrey (1960) presents conditions for the case of perfect competition with two products, and also gives a variety of practical examples. Coase (1946) provides a useful graphical analysis of how the paradox can occur.

More recently, Salinger (1991) uses the logic underlying Edgeworth’s paradox to show that vertical integration may decrease welfare in multi-product settings (whereas it is always beneficial with a single product). Price-reducing taxes also exist in two-sided markets such as newspapers and credit cards; see Kind, Koethenbueger and Schjelderup (2008).

In this paper, I present a new version of Edgeworth’s paradox of taxation. The basic setup involves a market with a low-cost incumbent

¹The original version of Edgeworth’s paper was in Italian (and first published in 1897). See Creedy (1988) and Moss (2003) for further historical background on the taxation paradox.

and a higher-cost potential entrant. Initially, that is, before the unit tax is introduced, the entrant decides not to enter the market because of an entry cost. The incumbent firm initially acts as a monopolist, charging the monopoly price.

However, the introduction of the tax “levels the playing field” between the incumbent and the entrant in the post-entry game. In particular, the tax increases the operating profits of a sufficiently small entrant (see Lemma 1), and can therefore attract additional entry.

The basic trade-off is clear: Although the unit tax as such leads to an increase in price (as in a standard model), it can also induce the higher-cost firm to enter the market, which, all else equal, reduces price. My main result gives conditions under which *any* sufficiently small unit tax induces entry and leads to a decrease in price for a range of values for the entry cost (see Proposition 1).

The simplest model makes this point in a single-product setting with Cournot-Nash competition (following entry) and a constant-elasticity demand curve. Of course, the conditions required for the paradox to arise are special — just as they are for Edgeworth’s original formulation. The two key elements of my approach are that (i) an input price increase (e.g., due to an excise tax) may increase profits, and (ii) entry reduces price. The first element applies more widely than is often realized — see also Seade (1985), and Anderson, de Palma and Kreider (2001) — while the second element is, of course, common to many models of competition.²

My version of the paradox is stronger than Edgeworth’s formulation in two respects. First, it shows that a tax can reduce price even in a single-product setting. Second, I show that, in a multi-product setting, in addition to decreasing prices, a tax can increase the output of *all* products. By contrast, other formulations of the paradox rely on a multi-product setting, and, although the price of the taxed good falls, its output does not increase; see also Salinger (1991).³

I also present two new applications of the paradox:

²With Cournot-Nash competition, for example, a unit tax always increases a sufficiently small firm’s operating profits with a log-convex demand curve.

³However, my version of the paradox is weaker in that it relies on imperfect competition in the product market.

First, with imperfect competition in the product market, a tax on industrial emissions may lead to an *increase* in emissions because it leads to additional entry of firms. A basic principle of environmental economics, following Pigou (1920), therefore fails under the conditions of Edgeworth's paradox.

Second, in a simple model of commercial banking, a rate cut by the central bank may lead to a *decrease* in bank lending — due to the exit of weaker banks. This result may provide a competitive explanation for why lending continued to fall in the 2007/9 financial crisis even when central banks around the world aggressively cut interest rates.⁴

The plan for the remainder of the paper is as follows. Section 2 sets up the basic model, and Section 3 derives the initial equilibrium before introduction of the tax. Section 4 shows how a unit tax can increase profits. Section 5 contains the main result, and Section 6 presents a simple numerical example of a price-decreasing excise tax. Section 7 discusses extensions to multi-product settings and other forms of competition. Sections 8 and 9 present applications to environmental economics and banking. Section 10 concludes.

2 Model

I use the simplest possible model to show how the taxation paradox arises. Consider an industry with two firms, the incumbent, firm A , with unit cost c^A , and a potential entrant, firm B , with unit cost $c^B > c^A$. The industry demand curve $p(X) = \beta X^{-1/\eta}$ has constant price elasticity $\eta > 1$ (where X is industry output).

Suppose that there is a fixed cost of K that firm B incurs by entering the market. If firm B decides to enter, there is Cournot-Nash competition in which firms choose their outputs X^A and X^B respectively. Let σ^A and σ^B denote the associated market shares (with $\sigma^A + \sigma^B = 1$). If firm B does not enter, the incumbent firm A acts as a (profit-maximizing)

⁴Of course, there are many other possible explanations for why bank lending decreased during the crisis, including reduced loan demand and changes in credit risk perceptions.

monopolist.⁵

Initially, the level of an excise tax per unit of each firm's output is set to zero. Firm B decides whether to enter, and the equilibrium market price is determined. Then, an excise tax of t per unit of output is introduced, followed by firm B 's entry decision and the market outcome.

How does the market price under the excise tax compare to the initial market price in the absence of the tax?

I am interested in situations where firm B initially does not enter the market because of the entry cost; in other words, firm B 's unit cost is sufficiently low for it to gain positive market share under Cournot-Nash competition before the tax is introduced, $c^B/c^A < \eta/(\eta - 1)$.

3 Initial equilibrium

Consider the (hypothetical) outcome of Cournot-Nash competition following entry in the absence of the tax. Let $\Pi^A(0)$ and $\Pi^B(0)$ denote, respectively, the incumbent's and the potential entrant's operating profits (at a zero tax rate, $t = 0$).

Assume that the entry cost is such that $K > \Pi^B(0)$, making entry unprofitable for firm B . It follows that the initial equilibrium has firm A as a monopolist, with market price

$$p(0) = \left(\frac{\eta}{\eta - 1} \right) c^A. \quad (1)$$

Note that $p(0) > c^B$, so the entrant can “undercut” this monopoly price and gain positive market share under Cournot-Nash competition.

4 Profit-increasing excise taxes

Now consider the situation after the introduction of the excise tax. The key issue is how the tax affects firm B 's operating profits following entry.

⁵To bring out the paradox as clearly as possible, I do not consider any possible entry-deterrence strategies that firm A may be able to pursue.

Lemma 1 *The impact of a unit tax on firm B 's operating profits is that*

$$\frac{d\Pi^B}{dt} \geq 0 \text{ if and only if } \sigma^B(t) \leq \frac{1}{(\eta + 1)}.$$

Proof. Write firm B 's operating profits after the introduction of the excise tax as $\Pi^B(t) = (p - c^B - t) X^B$. The impact of a change in the tax is given by

$$\frac{d\Pi^B}{dt} = \left(\frac{dp}{dt} - 1 \right) X^B + (p - c^B - t) \frac{dX^B}{dt}. \quad (2)$$

Under Cournot-Nash competition, firm B chooses its output such that

$$X^B = \frac{(p - c^B - t)}{-p'(X)}. \quad (3)$$

It follows that, with constant-elasticity demand, the change in firm B 's output

$$\frac{dX^B}{dt} = \frac{1}{-p'(X)} \left[\left(\frac{dp}{dt} - 1 \right) - \sigma^B \frac{(\eta + 1)}{\eta} \frac{dp}{dt} \right], \quad (4)$$

where firm B 's market share $\sigma^B = X^B/X$. Finally, with constant-elasticity demand and two firms, the rate of cost pass-through

$$\frac{dp}{dt} = \frac{\eta}{(\eta - \frac{1}{2})}. \quad (5)$$

Combining the three expressions from (3), (4), and (5) into (2) yields

$$\frac{d\Pi^B}{dt} = \frac{X^B}{(\eta - \frac{1}{2})} [1 - \sigma^B (\eta + 1)], \quad (6)$$

from which the lemma follows immediately. ■

The result shows that firm B actually benefits from the excise tax as long as its market share is sufficiently small, $\sigma^B(t) \leq 1/(\eta + 1)$.

The intuition is that the tax “levels the playing field” between the incumbent and the entrant by making their market shares more symmetric. For a sufficiently small firm, this effect outweighs the negative impact on profits implied by the reduction in industry revenue.

In particular, firm B 's market share can be written in terms of the tax as

$$\sigma^B(t) = \frac{\eta c^A - (\eta - 1)c^B + t}{(c^A + c^B) + 2t} < \frac{1}{2}. \quad (7)$$

This makes it clear that firm B 's market share increases in the unit tax, $d\sigma^B/dt > 0$ (since $c^B > c^A$). All else equal, higher market share implies higher profits.

Of course, the excise tax also increases price, and thus reduces industry revenue (since demand is price-elastic), *in the post-entry game*. All else equal, lower industry revenue implies lower profits.

For a sufficiently small firm, however, reduced industry revenue due to a small increase in the tax has a second-order effect on profits — while the gain in market share is first-order. Lemma 1 shows that, as long as $\sigma^B(t) \leq 1/(\eta + 1)$, the overall impact of the excise tax is to increase its operating profits. Note also that this condition is virtually always satisfied as the price elasticity $\eta \rightarrow 1$ (so industry revenue is approximately constant).⁶

Another perspective on the result is that, *for a fixed number of firms*, the rate at which an excise tax is passed through to consumers exceeds 100% under Cournot-Nash competition with constant-elasticity demand; see (5). So operating profit margins increase — by an equal amount (in dollars) for all firms — in response to the tax. In relative terms, this helps a smaller, lower-margin firm more, and its overall profits may rise as a result.

Since the excise tax can increase firm B 's profits, it can also induce it to enter the market by making its operating profits sufficient to cover the entry cost, $\Pi^B(t) \geq K$.

5 Price-reducing excise taxes

The basic trade-off is clear: Although the tax as such leads to an increase in price, it can also induce firm B to enter the market, which, all else

⁶Using the same arguments as in Lemma 1, the excise tax always reduces the incumbent's operating profits, $d\Pi^A/dt < 0$, as its lower unit cost implies that it has higher market share, $\sigma^A(t) > \frac{1}{2} > \sigma^B(t)$, for all $t \geq 0$.

equal, leads to a decrease in price.

The following proposition provides conditions under which the overall effect of an excise tax is to reduce price.

Proposition 1 *Suppose that firm A and B's unit costs satisfy*

$$c^B/c^A \in \left(\frac{\eta + 2}{\eta + 1}, \frac{\eta}{\eta - 1} \right).$$

Then, for any unit tax

$$t \leq \frac{1}{2} \left[\frac{\eta c^A - (\eta - 1)c^B}{(\eta - 1)} \right] \equiv t_{\max},$$

there is a range of values for the entry cost K such that:

- (i) the tax induces firm B to enter the market;*
- (ii) the final price is lower than the initial price, $p(t) \leq p(0)$.*

Proof. From (7), firm B's market share $\sigma^B(t)$ is increasing in t . So, from Lemma 1, $d\Pi^B/dt \geq 0$ for any t sufficiently low such that $\sigma^B(t) \leq 1/(\eta + 1)$. Again using (7),

$$\sigma^B(t) \leq \frac{1}{(\eta + 1)} \text{ if and only if } t \leq \frac{\eta^2 (c^B - c^A) - (\eta - 1) c^A}{(\eta - 1)} \equiv \tilde{t}. \quad (8)$$

This implies that firm B's operating profits $\Pi^B(t) > \Pi^B(0)$ for any $t \leq \tilde{t}$. Now observe that the market price under Cournot-Nash competition with the unit tax is

$$p(t) = \frac{\eta}{(\eta - \frac{1}{2})} \left[\frac{1}{2} (c^A + c^B) + t \right]. \quad (9)$$

Comparing this to the initial equilibrium price (where firm A is a monopolist) from (1) shows that

$$p(t) \leq p(0) \text{ if and only if } t \leq \frac{1}{2} \left[\frac{\eta c^A - (\eta - 1)c^B}{(\eta - 1)} \right] \equiv t_{\max}. \quad (10)$$

Note that $t_{\max} > 0$ since $c^B/c^A < \eta/(\eta - 1)$, and that

$$t_{\max} < \tilde{t} \text{ if and only if } c^B/c^A > \left(\frac{\eta + 2}{\eta + 1} \right). \quad (11)$$

Moreover, if $t_{\max} < \tilde{t}$, then, from above, $\Pi^B(t) > \Pi^B(0)$ for all $t \leq t_{\max}$. It now follows that, for $c^B/c^A \in ((\eta + 2)/(\eta + 1), \eta/(\eta - 1))$ and any $t \leq t_{\max}$, there is a range of values for the entry cost K such that (i) $\Pi^B(t) \geq K > \Pi^B(0)$, so the excise tax induces firm B to enter, and (ii) the final price is lower than the initial price, $p(t) \leq p(0)$. ■

Proposition 1 offers a new version of Edgeworth's paradox of taxation in form of an excise tax that reduces price because it attracts additional entry into the market.

The lower bound on firm B 's unit cost, $c^B > [(\eta + 2)/(\eta + 1)]c^A$, implies that firm B 's market share is sufficiently small such that the *any* excise tax that is not too large leads to an increase in its profits (see Lemma 1). Under these conditions, there is always a range of values for K such that the tax induces entry and leads to a decrease in price.

Put differently, choose the entry cost in a way that firm B is initially not too far away from entering the market. Then, for a sufficiently high-cost entrant, a small unit tax will increase (post-entry) profits, induce entry, and decrease the market price.

It is also clear that, under the conditions of Proposition 1, an excise tax *increases* consumer surplus, and increases total welfare insofar as sufficiently high weight is placed on consumers relative to producers.

To see why industry profits must be lower with the excise tax, let Π^M denote monopoly profits (by firm A), and observe that, by revealed preference,

$$\Pi^M(t) \leq \Pi^M(0), \quad (12)$$

while industry profits under Cournot-Nash competition with the excise tax

$$\Pi^A(t) + [\Pi^B(t) - K] < \Pi^M(t). \quad (13)$$

The paradox here also implies that equilibrium tax revenue exceeds the “naïve” revenue forecast that uses firm A 's initial monopoly output as the tax base (because industry output rises).⁷

⁷In this sense, too, the paradox “will surely be a grateful boon to the perplexed and weary secretaries of the Treasury and ministers of finance around the world,” Seligman (1921, p. 214).

6 Numerical example

The result can be illustrated with a simple numerical example. Let the price elasticity of demand $\eta = 2$ and the scale parameter $\beta = 100$, so the industry demand curve $p(X) = 100/\sqrt{X}$. Set firms' unit costs to $c^A = 1$ and $c^B = \frac{3}{2}$ respectively, and suppose that the entry cost $K = 130$.

Firm B 's initial operating profits $\Pi^B(0) = 120$ under Cournot-Nash competition are insufficient to cover the entry cost. Therefore, the initial equilibrium has firm A as a monopolist with market price $p(0) = 2$. Note also that firm A 's monopoly profits $\Pi^M(0) = 2500$ and consumer surplus $S(0) = 5000$.

It is easy to check that the conditions of Proposition 1 are satisfied for a unit tax $t = \frac{1}{5}$. Firm B 's operating profits under Cournot-Nash competition increase to $\Pi^B(t) \approx 151$. So the excise tax induces firm B to enter, and the equilibrium market price falls to $p(t) = 1\frac{14}{15}$.

Of course, the largest reduction in price is achieved when only a very small tax is needed to induce entry. In this case, the equilibrium price is just above the Cournot-Nash price at a zero tax, so $p(t) \approx 1\frac{2}{3}$, or about 17% lower than the initial price. Note also that (approximate) industry profits $\Pi^A(t) + [\Pi^B(t) - K] \approx 1920$, while consumer surplus $S(t) \approx 6000$, and there is also a small amount of tax revenue.

Two features are particularly noteworthy here: First, the equilibrium price may fall by more than the unit tax rises, and, second, the unit tax may increase social surplus (consumer and producer surplus), as well as total welfare (including tax revenue).⁸

More generally, under these demand conditions and whenever $c^B/c^A \in (\frac{4}{3}, 2)$, any unit tax $t \leq (c^A - \frac{1}{2}c^B) = t_{\max}$ induces entry and reduces price for a range of values for K .

Using the same basic idea, it is not difficult to construct similar examples of price-reducing excise taxes for market structures with more than two firms. In general, I expect such versions of the Edgeworth paradox to usually be more likely with fewer incumbent firms, more potential

⁸Of course, neither of these two features apply in general; it is easy to check that they do not hold for a unit tax $t = \frac{1}{5}$ and entry cost $K = 130$.

entrants, and a lower price elasticity of demand.⁹

7 Extensions

□ **Multi-product settings.** Proposition 1 shows how an excise tax can reduce the equilibrium price in a setting with a single product. The multi-product version of Edgeworth’s taxation paradox states that a tax increase on one product can lead to a reduction in the prices of *all* products.

It is straightforward to sketch the extension of Proposition 1 to such a multi-product setting. Imagine the same model as above, but suppose that the incumbent firm A offers N different products which, for simplicity, are independent in terms of demand conditions.

However, suppose that there is a small degree of diseconomies of scope in its joint cost function $C^A(X_1^A, X_2^A, \dots, X_N^A)$, so marginal cost for each product increases slightly when the output of the other products is increased. Otherwise, let the market for product 1 be as above, including a potential entrant, and suppose that firm A is (and remains) a monopolist in its other $N - 1$ markets.

Initially, there is no entry and firm A sets monopoly prices in all N markets. By the same argument that underlies Proposition 1, the introduction of a unit tax (only) in market 1 can induce firm B to enter this market and decrease price, $p_1(t) \leq p_1(0)$.

Whenever the excise tax and entry reduce firm A ’s output in market 1, this also lowers firm A ’s marginal costs in the *other* $N - 1$ markets due to diseconomies of scope.¹⁰ Since marginal revenue schedules are unchanged (as demand conditions are independent), this makes firm A increase output in each of these other markets.

Therefore, equilibrium market prices fall in all markets, that is, $p_i(t) \leq p_i(0)$ for all $i = 1, 2, \dots, N$. Moreover, in contrast to other (multi-product)

⁹Note that the argument that the paradox is more likely to occur with a lower price elasticity of demand is consistent with analyses of Edgeworth’s original formulation; see, e.g., Vickrey (1960).

¹⁰A sufficient — albeit not necessary — condition for this is that firms’ outputs are strategic substitutes (that is, best-response curves are downward-sloping).

formulations of Edgeworth’s paradox, the tax increases the equilibrium industry output of *all* products.

□ **Other forms of competition.** It is quite clear that the conditions required for Proposition 1 to arise are special — just as they are for Edgeworth’s original formulation of the paradox.

The two key elements of the approach are that (i) an excise tax may increase profits (Lemma 1), and (ii) entry reduces price. The second element is, of course, common to many standard models of competition.¹¹ However, the first element also applies more often than might be expected — both under price and quantity competition. This means that, for particular values of the entry cost, only a very small unit tax may be needed to induce entry — and thus make the equilibrium market price fall.

For quantity competition with conjectural variations, Seade (1985) provides general conditions under which a cost increase raises a firm’s operating profits — or even those of *all* firms in the industry. He observes that “the possibility of profits increasing as a result of a tax or a rise in costs seems very alien to intuition, and yet not only can this happen but is in fact not at all exceptional in oligopoly.” The result also appears to match the experience of the oil industry during the 1973/4 crisis — in which the price of its main input, crude oil, rose sharply while industry profits also increased.

Perhaps surprisingly, the first element can also go through in models of price competition with differentiated products. Anderson, de Palma and Kreider (2001) show that, with a fixed number of symmetric firms, an excise tax raises firms’ (short-run) operating profits in Bertrand competition under very similar conditions to those for Cournot-Nash competition (in particular, a sufficiently convex demand curve).¹²

The model from Section 2 offers what I believe to be the simplest

¹¹Exceptions to this central message of economics have recently been highlighted by Bulow and Klemperer (2002), Chen and Riordan (2008), and others.

¹²I am, however, not aware of any work on the profit impact of unit taxes under differentiated-products Bertrand competition with asymmetric firms — although it seems clear that profit-increasing taxes must also exist in such models.

way of capturing a price-reducing unit tax. The important feature for a sufficiently small firm B 's operating profits to increase with the unit tax (Lemma 1) is that the rate of cost-pass-through exceeds 100% for a given number of firms. With Cournot-Nash competition, this condition is equivalent to demand being log-convex — that is, sufficiently “fat-tailed”.¹³

However, the above arguments make clear that the mechanism underlying the paradox can also hold with multiple products and other forms of competition. Of course, this requires particular demand conditions; with linear demand systems, for example, the paradox does not arise.

8 Application I: Environment

Following Pigou (1920), a basic principle of environmental economics is that pollution can be controlled with a per-unit tax on the emissions from a polluting activity. Such an emissions tax makes pollution costly to firms (so they internalize the externality), and, under standard conditions, leads to a decrease in emissions. However, an application of the taxation paradox shows that this conclusion is not necessary.

Consider the model from Section 2, but now write a firm's operating profits as $\Pi^j(\tau) = (p - c^j)X^j - \tau E^j$ for $j \in \{A, B\}$, where $\tau \geq 0$ is a tax on its emissions E^j . For simplicity, suppose that emissions are a fixed proportion of output, $E^j = \lambda X^j$ for $j \in \{A, B\}$, where $\lambda > 0$ is the emissions intensity of production. (This may be a reasonable assumption for industries in which cleaner production is technologically infeasible or unprofitable at the prevailing tax rate on emissions.)

This setup maps into the above analysis by letting the excise tax $t = \tau/\lambda$. When emissions are unpriced, firm B does not enter the market

¹³For a general inverse demand curve $p(X)$ with curvature coefficient $\xi = -Xp''(X)/p'(X)$, the corresponding direct demand curve $D(p)$ is log-convex if (and only if) $\xi > 1$. (With constant-elasticity demand, $\xi = 1 + \eta^{-1}$, so log-convexity is always satisfied.)

Lemma 1 can be generalized to show that $d\Pi^B/dt \geq 0$ if and only if $\sigma^B(t) \leq 1 - \xi^{-1}$. So log-convexity is a necessary and sufficient condition for a “small” firm B 's profits to increase. However, since it is not possible to obtain closed-form expressions with a general log-convex demand curve (e.g., for t_{\max}), I use constant-elasticity demand to derive Proposition 1 above.

because of the entry cost. Under the conditions of Proposition 1, *any* emissions tax $\tau \leq (\lambda/2) [\eta c^A - (\eta - 1)c^B] / (\eta - 1) \equiv \tau_{\max}$ induces firm B to enter and decreases the market price for a range of values for K . Since total industry emissions $E(\tau) = \lambda [X^A(\tau) + X^B(\tau)]$ are proportional to industry output, *the emissions tax leads to an increase in emissions*, $E(\tau) \geq E(0)$.¹⁴

Levin (1985) has shown that, with Cournot-Nash competition, an emissions tax may increase industry emissions when firms have sufficiently asymmetric emissions intensities (also assumed to be fixed). Similarly, environmental regulation that applies only to a subset of firms in an industry can increase emissions due to “emissions leakage” to dirtier, unregulated firms; see, e.g., Fowlie (2009). By contrast, the above argument requires neither that firms have asymmetric emissions intensities nor that only a subset of firms in the industry is subject to regulation.

This shows that environmental regulation may have unintended consequences when it not only affects firms’ decision-making at the margin but also induces changes in market structure.

9 Application II: Banking

Edgeworth’s paradox of taxation can also be applied to the banking sector — for example, to examine the impact of monetary policy on equilibrium outcomes in loan markets.

Consider a setting with two commercial banks, an incumbent A and a potential entrant B , and suppose that the inverse demand for loans $r_L(L) = \beta L^{-1/\varepsilon}$, where r_L is the interest rate on loans, L is the total loan volume, and $\varepsilon > 1$ is the interest elasticity of demand for loans. Following Klein (1971), Hannan and Berger (1991), Neumark and Sharpe (1992), and others, suppose that a bank’s loan decisions are independent of the deposit market,¹⁵ and that the banks fund their loan portfolios by

¹⁴The same result can also go through for quantity-based regulation in form of a multi-sector cap-and-trade scheme for emissions in which (i) firms take the price of emissions permits as given, and (ii) the emissions cap does not bind for the sector under consideration.

¹⁵This assumption simplifies the exposition but clearly is not necessary for the

borrowing from the central bank at an interest rate $\tilde{r} = r + \Delta$.

Write a bank's operating profits as $\Pi^j(\Delta) = (r_L - r - \gamma^j - \Delta) L^j$ for $j \in \{A, B\}$, where γ^j is the bank's operating cost and Δ captures a change in the central bank's rate. As in Section 2, there is a fixed cost of K that bank B incurs by entering the market. If bank B decides to enter, there is Cournot-Nash competition in which banks choose their loan commitments L^A and L^B respectively. If bank B does not enter, the incumbent bank A acts as a monopolist for loans.

It is not difficult to see that this setting is strategically equivalent to that of the above analysis. Firm outputs correspond to bank loans, the market price corresponds to the loan rate, unit costs are related by $c^j = r + \gamma^j$ for $j \in \{A, B\}$, and the change in the central bank's rate corresponds to (a change in) the unit tax.

Suppose that bank B initially (that is, when $\Delta = 0$), stays out of the market due to the entry cost. From Proposition 1, *any* increase in the central bank's rate $\Delta \leq \frac{1}{2} [\varepsilon \gamma^A - (\varepsilon - 1) \gamma^B + r] / (\varepsilon - 1) \equiv \Delta_{\max}$, induces bank B to enter and decreases the market interest rate on loans, $r_L(\Delta) \leq r_L(0)$, for a range of values for the entry cost K . Contrary to basic principles, *a tightening in monetary policy leads to an increase in bank lending* under these conditions.

For example, let the interest elasticity of loan demand $\varepsilon = 3$, the central bank's initial rate $r = 3\%$, and the banks' operating costs $\gamma^A = \frac{1}{2}\%$ and $\gamma^B = 1\frac{1}{2}\%$ respectively. With bank A as a monopolist, the initial market interest rate $r_L(0) = 5\frac{1}{4}\%$. By Proposition 1, any increase in the central bank's rate $\Delta \leq \frac{3}{8}\%$ induces bank B to enter, and $r_L(\Delta) \leq 5\frac{1}{4}\%$ for a range of values for K .

The paradox can also be applied in the reverse direction. Suppose that bank B is in the market at the higher central bank's rate $\tilde{r} = r + \Delta$. Then, for some values of Δ and K , a *decrease* in the central bank's rate to r induces bank B to *exit* (as its operating profits fall), and so the equilibrium interest rate on loans increases, $r_L(0) \geq r_L(\Delta)$, while total bank lending falls.

This result may help explain a puzzling feature of the 2007/9 financial crisis: the *paradox to hold* in this setting.

cial crisis. As the crisis unfolded, central banks around the world aggressively cut interest rates (especially during the course of 2008) — but there was evidence that bank lending continued to fall (see, e.g., Ivashina and Scharfstein, 2009). Of course, there are many possible explanations for this, including reduced loan demand and changes in credit risk perceptions. The above argument, however, suggests a competitive explanation: Looser monetary policy may have put weaker (higher-cost) banks at a disadvantage relative to other banks, thus causing them to withdraw from parts of their loan business.¹⁶

10 Conclusion

This paper has presented a new version of Edgeworth’s taxation paradox: An excise tax may reduce price because it “levels the playing field” between firms and attracts additional entry into the market. In contrast to existing formulations of the paradox, my version can also hold in single-product settings.

The analysis shows that price-reducing taxes (Section 5) can result from profit-increasing taxes (Section 4) when the market structure is endogenously determined. It is particularly striking that the constant-elasticity demand conditions under which cost pass-through exceeds 100% for a fixed number of firms are also those for which cost pass-through can turn negative due to entry of additional firms in equilibrium.

A similar yet distinct mechanism operates in the multi-product framework of Hamilton (2009), in which firms choose prices as well as the breadth of their product variety. If demand conditions are such that cost pass-through would be high for a fixed product breadth, this induces firms to widen their product portfolios and increases competition — so pass-through, in equilibrium, is low. However, pass-through always remains positive in this framework and Edgeworth’s taxation paradox

¹⁶For example, there is anecdotal evidence for international banks and specialist lenders withdrawing from loan activities in the United Kingdom (especially those related to mortgages) during the course of 2008/9. (See House of Commons, Treasury Committee, Banking crisis: Dealing with the failure of the UK banks, May 2009; especially Section 5.)

does not arise.

Weyl and Fabinger (2009) suggest that empirical estimates of pass-through can be used to infer the curvature of demand (which is generally unobservable), and thus sign — or even quantify — many comparative statics in models of imperfect competition.¹⁷ My analysis makes clear that this technique, while promising, may be quite sensitive to the underlying assumption that the number of firms in the market is fixed.

The broader point is that taking into account firms' entry (and exit) decisions can have important implications for tax analysis, environmental regulation, monetary policy, and understanding the impact of changes in input prices more generally.

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¹⁷See also Hepburn, Quah and Ritz (2007) for an application to environmental economics that uses the same basic idea.

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