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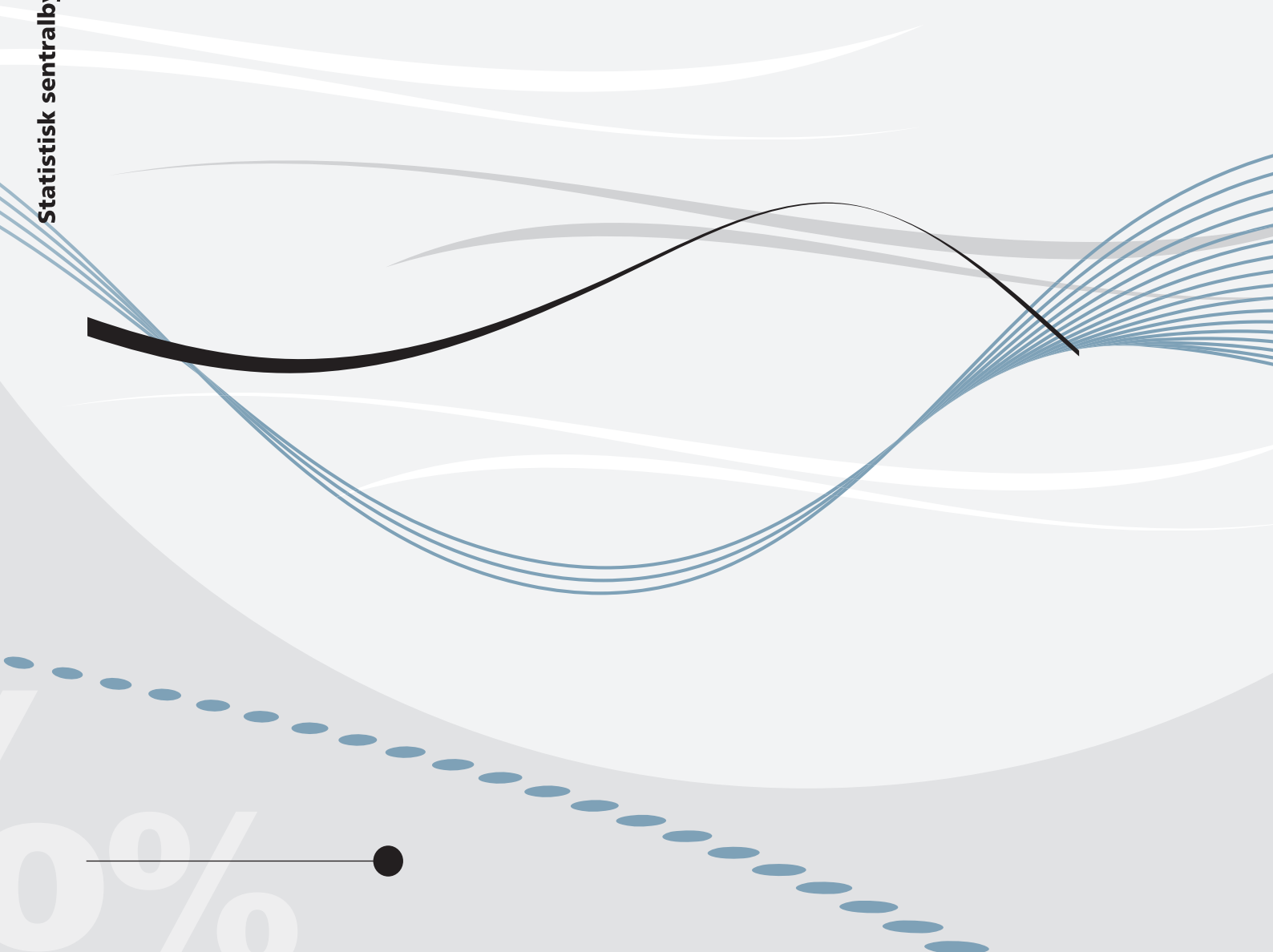

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Optimal indirect taxation and the uniformity debate: A review of theoretical results and empirical contributions

Abstract:
A review of the theoretical literature on optimal indirect taxation reveals that analytical arguments in favor of uniform indirect taxation seem weak and rather unrealistic; hence determining the optimal tax structure remains an empirical issue. However, reviewing the empirical contributions shows that most of them operate under rather restrictive and simplistic frameworks. The empirical support for uniformity seems weak, particularly when the models approach real world complexity. It appears that within a many-consumer economy, differentiated and progressive indirect taxation is likely to be the optimal solution.

Keywords: optimal taxation, indirect taxation

JEL classification: D3, D6, H2

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Sammendrag

I denne artikkelen gjennomgår vi litteraturen for optimale indirekte skatter, med fokus på hvorvidt den optimale indirekte skattestrukturen er uniform (like skatterater).

Gjennomgangen viser at analytiske argumenter i favør uniforme skatter er svake og ofte hviler på strenge forutsetninger. Det hele forblir dermed et empirisk spørsmål. Vi finner liten støtte for et uniformt system i den empiriske litteraturen, særlig dersom vi ser på de mer realistiske empiriske modellene. Mye tyder på at i en fler-person økonomi vil den optimale strukturen være differensiert og progressiv. Imidlertid er det temmelig få slike empiriske studier, og de som finnes opererer ofte innenfor svært restriktive rammer. Vi etterlyser derfor mer empirisk forskning på feltet for å belyse problemet ytterligere.

1. Introduction

A large part of the static optimal taxation literature is concerned with optimal indirect taxation, i.e. taxes on the supply and demand for different goods, focusing on the indirect tax structure and the optimal tax-mix between direct and indirect taxation. Since in a static model any uniform indirect tax structure can be replaced by a proportional direct (income) tax, the tax-mix issue and the issue of optimal indirect taxes are closely related. In this context the question arises: is there a need for differentiated indirect taxation? The purpose of this paper is to provide an up-to-date review of the literature on this topic.

In recent years several policy studies have appeared, arguing that indirect taxes should generally be uniform and distributional concerns should be left solely to direct taxes and welfare benefits (Mirrlees et al (2011); Arnold et al. (2011); European Commission (2013); IMF (2014); NOU (2014)). At the same time there is an inclination to recommend a shift from direct to indirect taxes.[1] In light of this, our review seems relevant to the ongoing tax policy discussion.

A related survey is Ray (1997), who reviews the literature on optimal commodity taxes and optimal reforms. Like Santoro (2002), who surveys the marginal reform approach (see section 3.5), we are narrower in scope, since we focus mainly on the tax uniformity issue. For that purpose, we put more attention to empirical contributions, their results, methods, and modelling assumptions. Our review of analytical results is used mainly to explain empirical studies and help in the interpretation of their results. Thus, we do not go into formal mathematical derivations, but focus instead on the intuition and assumptions behind the tax structure results, with special attention to the uniformity issue.[2]

The first attempt to analyze the optimal tax problem was Ramsey (1927). He posed the question: Suppose the government needs to raise a certain amount of tax revenue, how should it collect this revenue in a way that will minimize welfare losses? This started what could be called the `Ramsey tradition'. Ramsey studied a single-consumer economy in which direct taxation is absent. Later, the model was extended to the many-consumer case (Diamond, 1975; Diamond and Mirrlees, 1971), with the possibility of linear income tax (Deaton, 1979a; Deaton and Stern, 1986), and with externalities (Sandmo, 1975). The model was also interpreted and studied by several other scholars (Baumol and Bradford, 1970; Besley and Jewitt, 1995; Corlett and Hague, 1953; Deaton, 1979b, 1981, 1983; Dixit, 1970, 1975, 1979; Feldstein, 1972; Lerner, 1970; Mirrlees,1974; Munk, 1977; 1980; Sadka, 1977; Samuelson, 1982; Sandmo,1975, 1976; Stiglitz and Dasgupta, 1971). The only significant contribu-

[1] The principal arguments are that taxes on consumption affect less saving and investment decisions compared to income taxes, cause less work disincentives, are less vulnerable to tax evasion, hence are more favorable to economic growth.

[2] Several surveys deal with the theory of optimal indirect taxation, for example Auerbach (1985).

tions in the Ramsay tradition that suggested uniform commodity tax rates in a many-person setting are Deaton, (1979a) and Deaton and Stern (1986), for linear Engel curves and linear income tax.

James Mirrlees gave birth to what may be called the `Mirrlees tradition' (Mirrlees, 1971, 1976). Here the problem is asymmetric information, since the tax authority cannot discern each individual's ability. Mirrlees (1971) studied originally non-linear income tax, but later studies have focused on a mix, where the optimal non-linear income tax is combined with non-linear or proportional indirect taxes (Atkinson and Stiglitz, 1976; Mirrlees 1976; Stiglitz, 1982: Laroque, 2005; Kaplow, 2006)). As with the Ramsey tradition, several theoretical extensions exist, such as allowing for heterogeneous preferences (Saez, 2002), relaxing production efficiency (Naito, 1999), incorporating externalities (Pirttilä and Tuomala, 1997) and non-separable utility between commodities and leisure (Jacobs and Boadway, 2014). A number of studies in the 'Mirrlees tradition' suggested uniform commodity taxation in a many-person model. These include: Atkinson and Stiglitz (1976), Mirrlees (1976), Stiglitz (1982), Laroque (2005) and Kaplow (2006).

The empirical studies on commodity taxation based on this theory consist of certain key elements: First, some objective functions is specified, i.e. a welfare function. Second, a demand system is chosen (possibly, also including labor supply), followed by the determination of parameter values. Third, one decides the form of the income tax function (zero, linear or non-linear) to be optimized in the model or given exogenously. Finally, numerical methods are applied to find the solution to the optimization problem, conditional on the demand system and subject to a tax revenue constraint. In principle, supply side could be also brought in, and general equilibrium models could be applied, but no such studies exist to our knowledge. They would be very complex, at least in a many-person setting.

The present review reveals that the arguments in favor of a uniform tax structure seem rather weak and unrealistic in respect to analytical results, making empirical studies relevant. Further, we found that empirical contributions that are in line with multi-person theoretical models are relatively few, possibly because of the complexity and the heavy informational requirements for computing optimal taxes. But it is also possible that some of the prominent theoretical results in favor of uniformity have been given too much weight, thus retarding further research on this subject. Unfortunately, most empirical models operate under rather restrictive and simplistic assumptions. Although the empirical evidence seems thin so far, it appears that in models that approximate real world conditions, usually a differentiated and progressive indirect tax structure will prevail.[3] This is in contrast to the aforementioned policy related studies, which recommend uniform indirect taxation for distributional purposes. The unresolved controversy concerning tax uniformity calls for more empirical research, closer to real

[3] Progressive indirect taxation means higher taxes on luxuries and lower taxes or subsidies on necessities.

world complexity, to find out how the optimal indirect tax structure should look like. In the search for more realistic models with fewer restrictions, we warn against the uncritical use of flexible demand functions without global regularity, as seen in some more recent empirical studies.

2. Theoretical results

2.1. The Ramsey model and its extensions

The original Ramsey model considers a representative consumer economy, where the consumer can allocate his total budget between leisure and a number of goods (Ramsey, 1927). The model assumes constant producer prices and no profits. It should be clear from this set-up that this model only focuses on the efficiency aspects of commodity taxation. Income tax is assumed to be zero, which is the same as saying that a proportional income tax is allowed. The specifications of the Ramsey model suggest that in this second-best model the objective is to minimize total dead-weight losses (i.e. Harberger triangles).[4]

The well-known result from the Ramsey model states the following: At the optimum, a small intensification of all indirect taxes should decrease the compensated demand by the same proportion for all goods. Since substitution effects are associated with efficiency losses, it is not surprising that the focus is on compensated demand.

Diamond (1975) extended this model to a many-person model with an endogenously determined redistributive lump-sum grant, and showed the need for deviating from the principle of 'equal proportional reduction in compensated demand'. The proportional reduction should be less if the consumption of the good concerned is concentrated among groups, i) having a high welfare valuation of marginal income, or ii) having a high propensity to pay taxes. The first condition implies that given two goods with equal compensated demand elasticities, the one consumed more by higher income earners should be taxed at a higher rate. The positive correlation between tax rates and consumer group income implies a progressive tax structure. The second condition is closely linked to the shape of Engel curves. Linear Engel curves mean that marginal budget shares are equal, and the propensity to pay taxes will then be equal.

The Ramsey rule only characterizes properties of the optimum, and does not provide clear guidance about the optimal tax structure. To examine how the actual tax structure will look like, further assumptions are needed. Sadka (1977) proves that a necessary and sufficient condition for uniformity is that for every taxpayer the compensated elasticities in respect to the wage rate of different commodities are all equal. This means that a uniform decrease in wage rates following a proportional

[4] The first-best solution would be to impose a lump-sum tax.

income tax increase will always reduce compensated demands in the same proportions. Since this is what characterizes marginal changes at the optimum, it must lead to a uniform structure. A preference structure satisfying this condition is when direct utility can be written as $U(v(x), L)$, where x represents commodities; L is labor supply; $v(.)$ is a homogenous function of degree one.[5] This type of function implies equal Engel elasticities for all goods. It is possible that for some particular groups of goods, such a homogeneous sub-utility function will apply. Then these goods should be subject to the same tax rate. But based on empirical evidence, such an assumption cannot be applied to a complete demand system.

Elaborating more on tax structures, Deaton (1981) shows that homothetic implicit separability will lead to a uniform structure in the one-consumer case. Besley and Jewitt (1995) generalize the one-consumer result further and show that it applies to a certain kind of utility functions. Deaton (1981) also shows that if we move to a many-consumer economy and assume that the planner has preferences in favor of equity, then homothetic implicit separability leads to a progressive tax structure. Weak separability between commodities and leisure leads to a regressive indirect tax structure in the one-consumer case. Introducing an egalitarian planner and many-consumer economy, will move the solution towards progressivity (Deaton (1981)).

Another study focusing on tax structure is Baumoul and Bradford (1970), who derived the so-called inverse elasticity rule for a single-consumer economy, by assuming there are no cross-price effects between commodities, i.e. the demand for all goods depends only on its own price and the price of leisure, namely the wage rate. The rule states that the tax rate should be inversely related to the own price elasticity of a commodity and will be smaller the more complementary is the commodity with labor. Given that necessities typically have low elasticities of demand, this rule calls for a regressive commodity tax structure in a single consumer economy. A uniform tax structure will prevail if all own price elasticities are the same and utility is weakly separable between commodities and leisure.

Within a three-good setting (leisure and two commodities) Corlett and Hague (1953) examine which commodities should be taxed to supplement an existing income tax. Their analysis relies on a marginal reform approach, which considers the welfare change due to the introduction of a differentiated commodity tax structure, when the starting point is a uniform system, alternatively interpreted as an existing proportional income tax. They find that the commodity which is a stronger complement (in Hicks sense) to leisure should bear a higher tax. This is a marginal analysis, however, not a global one (see section 3.5). Still, the result also holds true within an optimal design framework (See Sandmo (1976), Jacobs and Boadway (2014)).

[5] Note, the definition of weakly separable utility is also U(v(*x*),*L*), but without a homogeneity condition on v.

2.2. The uniform taxation theorems

Weak separability between commodities and leisure is a necessary condition for all uniformity theorems, when moving away from the original Ramsey framework to many-person redistributive models.

2.2.1. Optimal non-linear income tax and the Atkinson-Stiglitz theorem

A prominent result in the literature is the Atkinson-Stiglitz (AS) theorem (Atkinson and Stiglitz, 1976). Conditional on an optimal non-linear income tax, they study the role of indirect taxation in a many-person redistributive model. The starting point to their analysis is the Mirrlees (1971) control theoretic optimal non-linear income tax model. Incorporating into the Mirrlees (1971) model non-linear commodity taxes, AS prove, using control theory, that in this situation optimal non-linear commodity taxes will be all zero, provided preferences are weakly separable between commodities and leisure. This implies that optimal redistribution could be achieved by income tax alone. Given that a portion of income tax can always be converted into uniform commodity taxes, the AS result implies the optimality of zero or uniform commodity taxation.

Christiansen (1984) extends the AS theorem by using conditional Marshallian demand functions within a marginal reform framework, in much the same manner as Corlett and Hague (1953). He shows how goods that affect the choice of leisure should be taxed or subsidized in the presence of an optimal non-linear income tax. He finds that given weakly separable utility and optimal income tax, optimal commodity tax rates should be zero or uniform.

However, it should be noted that weak separability between commodities and leisure is rejected in several empirical studies (e.g. Blundell and Walker, 1982; Blundell and Ray, 1984; Browning and Meghir, 1991), thereby invalidating the AS theorem. Furthermore, Saez (2002) shows that the AS result is no longer valid when considering the heterogeneity of household preferences. It is also hard to accept that an optimal differentiable non-linear income tax function a la Mirrlees (1971) is in place or ever will be (Boadway and Pestieau (2003)). Probably a piecewise linear income tax combined with differentiated lump sum grants is more realistic.

The AS theorem can be proved also using Stiglitz's (1982) "self-selection" model. This asymmetric information model is applied in a two person or small group setting. In this type of models commodity tax rates are combined with a non-linear income tax. Marginal income tax rates are determined at separate income tax brackets covering individual taxpayers. Income and commodity tax rates are chosen so as to ensure that high ability persons will not have the incentive to mimic the incomes of low ability persons. The self-selection approach was used in a number studies that investigated departures from the AS solution due to various "real-life" complexities. These studies include Boadway et al. (1994), Boadway and Pestieau (2003), Pirttilä and Tuomala (1997) and Bastani et al. (2014).

2.2.2. Optimal linear income tax with lump-sum grants

Assuming that income tax is restricted to be linear, Deaton (1979) proved that in a many-person model with identical preferences, weak separability and linear Engel curves, the optimal commodity structure will be uniform. This result is similar to the AS theorem, but given that income tax is linear, the assumption of linear Engel curves must be added in order to obtain a uniform commodity tax solution. The assumption of linear Engel curves for all goods is dubious and has been rejected in econometric studies; see e.g. Blundell and Ray (1984). Revesz (1997) shows that linear Engel curves for all goods imply nearly homothetic preferences, which is clearly unrealistic.

Deaton and Stern (1986) have taken the case with linear Engel curves and separability as a point of departure for generalizing further. They assume that consumers differ in preferences (and consumption patterns) partly due to differences in observable policy related characteristics (such as age or number of children) and partly due to idiosyncratic preference variation. Differences in preferences are represented in their model by differences in the intercept of the Engel curves. They show that if i) social valuation weights are correlated with differences in preferences, ii) variations in consumption are explained by differences in policy related characteristics, and iii) lump sum grants can be conditioned on policy related characteristics in a linear way, then uniform indirect taxation is optimal. In this case we only need to design an optimal set of lump-sum grants and differentiated indirect taxation is superfluous. However, if any of the above conditions is violated, then the optimal structure will not be uniform. Let us just note that the possibility of optimal lump-sum grants is somewhat problematic from a real world perspective, and as indicated earlier, the assumption of linear Engel curves for all goods is not supported by empirical evidence.

2.2.3. The Laroque-Kaplow proposition: Sub-optimal income tax

The Laroque-Kaplow (LK) proposition extends the AS theorem to apply to non-optimal income tax functions as well (Laroque, 2005; Kaplow, 2006). It states that with weak separability and identical preferences, it is possible to replace any non-uniform indirect tax structure by zero or uniform commodity taxes, by adjusting the non-optimal income tax function in such a way that all taxpayers will maintain or improve their utility position. Hence the LK proposition suggests that in a redistributive model eliminating non-uniform commodity taxes can lead to a Pareto improvement. In common with the AS theorem, the LK proposition ignores the empirical invalidity of weakly separable utility or of identical preferences for all households. But it has some other weaknesses as well.

Boadway (2010) discusses this proposition and stresses that if because of some reason (political or administrative), the appropriate income tax adjustment is not carried out, then such a reform may be welfare reducing. Since the LK proposition does not describe the design of the income tax

functions that combined with zero or uniform commodity taxes will yield improved welfare, this critique seems pertinent. Revesz (2014a) claims that the mathematical theorems presented by Laroque (2005) and Kaplow (2006) do not really prove that following the LK reform a Pareto improvement will necessarily occur. The problem seems to be that Laroque and Kaplow did not recognize properly that any change in the shape of the income tax function will inevitably lead to a change in labour supply.

2.3. Non-distributional factors

It is well known from the theoretical literature that differentiated commodity taxation can be justified on grounds other than raising tax revenue for redistribution, such as externalities, (de)merit goods and tax evasion.

Sandmo (1975) extends the Ramsey framework to include externalities, and shows that additional taxes equal to the marginal external effects should be added to the original solution. Pirttilä and Tuomala (1997) show how externalities should be taken care of in the presence of a non-linear income tax. Revesz (2014a, 2014b) finds that in a redistributive model the change in the tax rate due to an externality exceeds the corresponding Pigovian tax rate or subsidy. Studies taking into account the effects of tax evasion on optimal tax rates include Cremer and Gahvari (1993), Boadway et al. (1994) and Revesz (1997, 2014a, 2014b). Besley (1988) deals with the merit goods arguments. Another possible complicating factor is cross-border shopping. This is dealt with in Christiansen (1994) and Nygård (2014). Note that all these complicating factors violate the necessary conditions for tax uniformity.

3. Empirical contributions

3.1. Applying the theory

To apply the theory to empirical models raises several questions: What kind of information is needed? Which type of utility function should be used? What kind of methods and specifications should be applied? The first order conditions and the budget constraint will make our need for information about the individuals' demand and its derivatives immediately apparent. We will also need information on individuals' supply functions, i.e. labor supply.

Without imposing further restrictions, such as commodity/leisure separability, the wage rate and leisure consumption will influence the demand for commodities through substitution and complementarity and not only income effects. Given that separability between commodities and leisure has been rejected in several econometric demand studies (Blundell and Walker, 1982; Blundell and Ray,

1984; Browning and Meghir, 1991), it does not appear to be a very realistic restriction. On the other hand, there are few reliable estimates on leisure substitution-complementarity parameters (Jacobs and Boadway, 2014).

In line with earlier discussion, one could argue that the functional form of demand should be flexible enough to allow for non-linear Engel curves and non-separable utility. Yet we should be aware that undertaking an optimal design analysis requires the demand and supply function to be consistent with consumer theory globally and not only locally, since the optimal price structure could be far from the point at which the function is consistent with theory. So-called flexible functional forms do not automatically exhibit these properties in a global sense. The property of a flexible function form is its ability to take on any set of price and income elasticities at a particular data point, unrestricted by a priori assumptions. This seems very desirable, but it comes at a cost. As Caves and Christensen (1980, p. 423) make it clear, outside the initial data points the estimated flexible form indirect utility function may not be monotonic or strictly quasi-concave. An example of a popular and widely used flexible functional form is the almost ideal demand system (AIDS) introduced by Deaton and Muellbauer (1980). This function may provide an approximation to any arbitrary utility function and may exhibit many desirable properties locally, such as quasi-concavity. However, since it is an approximation, it can only show consistency with demand theory locally, and there is no guarantee for the same applying globally.

In addition, in a redistributive model the social welfare function must be specified in detail for a many-consumer economy. This raises issues in regard to the cardinalisation of utility and political value judgments, which are usually represented by the inequality aversion rate.

After a utility function has been selected and all the information needed is at hand, we can calculate optimal taxes. This is not a trivial task since taxes, prices, quantities and elasticities are interdependent in a non-linear way. Some kind of numerical method must be employed to yield a solution. If we relax the assumption of constant producer prices, the computation of optimal taxes will also require information about the producer sector, which would render the task even harder.

Having reviewed some of the difficulties with empirical studies, we can now turn to examine a number of empirical contributions. To our knowledge, apart from the self-selection model of Bastani et al. (2014), no attempt has been made to test numerically the theory of non-linear income tax along with commodity taxation according to the Mirrlees (1976) and Atkinson and Stiglitz (1976) tradition. We will therefore review mainly studies under the extended Ramsey model, i.e., linear or proportional taxation. The studies reviewed consider only the demand side, assuming constant producer prices.

3.2. Representative consumer models

We start the review of empirical studies with a number of studies that are considering a representative consumer economy. To what extent these one-person models are relevant to distributional models is an open question. Whatever the case may be, they illustrate various statistical and mathematical approaches to the commodity tax optimization problem.

Atkinson and Stiglitz's (1972) paper is the first, to our knowledge, to compute optimal tax rates from empirical data. In computing optimal taxes for five commodity groups they consider two demand systems: The linear expenditure system (LES) based on estimates by Stone (1954) and the direct addilog demand system based on estimates by Houthakker (1960). In both cases there is separability between commodities and leisure and they assume elastic labor supply. According to theory they should get a solution which is regressive, and so they do.[6]

Fukushima and Hatta (1989), using the same data set and the same model, find that reducing the (compensated) labor supply elasticities works in favor of a uniform system. With what they consider as more reasonable values (below 0.5), they find the structure to be fairly uniform.

Harris and McKinnon (1979) also calculated optimal tax rates for five product groups using a Stone-Geary (LES) function with leisure and commodities. The optimal structure, they conclude, varies with the assumed compensated labor supply elasticities. Fukushima (1991) uses the same data but with lower labor supply elasticity, which yields a result somewhat closer to a uniform solution.

Asano and Fukushima (2006) estimate the joint decision of leisure and commodity demand without imposing any separability restriction. They use Deaton's AIDS and compute optimal tax rates for ten commodity groups in Japan. Their conclusion is that the optimal structure is reasonably close to a uniform one, which suggests that the welfare losses associated with tax uniformity are small. Although the Asano and Fukushima model provides important improvements, including more goods, non-separability between commodities and leisure and the application of non-linear Engel curves, their results are weakened by uncertainty about the extent to which the model complies with properties required according to demand theory (see section 3.4).

Another study within the one-person economy framework is Nygård (2014). Using a LES system, he includes cross-border shopping and focuses on cross-border exposed goods for Norway. The goods purchased across the border are assumed to be non-taxable and externality-generating. He optimizes commodity taxes conditional on a pre-existing income tax. As expected, he shows that goods purchased at home should be taxed more leniently, because of the distortions caused by cross-border shopping. In particular, he shows how the effects get stronger because these goods are externality-generating. In general, the tax structure obtained is highly differentiated. When neglecting cross-

[6] For these theoretical results refer to Deaton (1981) and Baumol and Bradford (1970).

border shopping and external effects, he gets a more uniform solution, though still more differentiated than that of Asano and Fukushima (2006).

3.3. Many-consumer economy

3.3.1. Models without lump-sum grants

In almost all redistributive models lump-sum grants are represented by a single uniform grant for everyone, called the demogrant. In a number of models the demogrant is missing. This is supposed to represent the situation in many developing countries where direct transfer payments are absent. In these models, the presence of egalitarian objectives and the absence of the demogrant, implies progressive indirect taxation in optimum, because there is no other way to provide support to the needy, as limited as it may be. Here we shall review some of these models.

As far as we are aware, the first calculation of optimal taxes within a many-person framework is presented in Deaton (1977). Deaton's model relies heavily on simplifying assumptions. By employing what he calls strategic aggregation, he ends up having to consider the behavior of only two consumers, in his vocabulary, the social representative consumer and the average consumer. He calculates optimal taxes for eight goods. His study is based on inelastic labor supply and linear Engel curves. His specification of the welfare function is based on Atkinson (1970), and is similar to the welfare functions used in studies that will be reviewed below. In the absence of distributional goals, his results indicate a uniform tax structure. He finds that when the concern for equity increases, the structure becomes more differentiated and luxuries are taxed more heavily than necessities.

Heady and Mitra (1980) use a Stone-Geary LES utility function, implying both separability and linear Engel curves for nine goods, including leisure. Basically they find that the structure is highly non-uniform, no matter what assumption is adopted about equity.

Sensitivity of optimal tax rates to different demand systems is considered by Ray (1986). He calculates optimal tax rates for nine goods conditional on the prices, incomes and elasticities observed at a particular point of time. That means that his optimal tax rates are not optimal in a strict sense, but only reflect what the tax rates would have been had the initial situation constituted the optimum. He compares the linear expenditure system (LES) with the restricted non-linear preference system (RNLPS), which is a specialization of the non-linear preference system (NLPS) introduced by Blundell and Ray (1984). The RNLPS allows for non-linear Engel curves. He finds that the two demand systems agree at low level of concern for equity, but diverge when the inequality aversion rate increases. At low levels of inequality aversion they approach a uniform solution. A study that follows up Ray (1986) is Majumder (1988). Using the same conditional method, he tests other non-linear Engel curves specifications on the same data and discovers that the results are sensitive to the exact specifi-

cation of Engel curves non-linearity.

Murty and Ray (1987) use the general functional form of Blundell and Ray (1984), the non-linear preference system (NLPS), and investigate sensitivity to the assumption of weakly separable utility between goods and leisure. Their results indicate that the tax rates for the nine goods considered are highly sensitive to deviations from weak separability. All their results show a non-uniform tax structure.

Murty and Ray (1989) develop an algorithm based on the marginal tax reform approach of Ahmad and Stern (1984) to calculate optimal tax rates. Their results from LES and RNLPS are similar when inequality aversion is low, but diverge as the inequality aversion rate becomes higher.

Ray and Blacklow (2002) extend this model and incorporate demographic effects when they use RNLPS and LES to study optimal taxes in Australia for nine goods. The optimal tax rates, they conclude, move away from uniformity when demographics are introduced and affect the social welfare weights. The effect is more significant when considering the RNLPS than LES. In line with Ray and Murty's (1989) findings, their results also indicate that LES and RNLPS agree at low inequality aversion but diverge at higher inequality aversion rates. Furthermore, optimal tax rates appear to be more sensitive to the choice of functional form than to the inclusion of demographic effects, suggesting that the shape of Engel curves has a strong effect on the optimal solution.

It should be noted that a redistributive model without a lump-sum grant is hardly realistic in any country. Even in developing countries where direct support payments are absent, there is some kind of redistributive support provided through public education, health care and other in-kind transfers, which can be represented for modelling purposes by a demogrant.

3.3.2. Models with sub-optimal lump sum grants

Another class of empirical models deals with positive but sub-optimal lump-sum grants. The demogrant can be sub-optimal either because it is given exogenously or because it is calculated through partial optimization, which does not take into account all the variables present in the model. When the lump-sum grant is sub-optimal, progressive indirect taxation is needed to compensate for sub-optimal support provided to the needy.

Ray (1989) and Ebrahimi and Heady (1988) investigate the impact of demographical factors and child benefits. Both of them use data from a UK database covering four composite goods. Ray (1989) allows for non-linear Engel curves but does not include leisure, while Ebrahimi and Heady (1988) include leisure and linear Engel curves that are not always parallel across households. Since Ebrahimi and Heady combine a many-person model with variable labor supply and differentiated lump-sum grants, their study is probably one of the most sophisticated and comprehensive empirical models published so far. We shall return to their study in the next section. Ray (1989) finds support for

progressivity when the demogrant is sub-optimal, especially when inequality aversion is high. Ebrahimi and Heady (1988) conclude that the separability assumption determines to a large extent the structure of tax rates when demogrants (lump sum transfers conditioned on demographic characteristics) are not set optimally. In their numerical study they test and confirm the theoretical contribution of Deaton and Stern (1986).

Asano et al. (2004) use an AIDS system without variable labor supply, which has much in common with Ray (1989). If lump-sum grants are not included or are set at a sub-optimal level, they get a progressive structure, in line with Ray (1989). When the uniform lump sum grant is obtained from full tax optimization, they get a regressive tax structure. Given that in their model labour supply is fixed, it is not clear how they obtained finite tax rates from full optimization. In a redistributive model where the only primary input (labor) is fixed, one would expect the optimal solution to tax away and redistribute all incomes through the demogrant (implying infinite commodity tax rates), since output would be unaffected.

3.3.3. Models with endogenously determined optimal lump-sum grants

Ebrahimi and Heady (1988) also present results where lump-sum grants are determined through tax optimization, based on demographic characteristics and the tax revenue constraint. Under these conditions, they find that optimal commodity tax rates will be uniform, provided utility is weakly separable between commodities and leisure and provided Engel curves are linear and parallel across households, in line with the analysis of Deaton and Stern (1986). If either of these conditions is violated, optimal tax rates will not be uniform. In their model non-parallel Engel curves represent a mild case of non-linearity. But even that slight non-linearity of Engel curves led to marked differentiation in tax rates. Note, the differentiated lump-sum grants analyzed by Ebrahimi and Heady (1988) are more realistic than a uniform demogrant.

Revesz (1997) uses LES first with nine goods, then with 9 goods for the poor and 18 goods for the rich. In both cases leisure is separable from other goods and a uniform demogrant is calculated from the tax revenue constraint. In the first case he gets results in line with Deaton (1979a), namely uniformity. When applying the 18 goods set-up he gets a progressive structure, because of the non-linearity of Engel curves. The 9 goods parameter estimates used in this model are taken from Deaton and Muellbauer (1980).

Revesz (1997) has been developed further, to become a fairly comprehensive numerical model of optimal indirect taxation in Revesz (2014a, 2014b). Unlike other numerical studies mentioned earlier, Revesz (2014a, 2014b) does not calibrate his calculations to empirical data. Instead, he uses in his numerical examples arbitrary but plausible numbers. He justifies this approach by presenting approximate formulas for optimal commodity tax rates. The numerical results are used to illustrate and sub-

stantiate the analytical approximations. Revesz (2014a, 2014b) finds that under logarithmic utility specifications and without income tax, optimal commodity tax rates are highly differentiated and progressive. The dispersion of tax rates is further increased in the presence of "real life" complexities such as evasion, administrative costs, externalities and non-separable utility between commodities and leisure. The dispersion of tax rates is reduced if an exogenously given non-linear income tax function is incorporated into the model, or if the inequality aversion rate is low.

A computational study by Bastani, Blomquist and Pirttila (2014) examines the effect of strong leisure substitutes, such as child-care and aged-care services on optimal commodity tax rates, using a Stiglitz (1982) type self-selection model. In the self-selection model the zero intercept of the optimal non-linear income tax function represents an endogenously determined lump-sum grant. Bastani et al. (2014) examine optimal taxes-subsidies and changes in labour supply in a model involving two composite goods plus child care and leisure and four population groups – low and high wage earners, parents and non-parents. They find that provided child care is not fully paid by the government, progressive taxation of commodities is justified.

3.4. Some critical remarks on flexible demand functions

The demand systems used in early empirical work relied on very strict assumptions, such as separability and linear Engel curves. This does have the advantage of being perfectly consistent with consumer theory. More recent studies have avoided putting a priori assumptions on behavior, by using flexible function(al?) forms. The results risk inconsistency with consumer theory. While this issue is neglected in the literature, several examples can be given.

The study of Asano and Fukushima (2006) shows important improvements (such as increasing the number of goods and not imposing separability together with non-linear Engel curves), but their results are weakened by the fact that nothing is done in order to check global characteristics at the optimum. They discuss theory consistency for estimated elasticities at the sample mean, but make no attempt to clarify whether the same conditions will be fulfilled at the optimum.

The same criticism applies to other studies, such as Murty and Ray (1989) and Ray and Blacklow (2002). The flexible form demand system, NLPS, is not consistent with consumer theory globally (Blundell and Ray, 1984, p.802). How the restricted versions (such as RNLPS) perform in this regard has not been explained.

3.5. An alternative approach: Optimal marginal reforms

Another approach to the tax optimization problems is to consider marginal reforms instead of globally optimal tax designs (Ahmad and Stern, 1984). From an empirical point of view, its advantage is con-

siderably lower information requirements. Whereas the globally optimal tax approach demands knowledge about individuals' complete demand functions, the marginal reform approach only needs information about individuals' consumption expenditures, aggregate demand derivatives and tax rates in the initial situation (see Santoro (2007) for a survey). Moreover, the need for global regularity is not present, so flexible functional forms could be used with more ease. The marginal reform approach also seems to be more robust to the choice of specification than the globally optimal tax approach (Madden, 1995; Decoster and Schokkaert, 1990; Ray, 1986). All this makes marginal reform analysis attractive, but it remains somewhat limited in scope. It only indicates the direction for welfare improvement, without ensuring that the solution is the best possible outcome.

4. Uniformity and policy related studies

In recent years some important policy related studies have supported uniform indirect taxation. These include Mirrlees et al. (2011), Arnold et al. (2011), European Commission (2013), IMF (2014) and NOU (2014). The common rationale is that income taxation and welfare payments are more suitable tools for redistributive purposes than progressive indirect taxation. This reasoning is in line with the AS and LK theorems mentioned earlier. Yet, these analytical results are based on empirically incorrect assumptions, such as weakly separable utility and identical preferences for all households. Furthermore, they ignore complications such as tax evasion, administrative and compliance costs and the suboptimality of actual income tax schedules and welfare payments. The well-known labor and saving disincentives and evasion-avoidance problems associated with income tax, and false reporting with welfare payments, cast doubts about their suitability to address fully all distributional objectives. It is paradoxical that while these policy studies (with the exception of Mirrlees et al.(2011)) call for a reduction in income tax and its replacement by consumption taxes, at the same time they expect income tax to be the sole tax instrument to mitigate distributional problems. Some of these policy studies also mention other factors in favor of uniform taxation. These supposed benefits include:

- More effective support to the needy through lower income tax rates or higher welfare payments than through reduced taxes on necessities.
- Lower administrative costs with uniform indirect taxation.
- Narrowing the scope for tax evasion with uniform tax rates.

As indicated in Revesz (2014a, 2014b), these issues could be examined quantitatively through comprehensive computational modelling. There is no need to relegate these subjects to intuitive discussions separately from other issues. Arguably, policy analysis should rely more on empirical estimates combined with comprehensive computational modelling.

5. Conclusions

This review indicates that the theoretical arguments in favor of uniform indirect taxation for distributional purposes seem weak and rather unrealistic. Almost all empirical studies published so far yield non-uniform optimal tax rates; however, the frameworks of these empirical models usually differ from those underlying the uniform tax propositions. Many-person empirical models consistently yield progressive tax structures. The unresolved controversy concerning commodity tax uniformity calls for more empirical and computational research. Care must be taken when using flexible functional forms in future empirical studies, to ensure consistency with theoretical requirements, such as global quasi-concavity. The uncritical acceptance of the tax uniformity proposition in some recent policy related studies is a cause for concern. Hopefully, in the future policy advice will rely more on comprehensive and realistic empirical modelling.

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