Taxation, Time Allocation and Externalities

Jens Erik Nielsen*
Danish Transport Research Institute
and
University of Copenhagen

Ninette Pilegaard
Danish Transport Research Institute

September 2004
Preliminary work
Do not quote

Abstract

The approach introduced by Becker (1965) is used to derive a formula for the optimal tax policy when externalities are present. The same was done in Kleven (2004) in the case without externalities. Kleven concluded that goods which saves time should carry a lower tax than other types of goods which in the case of transport implies that sports cars should be taxed at a lower rate than slower cars. The present paper derives formulas for optimal tax rules having the result by Kleven as a special case. Furthermore the additivity property derived by Sandmo (1975), The Ramsey rule and the inverse elasticity formula also emerges. The paper also introduces welfare considerations into the tax formulas by allowing different households to have differents weights in the social welfare function.
Keywords: Taxation, Externalities, Household Production, Time Allocation
JEL Classifications:

*This paper has benefittet from the Marie Curie Program which allowed me to visit LMU in Munich.

1 Introduction

In many cities problems related to traffic congestion are increasing. As a result the politicians wish to regulate the traffic. It is therefore important to choose the right instruments so that the goals set up by the politicians are realized. Should one system be implemented or can other instruments achieve the same at lower costs? What problem is the instrument designed to address? Can a given instrument be used to generate public revenue? Are the chosen instruments politically feasible and how do they interact with the rest of the economy?

Often the concept of marginal cost pricing is mentioned as a way to internalize the external costs of transport and thereby induce an optimal usage of the transport infrastructure. But if a tax instrument is to be used it is important to know how the optimal tax scheme is to be designed. It is also important to know how people react to a given tax instrument and how this influences other parts of the economy.

In the theory of optimal taxation characterizations of the optimal tax scheme have been derived in different situations. Some of the best-known results are the Ramsey rule [Ramsey (1927)], the Colett-Hague result [Corlett and Hague (1954)] and the inverse elasticity rule (see for example [Auerbach and Hines (2002)] and [Sandmo (1976)]). One general conclusion from these rules are that the tax system should be constructed such that the distortions to the economy is minimized. Note that no distortion does not mean no effect on demand. Introducing taxes even in a lump sum way would introduce changes in the economy through the income effects. The point is that the substitution effects should be minimized. The reason for this is that when some goods are taxed and other goods are not the consumers change their consumption behavior away from the first best and this problem is at the core

of the discussion of the taxation of labor income. When the tax raises the relative price of work and lowers the price of leisure it induces lower work participation and higher demand for leisure. This problem is essentially what is dealt with in [Kleven (2004)]. He demonstrates that the inverse elasticity rule also emerges in the Becker setup though in a modified form named the inverse factor share rule. This rule states that commodities, which reduce time consumption in household production, should be taxed less than other goods. The reason for this is that by making more time available by taxing time consuming activities the consumers will respond by working more and therefore reduce the distortion caused by the income tax. In the case of cars this would indicate that fast cars (sport cars) should be taxed less because they increase the time savings involved in transport. Kleven points out though that the conclusion might not be so robust if externalities are included which is the case considered in the present paper.

Another result from tax theory deals with taxation as a way to internalize externalities referring to these as Marginal Cost Pricing or Pigouvian Taxation [Pigou (1920)]. The idea behind these taxes is that the externality comes from a misspecification of the price of the good in question and by imposing the right tax on the good the price failure can be corrected thereby internalizing the externality. A Pigouvian tax may seem very simple when looked upon in a world where the only goal is to internalize externalities. The presence of other taxes and the fact that the governments in general have to raise revenue to function complicates the problem. One must remember though that it is all the taxes in the economy that make up the tax system. It is therefore interesting to characterize the optimal tax system when externalities are present and the government has to raise revenue.

This approach was taken by Sandmo [Sandmo (1975)] in the standard model for optimal taxation. Based on his analyses one could state that only the actions and goods that cause externalities should be subject to extra taxation. This is known as the additivity property or the "principle of targeting". A similar result emerges here when externalities are included.

This paper will use the approach introduced by [Becker (1965)] representing time explicitly in the utility function to derive formulas that describes the optimal tax rules in the presence of externalities thereby extending the results found in [Kleven (2004)]. The extension makes the results found by Kleven less clear and emphasizes how externalities can be incorporated into the setup. Section 2 will present the model and derive a characterization for the optimal tax system. The generalization of this characterization makes it difficult to get clear-cut rules about the design of the tax system and section 3 therefore derives results, which gives more intuition. The final section concludes

2 The model

We assume that there are $N+1$ commodities and H households in the economy. Each household has a utility function given by

$$U_h = U_h(Z_h^0, Z_h^1, ..., Z_h^N) - \phi(\bar{Z}^N), \quad h = 1, ..., H \tag{1}$$

where $\bar{Z}^N = \sum_{h=1}^{H} Z_h^N$ is the total consumption of good N in the economy and $Z_h^i = f^i(X_h^i, L_h^i)$, $i = 0, ..., N$ represents the way good Z_h^i is being produced in household h using one market good X_h^i, time L_h^i and production technology f^i. We assume the production technology to be Leontieff and that every household uses the same technology in the production of Z^i. Intuitively this means that if a household

wants to see a movie at a cinema they have to allocate the time required to see the movie and they have to purchase movie tickets. One could argue that more than one market good could be required in the production which would result in X being a vector of these market goods, but to keep things as simple as possible we here assume that only one market good goes into the production of every consumption good. The function $\phi(\cdot)$ is assumed to be increasing in $\bar{Z}^N$. As a result the total consumption of good N decreases the utility of the households.

Assuming that the number of households H is large we make the standard assumption that the individual household behaves as if $\frac{\partial \bar{Z}^N}{\partial Z_h^N} = 0$ which means that the household may realize that it affects the total consumption of good N but regards its contribution as insignificant. Using this we can now formulate the optimization problem for household h as

$$\begin{aligned} \max_{\{X_h^i\}_{i=0}^N \{L_h^i\}_{i=0}^N} \quad & U_h(f_h^0(X_h^0, L_h^0), \quad f_h^1(X_h^1, L_h^1), ..., \ f_h^N(X_h^N, L_h^N)) \\ s.t. \quad & \sum_{i=0}^N P^i X_h^i = wN_h \\ & \sum_{i=0}^N L_h^i + N_h = T \end{aligned} \tag{2}$$

where w is the wage rate identical for all households, N_h is the amount of time spent on work for household h, P^i it the consumer price of market good X^i and T is the total time available to the households.

This description of the household shows that these are not only modelled as consumers but also as producers. Therefore we start by taking a closer look on the production process taking place inside the household. The household seeks to produce the good Z_h^i in the most efficient way. This problem can essentially be seen as an attempt to minimize the production costs of every unit of Z_h^i. Letting the factor input coefficients a_{Li} and a_{Xi} be the input of L^i and X^i in the production process

and assuming that households see P^i is fixed the household solves the following problem for every commodity Z^i

$$\begin{array}{lll} \min\limits_{a_{Xi},\ a_{Li}} & P^i a_{Xi} + a_{Li} & \\ s.t. & f^i(a_{Xi}, a_{Li}) & = & 1 \end{array} \tag{3}$$

Hereby they find the cheapest way to produce one unit of the consumption good Z^i. The solution is characterized by the unit cost functions $a_{Li}(P^i)$ and $a_{Xi}(P^i)$ describing the cost of producing one unit of Z^i measured in factor input. Using the solution to (3), normalizing both the wage rate w and the total time T to 1 and realizing that the two constraints in (2) are interdependent (through the variable N_h), we can restate the household's maximization problem as

$$\begin{array}{lll} \max\limits_{\{Z_h^i\}_{i=0}^N} & U_h(Z_h^0, Z_h^1, ..., Z_h^N) & \\ s.t. & \sum\limits_{i=0}^{N} Q^i(P^i) Z_h^i & = & 1 \end{array} \tag{4}$$

where $Q^i(P^i) = P^i a_{xi} + a_{Li}$. To see this remember that $a_{Xi} = \frac{X^i}{Z^i}$ and $a_{Li} = \frac{L^i}{Z^i}$ are constant due to the Leontieff production technology. Adding the two constraints in (2) and using the normalization of w and T we get the single constraint in (4). Note that $P^i a_{Xi}$ is the direct cost of using X^i as input and a_{Li} is the value of the time used for the production which equals the earnings lost due to lower working time. Therefore $Q^i(P^i)$ is the total cost of consuming one unit of Z^i.

It is easily seen that (4) is a standard utility maximization problem. The solution will therefore give the factor demand functions $Z_h^i(Q^0(P^0), ..., Q^N(P^N), y_h)$ and the indirect utility function $V_h(Q^0(P^0), ..., Q^N(P^N), y_h)$ where y_h represents artificial non-labor income for household h and given exogenously. We also know that standard results like Roy's Identity which states that

$$\frac{\partial V_h}{\partial Q^k} = -\lambda_h Z_h^k, \quad k = 0, ..., N \tag{5}$$

will apply where λ_h is the Lagranian multiplier from the household's utility maximization problem (the marginal utility of income for consumer h) and that the Slutsky equation

$$\frac{\partial Z_h^k}{\partial Q^j} = \frac{\partial \tilde{Z}_h^k}{\partial Q^j} - Z_h^j \frac{\partial Z_h^k}{\partial y_h} \tag{6}$$

holds where $\tilde{Z}_h^k$ is the compensated demand function for good k.

Having characterized the household's behavior, we now focus on the government. We assume that the government seeks to maximize a Bergson-Samuelson type social welfare function

$$W = W(\bar{V}_1, ..., \bar{V}_H) \tag{7}$$

where $\frac{\partial W}{\partial V_h} > 0$. Because the government takes account of the externalities in the economy the indirect utility function the government considers has the following form

$$\begin{aligned} \bar{V}_h(Q^0(P^0), ..., Q^N(P^N), y_h) &= V_h(Q^0(P^0), ..., Q^N(P^N), y_h) \\ &\quad -\phi(\sum_{h=1}^{H} Z_h^N(Q^0(P^0), ..., Q^N(P^N), y_h)) \end{aligned} \tag{8}$$

Furthermore the government must raise a revenue G resulting in the governmental budget constraint

$$\sum_{i=0}^{N}(t^i \sum_{h=1}^{H} X_h^i) = G \tag{9}$$

where t^i is the tax rate set by the government. Often it is assumed that good 0 can not be taxed. One interpretation of this is that the government can tax goods consumed through the taxation of the input of X_h^i. But assuming good 0 to be pure leisure and thus having $a_{x0} = 0$ the government can not tax this good. In the case

where the government can tax all goods it would be possible to introduce taxes in a first best way. We therefore assume that good 0 is untaxable.

Assuming that the production sector operates under constant returns to scale and fully competitive markets the producer prices p^i for good X^i are fixed. Defining the tax rates as $t^i = P^i - p^i$, $i = 1, ..., N$ the government therefore has full control over the consumer prices and we can write the governments problem as

$$\begin{aligned} \max_{\{P^i\}_{i=1}^N} \quad & W(\{\bar{V}_h(Q^0(P^0), ..., Q^N(P^N), y_h)\}_{h=1}^H) \\ s.t. \quad & \sum_{i=1}^N((P^i - p^i)(\sum_{h=1}^H a_{xi} Z_h^i(Q^0(P^0), ..., Q^N(P^N), y_h))) = G \end{aligned} \tag{10}$$

The Lagrangian function emerging from (10) is given by

$$\begin{aligned} L = \; & W(\{V_h(Q^0(P^0), ..., Q^N(P^N), y_h) \\ & -\phi(\sum_{\bar{h}=1}^H Z_{\bar{h}}^N(Q^0(P^0), ..., Q^N(P^N), y_{\bar{h}}))\}_{h=1}^H) \\ & +\mu(\sum_{i=1}^N((P^i - p^i)(\sum_{h=1}^H a_{xi} Z_h^i(Q^0(P^0), ..., Q^N(P^N), y_h))) - G) \end{aligned} \tag{11}$$

resulting in the first order conditions

$$\begin{aligned} \frac{\partial L}{\partial P_k} = & \sum_{h=1}^H \frac{\partial W}{\partial \bar{V}_h}(\frac{\partial V_h}{\partial Q^k}\frac{\partial Q^k}{\partial P^k} - \sum_{\bar{h}=1}^H \frac{\partial \phi}{\partial Z_{\bar{h}}^k}\frac{\partial Z_{\bar{h}}^k}{\partial Q^k}\frac{\partial Q^k}{\partial P^k}) \\ & +\mu(\sum_{h=1}^H a_{Xk} Z_h^k + \sum_{i=1}^N t^i \sum_{h=1}^H a_{Xi}\frac{\partial Z_h^i}{\partial Q^k}\frac{\partial Q^k}{\partial P^k}) = 0, \quad k = 1, ..., N \end{aligned} \tag{12}$$

Following [Diamond and Mirrlees (1971)] and [Diamond (1975)] we define the social marginal utility of consumption β^h and the social marginal utility of income $\bar{\beta}^h$ for consumer h as

$$\beta^h = \frac{\partial W}{\partial \bar{V}_h}\lambda_h \tag{13}$$

$$\bar{\beta}^h = \beta^h + \mu \sum_{i=1}^N t^i a_{Xi}\frac{\partial Z_h^i}{\partial y_h} \tag{14}$$

We see that β^h is the social value of increasing the utility of consumer h by increasing his budget. But if his budget is increased he will change his consumption pattern which will result in a change in the tax payments. The second term in the definition of $\bar{\beta}^h$ captures this effect and it is therefore the social marginal utility of income for consumer h. Using Roy's identity (5) the Slutsky equation (6) and the fact that $\frac{\partial \tilde{Z}_i^h}{\partial Q^k} = \frac{\partial \tilde{Z}_k^h}{\partial Q^i}$ we can rewrite the first order condition as

$$d_k = \frac{\sum_{h=1}^{H} \beta^h Z_h^k}{\mu \sum_{h=1}^{H} Z_h^k} - 1 + \frac{\sum_{i=1}^{N} t^i a_{Xi} \sum_{h=1}^{H} Z_h^k \frac{\partial Z_h^i}{\partial y_h}}{\sum_{h=1}^{H} Z_h^k} + \frac{\sum_{h=1}^{H} \frac{\beta^h}{\lambda^h} (\sum_{\bar{h}=1}^{H} (\frac{\partial \phi}{\partial Z_{\bar{h}}^k} (\frac{\partial \tilde{Z}_{\bar{h}}^k}{\partial Q^k} - Z_{\bar{h}}^k \frac{\partial Z_{\bar{h}}^k}{\partial y_{\bar{h}}})))}{\mu \sum_{h=1}^{H} Z_h^k} \tag{15}$$

$$= \frac{\sum_{h=1}^{H} Z_h^k \bar{\beta}^h}{\mu \sum_{h=1}^{H} Z_h^k} - 1 + \frac{\sum_{h=1}^{H} \frac{\beta^h}{\lambda^h} (\sum_{\bar{h}=1}^{H} \frac{\partial \phi}{\partial Z_{\bar{h}}^k} \frac{\partial \tilde{Z}_{\bar{h}}^k}{\partial Q^k} - \sum_{\bar{h}=1}^{H} \frac{\partial \phi}{\partial Z_{\bar{h}}^k} Z_{\bar{h}}^k \frac{\partial Z_{\bar{h}}^k}{\partial y_{\bar{h}}})}{\mu \sum_{h=1}^{H} Z_h^k}, \quad k = 1, ..., N \tag{16}$$

where

$$d_k = \frac{\sum_{i=1}^{N} \sum_{h=1}^{H} t^i a_{xi} \frac{\partial \tilde{Z}_h^k}{\partial Q^i}}{\sum_{h=1}^{H} Z_h^k}$$

is the index of discouragement defined in [Mirrlees (1976)].

This formula characterizes the optimal tax system in the economy. Knowing that the compensated demand decreases when the price increases the discouragement index is negative (if the tax is positive). The right hand side tells us that if a good is demanded by households who are socially important (they have a high value of $\bar{\beta}^h$) the discouragement should be reduced. We will now see how this general characterization reduces to some well known tax rules.

3 Tax rules

In this section we will derive several known tax rules. We will see, that the general condition found above (15) reduces to several well known results as well as some new ones.

3.1 The Ramsey rule

If we assume that there are no externalities in the economy ($\frac{\partial \phi}{\partial Z_h^k} = 0$) (15) reduces to

$$d_k = \frac{\sum_{h=1}^{H} Z_h^k \bar{\beta}^h}{\mu \sum_{h=1}^{H} Z_h^k} - 1, \quad k = 1, .., N \tag{17}$$

It is easy to see that if $\bar{\beta}^h$ is constant ($\bar{\beta}^h = \beta$) the expression simplifies to

$$d_k = \frac{\beta}{\mu} - 1, \quad k = 1, ..., N \tag{18}$$

The optimal tax therefore reduces the compensated demand for all goods with the same proportion which is the Ramsey Rule.

3.2 The inverse factor share rule

To obtain the inverse factor share rule found in [Kleven (2004)] we take (12) as a starting point. Assuming that all households are identical, that no externalities are present and that the government maximizes the unweighted sum of households utility the first order condition reduces to

$$\frac{\lambda - \mu}{\mu} = \sum_{i=1}^{N} \frac{\partial Z^i}{\partial Q^k} t^i a_{Xi} \frac{1}{Z^k}, \quad k = 1, ..., N \tag{19}$$

Assuming that there are no cross price effects in the economy, defining the constant

$$\theta = \frac{\lambda - \mu}{\mu} = (\frac{\lambda}{\mu} - 1) \tag{20}$$

we can simplify (19) to

$$\theta = t^k a_{Xk} \frac{\partial Z^k}{\partial Q^k} \frac{1}{Z^k}, \quad k = 1, ..., N \tag{21}$$

giving the optimality condititons

$$\frac{t^k}{P^k} = \frac{1}{\alpha_{Xk} \epsilon_{kk}} \theta, \quad k = 1, ..., N \tag{22}$$

where $\alpha_{Xk} = \frac{P^k a_{Xk}}{Q^k}$ is the cost share of X^k in the price of Z^k and $\epsilon_{kk} = \frac{\partial Z^k}{\partial Q^k} \frac{Q^k}{Z^k}$ is the own price elasticity of commodity k. This is the inverse factor share rule saying that goods which uses much household time in production should carry a lower tax rate than goods which primarely uses marked produced commodities in the household production. It is easy to see that the inverse elasticity formulae is imbedded in this formulation. Letting $a_{Xk} = 1$ the model reduce to the standard model used in the analysis of optimal taxation resulting in the inverse elasticity formula $\frac{t^k}{P^k} = \frac{\theta}{\epsilon_{kk}}, \quad k = 1, ..., N$.

Lifting the assumption about identical treatment of the households allows us to derive a more general version of the inverse elasticity rule where distributional considerations are taken into account. We thus relax the assumption about the government allowing it to maximize a more general welfare function and treat the households as being different. Again we start from (12) and rewrites the first order condition as

$$\frac{1}{\mu} \sum_{h=1}^{H} \beta^h X_h^k - \sum_{h=1}^{H} a_{xk} Z_h^k = \frac{t_k}{P_k} a_{Xk} \varepsilon_{kk}^M \alpha_{Xk} \sum_{h=1}^{H} Z_h^k, \quad k = 1, ..., N$$

where $\varepsilon_{kk}^M = \frac{\partial \sum_{h=1}^{H} Z_h^k}{\partial Q^k} \frac{Q^k}{\sum_{h=1}^{H} Z_h^k}$ is the own price elasticity for the market demand for good k. The tax formula resulting from this is given by

$$\frac{t_k}{P_k} = \frac{1}{\alpha_{Xk} \varepsilon_{kk}^M} \left(\frac{\sum_{h=1}^{H} \beta^h X_h^k}{\mu \sum_{h=1}^{H} X_h^k} - 1 \right), \quad k = 1, ..., N \tag{23}$$

The implications are the same as before, namely that goods using much household time in production should be taxed higher and that goods which have low elasticities should be taxed higher. But now also the social marginal utility of consumption plays a role in the taxation. If we compare (22) with (23) we conclude that the formulas are identical if $\beta^h = \lambda$ meaning that distributional considerations were ignored. For high values of $\sum_{h=1}^{H} \beta^h X_h^k$ we know that the good concidered is primarely consumed by households with a high social marginal utility of consumption and in this case the tax should be lower. The formula resembles the one found in [Sandmo (1976)] in the standard tax model.

3.3 The additivity property

When externalities are present we can derive a result similar to the one found above. Again we take (12) as a starting point, assuming that all households are identical and that the government maximizes the unweighted sum of households utility. This gives the first order condition

$$\frac{\lambda - \mu}{\mu} = -H \frac{\partial \phi}{\partial Z^N} \frac{\partial Z^N}{\partial Q^k} \frac{1}{Z^k} \frac{1}{\mu} + \sum_{i=1}^{N} \frac{\partial Z^i}{\partial Q^k} t^k a_{Xi} \frac{1}{Z^k}, \quad k = 1, ..., N$$

which simplifies to

$$\theta = t^k a_{Xk} \frac{\partial Z^k}{\partial Q^k} \frac{1}{Z^k}, \quad k = 1, ..., N-1 \tag{24}$$

$$\theta = t^N a_{XN} \frac{\partial Z^N}{\partial Q^N} \frac{1}{Z^N} - \frac{H}{\mu} \frac{\partial \phi}{\partial Z^N} \frac{\partial Z^N}{\partial Q^N} \frac{1}{Z^N} \tag{25}$$

giving the optimality condititons

$$\frac{t^k}{P^k} = \frac{\theta}{\alpha_{Xk} \epsilon_{kk}} = (1-\xi)(\frac{-1}{\alpha_{Xk} \epsilon_{kk}}), \quad k = 1, ..., N-1 \tag{26}$$

$$\begin{aligned} \frac{t^N}{P^N} &= \frac{\theta}{\alpha_{XN} \epsilon_N} + \frac{H}{\alpha_{XN} Q^N \mu} \phi' \\ &= (1-\xi)(\frac{-1}{\alpha_{XN} \epsilon_{NN}}) + \xi \frac{H \phi'}{\alpha_{XN} Q^N \lambda} \end{aligned} \tag{27}$$

where $\xi = \frac{\lambda}{\mu}$. Note that since λ is the marginal value of private income and μ is the marginal value of public income the parameter ξ can be interpreted as the marginal rate of substitution between private and public income. For the goods not causing externalities the optimal tax is still determined by the inverse factor share rule. When externalities are present the inverse factor share rule still plays a role but the tax rate now also takes account of the externality. It is seen that the extra term in the tax formulae enters additively. This additivity property was first noticed in [Sandmo (1975)] in a standard tax model with externalities and discussed further in [Kopczuk (2003)]. The interpretation of the result is that when externalities cause consumers to ignore the true marginal costs of the goods they consume the tax problem can be separated into two parts. First a tax is used to internalize externalities. Hereafter the government uses the inverse factor share rule to reach it's revenue requirement. The formula actually also tells us that if $\xi > 1$ then the revenue generated from internalizing the externalities more than covers the government revenue requirement and funds therefore has to be given back to the houseeholds. It is worth noting that in the case where $\xi = 1$ the government raises all its revenue throu the internalization and the tax system therefore is first best.

If we lift the assumption about identical treatment of the households the basic results from above does not change. In this case the formulas simply combines those previously found and we can simply write the tax rules as

$$\frac{t^k}{P^k} = (1 - \frac{\sum_{h=1}^{H} \beta^h X_h^k}{\mu \sum_{h=1}^{H} X_h^k}) \frac{-1}{\alpha_{Xk} \epsilon_{kk}}, \quad k = 1, ..., N-1 \tag{28}$$

$$\frac{t^N}{P^N} = (1 - \frac{\sum_{h=1}^{H} \beta^h X_h^N}{\mu \sum_{h=1}^{H} X_h^N}) \frac{-1}{\alpha_{XN} \epsilon_{NN}} - \frac{\phi'}{\alpha_{XN} Q^N \mu} \sum_{h=1}^{H} \frac{\beta^h}{\lambda^h} \tag{29}$$

We see that the distributional conciderations now enters the formulation both of the corrective term and the efficiency term. The additivity property still prevails and the separation of the problem into one of first correcting for the externality and thereafter setting the optimal tax according to efficiency (taking care of the distributional conciderations) emerges in this more general setup.

4 Conclusion and possible extensions

The tax rules found in the previous section help us to understand how the tax system should be designed. If distributional considerations are ignored the inverse factor share rule states that "Fast transportation should carry a lower rate of tax than slow transportation" [Kleven (2004)] which in the case of cars states that a sports car should be taxed less than a normal car. This conclusion is less clear when externalities are included because a faster car might cause externalities that a slow car does not (for example accidents and pollution). Furthermore we can see that if the choice of transport is highly sensitive to changes in its price the tax rate should be kept low in order to reduce distortions. If distributional considerations are included we see that the conclusion changes because sports cars are normally not used by households who are socially important.

Moving on the the question of equity we see that the tax rules are easily generalized to include these considerations. The results resembles those found elseware in the literature and it is worth noting that the corrective part of the tax which target the externality still enters additive in a fairly simpel form.

In this paper we have presented a model for household behavior where time enters the utility function directly as proposed by Becker [Becker (1965)]. Since

the consumption of time is very important in the transport sector the approach is a natural extension to the traditional microeconomic when this sector is being modeled. The method seems very natural if one thinks about the processes taking place in the society and it is therefore important to explore the properties of the model.

We have extended the results by Kleven and included externalities in the approach. We showed that the tax formulas emerging resemble those found by Sandmo and we therefore conclude that the additivity property survives in this new setup. Furthermore we make it possible to see how distributional questions will affect the tax system.

Applied to car transport this means that a fuel tax introduced to internalize pollution might be reduced by the fact that the general tax introduced after the externalities has been internalized turn out to be lower than expected. This is due to the inverse factor share rule saying that if the uses of the fuel saves time it should in general carry a lower tax rate. Whether or not the tax should be "high" or "low" depend on the magnitude of these two effects. It is important to realize though that the time savings involved in the activities influence the magnitude of the distortions in the economy and therefore also the level of the optimal tax rate.

The model presented here should be generalized in several ways. The modeling of the externalities in a separable way could be criticized and alternative ways of modeling this will be subject to future research. Furthermore to assume that all households earn the same wage might seem unrealistic and the assumption that all households have the same technologies available to them could also be questioned. In spite of this it is believe that the insights from the model are valuable.

References

[Auerbach and Hines (2002)] Auerbach, A. J. and Hines, J. R. (2002) Taxation and Economic Efficiency, *Handbook of Public Economics* **3**, Ed. by A. J. Auerbach and M. Feldstein, Elsevier Science B.

[Becker (1965)] Becker (1965) A Theory of the Allocation of Time, *The Economic Journal* **75**, 493-517

[Corlett and Hague (1954)] Corlett, W. J. and Hague, D. C. (1954) Complementarity and the Excess Burden of Taxation, *Review of Economic Studies* **21**, 21-30.

[Diamond and Mirrlees (1971)] Diamond, P. A. and J. A. Mirrlees (1971) Optimal Taxation and Public Production II: Tax Rules, *The American Economic Review* **61:3**, 261-278.

[Diamond (1975)] Diamond, P. A. (1975) A many-person Ramsey tax rule, *Journal of Public Economics* **4**, 335-342.

[Goulder (1995)] Goulder, L. H. (1995) Environmental Taxation and the Double Dividend: A Reader's Guide, *International Tax and Public Finance* **2**, 157-183.

[Kleven (2004)] Kleven, H. J. (2004) Optimum Taxation and the Allocation of Time, *Journal of Public Economics* **88**, 545-557.

[Kopczuk (2003)] Kopczuk, W. (2003) A note on optimal taxation in the presence of externalities, *Economics Letters*, **80**, 81-86.

[Miles (1995)] Miles, G. D. (1995) *Public Economics*, Cambridge University Press.

[Mirrlees (1976)] Mirrlees, J. A. (1976) Optimal Tax Theory: a Synthesis, *Journal of Public Economics* **6**, 327-358.

[Pigou (1920)] Pigou, A. C. (1920) *The Economics of Welfare*, Macmillian, London.

[Ramsey (1927)] Ramsey, F. P. (1927) A Contribution to the Theory of Taxation, *The Economic Journal* **37**, 47-61.

[Samuelson (1954)] Samuelson, P. A. (1954) The Pure Theory of Public Expenditure, *The Review of Economics and Statistics* **36:4**, 387-389.

[Sandmo (1975)] Sandmo, A. (1975) Optimal Taxation in the Presence of Externalities, *Swedish Journal of Economics.***77**, 86-97.

[Sandmo (1976)] Sandmo, A. (1976) Optimal Taxation, An introduction to the literature, *Journal of Public Economics* **6**, 37-54.