The diffusion of differentiated waste disposal taxes in the Netherlands

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Abstract

The diffusion of a novel taxing scheme among Dutch municipalities in the period 1998-2005 is studied. In this taxing scheme the waste disposal tax is made dependent on the amount of waste a household produces. Inspecting the pattern of the introduction of this tariff, it seems to be contagious: the probability of introduction is increasing in the number of neighboring municipalities that have already introduced this taxing scheme. A possible rationale is that the tax encourages illegal dumping of waste which in turn might increase the waste of neighboring municipalities (spillover effect). Using panel data it is possible to distinguish between municipal specific effects and the spillover effect. The results indicate the presence of strong spillovers.

Keywords: differentiated waste disposal taxes, tax diffusion, tax innovation

JEL classification codes: H23, H73, Q58, R15.

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1 Introduction

Policy decisions of local governments are seldomly chosen in isolation. If a municipality taxes the use of a public good and the externality of this public good extends beyond the municipal borders, then the impact of this tax will also extend beyond the border. Hence, a decision to change taxation by a single municipality can have far-reaching effects.

In this paper, the diffusion of differentiated waste disposal taxes in the Netherlands will be examined. In the period 1998-2005 sixty-four Dutch municipalities have introduced waste disposal charges that depend directly on the amount of waste a household produces. In total 112 of the 467 municipalities employ some form of DIFferentiated TARiffs (DIFTAR hereafter). This rapid diffusion is remarkable. Prior to 1990 this kind of taxation was unheard of. Moreover, one only has to examine a map to notice the strong clustering of DIFTAR-municipalities (see Figure 1). The purpose of this paper is to examine the causes and the strength of this apparent spillover effect.

— Insert Figure 1 here —

There could be a spillover effect for two reasons. First, (illegal) dumping of waste will become more prevalent. And this dumping will in general not be confined to the municipality that introduces DIFTAR. A study cited by Linderhof, Kooreman, Allers, and Wiersma (2001) confirms this: in the Dutch municipality of Oostzaan 4–5% of total waste reduction resulted from dumping in neighboring municipalities out of a total of 30% waste reduction. A second spillover is an informational one. If a neighboring municipality introduces DIFTAR, then the citizens of the municipality can better judge the impact of a DIFTAR-scheme and this may facilitate the introduction of a DIFTAR scheme. I will show how these kinds of externalities determine the introduction of DIFTAR.

The data that I will use to identify the presence of spillover effects, consists of a panel with yearly observations for all Dutch municipalities for the period 1998–2005. For each municipality it is known whether the municipality had DIFTAR in a certain year and what the bordering municipalities are. The results of the local elections are also known as well as a number of time-independent characteristics of the municipality. With cross-section data, it might be problematic to identify a spillover effect since the introduction of DIFTAR could equally well be attributed to an unobserved regional effect. Therefore, in this paper, I use spatial panel data to separate spillover effects from regional- and municipal specific effects. The results indicate the existence of a strong positive spillover effect.

The paper is organized as follows. An overview of the literature is given in Section 2. Section 3 presents a theoretical model. The institutional details and an overview of the data are given in Section 4. In Section 5, I present the econometric model and discuss the estimation results. Section 6 summarizes the results and discusses the welfare implications of the contagious nature of introducing DIFTAR.

2 Overview of the literature

Most research on DIFTAR has focused on the question whether and to what extent DIFTAR reduces the amount of waste produced by a household. Notable studies are Linderhof et al. (2001) and Fullerton and Kinnaman (1996). The study by Linderhof et al. uses data for each household in the municipality of Oostzaan before and after the introduction of a DIFTAR-regime that taxes households for each kilogram of waste produced. This allows for estimation of short- and long-run price effects, which they find to be strong and negative. Fullerton and Kinnaman use similar data for the city of Charlotteville, Virginia. The main difference is that the households are taxed per bag produced. In order to estimate weight reduction, for a selection of households the bags were weighted. The effect of the tax was a significant reduction in the amount of waste. Besides the aforementioned studies, there are dozens of studies that use aggregate data. Dijkgraaf (2004) is the most interesting of these studies from our perspective since it uses Dutch data. In the Netherlands, municipalities use a variety of DIFTAR-regimes: pricing per kilogram, pricing per bag, etcetera. Dijkgraaf finds that on average each of the regimes lowers the total amount of waste collected but the scheme with the most direct incentives (i.e. pricing per kilogram) reduces it by the largest amount.

The aim of this study is not to present further evidence that DIFTAR reduces the amount of waste collected, but to show that the introduction of DIFTAR imposes externalities on neighboring municipalities. Consequently, introducing DIFTAR raises strategic coordination issues.

Before we continue our discussion, notice that dumping refers here to two activities. The first activity is the illegal dumping of waste on publicly owned land such as parks or forests.

The second activity is either carrying waste to family/friends in neighboring municipalities that do not charge households per kilogram of waste produced or dumping the waste at work. The second activity is usually referred to as waste tourism. While this is legal, it is a form tax evasion.[1]

Both Fullerton and Kinnaman (1996) and Linderhof et al. (2001) present evidence that DIFTAR increases the incidence of waste dumping. Fullerton and Kinnaman refer to the first activity and claim that it may account for 43% of the waste reduction. Linderhof et al. refer to the second activity and suggest that 4–5% of waste is dumped in neighboring municipalities. Moreover, Linderhof et al. explicitly mention that the illegal dumping of waste on publicly owned land is a minor problem in the Netherlands. If DIFTAR implies the second kind of activity, then a municipality without DIFTAR can diminish the effect of waste tourism by introducing DIFTAR itself. This is an additional reason for a municipality to introduce DIFTAR: by doing so, it will avoid the cost of waste tourism. This argument is elaborated on in the theoretical model presented in Section 3.

There is a large literature, both theoretical and empirical, on policy diffusion. The two large strands in the theoretical literature are the Tiebout-hypothesis and yardstick competition. As a short remark on terminology, I use both diffusion and spillovers to denote any kind of diffusion whereas the Tiebout-hypothesis and yardstick competition denote two particular forms of diffusion which I will define in the following paragraphs.

Tiebout (1956) argues that citizens vote with their feet and move toward municipalities that offer the best combination of provision of local public goods and taxation. If local public goods are indeed local then the outcome should be an efficient provision of public goods, which is usually referred to as the Tiebout-hypothesis. This conclusion does not hold if local public goods have an effect on neighboring municipalities (and the government cannot internalize all externalities): then the outcome can be far from efficient.

Yardstick competition takes a different approach (Salmon, 1987). In this approach citizens are unable to directly evaluate the performance of local politicians. Citizens can observe policy outcomes, but they are unaware if a better outcome was available but not implemented. Assuming that politicians in neighboring municipalities face the same trade-offs, comparing

[1] There are other ways to reduce your output of waste. In Ireland, the introduction of DIFTAR has led people to burn waste in their backyard. Unfortunately this seems to have caused an increase in the number of burn victims (Murphy et al., 2007).

outcomes with neighboring municipalities might provide an opportunity to indirectly evaluate the performances of these local politicians. This leads politicians in neighboring municipalities to make the same choices. This theory does not predict that the outcome will be efficient or in which direction policy will move. In general, yardstick competition differs from the Tiebout-hypothesis and the theory presented in this paper, because the externality is not physical. Other non-physical externalities include learning models. The cost and benefits of introducing a new policy are uncertain. Consequently, the introduction of DIFTAR in a neighboring municipalities is potentially a useful experiment to examine to associated cost and benefits. The successful introduction of DIFTAR may then spur the introduction in neighboring municipalities.

A plethora of studies finds empirical evidence of both the Tiebout-hypothesis and yardstick competition. To name a few: Brown and Rork (2005) study lottery taxes among American states and find evidence that supports the Tiebout-hypothesis. It appears that American states lower their lottery tax in order to generate more revenue from state lotteries by attracting out-of-state buyers. Case, Rosen, and Hines (1993) observe strong correlation between the size of expenditures of American states and present this as evidence of fiscal interdependence. In a related study, Besley and Case (1995) study the effect of income taxation on outcomes in gubernatorial elections: lower taxes in neighboring states lead to a higher probability that the incumbent loses the election. This is in line with the yardstick competition theory. Allers and Elhorst (2005) study property taxes among Dutch municipalities and also find evidence in support of yardstick competition.

The above studies focus on tax rates and not on a tax innovation like DIFTAR. Following Walker (1969), political scientists and economists alike have also devoted many studies to the diffusion of innovative tax instruments, see Ashworth, Geys, and Heyndels (2006) and the references therein. For example, Ashworth et al. find that the rapid diffusion of a novel environmental tax among Flemish municipalities during the 1990's could be partly determined by the implementation of such a tax among neighboring municipalities. However, Ashworth et al. do not explain why the probability of implementation is increasing in the number of neighboring municipalities that have implemented the tax. Since the environmental tax amounts to reserving part of the budgets for environmental purposes, this tax is a purely symbolic act. Hence, there seems to be no reason for any spillover effect beyond imitation. In the case of DIFTAR studied in this paper, there is an externality present, which could explain the spillover effect.

3 A theoretical model

In the model presented in this section, the diffusion of DIFTAR is explained solely from dumping in neighboring municipalities. In a guide for introducing DIFTAR (AOO, 2004), aimed at municipalities, waste tourism is explicitly mentioned as an effect of introducing DIFTAR. As discussed in Section 2, this is by no means the only possible rationale for the diffusion of DIFTAR. It is also not the only reason why a specific municipality might introduce DIFTAR. Fairness concerns — polluters should pay — or environmental concerns could play a role as well. However, I focus entirely on the waste-tourism motive and I want to illustrate with a deliberately simple model how this externality works.

Suppose there are two neighboring municipalities: $i = 1, 2$. Consumers in municipality i have the following utility function:

$$U(D, C) = \alpha_i \sqrt{D} + (1 - \alpha_i) C, \tag{1}$$

where D is a (dirty) good that produces waste and C is a (clean) good that does not produce waste. It is assumed that if a household consumes one unit of D, it also produces one unit of waste. A fraction ρ_i of waste remains in the municipality of origin. The remaining fraction $(1 - \rho_i)$ is dumped in the neighboring municipality. A municipality can only tax the waste that is not dumped.

Assume that, for $i, j = 1, 2$ with $i \neq j$ and $0 < \rho < 1$, we have:

$$\rho_i = \begin{cases} \rho & \text{if } t_i > 0 \text{ and } t_j = 0, \\ 1 & \text{if } t_i = 0 \text{ or } t_j > 0, \end{cases} \tag{2}$$

where t_i is the tax rate per unit of waste in municipality i. Waste of municipality i is dumped in municipality j if and only if municipality i has introduced DIFTAR and municipality j has not introduced DIFTAR. This is in line with the waste tourism explanation: consumers will only dump their household waste at friends in neighboring municipalities if these friends can dump extra waste without additional cost. I do not explicitly model the decision to dump waste, it is assumed to occur at a rate independent of the cost of waste disposal. This is for the sake of simplicity and is meant to capture the negative externality imposed on a municipality if its neighbor introduces DIFTAR. Note that the fraction of waste that is dumped depends on the tax rate in both municipalities and, hence, ρ_i is a function of t_i and t_j.

If municipality 1 introduces a value tax per unit of waste and municipality 2 does not, then consumers in municipality 1 will try to avoid taxation by dumping waste in municipality 2. Since consumers in municipality 2 have no incentive to dump waste, the tax in municipality 1 will lead to an increase in waste for municipality 2. The cost of waste disposal in municipality 2 increases. In municipality 1 the cost goes down for two reasons. First, the price per unit of waste increases and thus less waste is produced. Second, part of this waste is dumped in the neighboring municipality 2, causing a further decrease in waste.

The (indirect) price of consuming one unit of D (assuming, to avoid cumbersome notation, that all prices are normalized to one) is $1 + t_i\rho_i$. The budget equation is:

$$(1 + t_i\rho_i)D + C = m - \beta_i, \tag{3}$$

where m is income and β_i is a lump-sum tax to cover the cost of waste disposal. If $t_i = 0$, then the municipality will raise revenue through the lump-sum tax β_i per household. Otherwise the municipality will raise revenue solely through the value tax $t_i > 0$ and β_i will be zero. Observe that β_i also depends on t_j, since in case $t_j > 0$ and $t_i = 0$, waste from municipality j is dumped in municipality i, which increases the lump-sum tax compared to the case in which $t_i = t_j = 0$. Since utility is quasi-linear, consumption of D does not depend on m or β_i as long as the cost of the optimal consumption of D does not exceed $m - \beta_i$. I will assume that every household can afford this.

While it may seem strange that the amount of waste produced does not depend on income, first of all note that Fullerton and Kinnaman (1996) in their empirical analysis find a negative relation between waste and income instead of the expected positive relation. This is difficult to reconcile with a theoretical framework of waste producing goods and non-waste producing goods. The theoretical model employed in Fullerton and Kinnaman (1993), that explicitly considers the option to (rationally) recycle, predicts that low-income households with their low opportunity cost recycle more. This would lead to a positive relation between waste and income. But then, what kind of model would result in a negative relation between waste production and income? I suggest that it should distinguish between two types of consumption goods: besides the basic consumption good, a luxury alternative should be available. If the basic consumption good is inferior and the luxury alternative produces less waste, then waste would decrease in income. These adjustment would not alter the results of the model presented here since the focus is on waste reduction as a consequence of DIFTAR and not on distributive considerations. So, I do not adjust the model to incorporate these elements.

Household waste production by a consumer in municipality i is:

$$\frac{A_i}{4(1+t_i\rho_i)^2}, \text{ where } A_i = \frac{\alpha_i^2}{(1-\alpha_i)^2}. \tag{4}$$

Total waste production in municipality i is:

$$\Omega_i = \frac{A_i}{4(1+t_i\rho_i)^2} S_i, \tag{5}$$

where S_i is the total number of inhabitants in this municipality. Utility of the consumer in the optimum is:

$$\alpha_i \sqrt{\frac{A_i}{4(1+t_i\rho_i)^2}} + (1-\alpha_i)\left[m - \beta_i - \frac{A_i}{4(1+t_i\rho_i)}\right]. \tag{6}$$

As a measure for consumer welfare I will derive the expression for consumers' surplus (CS_i) in case of quasilinear utility. Since I examine the change in consumer welfare, it makes sense to examine equivalent variation which in the quasilinear case is equivalent to consumers' surplus. The government takes into account the welfare of the consumers (i.e. CS_i) when deciding to introduce DIFTAR. Suppose a single consumer can only buy the non-waste producing good C and receives a compensation CS_i/S_i in terms of good C such that his utility is the same as in the optimum of (6). I compare the situation with a tax t_i and β_i with a situation in which all consumption is clean and there is no tax. Then CS_i/S_i is such that:

$$\alpha_i \sqrt{\frac{A_i}{4(1+t_i\rho_i)^2}} + (1-\alpha_i)\left[m - \beta_i - \frac{A_i}{4(1+t_i\rho_i)}\right] = (1-\alpha_i)\left[m + CS_i/S_i\right]. \tag{7}$$

It follows that:

$$CS_i = \frac{\alpha_i}{1-\alpha_i}\sqrt{\frac{A_i}{4(1+t_i\rho_i)^2}} S_i - \left[\frac{A_i}{4(1+t_i\rho_i)}\right] S_i - \beta_i S_i \tag{8}$$

$$= \frac{A_i}{4(1+t_i\rho_i)} S_i - \beta_i S_i. \tag{9}$$

Dijkgraaf and Gradus (2003) present evidence that the cost of waste disposal has constant returns to scale. Therefore, I assume that the cost function is linear in the amount of waste: $c\Omega_i$, where $c > 0$ is given. Assume that there are no further costs if a municipality decides to change from $t_i = 0$ to $t_i > 0$ (i.e. implement DIFTAR).

Suppose the local government tries to maximize consumers' surplus and to minimize the amount of waste subject to a financing constraint. This reflects two considerations the local government might take into account. It wants to be reelected and hence it must try to please the electorate. On the other hand, the local government and the citizens might also have environmental concerns. I use the amount of waste (both collected at the curb and dumped) as a proxy for the state of the environment. And ultimately the local government needs to cover the cost of waste collection. The government in municipality i faces the following problem:

$$\begin{aligned} &\max_{t_i} CS_i - \delta_i(\rho_i\Omega_i + (1-\rho_j)\Omega_j) \\ &\quad \text{s.t. if } t_i > 0\text{: } c(\rho_i\Omega_i + (1-\rho_j)\Omega_j) = t_i\rho_i\Omega_i, \\ &\qquad \text{if } t_i = 0\text{: } c(\Omega_i + (1-\rho_j)\Omega_j) = \beta_i S_i, \end{aligned} \tag{10}$$

where $\delta_i > 0$ is a parameter that signifies the strength of the environmental concerns. Examining the financing constraint, we see that, since $t_i > 0$ implies $\rho_j = 1$, the first constraint simplifies to marginal cost pricing: $t_i = c$. The other option is to set $t_i = 0$ and raise the money by taxing each household with a lump-sum tax $\beta_i = c(\Omega_i + (1-\rho_j)\Omega_j)/S_i$.

The following game is played: the municipalities simultaneously and independently decide to implement DIFTAR (i.e. set $t_i = c$) or not. It can be shown that all four pure strategy Nash equilibria are possible (for varying parameter values). Subsequently, I will characterize the best-response for municipality $i = 1, 2$ for varying parameter values in an attempt to provide insight in when certain equilibria occur.

Suppose municipality $j \neq i$ has chosen $t_j = 0$. Then municipality i will introduce DIFTAR if:

$$CS_i(c) - \delta_i\rho\Omega_i(c) \geq CS_i(0) - \delta_i\Omega_i(0), \tag{11}$$

where $CS_i(\cdot)$ and $\Omega_i(\cdot)$ are respectively consumers' surplus and total waste production as a function of t_i. After rearranging (11) the following expression is obtained

$$\frac{1}{1+c\rho} - \frac{\rho}{(1+c\rho)^2}\delta_i \geq 1 - c - \delta_i. \tag{12}$$

Inspecting (12), and using $\frac{\rho}{(1+c\rho)^2} < 1$, we see that if δ_i is large enough, then municipality i's best response is to introduce DIFTAR. One would expect green parties to have a high aversion of waste, implying a high δ_i and therefore be more likely to introduce DIFTAR even if the neighboring municipality has not. If ρ is equal to zero, then (12) reduces to $1 \geq 1-c-\delta_i$.

Consequently, if ρ is low enough, then it is also beneficial to introduce DIFTAR. If ρ is low, then both the cost of waste disposal and total waste production are reduced severely when DIFTAR is implemented. A Nash equilibrium in which no municipality introduces DIFTAR will not occur in the situation when ρ is low. Moreover, if c is high enough, then DIFTAR will also be implemented. If the cost of waste disposal is high, then a reduction in waste production will be more attractive.

Suppose municipality j has chosen $t_j = c$. Then municipality i will introduce DIFTAR if:

$$CS_i(c) - \delta_i \Omega_i(c) \geq CS_i(0) - \delta_i(\Omega_i(0) + (1-\rho)\Omega_j(c)). \tag{13}$$

which after some manipulations yields:

$$\left[(c+\delta_i)\frac{A_i}{4} - \delta_i \frac{A_i}{4(1+c)^2}\right] + \left[(c+\delta_i)\frac{(1-\rho)A_j}{4(1+c\rho)^2} \times \frac{S_j}{S_i}\right] \geq \left[\frac{A_i}{4} - \frac{A_i}{4(1+c)}\right] \tag{14}$$

Note that everything between brackets are non-negative quantities. Hence, a municipality i that either has a large enough δ_i or a neighbor that is large enough relative to its own number of inhabitants (i.e. S_j/S_i large) introduces DIFTAR. So, having a large neighbor that chooses to introduce DIFTAR can be the reason to introduce DIFTAR.

Now suppose that a social planner, e.g. a national government, determines the tax rates. The social planner maximizes $CS_1 + CS_2 - \delta_s(\Omega_1 + \Omega_2)$ subject to a financing constraint. The weight attached by the social planner to the amount of waste produced is $\delta_s > 0$ and is not necessarily equal to δ_1 and/or δ_2. Observe that for the social planner the only reason for introducing DIFTAR is a strong enough dislike of the amount of waste produced, i.e. a high δ_s. For the social planner, the dumping of waste is irrelevant to its decision.

The analysis above has shown three things:

1. The model can explain an isolated DIFTAR-municipality. An isolated DIFTAR-municipalities probably has a high δ_i and will introduce DIFTAR regardless of whether neighboring municipalities have introduced DIFTAR. These neighboring municipalities on the other hand have a low δ_i and not enough neighboring municipalities that have introduced DIFTAR.

2. The model can explain how DIFTAR spreads. A domino effect can occur: if a municipality introduces DIFTAR, then the best response of a neighboring municipality could

be to introduce DIFTAR as well. Generalizing, a mutual neighbor faced with two neighboring DIFTAR municipalities and consequently even more waste dumping might now implement DIFTAR.

3. The Nash equilibrium is not necessarily socially optimal. As the previous point shows, a municipality might be coerced to introduce DIFTAR through waste dumping. The social planner internalizes these externalities and could choose to not introduce DIFTAR in the neighboring municipality.

Concluding, the essence of this model can be captured by a panel data model in which we have municipal specific effects (indicating the tendency to introduce DIFTAR) and a variable, like the percentage of neighboring municipalities that have introduced DIFTAR (representing the threshold of S_i/S_j in (14)). Using the percentage of neighboring DIFTAR-municipalities as an explanatory variable yields a standard model in the spatial econometrics literature (cf. Anselin, 1988). I will also consider a variant, closer to the theoretical model, in which the explanatory variable is the total number of inhabitants of neighboring municipalities that have introduced DIFTAR divided by the number of inhabitants of the municipality itself.

4 Description of institutional details and the data

4.1 Institutional details

The Netherlands is, as of January 1, 2005, divided in 467 municipalities. The average municipality has an area of slightly less than 90 square kilometer, or less than 10×10 kilometer. The number of inhabitants ranges from a thousand to 750 thousand. A municipality usually consists of one larger city or a collection of villages. Despite these large differences, they have broadly the same obligations and means of taxation. They are required to execute several tasks, but have considerable autonomy regarding the details.

Local politics decides on these details. The political system in municipalities is based on proportional representation. Apart from a handful of municipalities, no single party has the majority. As in national politics, it is common to form a coalition with a majority backing. In fact, these coalitions tend to be larger than strictly necessary. The coalition parties provide aldermen. I will use the political alignment of the aldermen as the main political indicators. Two types of indicators will be constructed: percentage of alderman that are aligned with a certain political direction and a measure of concentration of the coalition with respect to the political alignment. It is posited that heavily fractured coalitions are less effective in causing major changes.

One of the things a municipality is required to do is to collect and dispose household waste. It raises revenue by taxing households to pay for the associated cost. The municipality is free to hire a company to take care of the collection and disposal of waste, but it can also choose to organize the collection of waste itself. In practice, small municipalities outsource completely and larger municipalities usually outsource only the disposal of waste. Waste that is not recycled is mostly incinerated.

No matter how waste is collected, it is the municipality that determines the manner and the height of the taxes. Until the early 1990s, practically all municipalities taxed consumers according to a flat fee (although possibly dependent on the size of the household). During the last decade many municipalities have made the tax dependent on the amount of waste a household produces. The main types of DIFTAR-schemes are:

Weight-based: In this scheme collected waste is weighted and households are charged per kilogram.

Volume-based: In this scheme households are equipped with a container of a certain size and they have to pay each time the container is presented at the curbside and emptied.

Expensive bag: Here waste is only collected if it is presented in a particular bag. A household buys these bags in advance in a nearby shop. The main advantage of this scheme are the low cost of implementation and the small administrative cost.

All these schemes lower the amount of waste (in kilograms), but the effect is most pronounced for the weight-based scheme (Dijkgraaf, 2004; Fullerton & Kinnaman, 1996).

I want to conclude this section with two remarks on some other aspects of DIFTAR: the politics of DIFTAR and the problem of dumping. Empirical evidence suggests that at the individual level the relation between income and waste production, if anything, is decreasing (Fullerton & Kinnaman, 1996). Then the introduction of DIFTAR is actually the introduction of a regressive tax where the poor may end up paying more than the rich. Of course, this effect is weakened by the incentive to produce less waste, but this could well explain why left-wing parties with a strong voter base among the lower classes (e.g. in the Netherlands this applies to the Socialist Party) are vehemently against the introduction of DIFTAR schemes.

Both Linderhof et al. (2001) and Fullerton and Kinnaman (1996) find evidence that a substantial part of the reduction in waste is due to dumping. Fullerton and Kinnaman (1996) even hypothesize that in a large, anonymous city like New York, a DIFTAR scheme would lead to near-100% dumping of waste. It is certainly clear that the introduction of a DIFTAR scheme can only be successful if laws against waste dumping are enforced. This may well be the reason that larger cities are reluctant to introduce DIFTAR. Even in cities like Groningen (in the northern part of the Netherlands) where the necessary infrastructure is present in much of the city (i.e. underground collection bins that record how much each household dumps) DIFTAR has not been introduced (as of 2007).[2]

4.2 The data

I have yearly data for the period 1998-2005 for all Dutch municipalities. A slightly complicating factor is the merging of municipalities.[3] In 1998 there are 553 municipalities of which 467 are left at the end of the sample. All data is for municipalities as they existed in 2005.[4] Note that the five Wadden-islands off the northern coast (Texel, Vlieland, Terschelling, Ameland and Schiermonnikoog, each of which is a separate municipality) do not share a border with any other municipality. There are $467 \times 8 = 3736$ observations.

I introduce the following variables:

Y_{it}: Value 1 if municipality i or a part of municipality i has DIFTAR in year t, and zero otherwise.

W_{ij}: Value 1/(total number of neighbors of municipality i) if municipality i and municipality j share a border, and zero otherwise. Note that $W_{ii} = 0$ and that for all municipalities except the Wadden-islands, $\sum_j W_{ij} = 1$. For the Wadden-islands, $W_{ij} = 0$ for all j. The (467×467) matrix $W \equiv \{W_{ij}\}_{i,j=1}^{467}$ is symmetric in the following sense: if $W_{ij} > 0$, then $W_{ji} > 0$. Figure 2 illustrates how the border matrix W is constructed.

[2]Dumping in some areas already occurs even though there are no monetary cost of throwing a bag in the bin.

[3]There used to be more than 1000 municipalities in the Netherlands, some having less than 500 inhabitants. In recent decades the Dutch government has striven to increase the size of municipalities.

[4]There is a great deal of policy synchronizing in the years leading up to a merger. Therefore treating municipalities, that are to merge, as if they have already merged seems to be the natural choice.

$PROV_i$: The province in which municipality i is located (Groningen = 1, Friesland = 2, Drenthe = 3, Overijssel = 4, Gelderland = 5, Utrecht = 6, North-Holland = 7, South-Holland = 8, Zeeland = 9, North-Brabant = 10, Limburg = 11 and Flevoland = 12).[5]

$RURAL_i$: The rurality of the municipality (None = 1, ...,Very = 5).

— Insert Figure 2 here —

I further have data on several other characteristics of municipalities such as the number of inhabitants, the income distribution, the average household size and the percentage single-member households. Finally, the results for all local elections are known. I focus on the number of aldermen each party has in each municipality. This data is summarized in the following variables:

$LEFT_{it}$: The percentage of aldermen representing a left-wing party (i.e. PvdA, GroenLinks, SP and local left-wing parties).[6]

$LOCAL_{it}$: The percentage of aldermen representing a local party (as opposed to a national party) including local left-wing and local christian parties. Local parties do not participate in national elections.

$CONFES_{it}$: The percentage of aldermen representing a christian party (i.e. CDA, SGP, ChristenUnie and local christian parties).[7]

HI_{it}: The Herfindahl-index of the coalition, i.e. the sum over the parties of the squared percentage of aldermen representing a party.

Remark that these are our only time-varying variables besides the DIFTAR-variable itself.

4.3 Descriptive statistics

Tables 1 and 2 show the number of DIFTAR-municipalities for the different categories of $PROV_i$ and $RURAL_i$. Almost all DIFTAR-municipalities are rural ($RURAL_i = 4$ or 5) and

[5]The Netherlands has three layers of government, which are, from bottom to top, municipalities, provinces and the national government. The provinces happen to roughly coincide with a sense of regional identity and culture.

[6]The PvdA is the social democratic party comparable to the British Labour Party, GroenLinks (literally GreenLeft) is a left-wing environmental party, SP is a socialist party.

[7]CDA is the mainstream christian-democratic party, both SGP and ChristenUnie represent orthodox protestants.

most of them are in North-Brabant or Limburg. Presence is notably increasing in Gelderland and Overijssel, as well as in smaller cities (i.e. $RURAL_i = 2$ or 3). In accordance with these facts, we see from Tables 3 and 4 that the typical DIFTAR-municipality tends to have few inhabitants, be (relatively) sparsely populated, have relatively high incomes, with large households. Politically, the local and christian parties are overrepresented.[8]

— Insert Table 1 here —

— Insert Table 2 here —

— Insert Table 3 here —

— Insert Table 4 here —

Table 5 shows the results of a simple regression of $Y_{i,2005}$ (municipalities that have DIFTAR in 2005) on dummies for province ($PROV_i$) and rurality ($RURAL_i$). It appears that there is a strong positive effect of being in North-Brabant or Limburg. Also if $RURAL_i = 2$ or 3, then municipalities are less likely to introduce DIFTAR then if $RURAL_i = 5$. There is no effect if $RURAL_i = 1$ (i.e. the municipality is one of the twelve biggest cities) or if $RURAL_i = 4$.

— Insert Table 5 here —

Table 6 shows the results of regressing $Y_{i,2005}$ on $LEFT_{i,2005}$, $HI_{i,2005}$, $LOCAL_{i,2005}$ and $CONFES_{i,2005}$. We see that HI, $LOCAL$ and $CONFES$ have a significant positive effect. The positive effect of both $LOCAL$ and $CONFES$ is due to the prevalence of DIFTAR in North-Brabant and Limburg: in both provinces these types of parties get a larger share of the vote than these parties have nationally. The regression also indicates that a highly concentrated coalition is more successful in introducing DIFTAR.

— Insert Table 6 here —

[8] In North-Brabant and especially Limburg, the two provinces where most DIFTAR municipalities are situated, in local elections mainly local parties participate.

Table 7 shows the average number of neighboring DIFTAR-municipalities for both DIFTAR- and non-DIFTAR-municipalities. Observe that, on average, DIFTAR-municipalities have more neighboring DIFTAR-municipalities than non-DIFTAR-municipalities. Naturally, since many municipalities have introduced DIFTAR in the last decade, the figure is rising for both types, but it has risen faster for DIFTAR-municipalities: the average for DIFTAR-municipalities has increased by 1.04, whereas this number has only increased by 0.34 for non-DIFTAR-municipalities.

— INSERT TABLE 7 HERE —

5 Econometric model and estimation results

The basic idea behind the econometric model is the following. The probability that a municipality i implements DIFTAR in year t is explained by the proportion of neighboring municipalities that have already introduced DIFTAR, $\sum_{j=1}^{N} W_{ij} Y_{j,t-1}$, a set of other explanatory variables (a row vector X_{it}), a (spatial) fixed effect η_i for each municipality and a time fixed effect ξ_t. This is broadly in line with the theory presented in Section 3. Note that $\sum_{j=1}^{N} W_{ij} Y_{j,t-1}$ can be interpreted as a weighted average. Moreover, the other explanatory variables have to vary over time. So, they consist of the political variables $LEFT_{it}$, $LOCAL_{it}$, $CONFES_{it}$ and HI_{it}. I want to estimate a model of the following form:

$$P[Y_{it} = 1] = F(\eta_i + \xi_t + \beta \sum_{j=1}^{N} W_{ij} Y_{j,t-1} + X_{it}\delta), \tag{15}$$

where $F(\cdot)$ is a cumulative distribution function, β a parameter indicating the strength of the spillover effect and δ a column vector of other parameters. The proportion of neighboring municipalities that have already introduced DIFTAR ($\sum_{j=1}^{N} W_{ij} Y_{j,t-1}$) is treated as an exogenous variable. First, consider the following linear probability model, where $F(x) = x$:

$$Y_{it} = \eta_i + \xi_t + \beta \sum_{j=1}^{N} W_{ij} Y_{jt} + X_{it}\delta + \epsilon_{it}, \tag{16}$$

where ϵ_{it} is an error term. If the error term is i.i.d., then this equation can be estimated using a standard fixed effects estimator. The results are shown in the first three columns of Table 8 for resp. no time fixed effects and no extra regressors, no time fixed effect but with extra regressors and with time fixed effects and with extra regressors. In all three regressions, β is positive, significant and approx. equal to 0.3. Observe that if all neighboring municipalities of municipality i have introduced DIFTAR, then β indicates by how much the probability, that municipality i introduces DIFTAR, will increase. According to these estimates this probability will increase by about 30%, which is substantial. The effect of the other regressors seems to be minimal: there is a small positive effect if more aldermen belong to christian parties and no time fixed effect is included and, surprisingly, a small negative effect if local parties are more strongly represented in the coalition and a time fixed effect is included.[9]

The literature on spatial econometrics argues that the assumption of i.i.d. error terms in spatial models will lead to biased estimates (cf. Anselin, 1988, and Elhorst, 2003). Specifically, it is easy to imagine that if municipalities are part of the same province, then a change in provincial policy (e.g., a temporary subsidy to introduce DIFTAR) could make each municipality in this province more likely to introduce DIFTAR. If we do not observe this subsidy, then the error terms of municipalities in this province will be correlated. To account for this, suppose that:

$$\epsilon_{it} = \gamma \sum_{j=1}^{N} V_{ij} \epsilon_{jt} + u_{it}, \tag{17}$$

where u_{it} is an iid error term with variance σ^2, γ a parameter signifying the spatial autocorrelation coefficient and V is a matrix such that $V_{ij} > 0$ if i and j share a common characteristic, e.g. if they are located in the same province.[10] This allows me to take into account common shocks that are not picked up by the other time-varying variables. I will consider three specifications of V:

Contiguity: In this specification, V is equal to W: $V_{ij} > 0$ if and only if municipalities i and j share a border

Same province: $V_{ij} > 0$ if and only if municipalities i and j are in the same province.

Same rurality: $V_{ij} > 0$ if and only if municipalities i and j are of the same rurality. This specification couples big cities to big cities and small rural municipalities to other small rural municipalities.

[9] In the simple regressions shown in Table 6, local parties seemed to have a positive effect on the introduction of DIFTAR.

[10] Furthermore, like W, the row sums of V are normalized to one. The diagonal of V consists of zeros. The matrix V is in general *not* symmetric in the usual sense, but if $V_{ij} > 0$, then $V_{ji} > 0$.

Identification of this model is essentially achieved by restricting interactions. The exogenous variables relating to municipality i are assumed to only have a direct effect on Y_{it}. So, e.g., a left-wing coalition in municipality i will only influence the probability of introducing DIFTAR in municipality i. Furthermore, the matrix V is assumed to be known.[11] Elhorst (2003) shows that with these restrictions the parameters of interest (β, γ and δ) can be estimated using a maximum likelihood estimator.[12]

The estimation results are shown in Table 8. First, the estimates of β are still positive and significant, but they are somewhat smaller and in the 20–25% range. Second, the effect of the political variables is still small. In short, a coalition with few aldermen representing local parties but with a lot of aldermen representing christian parties will be more likely to introduce DIFTAR. The estimates of the spatial autocorrelation coefficient γ is positive and significant for all three specification of V. However, the estimates of γ are substantially lower if the contiguity specification is used instead of the province- or rurality specification. This seems to suggest that most of the actual impact of neighboring municipalities is already picked up by the variable $\sum_{j=1}^{N} W_{ij} Y_{j,t-1}$. Finally, note that the province specification seems to yield a slightly better fit than the rurality specification.

Returning to (15), instead of choosing $F(\cdot)$ to be linear, another possibility is to choose the logit distribution or the standard normal distribution (probit). The advantage is that the discreteness of the dependent variable is accounted for. However, if we want to incorporate some form of spatial interdependence, then the estimation is decidedly less straightforward. Therefore, I only perform a rudimentary logit and probit estimation to confirm that the positive estimates of β do not vanish if a proper discrete choice model is used. The estimation results are shown in the last two columns of Table 8. Again, the estimates of β are positive and significant. But, unlike the previous estimations, none of the political variables are significant.

— Insert Table 8 here —

The use of the proportion of municipalities that have introduced DIFTAR as the main

[11] See Moffit (2001) for a general discussion of identification in models of social and spatial interactions.

[12] An implementation of this maximum likelihood estimator is included in LeSage's Econometrics Toolbox for Matlab (`http://www.spatial-econometrics.com/`) as the `sem_panel`-routine. An updated version of this routine is available from Paul Elhorst's website (`http://www.rug.nl/economics/faculty/medewerkers/elhorstjp/software`). All computations in this paper have been executed with Matlab R2007a and the Econometrics Toolbox.

explanatory variable is not entirely in line with the theoretical considerations of Section 3 where we argued that the relative size of these municipalities mattered. The reason for using it nonetheless is that if the proportion of municipalities matters more than the relative size, then this might be an indication that there is an informational spillover instead of a spillover as a consequence of waste dumping. Indeed Allers and Elhorst (2005) use contiguity to find evidence of an informational spillover in Dutch municipal property taxes (i.e. they use the unweighted average of the property tax rate of neighbors as their explanatory variable). For the next set of regressions the variable $\sum_{j=1}^{N} W_{ij} Y_{j,t-1}$ is going to be replaced by $\sum_{j=1}^{N} U_{ij} Y_{j,t-1}$, where U_{ij} is the number of inhabitants in municipality j divided by the total number of inhabitants in all neighboring municipalities of i if municipality i and j are neighbors and zero otherwise.[13] The results are shown in Table 9. Comparing Table 9 to Table 8, we see that they are broadly the same. The differences are mainly that the estimates of β are lower (but still positive and significant) and in the logit- and probit-specifications the Herfindahl-index of the coalition is now significant but negative. This would imply that a more shattered coalition is more likely to implement DIFTAR: the opposite of what was posited in Section 4 and the simple regression in Table 6 showed. Comparing the fit of the estimations in Table 9, where the relative size of the municipalities matters, to the estimations in Table 8 where it does not, we see that the fit does not improve although according to the theory of Section 3 it should. This casts some doubt on the hypothesis that the spillover is caused by waste tourism and points at the direction of an informational spillover. But this evidence is far from conclusive.

— Insert Table 9 here —

6 Concluding remarks

In this paper, a theoretical model was developed to explain how waste dumping can lead to the diffusion of DIFTAR-taxes. An econometric model, inspired by theoretical arguments, was subsequently used to test whether this diffusion takes place. The diffusion parameter β is positive and significant and the result is robust to a variety of estimation procedures. This gives us solid evidence that a taxation scheme which imposes externalities on neighboring

[13]This specification of U still has row sums to equal one and the variable $\sum_{j=1}^{N} U_{ij} Y_{j,t-1}$ is therefore a weighted average but now larger neighboring municipality have a bigger impact.

communities might be the cause for a similar kind of taxation scheme to be implemented in these neighboring communities. This particular conclusion is in line with the theory developed in Section 3.

The theory is further supported by the accuracy of the prediction that DIFTAR-municipalities tend to stay DIFTAR: in the data there are no instances of municipalities abandoning DIFTAR. Our final prediction — municipalities that introduce DIFTAR first are likely to have a high aversion of waste production — cannot be tested by the methods used in this paper, although anecdotal evidence suggests that pioneering municipalities do have a unique legislative composition. For instance, in the municipality of Oostzaan, GroenLinks was the largest party when DIFTAR was introduced, but nationally GroenLinks is one of the smaller parties. The finding that the percentage of neighboring municipalities that have introduced DIFTAR offers a better explanation than the relative size of these municipalities is definitely not in line with the theory as developed in Section 3 and points in the direction of an informational spillover. Further research in this field should try to answer this question.

From the viewpoint of the national government, the diffusion process may or may not be beneficial. This depends on whether the central government would choose to implement DIFTAR for all municipalities. If the national government is in favor of DIFTAR, then the contagious nature of DIFTAR can help to enforce this while municipalities are still autonomous. Of course, if the national government opposes DIFTAR, then the conclusion reverses. The national government should in that case restrict the freedom of municipalities especially in areas where non-local externalities are important or facilitate coordination.

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Table 1: The spread of DIFTAR conditional on the province in which the municipality is located

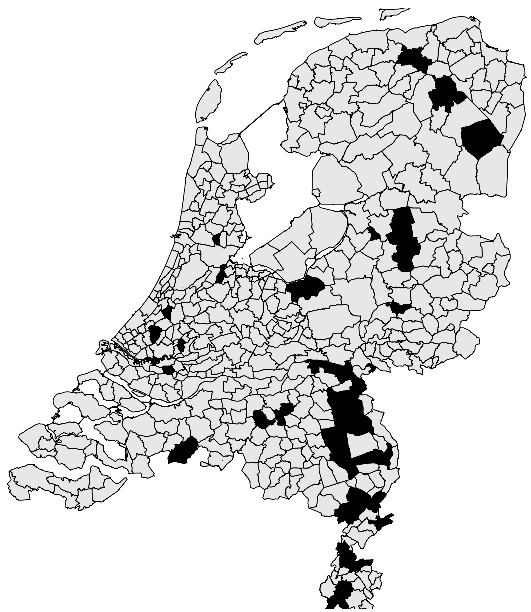
	Province											
1998												
	Gr	Fr	Dr	Ov	Gl	Ut	NH	ZH	Ze	NB	Li	Fl
all	25	31	12	25	56	32	65	87	13	68	47	6
DIFTAR	2	0	2	2	9	0	2	4	0	10	17	0
no DIFTAR	23	31	10	23	47	32	63	83	13	58	30	6
perc. DIFTAR	0.08	0.00	0.17	0.08	0.16	0.00	0.03	0.05	0.00	0.15	0.36	0.00
2005												
	Gr	Fr	Dr	Ov	Gl	Ut	NH	ZH	Ze	NB	Li	Fl
all	25	31	12	25	56	32	65	87	13	68	47	6
DIFTAR	5	3	2	10	22	0	3	3	0	33	30	1
no DIFTAR	20	28	10	15	34	32	62	84	13	35	17	5
perc. DIFTAR	0.20	0.10	0.17	0.40	0.39	0.00	0.05	0.03	0.00	0.49	0.64	0.17

NOTE: Gr = Groningen, Fr = Friesland, Dr = Drenthe, Ov = Overijssel, Gl = Gelderland, Ut = Utrecht, NH = North-Holland, ZH = South-Holland, Ze = Zeeland, NB = North-Brabant, Li = Limburg, Fl = Flevoland.

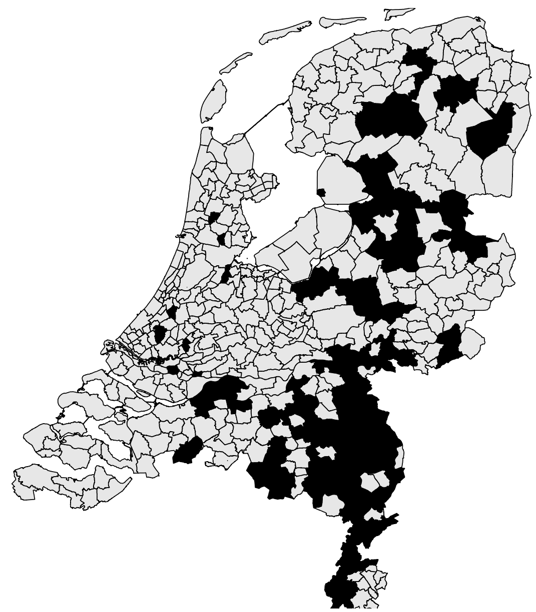
Table 2: The spread of DIFTAR conditional on the rurality of the municipality

	Rurality				
1998					
	None 1	2	3	4	Very 5
all	12	56	93	160	146
DIFTAR	0	1	6	22	19
no DIFTAR	12	55	87	138	127
perc. DIFTAR	0.00	0.02	0.06	0.14	0.13
2005					
	None 1	2	3	4	Very 5
all	12	56	93	160	146
DIFTAR	0	3	12	56	41
no DIFTAR	12	53	81	104	105
perc. DIFTAR	0.00	0.05	0.13	0.35	0.28

Figure 1: The spread of DIFTAR 1998-2005



1998

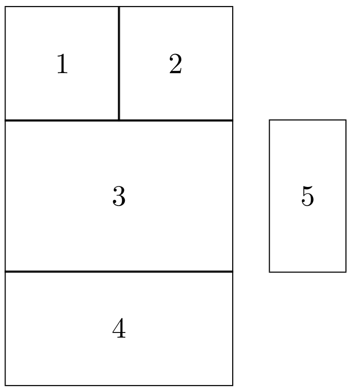


2005

NOTE: Municipal boundaries as they existed on January, 1 2005. DIFTAR municipalities are in black.

Figure 2: Example of a border matrix

Map



Matrix W

$$\begin{bmatrix} 0 & \frac{1}{2} & \frac{1}{2} & 0 & 0 \\ \frac{1}{2} & 0 & \frac{1}{2} & 0 & 0 \\ \frac{1}{3} & \frac{1}{3} & 0 & \frac{1}{3} & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Table 3: Characteristics of DIFTAR municipalities vs. non-DIFTAR municipalities

Average 1998							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
all	34.90	901.00	34.90	42.40	22.70	26.90	2.47
DIFTAR	23.50	654.00	33.40	43.40	23.10	24.30	2.52
no DIFTAR	36.20	929.00	35.10	42.30	22.60	27.20	2.47
2005							
all	34.89	900.73	34.90	42.41	22.69	26.90	2.47
DIFTAR	24.99	643.82	33.78	43.88	22.33	23.82	2.56
no DIFTAR	38.01	981.79	35.25	41.94	22.81	27.87	2.45

NOTE: Column (1) contains the number of inhabitants divided by 1000, column (2) the average number of addresses per square kilometer (a measure of population density), column (3) the percentage of households in a municipality that are in the lowest 40 per cent income group nationally, column (4) the percentage of households that are neither in the lowest 40 per cent income group nationally nor in the highest 20 per cent income group, column (5) the percentage of households that are in the highest 20 per cent income group nationally, column (6) the percentage of one-person households and column (7) the average number of persons in a household.

Table 4: Result of local elections in DIFTAR municipalities vs. non-DIFTAR municipalities

Mean percentage of aldermen after the first election in the period 1998–2002			
	LEFT	*LOCAL*	*CONFES*
all	0.27	0.23	0.50
DIFTAR	0.22	0.35	0.66
no DIFTAR	0.28	0.20	0.45

NOTE: In most municipalities the first municipal election is in 1998, but due to the frequent merging of municipalities in the 1990s some municipalities did not have an election until 2000.

Table 5: DIFTAR regressed on dummies for province and rurality

Ordinary Least-squares Estimates Dependent Variable: Y05			
Variable	**Coefficient**	**t-statistic**	**t-probability**
constant	0.1901	1.2	0.22
PROV=1	0.0148	0.1	0.93
PROV=2	-0.0828	-0.5	0.62
PROV=3	0.0024	0.0	0.99
PROV=4	0.2404	1.4	0.15
PROV=5	0.2220	1.4	0.16
PROV=6	-0.1427	-0.9	0.38
PROV=7	-0.0876	-0.6	0.58
PROV=8	-0.0923	-0.6	0.55
PROV=9	-0.1628	-0.9	0.37
PROV=10	**0.3153**	2.0	0.04
PROV=11	**0.4638**	2.9	0.00
RURAL=1	-0.1033	-0.9	0.36
RURAL=2	**-0.1479**	-2.4	0.01
RURAL=3	**-0.1255**	-2.5	0.01
RURAL=4	0.0332	0.7	0.46
R^2	0.30		
Adj. R^2	0.27		
σ^2	0.1328		
Durbin-Watson	2.0836		
Nobs	467		
Nvars	16		

NOTE: Bold indicates significant at a five percent level. The reference level is a rural municipality in the province of Flevoland.

Table 6: Regression on the political variables

Ordinary Least-squares Estimates			
Dependent Variable: Y05			
Variable	**Coefficient**	**t-statistic**	**t-probability**
constant	-0.1525	-1.5394	0.1244
LEFT05	0.2128	1.8241	0.0688
HI05	**0.3855**	3.8776	0.0001
LOCAL05	**0.3597**	2.2374	0.0257
CONFES05	**0.2668**	2.3970	0.0169
R^2	0.06		
Adj. R^2	0.05		
σ^2	0.1729		
Durbin-Watson	2.0391		
Nobs	467		
Nvars	5		

NOTE: Bold indicates significant at a five percent level.

Table 7: Average number of neighboring municipalities with DIFTAR

	1998	1999	2000	2001	2002	2003	2004	2005
all	0.48	0.73	0.84	0.94	0.97	0.98	1.06	1.14
DIFTAR	1.42	2.11	2.25	2.29	2.39	2.34	2.43	2.46
no DIFTAR	0.38	0.47	0.54	0.60	0.60	0.61	0.67	0.72

Table 8: The estimation results

	Linear probability									Logit	Probit
	Non-spatial error			Spatial error						Non-spatial error	
				Contiguity		Province		Rural			
	No time		Time	No time	Time	No time	Time	No time	Time	No time	
β	0.3229*	0.3264*	0.2560*	0.2670*	0.1784*	0.2106*	0.1924*	0.2650*	0.2465*	3.4804*	2.0434*
	(11.49)	(11.62)	(8.35)	(9.68)	(5.92)	(7.07)	(6.34)	(9.49)	(8.64)	(6.51)	(6.79)
γ				0.0949*	0.1109*	0.5089*	0.4369*	0.5109*	0.3779*		
				(3.74)	(4.40)	(13.26)	(9.93)	(8.69)	(5.05)		
LEFT		−0.0104	0.0057	−0.0111	0.0042	−0.0071	−0.0009	−0.0033	0.0022	0.1949	0.1712
		(−0.38)	(0.21)	(−0.43)	(0.16)	(−0.28)	(−0.03)	(−0.13)	(0.08)	(0.21)	(0.31)
LOCAL		−0.0437	−0.0624*	−0.0493*	−0.0670*	−0.0513*	−0.0579*	−0.0533*	−0.0595*	0.3099	0.2541
		(−1.73)	(−2.45)	(−2.10)	(−2.85)	(−2.19)	(−2.47)	(−2.26)	(−2.52)	(0.41)	(0.57)
CONFES		0.0653*	0.0503	0.0663*	0.0529*	0.0676*	0.0616*	0.0571*	0.0522*	−0.0464	0.0485
		(2.38)	(1.83)	(2.62)	(2.09)	(2.66)	(2.42)	(2.25)	(2.06)	(−0.06)	(0.11)
HI		−0.0705	−0.0525	−0.0796	−0.0627	−0.0619	−0.0557	−0.0622	−0.0561	−1.8508	−1.1195
		(−1.44)	(−1.08)	(−1.76)	(−1.39)	(−1.37)	(−1.24)	(−1.38)	(−1.25)	(−1.88)	(−1.91)
logL				1803.8	1826.3	1837.1	1845.7	1820.4	1828.1	-214.0	-214.6
σ^2	0.0229	0.0228	0.0225	0.0194	0.0191	0.0188	0.0188	0.0191	0.0191		
R^2	0.0451	0.0519	0.0639	0.8796	0.8813	0.8830	0.8832	0.8811	0.8814	0.1616	0.1594

NOTE: t-statistics between parentheses. Asterisk indicates significant at a five percent level. Spatial error means spatially autocorrelated errors and time indicates a time fixed effect. For the non-linear probability models, McFadden's pseudo R^2 is used.

Table 9: The estimation results (corrected for size of neighboring municipalities)

	Linear probability									Logit	Probit
	Non-spatial error			Spatial error						Non-spatial error	
				Contiguity		Province		Rural			
	No time		Time	No time	Time	No time	Time	No time	Time	No time	
β	0.2579*	0.2614*	0.1934*	0.2159*	0.1393*	0.1479*	0.1377*	0.1980*	0.1863*	3.0877*	1.8063*
	(9.40)	(9.53)	(6.70)	(8.23)	(5.06)	(5.38)	(4.98)	(7.49)	(6.98)	(5.83)	(6.06)
γ				0.0649*	0.0769*	0.5549*	0.4649*	0.5819*	0.3989*		
				(3.18)	(3.78)	(15.95)	(11.11)	(11.58)	(5.52)		
LEFT		−0.0115	0.0088	−0.0123	0.0068	−0.0062	−0.0000	−0.0001	0.0050	−0.0134	0.0145
		(−0.41)	(0.31)	(−0.48)	(0.27)	(−0.24)	(−0.00)	(−0.00)	(0.19)	(−0.01)	(0.02)
LOCAL		−0.0360	−0.0610*	−0.0398	−0.0625*	−0.0487*	−0.0556*	−0.0510*	−0.0572*	0.3418	0.2432
		(−1.41)	(−2.39)	(−1.69)	(−2.65)	(−2.08)	(−2.37)	(−2.15)	(−2.41)	(0.46)	(0.55)
CONFES		0.0683*	0.0491	0.0686*	0.0514*	0.0708*	0.0642*	0.0566*	0.0518*	0.2101	0.1632
		(2.46)	(1.78)	(2.68)	(2.02)	(2.78)	(2.52)	(2.21)	(2.03)	(0.30)	(0.39)
HI		−0.0787	−0.0543	−0.0829	−0.0597	−0.0657	−0.0589	−0.0646	−0.0583	−1.9576*	−1.2123*
		(−1.60)	(−1.11)	(−1.82)	(−1.32)	(−1.46)	(−1.31)	(−1.43)	(−1.29)	(−2.02)	(−2.08)
logL				1777.9	1810.8	1829.6	1838.7	1807.4	1815.5	-219.8	-220.4
σ^2	0.0232	0.0231	0.0227	0.0197	0.0193	0.0189	0.0189	0.0193	0.0192		
R^2	0.0306	0.0362	0.0558	0.8776	0.8801	0.8827	0.8829	0.8803	0.8805	0.1387	0.1366

NOTE: t-statistics between parentheses. Asterisk indicates significant at a five percent level. Spatial error means spatially autocorrelated errors and time indicates a time fixed effect. For the non-linear probability models, McFadden's pseudo R^2 is used.