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Challenges in Achieving Consensus on Data Localization: Digital Inequality of Digital Service Trade

Yuliang Gao[1,a], Zhiyong Xie[1,b,*], Xiaohang Zhang[1,c]

[1]Department of Economics and Management, Beijing University of Posts and Telecommunications, Beijing, 100876, China
a. gaoyuliang2001@bupt.edu.cn, b.xiezhiyong@bupt.edu.cn, c. zhangxiaohang@bupt.edu.cn
**corresponding author*

Abstract: The disagreements on data localization policies significantly hamper the progression of digital service trade and free cross-border data flow. This study adopts the Theory of Comparative Advantage and the Heckscher-Ohlin Theory (H-O Theory) to construct an analytical model that investigates the inequality of digital service trade on the well-being of nations and the valuation of digital factors. Our findings suggest that digital service trade exacerbates the terms of trade for developing countries. In an environment of unrestricted data flow, developed countries capitalize on the data resources from developing nations, thereby augmenting their digital comparative advantages and factor endowments. The dynamics foster a state of digital inequality or digital poverty, where late-developing countries are disadvantaged in keeping pace with their developed counterparts. Notably, data localization, while seemingly a protective measure for developing countries, may not be the optimal strategy. It potentially undermines the overall well-being of all participants by diminishing network effects. The paper argues that the path towards the liberalization of digital trade and data flows will be a lengthy and complex one, demanding concerted international efforts to overcome entrenched trade barriers.

Keywords: Data Localization, Digital Service Trade, Digital Inequality, Digital Comparative Advantage, Digital Factor Endowment

1. Introduction

There is a long history of divisions and conflicts regarding data localization. *Data localization* is defined as an administrative requirement stipulating that data be stored or processed within a specified jurisdiction [1]. It is widely recognized that data localization requirements significantly hinder cross-border data flow and communication connectivity, which are key factors in enhancing digital commerce [2]. Some empirical researches indicate that a 1% increase in a nation's data restrictiveness can reduce its gross trade output by 7% and increase trade costs by 1.1% to 1.4% [3-4]. Nevertheless, developing economics claim that data localization is a necessary provision for overseeing domestic sensitive information. According to Cockroach Labs, approximately 120 countries have implemented data localization regulations, with an additional 40 countries considering such measures. Russian and China mandate their providers to locate their servers within domestic territory [5-6]. Similarly, Indonesia and Bangladesh have introduced a suite of bills covering various digital sectors to require electronic payment providers to process personal data exclusively in domestic data centers [7-8].

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Table 1 indicates a thread of data localization requirements from 2021 to 2023. In contrast, the developed support free cross-border data flow to benefit from digital service trade. By May 2022, 21 legislative enactments explicitly prohibit data localization as a prerequisite for local business presence, predominantly supported by developed countries. Such divergent viewpoints have led to an intense debate and a failure to reach a consensus in multilateral trade settings. This raises a critical issue: *what factors contribute to the disagreements between developed and developing economies in reaching a consensus on data localization provisions?* Majority of scholars attempt to interpret the reasons of data localization in the view of security, the political position, and human right. Contrary to these perspectives, the article argues that data localization is an inequality issue. The conflict between developed and developing countries over data localization stems from the unequal distribution of well-beings in digital service trade. However, the policymakers tend to address this issue within the confines of political or technological paradigms.

To illustrate this issue, the remain structure of the article is organized in following orders: Section 2 gives a comprehensive overview of data localization issues and unravel the various standpoints of data localization. Section 3 and 4 develop a model based on Theory of Comparative Advantage and Heckscher-Ohlin Theory (H-O Theory) to illustrate why developing countries often benefit less from digital service trade due to digital inequality. Section 5 interprets the reasons of data localization requirements for the developing economics, and gives some attempts to eliminate the digital inequality. Finally, the section 6 presents the conclusions derived from the paper and expected future.

Table 1: The Thread of Data Localization from 2021 to 2023

Event Date	Intervention name	Jurisdiction	Intervention Status
2021-01-01	Data residency obligation in Regulation on Information Systems and Electronic Banking Services of Banks	Turkey	In force
2021-01-15	Location of computing facilities provisions in Regulation of Financial Technology Institutions Law	Mexico	Adopted
2021-02-03	Data localization requirements in Cloud Cybersecurity Controls	Saudi Arabia	Adopted
2021-02-15	Guidelines on Geo-spatial services and data	India	Adopted
2021-04-01	Data residency obligations in South Africa Draft National Data and Cloud Policy	South Africa	Processing consultation
2021-04-01	Data Residency Obligation in Ministry of Communications and Informatics Regulation	Indonesia	In force
2021-04-28	Data residency obligation in Personal Information Protection Law	China	In force
2021-08-21	Safety Management Guidelines for Providers of Information Systems and Services that Handle Medical Information	Japan	Processing consultation
2021-08-30	Normative Instructions on Cloud Computing Services	Brazil	Adopted
2021-09-27	Data Localization Requirements in Regulation on the Administration of Credit Investigation Industry	China	In force
2021-10-04	Data localization requirements in Government Regulation No. 71 of 2019 on Organization of Electronic Systems and Transactions	Indonesia	Under deliberation

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Table 1: (continued).

2021-10-13	Data localization requirement in Removal and Blocking of Unlawful Online Content (Procedure, Oversight and Safeguards) Rules 2021	Pakistan	Adopted
2022-02-10	Reserve Bank of India (Outsourcing of Information Technology Services)	India	In force
2022-03-15	Data localization measures in Pakistan Personal Data Protection Bill	Pakistan	Under deliberation
2022-04-28	Data localization requirement in CERT-In Cybersecurity Directive	India	In force
2022-07-07	Data localization requirements in OJK Regulation	Indonesia	In force
2022-07-16	Data localization requirement in Data Protection Act	Bangladesh	Under deliberation
2022-08-05	Financial data localization requirement in Companies (Accounts) Fourth Amendment Rules	India	In force
2022-08-10	Data Localization Requirements in Regulatory Framework for Digital Lending	India	In force
2022-08-15	Data localization measures in new Vietnamese Cybersecurity Law	Vietnam	In force
2022-09-21	Data Localization Requirement in Interim Measures for the Administration of Online Taxi Booking Business	China	In force
2023-01-19	Data localization requirements in Amendment to Cloud Security Assurance Program including data localization requirements	Republic of Korea	In force
2023-07-17	Data Localization Requirement in Draft Decree 72 on the management, provision and use of internet services and online information	Vietnam	Processing consultation
2023-07-24	Data localization requirements in Measures for the Administration of Data Security in the Business Field of the People's Bank of China	China	Processing consultation
2023-09-20	Philippines data residency	Philippines	Under deliberation
2023-11-02	Data localization requirements in Measures for Data Security Management of Accounting Firms	China	In consultation

Source: Digital Policy Alert. https://digitalpolicyalert.org/threads/Data-localisation-requirements

2. Background and Literature Review

Nowadays the existing free trade agreements (FTAs) are encountering with significant challenges in formulating cohesive agreements that address the issues of digital service trade [9]. This phenomenon is reflected in the fact that lots of divisions on data localization lead to a failure to shape a multilateral consensus in WTO framework [10], and *the noodle bowl effect*--a fragmented digital trade policies in the regional trade agreements (RTAs) [11]. In fact, there is a trilemma of cross-border data transfer: personal data protect, free data flow and the expansion of national jurisdiction [12]. The progress in

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the realm of data localization has been slow [13-14]. Some initiatives, such as the *Data Free Flow with Trust* (DFFT), *Digital Economic Agreements* (DEAs) and *Digital Economy Partnership Agreements* (DEPAs), achieve a significant breakthrough in the multi-round negotiations on data governance [15]. Yet, these agreements are not incorporated in the WTO framework and not widely adopted by the emerging economics [16]. Recent statistics from Digital Policy Alter (DPA) indicate a significant surge in the number of digital policy instruments between 2020 and March 2023 (Fig. 1). Fig. 2 illustrates the DSTRI (Digital Service Trade Restrictive Index) of global major economics in 2022. Fig. 3 indicates the quarterly increase of number of economics implementing data localization policies. Table 2 illustrates *the noodle bowl effect* among four main digital trade provisions.

And the divisions on data localization between developed and developing economics become increasingly pronounced [17-18]. The U.S. and EU seek to promote a seamless global digital market by establishing a multilateral digital agreement system with identification [19-20]. Japan, advocating the DFFT initiative, is working to create a balanced digital ecosystem to encourage data flow with trust [21]. Meanwhile, scholars critique the data regulatory policies of developing countries. Aho and Duffield and the U.S. Congress allege that China's data regulatory policies are "surveillance capitalism" and undermine the benefits of U.S. digital platforms [22-23]. Jiang suggests that China should reconsider its data localization requirements to strike a balance between free information transfer and national security [24]. The existing literatures (Table 3) explore the negative implications of data localization from various perspectives, including data governance [25-26], development [27-30], personal privacy [31-32], the national security [33-35] and the human right [36-39]. While these studies are insightful, this article attempts to answer why is data localization implemented from the view of digital service trade and its inequality, which is also supported by empirical evidences. Fig. 4 indicates that lower level of digital prosperity is associated with increased digital barriers by the regression between the DSTRI with the export of services. Some scholars contend that data localization erects non-tariff barriers, thereby undermining the exports and imports in digital services sectors [40-42].

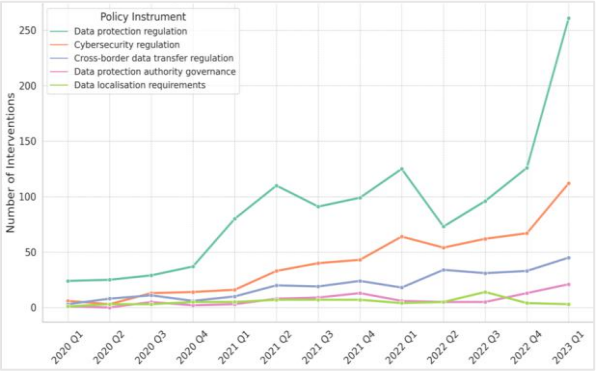

Figure 1: Digital Policy Instrument Dynamics from 2020 to 2023

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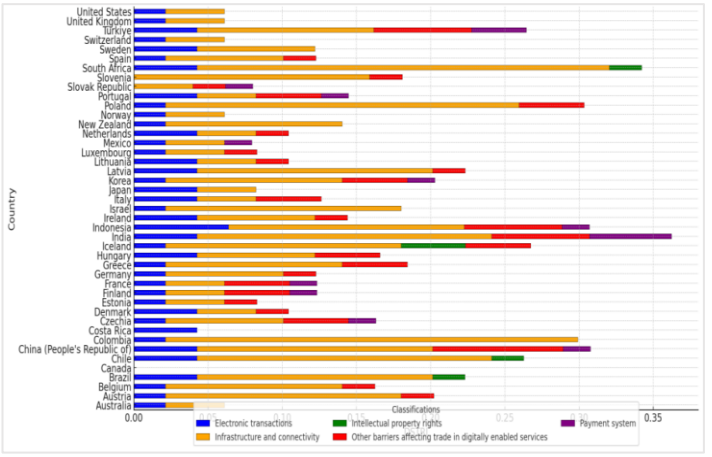

Figure 2: The DSTRI of Major Economics in the world in 2022.

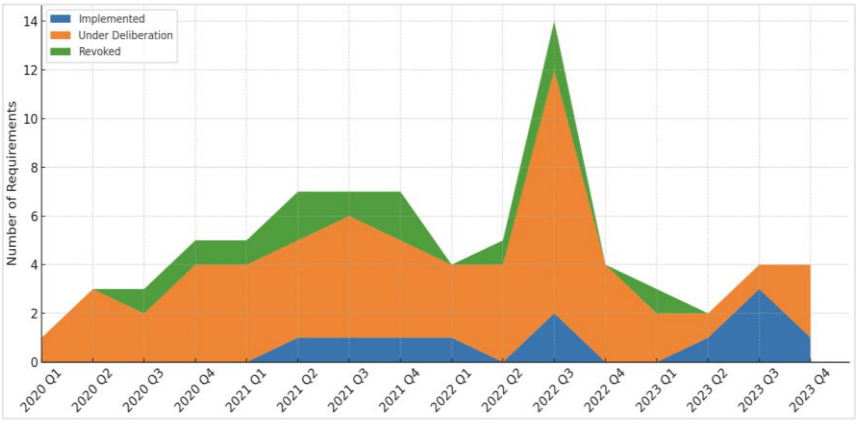

Figure 3: Data Localization Requirements from 2020 to 2023.

Table 2: The Conflicts among the CPTPP, EU-UK, RECP and USMCA Provisions[a]

	CPTPP[b]	EU-UK[c]	RECP[d]	USMCA[e]
Access to telecommunication network	√	√	√	√
Anti-competitive practices	√	◎	√	√
Critical data transfer	×	√	√	◎
Customs duties on electronic transmissions	×	√	◎	◎
Cybersecurity	√	√	◎	◎
Data localization	×	×	√	◎
Data privacy	√	√	√	√
Delivery of digital service	√	√	◎	√
Electronic integrated circuits and micro-assemblies	◎	◎	◎	×
Electronic transmission and electronic authentication	√	√	◎	×
Free digital service trade	√	√	√	√
Integrity of telecommunications networks or services.	◎	√	√	◎

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Table 2: (continued).

License is required for the supply of public telecommunications networks	√	√	√	√
Licenses or certifications granted in the territory of another party	√	√	◎	√
Locating computing facilities within a party's territory as a condition for conducting business	×	√	◎	◎
Most-Favored-Nation Treatments	√	×	◎	√
Online costumer trust	◎	√	◎	◎
Open government data	◎	√	◎	◎
Protection of cross-border service consumption	√	√	√	◎
Restriction on connection of telecommunications networks abroad	×	◎	√	×
Specified technical interfaces and requirements, for connection with public telecommunications networks and services	◎	√	√	√
Technology regulation of ICT	√	√	√	√
Telecommunications services for the movement of information across its borders	√	√	√	√
Transfer or access to the source code of software	×	√	◎	×
Unbundled network (Clouding computation)	√	◎	◎	√

a. "√" indicate "permission", "×" indicate "prohibition", "◎" indicate "not mentioned"

b. *Comprehensive and Progressive Agreement for Trans-Pacific Partnership* (CPTPP) Source: https://www.dfat.gov.au/trade/agreements/in-force/cptpp/comprehensive-and-progressive-agreement-for-trans-pacific-partnership

c. *EU-UK Trade and Cooperation Agreement* (EU-UK) Source: https://trade.ec.europa.eu/access-to-markets/en/content/eu-uk-trade-and-cooperation-agreement

d. *The Regional Comprehensive Economic Partnership* (RCEP) Source: https://asean.org/our-communities/economic-community/integration-with-global-economy/the-regional-comprehensive-economic-partnership-rcep/

e. *United States-Mexico-Canada Agreement (USMCA)* Source: https://ustr.gov/trade-agreements/free-trade-agreements/united-states-mexico-canada-agreement/agreement-between

Table 3: The Literature Review

Views	Authors	Year	Abstract
Data Governance	Drake et al.	2016	Data localization contributes to the fragmented data governance landscapes with the blocking of data flow
	Abraham et al.	2019	Due to the absence of sufficient capacities to define the extent to which users may be constrained by data governance, the authorities frequently resort to "over-governance", potentially hindering data-driven innovation.

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Table 3: (continued).

Development	Meltzer	2015	The Internet restrictiveness hampers the consumers' well-beings
	Cory	2019	The data localization requirements hinder the Small and Medium Enterprises (SMEs) from utilizing the Internet for international trade.
	Coyle and Nguyen	2019	Data localization undermines the development of cloud computing, because of significant investments in digital infrastructure for local storage and processing.
	UNCDF	2022	Data localization hinders consumers' participation in the digital businesses, ultimately disadvantaging the consumers.
Personal Private	Chander	2020	Data localization is ineffective to solves data breach issues and enhancing individual privacy, instead undermining *common European values*.
	Casalini et al.	2021	The patchwork of data localization is making it difficult not only to effectively enforce public policy goals such as privacy and data protection across different jurisdictions,
National Secuity	ITIF	2017	Some nations base their decisions to erect such barriers on the mistaken rationale that it will mitigate privacy and cybersecurity concerns
	DPA	2021	Data localization poses a business risk for digital enterprises operating under different regulatory umbrellas.
	Giovane et al.	2023	He challenges the prevailing belief that data is more private and secure when stored within domestically.
Human Rights	West	2016	China's data localization requirements are a "digital nationalism".
	Cattaruzza et al.	2016	Data localization undermines human rights and tends to create a *Cyber Balkanization* phenomenon.
	UNCTAD	2018	Unrestricted global flow of non-personal data can bolster South-South Cooperation
	Schneider	2022	The Internet should remain no boundary to support public discourse.

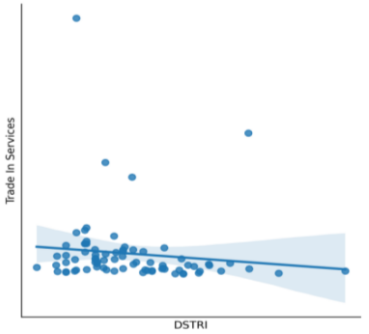

Figure 4: The DSTRI vs The Export of Services

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3. Conditions For Digital Trade: Comparative Advantages

3.1. A Review to the Theory of Comparative Advantages

The predominant theoretical frameworks in international trade encompass three models: Classical Trade Model, New Trade Model and New New Trade Model. New New Trade Model, focusing on firms, is less relevant to our study, which aims to understand trade between nations. The New Trade Theory, which considers product differentiation and economies of scale, is more applicable to current digital trade dynamics. But it is better suited for explaining intra-industry trade among developed countries rather than inter-industry between developed and developing ones. In fact, a non-restrictive data flow environment is similar with a perfectly competitive market in Classical Trade Model's assumption, but the current landscape of digital goods production is characterized by imperfect competition and oligopoly, which is a key distortion between the production and consumption sector. Indeed, applying Theory of Comparative Advantage to the topic of this paper is particularly proper. This theory elucidates the well-beings of international trade and labor division by focusing on the commodity production and benefit distribution in international trade. In orders to align with monopolistic characteristics of digital market reality, the adjustments to assumption of this model will be expounded upon subsequently.

3.2. An Adjustment to the Key Assumption

We postulate that country A holds an absolute advantage in both production sectors X and Y. However, assuming the two sectors as the digital sectors is not entirely applicable in the digital domain, because the exchange of digital goods between developed and developing countries does not align with digital economic dynamics. Given that the digital industry is characterized by economies of scope, digital platforms often offer varied services using the same data source instead of specialization [43]. The assumption of one sector being digital and the other being goods-related is not entirely precise either. This scenario parallels the e-economics sector, but e-economic is believed to contribute to enhancing the trade gains both for developed and developing nations [44], so this assumption may not sufficiently address the unequal benefits of digital service trade. Thereby, it is more prudent to assume that country A specializes on digital service X, while country B specializes data material Y. It aligns more closely with current business dynamics--developed countries dominate the global market in providing digital services and products. Given the cost-free transmission of digital products without digital barriers, their markets extend beyond national boundaries to a global scale [45]. Furthermore, users' footprints--users' data, a by-product of digital service consumption, flow seamlessly back to the product developers and be combined with traditional factors to generate value [46]. The current pattern of digital service trade is indicated by Fig. 5. Guarascio and Stöllinger view the labor activities to data factors and digital products as *digital tasks* [47], encompassing both the *digital labors* of developers [48] and *user interactions* with digital products [49]. Obviously, the former contributes to digital product production, while the latter to data production. Developed countries are superior in creating digital goods and data, mainly due to their higher quality of digital labor. However, the efficiency of data production depends largely on user networks. Developing countries, with their larger populations, have the potential to have a comparative advantage in the data sector. This approach aligns with both real-world economic conditions and the theoretical basis of the model. Notably, the academic communities adopt varied perspectives on the nature of data, encompassing views of an asset [50-51], a factor [52-53], technological advancement [54-55] and a form of property [56-57]. This model views data as commodity--a form of individual's property.

Data is universally accessible and lacks significant differentiation among individuals, so data production dynamics are conceptualized as a perfectly competitive market. Nowadays many scholars

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posit that the digital industry is distinguished by high fixed costs and low marginal costs [58]. Once a digital product is created, the cost of reproduction and distribution is nearly zero [59], which stems from non-competitive and non-consumable nature of data [60]. This allows firms to expand their market sizes significantly with low marginal costs, thereby realizing economies of scale [61]. Digital platforms often offer services for free, which is a strategy not necessarily leading to financial loss, because they can profit from user data by mining its value for other business purposes [62]. Digital products can be priced at the cost before reaching minimum efficient scale (MES), which intends to enjoy network value after occupying the whole market share with free services [63]. Thereby, though the digital product market is not perfectly competitive, we still can assume that the pricing strategy of digital products is average cost price, and it is equal to marginal cost.

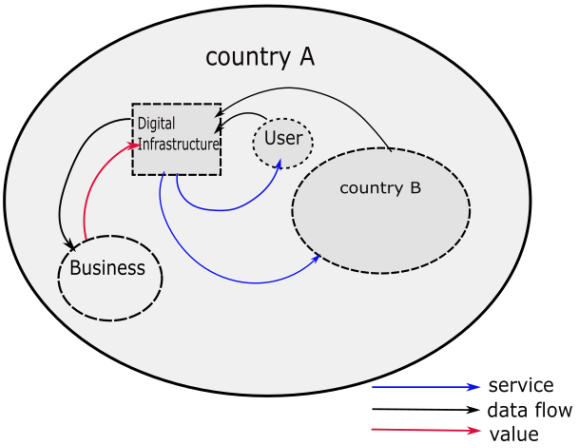

Figure 5: Free Data Flow Model Source: Own Elaboration

3.3. A Model of Free Data Flow

We assume a 2×2 model (Table 4).

Table 4: The Productivity of country A and B

	Output per unit of time	
country	*X*	*Y*
A	a_1	a_2
B	b_1 ($a_1 > b_1 > 0$)	b_2 ($a_2 > b_2 > 0$)

The necessary conditions of international trade are:

$$a_1/a_2 > b_1/b_2 \quad (1)$$

$$P_A < P_W < P_B \quad (2)$$

where the P_A and P_B are the relative prices in country A and B, the P_W is the world price of service X and data Y ($P_W = P_A/P_B$). P_A and P_B are determined by the reciprocal demands of goods X and Y while the world price is influenced by the domestic relative prices. However, the price of digital goods is mainly determined by the cost of supply. That is because: (a) The production of digital services involves substantial sunk costs. And the costumers focus not on the demand of quantity, but on the *attention* to the services. However, this attention is neither a determinant nor a result of pricing strategies. (b) The supply of data goods is characterized by complete inelasticity. The value of data is solely unlocked within the borders of country A, making country B become export-oriented

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producer of data material Y. Conversely, country A's demands for data is satisfied not through trade but through consumer engagement with digital services. Therefore, we conceptualize the costumers' utility function:

$$U(t,n,z)=t^{\alpha}n^{\gamma}z^{\varepsilon} \tag{3}$$

t is the online time of the consumers, n is the $n$umber of consumers using a digital service, z is the abundance of contents in the user networks. According to Fann et al.'s contribution [64], we conceptualize the data generation function:

$$d(t,n)=\left(\sum_{i=1}^{n}\left(\int_{0}^{t}z_i(x)dx\right)^{\frac{n}{n-1}}\right)^{\frac{n-1}{n}} \tag{4}$$

where $z(t_i)$ represents the correlation between the abundance of contents and online time. The pricing of digital goods should cover the costs. Let C_A and C_B represent the costs of Internet access in countries A and B respectively. P_X and P_Y denote the prices of digital services and data. The variable λ signifies the level of digitization, analogous to the productivity factor a_1. Assume that both the wage rate of labor (w_A) and the labor force amount (L_A) in country A, the pricing of the digital product should cover the cost, so:

$$C_A+w_AL_A=nP_X+a_1d(t,n) \tag{5}$$

$$P_X=\frac{C_A+w_AL_A-a_1d(t,n)}{n} \tag{6}$$

For service developers, the fixed costs associated with data collection primarily include the costs of Internet access and the expense of digital services. These costs are typically amortized over the vast quantities of data collected, so:

$$P_Y=\frac{C_i+P_X}{d(t,n)} \tag{7}$$

The relative prices of X to Y in country A and B are:

$$P_A=\frac{P_{AX}}{P_{AY}}=\left(\sum_{i=1}^{n}\left(\int_{0}^{t}z_i(x)dx\right)^{\frac{n_1}{n_1-1}}\right)^{\frac{n_1-1}{n_1}}\left(1-\frac{C_A}{C_A+P_A}\right) \tag{8}$$

$$P_B=\frac{P_{BX}}{P_{BX}}=\left(\sum_{i=1}^{n}\left(\int_{0}^{t}z_i(x)dx\right)^{\frac{n_2}{n_2-1}}\right)^{\frac{n_2-1}{n_2}}\left(1-\frac{C_B}{C_B+\eta P_A}\right) \tag{9}$$

where the P_{AX} represents the price of X in country A. η is the parameter of expressing the relationship between the price elasticity of demand for X in country A and B. In traditional trade of physical goods, P_{BX} (the price of X in country B) tends to be higher than P_{AX} due to price discrimination. However, in the digital market, the price of the same digital product might be uniform in different markets. The interconnectedness of user networks effectively merges the two markets into a single entity with a homogenous utility function for consumers in both countries. Additionally, the negligible transportation costs in digital trade further reinforce this uniformity, so $\eta=1,n_1=n_2$. Thereby:

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$$\frac{P_A}{P_B}=\frac{C_B+P_X}{C_A+P_X} \tag{10}$$

If there are no trade barriers, the costs of Internet access are identical in country A and B. Thus, the price ratio between the two countries is equal to 1, so:

$$P_A=P_W=P_B \tag{11}$$

In the realm of physical trade, exchange ratios correspond to price ratios. In digital market, we distinguish *monetary price*-the price of a digital service in market, and *real price*, which refers to the exchange ratio between goods. The unique nature of digital products often results in a divergence between monetary and real price, with the exchange ratios not necessarily mirroring the relative price ratio. For instance, in country A, consuming digital services enables service providers to *exchange* substantial quantities of user data, instead of purchasing by money. Conversely, in country B, even with abundance of user data, it's impossible to exchange for a digital service. This exchange ratio is better represented in attention to the service or online time rather than quantity of consumption. The users in country B tend to spend more spare time on the online service, because the consumers with lower incomes tend to invest more attention in digital products as they derive greater utility from them [64-65], consequently generating more user data. This implies that users require more data (Y) to exchange for a digital good (X), leading to a decrease in the true price of Y as demand for X escalates. Thereby the trade zone for digital service trade is likely to be more extensive, though the proximity of relative prices between the two countries (such as Fig. 6). And the world price may lean more towards domestic prices in country B, potentially exacerbating its terms of trade.

The monetary price fails to reflect real values of a digital service and its networks in exchange ratios accurately. Free digital services, while not directly measurable in GDP terms, substantially enhance consumer well-beings [66]. Indeed, the actual value of digital products often exceeds their transactional value. Brynjolfsson and Oh estimated the true value generated by free digital services at approximately $10 billion [67]. The value of data and digital products is determined by their usage rather than their inherent qualities. In country A, digital products can exchange for more extensive user data which can be leveraged in various business activities for profits. This process's value exceeds the well-beings of direct consumption in country B. Consequently, the export of digital product X to country B reduces its real value, while the export of user data Y to country A enhances its value. If we view the value of digital products and data as commodities in international trade, country A exchanges higher-value data commodities with lower-value digital products. This dynamic disproportionately benefits developed countries, and exacerbates the inequality of well-beings in the digital service trade (As depicted in Fig. 7). *Prebisch-Singer hypothesis* believes that international trade exacerbates the terms of trade for primary product-exporting countries, which is also reflected in the realm of digital service trade. However, the deterioration in terms of trade is manifested not in reduced trade revenues or deficits, but in the diminished capacities to exploit value of data, or a weakening of digital comparative advantages.

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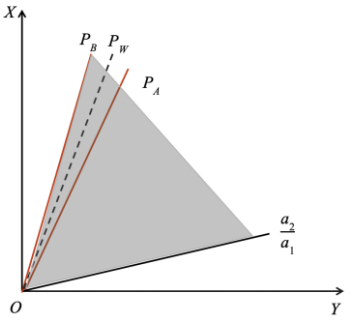

Figure 6: The Trade Zone of Digital Goods Source: Own Elaboration

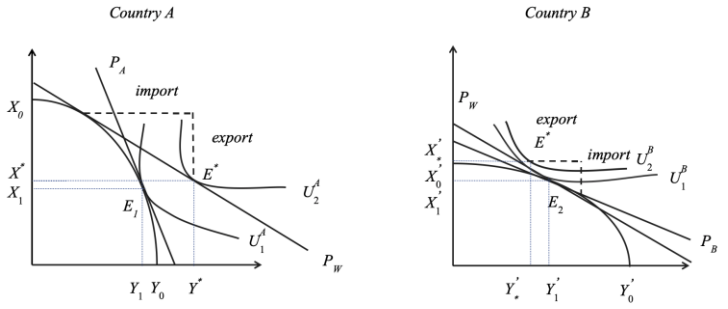

Figure 7: The Well-beings of Digital Service Trade Source: Own Elaboration

4. Factor Endowment--The Source of Comparative Advantage

4.1. An Improvement to this Model

The digital service trade deteriorates developing countries' terms of trade. However, why these countries implement the data localization requirements instead of import substitution strategy to keep up with the developed countries is another issue. The shifting comparative advantages in certain industries and the following industrial transfers have enabled numbers of countries to participate in value creation and distribution, though the distribution of benefits is also inequality. However, such dynamics seem less likely in the digital service trade, due to the economies of scale and network effects, which impede the transfer of digital comparative advantages, thereby limiting the abilities of latecomer countries to engage in value distribution. To thoroughly understand this, it is imperative to examine the origins of digital comparative advantages. Therefore, the application of the Heckscher-Ohlin (H-O) theory is necessary to address this critical question.

4.2. An Adjustment to the Original Theory

The H-O Theory sees data as both a goods and a factor endowment, acknowledging the data as the *raw material* for the digital service. The original version's assumption is that factor is limited to transfer across nations, while the free flow of data factor across countries raises a key challenge. Furthermore, in the last chapter, the business dynamics of digital services are conceptualized as perfectly competitive market based on their pricing strategies. However, the H-O theory primarily focuses on goods production and factor. The digital market exhibits monopolistic characteristics. Balassa believes that the economies of scale complicates the measure of comparative advantages [68]. Baskaran et al. and Qiu et al. assert that the network effects can diminish or substitute the impact of factor endowments, rending the capital and labor factors less effective [69-70]. In fact, economies of

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scale indeed exist in the digital sector, but it is considered here as an advantage of factor endowment instead of enterprises' market power. Sundararajan et al. believe that data can create networks, which in turn generate value, suggesting economies of scale and network effects are intrinsic to data itself, not merely market structure or firm power [71]. Data factors' value inherently relies on economies of scale and network effects [72]. Smaller datasets struggle to exert economic influence, which is a distinction between data and traditional elements. Thus, data factors, owing to their unique properties, are likely to yield higher payoffs than traditional factors.

4.3. An Interpretation Based on the Factor Endowment

Drawing on Spilimbergo et al.'s contributions [73], in perfectly competitive markets:

$$Q^*=F(E_i) \tag{12}$$

$$P^*=P(Q^*) \tag{13}$$

$$P^*F'(E_i)=W^* \tag{14}$$

where P^* represents the equilibrium price of goods, E_i represents the factor endowment, W^* represents the factor payoffs. According to the Equation (14), we can get:

$$W^*=W(P_i,E_i) \tag{15}$$

Plugging Equation (12), (13), (14) into Equation (15), we obtain:

$$W^*=W(E_i) \tag{16}$$

In a closed economy, relative factor price is fundamentally influenced by the relative abundance of factor. However, in the context of a small open economy, under the assumption that international market is equilibrated and factor price is driven by the world price of the final product. According to the principle of induced demand, we can get:

$$W^*=W(P_W) \tag{17}$$

Equation (17) remains robust under two conditions: (a) The production functions of each country exhibit homogeneity; (b) There is an absence of factor intensity reversal. If either of these conditions is not satisfied, then the relative price of factor within a country is determined by both the world price of the final product and the country's relative factor abundance. This can be expressed as:

$$W^*=W(P_W,E) \tag{18}$$

According to Dixit and Norman's contribution [74], the world price should be determined by the relative abundance of the two factors in global market:

$$P_W=P(E_W) \tag{19}$$

Plugging Equation (19) into (18), we can get:

$$W^*=W(E_W,E) \tag{20}$$

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We continue to assume that country A and B specializes on digital good X and data Y respectively. Fig. 8 illustrates the process of production and consumption of digital goods. The production of digital services requires, not only data collections, but also labor with digital skills, equipment for data procession and the cost of access to Internet. According to Stöllinger and Guarascio's contribution [75], we assume that the factors for the two goods are *digital task* and *ICT capital*. Here, digital task retains their previously meaning, while ICT capital refers to digital infrastructure, encompassing aspects like network connectivity, data centers, cloud computing services, the Internet of Things (IoTs), and digital payment systems. Digital infrastructure is crucial for realizing the value of data [76-77]. In our model, digital task is analogous to labor (L), and ICT capital corresponds to capital (K), leading to the following production function:

$$X=F_A(L_A,K_A,Y) \tag{21}$$

$$Y=F_B(L_B,K_B) \tag{22}$$

where L_A, L_B, K_A, K_B is the digital tasks and ICT capitals in country A and B respectively. F is the production function. Plugging the Equation (22) into (21), we can get:

$$X=F_A\,(L_A,K_A,L_B,K_B) \tag{23}$$

From equation (23), the free flow of data allows developed countries to view the two countries as the whole market, with access to both domestic and foreign digital factor endowments. As an exporter of data, country B is unable to leverage the factor endowments of country A for production, effectively rendering it a closed economy. Consequently, the factor price in country A is influenced both by the global market's relative factor abundance and its domestic factor abundance. In contrast, country B's factor price is solely determined by its domestic factor abundance. According to Harkness and Debaere's contribution [78-79], we can formulate the relative factor abundance in the domestic economy and world market:

$$E_i=\sum_{i=1}^{N} f_{ki}\beta_i M_i/\sum_{m=1}^{N} f_{km}\beta_m M_m \tag{24}$$

$$E^*=\sum_{j=1}^{J}\sum_{i=1}^{N} f_{ki}\beta_i M_i/\sum_{j=1}^{J}\sum_{m=1}^{N} f_{lm}\beta_m M_m \tag{25}$$

where M_i represents the ith final product, f_{ki} denotes the input ratio of factor k to produce the ith final product, and β_i symbolizes the average propensity to consume of ith good, with j indicating the specific country.

The exchange of goods alters the relative factor abundance between countries due to consumption in the production process. However, the non-consumptive characteristic of digital task and ICT capital results in digital service trade having no impact on the switch of a country's factor endowments. Consequently, the ratio of factor input in calculating relative factor abundance becomes irrelevant. Additionally, the frictionless transmission of digital products negates the need to factor in the ratio of domestic consumption to exports when assessing relative factor abundance. Thereby:

$$E_i=K_i/L_i \tag{26}$$

$$E^*=(K_i+K_j)/(L_i+L_j) \tag{27}$$

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We derive the formula for calculating a country's relative factor abundance and that of the global market:

$$W_A=\mu_1[(E^*)^{\frac{\xi_1}{\xi_2}}(E^*)]^{-(n_1+n_2)} \tag{28}$$

$$W_B=\mu_2[(E^*)^{\frac{1-\xi_1}{1-\xi_2}}]^{-n_2} \tag{29}$$

where ξ_1 and ξ_2 represent the relative proportions to the total supply of ICT capitals and digital tasks coming from country A in global market. Given the abundance of ICT capital in country A, we posit that $\xi_1 > \xi_2$. The parameters μ_1 and μ_2 are introduced to model the functions. The factor price is inversely correlated with relative factor abundance. Moreover, considering the role of network effects in the digital economy, we define n_1 and n_2 as the number of users in countries A and B respectively ($n_1>n_2$). Notably, as a country receiving data inflow, the economy of country A is open, so the size of its user networks should be viewed as an aggregate of both countries' network scales. Thereby we can get:

$$\frac{W_A}{W_B}=(E^*)^{-(2n_1+n_2)}\left(\frac{\frac{1}{\xi_1}-1}{\frac{1}{\xi_2}-1}\right)^{n_2}\left(\frac{\xi_2}{\xi_1}\right)^{n_1}<1 \tag{30}$$

According to Heckscher-Ohlin-Samuelson (H-O-S) theorem, international trade should lead to the equalization of relative factor prices, thereby bridging the economic disparity between developed and developing nations. Ideally, this would result in countries A and B receiving commensurate factor payoffs. However, the Equation (30) indicates a persistent discrepancy in factor costs for digital goods production, with country A consistently incurring lower factor costs than country B. This scenario precipitates a constant decline in country B's terms of trade in terms of factor incomes. The unrestricted inflow of data into country A enables it to reap factor payoffs from country B's data factors without any corresponding factor cost obligations to country B. Conversely, the absence of data inflow into country B, coupled with no compensatory factor payments from country A for its contribution of digital factor endowments in international production, unequivocally exacerbates country B's economic position. This situation mirrors the *impoverished growth* concept articulated by Bhagwati, where international trade paradoxically leads to diminished well-beings of developing countries (as illustrated in Fig. 9).

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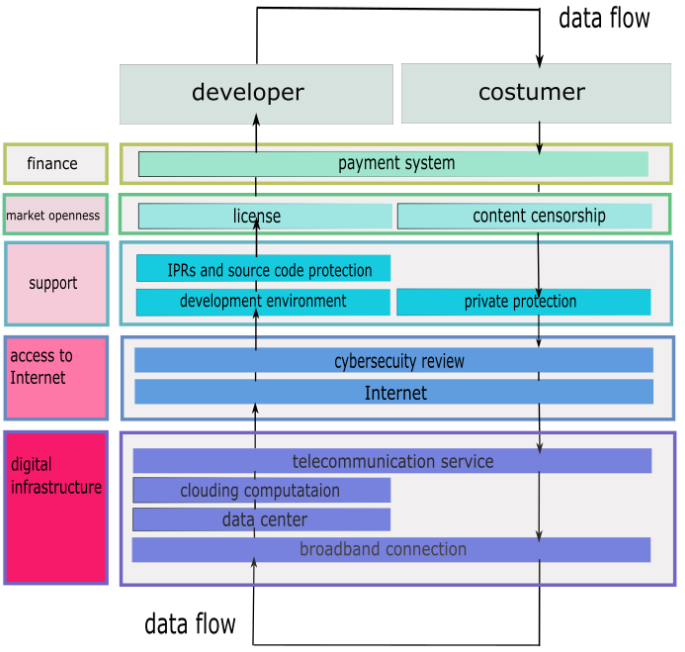

Figure 8: The Production and Consumption of Digital Goods Source: Own Elaboration

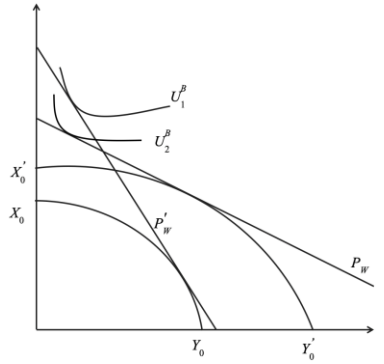

Figure 9: The Impoverished Growth Source: Own Elaboration Source: Own Elaboration

4.4. An Illustration on impoverished growth of digital service trade

Data has become a key factor for the data-driven industries. The digital factor endowments of a nation are rooted at data scales and digital capacities. The data inflow, particularly prevalent in developed countries, amplifies their comparative advantages in the realm of digital service trade. This phenomenon not only fortifies their market position but also establishes formidable barriers to market entry for the developing. The barriers encompass the digital infrastructure disparity, the economies of scale and network effects, the homogenization of factor endowment. A nation's comparative advantages in digital services are often rooted in its digital infrastructure and skills [80]. Because sophisticated digital infrastructure, fueled by big data, have the potentials to realize the value of data and foster more pronounced comparative advantages in digital services. As a channel for data transfer and processing, the physical locations of digital infrastructure play a key role in directing data flow. Consequently, it is plausible to believe that data inflow signifies the accumulation of digital comparative advantages. However, there is a significant divide on digital infrastructure between the

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developed and developing economics [81], which leads to huge difficulties to enhance the amount, qualities and capacity of digital factor endowments for the latter. Additionally, the gaps of skills to use and process the data effectively prevent individuals and businesses from taking full advantages of the data and Internet [82]. Consequently, the absence of comparative advantages leads to the digital inequality within a free trade environment for developing countries from digital trade.

The economies of scale and network effects diminish the likelihood of industrial transfers and factor spillovers, further exacerbate the challenges faced by late-developing countries in participating in the value realization [83]. In the view of traditional international trade, it is feasible for developing countries to catch up with the developed countries in global market dynamics, because the developing countries have the potentials to narrow the gaps in comparative advantages of tangible goods production gradually [84]. This phenomenon is substantiated by the facts and empirical data of industrial transfers post-the World War II., driven by increasing labor costs and diminishing marginal factor payoffs. Thereby, comparative advantages and factor endowments begin to shift from developed countries into developing countries with industrial transfers [85-86], which help to develop local industries gradually in poor regions. However, this dynamic is notably absent in digital service trade. The digital economy is distinctively marked by economies of scale and network effects, which hinder the incentives for industry transfers and factor spillovers. The developing countries have a lack of external incentives for the development of digital industries. For instance, if some developed countries only specialize on the core aspects of digital services and deliver some non-critical functions to the developing economics, the countries which embrace these productions need to reach a "threshold". Because cross-border service trades rely on digital infrastructure for delivery, production will be difficult if the infrastructure and connections on the both sides are weak [87].

The homogenization of factor endowment prevents the developing countries from creating value by other factor endowments. In the sector of physical goods, latecomers possessing any one of these factor endowments can leverage their comparative advantages to engage in value creation. This dynamic is commonly observed in labor-intensive and resource-intensive sectors. The developing countries possess comparative advantages naturally to take on these industries as comparative advantages of developed countries shift to capital-intensive and technology-intensive industries [88]. However, in the digital domain, digital factors emerge as the sole factor endowment crucial for the data-driven products. Unlike traditional sectors, data factors are not amenable to self-accumulation or spill-over through industrial transfers. Furthermore, the network effects inherent in the digital economy often result in higher factor payoffs compared to traditional factors, which diminishes the relative value of traditional factor endowments, thereby impeding developing countries' abilities to leverage their existing comparative advantages.

5. Data Localization: A Novel Protectionism

Data localization requirement is a novel form of trade protectionism. At the dawn of free trade era, Hamilton and Lister advocated for trade protection policies in latecomer economics, like today's data localization, to safeguard their interests. The predication that all countries take part in the international is that they can reap benefits from engaging in global value chains (GVCs) [89]. As an exporter of raw materials, developing countries struggle to reap well-beings and accumulate their own comparative advantages, hindering their participation in the chain of digital products. We call this digital inequality as *digital poverty*.

Indeed, Data localization effectively introduces a substantial fixed cost (T_0) to the production of digital services, as companies are frequently compelled to establish local digital infrastructure for the preservation and processing of local data. We define parameter ρ to denote the restriction on the export of data, so that the digital factor price in country A is:

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$$W_A=W_A(\rho E_W,E_A,T_0) \tag{31}$$

Data localization policies significantly influence the trade dynamics in digital services, particularly impacting income distribution and factor prices. Firstly, the investment in data centers and digital infrastructure within the host country acts as a compensatory mechanism for the utilization of its digital factors. This investment essentially improves the terms of trade for late-developing countries, effectively narrowing the digital infrastructure gap with developed countries and bolstering their digital comparative advantages. In this way, developing countries can occupy some vital nodes in digital trade networks and to some extent, create, capture and share common value with developed countries in digital business dynamics. This phenomenon can be perceived as a form of compulsory industrial spillover. Secondly, by restricting the outflow of domestic data, these policies hinder developed countries from exploiting digital factors from other countries and decrease the abundance of digital factors in global market. This restriction effectively diminishes the global pool of digital factors, elevating the cost of data factor utilization and consequently attenuating the dominance of developed countries. Although it continues to reap the benefits of factor payments from both countries A and B, it now incurs substantial costs. But certain digital enterprises find themselves compelled to accept the data localization policies of their host countries. Often, this acceptance is driven by the significant factor endowments that a large user network in the host country can provide, as exemplified by Apple's operations in China. This suggests that companies may acquiesce to the host country's regulations when the potential factor payoffs in that country outweigh the associated compliance costs.

Nonetheless, the implementation of data localization policies does not necessarily translate to increased well-beings in international trade. Data localization can diminish the overall value of global digital goods. According to Metcalfe's law, the value of a network is proportional to the square of its number of connected users [90]. The value of digital goods is largely dependent on their user networks, more specifically, on the volume of user data they amass. By limiting the scope of available data factors, data localization adversely will diminish network effects and economies of scale, thereby devaluing digital services and the associated factor payoffs. Thereby, the creation of digital products within isolated environments leads to resource inefficiency and diminished well-beings compared with participation in a more valuable network. Additionally, a liberal and standardized trading environment is crucial for developing comparative advantages [91]. Fragmented data governance forces firms to adapt to varied regulations, incurring substantial compliance and transaction costs, contradicting the WTO's principles of free trade. This paper presents two proposals aimed at fostering the free flow of data: (a) Bolstering digital hardware infrastructure to facilitate the local data mirrors. González et al. classify the data localization requirement as storage requirement no flow restriction, storage requirement with defined transfer and storage and processing requirement with prohibition [92]. On one hand, developed countries recognize that stringent data localization undermines the value of data factors. On the other hand, developing countries fear that unrestricted data flow may impede their digital capabilities. Establishing local data mirrors offers a viable compromise. (b) Remunerating developing countries for the utilization of digital factors. In a free data flow environment, while developed nations can exploit factor resources globally without direct costs, equitable factor compensation to developing countries is crucial for improving their well-beings. At present, some scholars from developing countries refer to developed countries which dominate the digital service market as *digital colonialism* or *digital empire* [93-94], which is a kind of inherent bias. These payments could serve to build mutual trust and encourage more balanced global data flow based on mutual respect and equity.

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6. Discussion and Conclusion

Our model is developed to elucidate the reasons of data localization requirements from a perspective focused on well-beings of digital service trade. We suggest that the current trade pattern will lead to an unequal chance to participate in the digital service trade for developing countries. Due to the unequal digital capacities, the developing countries serve as the exporters of data materials, which worsens their terms of trade, diminishes their digital comparative advantages and digital factor endowments. The nature of data places a great barrier on the latecomers to occupy some positions in the digital industrial chains, and amplifies the comparative advantages of developed countries. We call this phenomenon as digital poverty. However, reducing the scales of datasets and networks in global market, data localization might inadvertently undermine the developed countries' digital comparative advantages. Paradoxically, this weakening could also negatively impact the well-beings of developing countries. Data localization is not an optimal strategy for addressing the challenges of digital poverty. It suggests that it is necessity to put forward more nuanced provisions to balance the interests of both developed and developing countries within the WTO framework.

The marginal contributions of this paper are: (a) Diverging from existing research paradigms, this article explores the reason why the developing countries support for data localization from the perspective of trade, which offers a novel research direction to facilitate the free data flow. (b) This article employs Classical Model to elucidate the uneven distribution of the well-beings in digital service trade, which results from unequal digital comparative advantages and factor endowments, forcing developing countries to implement data localization. (c) This article sheds light on a key reason impeding progress in negotiations on data localization: the inherent contradiction between monopolistic production of digital products and the principle of free trade.

Indeed, the rapid development of the digital economy has historically outpaced the evolution of its regulatory frameworks [95]. The Theory of comparative advantage and H-O Theory do not singularly encapsulate the complexities of digital service trade as observed today. The Classical Model, though insightful, exhibits intrinsic limitations in explicating contemporary trade phenomenon [96]. Our utilization of this theory serves not only the objectives of this paper but also traces the evolution of international trade theories. This historical journey, spanning from the early concepts of mercantilism and liberalism through trade protectionism, has culminated in the global consensus on free trade. The progression of digital service trade mirrors this trajectory: from data localization and fragmented regulatory policies to the anticipated realization of free data flow, each phase necessitates substantial international collaborations. The theoretical framework presented in this paper, is anticipated to evolve and be superseded by more advanced models in the future. We also invite future empirical researches to validate our propositions and expand these insights.

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We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

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