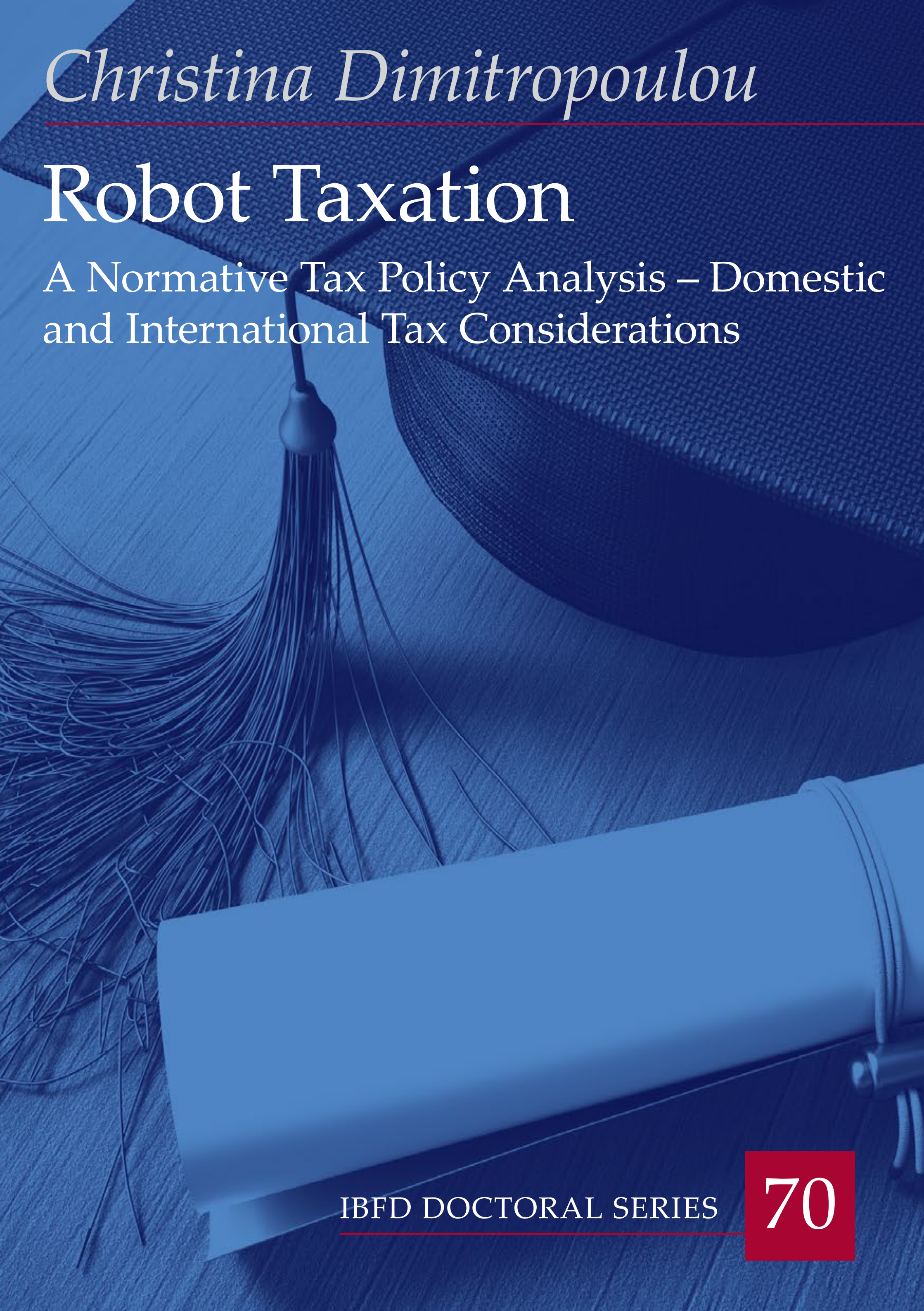

Christina Dimitropoulou

Robot Taxation

A Normative Tax Policy Analysis – Domestic and International Tax Considerations

IBFD DOCTORAL SERIES 70

Robot Taxation: A Normative Tax Policy Analysis

Why this book?
The use of robots and AI in business has been proliferating, reintroducing global concerns on the future of work and the sustainability of the tax systems. Scholars and policymakers have been discussing the taxation of robots and AI systems for many years without any real action being taken by any jurisdiction, with very few exceptions. This book introduces an innovative, comprehensive analysis of how robot tax policy should be approached and what tax designs might be more appropriate to address the negative impact of AI automation in the labour market and the tax system. The book addresses, among other things, how changes in employment relationships and factor shares affect the tax system, under what tax principles robot taxation may be justified, how to define or proxy a robot or an AI automation system for tax purposes, whether a robot performing labour functions autonomously and distantly from any human control could be treated as a separate taxpayer similar to an individual or a legal entity, whether this would also make sense from an international tax policy perspective and what tax designs might be appropriate in light of the purpose of the tax and the principles of equity and efficiency.

The book relies on tax theory, fundamental tax principles and indicative tax laws while providing interdisciplinary insights from economic theories and studies, accounting and technology to establish a theoretical framework for examination of robot taxes. The thesis approaches robot taxation from the perspective of whether taxing robots achieves tax neutrality between labour and capital, with the ultimate aim of redistribution using the income tax system as a reference. In view of the above, robot taxation is discussed principally as special taxation on certain industries, while the examined tax designs focus on imputed income taxes and presumptive taxes on business assets and turnover. Lastly, the book assesses the impact of robot taxes on international tax policy, looks at their tax treaty coverage and draws some parallels to the recent digital tax initiatives on behalf of the OECD.

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This book is based on the thesis submitted for a doctoral degree at Wirtschaftsuniversität Wien

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In dedication to my family and especially my mother for all her efforts and sacrifices and to my wonderful husband for his limitless love and support.

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Abstract

The book aims to examine whether the taxation of robots and artificial intelligence is justified under normative tax principles, which tax designs would be more appropriate in light of the purpose of the tax and the principles of equity and efficiency, what the legal and tax policy constraints are in designing the tax and whether the trade-offs identified are proportional to the aims of the tax. The analysis concentrates on whether robots and labour are comparable and to what extent, so that a tax policy for addressing the negative effects on the labour market and the tax system can be designed in the name of the principle of neutrality and of equalizing the transactional relationship between robots and labour. To that end, robots qualified as capital and the tax bases on which a tax labeled as "robot tax" could be based followed those that are justified under the benefit theory. A robot tax on the imputed income tax on hypothetical salaries of the labour substituted has been evaluated as inappropriate together with presumptive taxes on assets and turnover. In addition, the book discusses some international tax implications of the robotization of the economy and its similarities with and differences from those of the digitalization of the economy from an international tax policy perspective, as well as dealing with possible tax coordination issues under the current tax treaty law framework of the tax designs that the analysis finds as more appropriate to be implemented subject to the relevant caveats. In view of the above, it is argued that a robot tax is hard to apply as a special tax on certain technological equipment that could proxy robots but should rather be considered as a trigger for a broader business income tax reform or a reconsideration of the current tax mix as a whole.

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A last but big thank you to my parents for setting me off on the road to this PhD and for all the years of unconditional support, and to my husband – without him this work could not have been done (and for his technical knowledge, which was much needed for this study, special thanks!).

The tragic aspect of policy-making is that when your scope for action is greatest, the knowledge on which you can base this action is always at a minimum. When your knowledge is greatest, the scope for action has often disappeared.

H. Kissinger

Chapter 1

Introduction to the Research Topic

This chapter offers the background on which the idea of robot taxation is based and presents the arguments for why the current era might differ from the historical pattern followed in the previous industrial revolutions as far as the attributes of robots and similar automation technologies are concerned. This background consists of various legal, economic, policy and technological studies analyzing the impact of new automation technologies in the economy and society and form the framework of the policy concerns justifying the undertaking of relevant policy measures. The above concerns have gradually arisen over the years from the initial steps of the digitalization of the economy and more importantly from robotization that seems to grow more "aggressively" towards the automation of production processes and services. The core of the examination of the policy measures that will have to be taken in order to address the new automation challenges in this book centres on fiscal measures and possible tax design options of what are typically termed "robot taxes". These fiscal measures are examined in light of two broad tax policy goals that may either coexist in a tax design option or be addressed separately by different tax policies. Specifically, on the one hand, robot taxes are discussed with the intent of regulating the negative externalities that artificial intelligence (AI) automation creates for labour and thus, lie on a legitimate social and economic justification for governments to intervene in the economy to correct market failures. On the other hand, robot taxes are discussed as a remedy for the tax system itself, assuming that the new economic norm has challenged the neutrality of the tax system and has created inequities and inefficiencies that the current tax tools can no longer adequately deal with.[1]

1. As a general disclaimer of the scope of this book, it is highlighted here that the next chapters will examine several tax design options that could possibly be seen as robot taxation or variations of it, all of which fall under the general theme of "direct taxation" and specifically, corporate or business income taxation either concentrating on income as such or indirect economic indications of it. Therefore, this book does not discuss indirect tax design options, namely VAT or other taxes on consumption that could be potentially relevant for robot taxation. This is essentially based on two reasons: one is the limitations of one book to sufficiently cover all tax topics; the second is that normatively, the stance of the author of this contribution is that robot taxation should be seen from the perspective of its policy justifications that have mainly to do with the alleged equalization of the transactional position of robots and labour for tax

To lay the groundwork for analyzing robot taxation in light of the above goals and concerns, this section aims to set down a few preliminary definitions and concepts on which the rest of the book will be based. These are, for example, the concept of robots and artificial intelligence (or automation systems in general), the new economic model based on advanced technologies, the shift towards more knowledge-based production models and the new status (economic, legal and tax) of labour and capital in the economy and the tax systems. The term "robot" is going to be used as a technical term in this book for the purposes of the chapters to follow. Since the definition of the term "robot" will be the main issue throughout the whole analysis, it is important to try to present firstly, how this concept is used by the different disciplines that rely on it to describe its main representative features (technical characteristics) and its estimated economic and social impact; and secondly, to include it in a tax law framework where an operational definition of robots for tax law purposes is essential. However, if in this initial attempt to conceptually decipher the term "robot", we end up with a robot definition that might be problematic, insufficient or impractical for tax law purposes, it is still important to have in mind how a robot is conceived and how possible definitions of it can be accommodated or not within specific tax law designs.[2]

1.1. Background of policy concerns and related measures in the revival of automation anxiety

Technological development has always been the source of discord over the years due to its contradicting effects on economy and society. On the one hand, technological revolutions have an undeniably positive impact on economic growth. On the other hand, this growth is usually accompanied by a negative effect on labour and employment, at least in the short term. In particular, automation is responsible for a large substitution of labour by machines, which has been historically linked with two broad negative consequences for the economy and society:[3] one is technological unemploy-

purposes and which focus on the neutrality of the income tax and business taxation in general. For more details on the above scope delimitation, *see* ch. 4.

2. In the next chapters the concept of robot is analyzed in all different frameworks relevant for tax law purposes and is used interchangeably with the term artificial intelligence (AI).

3. These are the most prominent concerns related to the future of work from an economic perspective, which is equally relevant for tax purposes. Others relate to stagnation and possibilities for growth in an international competitive economic setting as well as to the nature of work that is being more and more dehumanized and the development of employment relationships. *See*, to that effect, E. Gasteiger & K. Prettner, *A*

ment[4] due to the replacement of labour by machines and the consequent job losses, while the other is the increase in income inequality due to job polarization[5] and skills competition driven by automation.[6] These phenomena have been more intensively sensed at the dawn of the 4th Industrial Revolution[7] with the advent of more technologically advanced and efficient technological applications and have been recently brought more to the fore after the outbreak of the COVID-19 pandemic, which accelerated some

Note on Automation, Stagnation, and the Implications of a Robot Tax, Discussion Papers from Free University Berlin, School of Business & Economics No 2017/17, available at https://econpapers.repec.org/paper/zbwfubsbe/201717.htm (accessed 28 Sept. 2023); D. Acemoglu & P. Restrepo, *Secular Stagnation? The Effect of Aging on Economic Growth in the Age of Automation*, 107 American Economic Review: Papers & Proceedings 5, pp. 174-179 (2017); *see* i.e. D. Weil, *The Fissured Workplace Why Work Became So Bad for So Many and What Can Be Done to Improve It* (Harvard University Press 2014); C. Estlund, *What Should We Do After Work? Automation and Employment Law*, 128 The Yale Law Journal 2, pp. 254-326 (2018).

4. The term "technological unemployment" is attributed to John Maynard Keynes, defining it as the discovery of means to economize the use of labour, which, however, outraces the pace at which labour can find new uses; *see* J.M. Keynes, *Economic Possibilities for our Grandchildren* (1930), reprinted in: J.M. Keynes, *Essays in Persuasion* pp. 358-373 (W.W. Norton & Co. 1963). For a historical overview of the idea of technological unemployment since the Luddite movement, *see also* R. Campa, *Technological Unemployment: A Brief History of an Idea*, 7 ISA eSymposium for Sociology 1, pp. 1-16 (2017), available at: http://www.sagepub.net/isa/admin/viewEBPDF.aspx?&art=EBul-Campa-Mar2017.pdf.

5. K. Breemersch, J.P. Damijan & J. Konings, *Labour Market Polarization in Advanced Countries: Impact of Global Value Chains, Technology, Import Competition from China and Labour Market Institutions*, OECD Social, Employment and Migration Working Papers 197 (OECD 2017).

6. J. Eißer, M. Torrini & S. Böhm, *Automation Anxiety as Barrier to Workplace Automation: An Empirical Analysis of the Example of Recruiting Chatbots in Germany*, in *Proceedings of 2020 ACM SIGMIS Computers and People Research Nuremberg Conference* pp. 19-21 (ACM 2020), available at https://doi.org/10.1145/3378539.3393866 (accessed 28 Sept. 2023); J. Mokyr, C. Vickers & N.L. Ziebarth, *The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?*, 29 Journal of Economic Perspectives 3, pp. 31-50 (2015); D.H. Autor & D. Dorn, *The Growth of Low-Skill Service Jobs and the Polarization of the US Labour Market*, 103 American Economic Review 5, pp. 1553-1597 (2013); D. Acemoglu & D. Autor, *Skills, Tasks, and Technologies: Implications for Employment and Earnings*, in *Handbook of Labor Economics*, vol. 4B (O. Ashenfelter & D. Card eds., Elsevier 2011); D. Acemoglu & P. Restrepo, *The Race Between Machine and Man: Implications of Technology for Growth*, *Factor Shares and Employment*, 108 American Economic Review 6, pp. 1488-1542 (2018).

7. What the Fourth Industrial Revolution means and why it might be different from the previous ones relates to a broad range of factors and combination of technologies that penetrate the business production process and radically transforms it; *see*, in that regard, K. Schwab, *The Fourth Industrial Revolution* (World Economic Forum 2016); I-Scoop, *Industry 4.0 and the Fourth Industrial Revolution Explained*, available at https://www.i-scoop.eu/industry-4-0/ (accessed 10 Sept. 2021).

forms of automation and changed work patterns more rapidly and radically in response to the pandemic.[8]

The global trend towards the adoption of AI automation processes and robots has been increasing steeply together with the above risks on unemployment and economic inequality.[9] Just as an illustration, a study conducted for the US market showed that each robot introduced to the workforce has the effect of replacing 3.3 jobs across the United States.[10] Other relevant studies have also predicted great numbers of human-machine substitutions in different occupations, which vary depending on the industry and region.[11]

The truth is that the intimated negative effects of automation that have been recently connected with the rise of robots and AI[12] are not going to

8. D.H. Autor & E. Reynolds, *The Nature of Work after the COVID Crisis: Too Few Low-Wage Jobs* (The Hamilton Project, Brookings Institution 2020); McKinsey Global Institute, *The Future of Work after COVID-19* (18 Feb. 2021), available at https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19; M. O'Brien & P. Wiseman, *Do We Need Humans for That Job? Automation Booms After COVID*, AP (5 Sept. 2021), available at https://apnews.com/article/technology-business-health-coronavirus-pandemic-d935b29f631f1ae36e964d23881f77bd; C. Lago, *Covid-19 has Exacerbated Automation Anxiety but Fear of Machines is Nothing New*, Tech Monitor (30 Apr. 2021), available at https://techmonitor.ai/technology/ai-and-automation/covid-19-and-automation-anxiety.

9. OECD, *Data on the Future of Work*, *The Future of Work* (OECD 2019), available at http://www.oecd.org/future-of-work/reports-and-data/data-infographics.htm; IFR, *Service Robots – Global Sales Value Reaches 12.9 billion USD Says IFR*, IFR Press Releases (18 Sept. 2019), available at https://ifr.org/ifr-press-releases/news/service-robots-global-sales-value-reaches-12.9-billion-usd; and IFR, *Annual Installations of Industrial Robots in Top 15 Countries*, in *World Robotics 2020 Report* (IFR 2020), available at https://ifr.org/ifr-press-releases/news/record-2.7-million-robots-work-in-factories-around-the-globe.

10. D. Acemoglu & P. Restrepo, *Robots and Jobs: Evidence from US Labor Markets*, 128 Journal of Political Economy 6, pp. 2188-2244 (2020). For the German market, *see* W. Dauth et al., *The Rise of Robots in the German Labour Market*, VoxEU (19 Sept. 2017), available at https://voxeu.org/article/rise-robots-german-labour-market (finding that robots raise average productivity in the aggregate but not average wages).

11. C.B. Frey & M.A. Osborne, *The Future of Employment: How susceptible are jobs to computerization?* pp. 1-72 (17 Sept. 2013), available at https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf (estimating that 702 occupations on the US labour market are susceptible to computerization, which means that about 47% of total US employment is at risk); *see also* M. Arntz, T. Gregory & U. Zierahn, *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis*, OECD Social, Employment and Migration Working Papers No. 189 (2016), available at http://dx.doi.org/10.1787/5jlz9h56dvq7-en.

12. *See* E. Brynjolfsson & A. McAfee, *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy* (Digital Frontier Press 2011).

materialize with certainty, at least not to the extent that some are expecting them to.[13] The studies on the above effects are still ongoing and remain contradictory in their results.[14] In fact, there is no general consensus on the upcoming technological unemployment but there seems to be an agreement on the risk that robots and AI increase or exacerbate economic inequality.[15] In view of the above, despite the uncertainty of what exactly will be the impact of robots and AI on labour – and its magnitude – this uncertainty should not be a decelerator for policy makers and societies to prepare accordingly and initiate a substantial discussion on whether and which actions must be taken for the problems identified above in order to ensure a smooth transition to the new economic production model.[16]

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13. It is already known that the debate on the effects of AI on labour divides the economists into basically two camps: the optimists and the pessimists, or the "traditionalists" and the "futuristas". The former deal with AI as another phase of an industrial revolution that does not in principle differ from the previous ones and simply mirrors the past. The latter, however, see AI as something that brings with it a more radical transformation (at least of work patterns) where robots will replace much more jobs in a great range of occupations and skills. Replacement of course will happen possibly more massively than in the past, but other jobs will normally be created as well. These are, for example, jobs where robots will complement labour in work performance or jobs that still cannot be done by robots (i.e. creative and analytical tasks); *see* S. Kessler, *The Optimist's Guide to the Robot Apocalypse*, (9 March 2017), available at https://qz.com/904285/the-optimists-guide-to-the-robot-apocalypse/; H. Winthrop, *Optimistic and Pessimistic Views Concerning Automation and Cybernation*, 62 The Social Studies 2, pp. 77-82 (1971); D. Acemoglu & P. Restrepo, *Automation and New Tasks*, 33 Journal of Economic Perspectives 2, pp. 3-30 (2019); J. Manyika et al., *Jobs Lost, Jobs Gained: What the Future of Work will Mean for Jobs, Skills, and Wages*, McKinsey Global Institute, pp. 10-11 (28 Nov. 2017), available at https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages.
14. For example, some economists argue that the economy will adapt quickly to the short-term technological unemployment driven by robots and that firms that adopt robots experience more employment growth than those that do not. These firms also appear in the studies conducted so far to be more productive, which potentially will benefit final consumers. However, it is noted that the more productive firms will probably gain at the expense of the firms that will not adopt robots. *See*, in this respect, R. Seamans, *Tax Not the Robots*, Brookings (25 Aug. 2021), available at https://www.brookings.edu/research/tax-not-the-robots/; J. Furman & R. Seamans, *AI and the Economy*, National Bureau of Economic Research, Working Paper 24689 (June 2018), available at https://www.nber.org/papers/w24689; *see also* D.H. Autor, *Why Are There Still So Many Jobs? The History and Future of Workplace Automation*, 29 Journal of Economic Perspectives 3, pp. 3-30 (2015), pointing to the effect of robots on labour demand rather than on substitution per se.
15. *See*, inter alia, A. Berg, E.F. Buffie & L.F. Zanna, *Should We Fear the Robot Revolution? (The Correct Answer is Yes)*, International Monetary Fund WP/18/116, Institute for Capacity Development (2018), available at https://www.sciencedirect.com/science/article/abs/pii/S0304393218302204.
16. The said smooth transition is supposed to address the short-term disruption in the labour market that is caused by the adoption of robots that changes the balance

The role of technology in the current stage of economic development is more than central. The current and the future digital transformation of the economy and work will undoubtedly be governed by AI and robotics. Those are considered the most disruptive technologies and at the same time, the more "threatening" for the sustainability of the labour market because, above all, they seem to disturb and gradually redefine the fundamental concepts of labour and capital in the production process and their relationship.[17] Specifically, due to robots and AI substituting for labour, factor shares are unevenly allocated since more and more labour tasks – of a big array of skills and education levels – have been taken over by technology.[18] This is the cause of the concern around inequality that the previous economic studies highlight. In fact, the range and magnitude of substitution of robots for labour tasks and the subsequent uneven distribution of factor inputs in production has an immediate effect on whether the definitions that used to apply for each of the main factor inputs are still adequate. The definitions are also crucial since the current tax treatment depends on them and therefore, lack of consensus on how we should treat robots or AI may have unintended consequences on the distribution of income.

In particular, it is no longer clear whether technologies exhibiting the features of robots and AI should be still classified by the term "capital" or

between supply and demand. This is happening because robots' expertise in the way they perform tasks is diminishing the value of workers, resulting in increasing demand for robots, which equates with less production costs for the business using robots relative to the business using labour for the production of the same output. This situation is thought to lead to increased inequality because, although robots will contribute to higher productivity and hence higher profits, those will be concentrated among those owning the robots (i.e. capital) or those that have high skills and will dominate the labour market. This phenomenon is in turn likely to lead to less consumption but more savings; *see* H.W. Peck, *The New Economy and the Machine*, 22 Soc. F. 1, pp. 47-55 (1943); M. Ford, *Rise of the Robots: Technology and the Threat of a Jobless Future*, pp. 63, 250 et seq. (Basic Books 2015); R. B. Freeman, *Who Owns the Robots Rules the World*, 5 IZA World of Labor (2014), available at https://www.econstor.eu/bitstream/10419/125230/1/iza-wol-005.pdf.

17. C. B. Frey, *The Technology Trap: Capital, Labour and Power in the Age of Automation* (Princeton University Press 2019).

18. Declining labour shares in the production processes that are defined as a set of tasks are due to the substitution by capital and the capital-biased technological progress; *see* J. Martinez, *Automation, Growth and Factor Shares* (2019), available at http://josebamartinez.com/pdf/Martinez_AutomationGrowthFactorShares.pdf; D. Acemoglu & P. Restrepo, *Low-Skill and High-Skill Automation*, Working Paper 24119 (2019), available at https://www.nber.org/system/files/working_papers/w24119/w24119.pdf, showing that low-skill (high-skill) automation corresponds to tasks performed by low-skill (high-skill) labour being taken over by capital. *See also* L. Karabarbounis & B. Neiman, *The Global Decline of the Labor Share*, 129 The Quarterly Journal of Economics 1, pp. 61-103 (2014).

should rather be dealt with as "labour" from an economic or legal perspective. The view that robots tend to be conceptually closer to labour than traditional capital is more and more developed and elaborated and seems to be based on the assumption that, if robots and AI were capable of substituting for labour in cognitive tasks rather than routine and manual tasks, they would be treated as labour.[19] Hence, where robots are positioned conceptually (i.e. in between the two edges of the production chain, namely between labour and/or capital) is one of the key aspects that concerns both law and economics but has not yet been answered in a definite way since it is an inherently multidimensional task.[20] For this reason, it is essential to provide an outlook of the concepts of robot and AI as defined by different disciplines.

1.2. Terminology

1.2.1. Defining the terms "automation" and "automative systems"

There is no universally accepted definition of "automation" since the term is constantly in transition due to the technological development and capabilities of the machines. However, the first use of the term "automation" was meant to describe "the automatic handling of parts between progressive production processes"[21] but later on the term became broader to include "the integration of machines with each other into fully automatic and, in some cases, self-regulating systems".[22] Automation was initially closely and solely linked with the production process and was sometimes

19. Similarly, V. Fleischer, *Taxing Alpha: Labor is the New Capital*, Tax Law Review (7 Apr. 2019), discussing the qualification of income earned by the top one percent of people at the top of the income distribution such as Mark Zuckerberg when he sells shares of Facebook whose income qualifies as capital gains but is rather labor income in disguise.
20. This is one of the main questions that this thesis will be occupied with throughout all stages of the analysis that will follow. The answer to the above question is hence fundamental for the discussion of the tax policy proposals on AI automation and beyond.
21. The definition is credited to D.S. Harver of the Ford Motor Company, as quoted by H.L. Kahn, *Automation and Employment*, 10 Labor Law Journal, p. 796 (1959).
22. This definition was proposed by John Diebold in 1952. According to Diebold, automation was the next phase of mechanization and denoted not only the automatic operation per se but also the process of making things automatic, which included several areas of industrial activity. *See*, in this respect, D. de Wit, *The Shaping of Automation, A Historical Analysis of the Interaction between Technology and Organization, 1950-1985* p. 78 (Verloren 1994).

replaced by the term "automatic production" since it was seen as a technique of replacing men with machines so that the final product reached the end of the manufacturing process untouched by human hands.[23] Automation, however, could be applied either partly or entirely in the production chain. Entire or complete automation also covers office work where machines instead of men do the work, e.g. bookkeeping and accounting.[24]

The more the technology advanced, the broader the definition of the term automation became, so that now it generally refers to both the process itself, which aims at eliminating human intervention in performing tasks and handling information, and the outcome of that process. Nevertheless, the technical possibility of making a production process or a product automated does not necessarily mean that it eventually will be. This is because the basic reasons for the automation are the outer demands and changes surrounding the process, as well as inner factors concerning the organizational and human resource level.[25]

Thus, the decision to automate depends on several factors and is determined by a previous cost-benefit analysis, namely, whether the cost of automation is balanced by the beneficial economic anticipated outcome. However, there are cases in which automation is not appropriate because of the nature of the task to be automated or the nature of the final product or because sensitivity requires this task to be performed by a human. For example, when a task to be automated includes a product with a short life cycle, or there is a customized product that comes with a demand for uniqueness or where – in the case of introducing a brand new product – the market is uncertain and there is no clearness about how successful it will be, automation is not preferred.[26] Irrespective of the above, in the face of globalization and rapidly changing technologies, automation is considered a major tool for coping with competition, as it is typically motivated by two interrelated factors: the desire to reduce the amount of human labour required to complete a task and thus, to lower production costs; and the

23. F. Pollock, *Automation, A Study of its Economic and Social Consequences* pp. 3-8 (F.A. Praeger ed., Prager 1957).
24. Id.
25. J. Bessen, *How Computer Automation Affects Occupations: Technology, Jobs, and Skills*, Boston Univ. School of Law, Law and Economics Research Paper No. 15-49, p. 7 (2016).
26. V. Granell, J. Frohm & M. Winroth, *Controlling Levels of Automation – A Model for Identifying Manufacturing Parameter*, 39 IFAC Proceedings Volumes 4 (2006); M.P. Groover, *Automation, Production Systems and Computer-Integrated Manufacturing* (Prentice Hall 2005).

desire to achieve performance benefits, such as superior speed, accuracy or quality, which may or may not be within the capacity of human beings.[27]

Where automation describes the process or its outcome, automative systems are the "agents" of automation through which automation is realized. The qualities of these systems prescribe the decision and the level of automation in the production process. However, the conceptual understanding of an automative system or an agent of automation refers to a system that is, in an economic sense, a "substitute" for a human performing a task.[28] This substitute can take any form. For example, the steam engine during the first industrial revolution was an automative system functioning as a substitute for humans performing similar tasks. In Industry 4.0, the agents that perform automation focus on robots and AI as being, so far, the most disruptive forms of technology, being able to substitute not only blue collar but also white collar jobs and tasks. These are the most advanced human substitutes, whose implementation and promising capabilities threaten the sustainability of the labour market and tax system respectively.

1.2.2. An overview of relevant definitions

1.2.2.1. The notion of "Robot"

As happens with any evolving technology, the notion of what a robot consists in has changed over the years. There are broadly two ways to define a robot, either by reference to its technical characteristics and technical capabilities or by reference to the framework within which it acts and the actions it performs. Both are necessary to reach a definition comprising the "corpus" and the "animus" of a robot, which are in turn determined by technical, economic, legal and ethical dimensions. Defining both the corpus and the animus of the robot should offer a delimitation of those criteria that are crucial for essentially identifying why robots represent an exceptional technology. In the event the relevant criteria are identified they will be tested against the real economic concern that the projection of a robot's capacity in the foreseeable future creates for the sustainability of the labour market and the tax implications resulting therefrom.

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27. McKinsey Global Institute, *A Future that Works: Automation, Employment and Productivity* p. 11 (McKinsey 2017).
28. J. Balkin, *The Three Laws of Robotics in the Age of Big Data*, 78 Ohio State Law Journal, pp. 8-9 (2017): ("robots, AI agents, and algorithms substitute for human beings. They operate as special purpose people").

At the outset it is reiterated that in 1920, the term "robot"[29] was first published in the Czech science fiction play, Rossum's Universal Robots. From the etymology of the word it seems that a robot connotes the term "work" or "worker" and more specifically means labour and forced labour.[30] It was then gradually popularized after 1942 following the publication of the Runaround, a work of science fiction by Isaac Asimov that introduced the three laws of robotics.[31] Robotics and robots are often used interchangeably; however, they differ in that robotics intend to describe the branch of technology that deals with the design, construction, operation and application of robots.[32] On the other hand, *robots* is a complex and multidisciplinary term that may have a different meaning depending on the characteristics stressed by each discipline. In addition, robots may be classified by the tasks they perform based on the type of industry in which they are implemented. For example, a distinction is made between "industrial robots" and "service robots", with the latter being used for either "personal" or "professional" purposes.[33] A definition for industrial robots is provided by the International Organization for Standardisation (ISO) 8373, according to which an "industrial robot" is "[a]n automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications"[34]. The term "automatically controlled" refers to the ability of autonomous operation,[35] while the adjective "reprogrammable"

29. *See* K. Čapek., *R.U.R. (Rossumovi Univerzální Roboti)*, in *Sense of Wonder: A Century of Science Fiction* (Wildside Press 2011), introducing the word robot to the English language and to science fiction as a whole; cf. D. Harper, *Etymology of robot*, Online Etymology Dictionary, available at https://www.etymonline.com/word/robot (accessed 28 Sept. 2023), where "Czech robotnik 'forced worker,' from robota 'forced labor, compulsory service, drudgery,' from robotiti 'to work, drudge,' from an Old Czech source akin to Old Church Slavonic rabota 'servitude,' from rabu 'slave,' from Old Slavic *orbu-, from PIE *orbh- 'pass from one status to another' (see orphan). The Slavic word thus is a cousin to German Arbeit 'work' (Old High German arabeit)".
30. Id.
31. I. Asimov, *Runaround* (Street and Smith 1942), introducing the three laws of robotics.
32. M. Asada, *Robotics*, in *Encyclopedia of Information Systems* pp. 707-722 (Academic Press 2003); I.A. Joiner, *Robotics: Robots to the Rescue*, in *Emerging Library Technologies: It's Not Just for Geeks*, Chandos Information Professional Series, pp. 23-44 (Chandos Publishing 2018).
33. IFR, *Service Robots*, available at https://ifr.org/service-robots (accessed 28 Sept. 2023), defines service robots as robots "that performs useful tasks for humans or equipment excluding industrial automation applications (ISO 8373)".
34. ISO, *ISO 8373:2012(en) Robots and robotic devices — Vocabulary*, available at https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en.
35. *See also* UN, *Trade and Development Report – Beyond Austerity: Towards a Global New Deal*, United Nations Conference on Trade and Development, pp. 38-39 (UN 2017), available at https://unctad.org/system/files/official-document/tdr2017_

means that the robot's programmed motions or auxiliary functions may be changed without physical alterations. The word "multipurpose" defines a robot's capability of being adapted to a different application with physical alterations, namely mechanical systems and control systems. This implies that a robot is capable of performing a great range of different tasks rather than only repeating a single task. The term "axis" specifies the robot's motion in a linear or rotary mode,[36] meaning that a robot exhibits significant dexterity as per ISO 8373. The said definition does not reveal the whole potential of a robotic equipment or all possible characteristics of it. It simply provides for a general framework of different criteria according to which industrial robots could be further classified. In this regard, robots could be further classified based on their mechanical features as "fixed robots" or "mobile robots", or according to their working environment (i.e. industrial and personal robots). Industrial robots are located in a geometrically predefined and structured environment where robots perform actions such as material handling, manipulation and measurement, while advanced and service robots operate in unstructured environments where they are able to adapt accordingly. Based on the level of human-robot interaction, robots could be further classified according to the tasks performed and the level of human involvement in that task (either based on a human-robot ratio in performing a task or on the level of autonomy and decision-making of the robot itself, etc.).[37] It is fruitless to try to reach a single and uniform definition of robots by reference to their mechanical and technical capabilities or business applications. In addition, relying on the existent ISO definition of industrial robots may be a start; however, such definition will very soon risk becoming incomplete and eventually misleading and contradictory. The difficulty of defining robots lies in their multidisciplinary nature, which indicates that if they were to be approached only for the purposes of one discipline, in practice such a definition would not be easily applicable. On the other hand, it could be argued that one can recognize a robot when he/she sees it. For instance, there are different robotic applications that present different characteristics and affect the social and economic environ-

en.pdf [hereinafter *UNCTAD 2017*], where they explain the ISO proposed definition on industrial robots and stress that robots are different from conventional capital equipment because of these characteristics, as well as from other forms of automation such as Computer Numerical Control systems that have allowed for the automation of machine tools since the 1960s but are designed to perform very specific tasks. The latter, even if they are digital, still lack the flexibility and dexterity of industrial robots.

36. Id.

37. *See* P. Salvini, *Taxonomy of Robotic Technologies* p. 17 (Robolaw Grant Agreement No 289092, D4.1.2013); cf. G. Verruggio & F. Operto, *Roboethics: Social and Ethical Implications of Robotics*, in *Handbook of Robotics* p. 1151 (B. Siciliano & O. Khatib eds., Springer 2008).

ment in different ways, ranging from an automated vacuum cleaner to exoskeletons, personal robot assistants, driverless cars, drones and softbots. All these classify as robots without however someone being able to identify the red line between what is a robot and what is not in a principled way.

However, rather than trying to form a definition of robots, it is better to be able to structure some criteria for their classification that would mirror the concerns/risks that robots raise for the labour market. These criteria will be based on existent applications, as no one can predict the future and therefore, in any case will be subject to future reviews and updates. The same "classification approach" has been similarly adopted by other scholars occupied with the implications of robots in various fields of law, namely civil law and liability rules. In this respect, Nevejans classifies a robot based on the following elements as: (i) a physical machine ("*machine matérielle*"); (ii) alimented by energy; (iii) with a capacity to act in the real world; (iv) analyse the environment; (v) render decisions; and (vi) learn.[38] In addition, Bertolini[39] delimited the criteria into those of: (i) embodiment or nature; (ii) level of autonomy; (iii) function; (iv) environment; and (v) human-robot interaction, proposing at the same a time a descriptive definition of the notion of a robot, according to which, regardless of the purposes of the definition, a robot may be: "a machine, which (i) may be either provided of a physical body, allowing it to interact with the external world, or rather have an intangible nature–such as a software or program–, (ii) which in its functioning is alternatively directly controlled or simply supervised by a human being, or may even act autonomously in order to (iii) perform tasks, which present different degrees of complexity (repetitive or not) and may entail the adoption of not predetermined choices among possible alternatives, yet aimed at attaining a result or provide information for further judgment, as so determined by its user, creator or programmer, (iv) including but not limited to the modification of the external environment, and which in so doing may (v) interact and cooperate with humans in various forms and degrees."[40]

In the same direction, on 12 January 2017, the European Parliament's Legal Affairs Committee adopted a workshop report by Luxembourg MEP Mady Delvaux submitted on 31 May 2016, with recommendations to the Com-

38. N. Nevejans, *Les robots : tentative de définition*, in A. Bensamoun et al., *Les robots* pp. 79-117 (Mare et Martin, Presses Universitaires de Sceaux 2015).
39. A. Bertolini, *Robots as Products, The Case for a Realistic Analysis of Robotic Applications and Liability Rules*, 5 Law Innovation and Technology 2, pp. 214-147 (2013).
40. Id., at p. 219.

Notes

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