CHAPTER 2

Digitalization and Taxation

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INTRODUCTION

In an ideal world, governments would be able to completely verify all relevant economic outcomes and characteristics of taxpayers at zero cost. In such a world, non-distortionary, individualized lump-sum taxes would be available to redistribute income and to raise revenue. Indeed, the government could then condition its tax policy on all the characteristics of taxpayers on which it likes to base income redistribution: earning ability, needs, initial endowments, inheritances, luck, and so on. Moreover, if information were perfect, tax avoidance and evasion would not exist. Governments would just know how much individuals earn, save, and consume. If markets were perfect as well (no externalities, no monopoly, complete contracts, symmetric information, complete markets, and zero transaction costs), the second fundamental theorem of welfare economics would apply: governments could completely separate issues of allocation and distribution, since any efficient market outcome could be achieved with suitable redistributions using individualized lump-sum taxes and transfers.

The world is not ideal, however, since information on economic outcomes and characteristics of taxpayers is not perfect. Information constraints lie at the heart of the traditional economic analysis of taxation. Government is not able to verify all economic outcomes of individuals or households. Indeed, taxpayers may misrepresent their incomes, consumption, wealth, or bequests to avoid or even evade paying taxes. Information constraints determine a government's tax enforcement capacity. Governments use costly verification of economic outcomes (tax audits) and penalties for noncompliance, to alleviate information problems in verifying economic outcomes. The taxpayer's willingness to tolerate risk, the size of penalties if caught evading, and the tax enforcement technology determine the extent of tax avoidance (Allingham and Sandmo 1972).

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Furthermore, governments cannot verify important characteristics (such as earning abilities) and economic behaviors of individuals and firms (such as work effort). As a result, non-distortionary, individualized lump-sum taxes are not feasible and government must rely on taxing verifiable economic outcomes such as income (output), consumption, savings, and bequests. Information constraints imply that government inevitably distorts incentives to earn income, to consume, to save, and to leave a bequest. Such constraints are, therefore, the fundamental reason for the ultimate trade-off between equity and efficiency (Mirrlees 1971).[1]

Information constraints thus determine the opportunities for tax avoidance and evasion and shape the inescapable trade-off between equity and efficiency. This chapter argues that digitalization can help alleviate these constraints in two ways.

First, digitalization can help relax information constraints through better ways to verify the true economic outcomes of taxpayers. Digitalization makes it easier for governments to link existing information in various parts of the tax system to better detect evasion or avoidance. Digitalization can thus be seen *as improving the tax enforcement technology* of the government. Better tax enforcement allows governments to raise the same revenue with lower taxes (more efficiency) or to raise more tax revenue with the same taxes.

Second, digitalization can allow governments to implement more sophisticated tax systems. For example, tax liabilities can be conditioned not only on current yearly (labor) income, but also on income earned in different periods, income earned by spouses, asset holdings, and so on. By conditioning tax schedules on more information, government can better target income redistribution. Consequently, the same income redistribution can be achieved with lower tax rates, or the same tax rates can achieve more income redistribution. By using more information in the design of tax systems, digitalization can thus *alleviate the equity-efficiency trade-off*.

Importantly, however, digitalization can never negate the equity-efficiency trade-off. Important economic behaviors remain the private information of taxpayers and therefore unobservable to tax authorities (such as work effort). This remains so even in a fully digitized world, and even if there were no tax avoidance or evasion. However, by conditioning tax schedules on variables that go beyond current incomes, governments can improve the equity-efficiency trade-off while respecting the fundamental information constraints on the non-verifiability of certain economic behaviors.

This chapter follows a classical public finance approach, which is firmly rooted in welfare economics. The main goal is to identify desirable tax policies as if they are set by an enlightened dictator. Naturally, enlightened dictators do not exist and discussions on taxation cannot be seen in isolation from political economy,

[1]At low levels of taxation, the trade-off between equity and efficiency might not be present if income redistribution enhances economic efficiency, such as by providing income insurance or alleviating capital market failures (for example, promoting investment in education). Moreover, if tax systems are not optimized there may not be a trade-off between equity and efficiency. Removing the inefficiency can then enhance both equity and efficiency.

legal (horizontal equity), and privacy concerns. Nevertheless, this chapter aims to provide information to policymakers on whether it would be possible to improve tax policies. This is important policy information, irrespective of whether political and other concerns would ultimately prevent societies from implementing welfare-improving tax reforms.

Digitalization affects both the public and private sectors. Digitalization may foster stronger tax avoidance and evasion and raise behavioral responses to taxation, such as through more aggressive tax planning. Digitalization can therefore also raise the efficiency costs of taxation, which tend to lower optimal taxes. Moreover, by fostering tax avoidance and evasion, digitalization can contribute to rising inequality in income and wealth, both of which tend to increase optimal taxes. As such, digitalization in the private sector is likely to raise both the efficiency costs and the equity gains of redistributive taxes, and it is not clear whether digitalization in the private sector should result in lower or higher optimal tax rates. The analysis here remains applicable, however, since better use of information in the *public* sector allows for more efficient tax systems for all possible efficiency costs and distributional gains of taxation.

What does digitalization imply for optimal tax design? The chapter analyzes the promise of digitalization for (1) reducing tax avoidance and evasion and (2) the optimal design of taxes on labor, capital, and consumption. It provides 13 policy ideas to improve existing tax systems. Five ideas relate to improving the tax enforcement technology of the government by exploiting more information on taxpayers' economic outcomes. Eight ideas relate to alleviating the equity-efficiency trade-off in current tax systems by exploiting more available information in designing tax schedules.

This chapter discusses digitalization and tax enforcement, followed by a look at digitalization and tax design, and concluding with a summary of policy proposals on digitalization and taxation and reflections on tax policy and digitalization.

DIGITALIZATION AND TAX ENFORCEMENT

Allingham and Sandmo (1972) is the classic contribution on the economics of tax evasion. In their analysis, taxpayers need to report their income to the tax authorities. They can conceal part of their income, but at the cost of a penalty when they are caught evading taxes. The informational constraint is that the government does not know the true income of taxpayers and it can only figure out whether taxpayers are cheating by auditing them, at some cost. In Allingham and Sandmo (1972) taxpayers are audited with a given probability. The optimal strategy of the taxpayers is to underreport income if expected penalties are low enough compared to the tax savings on undeclared income.

Audits are a costly state-verification or monitoring device, the state being the true income of the taxpayers. The *tax enforcement technology* describes how efficient the government is in verifying the true incomes of taxpayers. The tax

enforcement technology thus tells us how much tax evasion is detected for a given amount of resources spent on auditing and enforcing tax compliance. Trivially, the tax enforcement technology becomes perfect, that is, nearly costless, if the government can impose infinitely large penalties on cheating taxpayers, no matter how low auditing probabilities are (Mirrlees 1999). In that case, no taxpayer finds it in its interest to underreport income. However, the law constrains the penalties that governments can impose, for example, because the government can also make mistakes in correctly applying the tax laws. Given that infinite penalties on tax evaders are impossible, the enforcement technology is primarily determined by the effectiveness with which tax authorities can process information on taxpayers to detect evasion.[2]

Digitalization holds the promise of improving the tax enforcement technology of the government. In particular, digitalization allows the government to process more information on the different economic outcomes of taxpayers, such as their earnings, capital incomes, consumption expenditures, gifts, and bequests. Information from various sources can thus be used to more easily identify taxpayers who evade taxes. Consequently, if digitalization improves the enforcement technology, digitalization can lower tax evasion. Hence, government revenue increases for the same statutory tax structure.

How can digitalization help improve the enforcement technology? To fix ideas, consider the budget constraint of a particular individual in a particular year. The individual budget constraint implies that increases in net wealth Δa, plus net bequests/gifts received b^* equals net capital income r^*a plus net labor income w^*l minus net consumption expenditures p^*c minus net bequests/gifts made g: $\Delta a + b^* = r^*a + w^*l - p^*c - g$, where an asterisk denotes an after-tax value. Tax authorities collect information on many parts of the household budget constraint. Whether such information is available depends on whether income from labor and capital and bequests are taxed.

What information is currently available to tax authorities? Nearly all countries levy taxes on labor income, hence tax authorities need to verify before-tax labor earnings wl. Typically, most developed countries have third-party reporting by firms on labor income earned by employees. However, perfect verification of labor earnings is not feasible, which holds especially for the self-employed, where third-party reporting is difficult or even impossible. Similarly, most countries also levy taxes on capital income, which requires verifiability of before-tax capital incomes ra. Verifying capital income can be more complicated than verifying labor income in view of the larger international mobility of capital. Nevertheless, there is also third-party reporting by financial firms on various sorts of capital incomes of individuals. This information mainly concerns deposits (including interest) in bank accounts, assets and their returns in investment funds, assets and returns on these assets from insurance policies and in pension funds. By using the

[2]Keen and Slemrod (2016) analyze the optimal enforcement of taxes. Governments need to make a trade-off between the benefits of larger tax revenue and the public costs of better tax enforcement.

information from financial institutions, governments can also exchange information internationally. However, some important parts of capital income—housing and pensions—are generally taxed very lightly or not taxed at all. Many countries collect information on property values in property registers, often at the local level of government. Governments may also resort to land and satellite imagery to enforce property taxes.

Moreover, in most countries, not all elements of the individual budget constraint can be observed, because no taxes are levied at the individual level, especially on consumption pc. Most consumption taxes (value-added tax [VAT], sales tax) are levied as a withholding tax at the firm level. Third-party reporting on consumption from consumer transactions data and customs is sometimes observed. Moreover, most countries do not levy wealth taxes, and as a result, information on wealth accrual Δa at the individual level may not be available. Finally, bequests or gifts g might only be lightly taxed, if at all. The more items in the individual budget constraint are non-verifiable to the government, the easier it is for individual taxpayers to avoid or evade paying taxes.

The individual budget constraint can also be written in lifetime, rather than yearly, terms. The net present value of lifetime consumption C plus the net present value of bequests made net of bequests received B equals the net present value of earnings Y: $C + B = Y$. If tax authorities had the information on lifetime income Y and lifetime consumption C, it would be much easier to detect evasion or avoidance in taxes on bequests and gifts B. Indeed, at any period during the lifecycle, if the net present value of consumption C substantially deviates from the net present value of income Y, tax authorities may expect avoidance or evasion of taxes on bequests or gifts.

Although it is perhaps not a surprising or novel idea, digitalization still has the potential to reduce tax evasion and avoidance by gathering more information on the economic outcomes of taxpayers. Digitalization may be useful to gather information on individual or household consumption levels, individual or household capital incomes or assets, and individual or household bequests and gifts. Moreover, digitalization may facilitate third-party reporting, not only on labor income, but also on consumption, capital income, and assets. The remainder of this section gives five ways improve tax enforcement.

Linking Data on Consumption

Digitalization may provide the government with more information on total individual consumption expenditures, for example, due to greater use of digital payment methods. Indeed, in the future all consumption transactions may eventually become electronic and cash may be abolished (Rogoff 2016).[3] By definition, total consumption plus accrued wealth (including bequests) equals labor

[3]Abolishing cash and relying only on electronic consumer transactions make barter exchange more profitable. This form of tax evasion needs to be taken into account when designing tax systems in cashless economies.

income plus capital income. Consumption is typically not observed at the individual level. However, by recording consumption transactions, digitalization provides possibilities to link total individual consumption expenditure to data on labor income, capital income, and wealth.

Suppose that the government could indeed verify total consumption at the individual level. Then, from the yearly budget constraint of an individual, it follows that tax authorities could verify whether reported (labor and capital) income and wealth holdings were in line with observed consumption levels. If not, tax authorities might check whether this taxpayer avoids income taxes. Tax authorities may already rely on consumption measurements to detect evasion in income taxation. However, systematic recording of all consumption transactions would greatly enhance the measurement of total consumption expenditures of individuals. This is relevant not only for wealthy taxpayers, but also for the big group of poor taxpayers that never files for income taxation, because their taxable incomes are too low to pay tax, for example, due to the general tax exemption or various (income-dependent) tax credits.

Moreover, if information on individual consumption were available, tax authorities could also verify whether reported wealth (increases in wealth) were in line with income and consumption data. If reported wealth levels are too low to be consistent with observed income and consumption levels, tax authorities can check whether the taxpayer evaded taxes by moving wealth toward the unofficial sector or abroad. International coordination and information exchange is then needed to verify whether taxpayers are indeed shifting wealth abroad.

If all consumption and income were recorded every year, then tax authorities could also calculate the differential between the present value of consumption and the present value of labor earnings of a taxpayer until a particular moment in time. If asset holdings in that year and the bequest and gift behavior of the taxpayer until that year are incompatible with these measures, tax authorities might check whether the taxpayer used avoidance vehicles to transfer wealth to his or her spouse or children or moved wealth toward the unofficial sector or abroad. Hence, if digitalization made individual consumption verifiable, the government would be able to reduce tax avoidance and evasion in taxes on income, wealth, bequests, and gifts.[4]

Linking Data on Wealth and Capital Income

Digitalization could help to create and link data registers on wealth and capital incomes—savings, publicly traded assets, closely held assets, homeownership, pensions, and bequests/estates. By combining various sources of information on taxable wealth, capital incomes, and bequests, the government can reduce tax

[4]Moreover, making all consumption transactions electronic by abolishing cash transactions, governments can reduce the informal economy and conduct macroeconomic management in liquidity-trap conditions more effectively by helping to overcome the zero lower bound on nominal interest rates (Buiter and Rahbari 2015; Rogoff 2016).

avoidance and evasion. Verification of all assets and returns on assets requires information on home ownership, which can be made available from (local) property registers.[5] Tax authorities may also gain relatively easy access to information on pension entitlements and pension benefits of individuals in public pension plans. Digitalization can thus help verify total capital incomes and wealth levels of taxpayers, and thereby tax capital income and wealth more effectively (see also sections on Corporate Taxation and Optimal Taxation of Capital Income).

Cross-Border Linking of Data on Wealth and Capital

Taxpayers can avoid paying taxes on wealth and capital income by moving their assets abroad. Tax evasion can be reduced by Taxation Information Exchange Agreements, where countries share information on individuals' and firms' financial accounts in certain financial institutions. Many countries participating in the Organisation for Economic Co-operation and Development (OECD) Convention on Mutual Administrative Assistance in Tax Matters have reached bilateral agreements to share information on request for all types of investment income (including interest, dividends, income from certain insurance contracts, and other similar types of income), but also account balances and proceeds from sales of financial assets. Financial institutions include banks, custodians, brokers, certain collective investment vehicles, and certain insurance companies. Digitalization can help further to build and link international registers for asset ownership (shares, property, pensions) and capital incomes (interest, dividends, capital gains, property values, pension accrual) (Zucman 2015).

Naturally, such information exchanges are complicated by beneficial ownerships, bearer shares, and bearer bonds, and it is not clear whether digitalization can be helpful in these cases. Nevertheless, more complete registers and further information sharing between tax authorities would render tax avoidance much more difficult. Moreover, exchange of information makes it much easier for governments to tax capital income on a residence basis rather than on a source basis. Indeed, if it were possible to verify all assets and their returns at the individual level, then there would be no need for corporate income taxes. Corporate income tax could remain to serve as a withholding tax for individual capital income (see also section on Corporate Taxation).[6]

Financial Institutions as Third-Party Reporters

Information on capital income and asset holdings helps governments detect tax avoidance and evasion in taxing capital income. Although digitalization is not required for information exchange, it has the potential to substantially lower the costs of doing so, especially if countries would exchange financial information

[5]Returns on property are not directly measurable, and imputation of returns to property is necessary if the returns are to be taxed.

[6]Devereux and Vella (2017) discuss the implications of digitalization for the corporate tax in more detail.

automatically. Currently, 100 countries have agreed to automatically share financial information from the bilateral Tax Information Exchange Agreements by 2017 or 2018 (OECD 2016a). Digitalization allows financial institutions—banks, insurance companies, investment funds, pension funds, and so on—to act as third-party reporters on capital incomes and wealth for the government. Moreover, financial transaction taxes can help generate additional information on taxpayer assets.

Consumers as Third-Party Reporters

If most consumer transactions are digitized, consumers can act as third-party reporters for the VAT or sales tax. In a cashless economy, as advocated by Rogoff (2016), all consumer transactions would be digital. Governments could then employ electronic payment information (such as through debit and credit card payments) or use information on consumption from digital platforms (Chapter 3) to estimate the aggregate sales of particular firms. Information on sales of individual companies can help governments reduce tax avoidance and evasion of firms in the VAT or sales tax. However, firms that are evading taxes have strong incentives to transact in cash rather than electronically. Hence, digitalization brings only limited reduction of tax evasion if a large volume of consumer transactions remains in cash.

DIGITALIZATION AND TAX DESIGN

Optimal Taxation of Labor Income

The Nobel-prize winning article of Mirrlees (1971) shows how information constraints determine the inescapable trade-off between equity and efficiency. Mirrlees' static model analyzes optimal nonlinear taxation of labor income. One may view the Mirrlees model in broad terms as a theory of optimal income redistribution or, even broader, as a theory of the optimal welfare state. The Mirrlees framework determines how *effective* marginal tax rates should optimally vary with income. The effective marginal tax rates on labor income include statutory tax rates, as well as the impact of all income-dependent transfers, tax credits, tax deductions, and benefits aimed at redistributing income. The government aims to optimally set the effective marginal tax rate at each level of labor income. Individuals are different in their earning ability, which equals their productivity per hour worked. Individuals trade off the benefits of consumption and the costs of supplying work effort.[7] The government redistributes income from high-ability

[7]These costs may be narrowly interpreted as forgone leisure, but also more broadly as encompassing the costs of forgone household production or forgone income from the informal or black labor market. Consequently, elasticities of taxable income are bigger if the possibility of working in the informal sector strengthens behavioral responses to taxation.

to low-ability individuals. Social preferences for income redistribution are exogenously given.

The fundamental information constraint in the Mirrlees (1971) framework is that both earning ability and work effort are private information and are thus non-verifiable by the government. Indeed, all the government can verify is total labor income, which is the product of earning ability and work effort. Due to information constraints, the second theorem of welfare economics breaks down, since non-distortionary individualized lump-sum taxes based on earning ability cannot be implemented. The government can only redistribute income through a distortionary nonlinear tax schedule on labor income. By taxing labor income, the government not only redistributes the rents from earning ability, but also the fruits of labor effort. Hence, income redistribution distorts incentives to work.

Mirrlees (1971) theoretically derives the optimal nonlinear income tax schedule. The optimal marginal tax rate at each point in the income distribution is set such that the marginal distributional benefits of a higher marginal tax rate are equal to the associated marginal deadweight losses of distorting work effort. Recent literature has shown that the optimal tax schedule typically features a U-shape with income. The economic logic behind the U-shape is as follows. The redistributional benefits of setting a higher marginal tax rate at a particular income level always decline with income. Intuitively, an increase in marginal tax rates yields less additional tax progression if the rate is raised at a higher income level. Raising the tax at a higher income level gives lower revenues than raising the tax rate at lower income levels. Given that revenues are lower, tax credits, transfers, or deductions cannot be raised as much if marginal tax rates are increased at higher income levels. At the same time, the tax distortions of a higher marginal tax rate follow the shape of the income distribution: the tax base first increases with income and then decreases with income for most empirical distributions of income. For a given elasticity of taxable income, the same marginal tax rate thus yields low distortions at low incomes, highest distortions for middle-income groups, and then lower distortions for the high-income groups. This is standard Ramsey logic. Therefore, marginal tax rates start out high at low-income levels (high distributional benefits–low distortions), then decline toward the mode of the earnings distribution (lower distributional benefits–higher distortions), increase again after the mode (lower distributional benefits, but also lower distortions), and gradually converge to a constant top rate for high income earners.[8]

A crucial insight into the potential of digitalization follows directly from Mirrlees (1971): digitalization does *not* have any potential to improve the tax system under the assumptions of the Mirrlees framework. If earning ability (labor effort) is fundamentally non-verifiable, as Mirrlees assumes, then digitalization cannot change this fundamental information constraint: earning ability and labor effort remain non-verifiable even in a fully digitized world. Hence, digitalization

[8]For more elaborate explanation of the shape of the nonlinear tax schedule, see also Mirrlees (1971), Diamond (1998), and Saez (2001).

has no power to alleviate the equity-efficiency trade-off. This is in line with remarks in Kanbur (2017).[9] Another way to interpret this is that, if income redistribution is optimized through the nonlinear tax on labor earnings, the government fully exploits all available information on taxpayers' labor earnings. Moreover, digitalization cannot help to improve tax enforcement, since tax enforcement is already assumed to be perfect. That is, labor earnings are assumed to be completely verifiable in Mirrlees (1971).

Digitalization and Progressive Consumption Taxes

The Mirrlees (1971) model of optimal income taxation is not readily applicable to developing countries, where tax enforcement is generally too weak to verify labor incomes. Therefore, most developing countries have a strong reliance on consumption taxes to raise revenue or to redistribute income. Digitalization may help to alleviate the equity-efficiency trade-off if earned income is not verifiable to the government and the government is forced to tax consumption.

Electronic transaction systems and biometric identification technology could help to implement a non-individualized, lump-sum transfer besides the consumption tax.[10] Therefore, digitalization allows the government to implement a *progressive* consumption tax instead of a proportional consumption tax, even if income is not verifiable and untaxed. A progressive consumption tax can thus redistribute more income for the same consumption tax rates or lower consumption tax rates can be set for the same amount of income redistribution. Therefore, digitalization can improve the redistributive powers of the commodity tax system.

[9]In contrast, Chen, Grimshaw, and Myles (2017) argue that digitalization may, in the future allow the government to verify individual earning ability. If earning ability would indeed become verifiable, the incentive problem that is central to optimal tax theory vanishes, and first-best outcomes can be achieved. One should, however, be skeptical about this idea for a number of reasons. First, it is not immediately clear what should be the proper measure for exogenous earning ability. For example, earnings per hour worked are endogenous and the result of investments in education, occupational choices, on-the-job training, intensity of work effort, luck in the labor market, and so on. Second, it is hard to find truly exogenous measures for earning ability, since even supposedly exogenous measures, such as IQ or genes, may be malleable. This would introduce new behavioral responses, as Chen, Grimshaw, and Myles (2017) also point out. Third, finding measures for earning ability raise a host of philosophical, political, and legal issues as to what the proper measures of earning ability ought to be. Fourth, even if a tax on ability would be possible, a time-consistency problem in taxation emerges. Individuals anticipating fully individualized lump-sum taxation after they revealed their earning ability to the government, have strong incentives to misrepresent their earning ability or to game the tax system to prevent such first-best individualized lump-sum taxation (Roberts 1984).

[10]Consider a budget constraint of an individual that earns wl, where w is the wage and l is labor effort. This individual spends earned income on consumption c which is taxed at rate τ: $wl = (1 + \tau)c$. Clearly, if a non-individualized lump-sum transfer g could be provided to individuals, based on electronic transactions or biometric identification, the budget constraint would become: $wl + g = (1 + \tau)c$. This would change the consumption tax from a proportional to a progressive one, provided the transfer g is positive.

Many countries also rely on differentiated commodity taxes to redistribute income, such as through low VAT-rates on necessities. In the absence of an income tax, such a policy can be desirable for redistributive reasons. However, if the tax system would allow for a non-individualized, lump-sum transfer, besides linear consumption taxes, the government might be able to optimally reduce the reliance on low VAT rates to redistribute incomes.[11] Thus, the government could organize more income redistribution through a linear consumption tax supplemented with a lump-sum component, which would avoid the distortions associated with differentiated consumption taxes, such as low VAT rates.

Optimal Income and Commodity Taxation

The stylized Mirrlees model of optimal nonlinear income taxation considers only two commodities (consumption and leisure) and the government receives only one signal of earning ability: labor income. However, individuals in the real world may make many more choices: they choose between different consumption goods at one time, between consumption at different points in time (their savings), they choose how to save (portfolio choices), investments in education, and so on. Moreover, individuals may differ in more than their earning ability: their preferences, such as the preference for different commodities (rental housing, health care), time preference (for saving or borrowing), or risk aversion. Consequently, how should tax systems be optimized when individuals face choices among multiple commodities and may differ in their preferences? And, can digitalization help improve the equity-efficiency trade-off in tax systems that tax different consumption goods and consumption in different periods?

The starting point in the theory of optimal commodity taxation is the Atkinson-Stiglitz (AS) theorem, which derives the conditions under which government can organize all desired income redistribution with only a nonlinear tax on labor income, without resorting to commodity tax differentiation (Atkinson and Stiglitz 1976). The AS theorem is an important benchmark. If there is no need to differentiate commodity taxes, all redistribution can be carried out through nonlinear income taxes. With perfect enforcement of income taxes, as the AS theorem assumes, there is no need to have commodity taxation at all. Exactly the same economic outcomes can be achieved by setting all (uniform) commodity taxes to zero and proportionally adjusting the tax on labor income. How should taxes then be optimally divided between taxes on labor income and consumption? Under the conditions of the AS theorem, the distinction between taxes on income and consumption is immaterial. In practice, however, the

[11]Indeed, if individual preferences are of the Gorman polar form, which includes the Cobb-Douglas, constant elasticity of substitution (CES), Stone-Geary, linear expenditure system (LES), and iso-elastic utility functions, then the government optimally sets uniform consumption taxes even if the poor spend a disproportionate fraction of their income on necessities (Deaton 1977).

reliance on both income and consumption taxes presumably relies on issues of tax enforcement.[12]

The AS theorem shows that commodity taxes should be uniform if (1) individuals only differ in their earning ability, (2) earning ability only affects labor income, (3) individuals have identical preferences over various commodities, and (4) utility from commodities is weakly separable from utility of leisure (Atkinson and Stiglitz 1976; Laroque 2005; Jacobs and Boadway 2014). Weak separability implies that the willingness to supply labor is independent of how individuals like to spend their income. In particular, commodity demands are identical for all individuals earning the same income. Commodity demands thus do not reveal any more information on earning ability than is already present in labor earnings. Consequently, differentiated commodity taxes cannot redistribute any more income than the nonlinear income tax can, but in addition also distort commodity demands. Another (but equivalent) way to think about the AS theorem is that weak separability implies that all commodities are equally complementary to work (or leisure), because commodity demands are the same for everyone with the same labor earnings. Hence, differentiated commodity taxes cannot alleviate distortions on labor supply by taxing goods that are complementary to leisure (complementary to work) at higher (lower) rates, but only distort commodity demands.

Under the conditions of the AS theorem, digitalization has no promise to improve upon pre-existing tax schedules, since all redistribution should be carried out through the nonlinear tax on labor income. As argued above, digitalization has no promise under the conditions of the Mirrlees (1971) framework with only two commodities (consumption and leisure). A corollary to this result is that digitalization has no promise either to improve existing tax systems in the Atkinson and Stiglitz (1976) framework with multiple commodities if the conditions for the AS theorem indeed apply. Under these conditions, it is socially optimal to organize all redistribution through the nonlinear income tax and commodity taxes are superfluous. Consequently, any promise for digitalization to improve on the equity-efficiency trade-off relies on the breakdown of the AS theorem.

All the conditions underlying the AS theorem are expected to fail in the real world: even if individuals differ in only one "deep" characteristic—their earning ability—heterogeneity in earning ability may also determine their preferences for different commodities or parts of their income other than their labor income (such as capital income). Furthermore, individuals' preferences do not need to be

[12]Tax administration and enforcement of nonlinear income taxes can be more costly than that of linear consumption taxes. Most consumption taxes need to be linear, since individual consumption transactions are anonymous. However, linear consumption taxes are inferior instruments for income redistribution compared to nonlinear income taxes. Consequently, governments may want to use both linear consumption taxes and nonlinear income taxes to balance the costs of tax evasion and avoidance in income taxes with the distributional losses of consumption taxes (Boadway, Marchand, and Pestieau 1994).

weakly separable between labor and all other commodities, so that commodity demands interact with labor choices. Moreover, the AS theorem also breaks down if individuals differ in more than one "deep" characteristic. Think of health, time preference, and so on. In all these cases, commodity taxes are not redundant. If commodity taxes are not superfluous, there is potential for digitalization to improve the equity-efficiency trade-off.

A later section turns to the (complex) question of how taxes should optimally be set if individuals differ in multiple deep characteristics. The following sections focus on the case where heterogeneity is still one-dimensional, but affects more than only labor earnings. In particular, it focuses on commodity taxation and taxation of capital income.

Digitalization and Commodity Taxation

If the conditions for the AS theorem fail, commodities should be taxed besides labor income, possibly under a nonlinear schedule. This is the case if heterogeneity in ability—besides labor income—also determines preferences for commodities or capital (or other) income. Commodity demands then reflect not only differences in labor earnings, but also preferences for commodities or the other source of income. For example, earning ability can be correlated with endowments, capital income, or inheritances.

It is optimal to tax commodities at higher rates if commodity demand—conditional in labor income—correlates positively with earning ability, which is due to the correlation of earning ability with initial endowments of commodities (Cremer, Pestieau, and Rochet 2001; Gerritsen and others 2017).

Moreover, individual preference may depend on ability. Commodities should be taxed at higher rates if the high-ability individuals like to consume these commodities more than low-ability individuals—conditional on labor income (Mirrlees 1976; Saez 2002). Intuitively, if commodity demands differ by individual, then commodity demands reveal additional information on earning ability, besides the information obtained by observing labor earnings.

Furthermore, even if preferences for certain commodities are the same for all individuals, but not weakly separable from labor, then some commodities are stronger (weaker) complements to work than others. Hence, the willingness to consume certain goods varies by individuals' labor effort. The government then optimally lowers (increases) the tax on commodities that are complementary to work (leisure) to alleviate the distortions of the income tax on labor supply (Corlett and Hague 1953; Atkinson and Stiglitz 1976; Jacobs and Boadway 2014).[13]

Optimal commodity taxes should be nonlinear and depend on individual commodity demands (Atkinson and Stiglitz 1976; Mirrlees 1976). Of course,

[13]The Ramsey inverse elasticity rule is a special case of the Corlett-Hague motive for commodity tax differentiation; the most elastic goods are the goods that are the strongest complements to work (Ramsey 1927).

commodity tax differentiation—whether for redistributional or efficiency reasons—always comes at a cost in terms of distorted commodity demands.

How, then, does digitalization affect the setting of optimal commodity taxes, provided that commodity tax differentiation is indeed desirable? Nonlinear commodity taxation requires that the government can verify individual commodity demands. Digitalization may be especially helpful if it helps to collect information on individual consumption, as argued above. If all consumption transactions were verifiable, through electronic payment systems, for example, then governments could be in the position to levy individualized, nonlinear consumption taxes. Important examples of such commodities are water, electricity, and gas. Nonlinear taxes (subsidies) are also often levied on many services, such as health care, education, and (house) rentals.

However, in practice, most taxes on commodities are linear. Nonlinear taxation of commodities is impossible if commodities can be traded in secondary markets, and if these trades cannot be verified by the government. Secondary markets exist for commodities that are transportable, durable, and storable. Hence, individuals paying different nonlinear commodity taxes trade on secondary markets until all net price differentials are arbitraged away. Non-verifiable trades in secondary markets effectively make individual commodity demands non-verifiable so that only linear commodity taxes can be implemented.[14] Commodities that are non-transportable, perishable, and non-storable are difficult to trade in secondary markets, and, hence, these commodity demands can be verifiable to the government. Consequently, these commodities can be taxed nonlinearly.[15]

Digitalization may, therefore, complement existing commodity tax systems by allowing for nonlinear taxes on individual commodity demands of verifiable commodities. Nonlinear commodity taxes redistribute income at lower efficiency cost than linear commodity taxes—provided individual commodity demands can be verified. Although a theoretical case for nonlinear commodity taxation can be made easily, it is not clear which commodities should be taxed and how commodity taxes should then be differentiated. Empirical literature clearly rejects the conditions for the AS theorem.[16] At the same time, the literature provides very little guidance for the setting of commodity taxes. More empirical research on

[14]Diamond and Mirrlees (1971a, b), Atkinson and Stiglitz (1976), Saez (2002), Mirrlees (1976), and Jacobs and Boadway (2014) show that optimal linear commodity taxes need to be used for redistributive reasons—if taxes on income are constrained to be linear or if preferences are heterogeneous and, for efficiency reasons, to reduce labor-tax induced distortions on labor supply.

[15]Secondhand markets also become increasingly more digitized, such as through online platforms for secondhand commodities. However, it is unlikely that this would allow for nonlinear consumption taxes on the goods traded on these platforms, since the characteristics of the commodities do not change as a result of trading them on secondhand platforms. In particular, nonlinear commodity taxation would induce tax arbitrage because the commodities are still durable, transportable, and storable.

[16]For example, see Browning and Meghir (1991); Crawford, Keen, and Smith (2010); Gordon and Kopczuk (2014); and Pirttilä and Suoniemi (2014).

commodity demands is, therefore, needed to inform the policy discussion on the optimal setting of consumption taxes in a digitized world.

Taxation of Corporate Income

The corporate income tax is presumably the most distortionary tax in most modern tax systems. Indeed, optimal tax theory provides no solid welfare-economic basis for taxing capital income at source. Taxing capital income at source interferes with production efficiency, as it distorts a firm's investment, leverage, and location decisions. Production inefficiencies should preferably be avoided, even in second-best settings with distortionary taxation (Diamond and Mirrlees 1971a, b).[17]

Arguably, the most important task of the corporate income tax is to act as a "backstop" for the personal income tax. It is more difficult for governments to tax each shareholder individually under the personal income tax than to tax firms paying out dividends to many different shareholders. Moreover, taxing shareholders individually is more difficult in a financially globalized world, where individuals have their assets located in many countries. Hence, if taxing capital income on a residence basis is too difficult or costly to implement, then taxing at source may be the only way to tax capital income.[18]

Digitalization would hold a big promise to tax shareholders directly if international registers would be set up in which information on all assets and asset incomes were collected. If individual capital incomes can be verified by governments, then capital income can be taxed on residence basis rather than on source basis. Moreover, if assets and capital incomes are registered digitally, substantial improvements in tax collection can be achieved. The corporate income tax might then no longer be needed to backstop personal income tax.

In its most radical form the corporate income tax can be abolished entirely. Alternatively, the corporate income tax can still be used as a withholding tax on dividend incomes, as it was originally intended when introduced (Zucman 2015). In doing so, the government could rely on third-party reports on dividend payouts of firms, and thereby reduce tax evasion in reported capital incomes. Moreover, by levying a withholding tax at the corporate level, rather than at many

[17]The production efficiency theorem relies, however, on a number of important assumptions, which need not be met in reality (Diamond and Mirrlees 1971a). First, the government needs to verify all factor payments in all production sectors of the economy. Hence, the production efficiency theorem breaks down if there are untaxed informal or black sectors. Second, all labor types (or occupations) need to be perfect substitutes in production, such that all wage rates per hour worked are symmetrically affected by production distortions. If labor types are not perfectly substitutable, the government needs to set a labor type (occupation)-specific labor tax schedule (Scheuer and Werning 2016). Third, there need to be constant returns to scale in production (zero profits) or the government needs to have access to a 100 percent tax on pure profits.

[18]Alternatively, the corporate income tax could be viewed as a benefit tax to compensate governments for investments in infrastructure, human capital, institutions, and so on. Furthermore, the corporate income tax could be seen as a way to shift part of the tax burden to foreign shareholders. The latter argument becomes less important in practice due to high and increasing capital mobility.

shareholders in the personal income tax, there can still be economies of scale in the collection of taxes on dividends.

Removal of source-based taxes on corporate income would eliminate the substantial economic distortions generated by the corporate income tax. In particular, most countries have adopted a "classical" corporate tax system, where the costs of equity finance (dividends) are not deductible from the corporate income tax, whereas costs of debt finance (interest) are. Consequently, by taxing the normal and above-normal returns to equity, the corporate income tax raises the user cost of capital as long as not all investments are financed with debt, so that the corporate income tax reduces corporate investment. Moreover, due to the asymmetric tax treatment of debt and equity, corporations have tax-induced incentives to finance their activities relatively more with debt. This "debt bias" not only distorts the optimal capital and risk allocation in economies, but high leverage also promotes financial instability and fragility (IMF 2016). Further, differentials in corporate income tax rates across countries provide incentives to relocate real economic activities to lower-taxed countries or to shift profits to lower-taxed countries through transfer price manipulation, debt shifting, or licensing. If capital income were taxed on a residence basis, rather than at source, all these distortions would disappear. Tax arbitrage through the corporate income tax would stop as well.

Moreover, taxing capital income on a residence basis would end tax competition in the corporate income tax. Countries may respond strategically to the setting of corporate income tax rates of other, neighboring countries to attract economic activity (Keen and Konrad 2013). Empirically, tax rates are found to be strategic complements, especially in the European Union, which implies that countries lower their corporate income tax rates if other countries do so (Devereux and Loretz 2013). Therefore, tax competition may result in a "race to the bottom," where corporate income tax rates are driven down to very low or even zero levels. Such fears are stoked by observed declines in corporate income tax rates in most of the Western world in recent decades. If taxation of capital income were no longer at source, but on a residence basis, part of the tax competition for mobile capital would presumably move from the corporate income tax to the personal income tax, as countries might lower taxes on interest, dividends, and capital gains in the personal income tax to attract high-net-worth individuals instead of firms.

Optimal Taxation of Capital Income

The AS theorem also provides the foundation for the well-known theoretical result that the (normal return to) capital income should not be taxed in the personal income tax if preferences are identical and weakly separable between labor and consumption in different periods, and heterogeneity in earning ability only

affects labor income.[19] However, as with commodity taxes, these conditions for zero capital taxation are not met in practice. Taxes on capital income should be positive for a number of equity reasons, because of the following:

- discount rates decrease with earning ability (Mirrlees 1976; Saez 2002; Banks and Diamond 2010; Diamond and Spinnewijn 2011)
- initial assets or bequests typically increase with earning ability (Cremer, Pestieau, and Rochet 2001; Piketty and Saez 2013)
- asset returns increase with earning ability (Gerritsen and others 2017)
- assets or bequests increase with positive shocks in earning ability (Jacobs and Schindler 2012).

Consequently, capital incomes are higher for high-ability individuals—even if labor earnings would be the same. Positive taxes on capital income are therefore optimal for income redistribution.

Optimal taxes on capital income should also be positive for a number of efficiency reasons. In particular, taxes on capital income are desirable because they accomplish the following:

- prevent tax arbitrage with labor taxation (Christiansen and Tuomala 2008; Reis 2011);
- tax rents (Correia 1996)
- reduce labor supply distortions (Corlett and Hague 1953; Atkinson and Stiglitz 1976; Erosa and Gervais 2002; Conesa, Kitao, and Krueger 2009; Jacobs and Boadway 2014)
- reduce human capital distortions (Jacobs and Bovenberg 2010)
- alleviate capital market failures (Aiyagari 1995)
- alleviate insurance market failures (Golosov, Kocherlakota, and Tsyvinski 2003; Golosov, Troshkin, and Tsyvinski 2016; Jacobs and Schindler 2012; Fahri and Werning 2012).

There are thus good economic reasons to tax capital income at a positive rate, disposing of the theoretical argument for a consumption (or expenditure) tax that implies no taxation of (the normal return to) capital income. However, there is no reason to presume that taxes on capital income should be the same as taxes on labor income (a synthetic income tax), given that taxes on labor and capital income have both different excess burdens and different distributional benefits. Hence, a dual-income-tax system, where labor and capital income are taxed under separate schedules, is likely to be optimal (Jacobs 2013).

[19]Chamley (1986) and Judd (1985) also find that the optimal tax on capital income is zero in the long run. Jacobs and Rusu (2017) show that this result ultimately derives from optimal commodity tax principles. In particular, the long-term tax on capital income is zero because consumption over time has become equally complementary to leisure. Hence, taxing capital income has no benefit in terms of lower labor market distortions, but only costs in terms of saving distortions. Consequently, Chamley (1986) and Judd (1985) can be interpreted as a special case of the AS theorem.

By the same argument, one would expect that differential taxation of various sources of capital income—interest on saving deposits and loans, dividends and capital gains on traded shares and non-traded closely held shares, rent and capital gains from housing, and asset accrual in pension funds—would be desirable. However, a differential tax treatment of various assets is likely to provoke large-scale tax arbitrage among asset classes, since it is easy to transform one asset into another, for example, through investment funds, housing, pensions, and firm ownerships. Therefore, all capital income probably needs to be taxed under a uniform tax regime.

Most tax systems apply differing tax rates on the various sources of capital incomes and wealth (Harding 2013; OECD 2011, 2016b). Housing is often subsidized (mortgage rent deductibility, very low or no taxation of imputed rent). Pensions are generally subsidized (often tax-exempt pension accrual, various tax advantages in the personal income tax). Interest income, dividends and capital gains are generally taxed in the personal income tax, although some countries do not tax capital gains. Asset income from personal businesses often receives a separate tax treatment, and generally entails various tax advantages. For example, countries that tax capital gains on a realization basis—on traded shares or closely held shares—generally do not account for interest accrued on unrealized capital gains (Auerbach 1991).

The differential tax treatment of various sources of capital income opens the door to tax arbitrage, between asset classes, between persons or legal entities, and over time (such as through pension constructions). Moreover, a patchwork of capital taxes creates all sorts of economic distortions. A non-exhaustive list includes too-high leverage in household financing decisions as a result of debt bias (in housing and sole proprietorships), and distorted risk allocations due to poorly diversified household portfolios (such as over-exposure to housing market risk, too high investment in illiquid pension wealth). Low taxes on capital incomes (or even subsidies) result in greater distortions in labor markets as the tax burden is shifted to labor income or consumption. Higher taxes on both labor income and consumption weaken incentives to supply work effort, to participate in the labor market, to invest in human capital, and to retire later.

Digitalization allows governments to create and link data registers on wealth and capital incomes—savings, publicly traded assets, closely held assets, home-ownership, pensions, and bequests/estates. Digitalization therefore makes it possible to implement a dual-income-tax system in which "comprehensive" capital income and wealth can be linked and taxed symmetrically under a single overall regime for capital income: a "synthetic capital income tax." Under this regime, all capital income would be added and taxed under a single schedule. This schedule would preferably entail a flat tax rate that is applied to all capital income above a certain tax-free exemption.[20] This tax change is desirable to reduce tax arbitrage

[20]The government may provide tax incentives to save for retirement by introducing a larger tax-free exemption for the tax on capital income. The government then provides incentives for retirement saving irrespective of how individuals save for retirement: whether through personal

and raise the efficiency and equity of current personal income tax systems. A single rate on all sources of capital income eliminates arbitrage across all sources of capital income, over time, and between persons or legal entities. Moreover, capital and risk allocations would no longer be distorted. Finally, the government could more easily achieve an optimal mix of taxes on labor and capital income.

Jointness in Tax Systems

Real-world tax systems are generally quite simple. In its most simple form, all sources of income are taxed under one progressive tax schedule (synthetic income tax). However, various countries levy separate tax schedules on different sources of income. These tax schedules are generally independent or "disjoint" from each other. For example, the marginal tax rate on labor earnings depends on only labor income and is independent of the level of capital income or wealth. Similarly, the marginal tax rate on capital income—in a dual-tax system—depends on only capital income and not on labor income.

Of course, exceptions do exist. Although tax rates on labor earnings are generally independent of capital income (in dual-tax systems) or assets (in synthetic-tax systems), many countries apply asset tests in benefits or sickness, disability, unemployment, or welfare. Hence, the tax-benefit schedule features "jointness": the effective marginal tax rate (that is, including the impact of benefits, tax deductions, and tax credits) on labor income depends on wealth. The question is then whether cross-dependencies—or jointness—in tax schedules are socially desirable. If they are, then digitalization can be very useful to administer and implement these much more complex tax systems.

The starting point to think about cross-dependencies in tax schedules is Mirrlees' (1976) analysis of optimal income and commodity taxation. Mirrlees assumed that earning ability is the only "deep" primitive parameter that determines all heterogeneity among individuals in not only labor earnings, but potentially also their preferences, endowments, and so on. Mirrlees already showed that it is optimal to levy *separate* nonlinear taxes on income and commodities. Hence, if individuals differ in only one deep characteristic, cross-dependencies in tax schedules are superfluous (see also Renes and Zoutman 2016b). Consequently, digitalization would once more not be helpful in improving existing tax systems by being able to create jointness in tax schedules.

Jointness in tax schedules is desirable if individuals differ in *more* dimensions than just their earning ability. Kleven, Kreiner, and Saez (2009); Golosov, Tsyvinski, and Werquin (2014); Renes and Zoutman (2016a, b); and Spiritus (2017) build on Mirrlees (1976) to analyze optimal nonlinear taxes in models in which individuals may differ in more than one characteristic, such as their earning ability, participation costs, health status, time preference, risk aversion, and so on. Consequently, not all heterogeneity between individuals can be reduced to

savings and stock market investments, through their house, through personal businesses, or through pension funds.

one underlying factor, as in nearly the entire optimal tax literature. These authors all derive that optimal tax systems feature cross-dependencies in tax schedules. For example, the optimal tax rate on labor earnings depends on capital income or assets (and vice versa). Similarly, the tax rate on certain commodities depends on labor income and capital income or assets. Cross-dependencies thus become desirable if individuals differ in more than one dimension than their earning ability.

As a rule of thumb, an optimal tax system has a number of interdependencies among tax schedules that is equal to the number of characteristics in which people differ (that is, the dimensionality of the type space).[21] Intuitively, the role of introducing cross-dependencies in tax schedules is to reduce the economic distortions of tax systems. If individuals differ in multiple dimensions, they can adjust their behavior in multiple dimensions, making it harder for governments to target income redistribution toward the individuals it likes to support. However, by introducing jointness in tax schedules, governments can more effectively "control" the behavioral responses to income redistribution. In terms of optimal tax jargon: multidimensional heterogeneity allows individuals to "game" the tax system by making profitable ("double" or "joint" deviations).[22] Introducing jointness in tax schedules makes these joint deviations less attractive. Hence, incentive constraints associated with income redistribution are relaxed. Consequently, introducing joint tax schedules allows governments to achieve the same (more) redistribution at lower (the same) efficiency costs.

To see how jointness in tax systems can be desirable, consider the following simple example, inspired by Diamond and Spinnewijn (2011). Suppose that labor income is taxed and capital income is not. Then, the individuals with both a high earning ability and a strong time preference can work less tomorrow and save more today to reduce labor income taxes and increase leisure tomorrow, while sacrificing some consumption today. This strategy is desirable if the individual ultimately pays less labor tax by simultaneously changing labor supply and saving behavior. Therefore, for any marginal tax rate on earnings, the labor tax achieves less income redistribution. Now, if the government conditions the tax

[21]Intuitively, the optimal tax function must implement the second-best allocation of a direct mechanism in which the government designs a resource-feasible and incentive-compatible allocation, in which each individual truthfully reveals all hidden characteristics by a particular choice of commodities. To have full revelation of J hidden characteristics, the optimal wedge on each good should also be a function of the demand of at least J commodities.

[22]It is not guaranteed that joint schedules can in fact be implemented. Implementation problems arise because individuals can make combinations of commodities using market transactions that would be unavailable to them in an optimal direct mechanism. This is again the problem of "joint deviations." Renes and Zoutman (2016b) derive that implementation of joint schedules is possible in two classes of tax problems. In the first class of tax problems, the allocations should be (second-best) Pareto efficient and there should be no externalities. In the second class of tax problems, the second-best allocation should be surjective onto the choice space, so that implementability conditions coincide with incentive compatibility constraints. Golosov, Tsyvinski, and Werquin (2014) and Spiritus (2017) *assume* that all given joint tax schedules are implementable for any set of model primitives. These authors only analyze the optimality properties of optimal tax systems.

rate on labor income on capital income, such that individuals with higher incomes pay a positive marginal tax on saving, then the individual is discouraged from making the double deviation of saving more and working less to reduce its tax bill. Hence, there will be smaller behavioral responses to income redistribution, so that the government can alleviate the equity-efficiency trade-off by introducing a joint schedule on labor income and assets.

An important policy question is: How should optimal taxes be designed when individuals are heterogeneous in more than one dimension? The remainder of this section considers several suggestions where jointness can improve existing tax systems. However, not much is known theoretically and empirically about how such joint schedules should be designed. More research is needed to identify the potential welfare gains of implementing joint tax systems and how they should be designed in practice.

Taxation of Lifetime Income

The main insight of the previous section—tax systems should optimally have as many cross-dependencies as characteristics of individuals—generalizes to settings in which individuals have different earning abilities at different moments in time. Hence, a joint tax schedule based on the entire history of earnings is optimal. Jointness implies that the marginal tax rate on earnings in year t depends not only on the earnings in year t, but also on all earnings in all other years $s \neq t$. The optimal tax rate on labor income in each year thus depends on the entire history of labor earnings, including all future earnings. Roughly speaking, earnings in a given year are a reflection but not a perfect indicator of "average earning ability" over the lifecycle or "lifetime earning ability." Hence, by basing taxation on each year's labor earnings, the government can redistribute better toward the individuals who have, on average, lower earnings ability and thus lower lifetime earnings. Earnings in each period provide useful information on the lifetime earning ability of individuals. Consequently, by using the entire history of earnings, the government employs more signals of lifetime earning ability in setting taxes. Thus, governments can tax labor income with lower efficiency costs—for given distributional objectives—by conditioning tax schedules on the entire history of labor income.

If individuals do indeed have different earnings ability in each year of their lifecycle, under which conditions is a time-invariant (or age-independent) nonlinear income tax optimal? Werning (2007) shows that optimal marginal tax rates over time are generally not constant, since neither tax distortions nor distributional gains of income taxes are constant over time. Tax schedules are only constant over time ("tax smoothing") with power utility functions—resulting in constant elasticities—and age-earnings profiles that are parallel across individuals. The latter implies that there is really only *one* underlying source of heterogeneity (Werning 2007). Hence, only in this special case is it sufficient to have a tax schedule based on yearly earnings only.

The discussion of taxing the history of labor earnings is also related to an old idea of Vickrey (1939, 1947) to base income taxation on cumulative averaging of

income. Horizontal equity principles suggest that lifetime taxation is preferable over yearly taxation. Intuitively, individuals with the same average lifetime income, but with more fluctuations in their incomes, will pay more tax under a progressive income tax system based on yearly income. Moving toward lifetime taxation would remove this inequity. Yearly income may also be poor measure for lifetime income in the presence of strongly changing earnings profiles over the lifecycle, insurance market failures (no insurance of risk in labor and capital income), and incomplete capital markets (borrowing/liquidity constraints). Consequently, lifetime taxation may redistribute income more effectively and alleviate some of the capital and insurance market imperfections by lowering tax burdens in low-income phases/states and raising the tax burden in high-income phases/states. Moreover, progressive yearly tax systems create incentives for shifting incomes over time from periods with high tax rates toward periods with low tax rates, particularly capital income. These disincentives can be avoided by moving to a lifetime tax system.

Vickrey (1939, 1947) proposed to tax the yearly average of taxable income, as if all taxable incomes had been constant over time.[23] Very little attention has been paid to taxation of the cumulative average of earnings in the tax literature. An exception is Liebman (2003) who analyzes income averaging in taxing labor income if there is no taxation of capital income. He shows that cumulative averaging of labor taxes can produce small equity gains and substantial efficiency gains in terms of lower labor supply distortions and better smoothing of consumption in the presence of present bias or borrowing constraints. In many countries, electronic tax files are available for many years for individual taxpayers. Digitalization therefore makes it possible to implement Vickrey's (1947) proposal for an average tax on cumulative income, which converges to the taxation of lifetime income. No country has until now implemented Vickrey's tax cumulative earnings.[24] Alternatively, digitalization may allow for marginal tax rates dependent on entire earnings histories. Doing so can raise social welfare by achieving distributional objectives at lower efficiency costs by targeting income redistribution better toward the lifetime poor.

Joint Taxation of Labor and Capital Income

As argued above, if individuals differ in more than one characteristic, then cross dependencies in tax schedules are generally optimal. The so-called New Dynamic Public Finance literature (Golosov, Kocherlakota, and Tsyvinski 2003; Kocherlakota 2005, 2010; Golosov, Tsyvinski, and Werning 2007)

[23]Since Vickrey (1939, 1947) discussed a traditional synthetic income tax, he proposed provisions to account for taxing interest on unrealized capital gains so that all incentives for deferral of capital gains would be removed. See also Auerbach and Bradford (2004) for more on this.

[24]Vickrey (1939) shows that one requires only two consecutive tax returns to practically implement a tax on the cumulative average of income. Hence, the "digitalization" requirements to implement such a system are minimal (or even absent).

analyzes nonlinear taxes on income, consumption, and capital in models where individuals are heterogeneous in their earning ability in every period of their lifecycle.[25] This entire literature demonstrates that optimal taxes on labor income generally depend on the level of assets or capital income and vice versa. Consequently, some form of asset testing is optimal. Intuitively, by conditioning income redistribution on the level of assets (or capital incomes), individuals get weaker incentives to jointly distort labor supply and saving behavior to benefit from the redistributive schemes aimed at the (lifetime) poor. For example, Golosov and Tsyvinski (2006) show that individuals may save more income in early periods of the lifecycle to falsely claim disability benefits in later stages of their lifecycle. Asset testing of disability benefits makes this "joint deviation" (saving more and falsely claiming disability) less attractive. Their simulations demonstrate that the potential welfare gains from asset testing are substantial.[26]

Digitalization makes it potentially easier to levy sophisticated joint tax schedules over labor and capital income or wealth, where marginal tax rates on labor income can depend on capital income or wealth and vice versa. Indeed, in many countries income support programs are often means tested not only on labor and capital income, but also on wealth. By introducing jointness in tax schedules, the equity-efficiency trade-off can be improved. Digitalization thus holds the promise to more precisely target income support to the lifetime poor, which raises equity (more redistribution for given tax rates), efficiency (lower tax rates for given redistribution), or both.

Joint Taxation of Individual and Household Income

Most tax systems tax either individual incomes or household incomes. The distinction between individual and household taxation is generally not precise. Many countries with individual-based tax systems also allow for dependencies on household income, such as in income support for housing, health care, tax credits, or welfare benefits. Similarly, tax systems are generally not purely based on household income, due to individual-specific elements in tax-benefit systems. In

[25]Earning ability is typically modeled as a stochastic variable, which evolves over time as a Markov-process, possibly exhibiting persistence. In addition, these models may allow for aggregate productivity shocks.

[26]The implementation of optimal second-best allocations requires very complex tax schedules (see also footnote 24). Since insurance markets are missing, externalities are present and implementations of optimal allocations with separate tax schedules generally do not exist (Renes and Zoutman 2016b). Albanesi and Sleet (2006) analyze a version of the New Dynamic Public Finance model with preference shocks (to the disutility of work) rather than skill shocks. If preference shocks are independent and identically distributed, then the optimal nonlinear joint tax schedule depends on current labor income and wealth. Simulations show that marginal labor taxes are declining in wealth. Expected wealth taxes are at most 2 percent, which is quite substantial. Kocherlakota (2005, 2010) allows for general processes of skill shocks and aggregate risks as in the canonical New Dynamic Public Finance model. Optimal nonlinear labor taxes and linear taxes on wealth are shown to be functions of the entire history of earnings. Moreover, the optimal wealth tax is zero in expectation. But these results depend on the particular implementation chosen.

the economics literature, there is a long-standing economic debate on whether it is better to levy taxes based on individual or on household income (such as Boskin and Sheshinski 1983; Kleven, Kreiner, and Saez 2009). This debate has not been settled, since it is fraught with conceptual difficulties as to what the proper objective of policy should be: should it be based on individual or on household welfare? However, even without delving into these discussions, and adhering to a strictly individualistic approach to social welfare, the problem of optimal taxation of individuals in different households is a complex one.

The standard Mirrlees (1971) framework assumes that earning ability is private information and is the only source of heterogeneity. However, if we would allow for households consisting of different individuals, not only is earning ability private information, so are the transfers among household members. If primary earners transfer resources to secondary earners, individual incomes are a poor proxy for individual consumption, and thus for individual welfare. Moreover, income tax schedules cannot be conditioned on individual income after intra-household transfers. A tax system based on household income implicitly takes intra-household transfers into account by basing the total tax liability on joint earnings.

How does the tax system affect efficiency and redistribution if it is based on either individual or household income? To understand the differences between individual and household taxation, assume that a household consists of two income earners. The primary ("male") earner has—by definition—a higher income than the secondary ("female") earner. Furthermore, assume that the secondary earner is more elastic in its labor supply decisions than the primary earner. Suppose furthermore that tax systems are progressive and feature increasing tax rates with income. All these assumptions are empirically valid. Taxation of household income under a progressive tax schedule raises tax rates of the secondary earner and lowers tax rates of primary earners compared to a system of individual taxation—assuming the ordering of incomes of primary and secondary earners remains the same. Given that secondary earners are more elastic in their labor supply decisions, incentives to work will be weaker under a system of household taxation compared to a system of individual taxation. At the same time, a progressive individual tax system puts a larger tax burden on households with a more unequal distribution of labor income ("traditional couples") than on households with a more equal distribution of labor income ("modern couples") if household income is the same in both traditional and modern couples.[27] Hence, a move from a tax system based on individual income to a tax system based on household income redistributes income from "modern" to "traditional" couples. This is the mirror image of the larger labor-supply distortions—on average—implied by household tax system compared to the individual tax system.

[27]This is similar to the notion that progressive tax systems imply a higher average tax burden on more volatile incomes for the same average incomes.

Kleven, Kreiner, and Saez (2009) analyze the joint taxation of households where the primary earner supplies labor on the intensive margin and the secondary earner on the extensive margin. They show that, if two-earner households are better (worse) off than single-earner households, the optimal income tax schedule features a positive tax (subsidy) on labor participation of the secondary earner. The tax schedule displays jointness, since the optimal participation tax on the secondary earner depends on the labor income of the primary earner. In particular, there is negative (positive) jointness if the participation tax (subsidy) decreases in the income of the primary earner. The participation tax converges to zero for very high incomes of primary earners.

Renes and Zoutman (2016a) also provide an example of the optimal joint taxation of couples. They demonstrate that the optimal tax schedule on labor income of the primary (secondary) earner strongly depends on the income of the secondary (primary) earner. Simulations indicate that the marginal tax rate of a top-income primary earner with a spouse having nearly zero earnings faces a marginal tax rate of about 25 percent. However, if both spouses are top income earners their marginal tax rate is about 65 percent. Hence, optimal tax schedules feature (positive) jointness in the income of primary and secondary earners.

Digitalization may allow tax authorities to more easily implement and administer more complex tax schedules that are based on both individual and household income. This is equivalent to conditioning tax schedules on incomes from primary and secondary earners. By levying a joint tax schedule on individual and household (or, equivalently, partner) income, the government can achieve its distributional goals at lower efficiency costs. Such tax systems generate fewer distortions, more equity or a combination of both compared to purely individual-based or household-based tax systems.

Tagging in Nonlinear Tax Schedules

In general, nonlinear tax schedules should be conditioned on immutable household characteristics that can be verified and that are correlated with earning ability—age, gender, unemployment, illness—or related to distributional objectives ("needs")—children, non-working dependents, disability, health. This is the old idea of "tagging" of Akerlof (1978). Indeed, practically all tax countries in the world apply tagging in their tax-transfer systems through tax credits and deductions, and benefits for particular groups that are considered to be more deserving or have larger needs.

However, there is ample room for improving existing tax schedules. The most obvious areas where policy could improve is to implement age- and gender-based nonlinear taxes on earnings. Furthermore, tax schedules could be made (more) dependent on the number of household members. Digitalization could help administer and implement such "tag-dependent tax schedules" based on individual or household characteristics, other than labor or capital income or wealth, that are correlated with ability or need. Intuitively, it is better to levy tag-specific nonlinear tax schedules than to levy one nonlinear income tax schedule

supplemented with various income- or needs-based programs. By introducing separate tax schedules based on individual or household characteristics, governments could once more achieve distributional objectives at lower efficiency costs. Indeed, age-based taxation is shown to substantially improve the equity-efficiency trade-off in Weinzierl (2011); Bastani, Blomquist, and Micheletto (2013); and Fahri and Werning (2013). Similarly, Boskin and Sheshinski (1983) and Cremer Gahvari, and Lozachmeur (2010) demonstrate that gender-based tax schedules can substantially improve equity, efficiency, or both.

Interactions between Tax Complexity and Costs of Tax Enforcement

Digitalization may allow governments to implement more sophisticated tax systems that improve the equity-efficiency trade off. If tax systems are made more complex and sophisticated, as indicated in various policy suggestions, the costs of tax enforcement and tax compliance increase. A related concern is that tax systems would become less transparent and more difficult to understand for taxpayers.

Digitalization may also be useful to make tax systems more transparent and easier to understand. For example, digitalization could help taxpayers gain direct access to their tax returns. Furthermore, governments could provide sophisticated online tax-benefit calculators to assist individual taxpayers with their financial planning. Moreover, as argued above, digitalization potentially also reduces the cost of tax enforcement and compliance. Hence, digitalization may potentially allow for more complex tax systems.

Nevertheless, it is not guaranteed that more complex tax systems are socially desirable. The costs of greater complexity always need to be traded off against the welfare gains of better tax systems in terms of an improved equity-efficiency trade-off. Only if the costs of higher complexity and resulting lack of transparency are sufficiently low will it be socially desirable to implement more complex and sophisticated tax schedules.

CONCLUSION

Digitalization may improve the tax enforcement technology by collecting more and more reliable information on the economic outcomes of taxpayers, and improve the equity-efficiency trade-off by implementing more complex tax systems to better target income redistribution. In doing so, digitalization potentially allows governments to lower tax rates to collect the same amount of revenue or to redistribute the same amount of income as in current tax systems.

The chapter identified five proposals to improve the tax enforcement technology of the government:

1. Digitalization may provide the government with greater information on individual consumption, such as due to increased use of digital payment methods and the phasing out of cash payments.

2. Digitalization can help to generate information on and improve existing links between wealth (traded and non-traded assets, homeownership, pensions) and capital incomes (interest, dividends, capital gains, property income, pension accrual).
3. International information exchange can be made automatic and can be improved by creating international registers for asset ownership and capital incomes.
4. Digitalization allows financial institutions to act better as third-party reporters on capital incomes and wealth for the government.
5. Digitalization makes it possible for consumers to act as third-party reporters for the VAT or sales tax, for example, by using electronic payment information (such as debit and credit card payments).

Moreover, the chapter identified eight proposals to improve the equity-efficiency trade-off by designing more efficient tax systems—more efficient in the sense that distributional objectives can be achieved with lower tax rates and thus lower efficiency costs.

1. International registers of asset ownership and shareholders allow for taxation of capital income on residence rather than on source basis. The corporate income tax could be used as a withholding tax on dividend income or abolished altogether.
2. By combining information on all assets and capital incomes, a dual-income-tax system could be introduced, under which all capital incomes and wealth are linked and taxed under a single tax schedule: a synthetic capital income tax.
3. In developing economies, biometric identification and electronic transaction systems could allow progressive consumption taxes, reducing the need for low VAT rates on necessities for income redistribution.
4. Nonlinear consumption taxes could be levied on goods that are perishable, non-storable, and non-transportable.
5. Vickrey's (1947) proposal for an average tax on cumulative income could be implemented. Alternatively, marginal tax rates could be made dependent on entire earnings histories.
6. Tax schedules could jointly tax labor and capital income or wealth.
7. Tax schedules could jointly tax individual and household income.
8. Separate tax schedules could be introduced based on individual or household characteristics, such as gender, age, disability, health, or children ("tagging"; Akerlof 1978).

Whether governments would like to implement such tax reforms is determined not only by the economic benefits of having better tax enforcement or more efficient tax systems, but also by horizontal equity, privacy concerns and avoiding abuse of state powers. Indeed, these concerns might be the reason many of the suggested tax reforms have not been implemented so far, such as

age-dependent or gender-based tax schedules. Moreover, political-economy constraints can prevent moving to the second-best frontier as identified by optimal tax analysis. However, information on the second-best frontier is important for policymakers, irrespective of whether political constraints prevent reaching this frontier.

Clearly, political distortions are important in real-world policymaking, but the literature does not provide crystallized ideas how political constraints interact with tax distortions. Government can use the information provided by digitalization for both good and bad. Digitalization raises issues about the quality of government institutions and the protection of the privacy of citizens. Digitalization can improve tax systems, increase economic efficiency, and promote equity in countries with good institutions, well-functioning democracies, enforcement of the rule of law, and strict protection of the privacy of citizens. However, more digitalization may well prove counterproductive in countries with bad institutions, greater corruption, more authoritarian regimes, little or no rule of law, and no protection of the privacy of its citizens. Indeed, greater use of information can also enable bad governments to better realize bad policy objectives.

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