行政院國家科學委員會專題研究計畫成果報告

非點污染管制的誘因機制之研究

A Study of Incentive Mechanisms on Nonpoint Pollution Control

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主持人：胡均立　　私立淡江大學產業經濟系

電子信箱(E-mail)位址：jinlihu@ms14.hinet.net

一、中文摘要

隨著經濟成長，國人開始重視周遭環境品質，對污染加以管制乃成為政府刻不容緩之議題。根據污染來源是否能夠完全區分，環境學者將其分為點源污染與非點源污染兩種。在非點源污染的問題中，政府無法區分個別污染源之排放量，因此必須設計一有效的誘因機制解決「搭便車」的問題。

對於點源污染誘因機制的研究已相當成熟，不過其污染管制工具並不能一體適用於非點源污染管制，而綜觀環境經濟學文獻，在非點源污染的研究領域裡尚缺乏將經濟工具組合之比較、執法成本、廠商合作行為等做一考量，同時也較缺乏寡占市場結構的討論。因此在本文的研究中，我們在雙占市場結構下，討論課徵排放稅、產品從量稅時，廠商的產量決策與污染防治行為，並討論兩種稅制下之社會福利大小以比較其優劣。最後我們還討論廠商可以選擇不同的生產技術時，比較排放稅和產品從量稅下，廠商改變生產技術的誘因。

環境經濟學者Segerson (1988) 率先研究非點源污染誘因機制設計，在Segerson的機制設計中，要求政府必須知道個別廠商對環境的損害函數，且實施現行法律所禁止的差別性稅率結構。另外，對於污染管制的相關文獻中，多數皆以完全競爭市場及市場結構為獨占下做探討，較少對寡占市場結構下的污染誘因機制做討論。Tomasi et al. (1994) 指出，相較於點源污

染管制文獻，非點源污染管制尚缺乏執法成本、廠商的合作行為及不同經濟工具組合之比較等思考方向，而這也是本論文的努力方向。

在本文中，我們設定一個Cournot雙占模型，廠商生產過程中產生污染，政府無法區分個別廠商的污染排放量（監測個別廠商的成本相當高）而僅能觀察污染總量（監測總污染量的成本很低）。我們比較課徵排放稅 (emission tax)、產品從量稅 (output tax) 和同時使用前述兩種稅制時，廠商在不同誘因機制下的產量和減污量決策，以及其所對應之社會福利水準。另外，我們將模型擴展，允許廠商可以選擇不同的生產技術，並討論在政府課徵排放稅和產品從量稅下，廠商改變生產技術的誘因。

在本研究中，非點源污染中資訊不對稱的問題源自於政府並不知道廠商的生產技術類型，因此我們假設政府與廠商皆以相同的機率猜測廠商彼此間的生產技術類型。另外我們假設廠商的污染防治行為與生產成本間並無任何關聯，故可分開處理。在課徵排放稅時，兩廠商依聯合責任制分擔稅負，如T. H. Tietenberg (1989)，而政府則觀察監測成本較低的總污染排放量。

在討論排放稅和產品稅後，我們發現只有在課徵排放稅下，廠商才會把對手為何種技術類型的資訊考慮進自身的產量決策中，並且在此時廠商才會從事減污量的投入。因此在排放稅下 ，廠商除了考慮對手的產量決策外，還會同時考慮減污量的決策；而在產品從量稅下，廠商只考慮到對手的產量決策。唯有當政府以排放稅直接管制排放量時，污染防治對產量有策略效果，

當政府以不同的誘因機制管制污染排放量時，究竟是如何影響廠商達成污染減量的目的？Chiou and Hu (1999) 指出：在面臨政府管制下，為達成污染減量，廠商可以透過減產或投入污染防治工作。本文中我們在排放稅制下發現：當需求彈性較小時，廠商會減少產量以增加自己的利潤，而在此時，廠商乃以減產來達成大部份污染減量的目標；需求彈性較大時，廠商會增加產量以增加自己的利潤，此時廠商將投入較多的污染防治工作以達成污染減量的目的。

本文中我們所關心的是當最適稅率為正的時候：因為在此時污染確為決策者所關心的議題，因此政府希望以正的稅率來誘導廠商減少污染量；稅率為負，則是表示社會生產不足，須要更多的產量，污染對於社會整體而言所造成的損害就變的較不重要了。因此在最適稅率為正的情況下，政府使用課徵排放稅來管制非點源污染行為優於產品從量稅。這是因為當政府課徵排放稅時，對廠商而言，他們可以透過產出的減量來達成減少污染排放量的目

標，同時也可以透過減污量的投入來降低排放量，因此對廠商而言，其選擇的調整工具較多。因此，排放稅自然較課徵產品從量稅時，透過減產來間接調整污染排放量為唯一的調整工具下要好。除此之外，當政府課徵排放稅時，對於污染採取聯合責任的制度，所以廠商會利用彼此所知的資訊 (對手是何種類型的廠商)，並考慮對手的污染防治行為；而當政府課徵產品稅時，廠商們皆不會將上述的資訊考量至本身的決策中，而只會考慮對手的產量決策，因此課徵排放稅較使用產品稅多了一項資訊價值。

若我們考慮政府政策會影響廠商生產技術類型時，可以發現：在當政府課徵排放稅時且需求彈性較小時，廠商會傾向選擇高污染生產技術；而當需求彈性較大時，廠商會傾向選擇低污染生產技術。而當政府以產品從量稅來管制污染排放量時，則廠商必定選擇高污染生產技術來進行生產，沒有任何誘因選擇低污染生產技術。因此排放稅在誘導廠商選擇技術類型上優於產品從量稅。若政府設定一高排放稅來說，則廠商的上策為選擇低污染類型，則非點源污染問題便可以得到解決。

綜合以上所述，我們在本文中發現，對於非點源污染問題的處理上，排放稅優於產品從量稅，這除了其對資訊的運用較佳外，同時也使廠商們體認到對於污染損害的責任歸屬問題，而在排放污染量時能有所節制並互相制衡；同時在誘導廠商選擇技術類型上，排放稅也優於產品稅。另外在以往的認知中，在寡占市場下課徵租稅，廠商會聯合減少產量，抬高價格以增加本身的利潤。然而在本文中我們發現：若政府課徵排放稅，廠商有誘因選擇低污染生產技術，增加產量，進而接近社會最適產量的境界之中。

排放稅制除了上述的優點外，尚有如：(1) 直接調整污染排放量，這較符合我們環境保護目標。(2) 比起直接管制，政府干涉減少許多，給予廠商大幅度自由決定的空間，同時也能促進污染防治工作技術的進步。在本文中未考慮之處為：(1) 我們假設政府的監測成本很低，因此得出排放稅制較優，而當監測成本很高的時候，Schmutzler and Goulder (1997) 認為排放稅制並非社會最適，反到是對較易觀察的產出課稅較有效率。(2) 稅率及其他代表市場狀況的參數要如何訂定，我們必須要蒐集資訊，而資訊的蒐集是相當困難的。(3) 我們單純的將廠商的生產活動和污染防治工作分開處理，而未考慮其彼此的關聯性，因此課徵產品從量稅下，廠商是否完全不從事污染防治就並不一定了。

綜合歸納後，我們在本研究中得到以下結論：

(1) 當需求彈性較大時，政府應選擇課徵排放稅來管制廠商的污染排放行為，因其社會總剩餘在此時較產品

從量稅下為高；反之，需求彈性較小時，政府應選擇課徵產品從量稅。

(2) 在課徵排放稅下，廠商會將對手技術類型的資訊考量進自身的產量決策中，並有誘因投入汙染防治工作及選擇低污染生產技術。

(3) 在課徵產品從量稅下，廠商不會將對手技術類型的資訊考量進自身的產量決策中，並且沒有誘因投入汙染防治工作，而廠商必定選擇高污染生產技術。

關鍵詞：非點源污染、排放稅、產品稅、聯合責任

二、英文摘要

As the economic development goes forward, the people emphasize the environmental much more than before. Therefore, the environmental regulation issue has become an important research and policy issue. Upon the nonpoint pollution, the government is not able to monitor the individual pollutant sources. Hence, an incentive scheme is needed to solve the free-riding problem in the presence of nonpoint pollution.

The study of point pollution regulation is quite well developed. However, not all of the conclusions in the literature on point pollution may be applied to point pollution regulation. There is still a lack of combined economic instruments, enforcement cost, cooperative behavior of firms, oligopoly market structure, etc., in the existing literature of nonpoint pollution regulation. Therefore, in this article we compare the effects of emission and per unit output taxes on a duopoly's choice of output, pollution abatement, production technology type, etc.

Segerson (1988) pioneer in the incentive scheme design on nonpoint pollution regulation. However, Segerson's incentive scheme design requires the government to know the damage functions of the individual firms and to be able to implement discriminative tax rates. Moreover, most of the existing literature on pollution regulation assumes perfect competition market and lacks the discussion on oligopolistic market. As Tomasi et al. (1994) point out, there is lack of enforcement cost, cooperative behavior of firms, and combination of economic instruments, etc., in the existing literature of nonpoint pollution regulation.

The information asymmetry arises from

the private information of the production technology type. We assume the beliefs on the firms' environmental technology among the government and the duopolistic firms to be symmetric. Furthermore, it is assumed that cost functions are additively separable in the production and pollution abatement costs. Under an emission tax, the two firms share the tax burden according to the joint liability (see Tietenberg 1989) and the government is able to monitor only the total emission amount but not the individual emission amounts.

After comparing the results under the emission tax and the output tax, we find that a firm will take into account the information of its opponent and do pollution abatement only under the emission tax. Moreover, under the emission tax, a firm will take into account both its opponent's abatement and output strategies. Under the output tax, a firm will consider only its opponent's output strategy but no abatement. Therefore, under the emission tax an abatement decision has a strategic effect on output.

Chiou and Hu (1999) pointed out, under the government regulation, the firms can either do abatement or reduce output to reduce the total output. Under the emission tax, we find that when the elasticity of demand is small, firms will reduce outputs and abatement to increase their profits and reduce emission. When he elasticity of demand is large, firms will increase outputs and abatement to increase their profits.

We focus on the situation when the social optimal tax rates are positive. This is because when pollution is an issue concerned by the social planner, the government wants to reduce emission by a positive tax rate. When the social optimal tax rate is negative, it implies that the output is insufficient and the government wants to increase the output by a subsidy. When the optimal tax rates are positive, the emission tax is superior to the output tax since firms will adjust both abatement and output under the emission tax. However, firms do not do abatement under an output tax. Moreover, a firm will take into account the information of the type and abatement level of its opponent under the emission tax. Therefore, the emission tax can induce the firms to make use of the information of the opponent's type.

Our major findings are as follows: (1) If the demand elasticity is large, it is optimal for the government to impose an emission tax rather than an output tax. Otherwise, it is optimal for the government to choose output tax. (2) Under an emission tax, each firm will take the belief on its opponent's type into account. The emission tax can induce the firms to undertake pollution abatement and choose the low-pollution production technology. (3) Under an output tax, each firm will not take the belief on its opponent's type into account. The output tax cannot induce the firms to undertake pollution

abatement; and the firms will always choose the high-pollution production technology.

Key words: nonpoint pollution, emission tax, output tax, joint liability.

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