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Evaluating Singapore's Digital Economy Agreements and Digital Trade

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Evaluating Singapore’s Digital Economy Agreements and Digital Trade

Mukund Kishore, Yunlong Song*

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Abstract

As the digital economy grows in importance yet remains constrained by pervasive policy barriers, Digital Economy Agreements (DEAs), a set of international agreements pioneered by Singapore, seek to address digital-governance challenges and facilitate digital trade. Utilising BaTiS data for 2015–2024, this paper empirically examines whether DEAs facilitate digital trade among member countries by combining difference-in-differences (DiD) specifications with matching methods. The results show that DEAs significantly promote bilateral trade in digitally deliverable services. The baseline DiD results indicate that the entry into force of a DEA increases trade in digitally deliverable service sectors by approximately 18.9–20.8%. The estimated gains are concentrated in digitally deliverable services, with no spillover to the services trade overall. Further analysis within digital sectors suggests that this positive trade effect is largely driven by highly digital-intensive sectors such as information and communications technology (ICT).

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1 Introduction

Digital trade, defined as all international trade that is digitally ordered and/or delivered,¹ is growing rapidly and becoming increasingly ubiquitous in global trade. Over the past decade, global digital trade has grown faster than other forms of trade, with a total increase of 42% from 2010 to 2020, compared with only 10% for other trade. A significant part of digital trade is the trade in services that can be delivered digitally, known as digitally deliverable services (DDS).² By 2020, DDS already represented 60% of global digital trade (OECD 2023). DDS include advanced and fast-growing service sectors, including Information and Communications Technology (ICT) and the financial sector, and are thus particularly important in advanced and digitally intensive economies such as Singapore and Canada.³

Despite its fast growth, digital trade is impeded by pervasive policy frictions such as data localisation requirements and limited interoperability between systems across borders (Meltzer 2019; OECD 2023). The Digital Economy Agreements (DEAs) are international agreements focused specifically on the digital economy, designed by Singapore to tackle barriers and promote digital trade. Together with Chile and New Zealand, Singapore was a pioneer in developing Digital Economy Agreements, beginning with the Digital Economy Partnership Agreement (DEPA) in 2021. It has since concluded DEAs with several major trading partners, including the United Kingdom and South Korea. Despite its promising policy vision, it remains unclear whether DEAs actually facilitate cross-border digital trade, especially for Singapore. Five years after its first DEA, a timely question is: has the entry into force of DEAs increased bilateral digital trade among member countries?

To answer this question formally, we utilise bilateral services trade data from the OECD–WTO Balanced Trade in Services dataset (BaTiS) for 2015–2024 and employ a staggered difference-in-differences (DiD) approach. We identify digitally deliverable service sectors (or simply, digital sectors) using the classification in the *Handbook on*

¹Following the *Handbook on Measuring Digital Trade*.

²Digitally deliverable services (DDS) are services that can potentially be delivered remotely over computer networks. Our analysis focuses on trade in DDS sectors, rather than measuring digital trade in its entirety.

³According to UNCTAD data, digitally deliverable services accounted for 57.4% and 54.4% of total services exports from Singapore and Canada, respectively, in 2024. Canada has also applied to join the Digital Economy Partnership Agreement (DEPA).

Measuring Digital Trade. As the time of DEAs’ entry into force coincides with multiple contemporaneous shocks, including the commencement of other trade agreements that include digital provisions (e.g. CPTPP), the US-China trade war, and COVID-19 exposure, all of which could affect bilateral trade of the signing parties, we incorporate corresponding controls to improve identification.

To further establish robustness, we use the matching technique to construct an appropriate comparison group for the DEA-signing parties. This comparison group, together with the treated parties, constitutes our sample for the DiD regression. This matching improves comparability between DEA and non-DEA country pairs on observed pre-treatment characteristics, which is vital since signatories are unlikely to be randomly selected, as they may already have stronger trade links with their partners based on these characteristics. Specifically, we use propensity score matching based on pre-treatment trade, economic, geographic, and digital policy characteristics to improve comparability between DEA and non-DEA country pairs. In addition to the matched comparison group, we also consider economies that have applied to join DEAs but have not yet joined the agreement during the sample period as an alternative comparison group, with the assumption that applicants share characteristics similar to those of actual DEA members in deciding to join the DEAs.

Our baseline DiD results indicate an increase in digitally deliverable services (DDS) trade, with estimated effects of 18.9–20.8%. Event-study estimates also indicate that DDS trade rises by 20.6% in the year after entry into force. The results also indicate sectoral heterogeneity in DEAs’ impacts: while DEAs promote DDS trade, they do not have a significant impact on trade in the overall service sector or in non-digital sectors. A further decomposition of the digital sectors suggests that ICT services trade is likely the main driver of the observed positive impact of DEAs. Results with DEA applicants as an alternative comparison group show some positive, but less robust, impacts on digital trade.

This paper is related to the broader literature that empirically quantifies the effects of trade agreements on international trade flows.⁴ Most of the modern studies rely on the gravity equation of trade and incorporate importer and exporter fixed effects that control

⁴Some examples include [Baier and Bergstrand \(2007\)](#); [Baier and Bergstrand \(2009\)](#); [Egger et al. \(2011\)](#); [Kohl \(2014\)](#); [Baier et al. \(2019\)](#). See [Larch and Yotov \(2024\)](#) for the latest overview.

the "multilateral resistance terms";⁵ see [Head and Mayer \(2014\)](#) for detailed discussions on gravity equations. Previous research generally concludes that trade agreements facilitate trade, while at the same time noting that not all agreements generate significant positive effects on trade.⁶ One major challenge in gravity estimation is endogeneity: countries expected to benefit most from a trade agreement are also more likely to sign one, and factors such as existing bilateral trade flows and economic size can simultaneously influence both the likelihood of entering an agreement and future trade flows. Methods addressing this problem include introducing an exporter-importer fixed effect ([Baier and Bergstrand 2007](#)), instrumenting the trade agreement treatment ([Egger et al. 2011](#)), and constructing counterfactuals with matching techniques ([Egger and Larch 2008](#); [Baier and Bergstrand 2009](#); [Egger and Tarlea 2021](#)). Relative to the literature, we focus specifically on the recently emerging DEAs—a class of digitally focused trade agreements. By combining DiD regression with propensity score matching, we provide additional evidence for evaluating trade agreements.

This paper is also related to studies on digital trade and governance of the digital economy. Only a few studies have examined digital trade and related policies.⁷ [Suh and Roh \(2023\)](#) empirically examined how digital trade policies affect bilateral trade and found that trade agreements including digital-specific provisions significantly promote bilateral trade. Similarly, [Wu et al. \(2023\)](#) showed that digital trade rules in preferential trade agreements increase GVC-related service exports. Those papers only examine traditional free trade agreements that include digital trade provisions. In contrast, we focus on the Digital Economy Agreements, agreements specifically designed for the digital economy and anchored by Singapore. To our knowledge, we are the first to empirically study the impacts of this class of trade agreements.

The remainder of the paper is organised as follows. Section 2 outlines a brief background on digital trade, its policy barriers, and the DEAs as a potential solution to those barriers. Section 3 introduces the empirical method and data. Sections 4 and 5 discuss estimation results for the matched and applicant comparison groups, respectively. Section

⁵The "multilateral resistance terms" were first introduced by [Anderson and Van Wincoop \(2003\)](#) in the gravity framework.

⁶For example, [Baier et al. \(2019\)](#) found that only 53.9% of the 65 trade agreements have significantly positive effects; [Kohl \(2014\)](#) also showed that over fifty percent of 166 trade agreements between 1950-2010 have no discernible impact on trade.

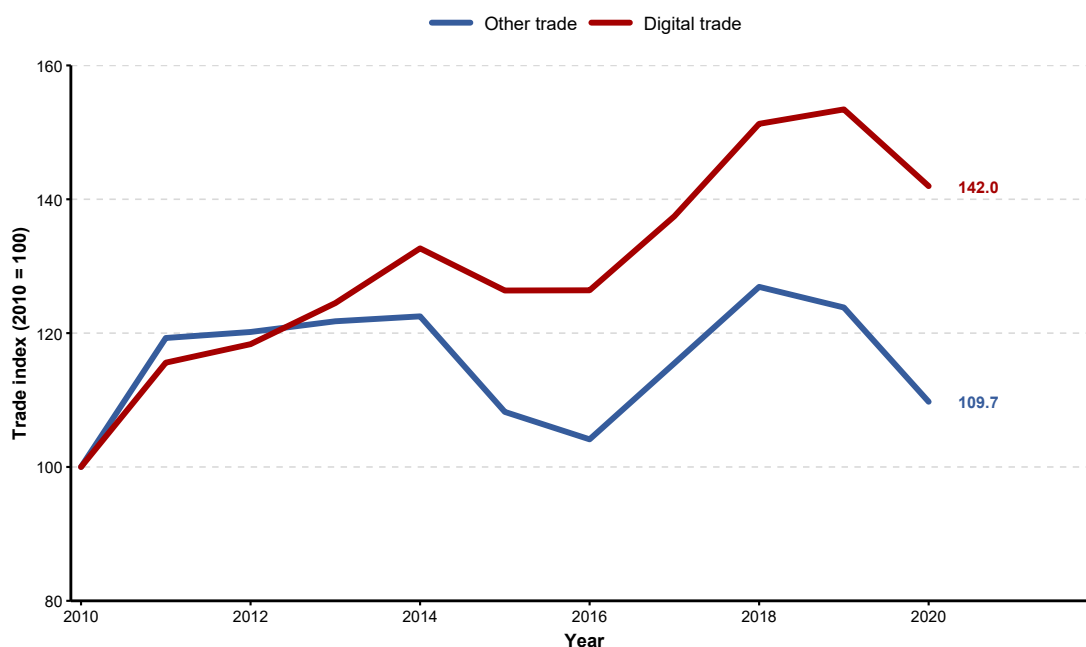
⁷See [Meltzer \(2019\)](#) for an introduction to digital trade and its governance.

6 concludes.

2 Policy Background

Thanks to advances in digital technology and the presence of e-commerce, global digital trade has expanded substantially faster than other forms of trade over the past decade.⁸ As Figure 1 shows, the digital trade index, normalised to be 100 in the initial year of 2010, reached 142.0 in 2020, compared with 109.7 for other trade. This represents cumulative growth of approximately 42.0% and 9.7%, respectively.

Figure 1: Growth of digital trade and other trade, 2010–2020



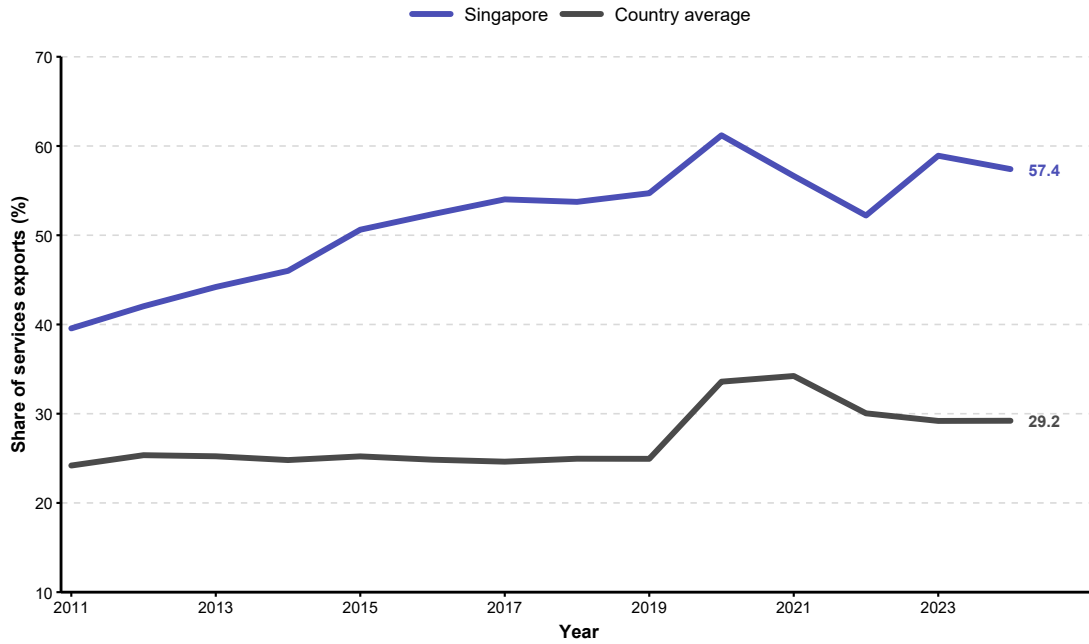
Source: (OECD, 2023).

Singapore has emerged as a leading participant in the global digital economy, supported by its high degree of digitalisation and strong orientation towards digitally deliverable services (DDS). Singapore’s two-way trade in DDS nearly quadrupled between 2011 and 2024, increasing by 294.4%. Over the same period, DDS also rose from 39.6% to 57.4% of Singapore’s services exports, compared with an increase from 24.2% to 29.2% in the global average across reporting economies (Figure 2).⁹

⁸Following the *Handbook on Measuring Digital Trade* (World Trade Organization et al., 2023), digital trade comprises all international trade that is digitally ordered and/or digitally delivered.

⁹Authors’ calculations using unweighted mean across reporting economies based on UNCTADstat, *Services (BPM6): Exports and Imports by Service Category*, trading partner World, annual data.

Figure 2: Digitally deliverable services as a share of services exports



Source: Authors' calculations using UNCTADstat data on digitally deliverable services.

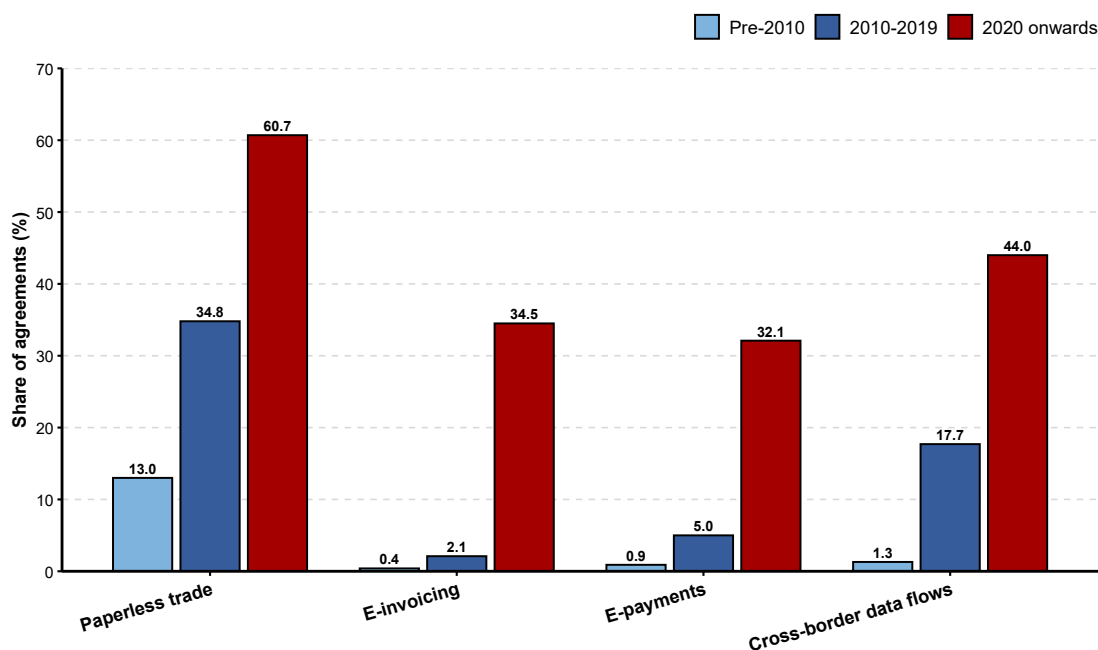
2.1 Recent Policy Response

The growth and continued evolution of the digital economy have created new challenges for governments seeking to govern and facilitate international trade (OECD, 2023). For much of the trade in digitally delivered services, conventional border measures such as tariffs are negligible. Instead, digital trade can be constrained by regulatory and transaction frictions arising from restrictions on cross-border data flows, differences in regulatory frameworks and standards, paper-based processes, payment frictions, and difficulties in establishing trust and identity across jurisdictions. These frictions can increase the costs and uncertainty of conducting business across borders, thereby hindering digital trade. As trade becomes increasingly dependent on digital platforms and data-intensive technologies, the nature of these frictions is shifting towards data governance, cybersecurity, and interoperability across digital systems (OECD, 2023).

Governments have responded to the digitisation of global trade and the bottleneck of policy barriers by including an increasing range of digital-economy and cross-border trade provisions in trade agreements. This expansion has been particularly pronounced since 2020. As Figure 3 shows, agreements signed since 2020 address digital-economy

issues more frequently than those signed in previous decades, particularly paperless trade, electronic invoicing, electronic payments, and cross-border data flows. The shift is evident not only in the breadth of issues covered but also in the extent to which the provisions create binding commitments. Binding commitments on paperless trade and cross-border data flows appear in 16.3% and 30.2% of coded agreements signed since 2020, more than three times their respective shares in 2010–2019.

Figure 3: Digital trade provisions by agreement signing period



Source: Authors' calculations using the TAPED database (Burri and Vásquez Callo-Müller, 2025).

Singapore has been a leading economy in this area through its network of Digital Economy Agreements (DEAs). Unlike conventional trade agreements, in which digital issues are usually addressed through an e-commerce or digital-trade chapter, DEAs are dedicated primarily to rules and cooperation in the digital economy. Their provisions cover areas such as paperless trade, cross-border data flows, electronic payments, digital identities, regulatory interoperability, SME participation, digital trust, and emerging technologies. Soprana (2021) finds that DEPA extends beyond recent preferential trade agreements, thanks to its standalone, modular structure and broader subject coverage. Using the TAPED database, Burri et al. (2024) similarly show that DEAs have expanded digital trade rulemaking into areas such as digital identities, financial technology, artificial intelligence, and regulatory interoperability, although many of these newer provisions are

cooperative rather than legally binding.

Singapore’s DEAs include bilateral agreements with individual economies and agreements with regional groupings. Since 2020, six such agreements have entered into force, involving partners such as Australia, the United Kingdom, and the European Union (Table 1). Singapore’s DEA network has expanded rapidly since 2020 and now spans bilateral, plurilateral, and region-to-region agreements (Table 1). Although certain provisions differ from one DEA to another (see [Allen and Liao \(2025\)](#)), these agreements generally combine binding rules on data flows and electronic transactions with cooperation on interoperability and emerging digital-economy issues.

The Digital Economy Partnership Agreement (DEPA) is a prominent example of DEAs. Singapore, Chile, and New Zealand established DEPA as a standalone, open plurilateral agreement organised into modules. It first entered into force for Singapore and New Zealand on 7 January 2021 and for Chile on 23 November 2021. The Republic of Korea became DEPA’s first acceding member on 3 May 2024. DEPA combines binding rules on matters such as paperless trade and data governance with cooperative provisions on digital identities, financial technology, artificial intelligence, and SMEs ([New Zealand Ministry of Foreign Affairs and Trade, 2026](#); [Singapore Ministry of Trade and Industry, 2024](#)). Several significant economies have applied to join DEPA, including China and Canada. It is therefore expected to expand further in the future.

Table 1: Digital Economy Agreements (DEAs) in force

Name	Countries	Date of entry into force
Singapore–Australia Digital Economy Agreement (SADEA)	Australia, Singapore	9 Dec 2020
Digital Economy Partnership Agreement (DEPA)	Chile, New Zealand, Singapore, Republic of Korea	7 Jan 2021 for Singapore and New Zealand; 23 Nov 2021 for Chile; 3 May 2024 for Korea
UK–Singapore Digital Economy Agreement (UKSDEA)	Singapore, United Kingdom	14 Jun 2022
Korea–Singapore Digital Partnership Agreement (KSDPA)	Republic of Korea, Singapore	14 Jan 2023
European Union–Singapore Digital Trade Agreement (EUSDTA)	European Union, Singapore	1 Feb 2026
EFTA–Singapore Digital Economy Agreement (ESDEA)	EFTA States, Singapore	1 Mar 2026 for Norway and Singapore

Notes: The table lists Singapore’s digital economy and digital trade agreements that have entered into force. The ESDEA was signed with the four EFTA States: Iceland, Liechtenstein, Norway and Switzerland. As of the date reported here, it had entered into force for Singapore and Norway.

2.2 Digital Trade Barriers and the Role of DEAs

A key objective of Digital Economy Agreements (DEAs) is to facilitate digital trade by reducing regulatory barriers that impede cross-border digital transactions. In particular, they aim to remove unnecessary barriers, align rules and standards across jurisdictions, and promote interoperability between digital systems (Singapore Ministry of Trade and Industry, 2026; Australian Government, Department of Foreign Affairs and Trade, 2026; United Kingdom and Singapore, 2022). This paper focuses primarily on trade in DDS, which is a primary target of DEAs.

Unlike trade in goods, DDS trade is generally exempt from tariffs. Its trade costs arise mainly from frictions such as domestic regulations governing data transfers, electronic transactions, payment systems, and other aspects of digital activity. The OECD's Digital Services Trade Restrictiveness Index (Digital STRI), developed by Ferencz (2019), groups these regulatory barriers into five categories:

- ***Infrastructure and connectivity*** covers restrictions affecting the digital infrastructure required for cross-border trade. These include restrictions on cross-border data flows, data localisation requirements, and limitations on communications services, including Virtual Private Networks.
- ***Electronic transactions*** covers the legal recognition of electronic contracts, signatures, and related transactions. Barriers arise when electronic documents lack the same legal validity as paper documents or when domestic frameworks are inconsistent with internationally recognised standards.
- ***Payment systems*** covers restrictions that limit the ability of foreign firms to access or use local payment services and receive payments from customers.
- ***Intellectual property rights*** covers the legal protection and enforcement of rights relating to digital assets, including software and online content.
- ***Other barriers affecting digitally enabled services*** includes requirements such as establishing a local commercial presence or transferring proprietary technology as a condition for operating in a market.

These barriers affect different stages of a cross-border digital transaction. Infrastructure and connectivity rules determine whether a firm can reach foreign customers and

transfer the data required to deliver its service. Electronic transaction rules determine whether online contracts, signatures, and invoices are legally recognised. Payment regulations affect whether customers can pay foreign suppliers, while intellectual property protections influence the risks of supplying software and other digital products across borders.

The relative importance of these barriers also varies. In the average Digital STRI score in 2022, infrastructure and connectivity accounted for approximately 58% of measured restrictions, highlighting that the majority of digital trade friction arise from fundamental restrictions such as those on cross-border data flows. Other barriers affecting digitally enabled services contributed approximately 18%, while restrictions on electronic transactions accounted for a further 14%. Payment systems and intellectual property rights constitute the remaining 10%.

DEAs seek to reduce these barriers by establishing common rules and promoting regulatory interoperability among their parties. Across DEPA and Singapore's bilateral agreements (including SADEA, KSDPA, and UKSDEA), several provisions map directly to the categories captured by the Digital STRI.

First, DEAs reduce regulatory barriers to cross-border data transfers. For example, under the amended DEPA, Articles 4.3 and 4.4 require parties to permit cross-border transfers of information and generally prohibit requirements to locate computing facilities domestically, subject to specified public policy exceptions. KSDPA Articles 14.14 and 14.15 set out comparable rules. Article 14.14 expressly applies to financial institutions and financial-service suppliers, while Article 14.16 provides a framework for cooperation on the use of computing facilities outside a party's territory by financial firms. By limiting data localisation requirements and clarifying the conditions governing cross-border data transfers, these provisions can reduce regulatory uncertainty and the need to duplicate data storage and computing facilities across markets ¹⁰.

Second, DEAs can increase legal certainty and interoperability in electronic transactions. DEPA Articles 2.2, 2.3, and 2.5 respectively address paperless trading, domestic electronic-transaction frameworks, and interoperable e-invoicing. SADEA Articles 10 and 12 similarly require e-invoicing measures to support cross-border interoperability in-

¹⁰Coverage nevertheless differs across agreements. DEPA generally excludes financial services except for Article 2.7 on electronic payments. KSDPA Article 14.14 covers financial institutions for cross-border data transfers, whereas Article 14.15 excludes them from its computing-facilities prohibition.

cluding through frameworks such as Peppol, and provide for electronic trade documents, connections between national single windows and cross-border data-exchange systems. These provisions can facilitate the recognition and use of electronic invoices, trade documents, and other commercial records across borders, thereby reducing administrative costs and processing delays.¹¹

Third, payment provisions can reduce the technical and regulatory fragmentation across national payment systems. DEPA Article 2.7 promotes international standards, interoperable payment infrastructure, application programming interfaces, and digital-identity-based authentication. KSDPA Article 14.11 goes further in several respects by addressing payment-messaging standards, access to payment infrastructure, APIs, and regulatory sandboxes. These measures can lower integration and onboarding costs and make it easier for firms to receive payments from customers abroad.¹²

DEAs therefore operate through two related channels. Their binding provisions can restrict the introduction of non-tariff measures such as data localisation requirements or discriminatory treatment of electronic transactions. Their cooperative provisions can also encourage governments to align standards, improve interoperability, and develop compatible regulatory frameworks. Together, these mechanisms reduce the regulatory uncertainty and transaction costs associated with cross-border DDS trade.

If these provisions reduce digital trade frictions as intended, they should facilitate greater trade in DDS. Whether such an effect can be detected at the aggregate level is the central question examined in the remainder of this paper.

3 Methodology

The aforementioned analysis hypothesises that DEAs could boost bilateral trade by reducing trade barriers, particularly in digital sectors. In this section, we first introduce the trade flow data and our samples, and then present empirical strategies to formally

¹¹CPTPP Articles 14.5 and 14.9 already address domestic electronic-transaction frameworks and paperless trading. DEPA goes further in detail: Article 2.2 places firmer obligations on the acceptance of electronic trade-administration documents and adds provisions on single windows and cross-border data exchange; Article 2.3 encourages adoption of the UNCITRAL Model Law on Electronic Transferable Records; and Article 2.5 adds a dedicated framework for interoperable e-invoicing. See (Chile, New Zealand and Singapore, 2020; Government of Canada, 2018)

¹²CPTPP Chapter 14 contains no dedicated article on electronic payments. DEPA Article 2.7 therefore broadens the subject matter, although most of its operative clauses are framed as principles rather than strict obligations. See (Chile, New Zealand and Singapore, 2020; Government of Canada, 2018).

evaluate DEAs' impact on Singapore's bilateral trade. We first define four sectors as digital sectors: 1) telecommunications, computer and information services, 2) financial services, 3) insurance and pension services, and 4) charges for the use of intellectual property.¹³ Throughout the paper, we refer to these sectors as digitally deliverable service (DDS) sectors or simply digital sectors, and trade in those sectors as DDS trade.

We source trade data from the OECD-WTO Balanced Trade in Services (BaTiS) dataset. BaTiS reports bilateral services trade flows by reporter, partner, service sector, and year.¹⁴ This enables us to construct an importer-exporter-sector-year panel and to examine changes in bilateral services trade flows for a given country pair, sector, and year. The analysis covers 11 service sectors at the two-digit BaTiS level from 2015 to 2024, including the 4 digital sectors, with 2024 the most recent year covered by the data.

Treatment is assigned based on the entry into force of Singapore's Digital Economy Agreements and related digital trade agreements. The first agreement in the sample enters into force in 2021, with staggered implementation across Singapore's DEA partners in subsequent years, including Australia, the United Kingdom, and Korea. Since we use annual data, the treatment year is the year in which an agreement entered into force if implementation occurred before July; otherwise, the treatment year is the following year. Agreements that entered into force after the sample period, including the EU-Singapore and EFTA-Singapore DEAs, cannot be evaluated within the 2015–2024 panel.

3.1 Baseline Difference-in-Differences

We employ the standard Difference-in-Differences (DiD) method to examine the average effects of DEAs on bilateral trade:

$$Y_{ijkt} = \beta T_{ijt} + \alpha_{ij} + \mu_t + \lambda_i + \delta_j + \sum_{k=1}^K \theta_k (Sector_k \times Trend) + \boldsymbol{\theta} \mathbf{X}_{ijkt} + \varepsilon_{ijkt}, \quad (1)$$

where the outcome variable Y_{ijkt} is the logarithm of bilateral trade flows between origin country i and destination j in sector k at year t ; T_{ijt} is the treatment dummy that equals 1 if both countries i and j are parties of DEAs and if the digital economy agreement between i and j has entered into force at year t ; ε_{ijkt} is the error term at pair-sector-year

¹³This classification follows the digitally deliverable services framework in the *Handbook on Measuring Digital Trade*, which identifies services that can be delivered remotely through computer networks.

¹⁴The reporter is the exporting economy and the partner is the importing economy.

level. The parameters α_{ij} , μ_t , λ_i , δ_j capture country-pair, year, origin, and destination fixed effects, respectively. The origin and destination fixed effects capture country-specific characteristics such as economic scale and average trade costs with the world (the multilateral resistance term). We add pair fixed effects, α_{ij} , following [Baier and Bergstrand \(2007\)](#), to control for unobserved, time-invariant bilateral variables that simultaneously affect the signing of DEAs and trade flows between the pair. The sector-specific time trend, $Sector_k \times Trend$, where $Sector_k$ is the sector dummy and $Time$ is a continuous time trend variable, captures sector-specific trajectories of sectoral trade flows, possibly driven by differences in technological development. Controlling for this difference is important, as we have seen that digital trade and non-digital trade have already exhibited diverging trends before the DEA's implementation. Lastly, $\mathbf{X}_{ijkt}$ is a vector of control variables aiming to control for important contemporaneous shocks that could violate the parallel trend assumption. It includes measures for the commencement of other trade agreements between countries i and j that include digital provisions, the joint exposure to the US-China trade war, and the intensity of the country's COVID-19 restrictions.

The coefficient of interest β captures the overall country-level impact of DEAs on bilateral trade flows. While the regression equation (1) allows us to evaluate DEAs' impacts on overall services trade, we consider two additional specifications to estimate the policy's impacts on the digital sector. The first is to use the same regression equation as (1) but to interact the country treatment dummy with the digital sector dummy, $T_{ijt} \times C_k$, where the digital sector dummy $C_k = 1$ if sector k is one of the pre-defined digital sectors. The coefficient on the interaction term then captures the heterogeneous impacts of DEAs on digital sectors. The second is to estimate regression (1) using only samples of digital-sector trade rather than all sectoral trade. Therefore, in this regression, we drop the 7 non-digital sectors and only keep 4 digital sectors in our sample. This exercise allows us to identify any clean trade effect of DEAs on digital sectors. Across the three specifications, the identification assumption is that, conditional on the fixed effects and controls, the bilateral sectoral trade flows between signing and control countries share a parallel trend.

3.2 Event Study Design

We further consider an event study design with the following specification to estimate the dynamic policy impacts:

$$Y_{ijkt} = \sum_{\ell=\underline{W}}^{\overline{W}} \theta_{\ell} \times D_{ijt}^{\ell} + \alpha_{ij} + \mu_t + \lambda_i + \delta_j + \sum_{k=1}^K \theta_k (Sector_k \times Trend) + \boldsymbol{\theta} \mathbf{X}_{ijkt} + \varepsilon_{ijkt}, \quad (2)$$

where the coefficients θ_{ℓ} capture the policy impact at ℓ years relative to the treatment year. The event time dummies D_{ijt}^{ℓ} are defined as $D_{ijt}^{\ell} = \mathbf{1}\{t = \tau_{ij} + \ell\}$ for any $\ell \in (\underline{W}, \overline{W})$, where τ_{ij} is the first year when DEAs were effective for countries i and j and $\mathbf{1}\{\cdot\}$ is the indicator function. We follow the convention in event study analysis and normalise the impact one year before the policy to zero: $\theta_{-1} = 0$. Since DEA treatment is staggered over time, we adopt the staggered event study estimation following [Sun and Abraham \(2021\)](#) to address heterogeneous treatment effects.

Similarly to the baseline DiD analysis, we consider three specifications in the event study: 1) equation (2) to estimate overall trade effects; 2) the same equation, but replacing the event time dummies D_{ijt}^{ℓ} in the first term with $D_{ijt}^{\ell} \times C_k$, to identify any sector specific effects on digital sectors; 3) equation (2) using a sample of digital sector trade only. The last two aim to estimate the dynamic DEA impacts specific to digital-sector trade.

3.3 Supplementary Data

We supplement BaTiS with several datasets that are used to construct controls. To control for digital provisions in non-DEA agreements between DEA members, such as the CPTPP, whose comprehensive digital provisions have applied between Singapore and Chile since 2023, we consider two different indicators constructed from the Trade Agreement Provisions on Electronic Commerce and Data (TAPED) database ([Burri and Vásquez Callo-Müller, 2025](#)). For agreements involving multiple parties, we treat each two-party combination as a country pair and identify the first year the agreement was in force for that pair.

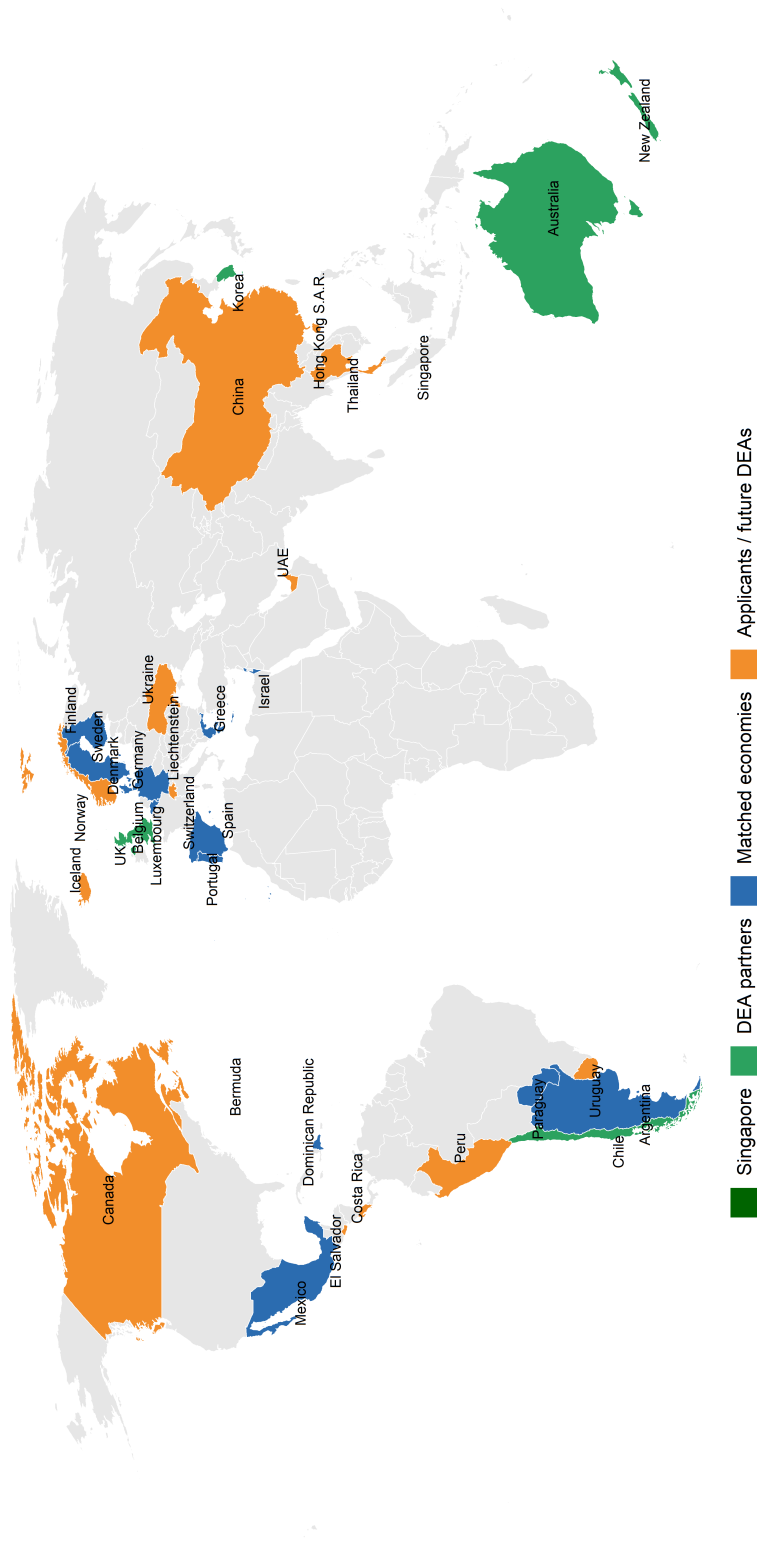


Figure 4: DEA partners and comparison economies included in the analysis

Note: After excluding the United States and Turks and Caicos Islands from the estimation sample, 17 matched comparison economies remain; these are the economies shown on the map.

Specifically, we include two country-pair-year indicators, named “other e-commerce chapter” and “other data flow provision”. The first equals one if the pair has a non-DEA agreement with an e-commerce or digital trade chapter in a year. It broadly characterises any digital trade liberalisation between the pair. The second equals one if an agreement in force for the pair includes all three of the following: (i) a provision supporting the free flow of data, subject to public-policy or security exceptions; (ii) a mechanism for addressing barriers to data flows; and (iii) a provision limiting or prohibiting data-localisation requirements. This indicator captures the depth of digital trade liberalisation by examining whether the agreement eliminates important policy barriers to digital trade — restrictions on cross-border data flows or data localisation requirements.

For the country pair’s joint exposure to the US-China trade war, we consider the country pair’s total trade with the United States and China to measure the degree of trade integration between the pair and the US-China. We use annual merchandise imports and exports from the IMF’s International Trade in Goods by Partner Country dataset (IMTS) ([International Monetary Fund, 2025](#)). For each country-year, exposure to the United States and China is measured by the country’s trade share with these two economies, computed as the sum of goods imports from and exports to these two economies divided by the country’s total goods imports from and exports to the world. Then the pair’s joint exposure is a simple average of their trade shares with the US-China.

Lastly, we measure the intensity of pandemic restrictions using the Oxford COVID-19 Government Response Tracker (OxCGRT) ([Hale et al., 2021](#)). For each country and year, we average the tracker’s daily national Stringency Index, a 0–100 composite of containment and closure policies and public information measures.

3.4 Constructing Control Groups

A key identification concern is that Singapore’s DEA partners are not randomly selected. Countries that enter DEAs with Singapore are likely to differ systematically from the average country pair: they have stronger pre-existing services trade links with Singapore, higher digital trade intensity, larger or more advanced services sectors, and greater prior exposure to e-commerce or digital trade provisions (Table 2). Therefore, digital trade between DEA partners could develop differently compared to that between non-DEA partners, even in the absence of DEAs. A simple comparison between DEA pairs

and all non-DEA pairs would therefore risk comparing Singapore’s DEA partners with structurally dissimilar economies.

To address this concern, we construct a matched comparison group using propensity score matching following the foundational approach of [Rosenbaum and Rubin \(1983\)](#) and applications of matching methods to endogenous formation of trade agreements by [Egger and Larch \(2008\)](#) and [Baier and Bergstrand \(2009\)](#). The matching unit is the Singapore–partner country pair. We first collapse the data to the country-pair level using pre-treatment information from 2014 to 2019, before any DEA in the sample enters into force.

The propensity score is estimated at the country-pair level using pre-treatment characteristics that capture trade intensity, digital trade exposure, economic size, economic similarity, geography, and prior digital trade commitments. Specifically, we estimate the following logit model:

$$p_{ij} \equiv \Pr(D_{ij} = 1 \mid \mathbf{Z}_{ij}) = \Lambda(\eta_0 + \mathbf{Z}_{ij}'\boldsymbol{\eta}) , \quad (3)$$

where $D_{ij} = 1$ identifies a Singapore–DEA partner pair and $D_{ij} = 0$ identifies a potential control pair. The vector $\mathbf{Z}_{ij}$ contains the eight covariates reported in [Table 2](#), and Λ denotes the logistic cumulative distribution function. We then apply nearest-neighbour matching with replacement using a 1:3 matching ratio. As our sample covers only the period through 2024, six DEA pairs can be analysed during the time period.¹⁵ Our matching, therefore, resulted in 19 nations being selected.¹⁶

The matched countries are largely similar to the DEA partners. They include similar DEA counterparts, such as Germany and Argentina; see [Figure 4](#) for the geographic distribution of all matched countries, along with DEA partners and applicants.¹⁷ The suitability of the matched sample is assessed using the balance diagnostics reported in [Tables 2 and 3](#). We summarise covariate balance using the mean absolute standardised

¹⁵The 6 pairs are: SG-AU, SG-NZ, SG-CL, CL-NZ, SG-UK, SG-KR. Later, as discussed in [section 4](#), the “*Bilateral*” specification has 5 pairs, omitting CL-NZ, while the “*Expanded*” specification contains all six pairs.

¹⁶We exclude the United States and the Turks and Caicos Islands from the regression sample because their economies are exceptionally large and small, respectively, relative to the other comparison economies.

¹⁷EFTA economies are included in the alternative comparison sample because the EFTA–Singapore Digital Economy Agreement was signed in 2025, after the estimation sample ends in 2024. They are therefore untreated throughout the sample period.

mean difference (SMD), which averages across the eight covariates the absolute treated–control difference in means divided by the pooled standard deviation.¹⁸ The matching procedure substantially improves balance across the observed pre-treatment characteristics: the mean absolute SMD declines from 0.841 before matching to 0.130 after matching, with seven of the eight covariates recording an absolute SMD below 0.20.

Table 2: Covariate balance before and after propensity-score matching

Covariate	Before matching			After matching		
	(1)	(2)	(3)	(4)	(5)	(6)
	Treated	Control	Abs. SMD	Treated	Control	Abs. SMD
Pre-treatment total services trade (log)	7.601	5.217	1.196	7.601	7.380	0.122
Pre-treatment digital trade share	0.507	0.427	0.460	0.507	0.481	0.154
Average GDP per capita (log)	10.732	9.787	1.647	10.732	10.684	0.126
GDP per capita gap (log)	0.624	2.388	1.627	0.624	0.664	0.060
Average population (log)	15.895	15.566	0.341	15.895	15.865	0.033
Population gap (log)	1.388	1.727	0.284	1.388	1.525	0.109
Bilateral distance (log)	9.204	9.071	0.247	9.204	9.314	0.277
Previous e-commerce chapter	0.667	0.237	0.925	0.667	0.741	0.163
Covariates with $ SMD < 0.20$	–	–	0 of 8	–	–	7 of 8

Notes: The table reports the covariates used to estimate the propensity score. SMD denotes the standardised mean difference, and absolute SMD values are reported. Values are rounded to three decimals. Matching was conducted using three nearest neighbours with replacement.

We also assess common support, that is, whether treated and comparison-country pairs have overlapping propensity-score ranges. This overlap is necessary because observations without comparable counterparts would otherwise make the estimated effect depend on extrapolation. The estimates show substantial overlap: eight of the nine treated pairs fall within the common propensity-score interval of 0.042 to 0.523, with Norway–Singapore the only treated pair outside this range.

¹⁸SMD is unit-free, comparable across differently scaled covariates, and less mechanically dependent on sample size than p -values from hypothesis tests. See [Austin \(2009\)](#) for a detailed discussion of SMDs as propensity-score balance diagnostics.

Table 3: Propensity-score overlap before and after matching

Sample	Group	(1)	(2)	(3)
		N	Mean	Median
Before matching	Treated	9	0.249	0.197
	Controls	169	0.040	0.005
After matching	Treated	9	0.249	0.197
	Matched controls	19	0.223	0.202

Notes: Propensity scores are estimated using logit. Values are rounded to three decimals. The treated group includes Norway and Switzerland (EFTA nations with available data) as well as Peru (in the process of acceding to DEPA).

4 Results

Since the data cover the period through 2024, we can identify the effects of DEAs that became effective by 2024. By combining DiD and matching, we aim to evaluate whether DEAs promote bilateral trade, particularly trade in DDS.

We focus on three questions. First, do DEAs facilitate digital trade? We answer this question using equation (1) and restricting the regression sample to trade flows in digital sectors to estimate DEAs' effects on digital trade. We denote this regression as *Digital Only*. Second, do DEAs promote total services trade? We answer this question using the regression equation (1) and the full sample, which includes trade across all sectors. Third, do DEAs particularly benefit trade in digital sectors relative to non-digital sectors after DEAs' commencement? We evaluate DEAs' heterogeneous sectoral effects by adding an interaction term to equation (1), as discussed earlier. We denote this specification as *Digital Gain*.

Within the matched country pairs, we further differentiate two comparison samples. First, in the *bilateral* trade specification, every country pair includes Singapore: Singapore's trade with a DEA partner is compared with its trade with a matched non-DEA partner. For example, trade between Singapore and Australia constitutes a treated pair, while trade between Singapore and Germany constitutes a matched control pair. This *bilateral* sample provides a clean counterfactual for Singapore's trade with DEA partners.

Second, in the *expanded* trade-flows specification, the treated pairs remain Singapore's trade with its DEA partners, but the control group is expanded to include trade among the matched comparison economies themselves. For example, Singapore–Australia remains a treated pair, while the controls include both Singapore–Germany and Germany–Sweden

trade flows. This specification provides a broader counterfactual and allows us to assess whether the results depend on restricting the comparison group to trade relationships involving Singapore.

4.1 Difference-in-Differences estimates

Our baseline DiD estimates indicate an increase in DDS trade between DEA partners relative to non-DEA pairs. Table 4 presents the main results. Estimates from the sample restricted to digital sectors (columns 5-6) show that DEAs significantly promote DDS trade among DEA parties by 18.9% to 20.8%.¹⁹ The estimated trade impact is in line with previous estimates of the trade effects of free trade agreements, lying at the lower end of the range. For example, [Baier et al. \(2019\)](#) estimate an average partial effect of 34% for free trade agreements on trade flows, using a sample of 70 countries over the period 1986-2006; [Larch and Yotov \(2024\)](#) suggest a relatively stable trade impact of 15 – 30% across various modern estimation methods of the gravity equation;²⁰ [Egger et al. \(2011\)](#) suggest partial effects of 67 – 74% when treating preferential trade agreements as exogenous, and 215 – 255% when explicitly addressing the endogeneity of the agreements. Our estimates are arguably small, as traditional trade agreements mainly deal with tariffs, a tangible and major obstacle to trade, while the DEAs can only reduce non-tariff barriers.

Note that our controls on digital provisions in other agreements (Other data flow provision and Other e-commerce chapter) are indeed associated with positive trade gains, as shown in Table 4. This result is consistent with findings from [Suh and Roh \(2023\)](#), who found that digital provisions in traditional trade agreements facilitate digital trade among partners. Even conditional on other digital provisions, our results still suggest that DEAs have a positive effect on digital trade.

The estimates also provide some evidence that digital sectors trade more than non-digital sectors (from the *Digital Gain* model). In the expanded specification, the relative increase is approximately 46.2% and is statistically significant at the 5% level (the bilateral estimate implies an increase of approximately 11.0% but is not statistically significant). Again, this is consistent with DEAs focusing on digital sectors and the digital economy.

¹⁹The estimates are converted into percentage terms by $100[\exp(\hat{\beta}) - 1]$. Thus, coefficients of 0.173 and 0.189 imply increases of approximately 18.9% and 20.8%, respectively.

²⁰See Table 1 Panel B in that paper.

Table 4: Baseline DID estimates

	Services		<i>Digital Gain</i>		<i>Digital Only</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
	Bilateral	Expanded	Bilateral	Expanded	Bilateral	Expanded
Overall services trade	0.024 (0.056)	0.120 (0.075)	– –	– –	– –	– –
Digital trade	– –	– –	0.104 (0.152)	0.380** (0.164)	0.189** (0.084)	0.173*** (0.066)
Other data flow provision	0.149*** (0.050)	0.096** (0.048)	0.137** (0.065)	0.084** (0.038)	0.208** (0.080)	0.372*** (0.113)
Other e-commerce chapter	0.100 (0.074)	0.061** (0.029)	0.099 (0.074)	0.060** (0.029)	0.091 (0.082)	0.126*** (0.034)
Fixed effects	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓
Observations	5,339	67,477	5,339	67,477	2,000	25,627
Adj. R ²	0.757	0.739	0.757	0.739	0.820	0.801

Notes: Estimates are from log-linear regressions estimated by OLS. Clustered standard errors are reported in parentheses and rounded to three decimals. Bilateral compares Singapore's trade with DEA partners against Singapore's trade with non-DEA partners. Expanded uses all bilateral trade flows among the countries represented in the PSM sample. Fixed effects include country pair, year, sector, reporter, partner, and sector-specific linear trends. Controls include COVID restrictions, other e-commerce chapters, data-flow provisions, and exposure to China and US trade.

Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

However, the estimates for overall services trade are positive but statistically insignificant. The implied effects range from approximately 2.4% to 12.8%, yet they are not statistically significant. The baseline results, therefore, do not provide evidence that DEAs increased aggregate services trade, at least over the short term. Given that DEAs are primarily focused on the digital economy, it is reasonable that the impact is concentrated in digital sectors.

We further consider the effects of DEAs on each digital sector and examine whether the estimated positive effect on digital trade is driven by any particular digital sector. Specifically, for each digital sector $s \in \mathcal{D}$, let $C_k^s = 1$ if sector k is the focal sector s , and zero otherwise. We estimate the following specification separately for each of the four digital sectors:

$$Y_{ijkt} = \beta_s (T_{ijt} \times C_k^s) + \alpha_{ij} + \mu_t + \lambda_i + \delta_j + \sum_{r=1}^K \theta_r (Sector_r \times Trend) + \boldsymbol{\theta} \mathbf{X}_{ijkt} + \varepsilon_{ijkt}, \quad (1a)$$

where β_s captures the effect of DEAs on the focal digital sector s . For the *Digital Gain* specification, the estimation sample contains a digital sector and the seven non-digital sectors. For the *Digital Only* specification, we estimate equation (1) using only observations from the focal sector and remove the sectoral time trend $Sector_r \times Trend$ as the sample now only has one sector. Both specifications are estimated separately for ICT, financial services, insurance and pension services, and charges for the use of intellectual property.

Table 5 suggests that the ICT sector benefits most clearly following DEA implementation, with significant impacts in both the *Digital Gain* and *Digital Only* models, while other sectors show mixed gains across specifications. In particular, in the *Digital Only* model, ICT services increase by approximately 49.2%, while IP charges increase by approximately 41.3%. In the *Digital Gain* model, the significant sector-level increases are approximately 28.1% for ICT services, 107.9% for financial services, and 48.0% for insurance and pension services. The positive effect of 28.1-49.2% on ICT trade is significant and large. To provide some context, the annual growth rate of Singapore’s pre-DEA ICT services trade between 2015 and 2019 is only 14.7%.²¹

²¹Similarly, aggregate trade across the four digital sectors used in the paper grew by approximately 10.6% per year over the same period. The growth rate is computed using the same BaTiS data. Trade is the sum of exports and imports, and compound annual growth is calculated as $100[(V_{2019}/V_{2015})^{1/4} - 1]$. Values are measured in current US dollars.

Table 5: DiD estimates by digital sector and PSM trade flow specification

	<i>Digital Gain</i>		<i>Digital Only</i>	
	(1) Bilateral	(2) Expanded	(3) Bilateral	(4) Expanded
ICT	0.148 (0.171)	0.248** (0.112)	0.215 (0.141)	0.400*** (0.145)
Financial services	0.054 (0.281)	0.732** (0.305)	0.063 (0.097)	-0.095 (0.130)
Insurance and pension services	0.231 (0.274)	0.392** (0.184)	0.065 (0.097)	-0.034 (0.067)
IP charges	-0.178 (0.238)	0.299 (0.385)	0.286 (0.224)	0.346** (0.135)
Fixed effects	✓	✓	✓	✓
Controls	✓	✓	✓	✓

Notes: Estimates are from log-linear regressions estimated by OLS. Clustered standard errors are reported in parentheses and rounded to three decimals. Bilateral compares Singapore's trade with DEA partners against Singapore's trade with non-DEA partners. Expanded uses all bilateral trade flows among the countries represented in the PSM sample. Fixed effects and controls follow the corresponding *Digital Gain* and *Digital Only* specifications.

Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The positive impact on ICT trade is unsurprising. ICT services and financial services are among the largest and most digitally intensive DDS sectors. There are also several chapters and articles in DEAs addressing topics specifically in these domains. Therefore, these sectors are most likely to see changes in their trade. Note that all statistically significant estimates come from the expanded trade-flows specification. The corresponding bilateral estimates are based on a substantially smaller comparison sample at the sector level and are therefore less precisely estimated and should be interpreted with caution.

4.2 Event Study Estimates

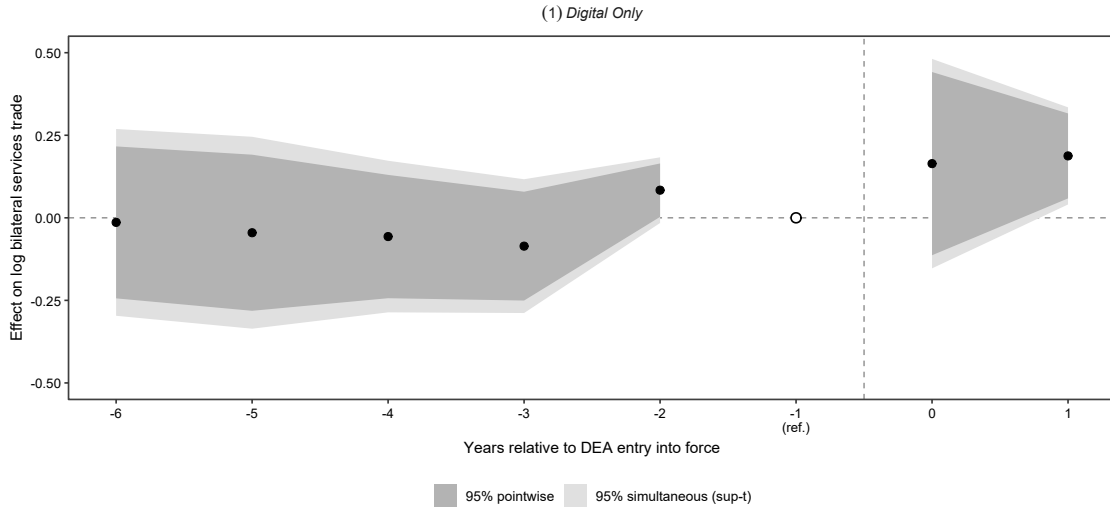
Our DiD results indicate that DEAs facilitate DDS trade but not overall service trade. To provide further details and test the parallel trend assumption, in this section, we utilise the event study design and estimate the dynamic effects of DEAs.

The event study estimates are consistent with the baseline DiD findings and provide additional evidence. The estimates for the *Digital Only* model show a significant positive effect after treatment. In particular, DEAs promote DDS trade by 20.6% in the second post-treatment year, a magnitude almost identical to the 20.8% increase from the baseline DiD result. However, a significant positive coefficient is observed two years prior to DEA

implementation for the *expanded* specification. A positive pre-treatment coefficient is also observed at the 10% level for the *bilateral* specification, but not at the 5% level. (See Table 6).

The results for the *Digital Gain* model also provide consistent evidence. In the expanded specification, there are no statistically significant pre-treatment coefficients (Figure 6). Digital sectors experience estimated gains of approximately 58.6% relative to non-digital sectors in the first post-treatment year and 47.2% in the second year, both statistically significant at the 5% level. The second-year effect is close to the 46.2% increase implied by the corresponding DiD estimate (column 4 in Table 4). In the bilateral specification, there are also no significant pre-treatment coefficients. The event-study estimates indicate increases of approximately 14.3% and 0.9% in the two post-treatment years. However, neither the DiD estimate nor the post-treatment event-study coefficients are statistically significant.

Figure 5: Event-study estimates for the *Digital Only* model: Bilateral sample



Note: Points show Sun–Abraham estimates relative to year -1 . Inner bands are 95% pointwise intervals; outer bands are 95% simultaneous sup- t intervals. Standard errors are clustered by country pair.

For the overall service trade, the event study estimation also indicates no significant trade-facilitation effect after the DEA’s entry into force, consistent with baseline DiD estimation. Collectively, there is no robust evidence that DEAs increased total services trade during the period examined.

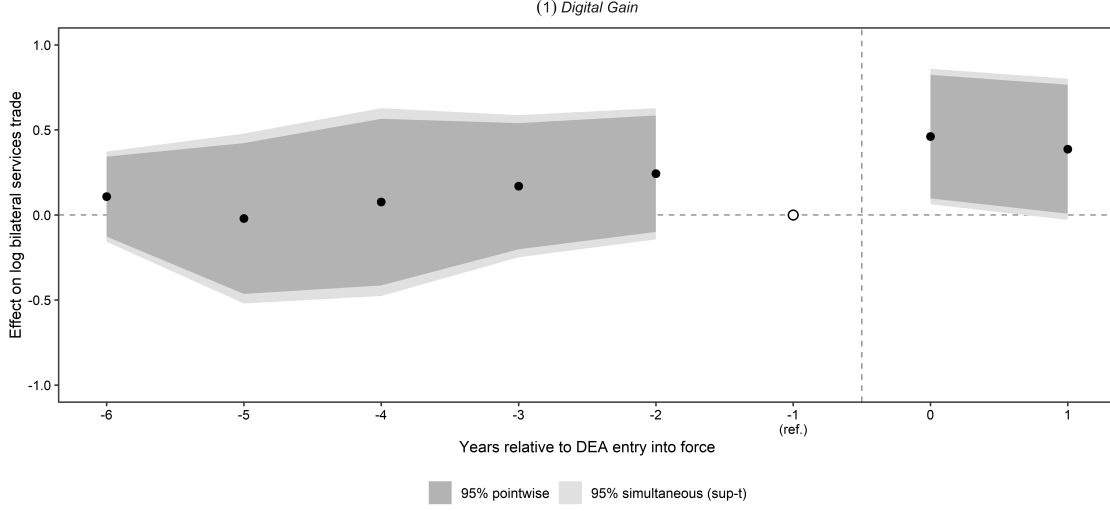
Table 6: Event-study estimates by model and PSM trade flow specification

	Services		<i>Digital Gain</i>		<i>Digital Only</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
	Bilateral	Expanded	Bilateral	Expanded	Bilateral	Expanded
Event time -6	0.016 (0.126)	-0.059 (0.114)	-0.240 (0.185)	0.108 (0.120)	-0.014 (0.117)	0.019 (0.068)
Event time -5	-0.046 (0.100)	-0.136* (0.070)	-0.237 (0.166)	-0.020 (0.226)	-0.045 (0.121)	-0.054 (0.115)
Event time -4	-0.083 (0.092)	-0.100* (0.059)	-0.184 (0.198)	0.076 (0.250)	-0.057 (0.095)	0.030 (0.106)
Event time -3	-0.152** (0.069)	-0.117*** (0.035)	-0.181 (0.218)	0.170 (0.189)	-0.086 (0.084)	0.051 (0.054)
Event time -2	-0.001 (0.043)	0.002 (0.032)	-0.056 (0.183)	0.243 (0.175)	0.084* (0.041)	0.136*** (0.036)
Event time 0	-0.034 (0.078)	-0.041 (0.088)	0.133 (0.164)	0.461** (0.185)	0.164 (0.142)	0.172 (0.135)
Event time 1	0.017 (0.069)	0.083 (0.081)	0.009 (0.177)	0.387** (0.193)	0.187*** (0.066)	0.183*** (0.060)
Fixed effects	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓
Observations	5,135	67,237	5,135	67,237	1,920	25,531
Adj. R^2	0.752	0.739	0.752	0.739	0.813	0.800

Notes: Estimates are from log-linear event-study regressions estimated by OLS. Event time -1 is the omitted reference period. Clustered standard errors are reported in parentheses and rounded to three decimals. Bilateral compares Singapore's trade with DEA partners against Singapore's trade with non-DEA partners. Expanded uses all bilateral trade flows among the countries represented in the PSM sample. Fixed effects and controls follow the corresponding DiD specifications.

Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 6: Event-study estimates for the *Digital Gain* model: Expanded sample



Note: Points show Sun–Abraham estimates relative to year -1 . Inner bands are 95% pointwise intervals; outer bands are 95% simultaneous sup- t intervals. Standard errors are clustered by country pair.

5 DEA Applicants as Possible Counterfactuals

Alternatively, we consider another control group comprising DEPA applicant economies and members of the European Free Trade Association (EFTA) and re-estimate the models. The DEPA applicants have demonstrated an interest in joining a digital economy agreement but remained untreated throughout the 2015–2024 sample period. The sample also includes Iceland, Norway, and Switzerland, which signed the EFTA–Singapore DEA only in September 2025, after the estimation period ended.²²

These economies provide a useful alternative comparison group because applying to join DEPA or subsequently signing a DEA with Singapore signals a policy orientation towards greater digital integration and cooperation. This makes them plausibly more comparable to Singapore’s existing DEA partners than the average economy, while they remain untreated throughout the period examined. Table 7 compares the groups using

²²The DEPA applicant economies included in the robustness sample are Canada, Costa Rica, El Salvador, Peru, Thailand, Ukraine, the United Arab Emirates, and Uruguay. China is an applicant but excluded from our analysis due to its significantly large economic size. Applicant status is drawn from the Singapore Ministry of Trade and Industry, *Digital Economy Partnership Agreement (DEPA)*, available at <https://www.mti.gov.sg/trade-international-economic-relations/agreements/digital-economy-agreements-dea/depa/>. Liechtenstein is excluded because separate observations are unavailable in BaTiS.

Table 7: Descriptive statistics across alternative control samples

	(1)	(2)	(3)	(4)
	DEA pairs	Matched controls	Applicant controls	Global average
<i>Pre-treatment characteristics, 2014–2019</i>				
Total services trade (log)	7.601 (1.932)	7.380 (1.682)	5.317 (2.194)	1.451 (2.917)
Digital services trade (log)	6.897 (2.058)	6.479 (2.139)	3.955 (2.616)	-0.724 (3.619)
Digital services share	0.507 (0.112)	0.481 (0.210)	0.316 (0.184)	0.218 (0.207)
Countries	9	19	11	204
Trade observations	1,856	3,810	24,794	3,210,461

Notes: Pre-treatment statistics are calculated at the country-pair level. Matched controls are selected using propensity-score matching (PSM), and applicant controls are drawn from the applicant-control robustness sample. The global average is unweighted across all BaTiS country pairs with available data. For the DEA and matched-control columns, the Countries row reports partner countries represented in the regressions and excludes Singapore, the common reference country. Standard deviations are reported in parentheses. *DEA pairs* include Norway and Switzerland (EFTA nations with available data) as well as Peru (in the process of acceding to DEPA).

three trade-related pre-treatment characteristics also employed in the PSM exercise: total services trade, digital services trade, and the digital services share. On each measure, the alternative controls are less closely aligned with the DEA pairs than the matched controls but remain closer to the DEA pairs than the global average.

As in the main analysis, the results are reported using a bilateral trade specification and an expanded trade-flows specification. We estimate the effects on overall services trade and DDS trade.

5.1 Difference-in-Differences estimates

Table 8 presents the DiD estimates using the applicant economies as an alternative control group. Overall, these estimates provide more limited evidence of an effect than those obtained using the matched control group.

The estimates restricted to digitally deliverable service sectors are positive in both specifications. DEA entry into force is associated with increases in digital services trade of approximately 7.5% and 20.6%. However, neither estimate is statistically significant. The estimates comparing digital with non-digital services are also statistically insignificant, providing no evidence that digital services grew faster than non-digital services on average after treatment. Similarly, the results do not provide evidence that DEAs increased aggregate services trade relative to the applicant control economies. In summary, the DiD estimates using applicant economies as controls show no statistically significant

evidence of a positive trade effect. Compared with the PSM results, this result suggests that applicants may still inherently differ from DEA countries, as shown in Table 7.

Table 8 further reports the estimates for individual digital sectors. The sector-level results provide some evidence of gains in ICT services. The estimated increases in ICT services trade in both *Digital Gain* and *Digital Only* models are significant at the 10% level. The estimate for Insurance and pension services is significant in the *Digital Gain* model; however, it indicates a negative impact. Financial services and IP charges are statistically insignificant. As with the PSM results, the limited sample size means the results should be interpreted cautiously, even if they are statistically significant.

Table 8: DiD estimates by model and applicant-control trade flow specification

	Services		<i>Digital Gain</i>		<i>Digital Only</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
	Bilateral	Expanded	Bilateral	Expanded	Bilateral	Expanded
Overall services trade	0.010 (0.105)	-0.071 (0.078)	– –	– –	– –	– –
Digital trade	– –	– –	-0.091 (0.200)	0.026 (0.091)	0.072 (0.162)	0.188 (0.176)
Other data flow provision	-0.065 (0.126)	0.270*** (0.067)	-0.030 (0.148)	0.214*** (0.069)	-0.338** (0.134)	-0.036 (0.132)
Other e-commerce chapter	-0.101 (0.103)	0.125* (0.067)	-0.088 (0.129)	0.122* (0.066)	0.197 (0.256)	0.239** (0.108)
Fixed effects	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓
Observations	654	3,333	654	3,333	286	1,332
Adj. R ²	0.766	0.745	0.766	0.745	0.838	0.832

Notes: Estimates are from log-linear regressions estimated by OLS. Clustered standard errors are reported in parentheses and rounded to three decimals. Bilateral compares Singapore's trade with DEA partners against Singapore's trade with applicant economies. Expanded uses all bilateral trade flows among the countries represented in the applicant sample. Fixed effects include country pair, year, sector, reporter, partner, and sector-specific linear trends. Controls include COVID restrictions, other e-commerce chapters, data-flow provisions, and exposure to China and US trade.

Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9: DiD estimates by digital sector using applicant controls

	<i>Digital Gain</i> (1) Expanded	<i>Digital Only</i> (2) Expanded
ICT	0.348* (0.196)	0.567* (0.317)
Financial services	0.188 (0.257)	0.015 (0.221)
Insurance and pension services	-0.559** (0.260)	-0.094 (0.133)
IP charges	-0.260 (0.368)	0.074 (0.127)
Fixed effects	✓	✓
Controls	✓	✓

Notes: Estimates are from log-linear regressions estimated by OLS. Clustered standard errors are reported in parentheses and rounded to three decimals. Only the Expanded specification is reported because the bilateral applicant-control sector regressions contain too few treated observations. The Expanded specification uses all bilateral trade flows among the countries represented in the applicant sample. Fixed effects and controls follow the corresponding *Digital Gain* and *Digital Only* specifications.

Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

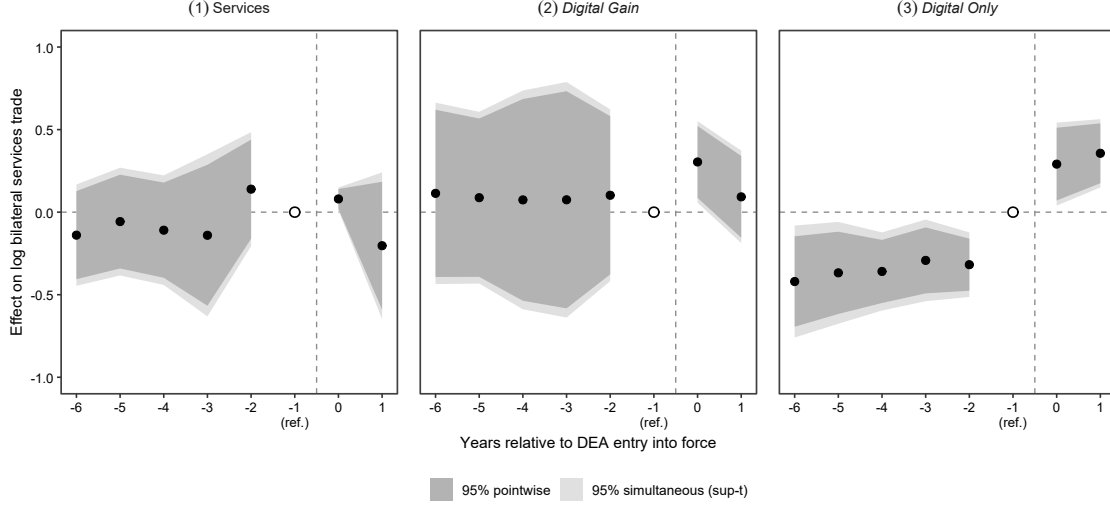
5.2 Event Study Estimates

The event-study estimates provide some supporting evidence of a positive effect on DDS trade. The expanded *Digital Only* specification indicates a significant positive effect after DEAs' entry into force (panel (3) in Figure 7). However, it also detects a clear pre-trend. Therefore, the positive effect on DDS trade should be interpreted with caution.

The expanded *Digital Gain* specification indicates that trade in digital sectors increases by approximately 35.5% relative to non-digital sectors in the treatment year and shows no significant pre-treatment coefficients. The estimate is statistically significant, although the effect diminishes and becomes statistically insignificant in the following year. The event study may point to a short-lived effect of the policy.

For the overall services trade, the expanded specification shows no statistically significant pre-treatment coefficients. Trade increases by approximately 8.3% in the first year of DEA enforcement, but the effect is not sustained in the following year. Interpreted alongside the statistically insignificant DiD estimate, this does not provide clear evidence of an increase in overall services trade.

Figure 7: Event-study estimates for the expanded applicant sample



Note: Points show Sun–Abraham estimates relative to year -1 . Inner bands are 95% pointwise intervals; outer bands are 95% simultaneous sup- t intervals. Standard errors are clustered by country pair.

6 Conclusion

The DEAs are designed to facilitate digital trade and promote international digital collaboration. To our knowledge, little empirical evidence exists on whether DEAs actually increase digital trade. Utilising BaTiS data for 2015–2024, we combine DiD specifications with matched countries as the control group to examine whether Singapore’s Digital Economy Agreements facilitate digital trade among member countries. We find that DEAs significantly promote bilateral trade in digitally deliverable services. The baseline DiD results indicate that the entry into force of a DEA increases trade in digitally deliverable service sectors by approximately 18.9–20.8%, while the event-study estimates provide broad support for this conclusion. The estimated gains are concentrated in digitally deliverable services, with no spillover to the overall services-sector trade: the estimates for an overall increase in services trade, while positive, are statistically insignificant. Given the DEAs’ focus on the digital economy and the policy barriers to digital trade, these results are expected.

Within digital sectors, the clearest sector-level evidence concerns ICT services. The estimates imply an increase of approximately 49.2% in ICT services trade, while other

digital sectors, including financial services, insurance and pension services, and charges for the use of intellectual property, show mixed results across specifications. One possible explanation is that DEAs reduce the regulatory costs associated with cross-border data flows, electronic transactions, and paperless trade. These changes are likely to be particularly important for ICT and other highly data-intensive services.

Several limitations should be recognised. First, matching improves comparability based on observed pre-treatment characteristics, but it cannot account for unobserved factors that may influence both agreement formation and services trade. Second, the estimates are based on a relatively small number of treated country pairs and a short post-treatment period, as most agreements entered into force recently. These limitations are particularly important for the individual-sector estimates, which are based on smaller samples and may therefore be less precise and more sensitive to particular country pairs. The analysis is consequently better suited to identifying short-run effects than longer-term changes in trade. Third, although the data distinguish between broad services sectors, they do not provide sufficiently granular information on firms, modes of delivery, or individual DEA provisions to identify the precise mechanisms underlying the estimated effects. Longer post-treatment periods, additional DEAs, and more granular data would help establish whether the gains persist and through which policy channels they arise.

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