# Alexa and Siri Do Not Pay Taxes!

## Shafik Hebous and Alexander Klemm*

International Monetary Fund

January 2022

Artificial intelligence and robots have raised concerns replacement of human jobs, intensified by the pandemic. This paper analyses whether this justifies taxing robots. It uses insights from economics to consider possible implementations of a robot tax, its incidence, its equity and efficiency effects, and alternative taxes. The paper argues that robot taxes cannot be borne by robots. While various economic models show that robot taxes could be used to enhance equity, they tend to make impracticable assumptions. Tax policy has more efficient ways to address the effects of artificial intelligence, such as rising capital income shares and inequality and declines in revenue. The most direct instrument would be higher capital income taxes, while a focus on rents would be most efficient.

Key words: robot tax, artificial intelligence, tax incidence, equity.
JEL codes: H21, H22, O33, D63

* The views expressed here are those of the authors and do not necessarily represent the views of the IMF, its Executive Board, or IMF management. We gratefully acknowledge comments by Kevin Fletcher, Michael Keen, Sergio Rodriguez, and Martin Schindler.

**Extended Abstract**

Artificial intelligence and recent significant advances in the performance of robots have spurred a heated debate about the implications of replacing human jobs. The COVID-19 pandemic can be expected to further accelerate digital and robotic transformation. One aspect of this multi-faceted debate is the role of taxation, which led to the call for taxing robots.

This paper summarizes the insights from economic theory and empirical research about the effects of taxing robots. It looks at: how a robot tax can be implemented and who would bear its burden; the equity and efficiency aspects; and alternatives to robot taxes.

There are four broad possible designs of a robot tax: (i) a tax on the purchase of robots; (ii) a tax on imputed salaries of robots; (iii) an annual tax on the *stock* of robots; and (iv) a surtax on profits from producing or using robots. None of these taxes—nor any other conceivable design—could be borne by robots, who do not have consumption needs. Any tax on robots can only reduce the welfare of robot producers, robot owners, or customers buying products made by robots. The distribution between those groups depends on the market structure.

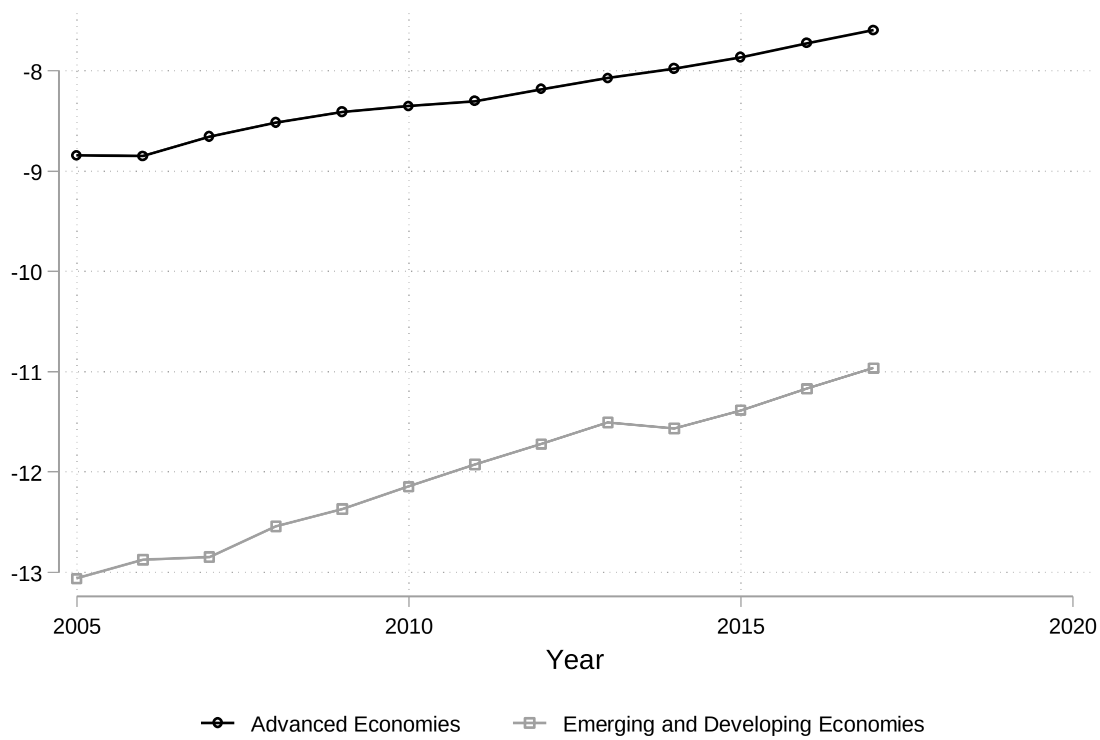
Various economic models show that robot (or similar) taxes could be used to enhance equity while reducing efficiency. Models explicitly considering the taxation of robots, however, tend to make unrealistic assumptions—such as nonlinear optimal tax schedules and ignore open economy aspects.

Moreover, even without robot taxes, tax policy can be used to address some of the effects of increased use of artificial intelligence—such as rising capital income shares, declines in revenues, and rising inequality. Most directly this can be done through higher capital income taxes, ideally with a focus on rent and while ensuring robustness to international spillovers.

## 1. Introduction—A Tax on Robots?

Artificial intelligence (AI) and recent significant advances in the performance of robots have spurred a heated debate about the implications of replacing human jobs—across many professions and skill levels—for the economy.[1] The use of robots has certainly been increasing rapidly over the last decades (Figure 1). The COVID-19 pandemic can be expected to further accelerate digital and robotic transformation, as a result of their immunity to human viruses and possibly a general push toward adopting more innovative working and production methods.

**Figure 1. Ratio of Robots to Humans**




Source: Authors' calculation using data from the International Federation of Robotics.

History provides many precedents of new technologies that raised aggregate productivity through lowering the cost of value creation—while inflicting significant adjustment costs on

[1] The term "robot" is used here to refer to machines, software, and combinations of both that are capable of emulating human functions or the intelligence of learning and problem solving. This paper uses the terms AI and robot interchangeably but acknowledges that other definitions are possible, and robots could in other contexts be defined to include machines that perform simple repetitive tasks.

society through large-scale replacement of labor by capital. With the invention of the steam engine and industrialization this process accelerates and touched all economic sectors. Ultimately, the higher capital stock implies that each worker can produce more and—as the relatively scarcer factor—earn higher wages. During adjustment, however, workers with obsolete skills faced wage cuts and unemployment. In general, these technological changes raised the demand for highly skilled workers while reducing it for less skilled workers, and the solution was more and different education to facilitate labor reallocation. What might be different about AI is that it replaces even some high-skilled and nonroutine tasks and that it might occur at an even faster pace.

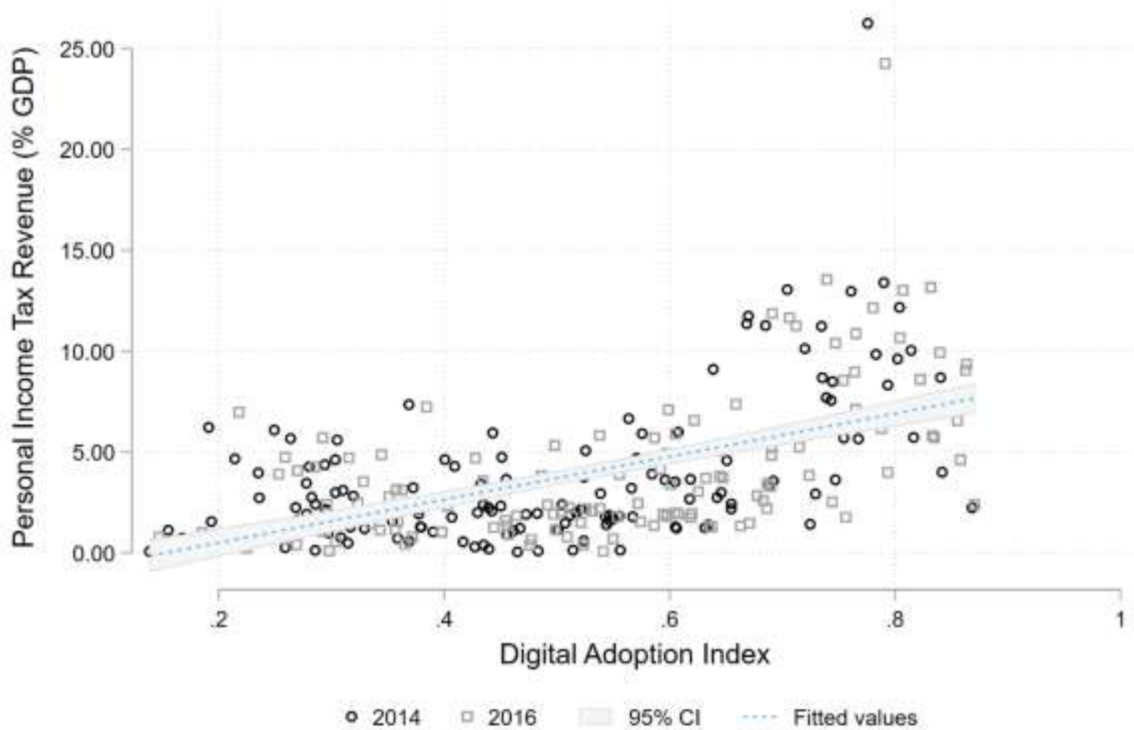
One aspect of this multi-faceted debate is the role of taxation. Some, including Bill Gates, are of the view that we should "tax robots" to alleviate the impacts of automation technology on human jobs. Others, including Larry Summers (2017), consider this a "fundamentally misguided" idea. The European Parliament rejected plans for an EU-wide robot tax in 2017. This discussion about a robot tax is far from settled.

One argument in favor of robot taxes is that a firm that employs robots (instead of human labor) avoids payroll taxes and social security contributions (e.g., Acemoglu and Restrepo, 2019). This is feared to result in (i) a tax preference for robots, leading to an inefficient capital-labor allocation and worsening income inequality; and (ii) a decline in revenues, possibly combined with an increasing demand for government services and transfers and thus public deficits. However, taxing robots jeopardizes the innovation process—including in technologies that create new tasks and jobs—, thereby slowing economic growth.

This paper summarizes the insights from economic theory and empirical research about the effects of taxing robots. It looks at: how a robot tax can be implemented and who would bear its burden (Section 2); the equity and efficiency aspects (Section 3); and alternatives to robot taxes (Section 4).

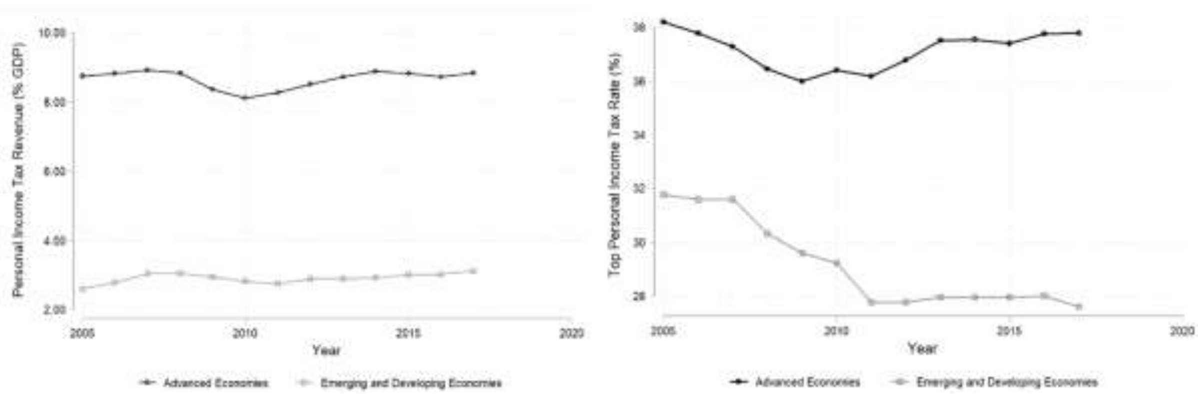
Before proceeding with our discussion, it is useful to document empirical regularities. First, so far digital adoption appears to be correlated with relatively high personal income tax revenue (Figure 2). Moreover, personal income tax collection has remained relatively steady (Figure 3, left panel) even though tax rates have not been increased and even fell in emerging and developing economies (Figure 3, right panel). Moreover, it is well-documented that the capital income share in aggregate income has been increasing for various reasons including globalization (IMF, 2017). But such trends certainly cannot be extrapolated into the future, especially if robot adoption and technological change accelerate more rapidly or even lead to sudden structural changes in economies.

**Figure 2. Personal Income Tax Revenue and Digital Adoption**




Source: Authors' calculations based on World Bank data

**Figure 3. Personal Income Tax Revenue and Top Rate**




Source: Authors' calculation based on IMF WoRLD and IBFD data.

## 2. Who Would Bear the Incidence of a Robot Tax?

There are four broad possible designs of a robot tax:

**I.** A tax on the purchase of robots (i.e., an excise);

II. A tax on imputed salaries of robots;[2]
III. An annual tax on the *stock* of robots (i.e., a wealth tax on a specific type of asset);
IV. A surtax on profits from producing or using robots.

It important to distinguish between the *legal* incidence of the tax—i.e., who is responsible for paying it—and the *economic* incidence—i.e., who ultimately bears the burden of the tax. The economic incidence of a tax is ultimately reflected in lower earnings and thus lower consumption, and it is key for understanding the impact of any tax on social welfare.

Determining the precise incidence of a tax—between consumers, producers, and workers—tends to be empirically challenging. It is, however, clear that none of the above robot taxes—nor any other conceivable design—could be borne by robots. Robots cannot consume less or have face a reduction in their welfare. Despite the speed of technological progress, a robot with artificial consciousness and hence desire for consumption, is a remote possibility, and would create greater challenges than taxation. Hence, for the foreseeable future, any tax on robots can only reduce the welfare of robot producers, robot owners, or customers buying products made by robots.

In case of excises, how the tax burden is shared between producers and consumers depends on the market structure (e.g., Stiglitz, 1988, Chapter 17). In perfect competition in the market for robots, their price equals the marginal cost of producing them. In such scenario, the price of robots rises by the entire amount of such excise. Under a monopolistic structure, the burden of the tax is determined by demand. The price of robots would, for example, rise by half of the tax in case of linear demand or by more than the tax itself under a constant price elasticity of demand. As robots are mostly purchased by other corporations as inputs, the ultimate incidence also depends on competition in the producing sectors who may or may not be able to pass on the increased cost to consumers.

Taxes on stocks of robots or imputed salaries raise the cost of using robots in production, and the extent to which this can be passed on to consumers depends, as for excises, on the market structure.

The incidence of capital income taxes is complex. Empirical evidence suggests that workers bear about 50 percent of the total corporate income tax burden and the burden is even higher for female and young employees (Fuest et al., 2018). The incidence of increasing the tax only on robot profits would possibly be different. In any case it would raise major difficulties in determining the share of profits due to the robot use.

## 3. What are the Efficiency and Equity Implications of a Robot Tax?

[2] Oberson (2017) discusses granting robots "legal personalities" for tax purposes. This would have no implications on the economic incidence of any resulting tax.

Most robots are intermediate goods in a production process. Diamond and Mirrlees (1971) famously show that taxing intermediate goods is generally inefficient. Their framework, however, assumes at most constant returns to scale, which may not apply for AI that is best characterized by increasing returns to scale.

The economic growth literature analyzes increasing returns. Romer (1986) presents a model with a production function that includes knowledge as a production factor that entails positive spillovers and increasing returns to scale. The study does not use the terms "robot" or "AI", but investment in knowledge has similar features implying that taxing the use of AI would have negative implications for growth by preventing associated positive spillovers. Recent growth models, however, show that robots replace unskilled labor, so it becomes abundant and wages fall in the short-term (Berg et al., 2018). Still, a robot tax is not the best tool to finance redistribution to displaced workers because it lowers growth, thereby also education (Prettner and Strulik, 2019).

Recent studies articulate arguments in favor of differential taxation by type of capital. Slavik and Yazici (2014) present a model with two types of capital: structure and equipment. Equipment could also be (roughly) interpreted as AI as it is assumed to be complementary to skilled labor—i.e., investment in such capital raises wage premiums of skilled workers. In this setup—which may not be the relevant anymore when AI also replaces skilled labor—applying a higher tax on equipment can be optimal by reducing the wage differences between skill levels. As only income is observed, but not the skill level, the mechanism is driven by the need to prevent skilled workers from pretending to be unskilled by reducing their labor supply so that their wage equals the unskilled one. In a similar vein, Guerreiro et al. (2017) develop a model with two types of skills (high and low)—and Thuemmel (2018) with continuous skill differentiation—explicitly considering the taxation of robots. This class of models posits that taxing robots can be desirable on equity grounds, because the tax reduces inequality, thereby allowing for more efficient labor taxation, again to prevent skilled workers from pretending to be unskilled (to save taxes).

While these models make theoretical arguments for taxing AI, the conditions under which they apply are not relevant in practice. No country uses a nonlinear optimal tax schedule. Instead, typical labor taxes are schedules that have stepwise rising marginal tax rates. As a result, it is most unlikely that skilled workers would be in the position in which they would want to pretend being unskilled, because even though taxation rises with income, net incomes do not fall with higher gross incomes, as might happen under a nonlinear schedule. With rising marginal labor tax rates, the more relevant aspect is that high-earning skilled workers experience a high substitution effect toward leisure.

From a global perspective, taxing AI is even more inefficient than implied by closed-economy reasoning as AI is extremely mobile, and the tax can in many cases be avoided by relocating or producing the AI abroad. A robot tax can therefore preclude technology adoption and turn a country into a comparative laggard.

## 4. What Are the Alternatives to a Robot Tax?

Even without robot taxes, tax policy can be used to address some of the effects of rising AI—such as rising capital income shares, declines in revenues, and rising inequality—most directly through higher capital income taxes. Not all capital income is related to the use of robots, but there are persuasive arguments to (i) tax all types of capital at the same rate; and (ii) especially tax supernormal profits (rents)—irrespective of whether they are due to robots. There are also arguments for taxing capital less than labor (Sørensen, 2007), but the rising importance of robots in production would likely shift the tradeoff between efficiency and equity toward higher capital taxes than so far—although not necessarily all the way up to labor tax rates.

Raising the corporate income tax rate is difficult, however, as corporate income is subject to international tax avoidance and tax competition. Moreover, the corporate tax is distortionary since it taxes normal returns and as noted, its incidence is likely to significantly fall on labor. This reinforces the argument for a robust system of rent taxation. For example, a fundamental reform option, proposed by Auerbach et al. (2017), is to globally adopt a destination-based cash-flow tax, which is efficient and robust to international challenges. Its incidence is on consumption financed out of non-wage income. Recent progress in automatic exchange of information between countries and other tax initiatives help in enforcing capital income taxation, but likely would not fully resolve the de facto disparity between capital and labor income taxation. A better taxation of rents is ultimately indispensable especially given the evolving increase in market power of monopolistic multinationals.

## 5. Conclusion

The increasing use of robots and their perceived under-taxation compared to laboring humans has led to calls for robot taxes. However, the burden of such taxes—irrespective of their design—cannot be borne by robots who cannot consume less. Instead, such tax would be borne by their owners, human workers, or consumers, with the precise split depending on market structures. Moreover, taxing robots is inefficient, discouraging innovation and likely slowing growth.

This is not to say that there is no possibility or need to undertake tax reforms to address changes resulting from the proliferation of robots. Notably, with a rising share of capital income in GDP, there is a case for increasing taxes on capital income to address the broader issue of inequality, while minimizing distortions to production decisions. If additional taxes are designed as targeting economic rents, they would be particularly efficient and avoid distorting investment decisions—in robots or other capital.

## References

Acemoglu, D., and Restrepo P., 2019, "Automation and New Tasks: How Technology Displaces and Reinstates Labor," *Journal of Economic Perspectives* 33(2), 3–30.

Auerbach, A., Devereux, M. P., Keen, M., and Vella, J., 2017, "International Tax Planning under the Destination-Based Cash Flow Tax," *National Tax Journal* 70(4), 783-802.

Berg, A., Edward B. F., and Luis-Felipe, Z., 2018, "Should We Fear the Robot Revolution? (The correct answer is yes)," *Journal of Monetary Economics* 97(C), 117-148.

Diamond, P. A., and Mirrlees, J., 1971, "Optimal Taxation and Public Production I: Production Efficiency," *American Economic Review* 61(1), 8-27.

Fuest, C., Peichl, A., and Siegloch, S., 2018, "Do Higher Corporate Taxes Reduce Wages? Micro Evidence from Germany." *American Economic Review* 108 (2), 393-418.

Guerreiro, J., Rebelo, S., and Teles, P., 2017, "Should Robots Be Taxed?", NBER Working Paper No. 23806.

International Monetary Fund, 2017, "Understanding the Downward Trend in Labor Income Shares," World Economic Outlook, April, Chapter 3.

Oberson, X., 2017, "Taxing Robots? From the Emergence of an Electronic Ability to Pay to a Tax on Robots or the Use of Robots," *World Tax Journal* 2017(2), 247-261.

Prettner and Strulik, 2019, "Innovation, Automation, and Inequality: Policy Challenges in the Race Against the Machine," *Journal of Monetary Economics*, In Press.

Romer, P. M., 1986, "Increasing Returns and Long Run Growth," *Journal of Political Economy* 94, 1002–1037.

Slavik, C., and Yazici, H., 2014, "Machines, Buildings, and Optimal Dynamic Taxes," *Journal of Monetary Economics* 66, 47-61.

Sørensen, P., 2007, "Can Capital Income Taxes Survive? And Should They?" *CESifo Economic Studies* 53(2), 172-228.

Stiglitz, J., 1988, "Economics of the Public Sector," Norton.

Summers, L., 2017, "Picking on Robots Won't Deal with Job Destruction," *Washington Post*, March 5.

Thuemmel, U., 2018, "Optimal Taxation of Robots," CESifo Working Papers No. 7317.