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Taxing Artificial Intelligences

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1 Introduction

The Fourth Industrial Revolution is well underway, and there is no doubt that artificial intelligences (AI) will profoundly transform the economy over the next decades. While the impact on the labor market is subject to lively discussions, the problem of how to adapt taxation to the new wave of automatization has received less attention. We provide a guideline to policy makers aiming at efficient and just taxation, thus minimizing distortions associated with taxes, while distributing the tax burden according to justifiable principles. Our main conclusion is that the advent of AI provides strong reasons to increase the share of consumption-based taxes relative to output-based taxes (such as income taxes), as symmetry arguments give rise a trilemma concerning the efficient and just taxation of humans and intelligent machines alike.

We begin by summing up current views on the impact of automatization on employment, wages, tax revenues and the distribution of the associated tax burden. Occasional calls for a "robot tax" notwithstanding, there is no consensus among economists and policy makers on whether, and how to

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specifically tax AI. Some commentators argue that AI will eventually replace most human labor and erode the associated tax base, thus making new taxes on AI indispensable. Other commentators claim that the Fourth Industrial Revolution is no different from earlier waves of automatization, hence AI will largely complement, rather than substitute, human labor, rendering "robot taxes" in addition to conventional capital gains taxes not only unnecessary, but harmful.

We argue that both dominant views are incomplete, suggesting a third view. Our view differs from the first view in that we argue the output generated by AI should be taxed at close-to-zero rates. It differs from the second view in that we argue that output produced by humans should not be taxed at a higher rate than AI's output and that the advent of AI will progressively put traditional output-based tax systems under stress. Our view is informed by empirical evidence and the theoretical literature on optimal taxation. Furthermore, we draw on insights from the philosophy of artificial intelligence to investigate as to whether or not machines can be equipped with truly general intelligence and consciousness. We derive our view from three widely shared core principles of just and efficient taxation, showing that they form a trilemma which cannot be dissolved while adhering to output-based taxation.

First, by reviewing the theoretical, empirical and normative literature on input factor taxation, we conclude that the optimal capital gains tax rate is close to zero under a reasonable set of assumptions. Furthermore, we argue that AI constitutes an extension of conventional, non-intelligent machines. Thus, they are part of the capital stock and their products subject to conventional capital gains taxation. Policy makers interested in minimizing tax-induced distortions and justifiable tax systems should therefore prefer close-to-zero taxes on AI.

Second, we compare humans and artificial intelligences with regard to consciousness, utility, dignity, natural rights, libertarian free will and investigate the consequences of this comparison for the taxation of human output and AI output. We find that human output should not be taxed higher than AI output.

Third, there is the widely shared objective that in a just society the income (as a proxy of output) of humans should be taxed, in order to redistribute from high-income humans to low-income humans, even at the expense of deadweight loss. This intuition is based on the assumption that a representative agent facing a risk-return tradeoff behind the Rawlsian veil of ignorance probably would not be entirely risk neutral but to some extent risk

averse and hence sacrifice a little bit of return so as to reduce risk. The representative agent would thus choose rules of income taxation that decrease the variance of the income distribution, putting up with a lower average income.

We thus identify a basic trilemma, where only two out of three desirable goals can be jointly pursued: AI's output should not be taxed; the output of humans and AI should be taxed in a symmetric way; human output should be taxed. We argue that this trilemma can be dissolved by shifting the tax base from factor incomes to consumption. Consumption taxes are less sensitive to shifting factor income proportions and have other desirable properties: they are less distortive and hence more efficient than income taxes. They conform to the requirements of a just tax system. Furthermore, they are flexible in practical implementation.[1]

2 The Impact of the AI Revolution: Will This Time Be Different?

The last decade saw growing interest in assessing the impact of artificial intelligences (AI) on labor markets, public finances and the distribution of the tax burden. Public and professional concerns are well illustrated by the large number of projections and impact studies such as McKinsey Global Institute [2017a], McKinsey Global Institute [2017b] and World Economic Forum [2016].[2]

Economists have also addressed the issue using theoretical models and projections based on past waves of automatization. An extreme, yet not uncommon view is that "this time is no different", i.e. the AI revolution will not differ from past waves of automatization and thus will not have a negative long-run impact on employment and labor income, thus not constituting a reason to redesign tax systems. Other research, however, stresses that AI entails unique properties such as its capability for autonomous self-improvement that have the potential to undermine human efforts to catch-up by learning other not-yet-automated skills and could thus have radically dif-

[1] In a future version of this paper, we will close by laying out some other implications of a consumption-based tax system in the context of an economy dominated by artificial intelligence. Most importantly, policy makers can influence how AI and their associated returns are distributed.

[2] However, discussion of the potential impact of AI on labor markets and taxation already featured in previous decades, see for instance Nilsson [1984]

ferent consequences than past automatization efforts. Another extreme view is thus that "this time is totally different" and human labor, and thus labor income and wage-based taxation will cease to play an important role in the future, necessitating a redesign of the tax system. The following sections briefly summarize recent literature on these issues.

2.1 Employment and Wages

Summarizing recent theoretical models of the impact of AI on labor markets, i.e. wages, labor demand and employment, Acemoglu and Restrepo [2018] identify several channels: (1) AI directly lowers labor demand and wages for jobs that focus on automated tasks. This is dubbed the "displacement effect". (2) AI increases productivity and labor demand for jobs with a focus on non-automated tasks. (3) Additionally, AI encourages capital accumulation and capital deepening that further increase labor demand. While (2) and (3) tend to counterbalance (1), the net effect is a reduction of the share of labor in total income under general circumstances.

However, (4) the creation of new jobs with new tasks in which human labor has a comparative advantage has the potential to outweigh net employment losses and the reduction in labor's share in total income resulting from (1) to (3), thus allowing for a balanced long-run growth path. Whether (4) is able to counterbalance employment losses crucially depends on the speed of labor's adaption to changing demand by learning new skills relative to AI's speed in automating these new skills. While this did not happen during past waves of automation, it is at least conceivable that AI's mastery of skills progresses faster than the human ability to identify new niches. Even in models that predict no long-run relative losses to labor, the short-run transition with dampened real wages and/or technological unemployment may "take a long time, typically 20 to 50+ years" [Berg et al., 2018]. Labor market depression may "last for decades and, in fact, the economy could be in a series of 'short runs' for even longer" [Furman, 2019].[3]

While empirical research on the impact of proper AI on labor markets is not yet available, several studies use past waves of automatization to infer the relative magnitude of the different channels and impact and their net effect. While a long-run view based on the past 200 years of automatization suggests

[3]The idea that the advent of machines being able to improve themselves will fundamentally change the nature of economic growth and distribution via the so-called *singularity* is further explored and put into context by Nordhaus [2015].

that automatization does not lower total employment and the labor share in total income [Aghion et al., 2017, Autor, 2015, Atkinson, 2018], short-run evidence from recent waves of automatization is mixed. For instance, looking at the effects of robotization on US labor markets between 1990 and 2007, Acemoglu and Restrepo [2017] find a significant negative effect of increased robot use on employment and wages. In contrast, looking at 17 countries between 1993 and 2007, Graetz and Michaels [2018] find no reduction in total employment induced by robotization. Bessen [2019] also finds positive employment effects of automatization over the past two decades.[4]

While Acemoglu and Restrepo [2018] set up a framework for understanding the impact of any automatization on labor markets, a more specialized literature has explored why the AI revolution might differ from past automatization waves. As reviewed by Martens and Tolan [2018], there are three reasons to think that "this time is different":[5]

(1) *AI as General Purpose Technology (GPT).* In contrast to most past instruments of automatization (such as industrial robots), AI, in particular Machine Learning algorithms, have potential use in most, if not all, sectors of the economy. Thus, there is relatively little scope for counterbalancing technology-induced employment losses through the creation of new jobs in other sectors. Furthermore, as argued by Brynjolfsson et al. [2018], past GPT induced exponential technological change and AI could thus spur technological change at a pace that outpaces growth in demand, leading to permanent unemployment if humans find no way of adapting [Trajtenberg, 2019].

(2) *Non-rivalry of algorithms.* Whatever a single artificially intelligent entity learns, it can instantly share with all other AI without compromising its own capabilities. This makes the knowledge acquired by AI and the respective set of performable tasks non-rival, in stark contrast to industrial robots that still need to be replicated and programmed. The non-rivalry of AI's algorithms are another reasons to expect quickly accelerating growth rates that have the potential to outpace human capabilities to adapt.

[4]See Petropoulos [2018] for a survey. Apart from such general equilibrium considerations, a growing literature assesses the risk of automatization for different tasks and job (see, for example, Frey and Osborne [2017], who claim that currently 47% of all occupations in the US could be automated over the next two decades.). While interesting for a variety a reasons, such studies cannot assess the overall impact of automatization and AI on labor markets.

[5]Another useful, though more policy oriented survey was compiled by Frontier Economics [2018].

(3) *Automated production of ideas.* AI, in sharp contrast to previous means of automatization, is able to produce ideas on itself, thus also transforming production functions across the economy [Martens and Tolan, 2018].

2.2 Tax Revenue and Burden

How will the AI revolution impact tax revenues and the distribution of the tax burden? Labor's share in total income has been persistently declining since the last four decades and there are reasons to expect that this does not constitute a short-term deviation from long-run stable factor compensation shares, but rather a permanent change [Karabarbounis and Neiman, 2014].[6] Moreover, some authors have argued that the AI revolution is likely to accelerate this redistribution process [Korinek and Stiglitz, 2017, Sachs, 2019, Berg et al., 2018, Autor and Salomons, 2018]. A permanent shift in relative factor incomes has clear implications for taxation as most tax regimes use different methods and schedules to tax income from different factors of production and capital incomes and wages in particular.

The typical reaction to the expected decline in labor's share in total income and associated wage tax losses is to recommend a "robot tax" that specifically targets the use or ownership of robots or AI.[7] The literature is abound with ideas how to design such taxes, with proposals including a "digital corporate tax" to be paid by owners [Ernst et al., 2018], "automation taxes" to be paid for the use of AI or tax preferences for human labor [Abbott and Bogenschneider, 2018] and many other specific instruments [Englisch, 2018]. As has been noted, many proposals suffer from unclear definitions of what exactly constitutes a robot, or AI, respectively [Marwala, 2018].

[6] Apart from its consequences for taxation, the income distribution is not of direct concern in this paper. See Martens and Tolan [2018] for a recent survey on the likely impacts of AI on the income distribution.

[7] As Englisch [2018] notes, apart from government revenue concerns, popular discussion features many additional reasons to tax AI, among them the possible civil law personhood of AI, the believe that income derived from capital ownership has to be taxed, the ideal of a "level playingfield" between human labor and AI, desire for an instrument to compress the wage distribution and in order to slow down the technological transformation.

3 The Case for Close-to-Zero Taxation of the Use of AI

A large literature in public finance and related disciplines explores the impact of different types of taxes on aggregate welfare, economic growth, and the distribution of the tax burden. A central finding of this literature is that taxes on capital gains should be low, or possibly zero. We first establish that AI should be considered part of the capital stock and the taxation of its output thus presents a form of capital gains taxation. In a second step, we defend the case for a close-to-zero capital gains tax based on three lines of argument, namely (1) the theory of optimal indirect taxation, (2) comparative empirical evidence, and (3) normative reasoning on the principles of just taxation.[8]

3.1 AI as Capital

In order to show that AI are capital goods we first have to define what capital actually is. There is a wide range of possible definitions for the concept of capital. An early definition was given by Scottish enlightenment economist Adam Smith who defined capital as "that part of men's stock which he expects to afford him revenue" [Smith, 1776/2008, book 2, chapter 1]. Could artificial intelligence be considered capital according to Smith's definition? Yes, indeed: If a human being owns a computer or a robot that is equipped with artificial intelligence, and if the human owner hopes and expects his artificial intelligence will enable him to generate revenue and thus to increase his income, then that artificial intelligence would be capital according to the Smithian view. Smith's definition, however, is not very precise and it remains unclear how capital differs from other factors of production, i.e. labor and land, that also form part of men's stock and generate revenue. Can more modern approaches shed light on the question?

According to neoclassical economics, capital is defined as one of the three

[8]The yet most comprehensive study of tax structure, based on theoretical, empirical and normative considerations, is the Mirrlees Review, a research and policy advice project focusing on the British tax system. Based on the mentioned criteria, it concludes that the normal return to household savings, i.e. capital gains, should be tax-free, while super-normal returns should be taxed [Mirrlees et al., 2011]. The Mirrlees Review's recommendations on capital gains taxation have generally been well-received by academic economists [Feldstein, 2012, Atkinson, 2012, Auerbach, 2012]. See, however, Apps and Rees [2012] for a critical discussion.

factors of production: Labour, land, capital. Production factors are the inputs that are used in the production process to generate output. Besides intangibles those inputs are labour, land and capital. Robots equipped with artificial intelligence clearly count as production factor, because they are tangible rather than intangible, and they can be used as input in the production process to generate output.[9]

Furthermore, artificial intelligence is not immediately used up in the production process, unlike intermediate goods or raw materials. Now assuming that artificial intelligences are part of the three production factors, to which of those three production factors do they most plausibly belong?[10] Land, including resources, occurs naturally and cannot be produced or increased. Artificial intelligence however is artificial rather than natural, and it can be produced and increased; so artificial intelligence is a production factor different from land. Is it labour, or is it capital? Labour is often defined as human effort. Since artificial intelligences are artificial rather than human, they do not count as labor, just as the work of a horse does not count as labor. So by the exclusion principle, artificial intelligences are capital.[11]

Austrian Economics allows for a different approach to a definition. Economist Eugen von Böhm-Bawerk, one of the fathers of the Austrian school of economics, pointed our that the roundaboutness of production processes could

[9]Are artificial intelligences really tangible? If we identify artificial intelligences with their underlying algorithms, rather than with the material in which they are instantiated, than one could argue that artificial intelligences are intangibles, just as goodwill, organization, entrepreneurship, knowledge, or management are. But most economists would not recommend levying an extra tax on intangibles either, so the overall argument against the taxation of artificial intelligences still holds, albeit in a slightly modified form: Premise 1: Artificial intelligences are intangibles. Premise 2: Intangibles should not be taxed. Conclusion: Artificial intelligences should not be taxed. Whether we consider artificial intelligences as capital or as intangibles depends on whether we consider intangibles like knowledge and algorithms as capital or as different from capital; that's rather a question of terminology.

[10]Seldom do neoclassical economists introduce production factors that are fundamentally different from labor, land and capital (including human capital). There is presently no case for assuming that artificial intelligences form a class of production factors on their own.

[11]We shall later see that if we slightly relax the definition of labour and instead define labour as "human or human-like effort" then artificial intelligence may also count as labor, or a labor-capital hybrid. The presence of artificial intelligence suggests that the labor-capital dichotomy is blurred; labor and capital form a continuum on which intelligence is placed, whether human or artificial.

be seen as a measure of capital intensity. He defined capital as goods of higher-order, meaning goods used to produce consumer goods, or goods used to produce goods used to produce consumer goods. Capital goods gain their value from those future consumer goods. While land and labor are also used to produce consumer goods, they cannot be produced themselves, occurring only exogenously to the economic production process. Capital goods are thus higher-order goods that are reproducable. Artificial intelligences fulfill these criteria and can hence be considered capital according to Böhm-Bawerk's definition: Humans cannot consume artificial intelligences right away, but we can consume goods produced by artificial intelligences: We can listen to music composed by an artificial intelligence; we can read a book authored by an artificial intelligence; we can eat a cake baked by an artificial intelligence. Production processes enriched by artificial intelligence are more "roundabout". Hence, artificial intelligences are higher-order goods. Furthermore, we can willingly reproduce artificial intelligences, in contrast to naturally given labor and land. Together, those two conditions identify artifical intelligences as part of the capital stock.

Neoclassical and Austrian working definition cannot finally solve the question whether artifical intelligences are to be considered part of the capital stock in all circumstances and further research in this matter is necessary. However, the widespread identification of artificial intelligences as capital both in theoretical models and empirical discussion, and the accordance with the presented working definitions constitute strong *prima facie* reasons to consider AI as capital.

3.2 The Theoretical Case

The theory of optimal taxation is concerned with identifying the tax mix that maximizes aggregate welfare under a set of constraints.[12] While the details of such an optimal tax mix vary with the definition of the relevant constraints, the available types of taxes, and the aggregate welfare function, the literature largely agrees that high taxes on capital gains are not part of the optimal mix under a reasonable set of assumptions, at least in the long run [Mankiw et al., 2009].

Whereas an older literature has mainly argued against capital gains taxes on the basis of them lowering the volume of savings and thus, via lower

[12]This section draws from Fink and Kappner [2016].

investments into the capital stock, decreasing future productivity, Feldstein [1978] has shown that theoretical predictions regarding the reaction of the volume of savings to taxation of capital gains are ambiguous and depend on the motives of savers.[13] While not necessarily lowering the volume of savings, capital gains taxes nonetheless induce welfare losses by distorting the intertemporal consumption decision.

In particular, the optimality of a close-to-zero capital gains tax is a corollary of the theory of optimal indirect taxation, i.e. the result that a uniform consumption tax rate on all classes of consumer goods minimizes distortions of consumer choice and the allocation of input factors across industries, thus minimizing welfare losses due to a taxation-induced deadweight loss. Importantly, this criterion requires uniform taxation not only across the consumption goods space, but also across time, that is independently of the timing of consumption. Establishing the modern view on capital gains taxes, Atkinson and Stiglitz [1976] show that such taxes, by raising the price of tomorrow's consumption relative to today's consumption violate the criterion of uniform consumption taxation and thus lower welfare relative to other forms of taxation.[14]

A second strand of literature develops a theoretical case against capital gains taxes based on the Corlett-Hague rule [Corlett and Hague, 1953]. If consumption of leisure cannot be taxed and depends on the consumption of other goods, the Corlett-Hague rule establishes that those goods that act as closer complements to leisure should be taxed higher. Building on Ramsey [1927], a large literature argues that today's and tomorrow's consumption act similarly complementary to leisure and thus should be taxed equally, implying close-to-zero capital gains taxes [Chamley, 1986, Judd, 1985, Stiglitz, 2015].[15]

While the early theoretical literature on capital gains taxation suggests elimination of capital gains taxation, recent studies identified several condi-

[13] Empirically, however, higher capital gains taxes go along with lower savings rates [Frank, 2005]. The effect is furthermore strengthened in the presence of inflation when nominal income gains are taxed rather than real income gains. Then we can have situations in which real income gains are 0 or negative, but those nominal gains are nonetheless taxed, making saving even less attractive.

[14] Atkinson and Stiglitz [1976]'s original results have been shown to hold under relaxed assumptions since; see Mankiw et al. [2009] for an affirmative, and Nygård and Revesz [2016] for a critical review, respectively.

[15] Recent contributions to this literature include Straub and Werning [2018] and Chari et al. [2018].

tions under which the optimal capital gains tax is positive, e.g. to remedy distortions arising from capital markets imperfection and tax arbitrage [Diamond and Saez, 2011, Jacobs, 2013, Saez and Stantcheva, 2018]. However, they do not conclude that capital gains should be taxed on the same rate as other gains, e.g. labor income. Neither do such finding make a case for high capital gains taxes.

3.3 The Empirical Case

Given the scarcity of real-world controlled experiments in taxation and the complicated general equilibrium mechanisms involved, empirical studies isolating the causal impact of capital gains taxes on income, growth and other economic indicators are rare.

While the direction of causality often remains unclear, cross-country comparative studies generally find that a lower share of capital gains taxes in total government revenues is associated with significantly higher GDP growth and investment activity.[16] These findings suggest that personal and corporate income taxes are more distortionary than taxes on consumption or immovable property, in particular in high-income countries, mainly due to their dampening effect on savings and investments [Havranek et al., 2015, McNabb, 2018, Alm and El-Ganainy, 2012, Lewis and Seidmann, 1998, Tanzi and Zee, 1998].

Recent studies exploit times series data and policy changes to provide causal estimates, mostly focusing on the corporate income tax, which is a special type of capital gains tax levied on corporations. According to these findings, higher corporate income taxes lower growth rates [Lee and Gordon, 2005], innovation activity [Mukherjee et al., 2017] and depress investment [Nallareddy et al., 2018]. However, exploiting the 2015 US dividend tax cut, Yagan [2015] finds no effect on labor compensation and corporate investments.[17]

A third type of empirical study uses real-world data to calibrate models that simulate the effect of tax reform. For instance, using U.S. data, Altig et al. [2001] demonstrates that a lower (capital) income tax rate would increase investments, productivity and growth. However, simulation exercises,

[16] See Akgun et al. [2017], Johansson [2016], Brys et al. [2016], Acosta-Ormaechea and Yoo [2012] for comprehensive surveys.

[17] See Auerbach [2018, 2013], Johansson [2016] for surveys on the effects of corporate income taxes.

while potentially accounting for complicated general equilibrium interactions, are inherently problematic as they abstract from many relevant features of real-world economies [Keuschnigg, 2011].

Tightly related are studies that empirically look into the incidence of capital gains taxation. Empirical studies on the incidence of personal capital gains taxes are, however, rare and suffer from estimation problems [Mulligan, 2002]. More attention has been given to the incidence of the corporate income tax. In theory, its distribution among factor income earners over the long run depends on their relative mobility and substitutability [Auerbach, 2006]. Felix [2007], Entin [2004], Sattinger [2010] also provide theoretical perspectives on the incidence of capital gains taxation, stressing that the owners of corporations absorb only a share of the tax burden associated with corporate capital gains taxes. For instance, Fuest et al. [2018] find that wage earners bear about half of the burden Germany's corporate income tax.[18]

3.4 The Normative Case

While the *efficiency* or *neutrality* criterion used in optimal taxation theory fundamentally depends on the normative assessments that minimizing distortions is desirable, the theory of just taxation features many other criteria that help evaluating tax systems, and capital gains taxes in particular.[19]. The literature on the principles of just taxation is far too voluminous to be reviewed here, going back at least as far as Smith [1776/2008] and Ricardo [1817/2008]. However, important criteria developed in the literature are (1) *simplicity* or *comprehensibility*, i.e. low compliance costs, transparency and administrative ease; (2) *equity*, i.e. similar people should pay similar taxes; (3) *predictability* or *non-arbitrariness*, i.e. the accruing tax burden (or its distribution) should be predictable with close-to-certainty before decisions bringing about the fact of taxation are taken; and (4) *legitimacy* by means such as unanimity [Blankart and Fasten, 2011] or agreement behind a Rawlsian veil of ignorance [Sugin, 2004]. These criteria, however, are not further discussed in this paper as capital gains taxes are able to fulfill these nor-

[18] Useful surveys on include Auerbach [2006], Gravelle [2011, 2013].

[19] Weinzierl [2014a,b], Fleurbaey and Maniquet [2018] argue that optimal taxation theory, at its current state, is not particularly useful for the normative evaluation of tax systems.

mative ideals in principle, though not always in practice.[20] A particularly useful synthesis of broadly shared normative criteria states that a tax regime should be fair with respect to differences in individual well-being, i.e. ensure that better-off people pay higher taxes.

Framed in more abstract terms, the fairness requirement states that (a) two individuals that experience the same lifetime utility should pay the same amount of taxes, and that (b) people that experience more lifetime utility should also pay more taxes.[21] Since utility is not objectively measurable, two alternative proxies are often employed: Individual utility can be proxied by individual (pre-tax-and-transfer) income or by individual consumption of goods and services priced on the market. We argue that income is a particularly poor proxy for individual utility and that differences in the consumption of priced goods and services, while also an imperfect proxy, are a preferable way to measure differences in utility and thus fulfill the fairness criterion.[22]

Why do income taxes in general violate the fairness criterion? An intuitive, yet ultimately unconvincing answer is that not all of an individual's income is also consumed. If consumption is the ultimate source of utility, income that is not spent for consumption should not increase an individual's tax burden.[23] However, an intuitive reply would be that saved income usually serves the deferment of consumption into the future and thus life income matches life consumption, where bequests and gifts merely complicate this fundamental equality by introducing voluntary inter-individual redistribution. Thus, income taxes could be thought of as capturing consumption and thus utility over an individual's lifetime, though not necessarily in a given

[20]More controversial criteria discussed in the literature on just taxation include the compensation-for-misfortune principle [Ooghe and Peichl, 2014], ability or tagging on unchangeable individual properties that predict capability [Weinzierl, 2012], the benefit approach that states that taxation should be proportional to the use of government-supplied goods and services [Weinzierl, 2018] and ability or resource based approaches [Duff, 2017]. As Duff [2009] notes, the appropriate principles depend on the objective of taxation, i.e. revenue-raising, redistribution or the regulation of behavior.

[21]Note that this allows for proportional, as well as progressive, regressive or any other monotonous schedules that preserve the pre-tax distribution of entitlements to utility.

[22]Attanasio and Pistaferri [2016] show that differences in consumption and income are correlated but not identical. Furthermore, consumption inequality seems to be less pronounced than income inequality.

[23]This argument assumes that wealth, i.e. past income not used for consumption, does not raise utility by its mere existence. Arguably, while conventional economic models ignore this effects, wealth may indeed be an independent source of utility as it represents security.

period.

However, life income taxes are neither practicable in the light of a governments relying on a steady stream of revenue, nor are they incentive-compatible as they would have to be paid upon death, i.e. in a situation when punishment for failure to pay taxes is not possible. For these reasons, income taxes are paid period-wise, usually once per year. Period-wise income taxation, however, breaks the equivalence of life income and life consumption. To see this, note that income from primary factors, most importantly labor, is taxed when generated, regardless of its subsequent use to finance consumption or savings. The saved fraction of income from primary factors then generates capital gains in future periods, and these gains are taxed once again before they can be used to finance consumption. Thus, the further in the future an individual prolongs the realization of a consumption possibility created by a given period's primary factor incomes, the higher this consumption will eventually be taxed.[24] At this point, a possible objection would state that an individual that defers consumption via saving will in fact be able to consume *more* in the future because savings yield a positive interest rate.[25] Thus, the taxation of gains from saved primary factors income may be thought of as a compensation for higher lifetime consumption and thus higher lifetime utility experienced by individuals with a low time preference.

However, due to inter-temporal incomparableness of utility, the construct of an atemporal sum of each point in time's realized utility is meaningless. More appropriately, an individuals' lifetime utility can only be defined at a given point in time and is then determined by present consumption and the stream of future expected consumption, where future consumption is discounted, i.e. relative to today's consumption, a larger consumption bundle is need to generate the same utility. Thus, a positive return on savings merely compensates for the lower present value of future consumption and does not increase lifetime utility relative to spending all present income on consumption. But this means that two individuals with identical lifetime utility can nonetheless experience different tax burdens, purely because of a different timing of utility-creating consumption. Furthermore, the individual

[24]Note that this argument is different from the popular claim that inheritance taxes are unjust because estates are formed out of assets that have already been taxed. Multiple taxation may violate other criteria of just taxation, but it does not necessarily break the equivalence of life income and life consumption.

[25]If savings do not yield a positive interest rate, there are also no capital gains taxes to be paid.

tax burden may be *decreasing* in lifetime utility despite increasing in income in a each period.

If period-wise income taxes violate the fairness criterion, consumption taxes may appear as the obvious alternative. However, period-wise income taxes only violate the fairness criterion to the extent that they tax income generated from secondary factors, i.e. capital, whereas a period-wise primary factor (i.e. labor and land) income tax is conceptually equivalent to a life consumption tax.[26] Their suitability is explored further in section section 7.

4 The Case for Taxing AI Output at a Higher Rate than Human Output

Here we could delve deeply into ethics, the philosophy of mind, or the philosophy of artificial intelligence.[27] For our argument, it suffices to distinguish two cases. In the first case humans and artificial intelligences are fundamentally similar with regard to the various properties: Just like humans, artificial intelligences may have consciousness; may be util bearers; may be bearers of dignity; may be endowed with natural rights; may have libertarian free will. If humans and artificial intelligences are similar in some or even all of those dimensions then by symmetry humans and artificials intelligences should be taxed in a similar way. Taxes on humans should not be higher than taxes on robots. In the second case humans and artificial intelligences are fundamentally different with regard to the various properties: Humans may be util bearers; artificial intelligences are not util bearers. Humans may be endowed with natural rights; artificial intelligences are not endowed with natural rights. Humans may have consciousness (in terms of qualia or inten-

[26] In practice, labor income taxes nonetheless may have different consequences than a theoretically equivalent consumption tax. Empirically, people seem to contract their labor supply more in reaction to a labor income tax than in reaction to an equivalent consumption tax. Also, in practice labor income taxes are likely to partly tax human capital that according to the arguments developed here should remain untaxed. Another difference arises out of the possibility to declare labor gains as capital gains, giving rise to tax shifting schemes and related inefficiencies. Finally, labor income and subsequently affordable consumption may be realized in different locations and thus under different tax regimes.

[27] See, for instance, Turing [1950], Lucas and Sayre [1972], McCarthy [2006], Russell and Norvig [2010], Deutsch [2012], Torrance [2012], Hakli and Mäkelä [2016], Müller [2017], Johnson and Verdicchio [2018], Bruiger, **?** and Hofstadter [1979], pages 476—477.

tionality); artificial intelligences have no such consciousness. Humans may be bearers of dignity; artificial intelligences are not be bearers of dignity. Humans may have libertarian free will; artificial intelligences have no libertarian free will.

Now assume, you are a philosophically sophisticated and totally benevolent finance minister and want to generate a revenue of, say, 100,000 euros. The country in which you are finance minister may consist of only two welfare creating, income producing beings: an human being and a robot based on artificial intelligence. You can generate your revenue by either taxing a human or by taxing an artificial intelligence. Being the finance minister you have to decide: What would you rather tax? The output of the human or the output of the artificial intelligence?

The choice should be straightforward: If you tax the human you reduce his utility since he may be a bearer of utils; if you tax the artificial intelligence you do not reduce anyone's utility since artificial intelligences are not bearers of utils. So from a utilitarian perspective, you should rather that the artificial intelligence, not the human, ceteris paribus. If you tax the human you infringe on his natural rights since he may be endowed with natural rights; if you tax the artificial intelligence you do not infringe on anyone's rights since artificial intelligences are not endowed with natural rights. If you tax the human, you hit a being with consciousness; if you tax the artificial intelligence, you hit no being with consciousness. If you tax the human, you hit a being with dignity; if you tax the artificial intelligence, you hit no being with dignity. If you tax the human, you hit a being with libertarian free will; if you tax the artificial intelligence, you hit no being with libertarian free will.

To sum up, there is a much stronger case for taxing the artificial intelligence and a much weaker case for taxing the human, ceteris paribus. It's true that we have no certainty whatsoever as to whether or not humans, or artificial intelligence, have utils, natural rights, consciousness, dignity, and libertarian free will; philosophers from a wide range of subdisciplines, such as ethics, philosophy of mind, and philosophy of artificial intelligence, discuss these and related questions, and there hasn't been anything like a consensus, as is common in philosophy. But we do not need absolute certainty to get to a well-thought-out decision. All we need is that it is more likely that humans are util bearers than it is that artificial intelligences are, and so forth, and that is clearly the case.

5 The Case for Taxing Human Output

Economists and members of the wider public advocate the taxation of human output. The most popular mechanism to achieve that is the taxation of human income. Income taxation can be interpreted as a proxy for output taxation.

There are several arguments for positive income taxes. Let us consider three arguments:

First, there is the widely shared objective that in a just society the income of humans should be taxed, in order to redistribute from high-income humans to low-income humans, even at the expense of deadweight loss. This intuition is based on the assumption that a representative agent facing a risk-return tradeoff behind the Rawlsian veil of ignorance probably would not be entirely risk neutral but to some extent risk averse and hence sacrifice a little bit of return so as to reduce risk. The representative agent would thus choose rules of income taxation that decrease the variance of the income distribution, putting up with a lower average income.

Second, some point to the decreasing marginal utility of income: For a rich person an additional euro has a lower value than for a poor person. From a utilitarian point of view, it might therefore make sense to take one euro from the rich and redistribute it to the poor.

Third, a further argument for positive income taxation is that we want to levy revenue to finance public goods. Public goods are non-excludable and non-rivalrous; hence they should be financed, at least subsidized through the government. In order to do so, government has to generate revenue and levy taxes, and income taxes are an obvious candidate.[28]

[28]In addition, we can interpret positive, progressive income taxation as an ingenious form of price differentiation for public goods and publicly provided club goods. Price discrimination means: Low-income earners pay a little bit less, while high-income earners pay a little bit more. In what sense is that a form of price differentiation? The production of public goods is associated with fixed costs as well as with marginal costs. In such constellations profit maximizing entrepreneurs have the incentive to adopt a strategy of price differentiation. So if the government were a private profit maximizing entrepreneur, say in a private law society, we might expect a system of progressive fees: lower fees for low-income customers, and higher fees for high-income customers. In the event of a conventional state, the finance minister may well decide to adopt income taxes that approximate the progressive fee structure that would emerge in a private law society run by profit-maximizing entrepreneurs. Efficient income taxes are hence likely to be positive (and possibly even progressive).

These three arguments form a strong cumulative case for income taxes exceeding zero.

6 A Trilemma of Taxation

We have formulated three desirable goals and given good arguments for each of them. However, these three goals form a trilemma. They cannot all be realized at the same time; only two of the three goals can be jointly pursued. Thus, at least one of the three goals has to be sacrificed. The three goals are as follows: First, the output produced by artificial intelligences should not be taxed. Second, the output of humans and the output of artificial intelligences should be taxed in a symmetric way. Third, the output produced by humans should be taxed.

If the output of humans and the output of artificial intelligences should be taxed in a symmetric way and if the output of humans should be taxed, then the output of artificial intelligences should also be taxed. So our second and third goal rule out the first goal. That kind of argument is often presented by advocates of AI or robot taxes. If the output of humans should be taxed and if the output of artificial intelligences should not be taxed, then the output of humans and the output of artificial intelligences should not be taxed in a symmetric way. That view is implicitly held by many economists who prefer low taxes on capital and slightly higher (or even significantly higher) taxes on income. If the output of artificial intelligences should not be taxed and if the output of humans and the output of artificial intelligences should be taxed in a symmetric way, then the output of humans should not be taxed either. So our first and second goal rule out the third goal.

We defend this third view. Let us present this view as a deductive argument:

Premise 1: The output of artificial intelligences should not be taxed.

Premise 2: The output of humans and the output of artificial intelligences should be taxed in a symmetric way.

Conclusion: The output of humans should not be taxed.

To see that this is a valid argument we reformulate premise 2 slightly:

Premise 1: The output of artificial intelligences should not be taxed.

Premise 2*: If the output of artificial intelligences should not be taxed, then the output of humans should not be taxed. (Symmetry)

Conclusion: The output of humans should not be taxed.

The conclusion follows logically from the two premises: If the two premises are both true, then the conclusion is also true. Hence, the argument is logically valid. Is the argument sound? A logically valid argument is sound, if all premises are plausibly true. Is premise 1 true? We have already presented strong arguments for premise 1 in section 3. Premise 1 was the conclusion of another deductive argument. Given that argument we have strong grounds to believe in premise 1. Are premise 2 and premise 2* true? Again, we have already presented strong arguments for premise 2 in section 4.

Hence, the conclusion is also true: The output of humans should not be taxed.

7 Solving the Trilemma by Taxing Consumption

If we wish to adhere to the first and to the second goal – and we have formulated strong argument for these two goals – then we have to give up the third goal.[29] Hence, the output produced by humans should not be taxed. But there still exists the need to raise tax revenues, based on the arguments presented above. How can we reconcile the conclusion that the output of humans should not be taxed with the arguments put forward to defend the notion that humans need to finance tax revenue?

Fortunately, taxing the output produced by humans is not the only possible approach to achieve those objectives. Alternatively, human consumption activities can be taxed. By taxing consumption, we can also achieve the specified objectives of raising tax revenues, keeping the tax rate on AI output close-to-zero and adhering to symmetric taxation. Taxes levied on consumption activities generate the revenue that allows to finance the production and provision of public goods.

All mature economies feature some forms of consumption taxation. However, these are mostly, if not exclusively indirect consumption taxes, most prominently Value Added Taxes (VAT) in Europe and Retail Taxes in the USA.[30] In contrast, direct consumption taxes, i.e. taxes not levied on sellers but on the consuming individual, do not contribute substantially to the tax

[29] This section draws from Fink and Kappner [2016].

[30] Additionally, many indirect taxes on the consumption of specific goods or classes of goods exist, such as alcohol excise taxes.

mix in any modern economy.[31]

However, shifting the tax burden from output to consumption not only solves the trilemma presented in section 6, it is also preferable to an output-based system on efficiency and justice grounds. In 2014, Bill Gates summarized an intuitive notion about the problems that capital income taxation poses: "Imagine three types of wealthy people. One guy is putting his capital into building his business. Then there's a woman who's giving most of her wealth to charity. A third person is mostly consuming, spending a lot of money on things like a yacht and plane." Referring to recent calls for higher capital income taxation in order to decrease inequality, he added: "While it's true that the wealth of all three people is contributing to inequality, I would argue that the first two are delivering more value to society than the third. I wish Piketty had made this distinction, because it has important policy implications."

Bill Gates emphasizes the intuitive notion that a tax system should consider in which way people use capital gains, and that there is a fundamental difference between using capital income to finance consumption or to finance investments. Here, we present arguments for why this view is indeed appropriate and consumption taxes are both more efficient and more just than output-based taxes, such as income taxes.[32]

7.1 Efficient Consumption Taxation

In summarizing the theory in section 3.2 and associated empirical findings in section 3.3, we made two crucial observations: (1) A lifetime income tax would solve the issue of intertemporal distortion as individual income and individual consumption balance over one's life, disregarding bequests and gifts. However, lifetime income taxes are not feasible. (2) Under certain circumstances, a period-wise labor income, i.e. wage tax is equivalent to a period-wise consumption tax, but this equivalence generally breaks down in open economies and in the presence of gains from human capital that are hard to distinguish from labor income. Furthermore, behavioral consequences differ.[33]

[31] See McLure Jr. and Zodrow [2007] for a survey of implementation attempts and discussions.

[32] There is, however, a pragmatic case for relying on a broad tax base that is not further explored here, see Gamage [2015].

[33] See Fink and Kappner [2016](9–10) for a review of relevant findings.

An alternative to both infeasible lifetime income taxes and pure labor income taxes ares period-wise direct consumption taxes levied on income less savings, or, equivalently, labor income. Early advocacy for a direct consumption tax-based system include Fisher [1939], Kaldor [1955/2003] and Andrews [1974], who argue for that administrative effort is minimal as individuals would only need to report their annual savings activity in order to establish the tax base.[34]

As a first approximation, income and direct consumption taxes seem very similar. Income taxes are mostly payed by consumers, and consumption taxes are mostly payed by people who generate incomes. Both allocate the tax burden to consumers and producers. Income taxes can be interpreted as taxes on consumption in advance, since people save to finance future consumption. Consumption taxes can be interpreted as taxes on income after the event, since today's income is eventually taxed, but only at the time it is actually used for consumption. However, in section 3.2 we argued that period-wise income taxation, to the extent that it includes capital gains taxes, entails efficiency losses because it raises the price of tomorrow's consumption relative to today's consumption, thereby distorting the intertemporal allocation of income to consumption.

For our purposes, a most important conclusion from the theory of optimal taxation is that a period-wise direct consumption tax does not distort the intertemporal consumption decision. This theoretical finding is strengthened by empirical studies and simulation exercises that find a positive correlation between the share of consumption taxes and economic indicators such as GDP on the national level.[35] An overview over such findings can be found in Fink and Kappner [2016](11–14).

7.2 Just Consumption Taxation

In section 3.4, we defended the notion that individual tax burden should be tied to individual welfare in such a way that two individuals experiencing the same lifetime utility should be subject to the same lifetime tax burden, and that individuals with higher utility should be higher taxes. We argued that capital gains taxes conflict with the widely shared notion as they introduce

[34] See Auerbach [2008] for an overview.

[35] A higher share of consumption taxes in the tax mix are also associated with higher savings rate, which, however, is not necessarily a consequence of their distortion-attenuating properties.

the possibility, that individuals with an identical lifetime utility pay different tax burden, depending on their intertemporal allocation of utility-generating consumption activities.

Period-wise direction consumption taxes, in contrast, do not suffer from this problem and thus conform with the basic requirements to a just tax system laid out before. Additionally, however, they have further desirable properties.

Flexibility with regard to progressivity. Some critics of a larger role of consumption taxes in the tax mix have based their objections on the presumption that the switch from a predominantly output-based tax system to a predominantly consumption-based one would be regressive, i.e. reduce (or eliminate) any progressivity in the distribution of the tax burden [OECD and Korean Institute of Public Finance, 2014, Pestel and Sommer, 2013, Decoster et al., 2011]. However, as Hubbard [1997], Correia [2010] argue that the regressive effects of certain indirect consumption tax regimes do not lead to the conclusion that direct consumption tax regimes are necessarily regressive relative to the status quo. In contrast, the schedule of a direct consumption tax can easily be rendered progressive, thus conforming to the widely shared notion that individuals experiencing higher utility should not only contribute proportionally more, but actually more than proportionally.

Indifference with respect to pre-tax income. A recurring issue in the discussion of just taxation is the issue of whether pre-tax incomes should have any significance with regard to the individual tax burden, given their dependence on political and regulatory arrangements that may themselves be questioned [Murphy and Nagel, 2002, Emerton and James, 2017]. A direct consumption ties the tax burden to individual utility, regardless of whether utility-generating consumption is based on a just or an unjust pre-tax income distribution.

The prospect of consuming AI. At present, AI is mostly thought of as a non-consuming machine that exhibits intelligent behavior comparable or surpassing humans, however without any form of consciousness and utility-enjoyment. It is, however, far from clear whether the status as a util-bearer and consumer will remain unique to humans. One scenario of AI development, for instance, speculates that AI most plausibly develops out of emulation of the human brain. Such emulations will then also feel a need for utility-maximization through consumption [Hanson, 2016]. Consumption taxes would be levied on consuming AI just like on consuming humans, making no difference between both entities.

8 Conclusion and Outlook

Let us conclude: We considered the questions: Should the output of artificial intelligences be taxed? Should the output of humans be taxed? Regarding these questions, we formulated three desirable goals: Our first desirable goal: The output produced by artificial intelligences should not be taxed. Our second desirable goal: The output of humans should not be taxed higher then the output of artificial intelligences. Our third desirable goal: The output produced by humans should be taxed.

We presented and defended arguments for the first desirable goal: Artificial intelligences should be treated as capital goods; the output of capital goods should not be taxed; hence the output of artificial intelligences should not be taxed. We presented and defended arguments for the second desirable goal: If humans and artificial intelligences are similar with regard to consciousness, utility, dignity, natural rights, free will, then there are strong grounds for symmetric taxation. If humans are conscious, utility bearers, dignity bearers, endowed with natural rights, equipped with libertarian free will, while artificial intelligences are not, then there are even grounds for taxing output by humans at a lower rate than output of artificial intelligences. We presented and defended arguments for the third desirable goal: The output of humans should be taxed so as to generate revenue to fund public goods and so as to redistribute from high-output humans to low-output humans.

Clearly, all three desirable goals cannot be realised at the same time; thus we have to sacrifice at least one of the goals. We noticed that there is an alternative approach to achieve the objectives associated with the third goal: taxing consumption instead of taxing output. We furthermore showed that consumption taxation is preferable to output taxation both on efficiency grounds and on justice grounds.

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