On Emissions Trading Taxation and Market Power

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Abstract

Our paper addresses how market power and emissions trading taxation might affect the efficiency properties of an international emissions market. We consider I countries and I representative firms (one for each country). Each firm emits pollution and trades emissions permits on an international market. Firms are divided in two categories, according to whether they have market power in the permits market or not. We claim that the negative effect of market power can be compensated, or even completely neutralized, by the presence of taxation, and viceversa. More specifically, we show that if tax differentials among competitive countries/firms and strategists exist, cost effectiveness can be restored without necessarily driving dominant firm(s) net demand to zero. Also, we show that the presence of emissions trading taxation increases the firms' ability to affect the equilibrium price in the permits market, and can therefore have an impact on the degree of market power.

STILL PROVISIONAL AND INCOMPLETE

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1 Introduction

In this paper we study how market power and emissions trading taxation affect the efficiency properties of an international emissions market. Indeed, since the seminal article of Montgomery (1972), an extensive literature has examined various aspects of the functioning of permit markets which are regarded as a cost-effective instrument for achieving abatement targets. However, such a confidence in emissions trading relies upon the somehow controversial hypotheses that permit markets are *i*) perfectly competitive and *ii*) outside of any fiscal regime. Even if there is no sufficient empirical evidence for or against the first hypothesis (Tietenberg, 2006), from a theoretical point of view it is well known that, if the assumption of perfect competition is relaxed, strategic sellers (buyers) can exploit their market power, decreasing supply (demand) and causing a greater aggregate abatement cost (Hahn, 1984; Westskog, 1996). As regards the second hypothesis, it is self-evident that emission permits are fiscally relevant and that the their fiscal treatment is a crucial issue, especially in international contexts where countries'laws differ in terms of the accounting nature of emission rights, the burden of initial allocation and transfer, the deductible character of penalties resulting from non-fulfilment of the delivery obligation and the tax breaks for emission rights transfers (Fisher, 2006). Nevertheless, most of the existing emissions trading systems, such as the EU ETS, have ignored for a long time the role of corporate/personal income tax and Value Added Tax (VAT), implicitly assuming that the impact of these taxes would be neutral. Recent contributions however contrast this implicit assumption and show that the tax treatment of tradeable emissions is likely to affect the permit market in terms of cost effectiveness, abatement decisions and welfare effects (see, for instance, Costantini et al., 2011). However, to the best of our knowledge, no paper has simultaneously addressed market power and emissions trading taxation yet.

To embody both market power and emissions trading taxation into the analysis, we adapt the classical theoretical model proposed by Hahn (1984), and extended by Westskog (1996) and Godal and Meland (2010). More specifically, we consider I countries and I representative firms (one for each country). Each firm emits pollution and trades emissions permits on an international market. Firms are divided in two categories, according to whether they have market power in the permits market or not. Each firm optimally chooses its level of emissions, given its initial endowment of permits and the tax rate applied in its own country to revenues or cost arising from its permit selling or buying behavior. Of course each firm decides whether to be a net seller or buyer of permits after comparing its cost of increasing/reducing emissions to the international price of permits which, however, is taken as exogenous or not according to whether the firm is price taker or has market power.

Our model provides some insightful results. First of all we can claim that, under some conditions, policies aimed at removing or reducing market power in the permits market can be detrimental. Indeed, if some form of taxation is charged on permits, the negative effect of market power can be compensated, or even completely neutralized, by the presence of taxation, and viceversa. In other words, cost effectiveness, which is violated by both market power and permits taxation when they are considered separately, can be guaranteed in those settings where market power and permits taxation coexist. In our model cost effectiveness is guaranteed by the presence of some tax rate differential, at least between countries hosting the competitive fringe and those countries hosting the set of dominant-strategists. This result contrasts with the cost effectiveness requirement implied by previous papers on emissions trading taxation (Kane, 2009; Costantini et al., 2011) where, given the competitive market of permits, it is necessary to have a homogeneous tax rate for all states. Finally, we show that the presence of emissions trading taxation increases the firms' ability to affect the equilibrium price in the permits market, and can therefore have an impact on the degree of market power. We complement our analysis with a tractable example featuring a dominant monopolistic firm and several competitive firms to further investigate the impact of emissions trading taxation on cost effectiveness and efficiency under market power. Using abatament costs related data from Godal and Klaassen (2006), we show that the explicit inclusion of taxation might reduce the welfare losses related to market power and get total costs closer to cost effectiveness.

The majority of papers considering emissions trading jointly with taxation regards both of them as regulatory instruments and deals with the overlapping issues of these instruments rather than with the application of taxation on emissions trading (Böhringer et al., 2008; Borghesi, 2010; Brechet and Peralta, 2007; Eichner and Pethig, 2009; Johnstone, 2003). To the best of our knowledge only few contributions deal explicitly with emissions trading revenues taxation. Among them, Fischer (2006) investigates the interaction between multinational taxation and abatement in an international emissions trading scenario where the equilibrium permits price is exogenous. Kane (2009), instead, provides a descriptive analysis of the different fiscal treatments affecting the permits trading markets, claiming that heterogeneous tax regimes among firms or jurisdictions are very likely to affect allocative efficiency in a multi-periods context. In a more formal setting, Yale (2008) examines under what circumstances income taxation interferes with cap-and-trade environmental regulation. He reaches two opposite conclusions according to the time horizon under scrutiny: within a single tax period, taxing returns from permits does not distort firms' choices at the margin between using and selling permits or between buying permits and abating. On the opposite, when permits are provided for free and their value is excluded from taxable income, taxes may distort firms' decisions regarding whether and to what extent they find permit banking convenient. In this case, the permit price will rise up to the point where tax exemption is capitalized into the price of permits and, accordingly, the relative costs of abatement in present and future periods result to be distorted. Finally, Costantini et al, (2011) deal with a perfectly competitive international permit market where permit price as well as emissions abatement decisions are derived endogenously. They show through both a theoretical partial equilibrium model and a computable general equilibrium model that, differently from Yale (2008), emission trading taxation leads to distortions even in a static context.

A partially dissenting voice comes from a policy oriented report by Copenhagen Economics (2010). By dealing with cost distortions related to the existence of differentiated tax treatment of permits across member States in the EU, this report concludes that such distortions are not expected to be significant. By showing how the presence of market power can mitigate the adverse effect of a differentiated taxation of permits among states, our paper can provide a further support to the reassuring conclusions of Copenhagen Economics (2010).

The rest of the paper is organized as follows: Section 2 presents the theoretical model and the main results under very general hypothesis; Section 3 provides some additional result by resorting to a a specific example; finally, Section 4 concludes.

2 Model and general results

We consider I representative firms operating in I countries which are part of an international emission permits market. Each firm $i \in I$ is assumed to minimize emissions costs, taking into account the price of permits and the tax treatment of revenues and costs generated by its permit selling or buying behavior:

$$\min_{x_i} c(x_i) + p(1-t_i)(x_i - e_i) \tag{1}$$

where the cost function $c(.)$ is decreasing and convex in firm's emissions (x_i), p is the equilibrium permits price, and e_i is the initial endowment of permits to firm i. The tax rate t_i is applied on revenues (or costs) generated by $(x_i - e_i)$, i.e. the amount of permits sold (when $x_i < e_i$) or bought (when $x_i > e_i$). Given the definition of t_i adopted in this paper, we do not need to specify further the nature of permit trading taxation which could be, for instance, the differentiated treatment among states of those transactions involved in markets for tradable emission permits in terms of either the application of (or exemption from) VAT, or corporate income tax.

Firms are divided in two categories, according to whether they have market power in the permits market or not. More specifically, firms can be part of a competitive fringe ($i \in F$) or can be part of a set of strategists ($i \in S$), where $F \cup S = I$ and $F \cap S = \emptyset$. We can represent our model as a two stage game: *in the first stage,* strategists set their emission quantities before the price takers firms clear the market *(the last stage)*. The tax rate and the received amount of allowances are exogenously given for any firm $i \in I$.

Solving backward we look first at the optimal choices of the firms belonging to the competitive fringe. Given the permits price, each firm $i \in F$ chooses the level of emissions minimizing the net emission costs. The first order condition of this minimization problem is as follows:

$$c'(x_i) + p(1 - t_i) = 0 \tag{2}$$

In the first stage, when the strategists decide their optimal levels of emissions, they anticipate how the fringe will react to their choices and, consequently, the equilibrium price of permits; the first order condition of their minimization problems is:

$$c'(x_i) + p(1 - t_i) + \frac{\partial p}{\partial x_i}(1 - t_i)(x_i - e_i) = 0 \tag{3}$$

for every $i \in S$.

From (2) to (3) we can infer the joint effects of permits taxation and market power on cost effectiveness.

Proposition 1 *If both F and S are nonempty sets, cost effectiveness requires that all the following conditions holds*

1. $t_i = t_j$ *for any possible pair of countries* $i, j \in F$*;*

2. $p(t_j - t_i) = \frac{\partial p}{\partial x_j}(1 - t_j)(x_j - e_j)$ *for any possible pair of countries* i *and* j*,* $i \in F$ *and* $j \in S$*;*

3. $p(t_j - t_i) = \frac{\partial p}{\partial x_j}(1 - t_j)(x_j - e_j) - \frac{\partial p}{\partial x_i}(1 - t_i)(x_i - e_i)$ *for any possible pair of countries* $i, j \in S$*.*

Proof. By a simple inspection of the first order conditions we have that (2) can be rewritten as follows

$$-c'(x_i) = p(1 - t_i) \tag{4}$$

for any $i \in F$, and (3) can be rewritten as

$$-c'(x_i) = p(1 - t_i) + \frac{\partial p}{\partial x_i}(1 - t_i)(x_i - e_i) \tag{5}$$

for any $i \in S$. Since cost effectiveness implies that $-c'(x_i) = -c'(x_j)$ for any $i, j \in I$ and since $I = \{F, S\}$, the proof is straightforward. ■

Proposition 1 brings about an important policy implication: policies aimed at removing or reducing market power in the permits market must be carefully evaluated when some form of taxation is charged on permits. Indeed, when the conditions listed in Proposition 1 hold simultaneously, the negative effect of market power, which is a typical source of inefficiency in the emissions trading markets (Hahn, 1984), is completely neutralized by the presence of another source of inefficiency, i.e. taxation, and viceversa.

Proposition 1 also provides some insights on a possible more efficient use of permits taxation at the international level. First of all cost effectiveness cannot be ensured whenever $t_i \neq t_j$ for at least a pair $i, j \in F$. This partly confirms the result by Costantini et al. (2011) dealing with permits taxation in a perfectly competitive permits market. It can easily be shown that our analysis tends to collapse to the model presented in Costantini et al. (2011), whenever S, the set of strategists, is empty. Differently from Costantini et al (2011), where cost effectiveness is ensured when tax rates are homogeneous in all countries, however, in our model the possibility of market power in the permits market complicates the results. Specifically, homogeneity in the tax rates can be required only for countries belonging to the competitive fringe. But even having $t_i = t_j$ for any possible pair of countries $i, j \in F$, $i \neq j$, is not sufficient for having cost effectiveness in the permits, as stated in Proposition 1.

Further, it is worth to note that in our framework, having $t_i = t_j$ for any possible pair of countries $i, j \in I$, $i \neq j$, is never optimal when market power is accounted for. Indeed, we can easily note that condition 2 in Proposition 1 is never satisfied for $t_i = t_j$, when $i \in F$ and $j \in S$. In other words, having assumed the co-presence of price takers and price makers firms in the permits market implies that some heterogeneity in the tax rates (at least between firms with market power and the competitive fringe) must be required. The following lemma defines better the terms of such heterogeneity.

Lemma 2 *If both F and S are nonempty sets, cost effectiveness needs that*

1. *the tax rate differential between any country $j \in S$ and all countries in F must be positive (negative) if the strategist is a net buyer (seller) in the permits market;*

2. *the greater the impact of strategists' emissions on equilibrium price, the greater the tax rate differential between strategists' countries and any country $i \in F$ in absolute terms.*

Proof. The proof derives by simply noting that i) the signs of the left hand side and the right hand side of the equation defined by the second condition of Proposition 1 depend on the signs of $(t_j - t_i)$ and $(x_j - e_j)$, respectively; and ii) the magnitude, in absolute terms, of the right hand side of the equation defined by condition 2 of Proposition 1 depends on the magnitude of $\frac{\partial p}{\partial x_j}$. ■

Lemma 2 provides information on the relative magnitude of the tax rates required to get cost effectiveness. One determinant of the relative ranking of the different tax rates is the magnitude of $\frac{\partial p}{\partial x_j}$, that is the impact of emissions of strategist j on the equilibrium price. Under this respect it is interesting to note that the magnitude of $\frac{\partial p}{\partial x_j}$ is endogenously determined by the tax rates. The following proposition clarifies this point.

Proposition 3 *The impact of an increase in emissions by any firm $j \in S$ on the equilibrium price is increasing in the tax rate of any country $i \in F$ and $s \in S$. Such an impact can be larger or smaller than under perfect competition.*

Proof. Market clearing requires that demand by the fringe equals the overall cap, i.e. $E = \sum_{k \in I} e_k$, minus the demand from strategists:

$$\sum_{i \in F} x_i(p) = \sum_{k \in I} e_k - \sum_{j \in S} x_j \tag{6}$$

Differentiating (6) with respect to x_j for $j \in S$ we get:

$$\left.\frac{\partial p}{\partial x_j}\right|_{j \in S} = \frac{1}{\sum_{i \in F} \frac{(1-t_i)}{c''(x_i)} + \sum_{j \in S} \frac{(1-t_s)}{c''(x_s) + (1-t_s)\left(\frac{\partial^2 p}{\partial x_s}(x_s - e_s) + \frac{\partial p}{\partial x_s}\right)}} \tag{7}$$

which is increasing in t_i. ■

Proposition 3 tells us that the impact of an increase in emissions by a strategist on the equilibrium price can be greater or smaller than the corresponding one when the market is perfectly competitive. Indeed, when we take emissions trading taxation into account we get, on one hand, $\sum_{i \in F} \frac{(1-t_i)}{c''(x_i)} < \sum_{i \in F} \frac{1}{c''(x_i)}$ which drives $\frac{\partial p}{\partial x_j}$ up, but the denominator is larger by the amount $\sum_{s \in S} \frac{(1-t_s)}{c''(x_s) + (1-t_s)\left(\frac{\partial^2 p}{\partial x_s}(x_s - e_s) + \frac{\partial p}{\partial x_s}\right)}$ which is positive in order for convexity to hold; this conclusion suggests a channel through which emissions trading taxation can affect the degree of market power. Consider for example taxation in the competitive fringe. From (7) we can see that, for any $i \in F$, when p increases, x_i decreases because the net benefit of polluting decreases, i.e. buying (selling) permits becomes more expensive (remunerative). Nevertheless, the higher t_i, the lighter the effect of p on x_i. As a consequence, if a strategist increases its emissions, i.e. increases (decreases) its demand (supply) of permits, it is necessary a higher increase in the equilibrium price to induce the fringe to clear the market.

3 A specific example with a single dominant firm

To shed some further light on the issue at hand we need derive the net demands of permits by the representative firms. In order to deal with this task and achieve some additional readable insights, we revert to a numerical example with specific functional forms. More specifically, we assume the following shape for the cost function:

$$c(x_i) = \frac{1}{2b_i}\left(b_i x_i - a_i\right)^2$$

The parameters a_i and b_i are allowed to vary across firms/countries, in order to have asymmetric business as usual emissions. Such emissions level is defined as the level that minimizes unregulated costs $c(.)$, that is:

$$x_i^B = \frac{a_i}{b_i}$$

We further assume that the set of strategists is made by a single dominant firm, labelled as firm 1, while the competitive fringe is formed by the remaining $I-1$ firms.

From (2), the first order conditions for the fringe can be rewritten as follows:

$$(b_f x_f - a_f) + p(1-t_f) = 0$$

$f = (2,..,I)$, impliying that emissions by firms belonging to the competitive fringe are:

$$x_f = \frac{a_f}{b_f} - p\frac{(1-t_f)}{b_f} \tag{8}$$

Similarly, from (3), the first order conditions for the dominant firm are:

$$(b_1 x_1 - a_1) + p(1-t_1) + \frac{\partial p}{\partial x_1}(1-t_1)(x_1 - e_1) = 0$$

so that equilibrium permits demand by the strategist is:

$$x_1 = \frac{\left(a_1 \sum_{f=2}^{n} \frac{(1-t_f)}{b_f} - \left(\sum_{f=2}^{n} \frac{a_f}{b_f} - E - e_1\right)(1-t_1)\right)}{\left(\sum_{f=2}^{n} \frac{(1-t_f)}{b_f} b_1 + 2 - t_1\right)}$$

In this setting the equilibrium on the permits market requires:

$$x_1 + \sum_{f=2}^{n} x_f = E$$

so that the equilibrium permits price as a function of the dominant firm's emissions is as follows:

$$p = \frac{x_1 + \sum_{f=2}^{n} \frac{a_f}{b_f} - E}{\sum_{f=2}^{n} \frac{(1-t_f)}{b_f}}$$

From the equilibrium permits price we can easily see what is the impact of a change in x_1 on p, i.e.

$$\frac{\partial p}{\partial x_1} = \frac{1}{\sum_{f=2}^{n} \frac{(1-t_f)}{b_f}}$$

which makes evident what we have stated in Proposition 3.

As a tractable example which allows to simulate our model in a hypothetical post-Kyoto scenario we consider the following case where $I = 4$, i.e. EEFSU (Estern Europe and Former Soviet Union), which is assumed to be the strategist, OECDEU (OECD Europe), CANZ (Canada, Australia and New Zeland), and JAPAN. Such aggregation of relevant countries, as well as the parameters' values, are taken from the inter-temporal computable general equilibrium model MERGE, which has been originally developed by Manne and Richels (2000), and then used in Godal and Klaassen (2006) and Godal and Meland (2010).Differently from Godal and Klaassen (2006), who consider a two period model where the US is allowed to participate either in both periods or only in the second one, we always consider the US out from the international emissions market. The parameterization of the model is summarized in the following table where we also derive the amout of permits assigned to each country by assuming a post-Kyoto reduction requirement of 20% with respect to the 2010 baseline emìssions for all countries but EEFSU.

EEFSU	$a_1 = 1410$	$b_1 = 1.569$	$e_1 = 899$
OECDEU	$a_2 = 1883$	$b_2 = 1.813$	$e_2 = 831$
CANZ	$a_3 = 478$	$b_3 = 2.216$	$e_3 = 250$
JAPAN	$a_4 = 1727$	$b_4 = 4.933$	$e_4 = 280$
			$E = 2260$

This parameterization allows to derive the levels of emissions which are optimally chosen by each country, as well as the equilibrium price of permits, as functions of the fiscal parameters t_i $(i = 1, 2, 3, 4)$. Let us now consider the following realistic corporate tax rates[1]: $t_1 = 0.2$, $t_3 = 0.3$, $t_4 = 0.4$ and leave

[1] See table 0.1, page 72 of Copenhagen Economics, (2010), Tax Treatment of Ets Allowances, Report prepared for EC DG TAXUD, October 2010 and, for FSU, http://www.cfe-

the tax rate in OECDEU (t_2) free. We get the following equilibrium values for emissions and permits price

$$x_1 = \frac{7.7772 \times 10^{26} t_2 - 2.6383 \times 10^{27}}{8.6542 \times 10^{23} t_2 - 3.1519 \times 10^{24}}$$

$$x_2 = \frac{a_2}{b_2} - p\frac{(1-t_2)}{b_2}$$
$$x_3 = \frac{a_3}{b_3} - p\frac{0.3}{b_3}$$
$$x_4 = \frac{a_4}{b_4} - p\frac{0.4}{b_4}$$
$$p = \frac{2.8597 \times 10^{28} - 1.0518 \times 10^{28} t_2}{2.3867 \times 10^{25} t_2^2 - 1.2972 \times 10^{26} t_2 + 1.5588 \times 10^{26}}$$

which are a function of t_2. If we define the total cost of emissions as

$$TC = \frac{1}{2b_1}(b_1 x_1 - a_1)^2 + \frac{1}{2b_2}(b_2 x_2 - a_2)^2 + \frac{1}{2b_3}(b_3 x_3 - a_3)^2 + \frac{1}{2b_4}(b_4 x_4 - a_4)^2$$

and subtitute the values of the parameters a_i and b_i ($i = 1, 2, 3, 4$), we get

$$TC_0 = 16634$$

when we consider a standard model of emissions trading without taxation ($t_i = 0$, for any $i = 1, 2, 3, 4$), and[2]

$$TC_t = \frac{1}{\Psi} \frac{-6.912 \times 10^{205} t_2 + 5.5095 \times 10^{205} t_2^2 - 1.9952 \times 10^{205} t_2^3 + 2.6825 \times 10^{204} t_2^4 + 3.6765 \times 10^{205}}{(4.0468 \times 10^{21} t_2 - 7.2569 \times 10^{21})^2 (1.8905 \times 10^{28} t_2 - 6.8854 \times 10^{28})^2}$$

In the following picture we plot TC_0 (red line) and TC_t (black curve) against t_2, that is the tax rate of OECDEU.

(FIGURE 1 ABOUT HERE)

eutax.org/taxation/corporate-income-tax/russia (accessed 19/09/2012).

[2] where $\Psi = 8556\,934\,048\,338\,184\,516\,199\,679\,564\,082\,259\,867\,253\,194\,827\,178\,070\,490$ $187\,300\,906\,117\,354\,512\,885\,922\,755\,308\,131\,645\,915\,136\,000$.

What we can see is that starting from a situation with market power and no taxation, an explicit inclusion of taxation might reduce the welfare losses related to market power and get total costs closer to cost effectiveness. As a matter of fact, the numerical simulation shows that the total cost associated to a differentiated level of permits taxation among countries (i.e. $t_1 = 0.2,\ t_3 = 0.3,\ t_1 = 0.4$ and t_2 which is between an approximate range of 0.2 and 0.5) is less than the total cost that would arise by implementing an international emissions trading system characterized by market power and where revenues and costs related to permits' exchange are taken out the taxable corporate income. The policy implication that we can derive from this picture is that any proposal of avoiding or removing permits taxation in the EU should be evaluated very carefully. Indeed, if the international permits market is affected by some degree of market power, a unilateral tax exemption by the EU would rise the total costs of pursuing the post-Kyoto targets.

4 Conclusions

In this paper we have studied how market power and emissions trading taxation affect the efficiency properties of an international emissions market. We have seen that, in the presence of an ad valorem taxation on the permits exchanged in the market, it is possible to have cost effectiveness even without driving dominant firm(s) net demand to zero. We have also been able to define the necessary conditions guaranteeing cost effectiveness, showing that it is guaranteed by the presence of some tax rate differential among states, at least between states hosting the competitive fringe and states hosting the dominant-strategists. This result contrasts with the cost effectiveness requirement implied by previous literature on emissions trading taxation that, because of the assumed perfect competitiveness in the permits market, requires a homogeneous tax rate for all states. Finally, our numerical simulation suggests that, if the international permits market is affected by some degree of market power, the EU should not reduce its taxation on permits since this policy could rise the total costs of pursuing the post-Kyoto targets.

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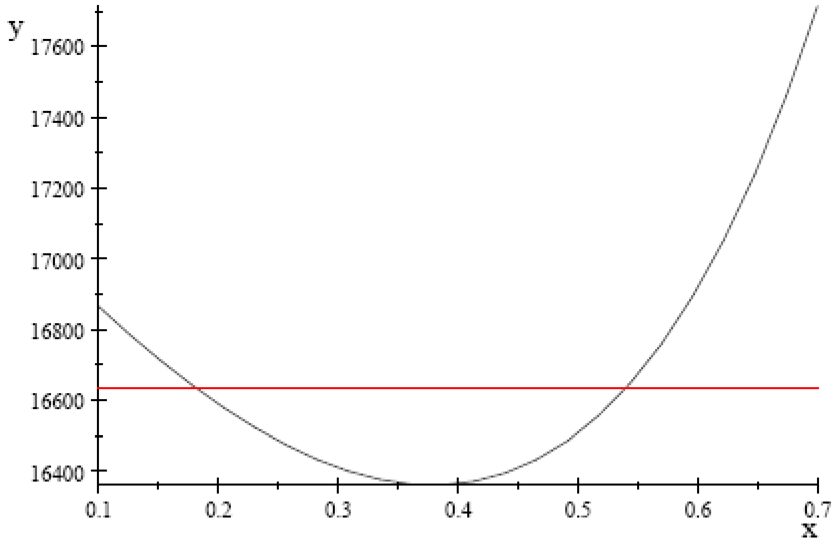
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Figure 1