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A Game Model Analysis of the International Digital Service Tax in an Asymmetric Market Duopoly

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ABSTRACT

Against the backdrop of the rapidly expanding digital economy, multinational corporations are increasingly exploiting information asymmetry in the market to employ covert and diverse methods of tax avoidance. This poses a significant challenge to tax collection and administration. The proposal of a digital service tax aims to adapt the international tax system to the digitalization of the economy, ensuring fair and reasonable tax payments. To address these challenges, this article assumes an asymmetric international digital economy market and a domestic market characterized by duopoly. It establishes an asymmetric market duopoly game, calculates the digital gains of each country's market using the logistic function, determines the Nash equilibrium of the data service tax game, and analyzes the relationship between the digital service tax rates of strong and weak countries in the digital economy.

KEYWORDS

Asymmetric Information, Digital Service Tax, Duopoly, International Taxation

INTRODUCTION

Tariffs, as defined by customs authorities, are taxes imposed by sovereign states on goods exported through their customs territories in accordance with their respective laws. Typically, tariffs are considered to be high-level taxes set by the highest administrative unit of a country to determine tax rates. For countries engaged in extensive foreign trade, tariffs often constitute a significant portion of the national tax revenue and even national finances (Amiti et al., 2019; Fetzer & Schwarz, 2021). However, with the rapid growth of the digital economy, many multinational digital technology-based corporations can conduct transactions solely through information and communication technology in virtual spaces without the need for physical business entities. This allows them to effectively evade tax liabilities, resulting in a substantial reduction in their tax burdens.

Consequently, countries in which business income is generated face challenges in collecting taxes or only collect a portion of the taxes owed. In recent years, the issue of tax losses has compelled

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source countries to address tax collection and management in their digital economies (Tang et al., 2023; Zhu, 2021; Lee et al., 2021). Since 2018, the European Union, the United Kingdom, France, Spain, and other countries have proposed the implementation of the digital service tax (DST) to promote tax fairness and address the tax challenges posed by the digital economy (Shukla, 2020; Kofler & Sinnig, 2019). DST is levied on the revenue of large digital technology-based corporations that provide specific digital products or services through remote sales and service platforms. This business model encompasses social media corporations, e-commerce marketplaces, cloud services, and web-based service platforms (Kofler & Sinnig, 2019; Vella, 2019; Kofler, 2021; Bunn et al., 2020). The primary rationale behind implementing the DST is the substantial volume of data services provided by digital multinational corporations (MNCs) and asymmetry in the international data market, which undermines the economic interests of countries with weaker digital economies (Lowry, 2019). Therefore, the DST has certain implications similar to tariffs, but it differs from traditional tariffs on trade in products and services. Another attribute of the DST arises from the ownership and allocation of data, specifically the balance of rights between data ownership and data usage. Unclear rules regarding data ownership and allocation have become significant institutional obstacles in the development of the digital economy. As data processors, digital MNCs possess the right to use data, whereas the originators of data (including internet users) hold the right to data ownership. This creates a binary rights structure known as data tenure (Shen, 2023) that aims to achieve a balanced distribution of data property rights and interests (Tirole, 2023). In the data ownership game, data processors often hold a monopoly position because of their control over cyberspace and capital advantages (Fang, 2018).

The DST was initially proposed to address the issue of Base Erosion and Profit Shifting (BEPS) by digital MNCs in countries where they are not domiciled (Garcia-Bernardo & Janský, 2024; Nerudova et al., 2023; Mongrain & van Ypersele, 2023). These digital MNCs take advantage of differences in tax regimes and regulatory loopholes across countries, utilizing internal asset transfers, corporate function splitting, and asset pricing to avoid tax obligations. This practice has resulted in uneven regional tax distribution conflicts (Joshi, 2020; van Apeldoorn, 2018). In the digital era, the scale of the digital economy continues to expand, and many multinational corporations, particularly American digital MNCs, often employ strategies like the “double Irish-Dutch sandwich” to minimize their tax burdens (Beebeejaun, 2021; Ní Chasaide, 2021). By transferring profits from high-tax countries to low-tax countries, these companies can avoid a significant portion of their tax obligations, while still benefiting from the resources and infrastructure provided by high-tax countries. Digital MNCs, such as Apple, Google, Microsoft, Facebook, and Yahoo, have utilized such practices in the past (Cantos, 2022; Bateman, 2023). However, in other countries, this behavior is considered highly unethical. Countries that have experienced the erosion of their tax bases have voiced their concerns and initiated campaigns against the BEPS (Cantos, 2022; Langenmayr & Liu, 2023). In a study conducted by Makhalina an Makhalina (2020), international projects were developed to monitor tax services globally, considering the BEPS program and the requirements of the digital economy. Therefore, it is necessary for countries around the world to work together to tackle BEPS, reduce disparities in tax regulations between countries, prevent double and multiple taxation, and mitigate the negative impact on investment, employment, and global economic growth.

The coordination and cooperation required for the implementation of an international DST are indeed challenging because of differing interests and policy preferences among countries. With the sweeping of the big data era, game-theoretic approaches are increasingly being used to study the interconnections between different fields, and many researchers have constructed different meaningful game models (Li & Liu, 2020; Li et al., 2021; Ye & Li, 2021; Chen et al., 2021). Zheng and Li (2023) nested cooperative and noncooperative games, constructed a new two-layer game model, and derived the solution of the cooperative game as well as the payoff function of the noncooperative part of the game to get the optimal dual-form game profit maximization strategy and investment cooperation strategy. Liang and Li (2022) proposed a two-objective game for bidirectional link network formation, which simultaneously considers participants’ strategy choices and corresponding gains under the dual objectives of profit and link security. Researchers have explored these challenges using game theory and proposed solutions such as international tax agreements and multilateral conventions (Oats, 2023; Pirlot & Culot, 2021; Mpofu, 2022). For instance, Ye and Li (2021) examined the international tax policies adopted by the two countries in a non-cooperative game framework. They derived global pareto-efficient tax policies in a cooperative framework, highlighting the potential welfare gains that can be achieved through international tax policy coordination. The dominance of certain countries in global commerce can lead to conflicts of interest and disrupt international taxation. This necessitates the development of strategies to balance the relationship between business and society in the digital economy. Nestoryshen et al. (2021) developed a game model involving three players: the state, the economic operator, and society. They derived pure strategies for these players and emphasized the importance of finding a balance of interests among all participants, which can result in positive outcomes not only for specific businesses, but also for society. However, none of these studies have provided specific recommendations for the international DST and have paid less attention to the revenue generated by such a tax. Further research is needed to explore the potential revenue implications of the international DST and provide practical recommendations for its implementation. This involves considering the interests of all stakeholders and finding a balance that promotes fairness, efficiency, and economic growth in the digital economy.

The political battle between France and the United States over the DST reflects a larger game of economic interests and global economic governance in the midst of a tense global trade climate. Despite pressure from the US, France is still determined to introduce the DST (Faulhaber, 2019; Geringer, 2021). One important consideration for France is to promote the adjustment of global rules in the digital economy and to fight for its right to participate in global economic governance. The digital economy has fundamentally changed the way businesses operate, necessitating adjustments to global economic governance. From this perspective, it is clear that developed countries cannot avoid engaging in a long-term game regarding DST. Although the European Union released a report in 2014 advocating for the “localization of data” as a form of technological sovereignty, implementing localization initiatives has proven challenging due to data mobility and technical difficulties (Chander, 2020; Couture & Toupin, 2019). Therefore, the DST is not a traditional tariff but rather a special tax with some symbolic characteristics of a tariff imposed on digital MNCs. Even if sovereign states can localize data, the game surrounding DST differs from traditional tariff games in terms of goods and services because of the unique characteristics of data, such as its zero-cost copying, deletion, and destruction. This highlights the complexity of negotiations between the US and Europe regarding DST, particularly when determining the tax rate and tax base. In this international game of DST, suppliers in various countries have adjusted their strategies to gain a favorable position in the digital economy wave. Simultaneously, the demand side carefully assesses the impact of the tax and reacts accordingly, resulting in an intricate, strategic game. The negotiations and decision-making processes surrounding the DST are complex and require careful consideration of the interests and dynamics of the stakeholders involved.

In order to solve the DST puzzle, regarding the difficulty of dealing with DST fairness in asymmetric markets in practice, we formulate an asymmetric market duopoly game in the international market, considering the motivation behind taxing data services in the digital economy and the negotiations surrounding DST among cross-border digital service providers. The main contributions of this study are summarized as follows:

- A game theoretic model is employed to examine the impact of an international DST, considering the strategic interactions between suppliers and the demand side as well as the effects of the tax on market participants’ behavior.
- The findings of the DST game reveal the emergence of a delicate equilibrium between supplier and demand. As the tax rate increases, the cost of data services increases, which directly affects suppliers’ profitability. However, the demand side also faces the challenge of higher prices.

In this dynamic scenario, both parties seek optimal strategies to protect their interests to the maximum possible extent. The decisions and wisdom of both the supply and demand sides are intertwined in the digital economy tax chess game, ultimately shaping the prospects of the global digital economy.

- This study highlights the complex and ever-changing nature of the digital economy and strategic considerations involved in the implementation of DST. The interaction between supply and demand plays a crucial role in shaping the outcomes of the tax game. The decisions made by both parties have a significant impact on the development and future trajectory of the global digital economy.

The remainder of this paper is organized as follows. In the Model Assumptions Section, we make a series of assumptions about the model that we built and describe the basis for making these assumptions. Based on this, a design strategy is proposed to abstract the competitive situation of the international digital economy into an asymmetric market duopoly game. In Modeling and Solving, the specific game framework and process are described based on model assumptions, the welfare functions of the participants are accounted for, and the model is solved. In the Conclusions and Prospect section, we draw conclusions and provide suggestions on the implementation of the DST policy.

Model Assumptions

Based on the pattern of the international digital economy, distribution of giant digital MNCs, and state of market fragmentation, we abstract competition in the international digital economy as an asymmetric market duopoly game. The model assumptions were as follows.

Asymmetry of the Market

Data powerhouse countries, such as the United States and China, referred to as "Category I" countries, possess a substantial domestic data market and hold an absolute advantage in international data market competition. They have extended their data sovereignty to space through technologies, such as Baidu and GPS. Additionally, multinational internet giants such as AGMFY in the United States and BATH in China have emerged, enabling these countries to establish a strong presence in both the international and domestic digital economies. On the other hand, smaller and loosely organized economies, known as "Category II" countries (e.g., the European Union and the Eastern Alliance), lack strong multinational data corporations due to limited technological strength and market size. These countries rely heavily on multinational internet giants for data services in their domestic markets.

Under this assumption, China and the United States do not intend to introduce DST. The competition between these two countries revolves around data sovereignty and involves political confrontation and technological hegemony struggles, reflecting the competition for comprehensive national power. However, smaller economies either do not engage in DST games or have independent DST policies. The only possibility is to form alliances through international agreements to constrain the data hegemony of the United States. Consequently, the DST game, in a purely economic sense, exists only between Category I and Category II countries.

The significance of this assumption is to strictly confine the DST game to an economic context, implying that the DST game is solely an economic behavior. In a DST game between Category I and Category II countries, the DST rate in Category I countries can only be zero or negative, while the DST rate in Category II countries will not be negative.

The Marginal Cost of Scale Production is Zero

The marginal cost of multinational internet enterprises is assumed to approach zero, while the fixed costs are significantly positive. These fixed costs consist primarily of national and corporate investments in data infrastructure construction and operations. The data infrastructure includes both space-based facilities, such as satellites, and ground-based infrastructure. Once the data infrastructure is established, as the scale of the data increases, the costs associated with collecting, storing, and processing the data decrease rapidly. This implies that the operational and congestion costs associated with handling large volumes of data are minimal.

For instance, after launching a remote sensing satellite, the cost of collecting remote sensing data from outside the sovereign state becomes negligible or nonexistent because of the satellite's periodic orbit. The fixed costs of satellites, including solar panels and radar transmitting and receiving devices, have already been accounted for. When remote sensing data from satellites are shared globally for scientific purposes, the data at scale can be considered a quasi-public good with minimal congestion costs.

In summary, the assumption is that multinational internet enterprises have near-zero marginal costs, whereas their fixed costs are substantial, mainly attributed to data infrastructure construction and operation. Once the data infrastructure is in place, the costs associated with handling large volumes of data decrease significantly, thereby leading to minimal operational and congestion costs.

Unrestricted Cross-Border Data Transfer

Category II countries face challenges in regulating and controlling the flow of data across borders. This lack of technical ability allows multinational internet giants to leverage data from various countries, benefiting from economies of scale, and further consolidating their market dominance.

It is important to note that these assumptions simplify the model and capture the dynamics of international digital economy competition. However, in reality, the situation may vary across different countries and regions, and the technical capabilities of Category II countries may differ.

Domestic Market Duopoly

According to antitrust laws, domestic oligopoly data corporations are not allowed to emerge among internet powerhouses. Additionally, owing to the differentiation of data businesses among digital MNCs, such as Google focusing on search and Facebook focusing on social networking, it is unlikely that there will be many homogeneous digital MNCs within the domestic market of a data powerhouse. In rare cases in which multiple homogenized digital MNCs do exist, strong capital forces are likely to lead to mergers and acquisitions. Therefore, we can assume that digital MNCs with the same products operate duopoly. While this assumption may be subject to some controversy, appropriate simplification does not affect our analysis of the nature of the DST game.

Digitization Gain Per Country Market as a Logistic Function of Data Yield

The digitization gain per country market can be modeled as a logistic function of the data yield. As data accumulate, the physical cyberspace on which the data relies is established, and a certain number of users are gathered. The data generated by these users continuously becomes the data assets of the data processor, resulting in a sharp decrease in the cost of processing the data. This leads to a marginal cost of data processing, which converges to zero. Therefore, when the amount of data reaches a certain scale, the data-processing cost for internet enterprises primarily depends on the fixed costs associated with physical network construction and data-cleaning software.

A logistic function or logistic curve is commonly used to represent the scale effect of data processing (Rządkowski & Sobczak, 2020). It accurately captures the growth process of data processing costs, exhibiting exponential growth in the initial stages, followed by a slowdown as it approaches saturation and eventually reaches maturity when the increase stops. The logistic function serves as an activation function that effectively models the cost dynamics of data processing.

In summary, the assumption of a reality duopoly among digital MNCs with the same product and the use of a logistic function to represent the scale effect of data processing costs are appropriate simplifications that do not undermine our analysis of the nature of the DST game.

Modeling and Solving

Table 1. The explanations of parameters and variables

Nomenclature	
Indices	
A	Code name of the country
B	Code name of the country
i	The model assumes that different internet firm exist in Country A
Variables	
Q_A	Total production of Country A on the market
Q_B	Total production of Country B on the market
Q_1	Total output of Enterprise 1 in Country A
Q_2	Total output of Enterprise 2 in Country A
p_A	Domestic and foreign market clearing prices of Country A
p_B	Domestic and foreign market clearing prices of Country B
h_i	Enterprise i in Country A is the domestic market production
e_i	Export volume of Enterprise i in Country A
C_i	The total cost of production by Enterprise i in Country A
t_A	Value of tariff subsidies setting by Country A
t_B	Tariff rates setting by the Country B
π_i	The earnings of Enterprise i
W_A	Total welfare of a Country A
W_B	Total welfare of a Country B

continued on following page

Table 1. Continued

Nomenclature	
Parameters	
a_A	a positive constant, differing by Country A and B
a_B	a positive constant, differing by Country A and B
K_A, K_B	a positive constant, differing by Country A and B
r_A, r_B	a positive constant, differing by Country A and B
c	The fixed costs of the enterprise

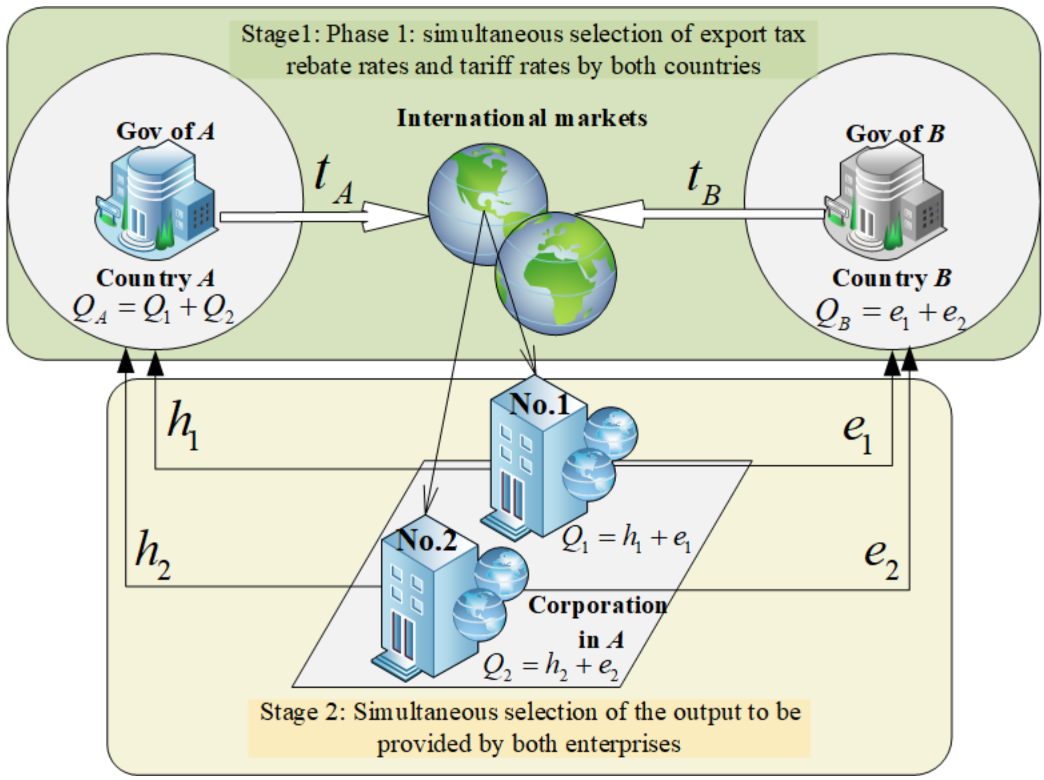
Description of the Model

Based on the given modeling assumptions, this study considers two countries denoted as Country A and Country B, where Country A is a Category I Country and Country B is a Category II Country. In Country A, there are two duopoly digital MNCs denoted as Enterprise 1 and Enterprise 2, denoted by Enterprise i, $i = 1, 2$. These enterprises supply and export their products to data consumers within the country. However, Country B does not have any internet enterprises, and a group of data consumers within the country purchases data products produced by national or foreign enterprises in the domestic market.

Based on these assumptions, this work can conclude that the clearing price in the domestic market of Country A is determined by the total production of the market, that is, the sum of the production of Enterprise 1 and Enterprise 2. Similarly, the settlement price in foreign markets is determined by the total production of the market in Country B. If the total production in the market of Country A is denoted as Q_A, then the clearing price in the domestic and foreign markets are denoted as $p_A(Q_A) = a_A - Q_A$ and $p_B(Q_B) = a_B - Q_B$, respectively, where a_A and a_B are both positive constants. We assume that Enterprise i in Country A produces h_i and exports e_i. In this case, the total production in the market of Country A and Country B are $Q_A = Q_1 + Q_2 = h_1 + e_1 + h_2 + e_2$, $Q_B = e_1 + e_2$, respectively.

Assuming that the enterprise's fixed cost is a constant c, and the marginal cost of data production is $c_i(Q_i) = 1 - \sigma(Q_i) = 1 - \dfrac{1}{1 + e^{-Q_i}}$, it is clear that when data output tends to infinity, the marginal cost of data production per enterprise tends to 0, and enterprises have an incentive to make large data volumes. Thus, the total cost of production for the enterprise is $C_i(Q_i) = C_i(h_i + e_i) = c + (1 - \dfrac{1}{1 + e^{-h_i - e_i}})(h_i + e_i)$. In addition, enterprises bear the cost of the DST when exporting their products and receive a subsidy from government A: if government B sets a tariff rate of t_B and government A sets a subsidy of t_A, enterprise i must pay tariff $e_i t_B$ to the government when exporting e_i to Country B. The subsidy is a cost of the DST. Of course, every country gains from the development of the digital economy, and we use a logistic function as the gain function, which satisfies the logistic differential equation:

Figure 1. Illustration of the international DST game



$$\frac{dR}{dy} = ry\left(1 - \frac{y}{K}\right). \tag{1}$$

The solution yields $R(y) = \dfrac{K}{1 + be^{-ry}}$, where the parameter K, r, b are different in different countries, reflecting differences in the level of the digitized economy in different countries.

In the given game sequence, the following steps occur:

- In the first stage, the governments of two countries choose both export rebate rates and tariff rates, simultaneously. Let's denote the export tax rebate rate chosen by Country I as t_A and the tariff rate chosen by Country II as t_B.
- In the second stage, enterprises observe the tariff rates set by the governments and simultaneously choose the amount of output for domestic consumption and the amount of output to be exported. Let's denote the amount of output for domestic consumption chosen by enterprise as (h_1, e_1) and the amount of output to be exported chosen by Enterprise as (h_2, e_2).

The revenue of Enterprise i is calculated as the difference between its total revenue and its expenses. The total revenue consists of revenue from domestic sales and revenue from foreign exports, while the expenses consist of the cost of production and the cost of taxes. Therefore, the revenue of Enterprise can be expressed as follows:

$$\pi_i(t_A,t_B,h_i,e_i,h_j,e_j)=[a_A-(h_i+h_j)]h_i+[a_B-(e_i+e_j)]e_i \\ -c-(1-\frac{1}{1+e^{-h_i-e_i}})(h_i+e_i)-(t_B-t_A)e_i.i=1,2.j=\{1,2\}\setminus i \tag{2}$$

For Enterprise i, its decision variables are h_i and e_i. In order to visualize the impact of the decision variables on the return worthiness of Enterprise i, the following 3-D graphs are plotted with h_i and e_i as the independent variables and π_i as the dependent variable, and the images of Enterprises 1 and Enterprises 2 are represented in Figures 2 and 3.

The total welfare of Country A is the sum of the consumer surplus enjoyed by the country's consumers, the profits earned by enterprises, and the tariff revenues collected by the government from enterprises.

$$W_A(t_A,t_B,h_1,e_1,h_2,e_2)=\frac{1}{2}Q_A^2+\pi_1(t_A,t_B,h_1,e_1,h_2,e_2)+\pi_2(t_A,t_B,h_1,e_1,h_2,e_2) \\ +\frac{K_A}{1+b_Ae^{-r_A(h_1+h_2)}}-t_A(e_1+e_2). \tag{3}$$

Figure 2. The profit curve of enterprise one

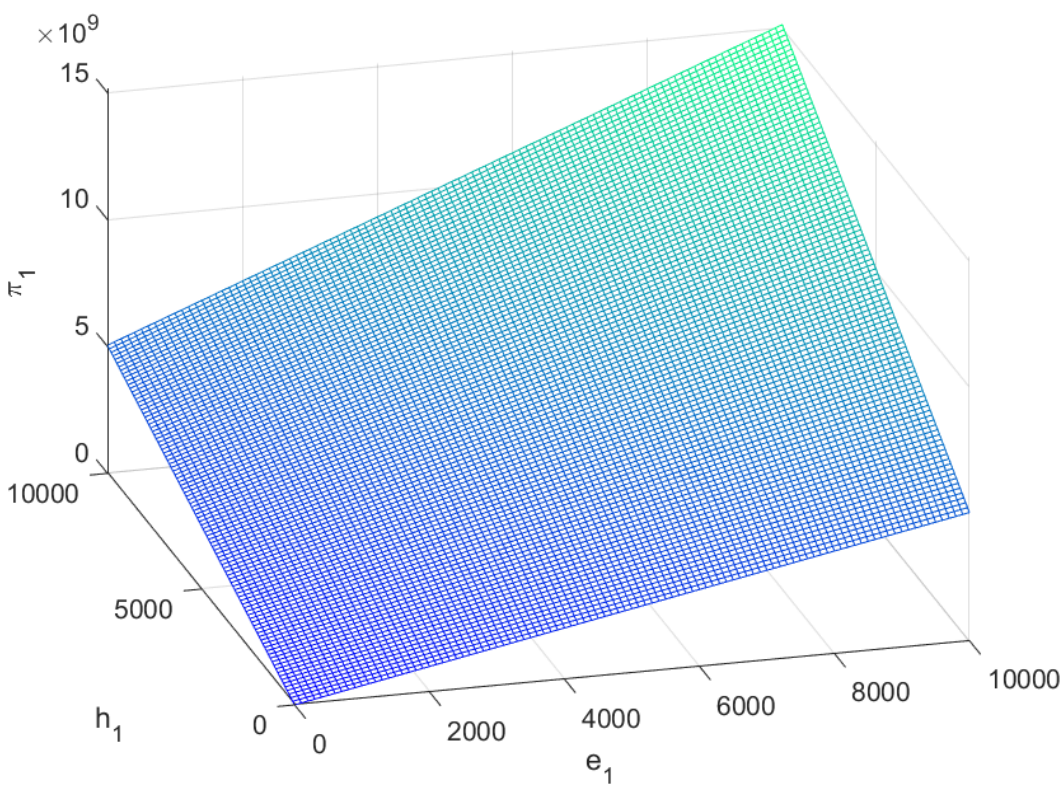
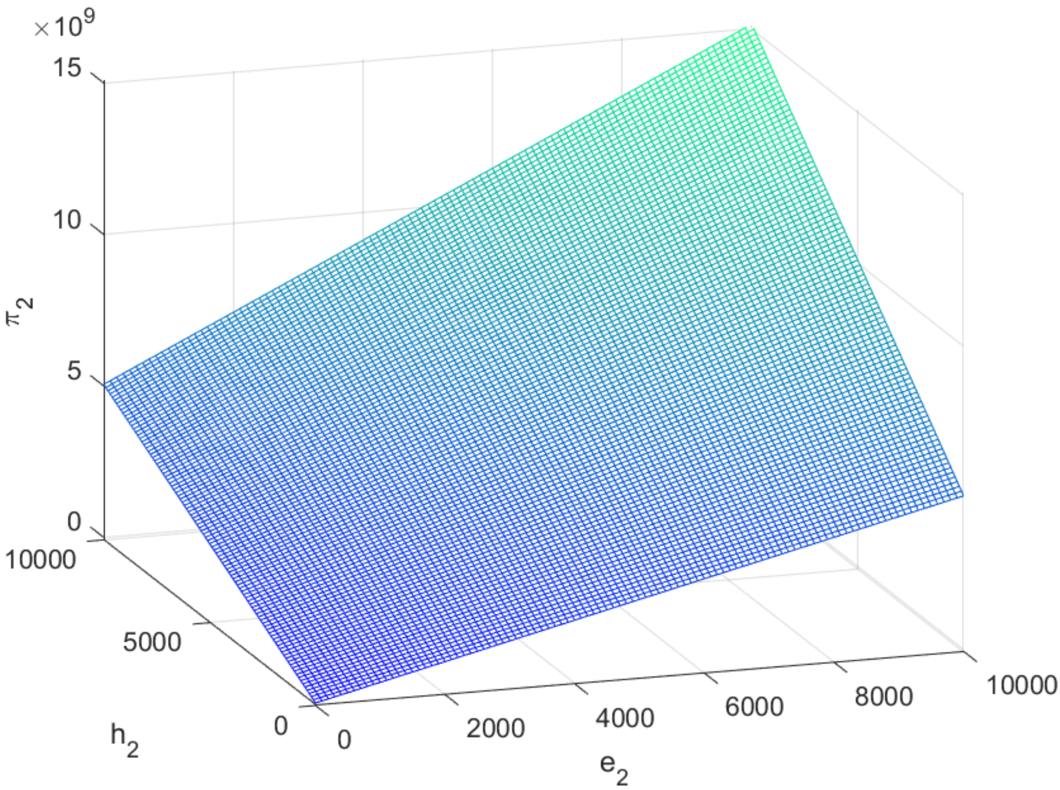


Figure 3. The profit curve of enterprise two



The total welfare of Country B consists only of the proceeds from the taxes paid by State A and the digitization gains:

$$W_B(t_A,t_B,h_1,e_1,h_2,e_2) = t_B(e_1+e_2) + \frac{K_B}{1+b_B e^{-r_B(e_1+e_2)}} \tag{4}$$

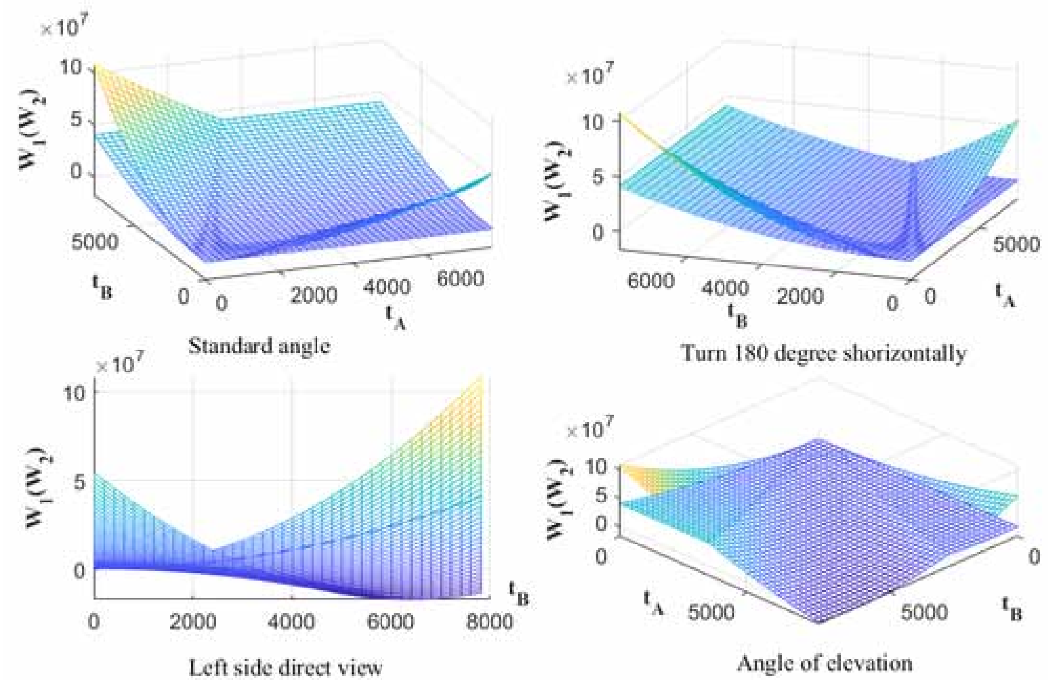
Similarly, for the countries, their decision variables are t_A and t_A. In order to visualize the worthwhile impact of the decision variables on the country's returns, the following graphs are plotted with t_A and t_A as the independent variables and W_A, W_B as the dependent variable, and the images of Country A and Country B are represented in Figure 4, showing the total welfare profiles of the two countries from different perspectives respectively.

Solving of the Model

Assuming that the government has chosen the tax rebate rate and the DST rate as t_A and t_B, if $(h_1^*, e_1^*, h_2^*, e_2^*)$ is a Nash equilibrium for the (two-market) game of Enterprise 1 and Enterprise 2, for each enterprise i, (h_i^*, e_i^*) must be satisfied that $\max\limits_{h_i,e_i} \pi_i(t_A,t_B,h_i,e_i,h_j^*,e_j^*)$.

Consider an enterprise whose cost function satisfies $\lim\limits_{x\to+\infty} C_i(x) = c$.

Figure 4. Total welfare of country A and B



Since $\pi_i(t_A, t_B, h_i, e_i, h_j^*, e_j^*)$ can be expressed as the sum of Enterprise i 's profit in market A and its profit in market B, and Enterprise i 's profit in market B is just a function of h_i and h_j^*, and its profit in market B is just a function of e_i, e_j^* and t_B, the optimization problem of Enterprise i in the two markets can be simply split into a single problem to be solved separately in each market, h_i^* mustbesatisfied $\max_{h_i \geq 0} h_i[a_A - (h_i + h_j^*)]$,and e_j^* mustbesatisfied $\max_{e_i \geq 0} e_i[a_B - (e_i + e_j^*)] - (t_B - t_A)e_i$.

Assuming that $h_i^* \leq a_B$, $e_i^* \leq a_B - t_B + t_A$, we could get:

$$h_1^* = h_2^* = \frac{1}{3}a_A, \tag{5}$$

$$e_1^* = e_2^* = \frac{1}{3}(a_B - t_B + t_A). \tag{6}$$

Comparing the Gounod game, both enterprises choose an equilibrium output of $(a_A + a_B - t_B + t_A)/3$, but this result is introduced based on the marginal zero cost of the data output and is an approximate solution when the data output is sufficiently large.

Having solved for the government's choice of tariff, to solve for the outcome of the two-enterprise game in the second stage, we can represent the first stage of interactive decision making between governments as the following simultaneous action game: first, the government chooses the tariff rate

t_B and the subsidy t_A at the same time; second, the government of Country A's payoffs are $W_A(t_A, t_B, h_1^*, e_1^*, h_2^*, e_2^*)$, and the government of Country B's payoffs are $W_B(t_A, t_B, h_1^*, e_1^*, h_2^*, e_2^*)$; here h_i^* and e_i^* are functions of t_i and t_j as shown in equation (4) and (5). We now solve the Nash equilibrium of this intergovernmental DST game.

To simplify the representation notation used, we determine e_i^* to be determined by $t_B - t_A$ implicitly in equation(4). Let $W_A^*(t_A, t_B)$ denote $W_A(t_i, t_j, h_1^*, e_1^*, h_2^*, e_2^*)$, and let $W_B^*(t_A, t_B)$ denote $W_B(t_i, t_j, h_1^*, e_1^*, h_2^*, e_2^*)$, i.e., the government of Country A chooses a subsidy t_A, the government B chooses a tariff t_B, and Enterprises i and j. The above Nash equilibrium chooses the payoffs to the government and the government when they act. If is a Nash equilibrium of this inter-governmental game, then enterprises i must satisfy $\max_{t_A \geq 0} W_A^*(t_A, t_B^*)$, $\max_{t_B \geq 0} W_B^*(t_A^*, t_B)$.

Considering that Enterprises 1 and 2 are duopolies, they have symmetry, so:

$$\begin{aligned}
W_A^*(t_A, t_B^*) &= \frac{1}{2}Q_A^2 + \pi_1(t_A, t_B^*, h_1^*, e_1^*, h_2^*, e_2^*) + \pi_2(t_A, t_B^*, h_1^*, e_1^*, h_2^*, e_2^*) \\
&\quad + \frac{K_A}{1 + b_A e^{-r_A(h_1^* + h_2^*)}} - t_A(e_1^* + e_2^*) \\
&\approx \frac{1}{2}(h_1^* + e_1^* + h_2^* + e_2^*)^2 + 2[[a_A - (h_1^* + h_2^*)]h_1^* + [a_B - (e_1^* + e_2^*)]e_1^* \\
&\quad - c - (1 - \frac{1}{1 + e^{-h_1^* - e_1^*}})(h_1^* + e_1^*) - (t_B^* - t_A)e_1^*] + \frac{K_A}{1 + b_A e^{-r_A(h_1^* + h_2^*)}} - t_A(e_1^* + e_2^*) \\
&= \frac{2}{9}\left(a_A + a_B - t_B^* + t_A\right)^2 + \frac{2}{3}\left(a_B - \frac{2}{3}(a_B - t_B^* + t_A)\right)(a_B - t_B^* + t_A) - \frac{2}{3}t_A\left(a_B - t_B^* + t_A\right) + f(h_1^* + h_2^*).
\end{aligned} \tag{7}$$

where $f(h_1^* + h_2^*)$ denote the sum of the remaining polynomials associated with $h_1^* + h_2^*$.

Let $\frac{dW_A}{dt_A} = 0$, so, $t_B^* \approx \frac{2}{3}a_A + \frac{4}{3}a_B$, and:

$$W_B^*(t_A^*, t_B) = t_B(e_1^* + e_2^*) + \frac{K_B}{1 + b_B e^{-r_B(e_1^* + e_2^*)}} \approx \frac{2}{3}t_B(a_B - t_B + t_A^*) + \frac{K_B}{1 + b_B e^{-\frac{2}{3}r_B(a_B - t_B + t_A^*)}}, \tag{8}$$

thus:

$$\frac{dW_B}{dt_B} \approx \frac{2}{3}\left(a_B - 2t_B + t_A^*\right) + \frac{2}{3}r_B\left(a_B - t_B + t_A^*\right)\left(1 - \frac{2(a_B - t_B + t_A^*)}{3K_B}\right) = 0, \tag{9}$$

When $e_1^* + e_2^* = K_B$, note that $K_B = e_1^* + e_2^* = 2e_1^* = \frac{2}{3}\left(a_B - t_B^* + t_A^*\right)$, hence:

$a_B - 2t_B + t_A^* = 0$, i.e. $t_B^* = \dfrac{a_B + t_A^*}{2}$

In summary, the solution to the DST game is as follows:

$$t_A^* \approx \frac{4}{3}a_A + \frac{5}{3}a_B \, , \; t_B^* \approx \frac{2}{3}a_A + \frac{4}{3}a_B \, , \; h_1^* = h_2^* = \frac{1}{3}a_A \, , \; e_1^* = e_2^* = \frac{2}{9}a_A + \frac{4}{9}a_B$$

At this time, $K_B = \frac{4}{9}a_A + \frac{8}{9}a_B$. In other words, although the data subsidy rate and data service tax rate after the export of data products are complex to determine, but when the data out production meets $K_B = \frac{4}{9}a_A + \frac{8}{9}a_B$ and export volume $e_1^* = e_2^* = \frac{2}{9}a_A + \frac{4}{9}a_B$, the Category I country pays two times the DST rate of the Category II country as an export subsidy, which is the Nash equilibrium of the DST game. This implies that, in the context of the digital economy reaching saturation, countries with a strong digital economy are willing to incur higher costs to access the markets of countries with weaker digital economies. By offering a higher export subsidy, the Category I country aims to gain a competitive advantage and multiply the cost of accessing the market of the Category II country.

This behavior can be attributed to strategic considerations and market dynamics in the digital economy. Strong digital economies may have a greater ability to leverage their data assets and economies of scale, allowing them to offer higher subsidies to gain market share and maintain their dominance. Meanwhile, countries with weaker digital economies may face challenges in competing for the scale and resources of stronger players.

It is important to note that the Nash equilibrium in this specific scenario may not hold in all situations because the outcome of the DST game can be influenced by various factors, including specific parameters, strategies, and market conditions.

CONCLUSION AND PROSPECT

Conclusion

Based on the analysis of strategic interactions between suppliers and the demand side as well as the impact of taxes on market participants' behavior, several important conclusions can be drawn.

First, we identify the characteristics of a duopoly in asymmetric markets, where suppliers hold a monopoly position, while the demand side faces limited alternative choices. This market structure creates a conflict of interest between suppliers and the demand side, which we modeled through a game to reflect the different attitudes of countries with duopolies towards the DST.

Second, the proposal of the international DST originated from the rapid development of the digital economy and the increase in cross-border data traffic. In our established game model, cross-border digital service providers aim to capture the favorable data economy market in countries with a strong digital economy, leading to the motivation for taxing digital services. This prompts strong digital economies to pay higher costs to obtain market share in countries with weaker digital economies, thereby consolidating their market position and competitive advantage. Furthermore, our model analyzes the strategic choices of suppliers and the demand side in the international DST game. The demand side views this tax as a means of protecting domestic enterprises and promoting fair competition. However, suppliers typically oppose international DST because of potential profit reductions and increased costs. Interestingly, our game model reveals that instead of opposing the international DST, digital economy powerhouses subsidize the national DST twice to protect domestic enterprises from unfair competition. Therefore, interaction, coordination, and cooperation among countries are crucial.

Finally, we examine the impact of international DST on the behavior of market participants and market returns. We find that tax significantly influences the pricing strategies, market shares, and profits of both suppliers and demand-siders, thereby better adapting to the tax policy needs of the digital era.

This study provides valuable insights for policymakers to formulate more effective policies and strategies to address the international DST game in asymmetric market duopolies. By considering the dynamics of the digital economy and promoting international cooperation, policymakers can achieve fair and balanced outcomes in the taxation of digital services.

Prospect

Our proposed model contributes to improving tax fairness, promoting healthy development of the digital economy, and facilitating changes in the international tax system by increasing international cooperation to promote coordination and cooperation. However, further research is required to determine whether potential tax costs affect the strategies of countries with strong digital economies. Indeed, simplifications and assumptions made in the model may limit its applicability to real-world scenarios. Future research should address these limitations by incorporating more comprehensive data and parameters, as well as considering the influence of additional factors that affect the digital economy and taxation.

By expanding the scope of the analysis and incorporating a wider range of variables, researchers can provide a more accurate and nuanced understanding of the complexities involved in digital economy taxation. This can help policymakers develop effective strategies and policies to address the challenges posed by the digital economy. Furthermore, exploring cross-border cooperation and coordination mechanisms is crucial to address the global nature of the digital economy. Future research can delve into the development of frameworks and mechanisms that facilitate international collaboration in tax matters, ensure fairness, and minimize tax avoidance or evasion. Additionally, addressing the lack of specific data and parameters in an article can enhance the credibility and reliability of the research. Conducting empirical studies and gathering relevant data will provide a stronger foundation for analysis and enable researchers to draw robust conclusions.

In conclusion, future research should focus on overcoming the limitations of the study by incorporating more comprehensive data, considering additional factors, and exploring cross-border cooperation mechanisms. By doing so, researchers can contribute to a deeper understanding of tax issues in the digital economy and provide more effective solutions for policymakers.

CONFLICTS OF INTEREST

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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REFERENCES

Amiti, M., Redding, S. J., & Weinstein, D. E. (2019). The impact of the 2018 tariffs on prices and welfare. *The Journal of Economic Perspectives*, *33*(4), 187–210. doi:10.1257/jep.33.4.187

Bateman, S. (2023). Double Irish, Dutch sandwich: Overcoming hybrid mismatch arrangements. *Corporate and Business Law Journal, 4*(2), 92–114. https://cablj.org/wp-content/uploads/2023/01/CABLJ_Winter2023_Bateman_Final.pdf

Beebeejaun, A. (2021). The double Irish and Dutch sandwich strategies and tax avoidance in Mauritius. *Journal of Money Laundering Control*, *24*(4), 737–751. doi:10.1108/JMLC-09-2020-0103

Bunn, D., Asen, E., & Enache, C. (2020). *Digital taxation around the world*. Tax Foundation. https://files.taxfoundation.org/20200527192056/Digital-Taxation-Around-the-World.pdf

Cantos, J. M. (2022). BEPS project and international tax reform: The 2021 agreements on taxing multinational companies. *Evaluation Review*, *46*(6), 725–749. doi:10.1177/0193841x221103338 PMID:35654755

Chander, A. (2020). Is data localization a solution for Schrems II? *Journal of International Economic Law*, *23*(3), 771–784. doi:10.1093/jiel/jgaa024

Chen, S., Devereux, M. B., Shi, K., & Xu, J. (2021). Exchange rates, local currency pricing and international tax policies. *Journal of Monetary Economics*, *117*, 460–472. doi:10.1016/j.jmoneco.2020.02.005

Couture, S., & Toupin, S. (2019). What does the notion of “sovereignty” mean when referring to the digital? *New Media & Society*, *21*(10), 2305–2322. doi:10.1177/1461444819865984

Fang, B. (2018). *Cyberspace sovereignty: Reflections on building a community of common future in cyberspace*. China Science Press Singapore Springer. doi:10.1007/978-981-13-0320-3

Fang, B. (2018). *Cyberspace sovereignty*. Springer. doi:10.1007/978-981-13-0320-3

FaulhaberL. V. (2019). *Taxing tech: The future of digital taxation*. Ssrn.com. https://ssrn.com/abstract=3460741

Fetzer, T., & Schwarz, C. (2021, May 04). (202). Trade wars and politics: Evidence from Trump’s trade wars. *Economic Journal (London)*, *131*(636), 1717–1741. doi:10.1093/ej/ueaa122

Furceri, D., Hannan, S., Ostry, J., & Rose, A. (2018). Macroeconomic consequences of tariffs. *National Bureau of Economic Research, 25402*(December 2018). 10.3386/w25402

Garcia-Bernardo, J., & Janský, P. (2024). Profit shifting of multinational corporations worldwide. *World Development*, *177*(C), 106527. doi:10.1016/j.worlddev.2023.106527

Geringer, S. (2021). National digital taxes – lessons from Europe. *South African Journal of Accounting Research*, *35*(1), 1–19. doi:10.1080/10291954.2020.1727083

Joshi, P. (2020). Does private country-by-country reporting deter tax avoidance and income shifting? Evidence from BEPS action item 13. *Journal of Accounting Research*, *58*(2), 333–381. Advance online publication. doi:10.1111/1475-679X.12304

Kim, Y. R. (Christine). (2020). *Digital services tax: A cross-border variation of the consumption tax debate*. Papers.ssrn.com. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3578348

Kofler, G. (2021). Editorial: The future of digital services taxes. *EC Tax Review*, *30*(2), 50–54. doi:10.54648/ECTA2021006

Kofler, G., & Sinnig, J. (2019). Equalization taxes and the Eu’s “digital services tax.”. *Intertax*, *47*(2), 176–200. doi:10.54648/TAXI2019017

Langenmayr, D., & Liu, L. (2023). Home or away? Profit shifting with territorial taxation. *Journal of Public Economics*, *217*(104776), 104776. doi:10.1016/j.jpubeco.2022.104776

Lee, Y., Ng, S., Shevlin, T., & Venkat, A. (2021). The effects of tax avoidance news on employee perceptions of managers and firms: Evidence from Glassdoor.com ratings. *The Accounting Review*, *96*(3), 343–372. doi:10.2308/TAR-2019-0148

Li, D.-F., Liu, P., & Li, K. W. (2021). Big data and intelligent decisions: Introduction to the special issue. *Group Decision and Negotiation*, *30*(6), 1195–1200. doi:10.1007/s10726-021-09764-9

Li, D.-F., & Liu, P.-D. (2020). Big data and intelligent decision methods in economy, innovation and sustainable development. *Technological and Economic Development of Economy*, *26*(5), 970–973. doi:10.3846/tede.2020.13354

Liang, K.-R., & Li, D.-F. (2022). A biobjective biform game approach to optimizing strategies in bilateral link network formation. *IEEE Transactions on Systems, Man, and Cybernetics. Systems*, *52*(3), 1653–1662. doi:10.1109/TSMC.2020.3034480

Lin, P. P., Li, D-F., Jiang, B. Q., Wei, A. P., & Yu, G. F. (2019). Regional input–output multiple choice goal programming model and method for industry structure optimization on energy conservation and GHG emission reduction in China. *International Journal of Computational Intelligence Systems*, *12*(2), 1311–1311. doi:10.2991/ijcis.d.191104.002

Lowry, S. (2019). Digital services taxes (DSTs): Policy and economic analysis. In *Congressional Research Service Report* (p. 45532). https://sgp.fas.org/crs/misc/R45532.pdf

Makhalina, O. M., & Makhalin, V. N. (2020). Transformation of the digital economy into the national tax systems of foreign countries. *RSUH/RGGU BULLETIN. Series Economics. Management. Law*, *3*(3), 38–51. doi:10.28995/2073-6304-2020-3-38-51

Mongrain, S., Oh, D., & van Ypersele, T. (2023). Tax competition in the presence of profit shifting. *Journal of Public Economics*, *224*, 104940. doi:10.1016/j.jpubeco.2023.104940

Mpofu, F. Y. (2022). Taxation of the digital economy and direct digital service taxes: Opportunities, challenges, and implications for African countries. *Economies*, *10*(9), 219. doi:10.3390/economies10090219

Nerudova, D., Dobranschi, M., Solilová, V., & Litzman, M. (2023). Onshore and offshore profit shifting and tax revenue losses in the European Union. *Economic Modelling*, *119*, 106111. doi:10.1016/j.econmod.2022.106111

Ní Chasaide, N. (2021). Ireland's tax games: The challenge of tackling corporate tax avoidance. *Community Development Journal: An International Forum*, *56*(1), 39–58. doi:10.1093/cdj/bsaa054

Oats, L. (2023). *Principles of International Taxation*. Bloomsbury Publishing. doi:10.5040/9781526526199

Pirlot, A., & Culot, H. (2021). When international trade law meets tax policy: The example of digital services taxes. *Journal of World Trade*, *55*(6), 895–920. doi:10.54648/TRAD2021038

Rządkowski, G., & Sobczak, L. (2020). A generalized logistic function and its applications. *Foundations of Management*, *12*(1), 85–92. doi:10.2478/fman-2020-0007

Shen, W. (2023). On the hierarchical nature of the data property rights system: The "three-thirds" approach to data entitlement. *China Legal Science*, *4*, 26–48. doi:10.14111/j.cnki.zgfx.2023.04.001

Shukla, N. (2020). *Introduction of digital service tax by France targeting US digital companies-policy response by United States*. JHU. *Jscholarship*.library.jhu.edu. http://jhir.library.jhu.edu/handle/1774.2/63119

Tang, W., Zhao, X., Zhai, S., & Cao, L. (2023). Local government debt and corporate tax burden: A perspective based on the trade-off of government tax collection and management. *PLoS One*, *18*(7), e0287763–e0287763. doi:10.1371/journal.pone.0287763 PMID:37437050

Tirole, J. (2023). Competition and the Industrial Challenge for the Digital Age. *Annual Review of Economics*, *15*(1), 573–605. doi:10.1146/annurev-economics-090622-024222

van Apeldoorn, L. (2018). BEPS, tax sovereignty and global justice. *Critical Review of International Social and Political Philosophy*, *21*(4), 478–499. doi:10.1080/13698230.2016.1220149

Vella, J. (2019). Digital services taxes: Principle as a double-edged sword. *National Tax Journal*, *70*(4), 821–838. doi:10.17310/ntj.2019.4.08

Ye, Y.-F., & Li, D.-F (2021). A direct approach to compute triangular fuzzy Banzhaf values of cooperative games with coalitions' values represented by triangular fuzzy numbers. *IEEE Transactions on Fuzzy Systems*, *29*(6), 1567–1575. doi:10.1109/TFUZZ.2020.2981006

Zheng, X.-X., & Li, D.-F. (2023). A new biform game-based investment incentive mechanism for eco-efficient innovation in supply chain. *International Journal of Production Economics*, *258*, 108795. doi:10.1016/j.ijpe.2023.108795

Zhu, C. (2021). Analysis on tax collection and management of digital economy. *E3S Web of Conferences, 253*, 03046. 10.1051/e3sconf/202125303046

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