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**DOES COMMUTING CHANGE THE RANKING OF
ENVIRONMENTAL INSTRUMENTS?**

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Does Commuting Change the ranking of environmental instruments?

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Abstract

This paper studies the income effects of environmental policy in jurisdictions with a common labor market and a heterogeneous population (workers and polluters). A jurisdiction unilaterally improves its local environmental quality, using a subsidy, an environmental tax or command-and-control. In a closed economy, workers and polluters have some kind of a “natural ranking” of instruments for a given environmental objective. We find that commuting across jurisdictions may upset this “natural ranking” of environmental instruments. Further, we see that this inter-jurisdictional commuting exports pollution and the costs of environmental policy, possibly causing strategic behavior.

Keywords: Environmental Instrument Choice, Commuting, Interest Groups

JEL-classification: Q52, R23

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1. INTRODUCTION

This paper studies the ranking of environmental instruments by interest groups. In a closed economy, each interest group has some kind of a “natural ranking” of environmental instruments for a given environmental objective. For jurisdictions with a common labor market, we find that commuting may upset this “natural ranking”.

The model has n jurisdictions. Each jurisdiction has two interest groups, the workers and the asset owners (hereafter called polluters). A jurisdiction can improve its local environmental quality by choosing among three environmental instruments, i.e. a subsidy, a command-and-control and an environmental tax. In a closed economy, polluters “naturally” prefer a subsidy to a command-and-control and environmental tax, respectively. The workers, however, choose the opposite ranking. Similarly, the polluters prefer low asset taxes and high labor taxes to finance the public budget, whereas the workers choose high asset taxes and low labor taxes. We show that with a common labor market, inter-jurisdictional commuting may upset this “natural ranking”. Inter-jurisdictional commuting causes two leakages, exporting pollution and a part of the costs of environmental policy to the other jurisdictions.

This paper differs from the literature in four ways. First, we discuss a wider range of instruments compared to the literature on marginal environmental tax reforms (e.g. Bovenberg and Goulder, 1996; de Mooij, R.A. and Bovenberg, A.L., 1998). Second, the tax reform literature, typically, compares scenarios with identical changes in the environmental tax but different environmental effects. In de Mooij and Bovenberg (1998) the tax reform scenarios not only differ in non-environmental welfare effects, but also in environmental quality. This complicates comparison. This paper approaches the problem in the opposite way. We compare the instruments for an identical, exogenous environmental quality. Our approach is also more realistic from a policy point of view. Typically, decision makers first determine the environmental targets before thinking about the instruments to reach them. Moreover, the (minimum) environmental quality of lower-level jurisdictions is often decided by a higher-level government. The lower-level government merely can decide on how it will comply (e.g. environmental policy in EU and federal policy in US). Third, previous studies, comparing a wide range of alternative environmental instruments did not take into account the differential effects on interest groups (e.g. Goulder *et al.*, 1999; Bovenberg and Goulder, 2002). Several studies, however, stress

that the environment-economy trade-off often involves an intense conflict between interest groups¹. Finally, relatively few models in fiscal federalism authors have paid attention to commuting. Most models in fiscal federalism focus on capital and firm mobility. Oates and Schwab (1988) analyze the competition for mobile capital in presence of environmental quality and capital taxes. They conclude that jurisdictions tend to allow for too much pollution if only a source-based capital tax is available (race-to-the-bottom). In the model of Wellisch (1995), however, firms can move across the jurisdictions. The pollution rents are captured by firms, which are owned by non-residents. The residents bear the entire burden of the pollution and gain few benefits. He concludes that decentralized command-and-control regulation leads to environmental overprotection. Kuncze and Shogren (2005) combine the results of Oates and Schwab (1988) and Wellisch (1995). They also allow for non-resident ownership of polluting firms. They find, however, that local governments, facing fiscal constraints (and no Pigouvian or first-best fiscal instruments are available), adopt capital tax structures that exacerbate inefficiencies of decentralized command-and-control, reducing the overprotection and possibly even leading to a race-to-the-bottom. In these models, however, labor is considered as immobile. Braid (1996) studies the taxation decisions of suburban governments in a metropolitan area with a common labor market. Commuting takes the form of factor movement, i.e. jurisdictions compete for labor force. This approach differs from most commuting papers which focus on congestion or firm-worker matching on the labor market². Environmental policy in regions with a common labor market has not yet been analyzed.

Section 2 develops the model. Section 3 explains the welfare effects. We analyze the income effects in the reforming jurisdiction 1³ in section 4. Section 5 discusses the welfare effects for polluters and workers in the non-reforming jurisdiction 2. We illustrate the theoretical results in section 6 and conclude in section 7.

¹ An early paper investigating the role of interest groups on environmental policy is Buchanan and Tullock (1975). More recent contributions include, among many others, Gray and Shadbegian (2002), Fredriksson *et al.* (2005) and Anger *et al.* (2006)

² Papers analyzing congestion or labor market in presence of commuting include, among others, Anas and Xu (1999), Zenou (2000), De Borger and Van Dender (2003), Borck and Wrede (2005) and de Palma and Proost (forthcoming).

³ We denote the reforming jurisdiction as jurisdiction 1; whereas the $n-1$ non-reforming jurisdictions are represented by jurisdiction 2.

2. THE MODEL

2.1. *Structure of the model*

The model describes a metropolitan economy consisting of N jurisdictions in a world economy. Region 1 changes its environmental policy, whereas region 2 does not change anything. Each jurisdiction has four types of agents, namely firms, asset owners (hereafter called the polluters), workers and the local government. The model is medium-run static as we do not include growth or accumulation nor account for short run adjustments. Table 1 summarizes the model and the notation is defined at the end of the table. Appendix 1 log-linearizes the model around its initial equilibrium. A tilde ($\sim$) denotes a relative change⁴.

Firms

In each jurisdiction a representative firm describes firm behavior. The firms produce a single commodity, using labor and a natural asset as input. The neo-classical production function exhibits constant returns to scale with respect to its two inputs (2). The marginal productivity for a single production factor decreases. The output is traded on the world market for price 1. The firm maximizes profits (1), subject to the production function. Equations (3) and (4) are the implicit demand functions for labor and natural input.

Polluters

In each region the stock of natural asset is owned by a representative polluter. Interregional cross-ownership is absent. The natural asset is immobile and can be used as a production factor or left unused, contributing to the environmental quality (2 and 7). The first interpretation is that the polluters physically own the natural asset. They decide on the level of use (e.g. farmers own land and they decide on the area of cultivation and unspoilt forest and nature). A useful second interpretation is that the polluters do not own the natural asset but own the means to control the quality of this natural asset (e.g. a manufacturer does not own the air but controls its quality by adjusting the emissions of the factory's chimneys.). We normalize the asset endowment to unity (7). The polluter maximizes a homothetic utility function (5), subject to the budget constraint (6). This utility is a function of three variables: private consumption (CC_i),

⁴ Except for tax rates

environmental quality (N_i) and local public consumption (G_i). The budget constraint equals the after-tax returns of asset use $((1-T_{AS_i})R_iAS_i)$, minus the environmental tax payments (TE_iAS_i), plus the subsidy revenues (SUB_iN_i). In optimizing its utility, the polluter determines the level of asset use (AS_i). Higher asset use deteriorates environmental quality (N_i). The polluter trades off income to environmental quality. The representative polluter sets the private marginal utility of asset input equal to the private marginal utility of environmental quality. Equations (8) and (9) represent the implicit expressions for the supply of the natural asset as production input and polluter consumption demand, respectively.

Workers

The workers own all the labor time. We normalize the labor supply to unity (13). The worker maximizes a homothetic utility function (11), subject to the budget constraint (12). This budget constraint is equal to the after-tax labor income $((1-T_i^{LS})W_iLS_i)$. The worker may decide to commute, but he only benefits from the public consumption and environmental quality in his home region. Local public consumption and environmental quality are exogenous for a worker.

Regional Government

The local government has two roles. First, it supplies non-environmental public goods (G_i). Second, it is responsible for environmental policy. Four pre-existing taxes finance the local public consumption (16). On the labor side we find a source-based pay-roll tax (T_i^{LD}) and a residence-based labor income tax (T_i^{LS}). On the asset side we distinguish an asset demand tax (T_i^{AD}), on the use of the asset as production input, and a rent income tax (T_i^{AS}), on the asset returns. The local government has three instruments at its disposal for environmental policy: command-and-control, a subsidy for environmental protection (SUB_i) and an environmental tax (TE_i). We impose that the environmental policy must be budget neutral for the local government.

Table 1: The Model

<i>Firms</i>		
<i>Profits</i>	$Y_i - (1 + T_i^{LD})W_iLD_i - (1 + T_i^{AD})R_iAD_i = 0$	1
<i>Production Function</i>	$Y_i \leq f_i[LD_i, AD_i]$	2
<i>First-Order Conditions</i>	$\frac{\partial f_i}{\partial LD_i} = (1 + T_i^{LD})W_i$	3

		$\frac{\partial f_i}{\partial AD_i} = (1 + T_i^{AD})R_i$	4
<hr/> Households: Polluters			
Utility Function Polluter		$U_i^P = u_i^P[(CC_i, N_i), G_i]$	5
Household Budget Constraint Polluter		$CC_i = (1 - T_i^{AS})R_i AS_i - TE_i AS_i + SUB_i N_i$	6
Asset Supply		$AS_i + N_i = 1$	7
First-Order Conditions		$\frac{\partial u_i^P}{\partial N_i} = \lambda_i^P [(1 - T_i^{AS})R_i - TE_i - SUB_i]$	8
		$\frac{\partial u_i^P}{\partial CC_i} = \lambda_i^P$	9
Asset Market Clearance		$AS_i = AD_i$	10
<hr/> Households: Workers			
Utility Function Worker		$U_i^W = u_i^W[CL_i, N_i, G_i]$	11
Household Budget Constraint Worker		$CL_i = (1 - T_i^{LS})W_i LS_i$	12
Labor Supply		$LS_i = 1$	13
<hr/> Labor-market			
Metropolitan Labor-Market Equilibrium		$\sum_{i=1}^n LS_i = \sum_{i=1}^n LD_i$	14
Metropolitan Wage Equilibrium		$ W_i - W_1 \leq \text{Commuting Cost}$	15
<hr/> Regional Government			
Regional Government Budget Constraint		$G_i = T_i^{LD} W_i LD_i + T_i^{LS} W_i LS_i + T_i^{AD} R_i AD_i + T_i^{AS} R_i AS_i + TE_i AS_i - SUB_i N_i$	16
Metropolitan Walras Law		$\sum_{i=1}^n Y_i = \sum_{i=1}^n G_i + \sum_{i=1}^n CC_i + \sum_{i=1}^n CL_i + \text{Commuting Cost} \times \sum_{i=1}^n LD_i - LD_1 $	17
Y _i = Local Output	W _i = Local After-tax Wage	SUB _i = Environmental Subsidy	
LD _i = Local Labor Demand	R _i = Local After-tax Rent	TE _i = Environmental Tax	
LS _i = Local Labor Supply	CC _i = Local Polluter Income	T _i ^{LD} = Pay Roll Tax	
AD _i = Local Asset Demand	CL _i = Local Worker Income	T _i ^{LS} = Labor Income Tax	
AS _i = Local Asset Supply	G _i = Local Public Consumption	T _i ^{AD} = Ad-valorem Tax on Asset Demand	
LD _i = Local Labor Demand	λ _i = Marginal Utility of Polluter Income	T _i ^{AS} = Rent income Tax	
E _i = Local Environment			

Labor-market equilibrium, Environment, Walras Law

Labor demand may vary across jurisdictions and, workers may respond to it by commuting.

Equation (14) represents the equilibrium condition on the common labor market. Equation (15)

determines the relation between the wages across the jurisdictions. The commuting cost is the price the commuters have to pay to cross the regional borders for working⁵. This commuting cost is a loss for the metropolitan economy. If commuting cost is zero, the after-tax wage (W_i) is uniform across all regions. The total metropolitan output equals the sum of total local public consumption, the consumption of all polluters and workers and the commuting costs (17). There are no inter-regional environmental spill-overs.

3. WELFARE

In this section, we explain the policies between which the government of jurisdiction 1 can choose. Further, we decompose the income effects of environmental policy on the income of workers and polluters.

3.1. *Choice of Policy Scenarios*

In our analysis we compare 8 policy scenarios. These policy scenarios are a combination of the three environmental instruments with the four pre-existing taxes⁶. The policy scenarios are listed in Table 2 and Table 3. All policy scenarios have an identical environmental objective. Moreover, we impose that the local public consumption in jurisdiction 1 is kept at its initial level. Hence, the 8 policy scenarios only differ in their income effects for polluters and workers⁷.

The instruments and pre-existing taxes have different impacts on the income distribution. The polluters benefit from a subsidy but pay the environmental tax and prefer high labor taxes and low asset taxes. Obviously, the workers pursue the opposite. Sections 4 and 6 show that the polluters and workers have a kind of “natural ranking” of policy scenarios, if there is no inter-jurisdictional commuting.

This paper shows that commuting may upset this “natural ranking” of policy scenarios. Without commuting, both labor taxes are lump-sum transfers and their tax bases are the immobile resident workers. With commuting, however, the payroll tax and labor income tax have different distorting effects. The residence-based labor income tax is still non-distorting, whereas the

⁵ The most obvious commuting cost is the transport and time cost. But, more generally, the commuting cost can include any cost that is involved with inter-jurisdictional commuting (e.g. bureaucratic and legal costs, geographical obstacles, etc.)

⁶ Some of the 12 combinations are identical leading to 8 unique policy scenarios.

⁷ Similar analyses may be done with the focus on the labor-leisure choice. Here, the policies do not only differ in the income effect, but also in the amount of leisure that is chosen. This complicates the comparison of the policies.

burden of the source-based pay-roll tax falls on the labor demand. The payroll tax is distorting as higher payroll tax decreases labor demand. Both with and without commuting, the asset demand tax, the rent income tax and environmental tax have identical distorting effects. An increase of these taxes reduces the use of the asset.

3.2. *Income effects*

We distinguish four categories of income effects for polluters and workers, namely, the direct income effects, the instrument-specific income effects, the tax base erosion effects and the commuting effects. Table 2 and Table 3 arrange the decomposed income effects into three columns. Their first column represents the direct income effects. Both the instrument-specific instrument effects and the tax base erosion effects can be found in the second column. And, the third column reflects the commuting effects.

Direct Income Effects

The income of the polluters endures an asset use effect and a 1st substitution effect (Table 2). The former describes the income loss due a lower asset use. The latter reflects the accompanying increase of asset price due to scarcity. The only direct income effect for the workers is the 1st wage effect (Table 3). The wage drops as higher environmental quality reduces labor productivity.

Instrument-specific Effects

The choice for environmental tax or subsidy has important distributional consequences. An environmental tax generates tax revenues, while an environmental subsidy is a burden on the government budget. The government shifts the excess or deficit revenues to the interest groups by adjusting the pre-existing taxes⁸. Changing asset taxes has implications for the income of the polluters, whereas a change in labor taxes affects the workers.

Tax Base Erosion Effects of Environmental Policy

The tax bases for asset and labor taxes grow or erode. These changes can be both a physical erosion/growth and a “price” erosion/growth. The decline in asset use and outward commuting

⁸ Payroll tax (T^{LD}), labor income tax (T^{LS}), asset demand tax (T^{AD}), rent income tax (T^{AS})

are examples of physical erosion, whereas inward commuting leads to physical growth. The change in rents and wages cause a “price” erosion or growth of labor and asset taxes.

Commuting Effects

The environmental policy may cause commuting. In general commuting mitigates or exacerbates the previous direct income, tax erosion and instrument-related effects. The commuting elasticity (ε) links the environmental policy with the intensity and direction of commuting (18). This elasticity is a function of the commuting cost, the number of regions (N) and the policy scenario (19).

$$\widetilde{LD}_i = \varepsilon \widetilde{AS}_i \quad (18)$$

$$\varepsilon = \varepsilon(\text{Commuting Cost, N, Policy Scenario}) \quad (19)$$

$$\frac{\partial \varepsilon}{\partial \text{Commuting Cost}} < 0 \quad (20)$$

$$\frac{\partial \varepsilon}{\partial N} > 0 \quad (21)$$

$$\frac{\partial \varepsilon}{\partial TLD_i} > 0 \quad (22)$$

Higher commuting costs result in a lower elasticity and, hence, a lower intensity of commuting (20). Above a threshold value of commuting cost, commuting becomes zero ($\varepsilon=0$). Higher number of jurisdictions stimulates commuting (21). More jurisdictions generate more opportunities for the labor force. Finally, the elasticity also depends on the policy scenario. The asset taxes, labor income tax, environmental tax and subsidy are, given an environmental objective, non-distorting on the labor market. The pay-roll tax, however, is distorting. Equation (22) shows that a lower pay-roll tax alleviates outward commuting. Lowering the payroll tax may even reverse the direction of commuting, leading to inward commuting ($\varepsilon<0$).

4. INCOME AND OUTPUT EFFECTS IN JURISDICTION 1

We analyze the reduced-form coefficients for private income of polluters (Table 2) and workers (Table 3) in jurisdiction 1. Income effects depend on the general equilibrium price elasticities of

asset demand (Γ_A) and labor demand (Γ_L), the uncompensated elasticity of asset supply (η_u), income elasticity of asset supply (η_{inc}), the commuting elasticity (ϵ) and various shares of initial equilibrium (ω_A , ω_L , ω_{CC} and ω_{CL}).

4.1. Total Output in Jurisdiction 1

The local output is a function of asset use and labor use (23). In absence of commuting, output is identical for all policy scenarios. The choice for a policy scenario is an intra-regional zero-sum game between polluters and workers.

$$\tilde{Y} = \omega_A \widetilde{AS} + \omega_L \widetilde{LD} \quad 23$$

With commuting the scenario choice is not longer an intra-regional zero-sum game. The total output depends on commuting. The policy scenarios not only differ in income distribution across the workers and polluters, but also in total output.

4.2. Polluters in Jurisdiction 1

In Table 2 we decompose the income effect into the direct effect, instrument-related effects, the 1st tax erosion effects and commuting effects. The notation is defined at the end of Table 2.

The direct income effect is identical for all policy scenarios. It consists of an asset use effect and a first substitution effect, reflecting the lower asset use and price change of the asset.

Using an environmental tax or subsidy causes instrument-specific effects. A subsidy has a positive effect on the polluter's income (26), while the environmental tax causes a loss for the polluters (28). Equations (25) and (27), show a 1st asset erosion effect and a 1st labor tax erosion effect. The polluters pay for the foregone asset and labor tax revenues (or get excess tax revenues) through the asset taxes. In equation (25) the polluters finance their own subsidy.

Without commuting, the polluters have a "natural ranking" of the policy scenarios. They prefer the subsidy paid by higher labor taxes (26). On the second place, we find the command-and-control, where labor taxes pay for the erosion effects (24). On the third place, the polluters put the command-and-control or subsidy, where asset taxes pay for government deficit (25 and 27). On the last place, we find the environmental tax where the revenues are used to reduce the labor taxes (28).

In the third column the commuting effects alleviate or exacerbate the direct income effects, instrument-related effects and tax erosion effects. For all scenarios, outward commuting decreases the asset productivity and the 2nd substitution effect counteracts the asset price increase of the 1st substitution effect.

Three additional erosion effects appear in (25) and (27). First, the local government foregoes payroll tax revenues, as outward commuting erodes the payroll tax base. This 2nd labor tax erosion effect exacerbates the negative 1st labor tax erosion effect. Second, outward commuting alleviates the wage drop, preserving some labor tax revenues. This positive 3rd labor tax erosion counteracts the negative 1st and 2nd labor tax erosion effects. Third, the 2nd asset tax erosion effect is negative. The government foregoes more asset tax revenues as commuting reduces the asset productivity.

Table 2: Income of Polluters ($\widetilde{CC}$)

	Direct Income Effect	Instrument Effects and 1 st Tax Base Erosion Effects	Commuting Effects	
		$\widetilde{AS}$		
Scenario 1: Command-and-Control with T^{LS}	$\left(1 + \frac{\omega_L}{\Gamma_A}\right)$		$-\frac{\omega_L}{\Gamma_L} \varepsilon$	24
Scenario 2: Command-and-Control with T^{LD}	Asset Use (-) 1st Substitution (+)		2nd Substitution Effect (+ or -)	
Scenario 3: Command-and-Control with T^{AD} and T^{AS}	$\left(1 + \frac{\omega_L}{\Gamma_A}\right)$ Asset Use (-) 1st Substitution (+)	$+ \left[\begin{aligned} &\frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\omega_{CC}} \left(1 + \frac{\omega_L}{\Gamma_A}\right) \\ &\text{1st Asset Tax Erosion (+ or -)} \\ &-\frac{\omega_A}{\omega_{CC}} \left(\frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_A} \right) \\ &\text{1st Labour Tax Erosion (-)} \end{aligned} \right]$	$+ \left[\begin{aligned} &-\frac{\omega_L}{\Gamma_L} \\ &\text{2nd Substitution Effect (-)} \\ &+\frac{\omega_L\theta_{TLD}}{\omega_{CC}} + \frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_L} \\ &\text{2nd (-) and 3rd (+) Labour Tax Erosion} \\ &-\frac{\omega_{CL}}{\omega_{CC}} \frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\Gamma_L} \\ &\text{2nd Asset Tax Erosion (-)} \end{aligned} \right] \varepsilon$	25
Scenario 4: Subsidy with T^{LS}	$\left(1 + \frac{\omega_L}{\Gamma_A}\right)$ Asset Use (-)	$+ \left(\frac{N}{\eta_{inc} - AS\eta_u} \left(1 - \frac{\omega_L}{\Gamma_A} \eta_u\right) \right)$	$+ \left[\begin{aligned} &-\frac{\omega_L}{\Gamma_L} \\ &\text{2nd Substitution Effect (-)} \\ &+\frac{N}{\eta_{inc} - AS\eta_u} \frac{\omega_L}{\Gamma_L} \eta_u \\ &\text{2nd Subsidy Effect (-)} \end{aligned} \right] \varepsilon$	26
Scenario 5: Subsidy with T^{LD}	1st Substitution (+)			

Scenario 6:
Subsidy with
 T^{AD} and T^{AS}

$$\left(1 + \frac{\omega_L}{\Gamma_A}\right)$$

Asset Use (-)

1st Substitution (+)

$$+ \left[\begin{array}{l} \frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\omega_{CC}} \left(1 + \frac{\omega_L}{\Gamma_A}\right) \\ \text{1st Asset Tax Erosion (+ or -)} \\ - \frac{\omega_A}{\omega_{CC}} \left(\frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_A} \right) \\ \text{1st Labour Tax Erosion (-)} \end{array} \right]$$

$$+ \left[\begin{array}{l} -\frac{\omega_L}{\Gamma_L} \\ \text{2nd Substitution Effect (-)} \\ + \frac{\omega_L\theta_{TLD} + \omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\omega_{CC} \Gamma_L} \\ \text{2nd (-) and 3rd (+) Labour Tax Erosion} \\ - \frac{\omega_{CL}}{\omega_{CC}} \frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\Gamma_L} \\ \text{2nd Asset Tax Erosion (-)} \end{array} \right] \varepsilon \quad 27$$

Scenario 7:
Environmental
Tax with T^{LS}

$$\left(1 + \frac{\omega_L}{\Gamma_A}\right)$$

Asset Use (-)

1st Substitution (+)

$$+ \frac{1}{\eta_u} \left(1 - \frac{\omega_L}{\Gamma_A} \eta_u\right)$$

1st Environmental Tax effect (-)

28

Scenario 8:
Environmental
Tax with T^{LD}

Parameters

η_{un} = uncompensated elasticity of asset supply

η_{inc} = income elasticity of asset supply

ε_{ij} = uncompensated direct or indirect price elasticity of factor i with respect to price j ($i, j = AD, LD$)

General Equilibrium Price Elasticities

$$\Gamma_A = \varepsilon_{AA} - \frac{\omega_A}{\omega_L} \varepsilon_{AL} \quad \Gamma_L = \varepsilon_{LL} - \frac{\omega_L}{\omega_A} \varepsilon_{LA} \quad \Gamma_A = \Gamma_L$$

Taxes

$$\widehat{TAS}_i = \frac{dTAS_i}{1 - TAS_i}; \quad \widehat{TAD}_i = \frac{dTAD_i}{1 + TAD_i}; \quad \widehat{TLS}_i = \frac{dTLS_i}{1 - TLS_i}; \quad \widehat{TLD}_i = \frac{dTLD_i}{1 + TLD_i};$$

$$\theta_i^{TAS} = \frac{TAS_i}{1 - TAS_i}; \quad \theta_i^{TAD} = \frac{TAD_i}{1 + TAD_i}; \quad \theta_i^{TLS} = \frac{TLS_i}{1 - TLS_i}; \quad \theta_i^{TLD} = \frac{TLD_i}{1 + TLD_i};$$

Instruments: Environmental Subsidy and Environmental Tax

$$\widehat{SUB}_i = \frac{dSUB_i}{1 + SUB_i}; \quad \widehat{TE}_i = \frac{dTE_i}{1 + TE_i};$$

Shares

$$\omega_i^{CC} = \frac{CC_i}{Y_i}; \quad \omega_i^{CL} = \frac{CL_i}{Y_i}; \quad \omega_i^G = \frac{G_i}{Y_i}; \quad \omega_i^L = \frac{(1 + T_i^{LD})W_iLD_i}{Y_i}; \quad \omega_i^A = \frac{(1 + T_i^{AD})R_iAD_i}{Y_i};$$

In equation (26) the 2nd subsidy effect counteracts the positive 1st subsidy effect. Outward commuting decreases the asset productivity and, hence, reduces the subsidy level and polluter's income. Interestingly, commuting does not change the polluter's income in (28). The 2nd environmental tax effect neutralizes the 2nd substitution effect. Commuting, however, has an effect on the level of environmental tax rate. Figure 1 explains these results. The horizontal axis of Figure 1 represents the asset use and unspoiled environment. The polluter benefits from the marginal productivity of the asset (MPA). The marginal private utility of unspoiled environment is represented by MPUE.

Initially, the use of natural asset is AS_{IN} , where MPA crosses MPUE. Jurisdiction 1 uses environmental taxes to reduce the asset use to AS_{NEW} . As the asset input becomes scarcer, the

marginal productivity increases. Environment, however, is more abundant and its marginal utility decreases. The government taxes away the gap between the marginal asset productivity and the marginal environmental utility (TE). The shaded area represents the polluter's income $((MPA_{NEW} - TE) \times AS_{NEW})$. With inward commuting, there is an upward shift as more labor force raises marginal asset productivity (MPA'). Outward commuting causes a downward shift of marginal asset productivity (MPA^*). Commuting does not affect MPUE. The upward shift of MPA' leads to higher environmental taxes (TE'), while the downward shift of MPA^* reduces these environmental taxes (TE^*). The income of the polluter, however, remains equal to $(MPA_{NEW} - TE) \times AS_{NEW}$. This is consistent with equation (28). From the same reasoning, it is straight-forward to understand that inward commuting increases the subsidy rate, while outward commuting presses down the subsidy rate.

4.3. Workers in Jurisdiction 1

In Table 3 we decompose the change in workers' income into four categories of effects: the direct effect on the worker's income, the instrument-related effects, the 1st tax erosion effects and the commuting effects.

Higher environmental objectives reduce the wage and the first wage effect is unambiguously negative. Obviously, the subsidy has a negative effect on the workers' income (31), whereas the environmental tax increase the worker's income (33). Using labor taxes to keep initial public consumption constant, we find the (positive or negative) 1st asset tax erosion effect and the (negative) 1st labor tax erosion effect (29 and 31).

Without commuting, the workers have a "natural ranking" of the policy scenarios. They prefer that the environmental tax revenues are used to reduce the labor taxes (33). On the second place, the workers put the command-and-control or subsidy whit asset taxes paying for the budget deficit (30 and 32). On the third place, we find the command-and-control, where labor taxes pay for the erosion effects (29). On the last place, we find the subsidy paid by higher labor taxes (31). Obviously, the natural ranking is the opposite of its counterpart for the polluters, if there is no inter-jurisdictional commuting.

Table 3: Income of Workers ($\widehat{CL}$)

Direct Income Effect		Instrument Effects and 1 st Tax Base Erosion Effects		Commuting Effects		
		$\widetilde{AS}$				
Scenario 1: Command-and-Control with T^{LS}	$-\frac{\omega_A}{\Gamma_A}$	+	$\left[\begin{array}{l} \frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\omega_{CL}} \left(1 + \frac{\omega_L}{\Gamma_A} \right) \\ \text{1st Asset Tax Erosion (+ or -)} \\ -\frac{\omega_A}{\omega_{CL}} \left(\frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_A} \right) \\ \text{1st Labour Tax Erosion (-)} \end{array} \right]$	+	$\left(\begin{array}{l} \frac{\omega_A}{\Gamma_L} \\ \text{2nd Wage Effect (+)} \\ -\frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\Gamma_L} \\ \text{2nd Asset Tax Erosion Effect (-)} \\ +\frac{\omega_L}{\omega_{CL}}\theta_{TLD} + \frac{\omega_{CC}}{\omega_{CL}}\frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_L} \\ \text{2nd (-) and 3rd (+) Labour Tax Erosion} \end{array} \right) \varepsilon$	29
Scenario 2: Command-and-Control with T^{LD}	1st Wage Effect (-)					
Scenario 3: Command-and-Control with T^{AD} and T^{AS}	$-\frac{\omega_A}{\Gamma_A}$ 1st Wage Effect (-)			$+\frac{\omega_A}{\Gamma_L} \varepsilon$ 2nd Wage Effect (+)	30	

Scenario 4: Subsidy with T^{LS} Scenario 5: Subsidy with T^{LD}	$-\frac{\omega_A}{\Gamma_A}$ 1st Wage Effect (-)	$+ \left[\begin{aligned} &\frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\omega_{CL}} \left(1 + \frac{\omega_L}{\Gamma_A} \right) \\ &\text{1st Asset Tax Erosion (+ or -)} \\ &-\frac{\omega_A}{\omega_{CL}} \left(\frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_A} \right) \\ &\text{1st Labour Tax Erosion (-)} \\ &-\frac{\omega_{CC}}{\omega_{CL}} \frac{N}{\eta_{inc} - AS\eta_u} \left(1 - \frac{\omega_L}{\Gamma_A} \eta_u \right) \\ &\text{1st Subsidy Effect (-)} \end{aligned} \right]$	$+ \left(\begin{aligned} &\frac{\omega_A}{\Gamma_L} \\ &\text{2nd Wage Effect (+)} \\ &-\frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\Gamma_L} \\ &\text{2nd Asset Tax Erosion Effect (-)} \\ &+ \frac{\omega_L}{\omega_{CL}} \theta_{TLD} + \frac{\omega_{CC}}{\omega_{CL}} \frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_L} \\ &\text{2nd (-) and 3rd (+) Labour Tax Erosion} \\ &-\frac{N}{\eta_{inc} - AS\eta_u} \frac{\omega_{CC}}{\omega_{CL}} \frac{\omega_L\eta_u}{\Gamma_L} \\ &\text{2nd Subsidy Effect (+)} \end{aligned} \right) \varepsilon$	31
Scenario 6: Subsidy with T^{AD} and T^{AS}	$-\frac{\omega_A}{\Gamma_A}$ 1st Wage Effect (-)		$+ \frac{\omega_A}{\Gamma_L} \varepsilon$ 2nd Wage Effect (+)	32
Scenario 7: Environmental Tax with T^{LS} Scenario 8: Environmental Tax with T^{LD}	$-\frac{\omega_A}{\Gamma_A}$ 1st Wage Effect (-)	$+ \left[\begin{aligned} &\frac{\omega_{CC}\theta_{TAS} + \omega_A\theta_{TAD}}{\omega_{CL}} \left(1 + \frac{\omega_L}{\Gamma_A} \right) \\ &\text{1st Asset Tax Erosion (+ or -)} \\ &-\frac{\omega_A}{\omega_{CL}} \left(\frac{\omega_{CL}\theta_{TLS} + \omega_L\theta_{TLD}}{\Gamma_A} \right) \\ &\text{1st Labour Tax Erosion (-)} \\ &-\frac{\omega_{CC}}{\omega_{CL}} \frac{1}{\eta_u} \left(1 - \frac{\omega_L}{\Gamma_A} \eta_u \right) \\ &\text{1st Environmental Tax Effect (+)} \end{aligned} \right]$	$+ \left(\frac{\omega_L}{\omega_{CL}} \theta_{TLD} \right) \varepsilon$ 2nd Labour Tax Erosion (-/+)	33

The commuting effects alleviate or exacerbate the direct income, instrument-related or tax base erosion effects. Outward commuting generates a positive 2nd wage effect, expressing that it alleviates the wage drop of the negative 1st wage effect. The 2nd labor tax erosion effect is negative as the tax base of the payroll tax erodes. Outward commuting reduces the subsidy level, reducing the burden on the tax-paying workers. This positive 2nd subsidy effect counteracts the negative 1st subsidy effect. Similarly, outward commuting reduces the level of environmental tax. Hence, the workers receive less excess tax revenues and the 2nd environmental tax effect is negative. In equation (33) the 2nd environmental tax effect neutralizes the 2nd wage effect, the 2nd asset tax erosion effect and the 3rd labor tax erosion effect.

5. WELFARE IN JURISDICTIONS 2

With a common labor market, the unilateral environmental policy of a region influences private income, public consumption and environmental quality in the non-reforming jurisdictions 2. We find that inter-jurisdictional commuting causes two types of leakage, the export of pollution and

the export of a part of the costs of environmental policy. Outward commuting decreases the after-tax wage in jurisdiction 2, but mitigates the wage drop in jurisdiction 1. The workers of jurisdiction 1 export a part of the burden of environmental policy to their colleagues in jurisdiction 2. Moreover, outward commuting boosts asset use in jurisdiction 2. Jurisdiction 1 partially exports its pollution. The polluters in jurisdiction 2 benefit from the higher asset use, but the environment in jurisdiction 2 deteriorates. The workers suffer both from lower wages and a worse environmental quality. The change of public consumption in jurisdiction 2 is ambiguous and depends on the pre-existing taxes.

A lower payroll tax often induces inward commuting in region 1, mitigating the increase of after-tax wage in region 1. The workers in region 1 export a part of their non-environmental benefit to their counterparts in jurisdiction 2. Moreover, the environmental quality in jurisdiction 2 improves. The effect on the government budget is, again, ambiguous. The workers in jurisdiction 2 benefit from higher income and better environmental quality. The polluters in jurisdiction 2 trade off lower private income, public consumption and better environment.

The intensity and direction of commuting depends on the commuting cost, the number of jurisdictions and the policy scenario. If there is no commuting (i.e. commuting cost too high), the environmental policy in jurisdiction 1 does not affect jurisdiction 2.

6. SIMULATIONS

We illustrate the theoretical results for a model with two identical regions ($N=2$). In the simulation jurisdiction 1 improves its initial environmental quality with 5%. First, we describe the relation between commuting and commuting cost. Second, we discuss the effect of commuting on the private income of polluters and workers in jurisdiction 1. The commuting cost and commuting are expressed as a ratio of the initial after-tax wage and the resident worker population, respectively. We use the same calibration parameter for both regions (Table 5).

General Equilibrium Elasticities

The key of Table 2 represents the general equilibrium price elasticities. Γ_A is the elasticity of asset demand. It measures the consequences for the asset demand/output ratio due to two price changes, namely, the price change for the asset (measured by ε_{AA}) and, the change in

labor price (ϵ_{AL}). Similarly, Γ_L , expresses the effect on the labor demand/output ratio due to labor price (ϵ_{LL}) and asset price change (ϵ_{LA}).

The shares in the model roughly correspond to most Western European economies (de Mooij and Bovenberg, 1998). They are characterized by a large share of labor income in GDP and large initial labor taxes compared to environmental and fixed capital taxes. The labor taxes on the before-tax basis count for 50%. The asset taxes on a before-tax basis are set to one third. The price elasticity is conditional on output. Simulations with other targets have similar results, if the uncompensated elasticity, η_{un} , and the income elasticity, η_{inc} , are positive and negative, respectively. In Appendix 3, Table 6 gives the numerical results of the income effects without commuting and with commuting at zero commuting cost.

Relation Commuting and Commuting Cost

Figure 2 describes the inverse relation between the commuting cost and commuting. The scenarios using the non-distorting asset or labor income taxes (i.e. scenarios 1, 3, 4, 6 and 7) have identical commuting/commuting cost relations. With zero commuting cost, 2.23% of workers commute.

Increasing the distorting payroll tax for balancing the government budget (Scenarios 2 and 5) boosts commuting. With zero commuting cost, the outward commuting is 7.41% and 11.43% for scenarios 2 and 5, respectively. Scenario 8 uses the excess tax revenues to cut the distorting payroll tax, causing inward commuting. With zero commuting cost, commuters raise the labor force in region 1 with 28.78%.

On the horizontal axis in Figure 2, we observe that the scenarios differ in the commuting cost/wage ratio, above which no commuting can be observed (the threshold value). This threshold value expresses the wage gap between the two jurisdictions, if commuting were not allowed. Higher environmental targets increase both the intensity of commuting and threshold value. A higher number of identical regions ($N > 2$), however, only boosts intensity, keeping the threshold value constant.

Relation Polluter's Income and Commuting Cost in Reforming Region

Figure 3 represents the relation between polluter's income and commuting cost in jurisdiction 1. Without commuting the natural ranking of the polluter is, successively, the income increase of a subsidy with labor taxes, command-and-control with labor taxes, a subsidy or command-and-

control with asset taxes and an environmental tax with labor taxes. Commuting, however, upsets the instrument ranking of polluters. Scenario 5 falls from the first position (without commuting) to the last position but one (with zero commuting cost). Scenario 2 shows a similar but more moderate effect. Increasing the distorting payroll tax induces a high intensity of outward commuting, deteriorating the polluter's income. Consistent with Figure 1, commuting has no effect when environmental taxes are used (scenarios 7 and 8).

Relation Worker's Income and Commuting Cost in Reforming Region

Figure 4 relates the worker's income with the commuting costs in jurisdiction 1. The "natural ranking" of the workers is an environmental tax to a command-and-control with asset taxes, a command-and-control with labor taxes and a subsidy with labor taxes, respectively. Outward commuting exports a part of the costs or benefits of environmental policy to jurisdiction 2. Environmental policy may even increase the worker's income if environmental taxes are used (scenario 7 and 8). Here outward commuting reduces the income of workers, as they forego the payroll taxes paid by the commuters. In scenario 8, inward commuting raises worker's income as more payroll taxes are paid. The non-linear behavior of scenario 8, a kind of a "Laffer effect", combining the influence of the payroll tax and commuting cost on the commuting elasticity, ϵ (20 and 22).

Figure 2: Relation Commuting and Commuting Cost

Figure 3: Relation Polluter's Income and Commuting Cost

Figure 4: Relation Worker's Income and Commuting Cost

7. CONCLUSIONS

In environmental policy decision makers often care more about the effects for particular interest groups, rather than the optimal environmental quality and overall efficiency. One way they protect their supporters is by influencing the instrument choice, as this implicitly determines the distribution of burden and gains. In a closed economy, workers and polluters have some kind of a “natural ranking” of instruments for a given environmental objective. The instrument turns out to be a zero-sum game between the interest groups. We show that inter-jurisdictional commuting may upset this “natural ranking” of instruments. Moreover, commuting causes two leakages. It may export pollution and a part of the costs of environmental policy to the other jurisdictions.

For a given environmental objective, the policy scenarios may show different intensities of commuting. Commuting typically decreases the polluter's income and polluters are worse off with policy scenarios inducing higher payroll taxes and a lot of outward commuting. This

commuting may turn upside down the “natural ranking” of instruments. With commuting, we may get the paradox that polluters are worse off with a subsidy (financed by higher payroll taxes) than with a command-and-control (combined with higher asset taxes). Politicians backing the polluters may choose policy scenarios inducing low commuting levels or consider accompanying measures limiting outward commuting (i.e. increasing commuting costs). These measures may include taxing outward commuting (e.g. toll and high transport costs or a genuine tax) or reducing the distorting payroll tax (and increasing e.g. the labor income tax).

On the worker’s side, commuting mitigates the positive or negative income effects of environmental policy.

Commuting not only affects the reforming region, but also the other regions. Environmental policy in one jurisdiction changes the wages in all jurisdictions. Commuting exports a part of the non-environmental costs of environmental policy to the other jurisdictions. Moreover, the inflow of labor boosts the asset use and deteriorates their environmental quality in the non-reforming jurisdictions. One can say that commuting exports pollution.

These two leakages may lead to strategic interactions. Saveyn (2006) considers a metropolitan area where residents can commute between several jurisdictions. They try to preserve their living quality by pushing the polluting economic activity to the neighboring jurisdictions and keep their labor income as commuters. This induces a race-to-the-top/NIMBY behavior (Not-In-My-Backyard) among jurisdictions.

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10. APPENDIX 1: LINEARIZATION

To analyze the welfare effects of the environmental policy reforms, we log-linearize the model around its initial equilibrium. The log-linearized model is represented in Table 4. At the end of the table we define the notation. The supply of local public consumption (G_i) is fixed ($\widetilde{G}_i=0$).

Factor Demand Relations

We use the same model for the three environmental instruments. All three instruments achieve the same environmental quality. The three environmental policy instruments are environmental tax, environmental subsidy and command-and-control⁹. Equations (35) and (36) represent the factor demand equations for natural asset and labor. In this initial equilibrium, the environmental tax and subsidy are set 0 ($SUB_i=TE_i=0$). The elasticities, ε_{ij} , ($i,j =AD,LD$) represent the (cross) price elasticities of factor demand conditional on local output. Equation 37 expresses the non-profit condition. Equations 38 and 45 represent the respective polluter income and government budget constraint for the three model versions.

Asset Supply

With a Command-and-Control the level of asset use is exogenously set (39). Equations 40 and 41 represent the labor supply for respectively subsidy and environmental tax. We assume the uncompensated elasticity, η_{un} , is positive or negative. The income elasticity, η_{inc} , is unambiguously negative.

⁹ In this model the Command-and-Control policy is equivalent to grandfathered Emission rights.

Table 4: Linearized Model

<i>Firms</i>		
Domestic Output	$\widetilde{Y}_i = \omega_i^A \widetilde{AD}_i + \omega_i^L \widetilde{LD}_i$	34
Asset Demand	$\widetilde{AD}_i = \widetilde{Y}_i + \varepsilon_{AA}(\widetilde{R}_i + \widetilde{TAD}_i) + \varepsilon_{AL}(\widetilde{W}_i + \widetilde{TLD}_i)$	35
Labor Demand	$\widetilde{LD}_i = \widetilde{Y}_i + \varepsilon_{LA}(\widetilde{R}_i + \widetilde{TAD}_i) + \varepsilon_{LL}(\widetilde{W}_i + \widetilde{TLD}_i)$	36
Non-Profit Condition	$0 = \omega_i^A(\widetilde{R}_i + \widetilde{TAD}_i) + \omega_i^L(\widetilde{W}_i + \widetilde{TLD}_i)$	37
<i>Polluters</i>		
Polluter Income	$\widetilde{CC}_i = \widetilde{AS}_i + \widetilde{R}_i - \widetilde{TAS}_i + \frac{N_i}{CC_i} \widetilde{SUB}_i - \frac{AS_i}{CC_i} \widetilde{TE}_i$	38
<i>Asset Supply</i>		
Command-and-Control	$\widetilde{AS}_i = \text{Constant}$	39
Subsidy	$\widetilde{AS}_i = \eta_{un}(\widetilde{R}_i - \widetilde{TAS}_i) + \frac{\eta_{inc} - \widetilde{AS}_i \eta_{un}}{CC_i} \widetilde{SUB}_i$	40
Environmental Tax	$\widetilde{AS}_i = \eta_{un}(\widetilde{R}_i - \widetilde{TAS}_i - \frac{AS_i}{CC_i} \widetilde{TE}_i)$	41
<i>Workers</i>		
Labor income	$\widetilde{CL}_i = \widetilde{LS}_i + \widetilde{W}_i - \widetilde{TLS}_i$	42
Labor supply	$\widetilde{LS}_i = 0$	43
Labor-Market Equilibrium	$\sum_{i=1}^N \alpha_i^{LD} \widetilde{LD}_i = 0$	44
<i>Regional Government</i>		
Government Budget Constraint	$\begin{aligned} \widetilde{G}_i = & \frac{\omega_i^{CC}}{\omega_i^G} (\theta_i^{TAS} \widetilde{AS}_i + \theta_i^{TAS} \widetilde{R}_i + \widetilde{TAS}_i) + \frac{\omega_i^A}{\omega_i^G} (\theta_i^{TAD} \widetilde{AD}_i + \theta_i^{TAD} \widetilde{R}_i + \widetilde{TAD}_i) \\ & + \frac{\omega_i^{CL}}{\omega_i^G} (\theta_i^{TLS} \widetilde{LS}_i + \theta_i^{TLS} \widetilde{W}_i + \widetilde{TLS}_i) + \frac{\omega_i^L}{\omega_i^G} (\theta_i^{TLD} \widetilde{LD}_i + \theta_i^{TLD} \widetilde{W}_i + \widetilde{TLD}_i) \\ & - \frac{N_i}{G_i} \widetilde{SUB}_i + \frac{AS_i}{G_i} \widetilde{TE}_i \end{aligned}$	45
Environmental Quality	$\alpha_i^{AS} \widetilde{AS}_i + \alpha_i^N \widetilde{N}_i = 0$	46
<i>Shares</i>		
$\alpha_i^{AS} = \frac{AS_i}{AS_i + N_i}; \quad \alpha_i^N = \frac{N_i}{AS_i + N_i}; \quad \alpha_i^{LD} = \frac{LD_i}{\sum_{i=1}^I LS_i}$		
<i>Relations between Taxes and Shares</i>		
$\omega_i^A = \omega_i^{CC} + \omega_i^{CC} \theta_i^{TAS} + \omega_i^A \theta_i^{TAD} \quad \omega_i^G = \omega_i^{CC} \theta_i^{TAS} + \omega_i^A \theta_i^{TAD} + \omega_i^{CL} \theta_i^{TLS} + \omega_i^L \theta_i^{TLD}$		
$\omega_i^L = \omega_i^{CL} + \omega_i^{CL} \theta_i^{TLS} + \omega_i^L \theta_i^{TLD} \quad \omega_i^A + \omega_i^L = \omega_i^{CC} + \omega_i^{CL} + \omega_i^G = 1$		

General Equilibrium Elasticities

The key of Table 2 represents the General Equilibrium Elasticities. Γ_A is the elasticity of Asset Demand. It measures the consequences for the Asset Demand/Output ratio due to two price changes, namely, the price change for the asset (measured by ε_{AA}) and, the change in labor price (ε_{AL}). Similarly, Γ_L , expresses the effect on the Labor Demand/Output ratio due to labor price (ε_{LL}) and asset price change (ε_{LA}).

11. APPENDIX2:CALIBRATION PARAMETERS IN SIMULATIONS

Table 5: Calibration Parameters

Shares		Elasticities conditional on output		Asset Supply Elasticities
$\omega_L = 0.6$	$T^{LS} = 0.4$	$\varepsilon_{AA} = -0.48$	$\varepsilon_{LL} = -0.32$	$\eta_{un} = 0.3$
$\omega_A = 0.4$	$T^{LD} = 0.2$	$\varepsilon_{AL} = 0.48$	$\varepsilon_{LA} = 0.32$	$\eta_{inc} < 0$
$\omega_G = 0.45$	$T^{AS} = 0.17$			
	$T^{AD} = 0.25$			

12. APPENDIX 3: INCOME EFFECTS FOR POLLUTERS AND WORKERS

Table 6: Income of polluters and workers with and without commuting

	Polluters		Workers	
	No Commuting	Costless Commuting	No Commuting	Costless Commuting
Scenario 1	-0.51%	-2.46%	-3.23%	-2.86%
Scenario 2	-0.51%	-7.02%	-3.23%	-2.30%
Scenario 3	-3.51%	-6.27%	-1.54%	-0.71%
Scenario 4	3.57%	1.26%	-5.53%	-4.95%
Scenario 5	3.57%	-8.29%	-5.53%	-3.48%
Scenario 6	-3.51%	-6.27%	-1.54%	-0.71%
Scenario 7	-25.29%	-25.29%	10.71%	9.99%
Scenario 8	-25.29%	-25.29%	10.71%	11.27%

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