

AI-POWERED
INTELLIGENT
AUTOMATION AND



**AI-POWERED INTELLIGENT
AUTOMATION AND
INTERNATIONAL TRADE
IN SERVICES:
IMPLICATIONS FOR
SERVICE JOBS
IN APEC ECONOMIES**

Min-Seok Pang
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AI-Powered Intelligent Automation and International Trade in Services: Implications for Service Jobs in APEC Economies

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Introduction

Artificial intelligence (AI) has recently gained a tremendous attention from business leaders, technologists, policymakers, academics, and virtually all citizens around the world. The AlphaGo versus Lee Sedol Go match in March 2016 showcased the incredible cognitive power of an AI-powered machine, which made people imagine what other things AI could do better than humans in the future. Suddenly, people woke up to the realization that their jobs may not be as secure as they thought because machines might take them over sooner than later.

Historically, although technology developments have eliminated numerous old jobs, they created more new jobs, often resulting in a net increase. Many fear, however, that the unprecedented pace of developments in AI, robotics, digital technologies, and automation technologies will make more professions obsolete much faster and at a larger scale than ever before. As a result, policymakers are concerned that AI-powered automation will lead to a huge net loss in jobs, which creates a wide range of serious economic and social issues.

Previous automation technologies tend to automate manufacturing jobs and thus displace workers mostly in the manufacturing sector. However, AI-powered intelligent automation technologies can automate service jobs such as call center operations, fraud detection, legal document review, medical diagnosis, and software development. Simply put, intelligent automation is the combination of AI and automation. It has capabilities to sense and synthesize a vast amount of data and can automate service processes or workflows. With machine learning algorithms, intelligent automation systems

continue to learn and adapt, eventually performing better than human workers. Faster connectivity, greater computing power, advances in algorithms, and abundant data collectively expand the opportunities for service job automation to a whole new level.

Several recent studies have investigated the impact of automation on jobs. Notable studies include the ones published by Gartner, OECD, Oxford University, McKinsey, and World Economic Forum. Most of these studies focused on estimating the probability of automation for different occupations or the percentage of occupations that are likely to be automated. They mostly used survey data, expert opinions, and/or data relating to characteristics of different occupations to predict which occupations are more or less likely to be automated and by how much.

Although these studies may provide high-level insights on the impact of automation on occupations, their estimations vary substantially in part due to their reliance on survey data and expert opinions. Furthermore, they do not demonstrate empirical evidence of how automation technologies have been affecting service jobs based on objective, longitudinal economic data. As a result, when it comes to the impact of automation on service jobs, we have numerous predictions about what is going to happen, but we do not have much knowledge about what has happened recently and what is going on today.

Another shortcoming of prior studies is that they tended to focus on large economies such as the U.S., European Union, and China. However, little attention has been given to smaller developing economies or certain regions,

such as APEC member economies. Our study attempts to empirically test the impact of AI-powered intelligent automation on service jobs in developing economies around the world as well as APEC member economies by analyzing changes in international trade in services. The impacts of AI-powered intelligent automation on APEC member economies are likely to be significant as many of the APEC member economies rely on service exports for economic growth. Furthermore, intelligent automation may not only impact international trade in services in APEC member economies but also deepen digital divides and social inequality. For fostering shared prosperity in the region, APEC member economies need to have evidence-based knowledge about how intelligent automation affects their economies, such as international trade in services. Such knowledge will help them design and implement effective policies and regulations to cope with the challenges caused by AI-powered intelligent automation.

The objective of this study is to investigate whether and how the advances of intelligent automation affect international trade in services. Furthermore, this study investigates if the effect of intelligent automation is more significant in highly automatable service industries and in developing economies worldwide and within APEC members. To this end, we analyze the United Nations (U.N.) Comtrade trade data in 2000-2016 for 236 countries in 62 service industries. We use the Occupational Information Network (O*NET) database from the State of North Carolina in the United States (U.S.) to measure the degree of automation in each service industry. In addition, we use by the U.N. International Telecommunication Union (ITU)'s

ICT Development Index (IDI) to measure the level of ICT development in each country. We utilize the World Bank Open Data for control variables such as population, gross domestic product (GDP), and service industry sizes in the exporting and importing countries.

In conducting econometrics analyses that measure annual growth rates in global trade in services, we categorize the service industries into highly automatable (finance, professional, and information) and less automatable and compare the estimated growth rates between the two groups. We divide the sample into three different periods to examine the effect of recent developments in intelligent automation. In addition, we divide the countries into developed economies and developing economies and compare the trade growth rates, so that we can understand the impact of automation on service industries in developed and developing economies. Furthermore, we conduct the same analysis for APEC member economies only to gain insights on how intelligent automation affects services trade in APEC member economies.

Our empirical analyses yield several notable and interesting findings. First, we find that the global trade in services substantially increased during 2008-2014, but our estimation shows that all others being equal, the trade has shown a declining trend in 2014-2016. Second, we find that while the service industries that are more automatable (finance, professional, and information) experienced faster trade growth in 2000-2014, this growth has reversed in 2014-2016. This trend is most significant in the finance and insurance industries, which are the most automatable. While the estimated annual

growth rate in trade in the finance industries in 2008-2014 is 15%, it is estimated to be -20% in 2014-2016. We interpret that advances in intelligent automation or other technologies allow producers of highly-automatable services to rely more on automation and less on low-wage offshore workers.

Third, it is found that the service exports from the developed economies to the developing economies in the highly automatable service industries grew consistently in 2008-2014 but declined in 2014-2016. However, the same trend was not found in other service industries that are not highly automatable. We also obtain similar findings when we group countries into alternative classifications – high GDP vs. low GDP and high income vs. low income countries. For example, we find that service exports from low-income economies to high-income ones have declined in 2014-2016, particularly in more automatable service industries. Fourth, we find that trade in services between the economies with advanced ICT infrastructures appears to be declining in 2014-2016, but that between the economies with less developed ICT infrastructures has been rising for the same period. Finally, we find that APEC economies experienced a decline in both exports and imports in the finance/insurance industries in 2014-2016 and that within APEC economies, trade in the information and professional service industries has decreased in 2011-2016.

Based on the empirical findings, this research proposes several policy prescriptions for APEC member economies as follows. We first propose guiding principles for regulations and policies for intelligent automation. We advise policymakers to regulate automation technologies based on empirical

evidence; take an approach that advocates light-touch, permissionless innovation, and technology neutrality; and ensure consistency in policies and regulations for automation. We also make several recommendations for policy directions in the areas of workforce reskilling, education, labor, social protection and transition support, entrepreneurship, domestic service industries, infrastructure, and interagency coordination and public-private partnership. Next, we present more specific policy recommendations for APEC member economies. Finally, we discuss how South Korea can contribute to promoting shared prosperity in APEC member economies.

Chapter 1



International Trade in Services

1. Introduction to International Trade in Services
2. Historical Trends in International Trade in Services
3. Intelligent Automation, Services Trade, and Outsourcing

1. Introduction to International Trade in Services

Services are an essential part of modern economies worldwide. Services build the foundation for the development of other industries and are critical to foster social development. In 2017, services account for 65.1% of the global GDP and international trade in services accounts for 12.8% of the global GDP.¹⁾ In APEC economies, services have had a continuous growth for decades and represented more than 50% of the APEC's GDP in 2008.²⁾ For the APEC economies, services have increasingly become a crucial element of their export portfolio. For example, the Philippines became one of the largest business process services exporters in the world and Thailand and Malaysia have developed a fast-growing health services industry. International trade in the services has benefited from the ongoing liberalization of trade and investment in services at the multilateral level. Furthermore, technological progress has expanded the scope of the international division of labor and made it easier to outsource and delocalize a growing number of services activities. Consequently, the tradability of services has increased.³⁾

Trade in services differ from trade in goods in that trade in goods involves shipping goods from one country to another country, but cross-border trade is not the most common way of conducting international transactions in services.⁴⁾ For services that require personal contact between customers and clients, trade is possible only via sale through a foreign affiliate or if either

1) The World Bank Open Data, <https://data.worldbank.org/indicator/BG.GSR.NFSV.GD.ZS>

2) APEC Group on Services (2012), "Key Success Factors in Trade in Services," https://www.apec.org/-/media/APEC/Publications/2012/1/Key-Success-Factors-in-Trade-in-Services/2012_cti_gos-_Key-Success-Factors-Trade-in-Svcs.pdf

3) Lautier, M. (2014), International trade of health services: Global trends and local impact. *Health policy*, 118(1), 105-113.

4) Mattoo, A., Stern, R. M., & Zanini, G. eds. (2007), *A handbook of international trade in services*, The World Bank.

the customer or producer travels across borders. Also, services are highly regulated. Consequently, barriers to trade in services arise from domestic regulations that respond to market failures and protect local suppliers.

Research on international trade in services is very diverse and multi-disciplinary in nature. Indeed, prior studies have investigated a wide range of aspects related to international trade in services, including the effect of trade policies, the effect of exchange rates, the effect of external finance, and the effect of the Internet and information and communications technology (ICT). As for the effect of the Internet and ICT on international trade in services, prior research finds that the Internet stimulates trade. It has been found that a 10 percent increase in the growth of web hosts in a country leads to about a 0.2 percentage point increase in export growth.⁵⁾ Whereas one study found that the Internet had a positive and significant effect on the service trade of developing countries,⁶⁾ another study found that the impact of the Internet on services export was larger for developed countries than developing countries.⁷⁾ Other studies found that the benefits of electronic commerce are likely to be concentrated in developed countries in the short run but developing countries will have more to benefit in the long run and that more ICT-intensive firms purchase a greater amount of services on the market and they are more likely to purchase offshore than less ICT-intensive firms.⁸⁾

According to an APEC report,⁹⁾ the extant literature on international trade

5) Freund, C. L., & Weinhold, D. (2004), "The effect of the Internet on international trade," *Journal of international economics*, 62(1), 171-189.

6) Salmani, B., Pourebrahim, F., & Saremi, M. (2013), "The Effect of the Internet on International Trade in Services: Developing Countries' case study," *E-Commerce in Developing Countries: With Focus on e-Security (ECDIC)*, 7th International Conference.

7) Yousefi, A. (2018), "Estimating the Effect of the Internet on International Trade in Services," *Journal of Business Theory and Practice*, 6(1), 65-82.

8) Abramovsky, L., & Griffith, R. (2006), "Outsourcing and offshoring of business services: How important is ICT?," *Journal of the European Economic Association*, 4(2-3), 594-601.

9) APEC Group on Services (2012), "Key Success Factors in Trade in Services," https://www.apec.org/-/media/APEC/Publications/2012/1/Key-Success-Factors-in-Trade-in-Services/2012_cti_gos-_Key-Success-Factors-Trade-in-Svcs.pdf

in services has tended to focus on developed economies and has been directed at a firm level rather than an economy level. Our review of prior research on international trade in services reveals that few studies have investigated a possible negative impact of ICT on international trade in services. For example, with the advances in AI-powered intelligent automation, many service jobs could be done by technologies rather than by human workers, which leads to the reduction in international trade in services. Our study intends to fill this knowledge gap in prior research and shed light on the effect of advanced ICT such as intelligent automation on international trade in services worldwide as well as within APEC members.

2. Historical Trends in International Trade in Services

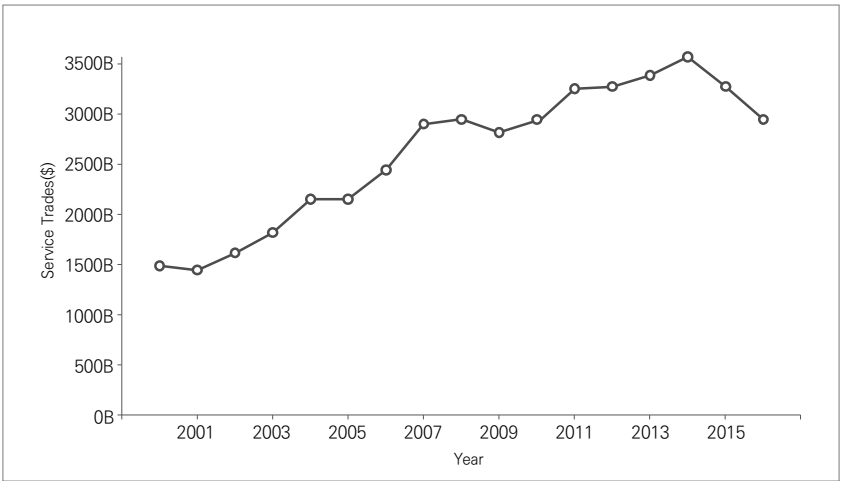
Advances in information technologies (IT) for the last few decades have been catalysts for rapid growth in international trade in services. According to data from Comtrade by the United Nations (U.N.), both global service exports and imports had doubled from \$1.5 trillion in 2000 to more than \$3 trillion¹⁰⁾ in 2014 (Figures 1 and 2, respectively), while we observe a decline in services trade after 2014. Thanks to the development of information and communication technologies (ICT), many service operations have been outsourced from high-wage developed economies to low-wage developing economies, particularly ones with a large population that speaks Western languages, such as the Philippines, India, Mexico, or Eastern Europe.¹¹⁾ This is one of the reasons why service exports from developing economies have increased from \$300 billion in 2000 to \$800 billion in 2015 (Figures 3-4).

10) in 2008 dollars

11) The New York Times (2011), “A New Capital of Call Centers,” <https://www.nytimes.com/2011/11/26/business/philippines-overtakes-india-as-hub-of-call-centers.html>

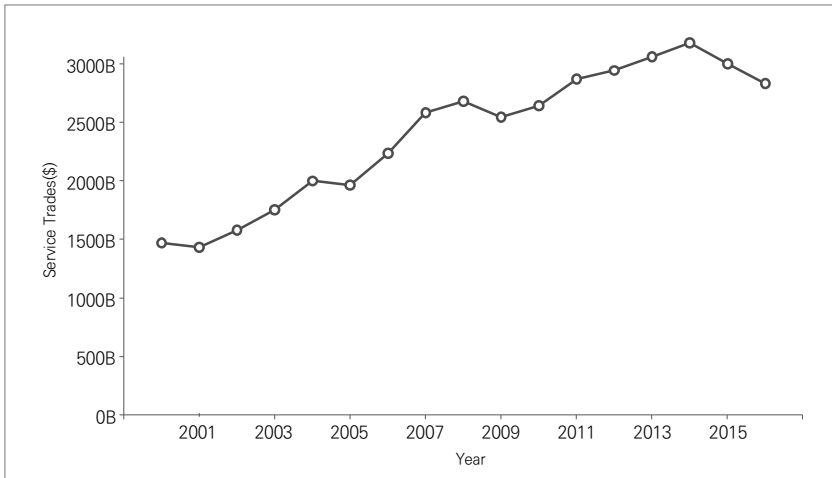
International trade in services has grown rapidly in many service industries, such as finance and insurance (Figure 5), professional services (Figure 6), and even construction (Figure 7). The amount of exports in the finance and insurance industries from developed economies had tripled from \$50 billion in 2000 to \$160 billion in 2014, despite the global financial crises in the late 2000s. The exports in professional, scientific, and technical services from developed economies, including legal, medical, or R&D-related services, have grown from \$10 billion to \$110 billion in 2000-2016.

Figure 1. Growth in Global Service Exports (2000 – 2016)



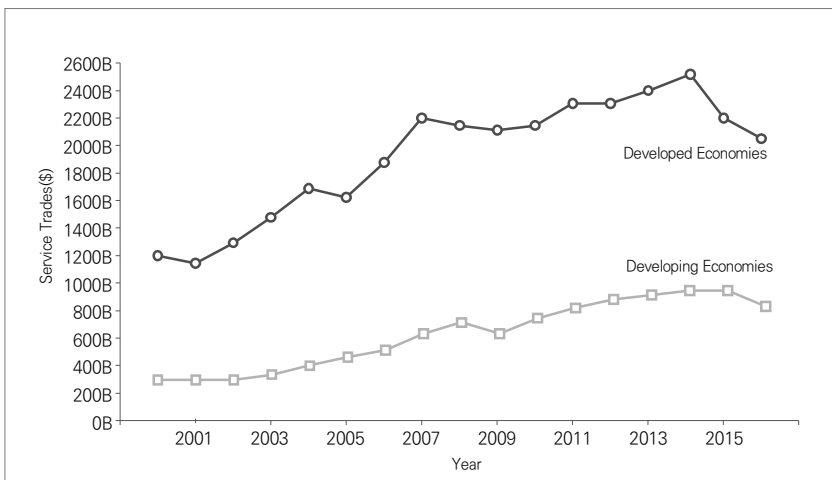
Source: Author's own compilation

Figure 2. Growth in Global Service Imports (2000 – 2016)



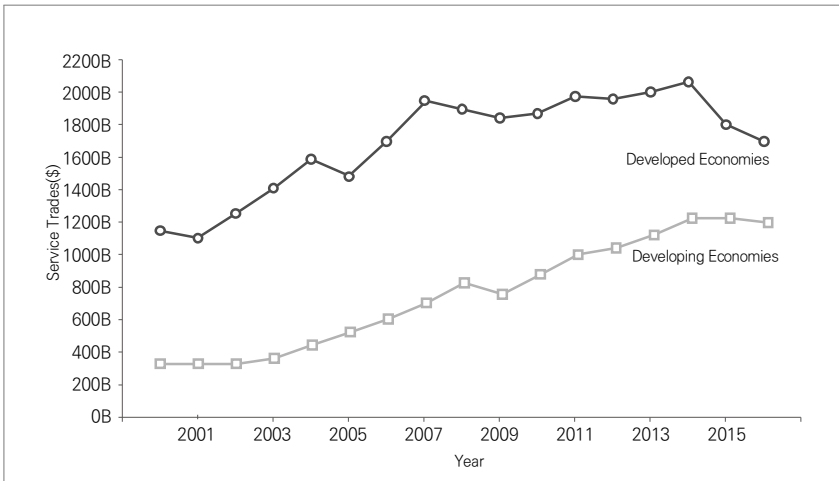
Source: Author's own compilation

Figure 3. Growth in Service Exports from Developed and Developing Economies (2000 – 2016)



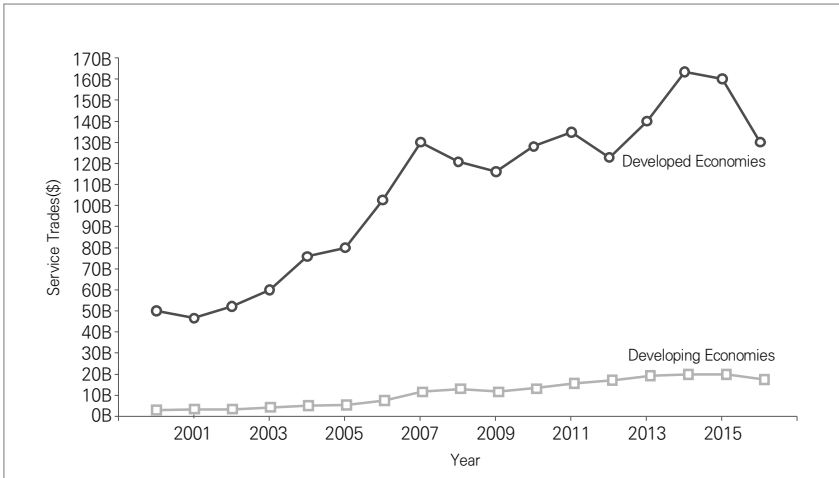
Source: Author's own compilation

Figure 4. Growth in Service Imports by Developed and Developing Economies (2000 – 2016)



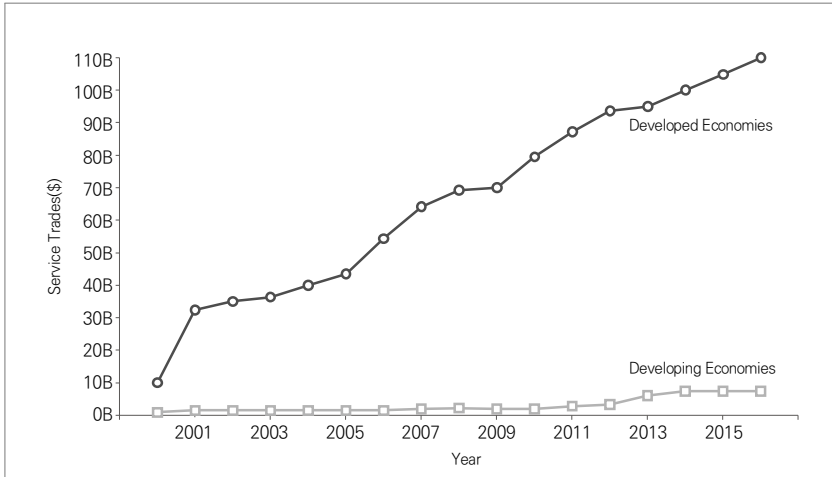
Source: Author's own compilation

Figure 5. Growth in Exports of Finance Services from Developed and Developing Economies (2000 – 2016)



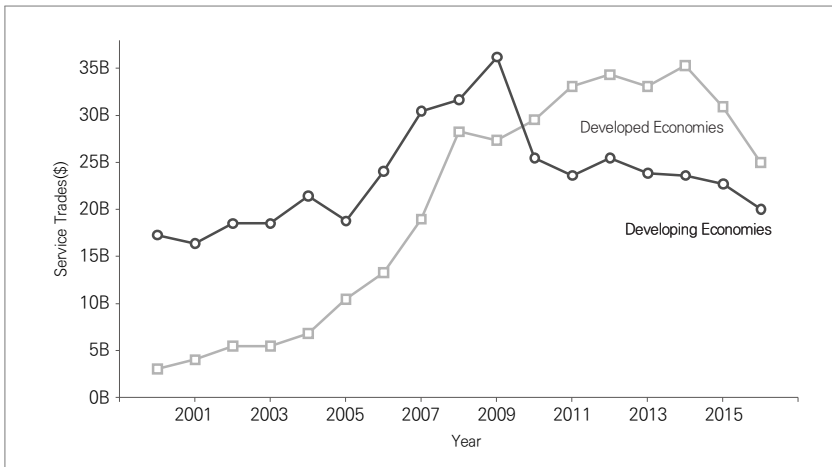
Source: Author's own compilation

Figure 6. Growth in Exports of Professional, Scientific, and Technical Services from the Developed and the Developing Economies (2000 – 2016)



Source: Author's own compilation

Figure 7. Growth in Exports of Construction Services from the Developed and the Developing Economies (2000 – 2016)



Source: Author's own compilation

3. Intelligent Automation, Services Trade, and Outsourcing

Many predict, however, that further development of intelligent automation technologies such as artificial intelligence (AI) and robotics will re-shape international trade in service industries. Intelligent automation is the combination of AI and automation. Intelligent automation applications sense and synthesize a vast amount of data and can automate entire processes or workflows, learning and adapting as they go by using machine learning or deep learning algorithms.¹²⁾ The range of business problems to which intelligent automation can be applied is expanding as technologies for voice recognition, natural language processing, machine vision, and machine learning improve and become usable by non-specialists.

In the past, IT has been automating business processes that entail routine, low-skilled work with well-documented job descriptions, such as clerical data-processing work.¹³⁾ However, as such intelligent automation technologies become advanced enough to automate even high-skilled, knowledge-intensive work, service producers in developed economies are more likely to replace low-wage, high-skilled workers in developing economies with intelligent automation technologies that are becoming cheaper and more powerful at an unprecedented speed.

A 2018 World Economic Forum report¹⁴⁾ shows that, in 2018, an average of 71% of total task hours across the 12 industries are performed by humans, compared to 29% by machines. But, by 2022 this average is expected to have

12) eoitte Insights (2014), “Intelligent Automation: A New Era of Innovation,” <https://www2.deloitte.com/insights/us/en/focus/signals-for-strategists/intelligent-automation-a-new-era-of-innovation.html>

13) The Telegraph (2017), “These are the jobs most at risk of automation according to Oxford University: Is yours one of them?” <https://www.telegraph.co.uk/news/2017/09/27/jobs-risk-automation-according-oxford-university-one/>

14) World Economic Forum (2018), “The Future of Jobs Report.”

shifted to 58% task hours performed by humans and 42% by machines. Furthermore, by 2022, 62% of information and data processing and information search and transmission tasks will be performed by machines, compared to 46% today. Even those tasks that require complex human interactions—communicating and interacting; coordinating, developing, managing, and advising; as well as reasoning and decision-making—will begin to be automated (30%, 29%, and 27% respectively by 2022).

There are a wide range of examples in which occupations that used to be outsourced to developing economies are now being automated by AI. Some examples are as follows.

- Call center operations have been outsourced overseas to English-speaking countries such as India or the Philippines. Recently, Silicon Valley startups are beginning to utilize AI, such as voice recognition and machine learning, to automate call center operations.¹⁵⁾ This is possible because a simple, straightforward question by a customer can be answered by an AI “chatbot” instead of a call-center clerk overseas.
- IBM has been developing its Watson platform to automate medical diagnosis, some of which has been outsourced and conducted by medical professionals in developing economies such as India, where their salaries are much lower than in developed countries.¹⁶⁾
- In the legal profession, contract-writing, document review, and legal discoveries are increasingly being outsourced overseas and automated by AI at the same time.¹⁷⁾
- Machine learning technologies are replacing human specialists for fraud detection in the banking and financial services industries.¹⁸⁾

15) <https://hackernoon.com/streamline-your-call-center-operations-with-artificial-intelligence-and-chatbots-4abac30d8d9a>

16) <http://www.healthtechzone.com/topics/healthcare/articles/2018/08/14/439124-how-ibm-watson-revolutionizing-cancer-research.htm>

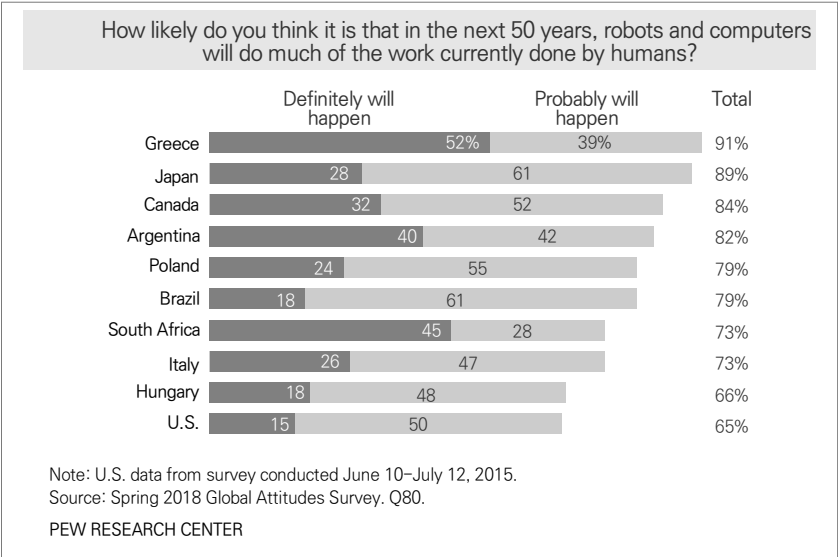
17) <https://www.law.com/legaltechnews/2018/07/23/looking-beyond-document-review-legal-is-branching-out-with-artificial-intelligence/?slreturn=20181007214557>

18) <https://www.fico.com/blogs/analytics-optimization/5-keys-to-using-ai-and-machine-learning-in-fraud-detection/>

People Believe Much Work Will Be Done by Machines in the Future

A 2018 Pew Research Center study shows that most people from both developing and developed countries think AI and robots will take over many jobs currently done by humans (Figure 8). According to the survey results, about 90% of the people in Greece and Japan think that in the next 50 years, robots and computers will do much of the work currently done by humans. On the other hand, about 65% of people in the U.S. and Hungary think so. Albeit a variance across countries, this study suggests that most people around the world believe that technology will take over a large portion of the work currently done by human workers.

Figure 8. People’s Perception of the Impact of AI and Robots on Jobs



- Even software development is expected to be automated by AI, possibly replacing offshore outsourcing.¹⁹⁾

19) <https://www.forbes.com/sites/julianmitchell/2016/07/11/robots-replacing-developers-this-startup-uses-artificial-intelligence-to-build-smart-software/#4a678584324c>

The common characteristics of the occupations that are likely to be replaced by AI-powered intelligent automation are as follows.

- First, these occupations do not require many face-to-face interactions with other people (e.g., customers, patients), and physical presence is not essential for service provision.
- Second, the problems, tasks, and processes for problem-solving are well-defined and can be documented,²⁰⁾ allowing workers in developing economies to do the same work at a lower cost.
- Third, even though some of the problems can be complex and require professional knowledge and expertise, many service jobs produce outcomes with clear expectations and answers.

These characteristics allow these service jobs to be easily outsourced overseas, but these same characteristics make them very prone to automation and digitization as well.

20) Harvard Business Review (2016), “The 3 Ways Work Can Be Automated,” <https://hbr.org/2016/10/the-3-ways-work-can-be-automated>

Chapter 2



AI-Powered Intelligent Automation

1. Impact of Intelligent Automation on Jobs
2. Advances in Intelligent Automation and Service Occupations

1. Impact of Intelligent Automation on Jobs

Artificial intelligence appears to begin to make an impact on the global economy as a broad range of companies are already using AI tools in a variety of ways and functions, including manufacturing, supply chains, preventive maintenance of assets, R&D, and sales and marketing.²¹⁾ AI-powered intelligent automation impacts not only manufacturing jobs but also service occupations such as customer service, financial service, and information service, to name a few. For example, improved speech recognition in call center management and call routing by applying AI techniques allows a more seamless experience for customers and more efficient processing.

While it appears to be certain that intelligent automation will have an impact on service jobs, we are seeing mixed forecasts with respect to how significant the impact will be: some predictions are bold and radical, whereas other predictions show more conservative estimates. Results of different studies on the overall impacts of job automation conducted over the past five years differ in their assessment and projections.²²⁾

According to Dr. Banatao, the chairman of the Philippine Development Foundation, most of the estimated 1.3 million Filipinos working in the business process outsourcing (BPO) industry will be displaced over the next two years by AI technology.²³⁾ This job loss is expected to be worth about \$50

21) McKinsey Global Institute (2018), “Notes from the Frontier: Modeling the Impact of AI on the World Economy.”

22) Some of the notable studies include (1) Arntz, M., T. Gregory and U. Zierahn (2016), “The risk of automation for jobs in OECD countries: A comparative analysis”, OECD Social, Employment and Migration Working Papers, No. 189, OECD Publishing, Paris. <http://dx.doi.org/10.1787/5jlz9h56dvq7-en>. (2) Frey, C.B. and M.A. Osborne (2013), “The future of employment: How susceptible are jobs to computerisation?”, OMS Working Papers, Oxford Martin Programme on the Impact of Future Technology, www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf. (3) Citibank (2016), “Technology at Work v2.0: The Future is Not What it Used to Be,” www.oxfordmartin.ox.ac.uk/downloads/reports/Citi_GPS_Technology_Work_2.pdf.

23) <https://www.manilatimes.net/artificial-intelligence-threat-opportunity/344678>

billion. Similarly, it is predicted that automation will impact 750,000 low-skilled service jobs in India.²⁴⁾ Researchers at Oxford University estimated in 2013 that half of the occupations in the U.S. are likely to be automated.²⁵⁾ According to Gartner Group, less than 30% of all IT service desk calls will be solved by a live person by 2020,²⁶⁾ and 40% of the outsourced services will leverage smart machine technologies by 2018, rendering the offshore model obsolete for competitive advantage.²⁷⁾ These bold predictions are in part based on substantial cost savings brought by intelligent automation. For example, it is estimated that the cost of a robotic process automation (RPA) virtual resource is only one-third of the cost of an off-shore resource.²⁸⁾

On the other hand, there are more conservative, cautious predictions about the impact of AI-powered intelligent automation on service job displacement. In 2016, based on its analysis of 830 occupations, McKinsey reached a conclusion that just 5% of them could be completely automated.²⁹⁾ According to Gartner, by 2020, 99% of the AI initiatives in IT service management (ITSM) will fail due to the lack of an established knowledge management foundation.³⁰⁾ Furthermore, a McKinsey survey of 3,000 AI-aware C-level executives across 10 countries and 14 industries finds that “the majority of firms did not expect AI to significantly reduce the size of their workforce.”³¹⁾

24) Phil Fersht and Jamie Snowdon (2018), “Automation to impact 750,000 low skilled Indian jobs, but create 300,00 mid-high skilled jobs by 2022,” https://www.horsesforsources.com/jobs-impact-automation_083017

25) Frey, C. and Osborne, M. (2013), “The Future of Employment: How susceptible are jobs to computerisation?,” <http://www.oxfordmartin.ox.ac.uk/publications/view/1314>

26) David Groombridge and Daniel Barros (2017), “The Impact of Intelligent Automation on Managed Workplace Services,” Gartner.

27) Frances Karamouzis, Ruby Jivan, and Sandra Notardonato (2015), “Predicts 2016: The Rise of the Machine Leads to Obsolescence of Offshoring for Competitive Advantage,” Gartner.

28) AT Kearney (2018), “Future of Work and Workers, Impact of Robotics and Artificial Intelligence.”

29) McKinsey Global Institute (2017), “Harnessing Automation for a Future that Works.”

30) Chris Matchett, Rich Doheny, Kenneth Gonzalez, and Magnus Revang (2017), “When Will AI Virtual Support Agents Replace Your IT Service Desk?,” Gartner.

Whether the impact of intelligent automation on service job employment will be radical or incremental, its impact will vary across different types of service jobs. An important question is what type of service jobs are more vulnerable to intelligent automation. In the case of RPA, Capgemini suggests that the jobs with the following three characteristics are candidates: (1) that the actions are consistent, with the same step being performed repeatedly; (2) that it is template driven, with data being entered into specific fields in a repetitive manner; and (3) that it is rules-based, to allow decision flows to alter dynamically.³²⁾

Although AI-powered intelligent automation is generally viewed as a threat to employment, it is also expected to create new jobs as previous new technologies did.³³⁾ Some experts predict that automation could create 300,000 mid-to high-skilled jobs in India by 2022³⁴⁾ and could help the Philippine BPO industry double its value to \$100 billion.³⁵⁾ In a 2017 forum organized by the U.S. Government Accountability Office, experts noted that automation has a potential for job increases in certain areas.³⁶⁾ Gartner predicts that many service jobs will transition from labor-centric to labor plus intelligent automation capabilities, creating a new demand for workers who can supervise or collaborate with automation technology.³⁷⁾

31) McKinsey Global Institute (2018), “Notes from the Frontier: Modeling the Impact of AI on the World Economy.”

32) Capgemini (2015), “BPO’s next wave of Robotic Process Automation,” https://www.capgemini.com/wp-content/uploads/2017/07/bpos_next_wave_of_robotic_process_automation.pdf

33) Autor, D.H. (2015), “Why are there still so many jobs? The history and future of workplace automation”, *Journal of Economic Perspectives*, Vol. 29/3, Summer, pp. 3-30, <http://dx.doi.org/10.1257/jep.29.3.3>.

34) Phil Fersht and Jamie Snowdon (2018), “Automation to impact 750,000 low skilled Indian jobs, but create 300,00 mid-high skilled jobs by 2022,” https://www.horsesforsources.com/jobs-impact-automation_083017

35) <https://www.manilatimes.net/artificial-intelligence-threat-opportunity/344678>

36) United States Government Accountability Office (2018), “Artificial Intelligence: Emerging Opportunities, Challenges, and Implications for Policy and Research,” GAO-18-132SP

37) Arup Roy, Twigg Lo, TJ Singh, and Susan Tan (2017), “Predicts 2018: Intelligent Automation Services Will Force Providers to Reinvent Themselves,” Gartner.

While an increasing amount of attention is paid to intelligent automation and its impact on job losses, little empirical research based on longitudinal international data has been done to investigate this issue. Some of the few prior studies tended to focus on large economies, such as the U.S., European Union, and China. However, little attention has been given to developing economies or certain regions, such as APEC member economies. As a result, very little is known about the potential impact of AI-powered intelligent automation on developing economies or APEC member economies.³⁸⁾

2. Advances in Intelligent Automation and Service Occupations

Throughout human history, technology developments have made numerous jobs obsolete and, at the same time, created a number of new occupations that had not existed before and which require a new set of skills. For example, internal combustion engines displaced drivers and maintenance workers for steam engines. While electricity displaced such occupations as lamplighters, switchboard operators, or ice cutters, it revolutionized all aspects of manufacturing, agriculture, and our lives, creating countless new jobs.³⁹⁾ The job of typewriters had become a thing of the past because of the arrival of personal computers, which in turn created so many new occupations, including programmers, technicians, and system administrators.

Many fear, however, that the unprecedented pace of development in IT, robotics, and other automation technologies will make more professions obsolete increasingly faster and on a larger scale.⁴⁰⁾ This is taking place not only

38) <https://www.un.org/development/desa/dpad/publication/frontier-issues-artificial-intelligence-and-other-technologies-will-define-the-future-of-jobs-and-incomes>

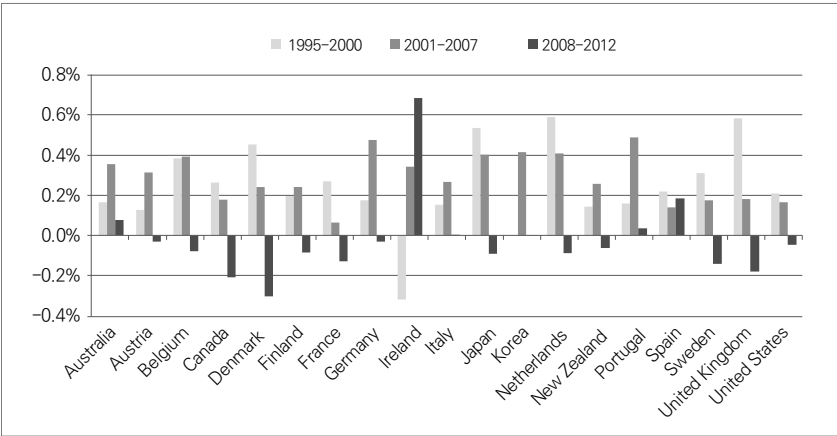
39) Foreign Affairs (2015), “Will Humans Go the Way of Horses?” <https://www.foreignaffairs.com/articles/2015-06-16/will-humans-go-way-horses>

in the manufacturing industry where physical labor either is being replaced by robots or becomes unnecessary at all but also in the service sector that requires knowledge and cognitive skills.

Effect of ICT Investment on Labor Demand in OECD Countries

Figure 9 shows the estimated effects of ICT investment on labor demand in OECD countries over the period of 1995-2012. ICT investment increased labor demand in most OECD countries from the mid-1009s until 2007. However, this trend is largely reversed thereafter, resulting in a decrease in labor demand. For example, Denmark experienced over 0.4% of average yearly employment growth rate in 1995-2000 but witnessed a sharp decline to -0.3% in 2019-2012.

Figure 9. Employment Growth due to Growth in ICT Investment



Source: OECD (2016), "ICTs and Jobs: Complements or Substitutes?", OECD Digital Economy Papers, No. 259, OECD Publishing, Paris, <https://doi.org/10.1787/5jlwnklzplhg-en>.

40) The New York Times (2012), "Jobs, Productivity, and the Great Decoupling," <https://www.nytimes.com/2012/12/12/opinion/global/jobs-productivity-and-the-great-decoupling.html>

For the past few decades, digital technologies have been automating business processes in all business functions, which lead to the displacement of white-collar occupations that perform such business processes.⁴¹⁾ Examples include travel agents, telephone operators, bank tellers, accountants, tax preparers, and payroll managers. One of the common characteristics of such jobs is that the nature of their tasks and duties are routine and well-defined and therefore can be easily described in words. For such jobs, it is possible to dictate necessary inputs, data processing and decision-making processes, and desired outcomes, and thus possible to document detailed steps in which the inputs are transformed into the outcomes. For example, for tax preparation, there exists a well-defined set of decision structures and rules for data manipulation/calculation that transforms inputs (income, expenses) to outcomes (amount of deduction and tax and other documents). If there is a clear, well-defined set of rules, steps, and routines for white-collar workers to follow, it is also straightforward to encode these rules and processes into the software.⁴²⁾ This is how digital technologies have been making a range of service professions obsolete so far.

The advances in AI expand the opportunities for job automation to a whole new level, thanks to the explosion of both computing power and abundance of data. Among many AI techniques, supervised machine learning is close to wide application and commercialization. In this technique, the machine is supplied with a large amount of data and desired outcomes, and it develops heuristics and algorithms by itself that mimic the cognition and decision making of human beings.⁴³⁾ For example, to develop image recognition, the machine leverages a large number of image files and human su-

41) PBS Newshour (2015), “3 white collar jobs that robots are already mastering,” <https://www.pbs.org/newshour/science/3-white-collar-jobs-robots-can-already-better>

42) Autor, Levy, and Murnane (2003), “The Skill Content of Recent Technological Change: An Empirical Exploration,” *Quarterly Journal of Economics*, 118(4), 1279-1333.

43) Harvard Business Review (2017), “The Business of Artificial Intelligence” <https://hbr.org/cover-story/2017/07/the-business-of-artificial-intelligence>

pervision (e.g., Image A has a cat, and Image B has a dog) to construct a convoluted neural network.⁴⁴⁾ The image recognition can be utilized for the development of driverless cars, medical diagnosis, or detection of pornography or other harmful images on the Internet. More generally, supervised machine learning for pattern recognition allows the machine to detect any pattern in digital files, be it voices, videos, financial transactions, or medical information. Hence, similar techniques can be used to develop algorithms for fraud detection, in which the machine analyzes a large amount of transactional data to uncover patterns for suspicious activities; for language translation, with a cornucopia of literature data; and for product recommendation, with past customer transaction and preference data.

This development in machine learning for intelligent automation, enabled by ubiquitous big data and cheaper computing power, implies that any occupations that involve a task of finding definable or correct answers can be automated by the machine.⁴⁵⁾ As explained above, machine learning is increasingly capable of translating one language to another, possibly displacing translators' roles.⁴⁶⁾ This is because there exists a definable outcome for translators (translated work), and the machine can be supervised to train with desirable outcomes and a large amount of original and translated work. It is even predicted that it can proofread and polish poorly-written manuscripts, a job that is being done by copyeditors.⁴⁷⁾ Insurance companies are adopting machine learning to evaluate insurance claims and determine the eligibility of payment, a job that can be done faster and more accurately than human insurance assessors. Again, this is possible because it is the assessors'

44) Sharma, Jain, Mishra (2018), "An Analysis of Convolutional Neural Networks For Image Classification" *Procedia Computer Science*, 132, 377-384.

45) Harvard Business Review (2016), "What Artificial Intelligence Can and Can't Do Right Now," <https://hbr.org/2016/11/what-artificial-intelligence-can-and-cant-do-right-now>

46) <https://www.forbes.com/sites/bernardmarr/2018/08/24/will-machine-learning-ai-make-human-translators-an-endangered-species/>

47) <https://www.capgemini.com/2017/10/how-artificial-intelligence-enables-smarter-claims-processing/>

job to produce a well-defined outcome – approval or decline of claims. This is the case with medical diagnosis as well, which produces a well-structured outcome (diagnosis). Media companies are also introducing machine learning tools to replace human journalists with algorithms that author structured, well-defined news articles in sports, weather forecast, or stock market reporting. Legal professions are also ripe for automation by AI as well, particularly in document review, legal research, due diligence, and contract writing.

Hence, advances in AI and other digital technologies can automate not only jobs that are programmable with well-structured tasks but also ones with well-defined outcomes and abundant data that can train the machine. This leads to a prediction that many service-industry jobs that are outsourced to other countries, particularly to developing economies with lower wages, can also be automated by AI. If history is any guide, computing power will be cheaper and more widely available at an exponential scale, to an extent that software and algorithms at some point can become cheaper than the wages of high-skilled professionals in developing nations. In addition, accuracy and performance of software are getting closer to or already exceeding human capabilities.⁴⁸⁾ If this trend continues, service producers in developed economies will be able to rely less on offshore human labor and resort more to AI-powered intelligent automation. We, therefore, expect that as technologies advance, international trade in highly automatable service industries can grow slower or even decline, compared to other less automatable service industries. This study conducts empirical investigations to see if this is the case.

48) <https://www2.deloitte.com/insights/us/en/deloitte-review/issue-20/augmented-intelligence-human-computer-collaboration.html>

Chapter 3



Overview of Data on International Trade in Services and Service Automation

1. Data on International Trade in Services
2. Data on Industry Automatability
3. Automation and Service Exports and Imports
4. Data Analysis Models

1. Data on International Trade in Services

Our dataset for international trade in services includes 567,074 observations from 236 countries in 62 service industries in 2000-2016. Table 1 lists the service industries in our dataset, as defined by the North American Industry Classification System (NAICS).⁴⁹⁾ This classification was jointly developed by the U.S., Canada, and Mexico in 1997. It has two broad sector categories (manufacturing and service sectors), and we use the service industry categorizations.⁵⁰⁾ The following section explains the automation scores in Table 1.

Table 1. Service Industries (The NAICS Classification)

(Unit: thousand USD)	
Industry	Automation
Finance and Insurance	39.79
Professional, Scientific, and Technical Services	33.53
Mining, Quarrying, and Oil and Gas Extraction	32.10
Administrative and Support	31.63
Information	31.34
Retail Trade	30.97
Real Estate and Rental and Leasing	29.65
Government	29.24
Health Care and Social Assistance	28.07
Transportation and Warehousing	27.50
Other Services	25.19
Educational Services	24.76
Construction	24.44
Arts, Entertainment, and Recreation	22.22

Source: www.census.gov/eos/www/naics

49) <https://www.census.gov/eos/www/naics/>

50) https://www.bls.gov/bls/naics_aggregation.htm

We build a panel dataset for international trade in services from 2000 to 2016 by combining the three data sources: the U.N. Comtrade, O*NET Online, and the World Bank Open Data. The U.N. International Trade Statistics Database, also known as Comtrade, is a global trade database operated by the U.N. Statistics Division, which offers the trading quantities and volumes between more than 230 countries from 1965. It provides two types of trade data: trade in goods and trade in services. We obtain annual service trading volumes in U.S. dollars in 2000-2016. This database defines service as “a production activity that changes the condition of a good or a person or that facilitates the exchange of products or financial assets.” Comtrade follows the Extended Balance of Payment Services (EBOPS) classification,⁵¹⁾ and we match the EBOPS and the NAICS industry classifications as in Table 2.

The unit of analysis in this study is a combination of Exporter-Importer-Industry-Year. For example, USA-Mexico-Legal-2007 refers to service exports in legal services from the U.S. to Mexico in 2007, or China-Russia-Information-2011 refers to service exports in information services from China to Russia in 2011. Comtrade does not offer service trading volume before 2000, and at the time of our data collection, the data after 2017 is yet to be available. We use the log-transformed volume of services trade in real 2008 dollars, which is deflated by producer price indexes, as a dependent variable. We also control for the size of trade in goods between the same exporter and importer in the same year in all our estimations.

We utilize the Occupational Information Network (O*NET)⁵²⁾ database to measure the characteristics of the service industries. O*NET is a publicly available database for occupational information developed by the North Carolina Department of Commerce with a grant from the U.S. Department of Labor. It provides standardized information and descriptions of over 1,000 occupations, such as telemarketers or insurance claims clerks. For

51) <https://unstats.un.org/unsd/tradeserv/TFSITS/msits2010/ebops2cpc.htm>

52) <https://www.onetonline.org/>

country-level control variables, we collect data from World Bank Open Data, such as population, gross domestic product (GDP), and unemployment rates, as will be explained below.

Table 2. Matching of the EBOPS and the NAICS Industry Classifications

EBOPS	NAICS	Automation
1 Transportation		
1.1 Sea transport	Transportation and Warehousing	27.50
1.2 Air transport	Transportation and Warehousing	27.50
1.3 Other transport	Transportation and Warehousing	27.50
1.4 Space transport	Transportation and Warehousing	27.50
1.5 Rail transport	Transportation and Warehousing	27.50
1.6 Road freight	Transportation and Warehousing	27.50
1.7 Inland waterway freight	Transportation and Warehousing	27.50
1.8 Pipeline freight	Transportation and Warehousing	27.50
1.9 Other supporting and auxiliary transport services	Transportation and Warehousing	27.50
3 Communications services		
3.1 Postal and courier services	Information	31.34
3.2 Telecommunications services	Information	31.34
4 Construction services		
4.1 Construction abroad	Construction	24.44
4.2 Construction in the compiling economy	Construction	24.44
5 Insurance services		
5.1 Life insurance and pension funding	Finance and Insurance	39.79
5.2 Freight insurance	Finance and Insurance	39.79
5.3 Other direct insurance	Finance and Insurance	39.79
5.4 Reinsurance	Finance and Insurance	39.79
5.5 Auxiliary services	Finance and Insurance	39.79
6 Financial services	Finance and Insurance	39.79
7 Computer and information services		
7.1 Computer services	Information	31.34
7.2 Information services	Information	31.34
7.2.1 News agency services	Information	31.34

Table 2. Continued

EBOPS	NAICS	Automation
9 Other business services		
9.1.1 Merchanting	Administrative and Support	31.63
9.1.2 Other trade-related services	Administrative and Support	31.63
9.3.1.1 Legal services	Professional, Scientific, and Technical Services	33.53
9.3.1.2 Accounting, auditing, bookkeeping, and tax consulting services	Professional, Scientific, and Technical Services	33.53
9.3.1.3 Business and management consulting and public relations services	Professional, Scientific, and Technical Services	33.53
9.3.2 Advertising, market research, and public opinion polling	Professional, Scientific, and Technical Services	33.53
9.3.3 Research and development	Professional, Scientific, and Technical Services	33.53
9.3.4 Architectural, engineering, and other technical services	Professional, Scientific, and Technical Services	33.53
9.3.5.1 Waste treatment and depollution	Administrative and Support	31.63
9.3.5.2 Agricultural, mining, and other on-site processing services	Mining, Quarrying, and Oil and Gas Extraction	32.10
9.3.6 Other business services	Other Services	25.19
10 Personal, cultural, and recreational services		
10.1 Audiovisual and related services	Arts, Entertainment, and Recreation	22.22
10.2 Other personal, cultural, and recreational services	Arts, Entertainment, and Recreation	22.22
10.2.1 Education services	Educational Services	24.76
10.2.2 Health services	Health Care and Social Assistance	28.07
10.2.3 Other services	Arts, Entertainment, and Recreation	22.22
11 Government services		
11.1 Embassies and consulates	Government	29.24
11.2 Military units and agencies	Government	29.24
11.3 Other government services	Government	29.24
Services not allocated	Other Services	25.19

Source: EBOPS, <https://unstats.un.org/unsd/tradeserv/TFSTTS/msits2010/ebops2cpc.htm>

2. Data on Industry Automatability

We measure the degree of automation of each service industry using the O*NET data. In O*NET, each occupation is evaluated with respect to required abilities (e.g., cognitive, physical, sensory), knowledge (e.g., design, physics, or sales), skills (e.g., problem-solving, judgement and decision making, or coordination), and activities (e.g., assisting and caring, analyzing data, or handling and moving objects). It started evaluation of the skills, knowledge, and activities since 2003 and has annually updated it until 2017. Based on these characteristics of each occupation in 2017, O*NET measures the degree of automation (how automated a job can be) on a 0-100 scale (100 being highly automatable). Table 3 lists some examples of occupations that are highly and less likely to be automated. As expected, occupations with more routine and definable tasks such as travel agents, claims examiners, and systems operators have higher automation scores, and jobs that involve more interactions and communications (nannies, therapists, and installers) or require creativity (musicians or makeup artists) have lower automation scores. The average automation score of all occupations is 29.43.

Next, in O*NET, each service industry in the NAICS classification is mapped with the occupations that it is expected to employ in 2016. For example, according to O*NET, the finance and insurance industries primarily hire customer service representatives, supervisors of administrative workers, and application software developers (Table 4). Using this mapping, we calculate the degree of automation in the service industries with the job-opening-weighted average of automation score of occupations. As expected, service industries in finance and insurance (39.79), professional services (33.53), and information (31.34) have a high likelihood of automation, while the education (24.76), construction (24.44), and arts and entertainment (22.22) industries are less likely to be automated.

Table 3. Examples of Occupations and Degree of Automation

Occupation	Degree of Automation
Farmworkers and Laborers	74
Claims Examiners, Property and Casualty Insurance	73
Travel Agents	70
Robotics Engineers	69
Postal Service Mail Sorters, Processors, and Processing Machine Operators	68
Medical and Clinical Laboratory Technologists	67
Chemical Plant and System Operators	66
Telephone Operators	66
Air Traffic Controllers	65
Reservation and Transportation Ticket Agents and Travel Clerks	65
Watch Repairers	4
Aerospace Engineering and Operations Technicians	3
Bicycle Repairers	3
Nannies	3
Automotive Glass Installers and Repairers	2
Manicurists and Pedicurists	2
Midwives	2
Art Therapists	1
Makeup Artists, Theatrical and Performance	1
Manufactured Building and Mobile Home Installers	1
Musicians, Instrumental	1

Source: O*NET database, <https://www.onetonline.org/>

Table 4. Occupations and Job Openings of Finance and Insurance Industries

Occupations	Automation	Projected Job Openings (2016–2026)
Customer Service Representatives	46	373,500
First-Line Supervisors of Office and Administrative Support Workers	33	153,000
Software Developers, Applications	27	85,700
Management Analysts	31	83,900
Market Research Analysts and Marketing Specialists	36	77,100
Insurance Sales Agents	53	54,700
Executive Secretaries and Executive Administrative Assistants	27	54,600
Tellers	48	51,500
Computer Systems Analysts	46	44,900
First-Line Supervisors of Non-Retail Sales Workers	32	39,000
Computer and Information Systems Managers	39	32,500
Training and Development Specialists	27	31,700
Loan Officers	54	30,400
Bill and Account Collectors	51	30,200
Financial Analysts	28	29,000
Loan Interviewers and Clerks	49	25,700
Personal Financial Advisors	47	25,500
Marketing Managers	28	21,300
Data Entry Keyers	55	16,800
Computer Network Architects	29	11,700
Operations Research Analysts	21	10,700
Information Security Analysts	36	10,400
Mail Clerks and Mail Machine Operators, Except Postal Service	49	9,400
Database Administrators	48	9,300
Compensation, Benefits, and Job Analysis Specialists	29	7,700
Insurance Underwriters	51	7,500
Credit Analysts	37	6,800
Brokerage Clerks	57	6,600

Table 4. Continued

Occupations	Automation	Projected Job Openings (2016–2026)
Title Examiners, Abstractors, and Searchers	51	6,000
Office Machine Operators, Except Computer	36	5,100
Financial Examiners	49	4,600
Statisticians	32	4,400
New Accounts Clerks	49	4,000
Credit Counselors	43	3,800
Training and Development Managers	27	3,500
Computer Operators	47	3,400
Actuaries	38	2,100
Statistical Assistants	41	1,600
Insurance Appraisers, Auto Damage	56	1,500
Compensation and Benefits Managers	45	1,200
Correspondence Clerks	36	800
Total Projected Job Openings		1,383,100
Job Opening–Weighed Automation Score	39.79	

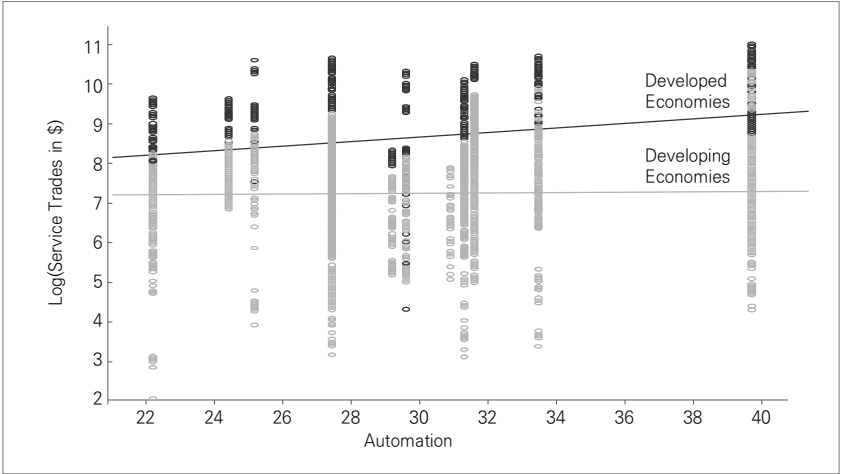
Source: O*NET database, <https://www.onetonline.org/>

Table 4 also shows projected job openings for each occupation in the finance and insurance industries. Note that the finance and insurance industries employ several occupations that are highly automatable (e.g., customer service representatives, insurance sales agents, tellers, and computer systems analysts), a reason why they have the highest automation score (Table 1). Professional service industries employ a large number of occupations that are susceptible to automation, including receptionists and information clerks, human resources specialists, data entry keyers, and payroll and timekeeping clerks. Likewise, information service industries largely consist of highly automatable jobs, such as computer programmers, database administrators, network administrators, and computer user support specialists.

3. Automation and Service Exports and Imports

Before presenting the results of our econometrics estimations, we offer some model-free descriptive statistics that visualize important longitudinal trends in international trade in services. Figure 10 illustrates the correlation between the amount of service export volumes (\$) and the degree of automation. Automation score comes from the calculation explained in the previous section. Each dot represents the volume of service exports in one industry from one country to the world with blue representing developed economies and orange representing developing economies. The dots and regression lines shown in Figure 10 demonstrate that the more automatable a service industry is, the larger the amount of exports taking place. This positive relationship between export volume and automation is stronger for developed economies (the blue regression line).

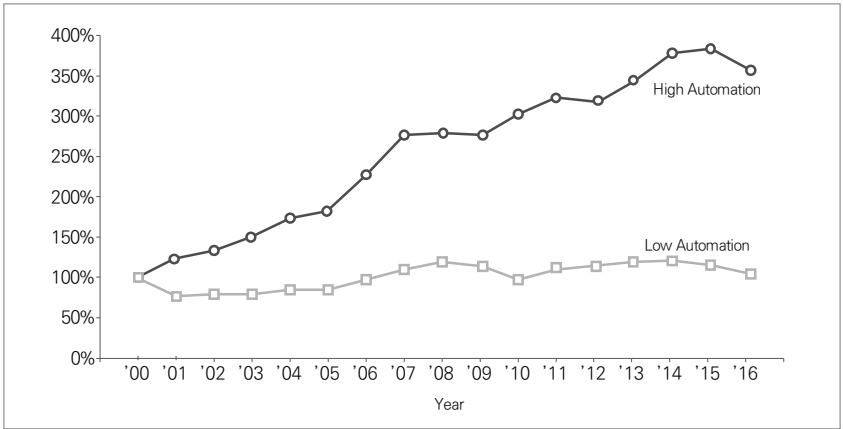
Figure 10. The Relationship between Degree of Automation and Service Exports in Developed and Developing Economies



Source: Author's own compilation

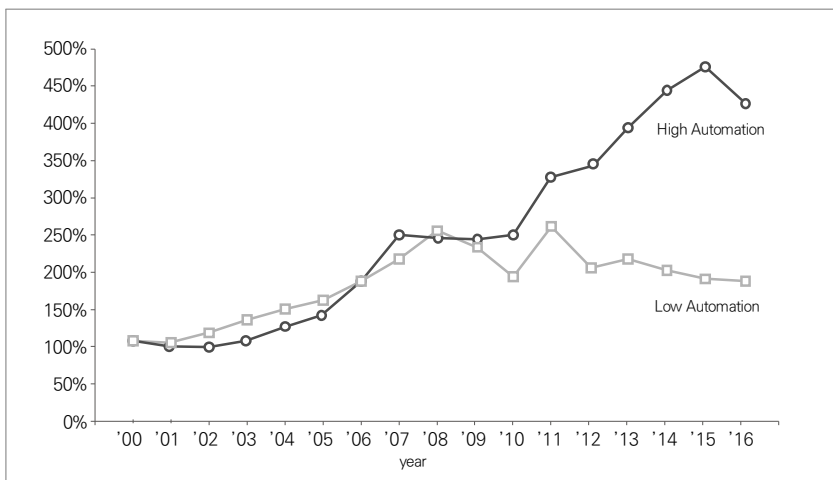
Figures 11 and 12 show exports growth in two types of service industries (with high and low automation) as a percentage of volume in the year 2000 from developed and developing economies, respectively. High-automation industries have an automation score greater than 30, including finance, information, and professional services (see Table 1). Figures 11 and 12 show that the service industries with a high automation measure have experienced faster growth in exports since 2000. We can observe, however, that the service export growth in the high-automation industries has stagnated since 2015, a fact that we will utilize in econometrics analyses below. Figures 13 and 14, with service imports by developed and developing economies, respectively, demonstrate similar patterns. Imports by developed economies grew substantially in highly automatable services industries, but not in less automatable industries (Figure 13). Imports by developing economies in highly automatable services industries have risen sharply after 2010 but declined in 2014 (Figure 14). Likewise, Figure 14 shows that the amount of service imports in less automatable industries by developing economies have not changed much in 2000-2016.

Figure 11. Growth in Exports from Developed Economies in High Automation and Low Automation Industries (2000 – 2016)



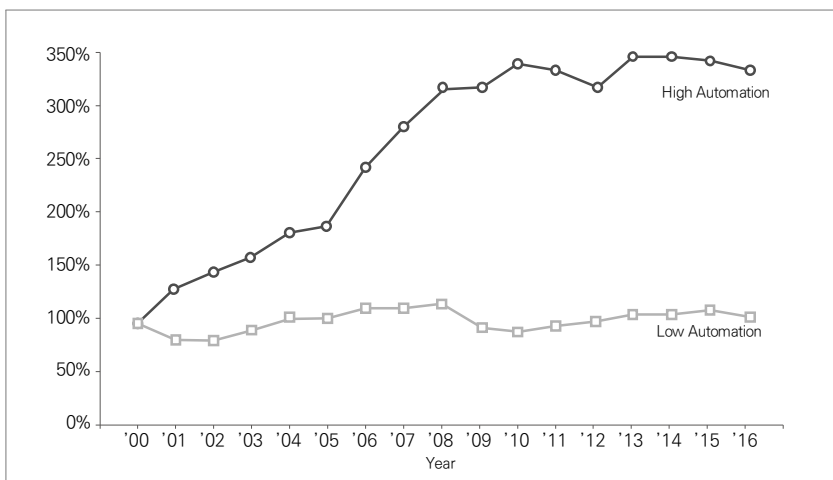
Source: Author's own compilation

Figure 12. Growth in Exports from Developing Economies in High Automation and Low Automation Industries (2000 – 2016)



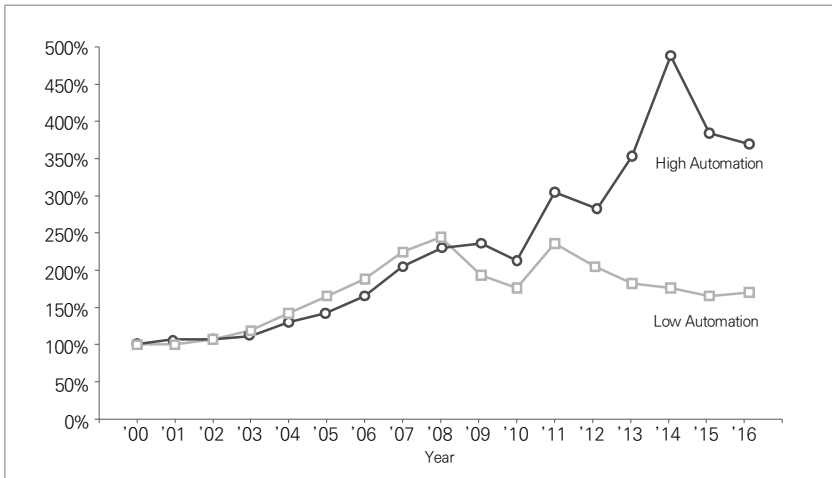
Source: Author's own compilation

Figure 13. Growth in Imports by Developed Economies in High Automation and Low Automation Industries (2000 – 2016)



Source: Author's own compilation

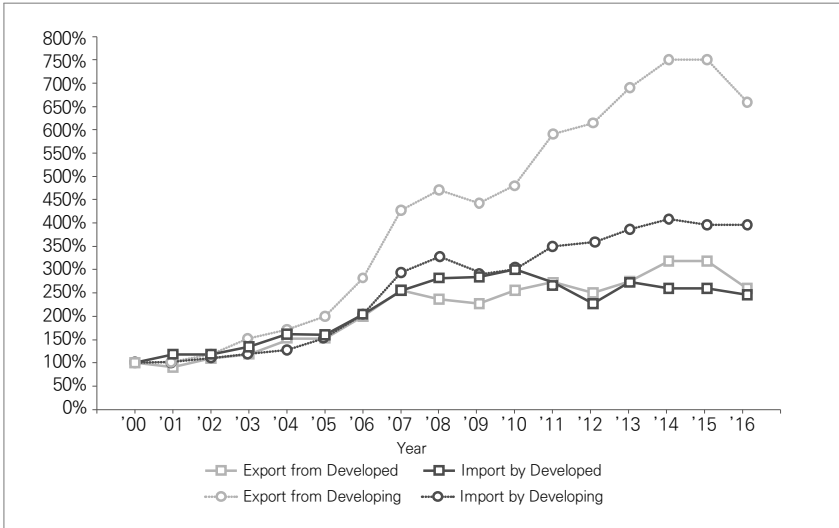
Figure 14. Growth in Imports by Developing Economies in High Automation and Low Automation Industries (2000 – 2016)



Source: Author's own compilation

We visualize trade patterns in specific service industries in Figures 15-17. Figure 15 illustrates international trade growth in the finance and insurance industries. Since 2000, the exports from developing economies have increased more than 700%, possibly thanks to outsourcing of operations, such as software development, call centers, trading, or other business process operations. At the same time, Figure 15 shows that the financial service exports from both developing and developed economies have declined since 2014, even though the overall finance industry continues to witness rapid growth after the financial crisis in 2008-2009. As outlined above, we speculate that this can be attributed to development in intelligent automation technologies.

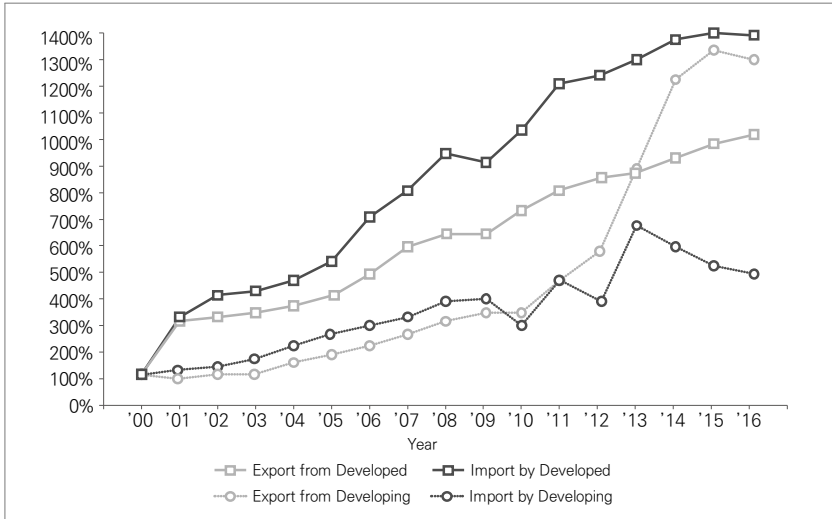
Figure 15. ServicesExport and Import in Financial Services
(2000 – 2016)



Source: Author's own compilation

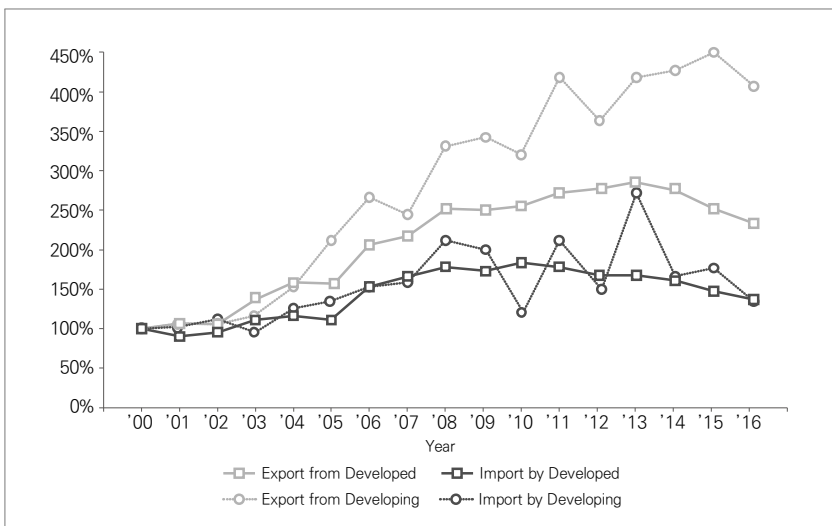
Figure 16 demonstrates exponential trade growth in the professional and technical service industries since 2000. While we see general growth patterns in all four lines, what is notable is a steep growth in exports from developing economies (red line). This is also thanks to advances in ICT and growth in outsourcing by service producers in developed economies. Similar to Figure 15, Figure 17 exhibits growth in global trade in the information industries until 2013 and subsequent decline after 2014. Likewise, thanks to service outsourcing by developed economies, service exports in information industries by developing economies experienced faster growth than imports. For comparison, Figure 18 shows growth in global trade in the art, entertainment, and recreation industries. It shows continuous growth in trade since 2000. While the exports from the developed economies started to decline in 2014, this pattern is not consistent across the other categories in the figure.

Figure 16. Services Export and Import in Professional, Scientific, and Technical Services (2000 – 2016)



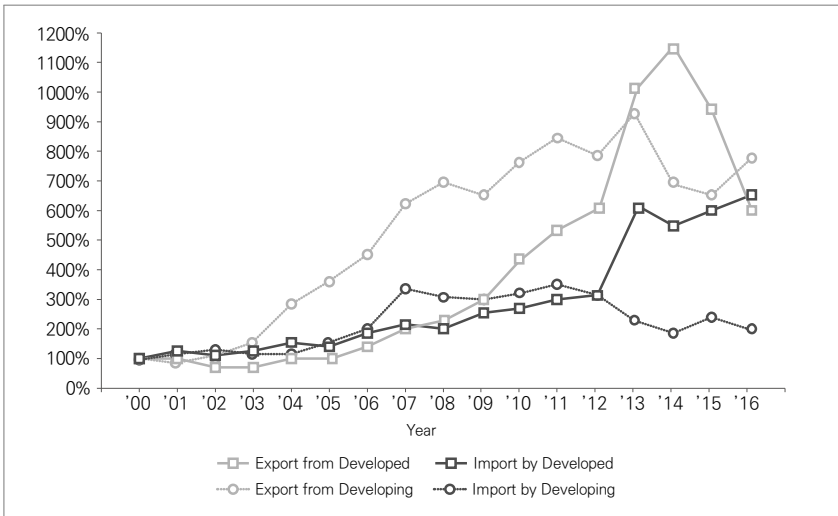
Source: Author's own compilation

Figure 17. Services Export and Import in Information Services (2000 – 2016)



Source: Author's own compilation

Figure 18. Services Export and Import in Art, Entertainment, and Recreation (2000 – 2016)



Source: Author's own compilation

4. Data Analysis Models

One of the widely used models for analyzing international trade is called the gravity equation.⁵³⁾ According to the gravity equation, the volume of trade between two countries is proportional to the product of their masses (GDPs) and inversely related to the distance between them. In this study, we take a slightly different approach to estimating the effect of intelligent automation on international trade in services. While we take into account the GDPs of the importing and exporting countries in our model, we do not explicitly include the distance between the exporting and importing countries. Instead, we include in the model importer/exporter fixed effects which absorb such attributes as distance.

53) Kmura, F. & Lee, H. (2006), “The Gravity Equation in International Trade in Services,” *Review of World Economics*, 142(1), 92-121.

To investigate the impact of automation in global trade in services, we estimate the following models. First, we estimate Eq. 1 as a baseline model.

$$Y = \beta_T T + X\beta_X + \epsilon, \quad (1)$$

where Y is the log-transformed amount of services trade in US Dollars (Services Trade), T is the year ranging from 0 to 16 (0 for 2000 and 16 for 2016), X is a covariate matrix, and ϵ is a random error term. Eq. 1 is to estimate the baseline annual growth of services trade (β_T). We expect $\beta_T > 0$, meaning that the volume of services trade grows each year.

In Eq. 1, X includes a range of control variables that might affect service trade volumes, such as population, GDP, and education spending of exporting and importing economies, as listed in Table 5. It is important to control these factors to estimate annual trade growth rates independent of other factors. For example, service exports and imports can grow between two countries just because the size of their population or economies (GDP) grows concomitantly. It is also likely that the larger amount of trade in goods takes place between the two, the larger trade in service occurs. The supply and demand for services depend on each economy's investment levels in R&D or education and size of the service sectors (measured by the percentage of service sector production and employment). The demand for service is likely to be associated with unemployment level in service importers; likewise, a high unemployment rate would allow service producers to export services at a cheaper price.

Eq. 1 also includes fixed-effects for exporting countries, importing countries, and service industries to account for country-specific and industry-specific unobserved heterogeneity that is not captured in the variables in Table 5. By doing so, our analyses can account for such factors as country-level trade policies, the presence of free-trade agreements or trade barriers between two countries, and idiosyncratic political environments. We estimate Eq. 1 and other models with ordinary least squares (OLS) regressions.

Table 5. Variable Descriptions

Variables	Definitions	Sources
Trade in Services	Log(service trade value in US\$)	UN Comtrade
Exporter Population	Log(population)	World Bank
Exporter GDP	GDP per capita (US \$1,000)	
Exporter Service Ind.	% of service sector GDP to total GDP	
Exporter FDI	Net foreign direct investments per capita (US \$1,000)	
Exporter R&D	% of R&D investments to total GDP	
Exporter Education	% of government education spending to total GDP	
Exporter Service Emp.	% of employment in the service sector	
Exporter Unemployment	Unemployment rates (%)	
Importer Population	Log(population)	
Importer GDP	GDP per capita (US \$1,000)	
Importer Service Ind.	% of service sector GDP to total GDP	
Importer FDI	Net foreign direct investments per capita (US \$1,000)	
Importer R&D	% of R&D investments to total GDP	
Importer Education	% of government education spending to total GDP	
Importer Service Emp.	% of employment in the service sector	
Importer Unemployment	Unemployment rates (%)	
Trade in Goods	Log(total value of trade in goods between the same exporter and importer in the same year in US\$)	UN Comtrade

Source: Author's own compilation

After setting up a baseline annual growth rate of services trade, we run Eq. 2 to test the moderating impacts of automation in service industries on annual trade growth.

$$Y = \beta_T T + \beta_{TA} \text{Automation} \times T + X \beta_X + \varepsilon, \quad (2)$$

If $\beta_{TA} > 0$, it would mean that global trade grows faster annually for service industries that are more automatable. If $\beta_{TA} < 0$, it would indicate that trade grows slower for highly automatable service industries.

In all our estimations, we control for the size of trade in goods (Trade in Goods) and several economic indicators of both exporting and importing

countries (Table 5). We control for population, per capita GDP, and the percentage of the service sector to GDP. The control variables include each country's investment patterns, measured by per capita net foreign direct investments (FDI) and the share of R&D investments. Our estimations control for employment characteristics with government spending on education, service sector employment, and unemployment rates. Appendix Tables A1 and A2 offer descriptive statistics and correlations among the variables, respectively.

Chapter 4



International Trade in Services and Automation

1. Annual Growth Rates in International Trade in Services
2. Growth Rates in Highly Automatable Service Industries
3. Growth in Services Trade in Developed vs. Developing Economies
4. Growth in Services Trade by Different Levels of ICT Development
5. Growth in Services Trade in High GDP/Income vs. Low GDP/Income Economies
6. Growth in Services Trade by APEC Member Economies
7. Analyses of Select APEC Member Economies
8. Summary of Key Findings

1. Annual Growth Rates in International Trade in Services

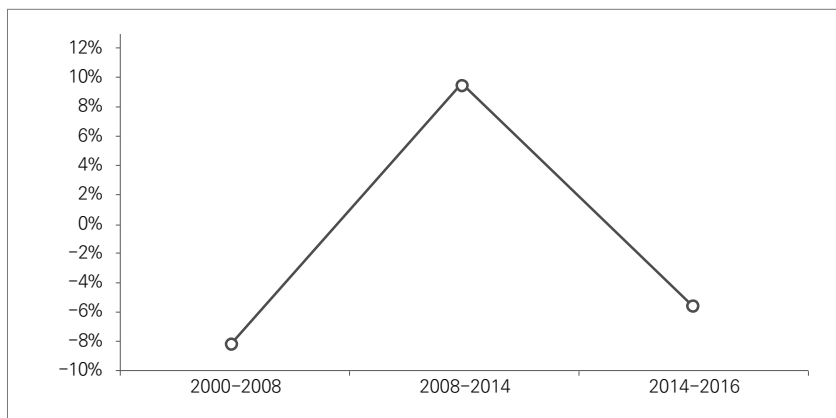
Appendix Table A3 presents the estimation results of Eqs. 1 and 2. As expected, the coefficient of Year is positive and significant in Column 1 for Eq. 1. The annual growth of international trade in services is estimated to be 1.67%.⁵⁴⁾ The coefficients of the control variables suggest that the volume of services trade is greater between the countries with larger R&D investments and smaller service production, but larger service sector employment. Both R2 and adjusted R2 in Column 1 are over 0.6, indicating significant explanatory power of the model. The estimation in Column 2 (Eq. 2) shows that the coefficient of Year $\times$ Automation is positive and significant. In other words, the service industries that are highly automatable have demonstrated faster growth in 2000-2016. This finding from Column 2 does not change when we use year fixed-effects, instead of the year variable, as in Column 3.

It might be the case that the speed of global trade growth changes over time because of technological developments, changes in geopolitical circumstances, and other factors. To examine this possibility, we divide our timeframe (2000-2016) into three periods (2000-2008, 2008-2014, and 2014-2016).⁵⁵⁾ We choose 2008 as a baseline for the second period for the global financial crisis. In addition, we consider 2014 a baseline for the third because Figures 1-4 indicate a decline in international trade in services after 2014. Appendix Table A4 presents the estimations of Eq. 1 with the three periods. Column 1 shows that controlling for other factors, such as population and GDP, the annual service growth (the coefficient of Year) was estimated to be negative and significant in 2000-2008. On the other hand, Column 2 shows that the

54) $e^{0.0166} - 1 = 0.0167$

55) The data in 2008 are included in the estimations in both Columns 1 and 2 of Table A4. Likewise, the data in 2014 are included in the estimations in both Columns 2 and 3 of Table A4

Figure 19. Estimated Annual Growth Rates in International Trade in Services



Source: Author's own compilation

estimated trade growth is positive and significant in 2008-2014. After 2014, however, the coefficient of Year is estimated to be negative but not statistically significant. Figure 19 visualizes this finding. This is consistent with Figures 3-5, which demonstrate a declining trend in services trade after 2014.

The coefficients of the control variables in Table A4 provide additional insights. For instance, the coefficients of exporter and importer GDP are positive and significant in Column 1 (2000-2008) but not in Columns 2 and 3 (2008-2016). In other words, in 2000-2008, a larger economy size is associated with greater service imports and exports, but that is not the case after 2008. More importantly, the coefficients of service employment of both exporters and importers are positive and significant in Column 1 (2000-2008) but become negative and significant in Columns 2-3 (2008-2016). This is a different result from Table A3. This result suggests that after 2008, a large amount of service exports is not associated with an increase in employment in the service sector. In a similar vein, Table A4 shows that the coefficients of unemployment rates in both the exporting and the importing countries are negative and significant in Column 1, but positive and significant in

Column 3. Again, it appears that in recent years, an economy can increase service exports without necessarily hiring more workers, possibly thanks to the use of automation technologies.

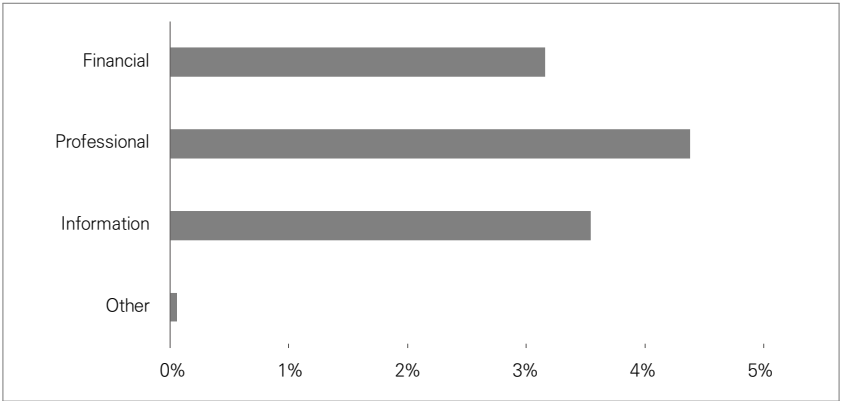
Appendix Table A5 presents the estimations of Eq. 2 with the three time periods. The coefficient of $\text{Year} \times \text{Automation}$ is estimated to be positive and significant in Columns 1-2 (2000-2008 and 2008-2014, respectively). In other words, the global trade in the service industries with a higher degree of automation rose faster than in other industries until 2014. However, Column 3 provides the opposite result; the coefficient of $\text{Year} \times \text{Automation}$ is negative and significant. Since 2014, it appears that the service industries that are highly automatable have not grown in trade as fast as other less-automatable industries. This is consistent with our prediction that advances in AI and other automation technologies allow service producers to automate the business processes and reduce their reliance on offshore service outsourcing.

2. Growth Rates in Highly Automatable Service Industries

In the preceding analyses, we investigate service trade growth in all service industries in aggregate. In this sub-section, we compare the trade growth rates of the three highly automatable industries – finance and insurance, professional, and information – to those of all the other service industries. To do so, we estimate a model with the interactions of Years and the indicators for the four service industries for 2000-2016. Appendix Table A6 presents the result, and Figure 20 exhibits the estimated annual growth rates in the four industries. We find that the service industries in professional, technical, and scientific fields witnessed the fastest annual growth in international trade (more than 4%). Services trade in finance and information also grew by more than 3% annually in 2000-2016. On the other hand, the overall growth rate of all other non-automatable services is found to be insignificant.

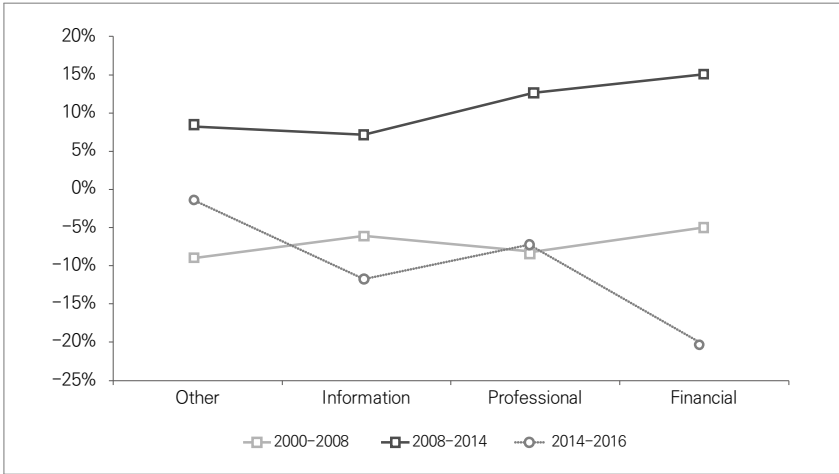
As in Tables A4 and A5, we estimate the growth trends in the three time periods separately for the four service categories. Appendix Table A7 reports the estimation results, and Figure 21 exhibits the estimated growth rates in 2000-2008, 2008-2014, and 2014-2016. As can be seen from Table A7 and Figure 21, the global trade growth in all service industries was lagging before 2008. After 2008, on the other hand, the highly-automatable service industries, particularly the finance/insurance and professional services, witnessed substantial trade growth by more than 10% annually in 2008-2014. This pattern once again reverses in 2014-2016. While the service industries other than finance, information, and professional did not experience as much decline in international trade in 2014-2016, all of the three high-automation service industries suffered a significant decrease in trade volume by more than 7% annually in the same period. The finance and insurance industries witnessed the biggest decline in trade growth rates by more than 20% per year in 2014-2016. This illustrates that advances in intelligent automation in recent years allow importers in finance/professional/information services to automate service production, leading a decrease in service exports, a pattern that we do not observe in other less automatable industries.

Figure 20. Estimated Growth Rates in Services Trade by Industries (2000 – 2016)



Source: Author's own compilation

Figure 21. Estimated Growth Rates in Services Trade by Service Industries and Three Periods



Source: Author's own compilation

3. Growth in Services Trade in Developed vs. Developing Economies

Next, we investigate how growth trends in services trade and the impact of automation differ in developed and developing economies. In doing so, we categorize the countries into developed economies and developing economies based on the designation in the 2018 World Economic Situation and Prospects (WESP) report⁵⁶⁾ by the U.N. Department of Economic and Social Affairs. As shown in Table 6, 37 countries are designated as developed economies, and all the other nations are grouped as developing ones.

56) United Nations (2018), “World Economic Situation and Prospects 2018,” https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/WESP2018_Full_Web.pdf

Table 6. List of Developed Countries Designated by the United Nations

European Union	New EU Members	Other Europe Countries	Other Countries
Austria	Bulgaria	Iceland	Australia
Belgium	Croatia	Norway	Canada
Denmark	Cyprus	Switzerland	Japan
Finland	Czech Republic		New Zealand
France	Estonia		The United States
Germany	Hungary		
Greece	Latvia		
Ireland	Lithuania		
Italy	Malta		
Luxembourg	Poland		
The Netherlands	Romania		
Portugal	Slovakia		
Spain	Slovenia		
Sweden			
The United Kingdom			

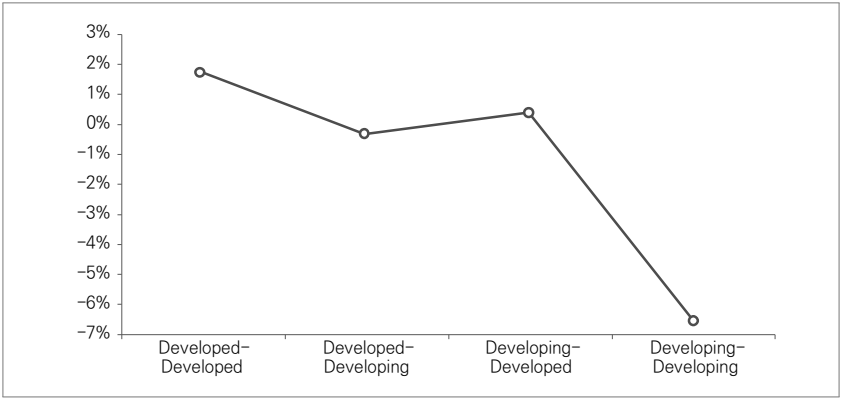
Source: United Nations (2018), “World Economic Situation and Prospects 2018.”

We create four dummy variables by a two-by-two designation (Developed-Developed, Developed-Developing, Developing-Developed, and Developing-Developing) to indicate the trading relationships. For example, Developed-Developed is equal to one when both an exporting and an importing country are among the developed economies (e.g., Australia to Canada or Japan to France). Developed-Developing is one when an exporter is a developed nation and an importer is a developing one (e.g., the U.S. to South Korea or New Zealand to Chile). We interact the four dummy variables with the year variable to estimate annual growth rates in services trade among the developed and developing economies.

Appendix Table A8 provides the estimation results with the full dataset for 2000-2016, and Figure 22 demonstrates the estimated growth rates for

the four possible combinations of trade between developed and developing economies. In 2000-2016, only the services trade between the developed economies has experienced positive growth (by 1.8% a year). We can see a decline in services trade between the developing economies in 2000-2016, while the growth rates in trade between the developed and developing economies are found to be statistically insignificant.

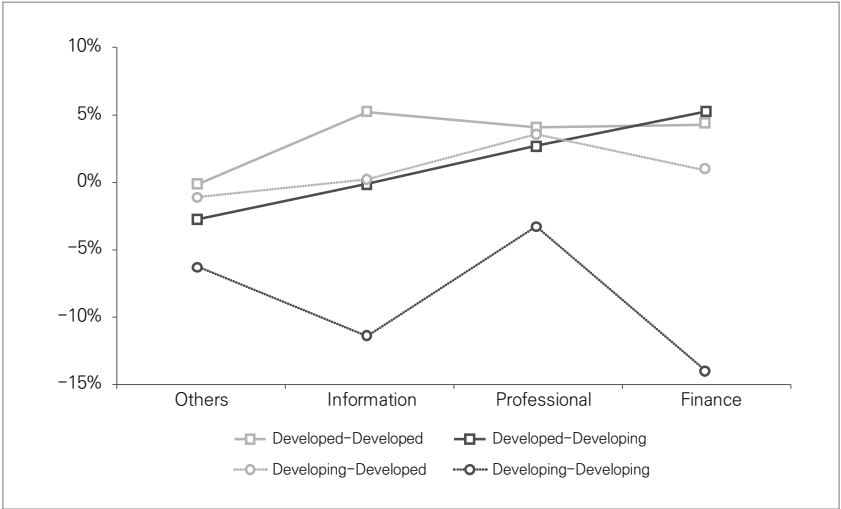
Figure 22. Estimated Growth Rates in Services Trade by Developed/Developing Economies (2000 – 2016)



Source: Author's own compilation

In Appendix Table A9, we further break down the trade growth rates among the developed and developing economies into the four service industries, whose results are exhibited in Figure 23. Appendix Table A9 and Figure 23 show that in the finance and professional service industries, there has been significant annual growth in trade between the developed economies and from the developing to the developed economies. The services trade between developing economies demonstrates a declining trend in all industry categories. Service exports and imports between developed economies have been growing for high automation industries (information, professional, finance).

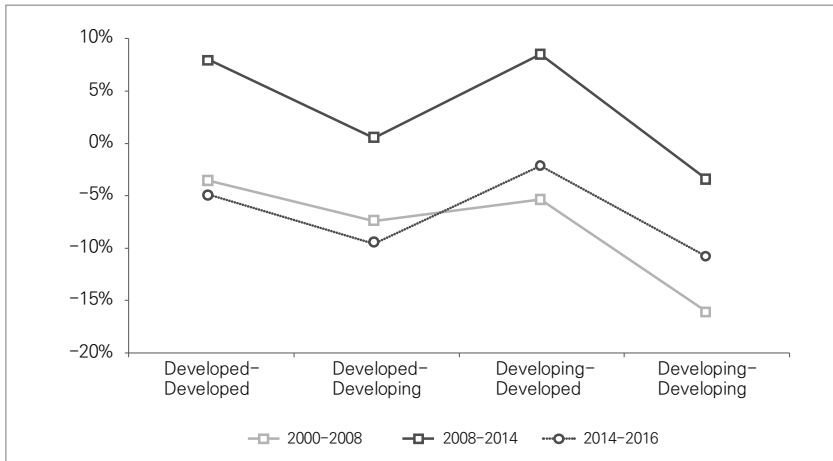
Figure 23. Estimated Growth Rates in Services Trade by Service Industries and Developed/Developing Economies (2000 – 2016)



Source: Author's own compilation

As in Appendix Tables A4 and A5, we divide the full dataset into the three periods (2000-2008, 2008-2014, and 2014-2016) and replicate the analyses in Appendix Tables A10 and A11. Appendix Table A10 and Figure 24 show that the services trade between the developed economies and the exports from the developing to the developed economies had a declining trend in 2000-2008 (Column 1 in Appendix Table A10) but an increasing move in 2008-2014 (Column 2). However, these growth rates have become statistically insignificant for 2014-2016 (Column 3). One explanation for this lack of growth in service exports from developing to developed economies in 2014-2016 is automation in service production in the developed economies. We observe similar patterns in the exports from developed to developing economies and in the trade between developing economies.

Figure 24. Estimated Growth Rates in Services Trade by Developed/Developing Economies and the Three Periods

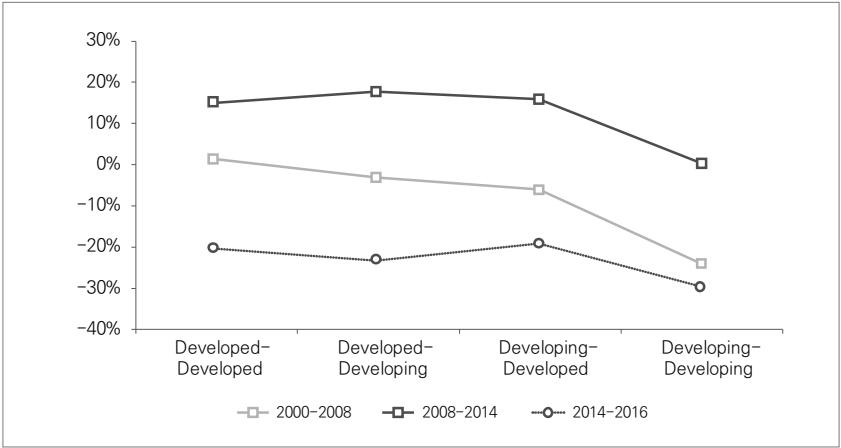


Source: Author's own compilation

In Appendix Table A11, we replicate the analysis in Appendix Table A9 with the three periods, and Figures 25-28 visualize the estimated growth rates in trade for the four service industries among the developed and the developing economies. All of Figures 25-28 demonstrate a clear pattern that international trade in services was growing in 2008-2014 but declining in 2014-2016. The difference between 2008-2014 and 2014-2016 is the starkest for the finance and professional service industries (Figures 25-26), the two industries that are most automatable. Figures 25-27 show that in all highly automatable service industries, the estimated growth rates in global trade in 2014-2016 are negative and significant for all trade relationships (Developed-Developed, Developing-Developed, Developed-Developing, and Developing-Developing). Appendix Table A11 and Figure 28 show that in the service industries that are not in the finance, professional, and information industries, the estimated growth rates in 2014-2016 are not significantly different from zero in all four trade relationships. This result further affirms our contention that since 2014, service producers increasingly

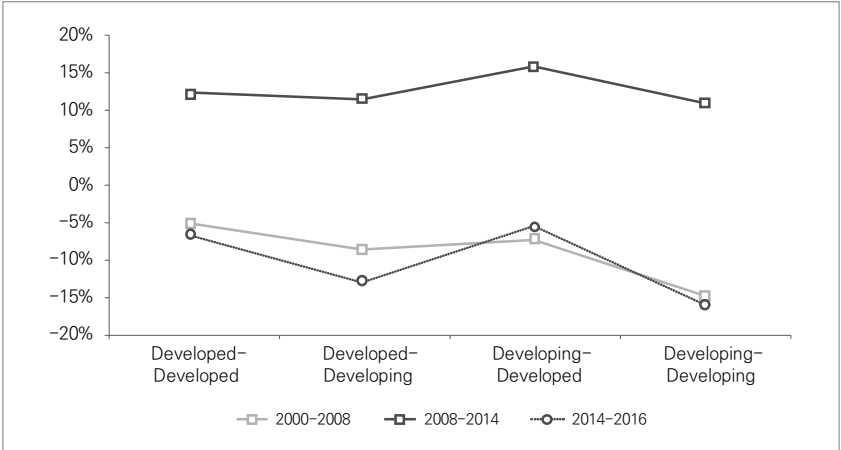
rely on digital technologies to automate their business processes, leading to a decline in service outsourcing that takes advantage of low-wage labors in the developing economies.

Figure 25. Estimated Growth Rates in Trade in Finance and Insurance Servicesby Developed/Developing Economies



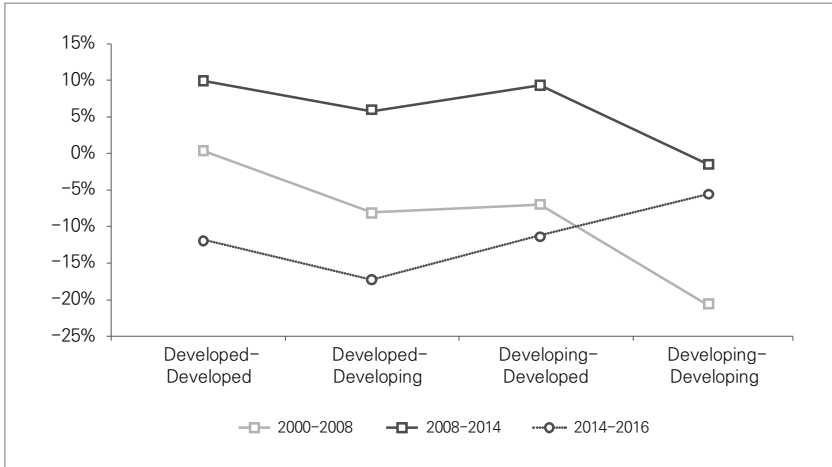
Source: Author's own compilation

Figure 26. Estimated Growth Rates in Trade in Professional, Scientific, and Technical Servicesby Developed/Developing Economies



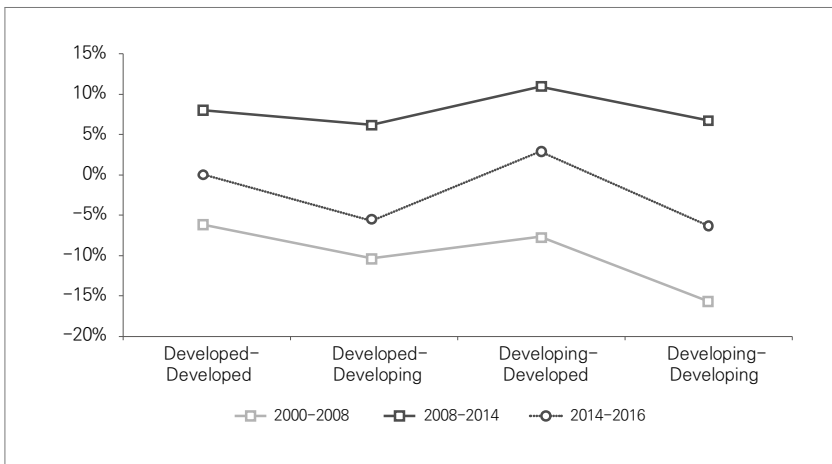
Source: Author's own compilation

Figure 27. Estimated Growth Rates in Trade in Information Services by Developed/Developing Economies



Source: Author's own compilation

Figure 28. Estimated Growth Rates in Trade in Other Low-Automatable Services by Developed/Developing Economies



Source: Author's own compilation

4. Growth in Services Trade by Different Levels of ICT Development

How does the development of information and communication technologies (ICT) in a country affect international trade in services with other economies? To explore this question, we utilize the economy-level ICT Development Index (IDI) measured by the United Nations International Telecommunication Union (ITU). The ITU has published the level of ICT development in each country by measuring ICT readiness (infrastructure, access), ICT use (intensity), and ICT capability (skill).⁵⁷⁾ To do so, it integrates several indicators such as the number of active mobile telephone subscribers per capita, broadband Internet bandwidth, and the percentage of households with broadband access. Table A20 lists the ten economies with the highest levels of ICT development and the ten others that are at the lowest levels. We expect that in the economies with more developed ICT infrastructure, service importers are better able to automate service production and more likely to replace service imports with automation.

To investigate this possibility, we replicate the analyses in Appendix Table A10. Instead of dividing the sample into the developed and the developing economies, we divide them into high-ICT and low-ICT economies based on the median value of ICT Development Index (5.84) and construct the four trading relationship indicators, just as we did in Appendix Tables A10-A19. In Appendix Table A21, HighICT-HighICT refers to services trade between the economies with more developed ICT infrastructure. LowICT-HighICT refers to service exports from an economy with less developed ICT to one with more developed ICT. Likewise, LowICT-LowICT indicates service trade relationships between the economies with less developed ICT infrastructure. In Appendix Table A21, the coefficients of the interactions of Year and the

57) <https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2016/methodology.aspx>

four training relationship indicators show the estimated annual growth rate in services trade. While all coefficients are positive and significant, t-tests show that that of $\text{Year} \times \text{LowICT-HighICT}$ is significantly smaller than those of $\text{Year} \times \text{HighICT-HighICT}$ and HighICT-LowICT ($p < 0.05$).

Appendix Table A22 provides interesting findings. Column 2 shows that in 2008-2014, global trade in services in all relationships, regardless of the level of ICT development, has grown year-by-year significantly, a finding that is consistent with Figure 24 and Table A10. By contrast, Column 3 shows that since 2014, services trade that is involved with high-ICT economies (either as exporters or importers) show a declining annual trend (as indicated by negative and significant coefficients with HighICT-HighICT , HighICT-LowICT , and LowICT-HighICT). The results in Appendix Tables A21 and A22 are in accordance with our conjecture that service importers in the economies with more developed ICT infrastructure can better take advantage of automation technology for service production, relying less on off-shore service outsourcing. Intriguingly, on the other hand, the positive and significant coefficients of $\text{Year} \times \text{LowICT-LowICT}$ shows that service trade amongst low-ICT economies has grown, and its annual growth rate has been larger than prior 2014 (Appendix Table A22, Column 1-2).

In Appendix Table A23, we dig deeper by interacting trade relationship indicators with industry-level Automation measures (Table 1). The coefficients of the interactions of Year, Automation, and the trading relationships in Column 2 shows that in 2008-2014, the annual growth rates of services trade are higher for more automatable industries in any trading relationships. On the other hand, the result in Column 3 demonstrates that the declining trends in service exports by or imports to the high-ICT economies are accentuated for highly automatable industries. This is not the case with service trade between the low-ICT economies; trades in highly automatable service industries grow faster annually between the economies with less developed ICT infrastructure in 2000-2016 (Columns 1-3).

5. Growth in Services Trade in High GDP/Income vs. Low GDP/Income Economies

In the preceding sub-section, we categorize the nations into developed and developing economies following the designation by the U.N. Here, instead of this classification, we use per capita GDP to group the nations. Using the median value of per capita GDP (approximately \$22,000), we divide the economies into high-GDP and low-GDP nations and create the four dummy variables in a similar manner with the previous section. Here, HighGDP-HighGDP indicates trading relationships between the high GDP nations, while HighGDP-LowGDP refers to exports from the high GDP to the low GDP countries. We replicate the analyses in Appendix Tables A8-A11 with the GDP classifications as presented in Appendix Tables A12-A15, which provide consistent results.

Table 7. List of High-Income Countries Designated by the United Nations

Australia	Estonia	Lithuania	Singapore
Austria	Finland	Luxembourg	Slovak
Bahrain	France	Malta	Republic
Barbados	Germany	The Netherlands	Slovenia
Belgium	Greece	New Zealand	Spain
Brunei and Darussalam	Hong Kong	Norway	Sweden
Canada	Iceland	Oman	Switzerland
Chile	Ireland	Poland	Taiwan
Croatia	Israel	Portugal	Trinidad and Tobago
Cyprus	Italy	Qatar	United Arab Emirates
Czech Republic	Japan	Republic of Korea	The United Kingdom
Denmark	Kuwait	Russian Federation	The United States
Equatorial Guinea	Latvia	Saudi Arabia	Uruguay

Source: United Nations (2018), “World Economic Situation and Prospects 2018”

We further analyze the trading patterns using income levels instead of GDP. We use the classification by the U.N. for high-income countries (Table 7), based on gross national income (GNI) and group the nations into high-income and low-income economies. Then we replicate the analyses in Appendix Tables A8-A11 with the high-low income classification. The results offered in Appendix Tables A16-A19 document similar results.

6. Growth in Services Trade by APEC Member Economies

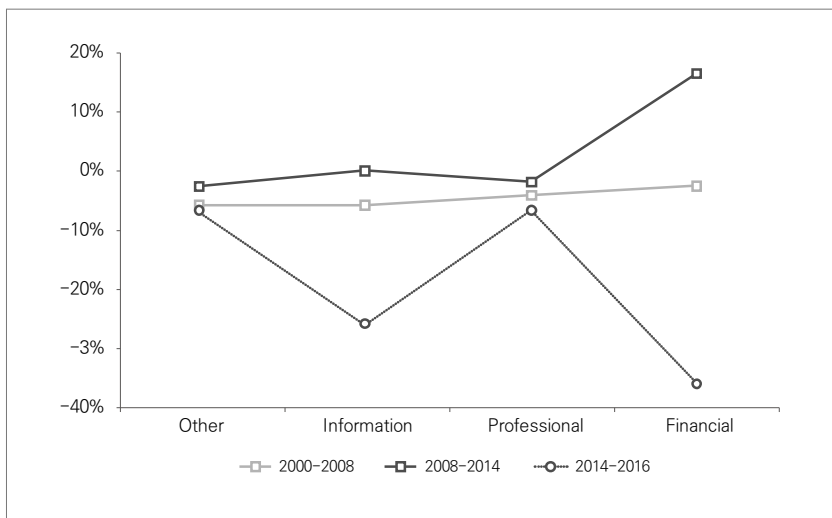
We investigate trade growth patterns by the economies in APEC. In Appendix Tables A24 and A25, we replicate the analyses in Appendix Table A7 by limiting the sample to APEC economies. Table 8 lists 21 APEC members.

Table 8. List of APEC Members			
Australia	Hong Kong, China	Mexico	Russia
Brunei Darussalam	Indonesia	New Zealand	Singapore
Canada	Japan	Papua New Guinea	Chinese Taiwan
Chile	Republic of Korea	Peru	Thailand
People's Republic of China	Malaysia	The Philippines	The United States
			Viet Nam

Source: APEC website, <https://apec.org/About-Us/About-APEC/Member-Economies>

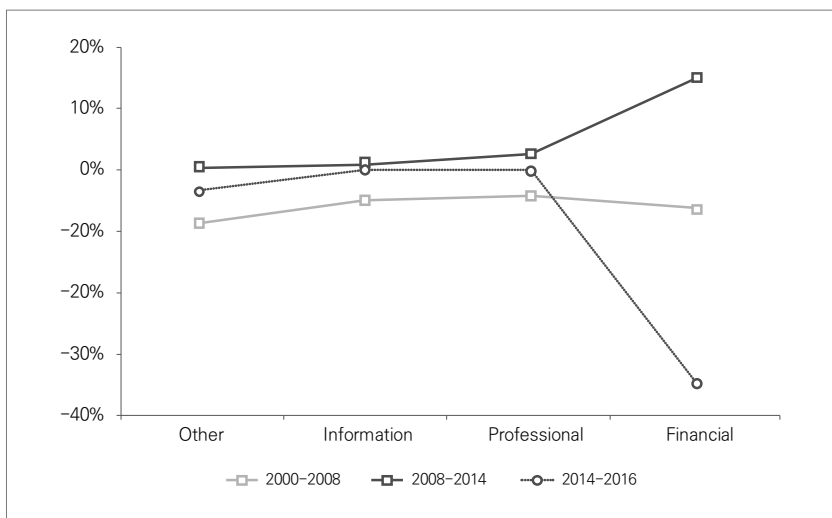
We analyze growth in service exports and imports by APEC economies in Appendix Tables A24 and A25, respectively. We obtain similar results in Appendix Tables A24-A25 to Appendix Table A7, which are visualized in Figures 29-30. Service exports and imports in the finance and insurance industries by APEC economies experienced substantial growth in 2008-2014

Figure 29. Estimated Growth Rates in Services Export from APEC Economies by Industries



Source: Author's own compilation

Figure 30. Estimated Growth Rates in Services Import by APEC Economies by Industries



Source: Author's own compilation

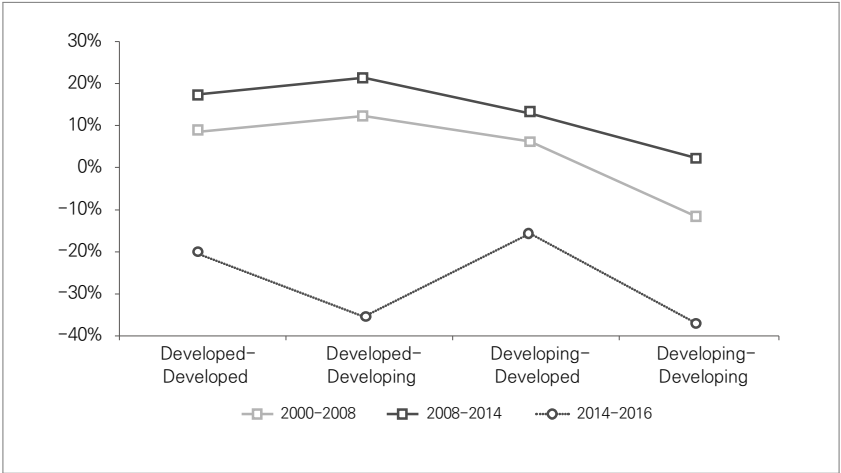
but the trends have reversed in 2014-2016. Exports in the information services from APEC economies have also declined in 2014-2016. These results signal that developments in intelligent automation in recent years may be replacing service exports with digitized service production. Figures 29 and 30 also show that growth rates in exports and imports in professional and other less automatable services by APEC economies have not changed much in 2000-2016.

With the same approach, we replicated Appendix Table A11 for service exports and imports by APEC economies in Appendix Tables A26 and A27, respectively. Once again, Appendix Tables A26 and A27 provide similar results to Appendix Table A11. Figures 31 and 32 exhibit service exports and imports in the finance and insurance industries, respectively. Figure 31 shows that service exports in the finance industries from the developed economies in APEC to other developing economies have decreased the most in 2014-2016. Likewise, Figure 32 demonstrates that service imports in finance by the developed economies from developing countries have declined most significantly, most likely because of digitization by intelligent automation in service outsourcing to the developing economies. Figures 31 and 32 also show similar trends for trade in finance industries between developed economies and exports from developed economies in APEC to other developing economies.

In Appendix Table A28, we investigate service trade patterns within APEC economies. In doing so, we limit the sample to service trade observations only between the APEC economies in 2000-2016. Figures 33-35 visualize the results from Appendix Table A28 and demonstrate that services trade within the APEC economies has declined in the period of 2011-2016 in highly automatable service industries (finance, information, and professional services). This trend is most noteworthy in the information industry (Figure 35) but does not appear to be statistically significant in the finance and insurance industries (Figure 33). The growth rates in trade for professional

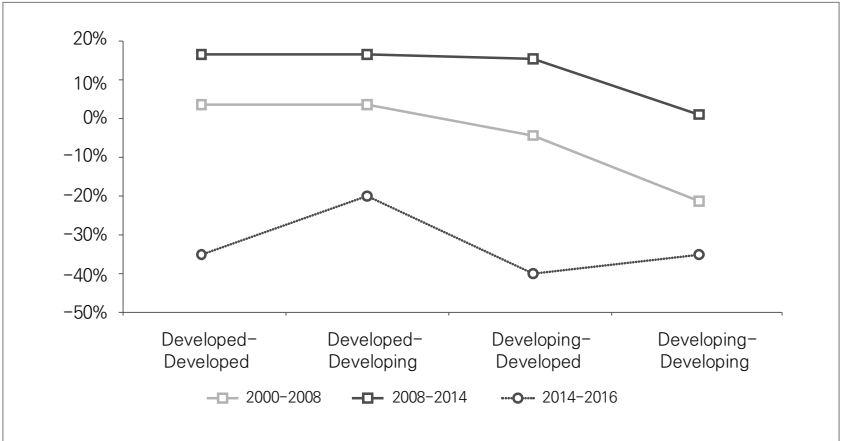
service industries within APEC were not statistically significant in 2000-2012 but it is negative and significant for 2012-2016 (Figure 34).

Figure 31. Estimated Growth Rates in Export in the Finance and Insurance Services from APEC Economies



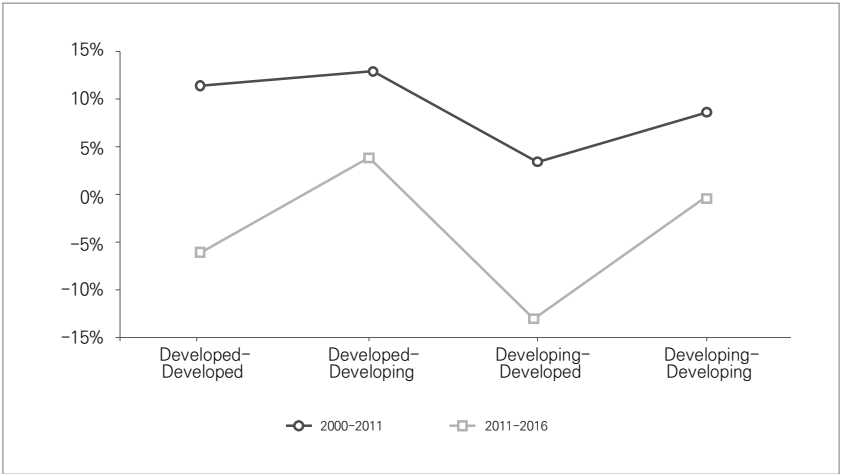
Source: Author's own compilation

Figure 32. Estimated Growth Rates in Import in Finance and Insurance Services by APEC Economies



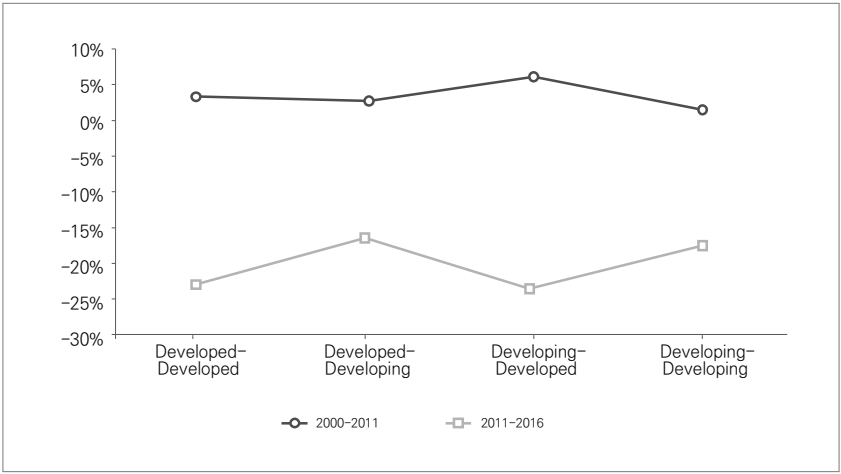
Source: Author's own compilation

Figure 33. Estimated Growth Rates in Trade in Finance and Insurance Services within APEC Economies



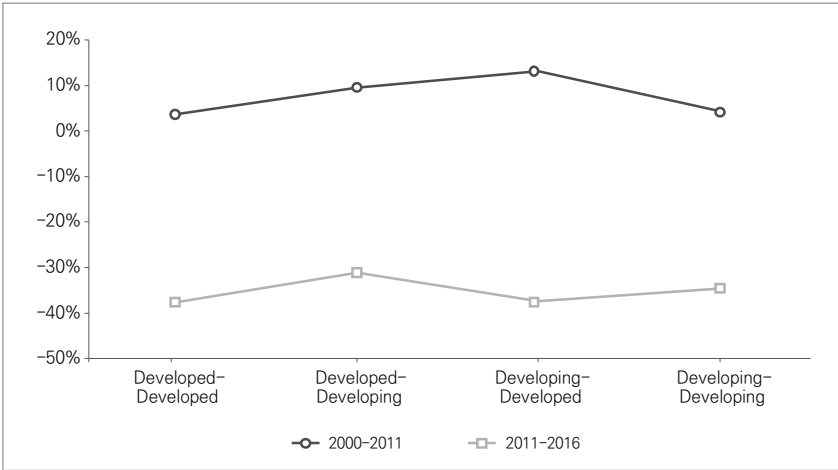
Source: Author's own compilation

Figure 34. Estimated Growth Rates in Trade in Professional, Scientific, and Technical Service within APEC Economies



Source: Author's own compilation

Figure 35. Estimated Growth Rates in Trade in Information Services within APEC Economies



Source: Author's own compilation

7. Analyses of Select APEC Member Economies

We also look at changes in service trade growth for specific economies in APEC and other regions. To do so, we replicate Appendix Table A7 for service exports from large developing economies as well as service imports by large developed economies.

In Appendix Tables A29-A36, we analyze service export trends in 2000-2012 and 2012-2016 from eight large developing economies: China, Russian Federation, Republic of Korea, India, the Philippines, Indonesia, Brazil, and Mexico. Table 9 summarizes the results from Appendix Tables A29-A36. We see a stark difference between 2000-2012 and 2012-2016 for China, Russia, Korea, and India. The service exports from these countries have grown significantly in 2000-2012, but this growth has become muted or reversed in 2012-2016. We could not observe a similar pattern for the other developing economies (the Philippines, Indonesia, Brazil, and Mexico).

Table 9. Growth Rates in Service Exports from China, Russian Federation, Republic of Korea, India, The Philippines, Indonesia, Brazil, and Mexico

		2012–2016	2000–2012
China	Other Services	ns	↑ ***
	Information	ns	↑ ***
	Professional	ns	↑ ***
	Finance	ns	↑ ***
Russia	Other Services	↓ ***	↑ ***
	Information	ns	↑ ***
	Professional	ns	↑ ***
	Finance	ns	↑ ***
Korea	Other Services	↓ +	↑ *
	Information	↓ *	↑ *
	Professional	ns	↑ +
	Finance	↓ *	↑ ***
India	Other Services	ns	↑ +
	Information	ns	↑ **
	Professional	ns	↑ +
	Finance	ns	↑ ***
The Philippines	Other Services	ns	ns
	Information	ns	ns
	Professional	ns	ns
	Finance	ns	ns
Indonesia	Other Services	ns	ns
	Information	ns	ns
	Professional	ns	ns
	Finance	ns	↑ *
Brazil	Other Services	ns	ns
	Information	ns	ns
	Professional	ns	↑ *
	Finance	ns	ns
Mexico	Other Services	ns	ns
	Information	ns	ns
	Professional	ns	ns
	Finance	ns	ns

ns = $p > 0.1$; + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's own compilation

In Appendix Tables A37-A43, we also conduct similar analyses for service imports by the developed economies (U.S., Japan, Canada, Australia, U.K., France, and Germany). Table 10 summarizes the results from Appendix Tables A36-A42. We observe that service imports by France and Germany have risen significantly in 2000-2012, a trend that has become statistically insignificant in 2012-2016. Service imports by Canada are declining in 2012-2016 as well, while service imports by Australia have grown substantially in 2012-2016 across all service industries.

Table 10. Growth Rates in Service Imports by U.S., Japan, Canada, Australia, U.K., France, and Germany

		2012–2016	2000–2012
USA	Other Services	ns	↓ **
	Information	↓ **	ns
	Professional	ns	ns
	Finance	ns	ns
Japan	Other Services	ns	↓ **
	Information	ns	ns
	Professional	ns	ns
	Finance	ns	ns
Canada	Other Services	↓ +	↓ *
	Information	↓ *	ns
	Professional	↓ +	ns
	Finance	ns	ns
Australia	Other Services	↑ ***	ns
	Information	↑ **	ns
	Professional	↑ ***	↑ *
	Finance	↑ **	ns
U.K.	Other Services	ns	ns
	Information	ns	ns
	Professional	↑ *	ns
	Finance	ns	ns
France	Other Services	ns	↑ +
	Information	ns	ns
	Professional	ns	↑ **
	Finance	ns	↑ ***
Germany	Other Services	ns	↑ *
	Information	↓ **	↑ ***
	Professional	ns	↑ *
	Finance	ns	ns

ns = $p > 0.1$; + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Author's own compilation

8. Summary of Key Findings

Our analyses of the global trade in services data from Comtrade yield several notable findings as follows.

- Growth in global trade in highly automatable service industries has slowed down in recent years (Figures 11-12, 15, 17, and Appendix Table A5).
- International trades in the finance/insurance and information service industries rose in 2008-2014 but declined precipitously in 2014-2016 (Appendix Table A7, Figure 21).
- Over 2008-2014, service exports from developing to developed economies grew by more than 8% annually, but this growth became stagnated in 2014-2016 (Appendix Table A10, Figure 24).
- Specifically, service exports from developing to developed economies experienced declines in 2014-2016 in the information and finance industries, but not in other less-automatable service industries (Appendix Table A11, Figures 25, 27). We find similar findings when we divide the countries into high-GDP and low-GDP economies (Appendix Table A15) and into high-income and low-income countries (Appendix Table A19).
- Trade in services between the economies with advanced ICT infrastructures appears to be declining in 2014-2016, but that between the economies with less developed ICT infrastructures has been rising for the same period (Appendix Tables A22-23).
- APEC economies experienced a decline in both exports and imports in the finance/insurance industries in 2014-2016 (Appendix Tables A24-A25).
- Within APEC economies, trade in the information and professional service industries decreased in 2011-2016 (Appendix Table A28).
- Service exports from China, Korea, Russia, and India grew in 2000-2012, but not in 2012-2016 (Appendix Tables A29-A32).
- Service imports by France and Germany rose in 2000-2012, but not in 2012-2016 (Appendix Tables A42-A43).

Chapter 5



Policy Implications and Recommendations for APEC

1. Principles for Policies and Regulations for Intelligent Automation
2. Recommendations for Policy Directions
3. Policy Recommendations for APEC Member Economies
4. Roles of Korea in Promoting Shared Prosperity in APEC Economies

Figure 36. Policy Principles, Directions, and Recommendations

Principles	• Regulate intelligent automation based on empirical evidence • Adopt a Permissionless Innovation Approach • Adopt a light-touch approach to regulation • Be technologically neutral • Ensure consistency in policies and regulations
Policy Directions	• Workforce reskilling and retraining for less automatable jobs • Educating future workforce for high-demand skills and knowledge • Matching employees and employers through digital platforms • Providing basic income and transition support • Creating jobs by promoting entrepreneurship and innovation • Restructuring domestic service industries to the next level • Investing in new network infrastructure • Ensuring interagency coordination in government • Facilitating public-private partnership for solving complex problems • Fostering international collaboration for learning and innovation
Policies for APEC	• Develop regional strategies for APEC member economies • Create APEC joint research programs • Develop an APEC online education platform for reskilling and retraining • Create regional certifications for digital skills • Develop a regional center of excellence for innovation and entrepreneurship • Create an APEC working group to facilitate policy dialogue and cooperation

Source: Author's own compilation

Our analysis results suggest that as AI-powered intelligent automation is becoming increasingly pervasive, global trade in services is declining. This trend is particularly salient since 2014. Furthermore, we find that the highly automatable service industries such as financial services, professional services, and information services have experienced a greater decline in trade than other service industries after 2014. Importantly, we find that the service exports from the developing to the developed economies in the highly automatable industries such as financial services and professional services have declined in 2014-2016. If this trend continues, developing economies that rely heavily on their service exports will face a significant challenge in maintaining, let alone growing, their economies. Therefore, the policymakers of developing economies should take this issue seriously and create smart poli-

cies that help displaced workers find new employment and foster job creation through innovation and entrepreneurship.

In the next section, we discuss the general principles that policymakers in both developing and developed economies in APEC should consider when creating new policies or regulations pertaining to intelligent automation and services trade. Then, we will present our recommendations for policy directions that are mainly geared toward developing economies in APEC. We then discuss more specific policy recommendations for APEC member economies. Figure 36 depicts these principles, policy directions, and policy recommendations.

1. Principles for Policies and Regulations for Intelligent Automation

We propose a set of principles that policymakers and regulators are advised to follow when creating new policies and regulations with regard to intelligent automation. An important objective of policies and regulations for intelligent automation is to strike an optimal balance between boosting innovation and promoting the welfare of citizens. This objective is valid for both developing and developed economies in APEC. The first three principles are closely related to each other in that they collectively promote minimal regulations in order to not hinder innovation. The last principle is based on our observation and analysis of the technology policy history since the birth of the Internet.

A. Regulate intelligent automation based on empirical evidence

There is still much uncertainty about how intelligent automation technologies will evolve and how they will impact services trade and jobs in the

future. Therefore, new regulations for these technologies mainly driven by speculation or fear can limit technological innovation. Instead of reacting prematurely to largely speculative concerns, policymakers should base their policy decisions in economic and empirical analysis. A rigorous cost-benefit analysis needs to be performed before new regulations are proposed. When policymakers need to address specific persistent problems relating to AI-powered intelligent automation, they need to make sure that the proposed policies and regulations target specific, demonstrated issues so as not to unnecessarily constrain innovation in intelligent automation.

B. Adopt a Permissionless Innovation Approach

A traditional regulatory approach tends to be rigid, bureaucratic, and inflexible. This approach can be particularly problematic when it comes to governing new technologies, such as intelligent automation. History suggests that humans have a very poor ability to predict the future of emerging technologies. Therefore, regulators run a risk of making unnecessary regulations if they attempt to create preemptive remedies for hypothetical problems relating to emerging technologies. Therefore, policymakers and regulators are advised to adopt a permissionless innovation approach to avoid this risk. The concept of the permissionless innovation approach is closely related to the evidence-based regulation approach discussed above. It refers to the idea that “experimentation with new technologies and business models should generally be permitted by default. Unless a compelling case can be made that a new invention will bring serious harm to society, innovation should be allowed to continue unabated, and problems, if they develop at all, can be addressed later.”⁵⁸⁾ The three principles of the permissionless innovation approach are as follows:⁵⁹⁾

58) Adam Thierer (2016), “Permissionless Innovation: The Continuing Case for Comprehensive Technological Freedom,” 2nd ed. Arlington, VA: Mercatus Center, George Mason University.

59) Adam Thierer (2017), Andrea Castillo O’Sullivan, and Raymond Russell, *Artificial Intelligence and Public Policy*, Mercatus Center, George Mason University.

- Constraints on innovation should be the last resort, not the first.
- A new policy should not be based on worst-case hypotheticals.
- Flexible, bottom-up solutions are better than rigid, top-down controls.

C. Adopt a light-touch approach to regulation

When it comes to regulating an emerging technology, there is a risk of over-regulation. Heavy-handed regulations limit innovation and increase costs.⁶⁰⁾ Using a light-touch approach, policymakers should allow for the industry and the market to address emerging issues. Furthermore, the existing regulatory framework, instead of rushed new regulations, should serve as a starting point in considering new regulations for intelligent automation. Policymakers should intervene only if market forces fail to address a persistent issue.

D. Be technologically neutral

Policymakers and regulators should not favor any particular technology. In other words, it is not their job to pick a winner or a loser for intelligent automation technologies. History shows that technology-neutral policies allowed for emerging technologies to fully realize their potential. A regulation that mandates particular technologies is not only unnecessary but also can be counterproductive. Policymakers and regulators should create a policy and regulatory environment in which any innovative technologies are freely developed, and the market decides the winner.

E. Ensure consistency in policies and regulations

Emerging technologies such as intelligent automation tend to be subject to oversight from multiple government agencies due to their multidisciplinary

60) Daniel Castro and Joshua New (2014), “10 Policy Principles for Unlocking the Potential of the Internet of Things,” New Center for Data Innovation.

nature. As a result, it is possible that multiple policymakers and regulators create inconsistent policies and regulations. Policymakers should ensure coordination among government agencies to harmonize their policies and regulations. Furthermore, except for certain matters germane specifically to a particular industry, policymakers should develop a holistic policy and regulatory framework that is effective across the industries.

2. Recommendations for Policy Directions

The increasing adoption of AI-powered intelligent automation will hurt service exports from both developing and developed economies. However, the impact of this decline in services trade will be magnified in developing economies such as India and the Philippines than in developed economies. Although we are beginning to see empirical evidence supporting the declining trend in highly automatable services trade, exactly how intelligent automation will play out to displace service workers in developing economies in the long run is still uncertain. Nevertheless, it appears indisputable that developing economies need to rethink their development strategy going forward. What follows are our recommendations for policy directions that are mainly geared toward developing economies in APEC, although some of them might be applicable to developed economies in APEC as well.

Our policy recommendations are based on two different types of strategies that developing economies should consider in response to the threat from AI-powered intelligent automation: (1) reskill and retrain displaced workers in highly automatable service industries and help them find new jobs in less automatable service industries, and (2) turn the threat of intelligent automation into an opportunity by upgrading workers' digital skills and fostering digital innovation and high-tech start-ups. Our recommendations are meant to serve as general guidance for policymakers rather

than solutions tailored to a specific economy. In fact, we do not believe that there is a one-size policy that fits all. Each economy will need to customize their policies and strategies based on the level of their workforce's education and skills, its ability to create and seize future opportunities, and other important economic and social factors.

A. Workforce reskilling and retraining for less automatable jobs

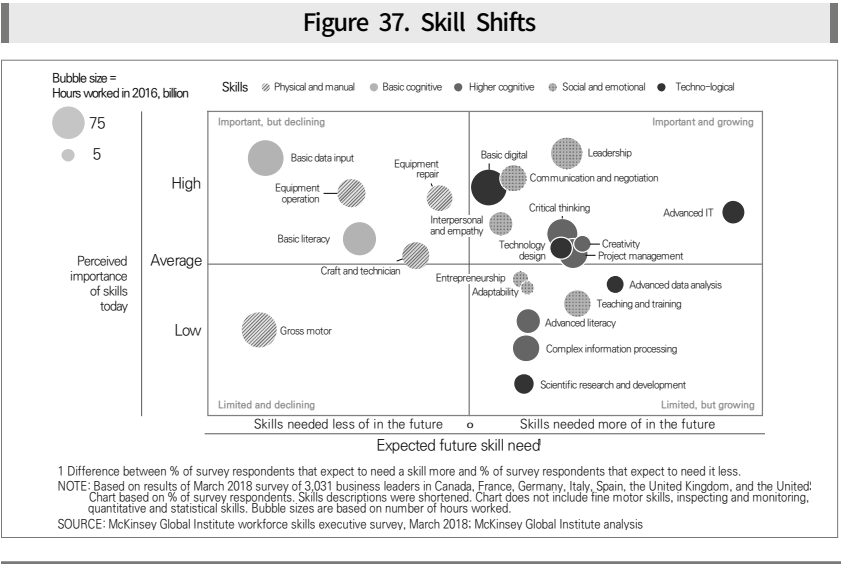
Our investigation provides evidence that intelligent automation is likely to reduce a developing economy's export of highly automatable services. As a result, the demand for highly automatable service jobs in developing economies will decline and many such jobs will be eliminated. However, less automatable service jobs will be less affected by intelligent automation, and their demand could continue to grow. Some of the job categories that might experience automation-driven growth in the future include:⁶¹⁾

- Engagement with automation technologies to complete a service task
- Monitoring and maintenance of automation technologies
- Development of automation technologies

61) Executive Office of the President, U.S.A. (2016), "Artificial Intelligence, Automation, and the Economy," <https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF>

Skills Needed in the Future

McKinsey Global Institute analyzed a wide range of skills and categorized them into skills needed more in the future and skills needed less of in the future. Figure 37 shows the result. The vertical axis indicates the extent to which skills are perceived important today. The horizontal axis indicates the extent to which skills are needed in the future. The top left grid represents skills that are important today but are expected to be needed less in the future. Service jobs based on these skills are more likely to be replaced by intelligent automation. For example, data entry jobs based on basic data input skills fall into this category. On the other hand, the bottom right grid represents skills that are not perceived to be very important today but are needed more in the future. They include advanced data analysis and complex information processing. These are the skills that displaced workers should acquire through retraining. The top right grid represents skills that are important today as well as in the future. Leadership, communication, negotiation, advanced IT, and technology design fall into this category. Finally, the bottom left grid represents skills that are not important today or in the future. These skills are not much of a concern for governments or employees.



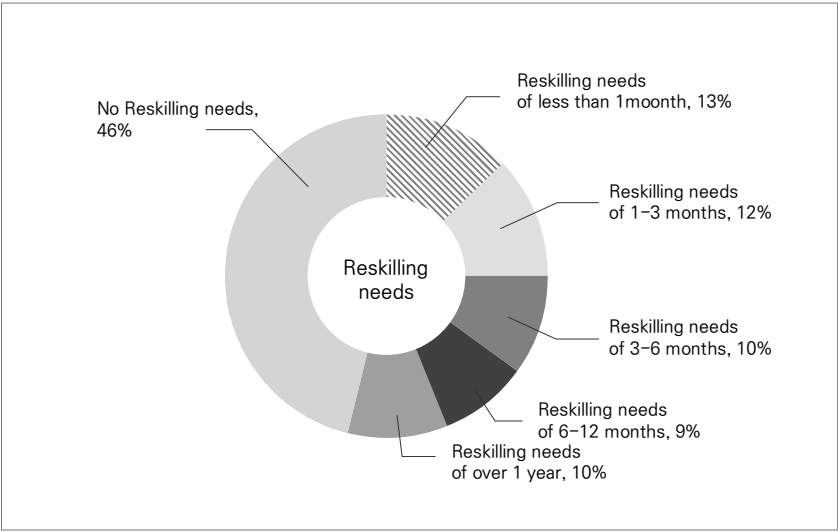
A key challenge is reskilling and retraining the workforce in highly automatable services to develop skills required by less automatable services. Mid-career retraining will become increasingly important as the skill sets needed for service jobs continue to change. History suggests that workforce reskilling on a large scale is by no means an easy undertaking; for example, many workers in the U.S. "Rust Belt" have failed to successfully transition from the skills required by the industrial economy to the ones demanded by the information economy. Therefore, developing economies should take this challenge very seriously. Those who lose their jobs are not always able to get back on track and find new ones. Policies should focus on addressing this issue. Many countries are experiencing low or even declining public investments in workforce training. It is, therefore, crucial to reverse this trend and increase investments in human capital. We recommend the following policies to support workforce reskilling and retraining:

- Incentivize employer's investment in retraining of employees through grants, subsidies, and tax breaks for the employer.
- Facilitate partnerships between employers and education providers.
- Develop online and offline training courses and programs and make them publicly available.
- Offer workers personal accounts that they can use to pay for training.
- Provide free training for the unemployed.
- Create certifications for skills that are in high demand.

Significant Investment Needed for Employee Reskilling and Retraining

According to a 2018 World Economic Forum survey, employers estimate that, by 2022, more than 54% of all employees will require significant reskilling and upskilling. Of these, 19% are expected to require retraining of more than 6 months, while 22% are expected to require retraining of between one month and six months and only 13% need retraining of less than one month (Figure 38). This result suggests a high demand for reskilling and retraining in the coming years. Companies should expect to substantially increase their spending on employee reskilling and retraining.

Figure 38. Expected Average Reskilling Needs (2018-2022)



Source: Future of Jobs Survey 2018, World Economic Forum

B. Educating future workforce for high-demand skills and knowledge

In addition to reskilling and retraining the current workforce, policy-makers should focus on educating the future workforce. Creating curricula and education programs that help students develop skills for which there is a demand should be a top priority in developing economies. However, this could be a slow process as it may take substantial time to develop and recruit qualified, talented educators. Policymakers should identify skills that are needed as intelligent automation diffuses. Such skills may include analytical and creative thinking, interpersonal communication, and emotional control.⁶²⁾ Another important skill might be the ability to tell the intelligent machine what to optimize. This requires understanding both the capabilities of the machine and the goals of the organization.

In addition to figuring out the skills taught in school, another important issue is whether the current education model, in which most education takes place early in students' life, is best. As it is likely that humans will need to continuously retool their skills to be employable, the structure of education delivery needs to adapt. An important issue is how policymakers can facilitate the evolution of education systems to prepare the future workforce to be successful in the era of intelligent automation. We recommend the following education policies to address the issue:

- Develop skill-set requirements appropriate for different educational levels: primary, secondary, and tertiary.
- Develop a mechanism to identify and update high-demand skills and inform new education programs of the evolving skill requirements.
- Establish joint education programs between universities and the private sector.

62) Manuel Trajtenberg (2018), "AI as the next GPT: A Political Economy Perspective," In Agrawal, Gans, and Goldfarb Eds. *The Economics of Artificial Intelligence: An Agenda*. University of Chicago Press.

- Partner with universities to develop AI curricula for primary and secondary schools.
- Create scholarship programs focused on educating high-demand skills.
- Incentivize universities to adopt massive open online courses (MOOCs) to teach critical skills in scale.
- Incentivize higher education institutes to offer continuing education programs focused on reskilling.

C. Matching employees and employers through digital platforms

If the labor market is not efficient, even qualified job seekers may not find their employer in a timely manner, and vice versa. How can policymakers facilitate the matching of workers and jobs? Policymakers in developing economies with inflexible labor markets may learn from some of the developed economies. For example, Germany transformed its federal unemployment agency into a powerful job-matching entity through deregulation. Furthermore, with the rise of the “gig economy,” the role of digital platforms for matching workers and jobs is becoming important. Such digital platforms can improve labor market dynamics and foster labor market fluidity. Policymakers should play an active role in matching skills and jobs and promote the development of digital talent platforms through incentives and deregulation.

D. Providing basic income and transition support

Beyond retraining and matching skills and jobs, policymakers should consider a range of policies that can help displaced workers during the transition. Such policies may include universal basic income, unemployment insurance, and public assistance in finding work.⁶³⁾ Various forms of transition assistance for displaced workers are essential for them to find their next jobs. For

instance, Finland has become the first country in Europe to pay its unemployed citizens a basic monthly income, in a pilot project aimed at reducing poverty and joblessness.⁶⁴⁾ Furthermore, as wages for many jobs can be depressed during workforce transitions, policies to supplement work incomes might be needed to maintain market demand and ensure societal welfare.

E. Creating jobs by promoting entrepreneurship and innovation

Policymakers are advised to consider not only policies that help reskilling and retraining of workers but also policies that facilitate job creation. What if the risk isn't necessarily jobs that are being eliminated, but the jobs that may never be created? One important policy direction to address this issue is to put a greater emphasis on entrepreneurship. It is important to develop and nurture innovation talent at all stages of the education process. In particular, the government should help improve education for entrepreneurship in higher education through partnerships between business and academia. In the era of AI, educating and training entrepreneurship requires a multi-disciplinary approach. Therefore, policymakers should make collaboration across different disciplines within and across universities easier by removing regulatory barriers and providing strong incentives. Furthermore, the government should consider partnering with incubators and accelerators to train future entrepreneurs through high-quality training programs.

Another important element is to strengthen the innovation ecosystem. The government should engage in various forms of funding programs that are open, transparent, competitive, and technologically neutral. For example,

63) McKinsey Global Institute, "Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation," December 2017

64) United Nations ESCAP (2017), "Artificial Intelligence in Asia and the Pacific"

policymakers may establish government-backed venture capital funding, encourage private venture capital investments and crowdfunding for innovative start-ups, and create sandboxes to allow companies to experiment freely without fear of breaking laws and with safeguards to limit the consequences of failure. For example, the U.K. has experimented with innovative regulations in the field of financial technology (FinTech). Their Sandbox policy allows businesses to test out financial services based on innovative FinTech without incurring all the normal regulatory consequences.⁶⁵⁾ In addition, the government should consider establishing a center of innovation to engage in R&D, applications development, training, and policy development.

F. Restructuring domestic service industries to the next level

Developing economies that rely on inexpensive labor for service outsourcing need to advance their service industries to the next level. Policymakers in developing economies are advised to assess the current status of their domestic service industries and develop policies to restructure the industries from low-skilled, routine service providers to high-skilled, creativity-based service industries. As we discussed earlier, routine, structured service tasks such as responding to customer calls or reviewing documents based on predefined rules are increasingly being digitized. Service industries in developing economies need to develop capabilities to offer less automatable services such as healthcare, design, or entertainment. Doing so would require a pool of talented workers who have skills that are more immune to automation, as described in Figure 37 (e.g., critical thinking, leadership, communication). Legal service providers in developing economies, for example,

65) United Nations ESCAP (2017), “Artificial Intelligence in Asia and the Pacific”

will need to offer advisory or consulting services for clients, beyond simple document processing services. As software development itself is increasingly being automated (i.e., software develops software), software outsourcing providers in developing economies will be required to be involved in more creative, design-intensive tasks, rather than routine coding tasks. South Korea offers a great example; it is now a powerhouse of service exports in entertainment such as TV shows, music (known as K-pop), or animation. This redevelopment of service industries in developing economies must be accompanied by reforms in education systems that we proposed above.

Over a longer term, developing economies are advised to build service-driven, consumption-based domestic economies. While it is not in the scope of this research, manufacturing industries are just as vulnerable to automation as service industries. Therefore, developing economies that depend on exports of either manufacturing or services are likely to be hurt most by advances in automation. Such countries are advised to develop domestic consumption-based, service-oriented economies.

G. Investing in new network infrastructure

A high-speed broadband network is a critical infrastructure that is required to reskill and retrain workers in scale, enable workers to work with intelligent automation applications, support start-ups, and facilitate the development of innovative technologies. Many future service workers will work from home or anywhere by using cloud-based software. It will be increasingly more difficult for workers to perform service tasks in an outdated network environment. Policymakers should make it a priority to upgrade both fixed and wireless networks. For example, the government can promote investment in such infrastructure by making government land available for towers and small cells to support 5G connectivity.

H. Ensuring interagency coordination in government

As many government agencies are likely to be involved in the issues pertaining to intelligent automation and service trade, poorly coordinated policies and regulations can confuse and frustrate businesses as well as workers. New forms of service jobs and related automation technologies might be subject to conflicting regulations imposed by different government agencies. Therefore, it is important to ensure effective coordination among them. One possible approach is to create an interagency task force that coordinates all relevant agencies on the issues pertaining to service trade and intelligent automation.

I. Facilitating public-private partnership for solving complex problems

A strong public-private partnership is crucial for addressing complex policy issues such as intelligent automation and its implications for service trade. Public-private partnerships can benefit many programs and initiatives that aim to address a declining service trade due to intelligent automation. For productive partnerships with the private sector, the government should engage in continuous dialogue with companies. Furthermore, the government should consider creating a National Advisory Board of policymakers, industry leaders, and academia that provide policy directions and guidance. Another way to promote public-private collaboration is to create a public working group to address specific issues. A good example can be found in the convening of the Public Working Group on Cyber-Physical Systems (CPS) formed under the sponsorship of the U.S. National Institute of Science and Technology (NIST). This open public forum has fostered stakeholder discussions to define and shape key characteristics of CPS.

J. Fostering international collaboration for learning and innovation

Many developing economies will face challenges associated with intelligent automation. Although these developing economies may be competitors in global trade in services, they will benefit from international collaboration with other developing economies. They may learn from one another in terms of effective policies and approaches that work to mitigate the risk of declining services trade. Furthermore, they can join forces to accelerate innovation. Therefore, governments in developing economies should engage in a continuous dialogue with their counterpart agencies in other countries. Governments should consider establishing a multilateral working group to coordinate on issues such as industry-led standards and pro-competitive policies.

3. Policy Recommendations for APEC Member Economies

The impacts of AI-powered intelligent automation on APEC member economies are likely to be significant as, according to the 2018 World Economic Situation and Prospects (WESP) report, only five out of 21 APEC member economies are considered developed countries. Our data analysis results shown in Figures 29-35 suggest that APEC member economies are already witnessing a decline in international trade in services in highly automatable industries, such as the information services industry and finance/insurance services industry. Furthermore, services trade in the information services industry within APEC member economies has declined most significantly.

Intelligent automation may not only impact international trade in services in APEC member economies but also deepen digital divides and social inequality as its negative impact on service jobs could be more severe for the socially vulnerable and underprivileged group. For fostering shared prosperity in the region, it is crucial for APEC member economies to strengthen their cooperation and collaboration to cope with unprecedented challenges caused by intelligent automation and AI technologies. In this section, we present several specific policy recommendations that APEC members should consider adopting.

(1) Develop regional strategies for APEC member economies

- Create comprehensive, high-level, long-term regional strategies by 2020 to address a wide range of economic and social issues caused by AI-powered intelligent automation
- Engage policymakers, business leaders in the AI and automation industries, think tanks, and academia in the strategy development process

(2) Create APEC joint research programs

- Examine the impacts of AI-powered intelligent automation on a wide range of issues, including services trade, job elimination, education, vocational training, digital divides, income inequality, gender inequality, and immigration
- Identify skills and knowledge that are increasingly required in the era of AI and intelligent automation
- Provide research grants to a consortium of world-class universities, research centers, and global digital companies based in APEC economies
- Disseminate research outcomes through APEC publications and meetings as well as other academic or industry publication outlets

(3) Develop an APEC online education platform for reskilling and retraining

- Develop online courses on high-demand skills and make them available for anyone in APEC member economies to access freely
- Assist the socially vulnerable, underprivileged group to be able to use on-line courses by providing financial and technical support

(4) Create regional certifications for digital skills

- Develop standardized certifications for critical digital skills to facilitate the matching of prospective employees and employers
- Use these certifications to assess the effectiveness of reskilling and retraining programs

(5) Develop a regional center of excellence for innovation and entrepreneurship

- Engage two global leaders in AI – the U.S. and China – in boosting innovation and entrepreneurship in all APEC member economies through joint projects, exchanges of best practices, and knowledge transfer
- Create an online platform like Innocentive.com for matching technical problems and solutions

(6) Create an APEC working group to facilitate policy dialogue and cooperation

- Create a working group comprised of representatives of all APEC members under APEC SOM Steering Committee on Economic and Technical Cooperation
- Charge the working group to develop strategies and implementation plans for the policies recommended above and serve as a platform for continuous policy dialogue and cooperation
- Collaborate and coordinate with existing APEC working groups and initiatives such as the APEC CBNI (Capacity Building Initiatives) and the APEC Education Strategy as well as the ILO's (International Labour Organization) Future of Work Centenary Initiative and the United Nations' 17 Sustainable Development Goals

4. Roles of Korea in Promoting Shared Prosperity in APEC Economies

South Korea can serve as a role model for other developing economies in APEC to follow when it comes to economic developments. Once a deprived country after the Korean War, it is among the biggest economies and largest exporters in the world. South Korea's service exports have grown from \$38.5 billion in 2000 to \$111 billion in 2014. One of its most well-known service exports, as we stated above, is entertainment, including what is known as K-pop or Korean Wave. Its exports in personal, cultural, and recreational services (service industries that are least likely to be automated) have risen from a mere \$167 million in 2000 to more than \$1 billion in 2016, a more than six-fold increase.

South Korea's success in the transformation from a manufacturing-oriented economy to a service-based, knowledge-oriented one offers a blueprint for other developing APEC economies. This transformation has been possible thanks to its highly-educated population, booming entrepreneurship, well-orchestrated industrial policies, and strong support for knowledge-driven service industries from the government. Its nationwide broadband network infrastructures and large conglomerates' R&D investments in technology (e.g., Samsung, Hyundai, LG, SK) have also made its innovation-driven economy possible.

Korea can support economic development and transformation in peer APEC economies in several ways. First, its high-quality educational institutions can aid developing economies to build a base of high-skilled talent. The schools can do so by educating foreign students from APEC countries, offering scholarships to such students, and operating academic programs in conjunction with local universities. For example, Seoul National University has been educating next-generation sports administrators from developing

countries around the world. This one-year residential program covers all educational and housing expenses for the students. Second, South Korea can help developing economies build high-speed broadband or mobile infrastructures by taking advantage of the world's leading telecommunication companies in South Korea. Third, it can set up policy blueprints in education, entrepreneurship, innovation for developing economies to follow. Fourth, South Korea can share its best practices and lessons learned with developing APEC economies through knowledge exchange programs and study visits. For example, South Korea has been transferring its experience in building an e-government and digital economy with developing countries around the world through the programs co-sponsored by the World Bank.



Conclusions

Developments in intelligent automation technologies are by no means a reversible trend. AI-powered intelligent automation will continue to threaten an increasing number of occupations across the industries in both developed and developing economies and reshape the global economy and international trade in a fundamental way. It is therefore incumbent upon policymakers to formulate proactive, sensible policies to address challenges emanating from automation. It is particularly the case for the officials in developing economies, whose competitive advantage vis-à-vis developed economies has been a large pool of low-cost labor. Without effective policies that can embrace and take advantage of economic potentials of AI and other automation technologies, developing countries will fall further behind in the global economy.

AI-powered intelligent automation is likely to impact APEC member economies significantly as many of developing economies within APEC heavily rely on services trade. Intelligent automation will not only impact APEC member economies' trade in services but also deepen their digital divides and social inequality. For fostering shared prosperity in the region, it is crucial for the APEC member economies to strengthen their cooperation and collaboration and develop smart policies and regulations to cope with unprecedented challenges caused by intelligent automation and AI technologies.

We acknowledge that this research is not free from limitations. First, due to data limitation, we were not able to measure the degree of digitization or adoption of intelligence automation in each country or in each industry. Instead, we use the automation scores from O*Net for each service industry as a proxy for intelligent automation, which only measures a potential degree

of automation. We also supplement the main analyses by using the ICT Development Index to measure the economy-level ICT infrastructures. In addition, while the degree of automation can change year-by-year in each country and in each service industry, our analysis was not able to capture temporal changes in automation. Second, we were not able to directly measure how many service occupations intelligent automation eliminates in exporting countries. We argue, however, that a decline in service exports from the developing countries is correlated with job losses in the service industries in such economies. Third, while we carefully selected a variety of economy-level control variables (Table 5) and our estimations include importer and exporter-level fixed effects, the estimation models might not capture all relevant economy-level heterogeneity, indicating possible presence of omitted variable bias. Despite these limitations, this research contributes to advancing our understanding of the relationship between service job displacement and intelligent automation by exploring and testing empirical data. We hope that this research helps policymakers make informed policy decisions with regard to service occupations and intelligent automation.

There are a number of avenues for future research in intelligent automation and related policies. First, researchers can evaluate the effectiveness of the policy recommendations we propose above in education, entrepreneurship, and public-private partnership. For example, one can examine whether offering tax incentives for worker training help displaced workers find employment. Second, future research can dig deeper on which specific service industries or which service occupations in international trade are most

affected by developments in intelligent automation. Third, researchers can develop a policy-maturity model that guides policymakers to formulate necessary policies to ensure domestic employment and augment international competitiveness of the service industries.

Appendix

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Table A1. Descriptive Statistics

Variables		Mean	Std. Deviation	Min.	Max.
Trade in Services	(1)	14.0131	3.2186	-0.0847	24.9649
Exporter Population	(2)	16.5660	1.6778	9.1507	21.0444
Exporter GDP	(3)	26.9551	21.2772	0.1310	162.9889
Exporter Service Ind.	(4)	66.1291	9.4135	0	93.2165
Exporter FDI	(5)	5.7463	60.6419	-335.1350	3545.8590
Exporter R&D	(6)	1.4509	0.9353	0	4.4055
Exporter Education	(7)	4.8634	1.1310	0	14.0591
Exporter Service Emp.	(8)	64.5323	13.3924	0	88.3490
Exporter Unemployment	(9)	7.9677	4.2855	0.1650	37.2500
Importer Population	(10)	16.5156	1.6827	9.1507	21.0444
Importer GDP	(11)	27.2634	21.3859	0.1301	162.9889
Importer Service Ind.	(12)	66.0386	9.6081	0	93.2165
Importer FDI	(13)	6.0647	63.9664	-335.1350	3545.8590
Importer R&D	(14)	1.4529	0.9485	0	4.4055
Importer Education	(15)	4.8765	1.1389	0	14.0591
Importer Service Emp.	(16)	64.4305	13.7500	0	88.3490
Importer Unemployment	(17)	8.0174	4.3222	0.1650	37.2500
Trade in Goods	(18)	19.3982	4.5841	0	26.8378
Year	(19)	7.8412	3.5368	0	16
Automation	(20)	30.1367	4.3888	22.2235	39.7912

Source: Author's own compilation

Table A2. Correlation Table

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1																		
(2)	0.158	1																
(3)	0.286	-0.204	1															
(4)	0.284	-0.173	0.560	1														
(5)	-0.020	-0.240	0.181	0.012	1													
(6)	0.270	0.092	0.622	0.427	-0.033	1												
(7)	0.116	-0.277	0.388	0.325	-0.086	0.457	1											
(8)	0.266	0.012	0.556	0.670	-0.257	0.540	0.431	1										
(9)	-0.108	-0.093	-0.339	-0.031	-0.004	-0.264	-0.123	-0.164	1									
(10)	0.183	-0.051	0.012	0.003	0.011	-0.003	0.030	-0.014	-0.021	1								
(11)	0.301	-0.012	0.065	0.055	-0.024	0.036	0.042	0.065	-0.031	-0.191	1							
(12)	0.292	-0.023	0.059	0.070	-0.019	0.042	0.049	0.069	-0.011	-0.147	0.548	1						
(13)	-0.020	0.012	-0.027	-0.024	-0.005	-0.018	-0.020	-0.013	0.008	-0.242	0.173	0.011	1					
(14)	0.285	-0.025	0.046	0.048	-0.018	0.027	0.045	0.052	-0.015	0.105	0.620	0.428	-0.036	1				
(15)	0.116	0.013	0.039	0.043	-0.020	0.036	0.027	0.056	0.001	-0.258	0.380	0.313	-0.083	0.456	1			
(16)	0.276	-0.041	0.076	0.076	-0.013	0.051	0.069	0.069	-0.022	0.049	0.542	0.644	-0.260	0.537	0.425	1		
(17)	-0.121	-0.022	-0.045	-0.022	0.017	-0.025	-0.006	-0.041	0.082	-0.094	-0.352	-0.052	-0.004	-0.274	-0.127	-0.173	1	
(18)	0.484	0.318	0.175	0.214	-0.187	0.288	0.093	0.334	-0.172	0.295	0.140	0.230	-0.174	0.245	0.103	0.327	-0.158	1
(19)	0.015	-0.016	0.037	0.094	-0.007	0.055	0.061	0.121	0.001	-0.009	0.036	0.094	-0.002	0.056	0.057	0.113	0.002	0.149
(20)	-0.054	0.031	0.052	0.035	0.003	0.056	0.008	0.049	-0.035	0.020	0.030	0.021	0.004	0.034	-0.004	0.025	-0.021	0.028
																		0.039

Source: Author's own compilation

Table A3. Estimation of Baseline Annual Growth Rates in International Services Trade in 2000-2016 (Eq. 1 and 2)

Dependent Variables	Services Trade (1)	Services Trade (2)	Services Trade (3)
Exporter Population	1.3416*** (0.1096)	1.2657*** (0.1094)	1.4170*** (0.1092)
Exporter GDP	-0.0033*** (0.0007)	-0.0031*** (0.0007)	0.0098*** (0.0009)
Exporter Service Ind	-0.0369*** (0.0020)	-0.0367*** (0.0020)	-0.0382*** (0.0020)
Exporter FDI	0.0001 (0.0001)	0.0001 (0.0001)	0.0002 (0.0001)
Exporter R&D	0.2354*** (0.0199)	0.2399*** (0.0199)	0.1981*** (0.0206)
Exporter Edu	-0.0261** (0.0095)	-0.0276** (0.0095)	-0.0045 (0.0098)
Exporter Service Emp	0.0149*** (0.0026)	0.0158*** (0.0026)	0.0282*** (0.0026)
Exporter Unemploy	0.0006 (0.0016)	0.0003 (0.0016)	-0.0025 (0.0016)
Importer Population	1.7781*** (0.1094)	1.7042*** (0.1092)	1.8161*** (0.1089)
Importer GDP	0.0025*** (0.0007)	0.0028*** (0.0007)	0.0155*** (0.0009)
Importer Service Ind	-0.0396*** (0.0020)	-0.0391*** (0.0020)	-0.0401*** (0.0020)
Importer FDI	-0.0000 (0.0001)	-0.0000 (0.0001)	0.0000 (0.0001)
Importer R&D	0.2283*** (0.0194)	0.2332*** (0.0194)	0.2026*** (0.0201)
Importer Edu	-0.0177+ (0.0095)	-0.0189* (0.0095)	-0.0014 (0.0098)
Importer Service Emp	0.0162*** (0.0027)	0.0166*** (0.0027)	0.0291*** (0.0027)

Table A3. Continued

Dependent Variables	Services Trade	Services Trade	Services Trade
Importer Unemploy	-0.0041** (0.0015)	-0.0041** (0.0015)	-0.0067*** (0.0016)
Trade in Goods	0.1891*** (0.0015)	0.1895*** (0.0015)	0.2009*** (0.0016)
Year	0.0166*** (0.0022)	-0.0668*** (0.0059)	
Year × Automation		0.0027*** (0.0002)	0.0026*** (0.0002)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
Year FE	NO	NO	YES
N	567,074	567,074	567,074
F	1,166***	1,124***	950.7***
R ²	0.5943	0.5945	0.5967
Adjusted R ²	0.594	0.594	0.596
Root MSE	2.051	2.050	2.045

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A4. Estimation of Growth Rates in Services Trade in the Three Periods (Eq. 1)

Dependent Variables	Services Trade 2000–2008 (1)	Services Trade 2008–2014 (2)	Services Trade 2014–2016 (3)
Exporter Population	0.7165** (0.2292)	0.1892 (0.3444)	–1.0987 (1.9591)
Exporter GDP	0.0118*** (0.0012)	–0.0016 (0.0019)	–0.0022 (0.0051)
Exporter Service Ind	–0.0595*** (0.0034)	0.0047 (0.0039)	0.0285* (0.0126)
Exporter FDI	0.0002+ (0.0001)	0.0005 (0.0005)	0.0062 (0.0047)
Exporter R&D	0.0134 (0.0417)	0.3228*** (0.0364)	0.0695 (0.0666)
Exporter Edu	0.0240+ (0.0136)	–0.0658*** (0.0162)	–0.0775 (0.0569)
Exporter Service Emp	0.0509*** (0.0043)	–0.0209*** (0.0057)	–0.0352+ (0.0210)
Exporter Unemploy	–0.0342*** (0.0026)	0.0015 (0.0032)	0.0513** (0.0167)
Importer Population	0.3662 (0.2388)	2.6945*** (0.3150)	–2.0724 (1.8753)
Importer GDP	0.0169*** (0.0011)	0.0032+ (0.0019)	–0.0028 (0.0047)
Importer Service Ind	–0.0555*** (0.0034)	–0.0082* (0.0038)	–0.0079 (0.0120)
Importer FDI	0.0002 (0.0001)	0.0003 (0.0003)	–0.0026 (0.0030)
Importer R&D	–0.1292** (0.0411)	0.3814*** (0.0351)	–0.0252 (0.0649)
Importer Edu	–0.0009 (0.0138)	–0.0723*** (0.0157)	0.0050 (0.0580)
Importer Service Emp	0.0497*** (0.0044)	–0.0275*** (0.0056)	–0.0426* (0.0188)

Table A4. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Importer Unemploy	–0.0442*** (0.0025)	0.0187*** (0.0031)	0.0507** (0.0167)
Trade in Goods	0.1756*** (0.0018)	0.4588*** (0.0050)	0.4972*** (0.0114)
Year	–0.0849*** (0.0057)	0.0920*** (0.0052)	–0.0572 (0.0366)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	678.2***	680.7***	124.3***
R ²	0.6187	0.5994	0.5933
Adjusted R ²	0.618	0.599	0.590
Root MSE	1.994	2.074	1.687

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A5. Estimation of Growth Rates in Services Trade
in the Three Periods (Eq. 2)**

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2018
	(1)	(2)	(3)
Exporter Population	0.6754** (0.2286)	0.0320 (0.3455)	–0.6395 (1.9634)
Exporter GDP	0.0116*** (0.0012)	–0.0016 (0.0019)	–0.0022 (0.0051)
Exporter Service Ind	–0.0592*** (0.0034)	0.0047 (0.0039)	0.0275* (0.0126)
Exporter FDI	0.0002+ (0.0001)	0.0005 (0.0005)	0.0062 (0.0047)
Exporter R&D	0.0127 (0.0417)	0.3230*** (0.0364)	0.0676 (0.0666)
Exporter Edu	0.0225+ (0.0136)	–0.0654*** (0.0162)	–0.0777 (0.0569)
Exporter Service Emp	0.0509*** (0.0043)	–0.0205*** (0.0057)	–0.0367+ (0.0210)
Exporter Unemploy	–0.0346*** (0.0026)	0.0015 (0.0032)	0.0508** (0.0167)
Importer Population	0.3155 (0.2385)	2.5623*** (0.3150)	–1.7116 (1.8772)
Importer GDP	0.0168*** (0.0011)	0.0033+ (0.0019)	–0.0025 (0.0047)
Importer Service Ind	–0.0551*** (0.0034)	–0.0080* (0.0038)	–0.0088 (0.0119)
Importer FDI	0.0002 (0.0001)	0.0003 (0.0003)	–0.0026 (0.0030)
Importer R&D	–0.1306** (0.0411)	0.3826*** (0.0351)	–0.0277 (0.0649)
Importer Edu	–0.0018 (0.0138)	–0.0722*** (0.0157)	0.0055 (0.0580)
Importer Service Emp	0.0496*** (0.0044)	–0.0273*** (0.0056)	–0.0428* (0.0188)

Table A5. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2018
Importer Unemploy	–0.0443*** (0.0025)	0.0185*** (0.0031)	0.0502** (0.0167)
Trade in Goods	0.1759*** (0.0018)	0.4586*** (0.0050)	0.4968*** (0.0114)
Year	–0.1683*** (0.0132)	–0.0164 (0.0173)	0.2686*** (0.0792)
Year × Automation	0.0028*** (0.0004)	0.0036*** (0.0005)	–0.0107*** (0.0023)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	645.4***	651***	119.1***
R ²	0.6188	0.5995	0.5935
Adjusted R ²	0.618	0.599	0.590
Root MSE	1.994	2.074	1.687

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A6. Estimation of Growth Rates in Services Trade
by Service Industries**

Dependent Variables	Services Trade
Exporter Population	1.2626*** (0.1094)
Exporter GDP	-0.0028*** (0.0007)
Exporter Service Ind	-0.0364*** (0.0020)
Exporter FDI	0.0001 (0.0001)
Exporter R&D	0.2423*** (0.0199)
Exporter Edu	-0.0272** (0.0095)
Exporter Service Emp	0.0163*** (0.0026)
Exporter Unemploy	0.0003 (0.0016)
Importer Population	1.7069*** (0.1092)
Importer GDP	0.0031*** (0.0007)
Importer Service Ind	-0.0389*** (0.0020)
Importer FDI	-0.0000 (0.0001)
Importer R&D	0.2350*** (0.0194)
Importer Edu	-0.0183+ (0.0095)
Importer Service Emp	0.0171*** (0.0027)
Importer Unemploy	-0.0042** (0.0015)

Table A6. Continued

Dependent Variables	Services Trade
Trade in Goods	0.1897*** (0.0015)
Year × Other Services	0.0006 (0.0024)
Year × Information	0.0348*** (0.0032)
Year × Professional	0.0429*** (0.0026)
Year × Finance	0.0311*** (0.0032)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	567,074
F	1,049***
R ²	0.5947
Adjusted R ²	0.594
Root MSE	2.050

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A7. Estimation of Growth Rates in Services Trade
by Service Industries and Periods**

Dependent Variables	Services Trade 2000–2008 (1)	Services Trade 2008–2014 (2)	Services Trade 2014–2016 (3)
Exporter Population	0.6616** (0.2286)	0.0082 (0.3454)	–0.4098 (1.9651)
Exporter GDP	0.0116*** (0.0012)	–0.0016 (0.0019)	–0.0026 (0.0051)
Exporter Service Ind	–0.0592*** (0.0034)	0.0048 (0.0039)	0.0265* (0.0126)
Exporter FDI	0.0002+ (0.0001)	0.0005 (0.0005)	0.0061 (0.0047)
Exporter R&D	0.0131 (0.0417)	0.3218*** (0.0364)	0.0655 (0.0667)
Exporter Edu	0.0225+ (0.0136)	–0.0648*** (0.0162)	–0.0770 (0.0569)
Exporter Service Emp	0.0509*** (0.0043)	–0.0201*** (0.0057)	–0.0374+ (0.0210)
Exporter Unemploy	–0.0348*** (0.0026)	0.0013 (0.0032)	0.0495** (0.0166)
Importer Population	0.3137 (0.2386)	2.5307*** (0.3151)	–1.6351 (1.8776)
Importer GDP	0.0169*** (0.0011)	0.0033+ (0.0019)	–0.0026 (0.0047)
Importer Service Ind	–0.0552*** (0.0034)	–0.0079* (0.0038)	–0.0094 (0.0119)
Importer FDI	0.0002 (0.0001)	0.0003 (0.0003)	–0.0026 (0.0030)
Importer R&D	–0.1299** (0.0411)	0.3816*** (0.0351)	–0.0280 (0.0649)
Importer Edu	–0.0015 (0.0138)	–0.0717*** (0.0157)	0.0066 (0.0580)
Importer Service Emp	0.0496*** (0.0044)	–0.0269*** (0.0056)	–0.0432* (0.0188)

Table A7. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Importer Unemploy	–0.0445*** (0.0025)	0.0185*** (0.0031)	0.0498** (0.0167)
Trade in Goods	0.1760*** (0.0018)	0.4585*** (0.0050)	0.4968*** (0.0114)
Year × Other Services	–0.0937*** (0.0058)	0.0794*** (0.0055)	–0.0140 (0.0379)
Year × Information	–0.0630*** (0.0073)	0.0691*** (0.0098)	–0.1249** (0.0452)
Year × Professional	–0.0853*** (0.0069)	0.1190*** (0.0063)	–0.0754+ (0.0391)
Year × Finance	–0.0513*** (0.0075)	0.1404*** (0.0090)	–0.2271*** (0.0468)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	586.4***	596.8***	108.5***
R ²	0.6188	0.5995	0.5936
Adjusted R ²	0.618	0.599	0.590
Root MSE	1.994	2.074	1.687

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A8. Estimation of Growth Rates in Services Trade by Developed/Developing Economies

Dependent Variables	Services Trade
Exporter Population	1.7853*** (0.1160)
Exporter GDP	-0.0038*** (0.0007)
Exporter Service Ind	-0.0335*** (0.0020)
Exporter FDI	0.0002+ (0.0001)
Exporter R&D	0.1696*** (0.0200)
Exporter Edu	-0.0380*** (0.0095)
Exporter Service Emp	0.0235*** (0.0027)
Exporter Unemploy	-0.0043** (0.0016)
Importer Population	2.3517*** (0.1168)
Importer GDP	0.0017* (0.0007)
Importer Service Ind	-0.0354*** (0.0020)
Importer FDI	0.0001 (0.0001)
Importer R&D	0.1591*** (0.0194)
Importer Edu	-0.0300** (0.0095)
Importer Service Emp	0.0255*** (0.0027)
Importer Unemploy	-0.0094*** (0.0015)

Table A8. Continued

Dependent Variables	Services Trade
Trade in Goods	0.1965*** (0.0016)
Year × Developed–Developed	0.0174*** (0.0022)
Year × Developed–Developing	–0.0032 (0.0033)
Year × Developing–Developed	0.0039 (0.0031)
Year × Developing–Developing	–0.0676*** (0.0041)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	567,074
F	1,093***
R ²	0.5953
Adjusted R ²	0.595
Root MSE	2.048

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A9. Estimation of Growth Rates in Services Trade by Developed/Developing Economies and Service Industries

Dependent Variables	Services Trade
Exporter Population	1.6691*** (0.1155)
Exporter GDP	-0.0029*** (0.0007)
Exporter Service Ind	-0.0346*** (0.0020)
Exporter FDI	0.0002+ (0.0001)
Exporter R&D	0.1851*** (0.0200)
Exporter Edu	-0.0350*** (0.0094)
Exporter Service Emp	0.0255*** (0.0027)
Exporter Unemploy	-0.0043** (0.0016)
Importer Population	2.2424*** (0.1163)
Importer GDP	0.0026*** (0.0007)
Importer Service Ind	-0.0355*** (0.0020)
Importer FDI	0.0001 (0.0001)
Importer R&D	0.1744*** (0.0194)
Importer Edu	-0.0297** (0.0094)
Importer Service Emp	0.0270*** (0.0027)
Importer Unemploy	-0.0091*** (0.0015)

Table A9. Continued

Dependent Variables	Services Trade
Trade in Goods	0.1967*** (0.0016)
Year × Developed–Developed	–0.0015
× Other Services	(0.0023)
Year × Developed–Developing	–0.0280***
× Other Services	(0.0034)
Year × Developing–Developed	–0.0113***
× Other Services	(0.0033)
Year × Developing–Developing	–0.0647***
× Other Services	(0.0043)
Year × Developed–Developed	0.0507***
× Information	(0.0032)
Year × Developed–Developing	–0.0012
× Information	(0.0049)
Year × Developing–Developed	0.0024
× Information	(0.0044)
Year × Developing–Developing	–0.1215***
× Information	(0.0061)
Year × Developed–Developed	0.0399***
× Professional	(0.0026)
Year × Developed–Developing	0.0267***
× Professional	(0.0036)
Year × Developing–Developed	0.0349***
× Professional	(0.0035)
Year × Developing–Developing	–0.0335***
× Professional	(0.0046)
Year × Developed–Developed	0.0420***
× Finance	(0.0032)
Year × Developed–Developing	0.0512***
× Finance	(0.0046)
Year × Developing–Developed	0.0086+
× Finance	(0.0047)

Table A9. Continued

Dependent Variables	Services Trade
Year × Developing–Developing	–0.1509***
× Finance	(0.0062)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	567,074
F	799.9***
R ²	0.5975
Adjusted R ²	0.597
Root MSE	2.043

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A10. Estimation of Growth Rates in Services Trade by Developed/Developing Economies and the Three Periods

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Exporter Population	1.0836*** (0.3077)	–0.6034 (0.4263)	–1.1105 (1.9912)
Exporter GDP	0.0120*** (0.0017)	–0.0011 (0.0020)	–0.0048 (0.0057)
Exporter Service Ind	–0.0546*** (0.0038)	0.0149*** (0.0043)	0.0306* (0.0126)
Exporter FDI	0.0000 (0.0001)	0.0007 (0.0005)	0.0062 (0.0047)
Exporter R&D	–0.0179 (0.0530)	0.3037*** (0.0412)	0.0725 (0.0670)
Exporter Edu	0.0993*** (0.0159)	–0.0578*** (0.0174)	–0.0526 (0.0581)
Exporter Service Emp	0.0401*** (0.0051)	–0.0272*** (0.0066)	–0.0392+ (0.0211)
Exporter Unemploy	–0.0560*** (0.0030)	0.0054 (0.0037)	0.0420* (0.0177)
Importer Population	0.7648* (0.3197)	4.5162*** (0.4126)	–1.4311 (1.9204)
Importer GDP	0.0149*** (0.0016)	0.0081*** (0.0020)	0.0002 (0.0052)
Importer Service Ind	–0.0454*** (0.0039)	–0.0096* (0.0042)	–0.0043 (0.0119)
Importer FDI	0.0002 (0.0001)	0.0002 (0.0003)	–0.0026 (0.0030)
Importer R&D	–0.2069*** (0.0523)	0.3894*** (0.0389)	–0.0083 (0.0648)
Importer Edu	0.0717*** (0.0162)	–0.0609*** (0.0169)	0.0122 (0.0590)
Importer Service Emp	0.0426*** (0.0053)	–0.0283*** (0.0064)	–0.0438* (0.0189)

Table A10. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Importer Unemploy	–0.0719*** (0.0030)	0.0276*** (0.0036)	0.0581*** (0.0177)
Trade in Goods	0.1793*** (0.0021)	0.4611*** (0.0051)	0.4978*** (0.0115)
Year × Developed–Developed	–0.0360*** (0.0070)	0.0769*** (0.0064)	–0.0499 (0.0396)
Year × Developed–Developing	–0.0769*** (0.0085)	0.0049 (0.0107)	–0.1007* (0.0472)
Year × Developing–Developed	–0.0549*** (0.0081)	0.0816*** (0.0097)	–0.0215 (0.0474)
Year × Developing–Developing	–0.1757*** (0.0097)	–0.0350** (0.0126)	–0.1147+ (0.0600)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	554.4***	496.9***	107.9***
R ²	0.6294	0.6017	0.5944
Adjusted R ²	0.629	0.601	0.591
Root MSE	1.963	2.086	1.685

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A11. Estimation of Growth Rates in Services Trade by Developed/Developing Economies, Service Industries, and the Three Periods

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
	(1)	(2)	(3)
Exporter Population	1.3372*** (0.2390)	–0.2990 (0.3563)	–0.2358 (1.9879)
Exporter GDP	0.0068*** (0.0013)	–0.0029 (0.0019)	–0.0048 (0.0056)
Exporter Service Ind	–0.0603*** (0.0033)	0.0038 (0.0039)	0.0291* (0.0125)
Exporter FDI	0.0004** (0.0001)	0.0005 (0.0005)	0.0060 (0.0047)
Exporter R&D	–0.0770+ (0.0418)	0.3271*** (0.0365)	0.0633 (0.0668)
Exporter Edu	0.0366** (0.0136)	–0.0598*** (0.0162)	–0.0511 (0.0580)
Exporter Service Emp	0.0576*** (0.0043)	–0.0227*** (0.0060)	–0.0423* (0.0210)
Exporter Unemploy	–0.0370*** (0.0025)	0.0026 (0.0032)	0.0422* (0.0177)
Importer Population	1.3424*** (0.2506)	2.6026*** (0.3385)	–0.9465 (1.9182)
Importer GDP	0.0098*** (0.0012)	0.0051** (0.0019)	0.0003 (0.0052)
Importer Service Ind	–0.0531*** (0.0034)	–0.0080* (0.0037)	–0.0055 (0.0119)
Importer FDI	0.0004** (0.0001)	0.0003 (0.0003)	–0.0026 (0.0030)
Importer R&D	–0.2296*** (0.0410)	0.3684*** (0.0348)	–0.0098 (0.0647)
Importer Edu	0.0078 (0.0138)	–0.0762*** (0.0156)	0.0161 (0.0586)

Table A11. Continued

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2016
Importer Service Emp	0.0574*** (0.0045)	–0.0214*** (0.0058)	–0.0458* (0.0189)
Importer Unemploy	–0.0459*** (0.0025)	0.0165*** (0.0031)	0.0580** (0.0176)
Trade in Goods	0.1825*** (0.0019)	0.4576*** (0.0050)	0.4971*** (0.0114)
Year × Developed–Developed × Other Services	–0.0640*** (0.0060)	0.0770*** (0.0054)	0.0005 (0.0405)
Year × Developed–Developing × Other Services	–0.1089*** (0.0072)	0.0598*** (0.0091)	–0.0585 (0.0480)
Year × Developing–Developed × Other Services	–0.0799*** (0.0070)	0.1038*** (0.0085)	0.0283 (0.0481)
Year × Developing–Developing × Other Services	–0.1710*** (0.0085)	0.0651*** (0.0114)	–0.0654 (0.0606)
Year × Developed–Developed × Information	0.0035 (0.0075)	0.0948*** (0.0096)	–0.1253** (0.0474)
Year × Developed–Developing × Information	–0.0835*** (0.0094)	0.0562*** (0.0127)	–0.1894*** (0.0541)
Year × Developing–Developed × Information	–0.0722*** (0.0090)	0.0893*** (0.0117)	–0.1184* (0.0540)
Year × Developing–Developing × Information	–0.2333*** (0.0106)	–0.0150 (0.0144)	–0.0567 (0.0674)
Year × Developed–Developed × Professional	–0.0525*** (0.0071)	0.1164*** (0.0062)	–0.0694 (0.0424)
Year × Developed–Developing × Professional	–0.0896*** (0.0085)	0.1086*** (0.0094)	–0.1388** (0.0490)
Year × Developing–Developed × Professional	–0.0754*** (0.0082)	0.1468*** (0.0091)	–0.0563 (0.0492)
Year × Developing–Developing × Professional	–0.1597*** (0.0096)	0.1036*** (0.0119)	–0.1736** (0.0609)

Table A11. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Year × Developed–Developed	0.0136+	0.1396***	–0.2279***
× Finance	(0.0077)	(0.0089)	(0.0492)
Year × Developed–Developing	–0.0318**	0.1629***	–0.2643***
× Finance	(0.0098)	(0.0118)	(0.0555)
Year × Developing–Developed	–0.0611***	0.1479***	–0.2110***
× Finance	(0.0097)	(0.0116)	(0.0563)
Year × Developing–Developing	–0.2748***	0.0031	–0.3508***
× Finance	(0.0111)	(0.0146)	(0.0676)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	430.3***	438.5***	81.11***
R ²	0.6211	0.6023	0.5967
Adjusted R ²	0.621	0.601	0.593
Root MSE	1.988	2.067	1.681

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A12. Estimation of Growth Rates in Services Trade
by High GDP/Low GDP Economies**

Dependent Variables	Services Trade
Exporter Population	1.6096*** (0.1129)
Exporter GDP	-0.0018* (0.0007)
Exporter Service Ind	-0.0363*** (0.0020)
Exporter FDI	0.0001 (0.0001)
Exporter R&D	0.2586*** (0.0198)
Exporter Edu	-0.0201* (0.0095)
Exporter Service Emp	0.0092*** (0.0027)
Exporter Unemploy	0.0031* (0.0016)
Importer Population	2.0913*** (0.1128)
Importer GDP	0.0042*** (0.0007)
Importer Service Ind	-0.0391*** (0.0020)
Importer FDI	-0.0001 (0.0001)
Importer R&D	0.2548*** (0.0193)
Importer Edu	-0.0124 (0.0095)
Importer Service Emp	0.0089** (0.0027)
Importer Unemploy	-0.0010 (0.0015)

Table A12. Continued

Dependent Variables	Services Trade
Trade in Goods	0.1840*** (0.0015)
Year × HighGDP–HighGDP	0.0117*** (0.0024)
Year × HighGDP–LowGDP	0.0119*** (0.0025)
Year × LowGDP–HighGDP	0.0070** (0.0024)
Year × LowGDP–LowGDP	0.0466*** (0.0026)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	567,074
F	1,062***
R ²	0.5951
Adjusted R ²	0.595
Root MSE	2.049

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A13. Estimation of Growth Rates in Services Trade by High GDP/Low GDP Economies and Service Industries

Dependent Variables	Services Trade
Exporter Population	1.5518*** (0.1124)
Exporter GDP	-0.0008 (0.0007)
Exporter Service Ind	-0.0358*** (0.0020)
Exporter FDI	0.0001 (0.0001)
Exporter R&D	0.2707*** (0.0198)
Exporter Edu	-0.0208* (0.0095)
Exporter Service Emp	0.0107*** (0.0027)
Exporter Unemploy	0.0025 (0.0016)
Importer Population	1.9679*** (0.1123)
Importer GDP	0.0054*** (0.0007)
Importer Service Ind	-0.0384*** (0.0020)
Importer FDI	-0.0001 (0.0001)
Importer R&D	0.2672*** (0.0193)
Importer Edu	-0.0117 (0.0094)
Importer Service Emp	0.0103*** (0.0027)
Importer Unemploy	-0.0016 (0.0015)

Table A13. Continued

Dependent Variables	Services Trade
Trade in Goods	0.1844*** (0.0015)
Year × HighGDP-HighGDP	-0.0240***
× Other Services	(0.0026)
Year × HighGDP-LowGDP	-0.0145***
× Other Services	(0.0026)
Year × LowGDP-HighGDP	-0.0104***
× Other Services	(0.0026)
Year × LowGDP-LowGDP	0.0468***
× Other Services	(0.0027)
Year × HighGDP-HighGDP	0.0488***
× Information	(0.0034)
Year × HighGDP-LowGDP	0.0465***
× Information	(0.0037)
Year × LowGDP-HighGDP	0.0270***
× Information	(0.0036)
Year × LowGDP-LowGDP	0.0271***
× Information	(0.0041)
Year × HighGDP-HighGDP	0.0445***
× Professional	(0.0029)
Year × HighGDP-LowGDP	0.0389***
× Professional	(0.0029)
Year × LowGDP-HighGDP	0.0423***
× Professional	(0.0029)
Year × LowGDP-LowGDP	0.0556***
× Professional	(0.0031)
Year × HighGDP-HighGDP	0.0657***
× Finance	(0.0036)
Year × HighGDP-LowGDP	0.0557***
× Finance	(0.0036)
Year × LowGDP-HighGDP	-0.0031
× Finance	(0.0038)

Table A13. Continued

Dependent Variables	Services Trade
Year × LowGDP–LowGDP	–0.0060
× Finance	(0.0043)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	567,074
F	814.6***
R ²	0.5980
Adjusted R ²	0.598
Root MSE	2.041

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A14. Estimation of Growth Rates in Services Trade by High GDP/Low GDP Economies and the Three Periods

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Exporter Population	0.4196+ (0.2301)	1.2412*** (0.3523)	–1.3488 (1.9482)
Exporter GDP	0.0077*** (0.0012)	–0.0023 (0.0019)	–0.0030 (0.0052)
Exporter Service Ind	–0.0596*** (0.0034)	0.0061 (0.0039)	0.0272* (0.0127)
Exporter FDI	0.0003* (0.0001)	0.0004 (0.0005)	0.0052 (0.0047)
Exporter R&D	–0.0551 (0.0424)	0.2784*** (0.0363)	0.0623 (0.0664)
Exporter Edu	0.0411** (0.0138)	–0.0590*** (0.0162)	–0.0627 (0.0576)
Exporter Service Emp	0.0545*** (0.0043)	–0.0317*** (0.0058)	–0.0441* (0.0210)
Exporter Unemploy	–0.0386*** (0.0026)	0.0007 (0.0032)	0.0590*** (0.0167)
Importer Population	0.1017 (0.2400)	3.6513*** (0.3191)	–2.0578 (1.8668)
Importer GDP	0.0132*** (0.0012)	0.0024 (0.0019)	–0.0011 (0.0047)
Importer Service Ind	–0.0552*** (0.0034)	–0.0066+ (0.0038)	–0.0057 (0.0120)
Importer FDI	0.0002+ (0.0001)	0.0002 (0.0003)	–0.0025 (0.0030)
Importer R&D	–0.1956*** (0.0416)	0.3284*** (0.0350)	–0.0418 (0.0648)
Importer Edu	0.0137 (0.0139)	–0.0660*** (0.0157)	0.0037 (0.0583)
Importer Service Emp	0.0528*** (0.0045)	–0.0381*** (0.0056)	–0.0477* (0.0189)

Table A14. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Importer Unemploy	–0.0481*** (0.0026)	0.0172*** (0.0031)	0.0536** (0.0168)
Trade in Goods	0.1762*** (0.0019)	0.4569*** (0.0051)	0.4720*** (0.0117)
Year × HighGDP–HighGDP	–0.0446*** (0.0062)	0.0407*** (0.0056)	–0.0561 (0.0367)
Year × HighGDP–LowGDP	–0.0865*** (0.0062)	0.0884*** (0.0055)	–0.0685+ (0.0370)
Year × LowGDP–HighGDP	–0.0890*** (0.0061)	0.0852*** (0.0055)	–0.0515 (0.0369)
Year × LowGDP–LowGDP	–0.0910*** (0.0062)	0.1375*** (0.0056)	–0.0293 (0.0372)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	601.9***	628.8***	156.3***
R ²	0.6191	0.6003	0.5955
Adjusted R ²	0.619	0.599	0.592
Root MSE	1.993	2.072	1.683

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A15. Estimation of Growth Rates in Services Trade by High GDP/Low GDP Economies, Service Industries, and the Three Periods

Dependent Variables	Services Trade 2000–2008 (1)	Services Trade 2008–2014 (2)	Services Trade 2014–2016 (3)
Exporter Population	0.3061 (0.2290)	1.1518** (0.3517)	–0.7256 (1.9497)
Exporter GDP	0.0074*** (0.0012)	–0.0023 (0.0019)	–0.0029 (0.0052)
Exporter Service Ind	–0.0604*** (0.0033)	0.0053 (0.0039)	0.0250* (0.0126)
Exporter FDI	0.0003* (0.0001)	0.0004 (0.0005)	0.0049 (0.0048)
Exporter R&D	–0.0699+ (0.0423)	0.2743*** (0.0363)	0.0548 (0.0664)
Exporter Edu	0.0400** (0.0138)	–0.0538*** (0.0162)	–0.0604 (0.0576)
Exporter Service Emp	0.0552*** (0.0043)	–0.0319*** (0.0057)	–0.0460* (0.0209)
Exporter Unemploy	–0.0393*** (0.0026)	0.0018 (0.0032)	0.0568*** (0.0167)
Importer Population	0.0547 (0.2387)	3.3239*** (0.3175)	–1.5681 (1.8656)
Importer GDP	0.0132*** (0.0012)	0.0026 (0.0018)	–0.0014 (0.0047)
Importer Service Ind	–0.0553*** (0.0034)	–0.0066+ (0.0038)	–0.0081 (0.0119)
Importer FDI	0.0002+ (0.0001)	0.0002 (0.0003)	–0.0025 (0.0030)
Importer R&D	–0.2048*** (0.0415)	0.3340*** (0.0349)	–0.0431 (0.0648)
Importer Edu	0.0138 (0.0139)	–0.0609*** (0.0156)	0.0045 (0.0582)
Importer Service Emp	0.0524*** (0.0044)	–0.0384*** (0.0056)	–0.0498** (0.0188)

Table A15. Continued

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2016
Importer Unemploy	–0.0487*** (0.0026)	0.0179*** (0.0031)	0.0540** (0.0168)
Trade in Goods	0.1763*** (0.0019)	0.4551*** (0.0050)	0.4718*** (0.0117)
Year × HighGDP–HighGDP	–0.0696***	0.0047	–0.0259
× Other Services	(0.0064)	(0.0060)	(0.0380)
Year × HighGDP–LowGDP	–0.1016***	0.0607***	–0.0330
× Other Services	(0.0064)	(0.0058)	(0.0382)
Year × LowGDP–HighGDP	–0.0900***	0.0624***	–0.0132
× Other Services	(0.0063)	(0.0058)	(0.0382)
Year × LowGDP–LowGDP	–0.0691***	0.1313***	0.0139
× Other Services	(0.0064)	(0.0059)	(0.0383)
Year × HighGDP–HighGDP	0.0092	0.0443***	–0.1633***
× Information	(0.0079)	(0.0099)	(0.0454)
Year × HighGDP–LowGDP	–0.0371***	0.0908***	–0.1614***
× Information	(0.0082)	(0.0102)	(0.0456)
Year × LowGDP–HighGDP	–0.0665***	0.0739***	–0.1571***
× Information	(0.0081)	(0.0099)	(0.0455)
Year × LowGDP–LowGDP	–0.1315***	0.0779***	–0.1116*
× Information	(0.0085)	(0.0104)	(0.0455)
Year × HighGDP–HighGDP	–0.0388***	0.0783***	–0.0462
× Professional	(0.0074)	(0.0067)	(0.0391)
Year × HighGDP–LowGDP	–0.0801***	0.1186***	–0.0777*
× Professional	(0.0077)	(0.0066)	(0.0393)
Year × LowGDP–HighGDP	–0.0851***	0.1283***	–0.0482
× Professional	(0.0075)	(0.0066)	(0.0393)
Year × LowGDP–LowGDP	–0.1097***	0.1535***	–0.0499
× Professional	(0.0078)	(0.0067)	(0.0395)
Year × HighGDP–HighGDP	0.0551***	0.1345***	–0.2051***
× Finance	(0.0082)	(0.0094)	(0.0467)
Year × HighGDP–LowGDP	–0.0238**	0.1711***	–0.2098***
× Finance	(0.0084)	(0.0092)	(0.0470)

Table A15. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Year × LowGDP–HighGDP	–0.0978***	0.1147***	–0.2255***
× Finance	(0.0087)	(0.0095)	(0.0470)
Year × LowGDP–LowGDP	–0.1807***	0.1207***	–0.1946***
× Finance	(0.0091)	(0.0099)	(0.0475)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	455***	468.9***	113.1***
R ²	0.6221	0.6035	0.5979
Adjusted R ²	0.622	0.603	0.594
Root MSE	1.985	2.063	1.678

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A16. Estimation of Growth Rates in Services Trade
by High Income/Low Income Economies**

Dependent Variables	Services Trade
Exporter Population	1.3444*** (0.1095)
Exporter Inc	-0.0049*** (0.0007)
Exporter Service Ind	-0.0331*** (0.0020)
Exporter FDI	0.0002+ (0.0001)
Exporter R&D	0.1818*** (0.0199)
Exporter Edu	-0.0392*** (0.0095)
Exporter Service Emp	0.0223*** (0.0026)
Exporter Unemploy	-0.0037* (0.0016)
Importer Population	1.7933*** (0.1093)
Importer Inc	0.0007 (0.0007)
Importer Service Ind	-0.0352*** (0.0020)
Importer FDI	0.0001 (0.0001)
Importer R&D	0.1694*** (0.0194)
Importer Edu	-0.0298** (0.0095)
Importer Service Emp	0.0242*** (0.0027)
Importer Unemploy	-0.0082*** (0.0015)

Table A16. Continued

Dependent Variables	Services Trade
Trade in Goods	0.1989*** (0.0016)
Year × HighInc–HighInc	0.0322*** (0.0023)
Year × HighInc–LowInc	–0.0224*** (0.0029)
Year × LowInc–HighInc	–0.0154*** (0.0029)
Year × LowInc–LowInc	–0.0652*** (0.0039)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	567,074
F	1,075***
R ²	0.5952
Adjusted R ²	0.595
Root MSE	2.048

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A17. Estimation of Growth Rates in Services Trade by High Income/Low Income Economies and Service Industries

Dependent Variables	Services Trade
Exporter Population	1.2697*** (0.1091)
Exporter Inc	-0.0040*** (0.0007)
Exporter Service Ind	-0.0337*** (0.0020)
Exporter FDI	0.0002+ (0.0001)
Exporter R&D	0.2011*** (0.0199)
Exporter Edu	-0.0366*** (0.0095)
Exporter Service Emp	0.0240*** (0.0026)
Exporter Unemploy	-0.0039* (0.0016)
Importer Population	1.6869*** (0.1089)
Importer Inc	0.0014* (0.0007)
Importer Service Ind	-0.0349*** (0.0020)
Importer FDI	0.0001 (0.0001)
Importer R&D	0.1850*** (0.0194)
Importer Edu	-0.0276** (0.0095)
Importer Service Emp	0.0252*** (0.0027)
Importer Unemploy	-0.0083*** (0.0015)

Table A17. Continued

Dependent Variables	Services Trade
Trade in Goods	0.1999*** (0.0016)
Year × HighInc-HighInc	0.0120***
× Other Services	(0.0024)
Year × HighInc-LowInc	-0.0414***
× Other Services	(0.0031)
Year × LowInc-HighInc	-0.0273***
× Other Services	(0.0030)
Year × LowInc-LowInc	-0.0540***
× Other Services	(0.0040)
Year × HighInc-HighInc	0.0637***
× Information	(0.0032)
Year × HighInc-LowInc	-0.0209***
× Information	(0.0044)
Year × LowInc-HighInc	-0.0019
× Information	(0.0041)
Year × LowInc-LowInc	-0.1077***
× Information	(0.0063)
Year × HighInc-HighInc	0.0545***
× Professional	(0.0026)
Year × HighInc-LowInc	0.0080*
× Professional	(0.0034)
Year × LowInc-HighInc	0.0126***
× Professional	(0.0033)
Year × LowInc-LowInc	-0.0588***
× Professional	(0.0051)
Year × HighInc-HighInc	0.0596***
× Finance	(0.0032)
Year × HighInc-LowInc	0.0016
× Finance	(0.0042)
Year × LowInc-HighInc	-0.0312***
× Finance	(0.0046)

Table A17. Continued

Dependent Variables	Services Trade
Year × LowInc–LowInc	–0.2151***
× Finance	(0.0085)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	567,074
F	768.5***
R ²	0.5971
Adjusted R ²	0.597
Root MSE	2.044

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A18. Estimation of Growth Rates in Services Trade by High Income/Low Income Economies and the Three Periods

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Exporter Population	0.8929*** (0.2303)	0.2121 (0.3448)	–1.0389 (1.9581)
Exporter Inc	0.0040** (0.0012)	–0.0024 (0.0019)	0.0003 (0.0055)
Exporter Service Ind	–0.0511*** (0.0033)	0.0046 (0.0039)	0.0306* (0.0128)
Exporter FDI	0.0005*** (0.0001)	0.0005 (0.0005)	0.0061 (0.0046)
Exporter R&D	–0.0521 (0.0417)	0.3458*** (0.0368)	0.0837 (0.0669)
Exporter Edu	0.0411** (0.0136)	–0.0607*** (0.0163)	–0.0809 (0.0571)
Exporter Service Emp	0.0536*** (0.0043)	–0.0247*** (0.0059)	–0.0314 (0.0214)
Exporter Unemploy	–0.0339*** (0.0025)	0.0028 (0.0032)	0.0549** (0.0167)
Importer Population	0.5438* (0.2391)	2.7003*** (0.3151)	–1.7797 (1.8757)
Importer Inc	0.0091*** (0.0012)	0.0039* (0.0019)	–0.0007 (0.0050)
Importer Service Ind	–0.0454*** (0.0034)	–0.0082* (0.0038)	–0.0060 (0.0122)
Importer FDI	0.0004** (0.0001)	0.0003 (0.0003)	–0.0025 (0.0030)
Importer R&D	–0.2088*** (0.0412)	0.3623*** (0.0352)	–0.0168 (0.0649)
Importer Edu	0.0133 (0.0138)	–0.0780*** (0.0158)	0.0035 (0.0579)
Importer Service Emp	0.0530*** (0.0045)	–0.0246*** (0.0056)	–0.0439* (0.0191)

Table A18. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Importer Unemploy	–0.0436*** (0.0025)	0.0176*** (0.0031)	0.0517** (0.0168)
Trade in Goods	0.1841*** (0.0019)	0.4586*** (0.0050)	0.4952*** (0.0113)
Year × HighInc–HighInc	–0.0233*** (0.0060)	0.0917*** (0.0053)	–0.0298 (0.0379)
Year × HighInc–LowInc	–0.1106*** (0.0069)	0.0689*** (0.0076)	–0.0702 (0.0444)
Year × LowInc–HighInc	–0.1084*** (0.0067)	0.1159*** (0.0074)	–0.0882* (0.0447)
Year × LowInc–LowInc	–0.1979*** (0.0080)	0.0959*** (0.0097)	–0.0930+ (0.0516)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	600.3***	593.7***	127.4***
R ²	0.6194	0.5995	0.5943
Adjusted R ²	0.619	0.599	0.591
Root MSE	1.992	2.074	1.685

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A19. Estimation of Growth Rates in Services Trade by High Income/Low Income Economies, Service Industries, and the Three Periods

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2016
	(1)	(2)	(3)
Exporter Population	0.8290*** (0.2292)	0.0857 (0.3443)	–0.3757 (1.9607)
Exporter Inc	0.0039** (0.0012)	–0.0024 (0.0019)	0.0004 (0.0055)
Exporter Service Ind	–0.0511*** (0.0033)	0.0032 (0.0039)	0.0285* (0.0128)
Exporter FDI	0.0005*** (0.0001)	0.0005 (0.0005)	0.0059 (0.0047)
Exporter R&D	–0.0477 (0.0417)	0.3510*** (0.0368)	0.0774 (0.0669)
Exporter Edu	0.0377** (0.0136)	–0.0580*** (0.0163)	–0.0832 (0.0571)
Exporter Service Emp	0.0534*** (0.0043)	–0.0238*** (0.0058)	–0.0312 (0.0213)
Exporter Unemploy	–0.0350*** (0.0025)	0.0034 (0.0032)	0.0539** (0.0167)
Importer Population	0.4763* (0.2384)	2.5017*** (0.3142)	–1.5343 (1.8783)
Importer Inc	0.0091*** (0.0012)	0.0040* (0.0019)	–0.0007 (0.0050)
Importer Service Ind	–0.0453*** (0.0034)	–0.0089* (0.0037)	–0.0077 (0.0122)
Importer FDI	0.0004*** (0.0001)	0.0003 (0.0003)	–0.0025 (0.0030)
Importer R&D	–0.2088*** (0.0411)	0.3658*** (0.0351)	–0.0161 (0.0650)
Importer Edu	0.0120 (0.0138)	–0.0741*** (0.0158)	0.0043 (0.0580)

Table A19. Continued

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2016
Importer Service Emp	0.0522*** (0.0044)	–0.0241*** (0.0056)	–0.0427* (0.0191)
Importer Unemploy	–0.0442*** (0.0025)	0.0180*** (0.0031)	0.0519** (0.0168)
Trade in Goods	0.1843*** (0.0019)	0.4574*** (0.0050)	0.4970*** (0.0112)
Year × HighInc–HighInc	–0.0403*** (0.0062)	0.0768*** (0.0056)	0.0128 (0.0391)
× Other Services			
Year × HighInc–LowInc	–0.1157*** (0.0071)	0.0476*** (0.0079)	–0.0324 (0.0455)
× Other Services			
Year × LowInc–HighInc	–0.1091*** (0.0069)	0.1011*** (0.0076)	–0.0333 (0.0458)
× Other Services			
Year × LowInc–LowInc	–0.1721*** (0.0082)	0.0950*** (0.0099)	–0.0378 (0.0528)
× Other Services			
Year × HighInc–HighInc	0.0210** (0.0076)	0.0867*** (0.0096)	–0.0982* (0.0465)
× Information			
Year × HighInc–LowInc	–0.1081*** (0.0090)	0.0269* (0.0119)	–0.1365** (0.0516)
× Information			
Year × LowInc–HighInc	–0.0911*** (0.0089)	0.0912*** (0.0112)	–0.1484** (0.0518)
× Information			
Year × LowInc–LowInc	–0.2331*** (0.0114)	0.0088 (0.0139)	–0.1695** (0.0578)
× Information			
Year × HighInc–HighInc	–0.0248*** (0.0072)	0.1182*** (0.0064)	–0.0457 (0.0405)
× Professional			
Year × HighInc–LowInc	–0.1059*** (0.0083)	0.0992*** (0.0084)	–0.1007* (0.0464)
× Professional			
Year × LowInc–HighInc	–0.1083*** (0.0081)	0.1435*** (0.0082)	–0.1007* (0.0466)
× Professional			
Year × LowInc–LowInc	–0.2192*** (0.0106)	0.1111*** (0.0108)	–0.1540** (0.0532)
× Professional			
Year × HighInc–HighInc	0.0402*** (0.0079)	0.1543*** (0.0091)	–0.1927*** (0.0478)
× Finance			

Table A19. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Year × HighInc–LowInc	–0.0800***	0.1278***	–0.2287***
× Finance	(0.0092)	(0.0109)	(0.0532)
Year × LowInc–HighInc	–0.1117***	0.1344***	–0.2775***
× Finance	(0.0098)	(0.0111)	(0.0536)
Year × LowInc–LowInc	–0.3501***	–0.0218	–0.2629***
× Finance	(0.0139)	(0.0148)	(0.0611)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	346,747	254,434	52,658
F	414.2***	418.6***	86.13***
R ²	0.6207	0.6016	0.5958
Adjusted R ²	0.620	0.601	0.592
Root MSE	1.989	2.069	1.682

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A20. ICT Development Index (IDI) in 2015

Top 10 economies with highest levels of IDI	Republic of Korea	8.93
	Denmark	8.88
	Iceland	8.86
	The United Kingdom	8.75
	Sweden	8.67
	Luxemburg	8.59
	Switzerland	8.56
	The Netherlands	8.53
	Hong Kong	8.52
	Norway	8.49
Bottom 10 economies with lowest levels of IDI	Mozambique	1.82
	Burkina Faso	1.77
	Democratic Republic of Congo	1.65
	South Sudan	1.63
	Guinea-Bissau	1.61
	Malawi	1.61
	Madagascar	1.51
	Ethiopia	1.45
	Eritrea	1.22
	Chad	1.77

Source: <http://www.itu.int/net4/itu-d/idi/2017/index.html>

**Table A21. Estimation of Growth Rates in Service Trade
by ICT Development Levels**

DependentVariables	Service Trade
Exporter Population	0.6406*** (0.1159)
Exporter GDP	-0.0033*** (0.0007)
Exporter Service Ind	-0.0017 (0.0020)
Exporter FDI	-0.0004 (0.0005)
Exporter R&D	0.2096*** (0.0192)
Exporter Edu	-0.0629*** (0.0096)
Exporter Service Emp	-0.0021 (0.0027)
Exporter Unemploy	0.0121*** (0.0015)
Exporter IDI	0.5053*** (0.1119)
Importer Population	0.0023** (0.0007)
Importer GDP	-0.0012 (0.0020)
Importer Service Ind	0.0003 (0.0004)
Importer FDI	0.2606*** (0.0189)
Importer R&D	-0.1066*** (0.0094)
Importer Edu	0.0041 (0.0027)
Importer Service Emp	0.0152*** (0.0015)

Table A21. Continued

Dependent Variables	Service Trade
Importer Unemploy	0.5579*** (0.0038)
Importer FDI	0.0409*** (0.0110)
Trade in Goods	-0.0597*** (0.0112)
Year × HighICT-HighICT	0.0233*** (0.0028)
Year × HighICT-LowICT	0.0205*** (0.0032)
Year × LowICT-HighICT	0.0168*** (0.0032)
Year × LowICT-LowICT	0.0279*** (0.0033)
Exporter FE	YES
Importer FE	YES
Industry FE	YES
N	536,355
F	1341***
R ²	0.6200
Adjusted R ²	0.620
Root MSE	1.929

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A22. Estimation of Growth Rates in Service Trades
by ICT Development Levels in Three Periods**

Dependent Variables	Service Trade 2000–2008	Service Trade 2008–2014	Service Trade 2014–2016
Exporter Population	–0.5029* (0.2537)	0.4866 (0.3704)	–1.0397 (1.9002)
Exporter GDP	0.0041*** (0.0012)	–0.0073*** (0.0020)	–0.0092+ (0.0049)
Exporter Service Ind	0.0063+ (0.0038)	0.0006 (0.0040)	0.0239* (0.0102)
Exporter FDI	0.0010 (0.0007)	0.0021** (0.0007)	–0.0003 (0.0028)
Exporter R&D	0.0784+ (0.0415)	0.3167*** (0.0361)	0.0557 (0.0710)
Exporter Edu	–0.0920*** (0.0141)	–0.0576*** (0.0163)	–0.0896 (0.0563)
Exporter Service Emp	0.0160*** (0.0045)	–0.0282*** (0.0058)	–0.0646** (0.0202)
Exporter Unemploy	0.0065* (0.0026)	0.0028 (0.0032)	0.0695*** (0.0177)
Exporter IDI	0.0392* (0.0198)	0.1216*** (0.0249)	0.5247*** (0.0947)
Importer Population	–0.8499** (0.2608)	2.2715*** (0.3269)	–3.1514+ (1.8710)
Importer GDP	0.0050*** (0.0012)	–0.0010 (0.0019)	–0.0008 (0.0048)
Importer Service Ind	0.0132*** (0.0038)	–0.0032 (0.0038)	0.0042 (0.0098)
Importer FDI	0.0010 (0.0007)	0.0022** (0.0007)	0.0052+ (0.0028)
Importer R&D	–0.0613 (0.0416)	0.3528*** (0.0349)	0.0029 (0.0704)
Importer Edu	–0.1712*** (0.0140)	–0.0751*** (0.0155)	–0.0404 (0.0551)

Table A22. Continued

Dependent Variables	Service Trade 2000–2008	Service Trade 2008–2014	Service Trade 2014–2016
Importer Service Emp	0.0111* (0.0045)	–0.0280*** (0.0056)	–0.0678*** (0.0200)
Importer Unemploy	0.0049+ (0.0026)	0.0203*** (0.0031)	0.0624*** (0.0178)
Importer IDI	0.0003 (0.0197)	–0.2282*** (0.0274)	0.2567** (0.0909)
Trade in Goods	0.5458*** (0.0048)	0.5784*** (0.0058)	0.5554*** (0.0066)
Year × HighICT–HighICT	–0.0275*** (0.0073)	0.1148*** (0.0083)	–0.1373*** (0.0392)
Year × HighICT–LowICT	–0.0156* (0.0069)	0.1157*** (0.0087)	–0.1309** (0.0398)
Year × LowICT–HighICT	–0.0112 (0.0069)	0.1101*** (0.0087)	–0.1235** (0.0399)
Year × LowICT–LowICT	0.0224*** (0.0064)	0.1108*** (0.0089)	1.3072*** (0.1121)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	325,458	243,467	51,685
F	752.5***	656.3***	322.2***
R ²	0.6424	0.6065	0.5943

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A23. Estimation of Growth Rates in Service Trades
by ICT Development Levels and Industry Automatability**

Dependent Variables	Service Trades 2000–2008	Service Trades 2008–2014	Service Trades 2014–2016
Exporter Population	–0.8791*** (0.2503)	0.9007* (0.3692)	–0.0981 (1.8916)
Exporter GDP	0.0003 (0.0012)	–0.0085*** (0.0020)	–0.0117* (0.0048)
Exporter Service Ind	0.0077* (0.0038)	–0.0018 (0.0040)	0.0246* (0.0102)
Exporter FDI	0.0005 (0.0007)	0.0020** (0.0007)	–0.0003 (0.0028)
Exporter R&D	–0.0024 (0.0415)	0.3224*** (0.0360)	0.0411 (0.0705)
Exporter Edu	–0.0625*** (0.0141)	–0.0582*** (0.0163)	–0.0438 (0.0559)
Exporter Service Emp	0.0232*** (0.0044)	–0.0244*** (0.0057)	–0.0664*** (0.0201)
Exporter Unemploy	–0.0006 (0.0026)	0.0008 (0.0032)	0.0506** (0.0173)
Exporter IDI	–0.0209 (0.0195)	0.0925*** (0.0243)	0.4652*** (0.0931)
Importer Population	–1.0330*** (0.2584)	2.4463*** (0.3252)	–2.0695 (1.8578)
Importer GDP	0.0028* (0.0012)	–0.0017 (0.0019)	–0.0017 (0.0047)
Importer Service Ind	0.0131*** (0.0038)	–0.0042 (0.0038)	0.0033 (0.0099)
Importer FDI	0.0007 (0.0007)	0.0021** (0.0007)	0.0051+ (0.0028)
Importer R&D	–0.1087** (0.0415)	0.3589*** (0.0348)	–0.0139 (0.0699)
Importer Edu	–0.1539*** (0.0140)	–0.0744*** (0.0155)	–0.0481 (0.0547)

Table A23. Continued

Dependent Variables	Service Trades 2000–2008	Service Trades 2008–2014	Service Trades 2014–2016
Importer Service Emp	0.0151*** (0.0044)	–0.0258*** (0.0056)	–0.0623** (0.0199)
Importer Unemploy	0.0022 (0.0026)	0.0190*** (0.0031)	0.0543** (0.0174)
Importer IDI	–0.0174 (0.0195)	–0.2396*** (0.0268)	0.2762** (0.0894)
Trade in Goods	0.5477*** (0.0048)	0.5780*** (0.0058)	0.5536*** (0.0066)
Year × HighICT–HighICT × Automation	0.0004* (0.0002)	0.0037*** (0.0002)	–0.0056*** (0.0011)
Year × HighICT–LowICT × Automation	0.0004+ (0.0002)	0.0036*** (0.0003)	–0.0055*** (0.0011)
Year × LowICT–HighICT × Automation	0.0001 (0.0002)	0.0032*** (0.0003)	–0.0064*** (0.0011)
Year × LowICT–LowICT × Automation	0.0007*** (0.0002)	0.0029*** (0.0003)	0.0140*** (0.0026)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	325,458	243,467	51,685
F	739.7***	662***	317.8***
R ²	0.6422	0.6067	0.5936

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A24. Estimation of Growth Rates in Service Exports
from APEC Economies**

Dependent Variables	Services Trade 2000–2008 (1)	Services Trade 2008–2014 (2)	Services Trade 2014–2016 (3)
Exporter Population	–3.0619*** (0.7178)	3.8130** (1.1630)	–14.6580* (7.2012)
Exporter GDP	0.0213*** (0.0037)	–0.0139** (0.0049)	–0.0059 (0.0136)
Exporter Service Ind	0.0002 (0.0080)	–0.0052 (0.0129)	0.1946*** (0.0419)
Exporter FDI	–0.0127 (0.0092)	0.0570*** (0.0136)	0.0401 (0.0283)
Exporter R&D	–0.3667*** (0.0863)	0.3865*** (0.0939)	0.1257 (0.1786)
Exporter Edu	–0.0352 (0.0316)	0.1412*** (0.0378)	0.0059 (0.1541)
Exporter Service Emp	0.0569*** (0.0104)	0.0016 (0.0096)	–0.0584 (0.0781)
Exporter Unemploy	0.0041 (0.0185)	–0.0426** (0.0142)	–0.0514 (0.0901)
Importer Population	0.4278 (0.4366)	4.9129*** (0.7089)	–8.3503 (5.8443)
Importer GDP	0.0265*** (0.0027)	0.0172*** (0.0048)	–0.0109 (0.0134)
Importer Service Ind	–0.0529*** (0.0075)	–0.0010 (0.0090)	–0.0571* (0.0277)
Importer FDI	0.0005** (0.0002)	0.0003 (0.0007)	0.0227+ (0.0129)
Importer R&D	0.1665+ (0.0959)	0.6144*** (0.0908)	–0.5020* (0.2138)
Importer Edu	–0.0177 (0.0316)	–0.0656+ (0.0394)	0.0296 (0.1474)
Importer Service Emp	0.0574*** (0.0096)	0.0201+ (0.0122)	0.1784** (0.0599)

Table A24. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Importer Unemploy	–0.0460*** (0.0056)	0.0101 (0.0083)	–0.0368 (0.0624)
Trade in Goods	0.1941*** (0.0054)	0.3923*** (0.0108)	0.5384*** (0.0238)
Year × Other Services	–0.0589*** (0.0139)	–0.0263 (0.0161)	–0.0715 (0.1039)
Year × Information	–0.0596*** (0.0163)	0.0008 (0.0229)	–0.3009* (0.1220)
Year × Professional	–0.0411** (0.0159)	–0.0184 (0.0165)	–0.0686 (0.1060)
Year × Finance	–0.0243 (0.0163)	0.1529*** (0.0211)	–0.4457*** (0.1253)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	62,947	45,745	9,785
F	113.8***	104.1***	33.62***
R ²	0.672	0.666	0.704
Adjusted R ²	0.671	0.664	0.695
Root MSE	1.984	2.102	1.793

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A25. Estimation of Growth Rates in Service Imports by APEC Economies

Dependent Variables	Services Trade 2000–2008 (1)	Services Trade 2008–2014 (2)	Services Trade 2014–2016 (3)
Exporter Population	0.8768+ (0.5107)	2.9458*** (0.7201)	–3.2604 (5.8555)
Exporter GDP	0.0265*** (0.0031)	0.0028 (0.0051)	–0.0411** (0.0138)
Exporter Service Ind	–0.0577*** (0.0083)	0.0088 (0.0096)	–0.0105 (0.0280)
Exporter FDI	0.0001 (0.0002)	0.0035*** (0.0009)	0.0015 (0.0126)
Exporter R&D	0.3532*** (0.1046)	0.5755*** (0.0961)	–0.4962* (0.2157)
Exporter Edu	–0.0154 (0.0355)	–0.0121 (0.0397)	0.1410 (0.1570)
Exporter Service Emp	0.0596*** (0.0113)	–0.0039 (0.0123)	–0.0267 (0.0596)
Exporter Unemploy	–0.0434*** (0.0062)	–0.0015 (0.0087)	–0.0780 (0.0632)
Importer Population	–1.6399* (0.7563)	4.4818*** (1.1429)	–8.1931 (7.2720)
Importer GDP	0.0203*** (0.0039)	–0.0047 (0.0049)	0.0209 (0.0136)
Importer Service Ind	0.0169+ (0.0089)	0.0286* (0.0128)	0.0496 (0.0425)
Importer FDI	–0.0146 (0.0096)	0.0094 (0.0134)	0.0367 (0.0260)
Importer R&D	–0.6235*** (0.0886)	0.2638** (0.0931)	0.1667 (0.1709)
Importer Edu	–0.0977** (0.0327)	–0.0248 (0.0378)	0.1148 (0.1508)
Importer Service Emp	0.0481*** (0.0109)	0.0019 (0.0096)	–0.0708 (0.0788)

Table A25. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Importer Unemploy	0.0054 (0.0194)	–0.0403** (0.0148)	0.0116 (0.0926)
Trade in Goods	0.2303*** (0.0069)	0.4506*** (0.0137)	0.7190*** (0.0321)
Year × Other Services	–0.0904*** (0.0150)	0.0031 (0.0161)	–0.0330 (0.1064)
Year × Information	–0.0510** (0.0180)	0.0082 (0.0223)	–0.2216+ (0.1285)
Year × Professional	–0.0434* (0.0172)	0.0260 (0.0166)	–0.2148* (0.1066)
Year × Finance	–0.0638*** (0.0176)	0.1400*** (0.0224)	–0.4271*** (0.1241)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	58,949	43,593	9,648
F	90.35***	86.67***	34.62***
R ²	0.645	0.651	0.694
Adjusted R ²	0.643	0.649	0.686
Root MSE	2.084	2.127	1.787

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A26. Estimation of Growth Rates in Service Exports from APEC Economies

Dependent Variables	Services Trade 2000–2008 (1)	Services Trade 2008–2014 (2)	Services Trade 2014–2016 (3)
Exporter Population	–5.1278*** (0.7285)	2.2169+ (1.1742)	–19.5968* (7.6287)
Exporter GDP	0.0320*** (0.0037)	–0.0140** (0.0050)	–0.0191 (0.0163)
Exporter Service Ind	0.0085 (0.0079)	–0.0005 (0.0134)	0.2124*** (0.0430)
Exporter FDI	–0.0160+ (0.0093)	0.0705*** (0.0145)	0.0542+ (0.0285)
Exporter R&D	–0.3483*** (0.0873)	0.3382*** (0.0995)	0.1772 (0.1771)
Exporter Edu	–0.0393 (0.0315)	0.1195** (0.0381)	0.1071 (0.1549)
Exporter Service Emp	0.0233+ (0.0121)	0.0107 (0.0099)	–0.0842 (0.0811)
Exporter Unemploy	0.0307 (0.0194)	–0.0461** (0.0146)	–0.1253 (0.1056)
Importer Population	1.8562*** (0.4625)	4.5339*** (0.7718)	–5.8650 (5.9013)
Importer GDP	0.0109*** (0.0030)	0.0164*** (0.0049)	0.0148 (0.0141)
Importer Service Ind	–0.0498*** (0.0074)	–0.0018 (0.0089)	–0.0388 (0.0268)
Importer FDI	0.0006*** (0.0002)	0.0002 (0.0007)	0.0193 (0.0127)
Importer R&D	0.0221 (0.0953)	0.5345*** (0.0894)	–0.3943+ (0.2131)
Importer Edu	–0.0012 (0.0311)	–0.0843* (0.0390)	–0.0105 (0.1458)
Importer Service Emp	0.0628*** (0.0096)	0.0153 (0.0124)	0.1713** (0.0595)

Table A26. Continued

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2016
Importer Unemploy	–0.0422*** (0.0055)	0.0149+ (0.0082)	0.0561 (0.0642)
Trade in Goods	0.1932*** (0.0055)	0.3693*** (0.0109)	0.4929*** (0.0245)
Year × Developed–Developed	–0.0708***	–0.0116	–0.0176
× Other Services	(0.0143)	(0.0169)	(0.1257)
Year × Developed–Developing	–0.1099***	–0.0146	–0.2791+
× Other Services	(0.0193)	(0.0228)	(0.1457)
Year × Developing–Developed	0.0721***	0.0141	0.0904
× Other Services	(0.0165)	(0.0181)	(0.1099)
Year × Developing–Developing	–0.1085***	–0.0735**	–0.2261
× Other Services	(0.0188)	(0.0245)	(0.1388)
Year × Developed–Developed	0.0213	0.0360	–0.1695
× Information	(0.0172)	(0.0232)	(0.1393)
Year × Developed–Developing	0.0152	–0.0010	–0.4237**
× Information	(0.0249)	(0.0287)	(0.1571)
Year × Developing–Developed	0.0611**	0.0112	–0.0901
× Information	(0.0188)	(0.0248)	(0.1257)
Year × Developing–Developing	–0.1613***	–0.1165***	–0.2596+
× Information	(0.0213)	(0.0310)	(0.1547)
Year × Developed–Developed	0.0065	0.0024	0.0526
× Professional	(0.0166)	(0.0174)	(0.1268)
Year × Developed–Developing	0.0355+	–0.0001	–0.2334
× Professional	(0.0207)	(0.0223)	(0.1460)
Year × Developing–Developed	0.0430*	–0.0192	0.1296
× Professional	(0.0182)	(0.0192)	(0.1135)
Year × Developing–Developing	–0.0882***	–0.0819**	–0.1833
× Professional	(0.0202)	(0.0250)	(0.1410)
Year × Developed–Developed	0.0825***	0.1608***	–0.2298
× Finance	(0.0172)	(0.0217)	(0.1436)
Year × Developed–Developing	0.1159***	0.1935***	–0.4383**
× Finance	(0.0235)	(0.0261)	(0.1556)

Table A26. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Year × Developing–Developed	0.0602**	0.1221***	–0.1697
× Finance	(0.0193)	(0.0238)	(0.1333)
Year × Developing–Developing	–0.1230***	0.0223	–0.4626**
× Finance	(0.0211)	(0.0293)	(0.1529)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	62,947	45,745	9,785
F	110.2***	95.26***	29.22***
R ²	0.679	0.670	0.709
Adjusted R ²	0.677	0.668	0.700
Root MSE	1.964	2.090	1.778

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A27. Estimation of Growth Rates in Service Imports
by APEC Economies**

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2016
	(1)	(2)	(3)
Exporter Population	2.2600*** (0.5359)	2.0484** (0.7799)	–0.6369 (5.8861)
Exporter GDP	0.0128*** (0.0034)	0.0001 (0.0052)	–0.0179 (0.0149)
Exporter Service Ind	–0.0593*** (0.0083)	0.0068 (0.0096)	0.0073 (0.0280)
Exporter FDI	0.0002 (0.0002)	0.0035*** (0.0009)	0.0011 (0.0126)
Exporter R&D	0.2354* (0.1050)	0.5279*** (0.0962)	–0.4155* (0.2117)
Exporter Edu	0.0009 (0.0353)	–0.0152 (0.0397)	0.0798 (0.1578)
Exporter Service Emp	0.0710*** (0.0114)	–0.0088 (0.0127)	–0.0324 (0.0593)
Exporter Unemploy	–0.0443*** (0.0062)	0.0040 (0.0087)	–0.0079 (0.0642)
Importer Population	–3.1267*** (0.7757)	3.7910*** (1.1494)	–15.0813+ (7.8096)
Importer GDP	0.0285*** (0.0039)	–0.0048 (0.0050)	–0.0038 (0.0164)
Importer Service Ind	0.0217* (0.0089)	0.0343** (0.0132)	0.0791+ (0.0438)
Importer FDI	–0.0157 (0.0096)	0.0202 (0.0143)	0.0551* (0.0267)
Importer R&D	–0.5944*** (0.0894)	0.2550* (0.1000)	0.1871 (0.1715)
Importer Edu	–0.1062** (0.0326)	–0.0535 (0.0380)	0.2480 (0.1536)
Importer Service Emp	0.0241+ (0.0129)	0.0088 (0.0098)	–0.1316 (0.0817)

Table A27. Continued

Dependent Variables	Services Trade	Services Trade	Services Trade
	2000–2008	2008–2014	2014–2016
Importer Unemploy	0.0275 (0.0203)	–0.0479** (0.0151)	–0.1358 (0.1113)
Trade in Goods	0.2358*** (0.0071)	0.4422*** (0.0136)	0.6885*** (0.0323)
Year × Developed–Developed	–0.0987***	–0.0022	–0.0978
× Other Services	(0.0153)	(0.0168)	(0.1237)
Year × Developed–Developing	0.0038	0.0175	0.1455
× Other Services	(0.0182)	(0.0187)	(0.1118)
Year × Developing–Developed	–0.1149***	0.0296	–0.1745
× Other Services	(0.0206)	(0.0221)	(0.1472)
Year × Developing–Developing	–0.1432***	–0.0261	0.0155
× Other Services	(0.0209)	(0.0248)	(0.1466)
Year × Developed–Developed	0.0018	0.0082	–0.2245
× Information	(0.0189)	(0.0235)	(0.1417)
Year × Developed–Developing	0.0317	0.0066	0.0065
× Information	(0.0210)	(0.0252)	(0.1306)
Year × Developing–Developed	0.0183	0.0358	–0.2772+
× Information	(0.0256)	(0.0268)	(0.1620)
Year × Developing–Developing	–0.1456***	–0.0616*	0.0054
× Information	(0.0240)	(0.0302)	(0.1566)
Year × Developed–Developed	–0.0247	0.0257	–0.2588*
× Professional	(0.0178)	(0.0172)	(0.1265)
Year × Developed–Developing	0.0265	0.0105	–0.0315
× Professional	(0.0200)	(0.0196)	(0.1140)
Year × Developing–Developed	0.0313	0.0549*	–0.3625*
× Professional	(0.0222)	(0.0224)	(0.1466)
Year × Developing–Developing	–0.0947***	–0.0269	–0.1718
× Professional	(0.0225)	(0.0255)	(0.1456)
Year × Developed–Developed	0.0348+	0.1503***	–0.4354**
× Finance	(0.0187)	(0.0229)	(0.1401)
Year × Developed–Developing	0.0393+	0.1489***	–0.2123+
× Finance	(0.0206)	(0.0249)	(0.1284)

Table A27. Continued

Dependent Variables	Services Trade 2000–2008	Services Trade 2008–2014	Services Trade 2014–2016
Year × Developing–Developed	–0.0410	0.1364***	–0.5204**
× Finance	(0.0254)	(0.0282)	(0.1591)
Year × Developing–Developing	–0.2465***	–0.0003	–0.4295**
× Finance	(0.0248)	(0.0314)	(0.1582)
Exporter FE	YES	YES	YES
Importer FE	YES	YES	YES
Industry FE	YES	YES	YES
N	58,949	43,593	9,648
F	84.55***	81.17***	27.23***
R ²	0.650	0.655	0.701
Adjusted R ²	0.648	0.652	0.692
Root MSE	2.068	2.116	1.770

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A28. Estimation of Growth Rates in Services Trade within APEC Economies

Dependent Variables	Services Trade	Services Trade
	2000–2011	2011–2016
	(1)	(2)
Exporter Population	-1.7448+	4.1337
	(0.9169)	(3.8780)
Exporter GDP	0.0143*	0.0071
	(0.0068)	(0.0138)
Exporter Service Ind	0.0176	-0.0026
	(0.0134)	(0.0412)
Exporter FDI	0.0209	0.0322
	(0.0193)	(0.0278)
Exporter R&D	0.4768***	0.3165
	(0.1362)	(0.3718)
Exporter Edu	-0.0286	-0.0059
	(0.0609)	(0.1481)
Exporter Service Emp	-0.0048	0.0041
	(0.0156)	(0.0395)
Exporter Unemploy	-0.0615**	-0.0832
	(0.0221)	(0.0673)
Importer Population	-3.6964***	-0.6681
	(0.9650)	(4.0274)
Importer GDP	-0.0004	-0.0480***
	(0.0067)	(0.0129)
Importer Service Ind	0.0670***	0.0709*
	(0.0137)	(0.0358)
Importer FDI	0.0116	0.0991***
	(0.0173)	(0.0297)
Importer R&D	0.2273+	-0.2483
	(0.1302)	(0.3568)
Importer Edu	-0.1952***	0.1840
	(0.0533)	(0.1425)
Importer Service Emp	-0.0036	0.0641
	(0.0167)	(0.0406)

Table A28. Continued

Dependent Variables	Services Trade	Services Trade
	2000–2011	2011–2016
Importer Unemploy	–0.0301 (0.0214)	–0.2750*** (0.0689)
Trade in Goods	0.5520*** (0.0194)	0.6402*** (0.0299)
Year × Developed–Developed × Other Services	–0.0330 (0.0233)	–0.3051** (0.0967)
Year × Developed–Developing × Other Services	–0.0281 (0.0250)	–0.1806* (0.0843)
Year × Developing–Developed × Other Services	0.0237 (0.0227)	–0.2733** (0.0850)
Year × Developing–Developing × Other Services	–0.0042 (0.0253)	–0.1843* (0.0746)
Year × Developed–Developed × Information	0.0361 (0.0309)	–0.4719*** (0.1069)
Year × Developed–Developing × Information	0.0913** (0.0290)	–0.3724*** (0.0972)
Year × Developing–Developed × Information	0.1239*** (0.0290)	–0.4687*** (0.0996)
Year × Developing–Developing × Information	0.0422 (0.0305)	–0.4236*** (0.1002)
Year × Developed–Developed × Professional	0.0358 (0.0268)	–0.2598** (0.0965)
Year × Developed–Developing × Professional	0.0307 (0.0278)	–0.1757* (0.0833)
Year × Developing–Developed × Professional	0.0574* (0.0261)	–0.2769** (0.0847)
Year × Developing–Developing × Professional	0.0111 (0.0273)	–0.1865* (0.0731)
Year × Developed–Developed × Finance	0.1132*** (0.0266)	–0.0630 (0.1044)
Year × Developed–Developing × Finance	0.1233*** (0.0285)	0.0362 (0.0922)

Table A28. Continued

Dependent Variables	Services Trade	Services Trade
	2000–2011	2011–2016
Year × Developing–Developed	0.0367	–0.1379
× Finance	(0.0282)	(0.0952)
Year × Developing–Developing	0.0851**	–0.0032
× Finance	(0.0299)	(0.0880)
Exporter FE	YES	YES
Importer FE	YES	YES
Industry FE	YES	YES
N	13,151	4,548
F	48.01***	22.73***
R ²	0.778	0.798
Adjusted R ²	0.776	0.793
Root MSE	1.865	1.632

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A29. Estimation of Growth Rates in Service Exports from China

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	5.4151 (14.9496)	0.5924 (1.9882)
Importer Inc	0.0373 (0.0497)	0.0126 (0.0096)
Importer Service Ind	–0.1779 (0.1852)	0.0234 (0.0300)
Importer FDI	–0.0198 (0.1498)	0.0072 (0.0067)
Importer R&D	–1.6059 (1.2310)	–0.5348* (0.2329)
Importer Edu	–0.0802 (0.4366)	–0.1298 (0.1195)
Importer Service Emp	0.7417*** (0.2130)	–0.0204 (0.0373)
Importer Unemploy	0.1627 (0.1404)	–0.0196 (0.0160)
Trade in Goods	–2.6791+ (1.3633)	0.0336* (0.0156)
Year × Other Services	0.0227 (0.1604)	0.1421*** (0.0316)
Year × Information	0.0992 (0.2958)	0.1713*** (0.0400)
Year × Professional	0.3001 (0.1852)	0.1749*** (0.0367)
Year × Finance	–0.1579 (0.2837)	0.2034*** (0.0464)
Importer FE	YES	YES
Industry FE	YES	YES
N	501	4,395
F	1.433*	20.44***

Table A29. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.753	0.699
Adjusted R ²	0.712	0.692
Root MSE	1.834	1.777

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A30. Estimation of Growth Rates in Service Exports
from Russia Federation**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	13.5924+ (7.7251)	0.4497 (0.2907)
Importer Inc	0.0205 (0.0247)	0.0167*** (0.0030)
Importer Service Ind	0.1186+ (0.0685)	–0.0118+ (0.0067)
Importer FDI	0.0099 (0.0543)	0.0002 (0.0001)
Importer R&D	–0.5789 (0.4268)	–0.0894 (0.0935)
Importer Edu	–0.1009 (0.1913)	–0.0477 (0.0329)
Importer Service Emp	0.1247 (0.0773)	0.0253** (0.0083)
Importer Unemploy	–0.0256 (0.0634)	–0.0393*** (0.0063)
Trade in Goods	0.3613** (0.1157)	0.0313*** (0.0067)
Year × Other Services	–0.2628** (0.0889)	0.0359*** (0.0092)
Year × Information	–0.0127 (0.1736)	0.0795*** (0.0140)
Year × Professional	–0.0924 (0.0989)	0.1179*** (0.0111)
Year × Finance	–0.0509 (0.1653)	0.1527*** (0.0146)
Importer FE	YES	YES
Industry FE	YES	YES
N	3,354	34,239
F	3.182*	66.14***

Table A30. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.673	0.636
Adjusted R ²	0.646	0.632
Root MSE	2.048	2.045

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A31. Estimation of Growth Rates in Service Exports
from Republic of Korea**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	35.1601* (16.0943)	–1.6413 (2.2317)
Importer Inc	0.0538 (0.0581)	0.0152 (0.0123)
Importer Service Ind	0.0716 (0.1776)	–0.0205 (0.0341)
Importer FDI	–0.1270 (0.0851)	0.0064 (0.0088)
Importer R&D	–0.2675 (0.7163)	0.0359 (0.2921)
Importer Edu	–0.2856 (0.5712)	–0.2629+ (0.1418)
Importer Service Emp	0.3652+ (0.2200)	0.0048 (0.0458)
Importer Unemploy	–0.1086 (0.1299)	0.0011 (0.0205)
Trade in Goods	–2.3772** (0.8454)	0.0261 (0.0221)
Year × Other Services	–0.2557+ (0.1408)	0.0758* (0.0383)
Year × Information	–0.5581* (0.2692)	0.1108* (0.0495)
Year × Professional	–0.1307 (0.1361)	0.0852+ (0.0447)
Year × Finance	–0.3688* (0.1589)	0.2093*** (0.0501)
Importer FE	YES	YES
Industry FE	YES	YES
N	578	3,043
F	1.755*	7.991**

Table A31. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.736	0.726
Adjusted R ²	0.695	0.716
Root MSE	1.569	1.721

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A32. Estimation of Growth Rates in Service Exports from India

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	39.6617** (12.9901)	4.1731* (2.0004)
Importer Inc	0.0873* (0.0394)	0.0135 (0.0095)
Importer Service Ind	–0.0812 (0.1689)	–0.0016 (0.0312)
Importer FDI	0.0268 (0.0614)	–0.0025 (0.0077)
Importer R&D	–0.4673 (0.6530)	0.0840 (0.2421)
Importer Edu	–1.0267* (0.4122)	–0.3099** (0.1180)
Importer Service Emp	0.8584*** (0.1851)	0.0280 (0.0403)
Importer Unemploy	0.1394 (0.1048)	–0.0238 (0.0170)
Trade in Goods	0.2584 (0.8547)	0.0594** (0.0211)
Year × Other Services	–0.1451 (0.1116)	0.0604+ (0.0320)
Year × Information	–0.2283 (0.2521)	0.1527** (0.0470)
Year × Professional	–0.0311 (0.1264)	0.0732+ (0.0391)
Year × Finance	–0.0905 (0.1598)	0.1755*** (0.0481)
Importer FE	YES	YES
Industry FE	YES	YES
N	689	3,561
F	3.187*	16.36***

Table A32. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.750	0.751
Adjusted R ²	0.716	0.743
Root MSE	1.557	1.617

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A33. Estimation of Growth Rates in Service Exports
from The Philippines**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	14.8406 (26.7076)	–3.5142 (3.6442)
Importer Inc	0.0246 (0.0706)	0.0350* (0.0139)
Importer Service Ind	–0.7194* (0.2983)	0.0068 (0.0522)
Importer FDI	0.0022 (0.0857)	–0.0056 (0.0105)
Importer R&D	0.4484 (0.8337)	0.4661 (0.3769)
Importer Edu	1.2836 (1.0625)	0.0652 (0.2230)
Importer Service Emp	0.5620 (0.3728)	–0.0583 (0.0841)
Importer Unemploy	–0.1300 (0.2345)	–0.0219 (0.0334)
Trade in Goods	–1.9293*** (0.3219)	0.0842+ (0.0477)
Year × Other Services	0.1591 (0.2100)	–0.0107 (0.0559)
Year × Information	–0.2783 (0.3975)	0.0510 (0.0735)
Year × Professional	0.0190 (0.2344)	–0.0254 (0.0626)
Year × Finance	0.1771 (0.3909)	0.0109 (0.0674)
Importer FE	YES	YES
Industry FE	YES	YES
N	290	1,702
F	4.429**	1.677*

Table A33. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.817	0.768
Adjusted R ²	0.770	0.754
Root MSE	1.345	1.627

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A34. Estimation of Growth Rates in Service Exports from Indonesia

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	3.7045 (21.6836)	0.2653 (3.4675)
Importer Inc	0.0063 (0.0609)	0.0021 (0.0131)
Importer Service Ind	–0.1297 (0.3592)	–0.0146 (0.0472)
Importer FDI	–0.0442 (0.0903)	–0.0028 (0.0086)
Importer R&D	0.2966 (0.8435)	0.6711+ (0.3791)
Importer Edu	–0.3598 (1.0876)	–0.3772+ (0.1942)
Importer Service Emp	0.5990+ (0.3385)	–0.0376 (0.0651)
Importer Unemploy	–0.0976 (0.1787)	0.0184 (0.0237)
Trade in Goods	–0.7311 (0.6655)	0.0238 (0.0245)
Year × Other Services	0.0040 (0.1483)	0.0354 (0.0484)
Year × Information	–0.0347 (0.4089)	–0.0288 (0.0615)
Year × Professional	–0.1109 (0.1781)	0.0413 (0.0691)
Year × Finance	–0.2702 (0.2923)	0.1463* (0.0635)
Importer FE	YES	YES
Industry FE	YES	YES
N	309	1,933
F	0.655	1.711

Table A34. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.762	0.755
Adjusted R ²	0.701	0.743
Root MSE	1.331	1.626

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A35. Estimation of Growth Rates in Service Exports from Brazil

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	–5.4223 (22.4133)	0.0520 (2.9149)
Importer Inc	0.0191 (0.0684)	0.0185+ (0.0106)
Importer Service Ind	0.0696 (0.2220)	0.0294 (0.0357)
Importer FDI	–0.1363+ (0.0766)	–0.0085 (0.0102)
Importer R&D	–0.6591 (0.7592)	0.0119 (0.2980)
Importer Edu	–0.4486 (0.8376)	–0.5692*** (0.1451)
Importer Service Emp	0.9182** (0.3380)	–0.0431 (0.0575)
Importer Unemploy	–0.1888 (0.1826)	0.0373 (0.0227)
Trade in Goods	–0.1765 (1.0141)	–0.0001 (0.0243)
Year × Other Services	–0.1956 (0.1816)	0.0506 (0.0443)
Year × Information	–0.1485 (0.3114)	0.0825 (0.0555)
Year × Professional	–0.0877 (0.1778)	0.1207* (0.0531)
Year × Finance	–0.3075 (0.2728)	0.0803 (0.0518)
Importer FE	YES	YES
Industry FE	YES	YES
N	482	2,716
F	1.112*	5.050**

Table A35. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.741	0.758
Adjusted R ²	0.696	0.749
Root MSE	1.560	1.637

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A36. Estimation of Growth Rates in Service Exports from Mexico

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Importer Population	–15.0165 (27.5885)	–5.5863 (3.6976)
Importer Inc	–0.0008 (0.0666)	0.0234+ (0.0131)
Importer Service Ind	0.4188 (0.3165)	–0.0526 (0.0430)
Importer FDI	–0.0785 (0.1013)	–0.0075 (0.0094)
Importer R&D	–0.1518 (1.0226)	0.6920* (0.3262)
Importer Edu	–0.2198 (1.1368)	–0.2473 (0.1865)
Importer Service Emp	0.7831* (0.3820)	0.0435 (0.0688)
Importer Unemploy	–0.0576 (0.1819)	0.0299 (0.0246)
Trade in Goods	–0.2026 (0.7251)	0.0427 (0.0497)
Year × Other Services	–0.0414 (0.2062)	–0.0071 (0.0507)
Year × Information	–0.1239 (0.2495)	–0.0086 (0.0624)
Year × Professional	–0.0172 (0.2209)	–0.0171 (0.0567)
Year × Finance	–0.0194 (0.2941)	0.0409 (0.0616)
Importer FE	YES	YES
Industry FE	YES	YES
N	362	2,010
F	0.978	2.387*

Table A36. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.787	0.783
Adjusted R ²	0.741	0.772
Root MSE	1.410	1.586

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A37. Estimation of Growth Rates in Service Imports
by the United States**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Exporter Population	1.0526 (2.3027)	2.1294** (0.6827)
ExporterInc	0.0050 (0.0080)	0.0020 (0.0041)
Exporter Service Ind	0.0008 (0.0174)	–0.0135 (0.0115)
Exporter FDI	0.0011 (0.0089)	–0.0070 (0.0043)
Exporter R&D	–0.0611 (0.1652)	0.2250+ (0.1266)
Exporter Edu	0.0234 (0.0792)	–0.0642 (0.0460)
Exporter Service Emp	0.0421 (0.0279)	0.0185 (0.0153)
Exporter Unemploy	0.0344 (0.0269)	–0.0096 (0.0091)
Trade in Goods	0.0969 (0.1282)	0.0744*** (0.0112)
Year × Other Services	0.0188 (0.0385)	–0.0449** (0.0143)
Year × Information	–0.1914** (0.0596)	0.0257 (0.0184)
Year × Professional	–0.0194 (0.0335)	–0.0214 (0.0170)
Year × Finance	–0.0282 (0.0628)	0.0063 (0.0209)
Exporter FE	YES	YES
Industry FE	YES	YES
N	4,442	11,816
F	1.760**	6.725***

Table A37. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.709	0.688
Adjusted R ²	0.700	0.685
Root MSE	1.305	1.592

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A38. Estimation of Growth Rates in Service Imports
by Japan**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Exporter Population	10.1418 (10.5321)	2.9816* (1.3194)
ExporterInc	0.0454 (0.0425)	–0.0035 (0.0071)
Exporter Service Ind	–0.1431 (0.1102)	–0.0453* (0.0203)
Exporter FDI	0.0360 (0.0536)	–0.0055 (0.0070)
Exporter R&D	–0.0743 (0.5184)	0.1673 (0.1767)
Exporter Edu	0.0843 (0.4858)	–0.1100 (0.0811)
Exporter Service Emp	0.1238 (0.1529)	0.0736** (0.0255)
Exporter Unemploy	0.1583 (0.1121)	–0.0038 (0.0133)
Trade in Goods	–0.2777 (0.4814)	0.0730** (0.0235)
Year × Other Services	0.0392 (0.1116)	–0.0637** (0.0236)
Year × Information	–0.0343 (0.1901)	0.0101 (0.0318)
Year × Professional	0.0254 (0.1233)	0.0316 (0.0268)
Year × Finance	–0.0601 (0.1803)	–0.0101 (0.0297)
Exporter FE	YES	YES
Industry FE	YES	YES
N	706	5,493
F	0.467	4.665**

Table A38. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.845	0.797
Adjusted R ²	0.820	0.793
Root MSE	1.314	1.603

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A39. Estimation of Growth Rates in Service Imports
by Canada**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Exporter Population	6.1428 (6.3713)	6.3118*** (1.2648)
ExporterInc	0.0085 (0.0181)	0.0092 (0.0063)
Exporter Service Ind	0.0134 (0.0529)	0.0045 (0.0221)
Exporter FDI	–0.0047 (0.0181)	–0.0103 (0.0071)
Exporter R&D	–0.1542 (0.4106)	–0.4923* (0.1953)
Exporter Edu	–0.1843 (0.1528)	–0.1348 (0.0883)
Exporter Service Emp	0.0892 (0.0714)	0.1153*** (0.0274)
Exporter Unemploy	–0.0260 (0.0546)	–0.0233+ (0.0125)
Trade in Goods	–0.2032 (0.3921)	0.0750*** (0.0198)
Year × Other Services	–0.1136+ (0.0665)	–0.0607* (0.0237)
Year × Information	–0.1944* (0.0947)	–0.0135 (0.0304)
Year × Professional	–0.1443+ (0.0795)	–0.0038 (0.0268)
Year × Finance	–0.0397 (0.1338)	–0.0302 (0.0311)
Exporter FE	YES	YES
Industry FE	YES	YES
N	1,194	5,464
F	0.707	9.320***

Table A39. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.802	0.752
Adjusted R ²	0.782	0.746
Root MSE	1.182	1.593

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A40. Estimation of Growth Rates in Service Imports
by Australia**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Exporter Population	–25.8304* (11.3142)	2.6355 (1.9367)
ExporterInc	0.0654* (0.0318)	0.0070 (0.0094)
Exporter Service Ind	–0.2852** (0.1065)	0.0393 (0.0318)
Exporter FDI	0.0009 (0.0327)	0.0010 (0.0088)
Exporter R&D	0.7802 (0.4758)	–0.1520 (0.2589)
Exporter Edu	0.4862 (0.3812)	–0.1690 (0.1034)
Exporter Service Emp	0.3429** (0.1260)	0.0241 (0.0374)
Exporter Unemploy	0.2756** (0.0919)	–0.0200 (0.0197)
Trade in Goods	0.2677 (0.3824)	0.0515* (0.0257)
Year × Other Services	0.4329*** (0.1161)	0.0143 (0.0315)
Year × Information	0.4805** (0.1801)	0.0152 (0.0402)
Year × Professional	0.5174*** (0.1315)	0.0864* (0.0351)
Year × Finance	0.3970** (0.1326)	0.0483 (0.0366)
Exporter FE	YES	YES
Industry FE	YES	YES
N	760	3,993
F	2.875**	7.598***

Table A40. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.784	0.743
Adjusted R ²	0.753	0.735
Root MSE	1.373	1.656

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A41. Estimation of Growth Rates in Service Imports
by the United Kingdom**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Exporter Population	–1.2551 (9.4936)	–2.2647* (0.9565)
ExporterInc	0.0246 (0.0277)	0.0085 (0.0055)
Exporter Service Ind	0.0785 (0.0788)	0.0269+ (0.0155)
Exporter FDI	0.0114 (0.0817)	0.0005 (0.0012)
Exporter R&D	–0.6910 (0.6571)	–0.5656*** (0.1547)
Exporter Edu	–0.0147 (0.2119)	–0.0744 (0.0573)
Exporter Service Emp	0.0104 (0.0774)	0.0370+ (0.0192)
Exporter Unemploy	0.0288 (0.0640)	–0.0282** (0.0091)
Trade in Goods	–0.0396 (0.4053)	0.0701*** (0.0124)
Year × Other Services	0.0635 (0.0847)	–0.0083 (0.0185)
Year × Information	0.1016 (0.1350)	–0.0049 (0.0291)
Year × Professional	0.2253* (0.1012)	0.0060 (0.0239)
Year × Finance	–0.1361 (0.1465)	0.0183 (0.0297)
Exporter FE	YES	YES
Industry FE	YES	YES
N	937	9,901
F	0.990	7.550***

Table A41. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.750	0.704
Adjusted R ²	0.726	0.700
Root MSE	1.375	1.503

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

**Table A42. Estimation of Growth Rates in Service Imports
by France**

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Exporter Population	0.7614 (6.9206)	–2.3861** (0.8135)
ExporterInc	–0.0379+ (0.0207)	0.0027 (0.0040)
Exporter Service Ind	0.0803 (0.0669)	0.0057 (0.0114)
Exporter FDI	–0.0768+ (0.0402)	–0.0004 (0.0005)
Exporter R&D	0.0389 (0.3282)	–0.3513** (0.1233)
Exporter Edu	0.2100 (0.1807)	0.0606 (0.0432)
Exporter Service Emp	–0.1042 (0.0751)	0.0320* (0.0139)
Exporter Unemploy	0.0093 (0.0580)	–0.0264** (0.0081)
Trade in Goods	0.4771+ (0.2515)	0.0458*** (0.0122)
Year × Other Services	–0.0099 (0.0701)	0.0221+ (0.0134)
Year × Information	–0.1322 (0.0976)	–0.0227 (0.0257)
Year × Professional	0.0339 (0.0779)	0.0561** (0.0190)
Year × Finance	–0.0621 (0.1125)	0.1099*** (0.0217)
Exporter FE	YES	YES
Industry FE	YES	YES
N	2,321	13,948
F	1.481**	10.40***

Table A42. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.678	0.706
Adjusted R ²	0.661	0.703
Root MSE	1.292	1.335

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Table A43. Estimation of Growth Rates in Service Imports by Germany

Dependent Variables	Services Trade 2012–2016	Services Trade 2000–2012
Exporter Population	4.5025 (4.3214)	0.0616 (0.4105)
ExporterInc	0.0034 (0.0171)	0.0123*** (0.0022)
Exporter Service Ind	–0.0136 (0.0440)	–0.0147* (0.0069)
Exporter FDI	–0.0088 (0.0129)	–0.0011** (0.0004)
Exporter R&D	0.0703 (0.1864)	0.1502+ (0.0807)
Exporter Edu	–0.1945+ (0.1144)	0.0006 (0.0279)
Exporter Service Emp	–0.0536 (0.0540)	0.0407*** (0.0074)
Exporter Unemploy	0.0602+ (0.0356)	–0.0261*** (0.0054)
Trade in Goods	0.2613 (0.2123)	0.0220* (0.0094)
Year × Other Services	–0.0262 (0.0526)	0.0162* (0.0081)
Year × Information	–0.2125** (0.0742)	0.0527*** (0.0105)
Year × Professional	–0.0402 (0.0557)	0.0223* (0.0093)
Year × Finance	–0.1211 (0.0873)	0.0125 (0.0146)
Exporter FE	YES	YES
Industry FE	YES	YES
N	3,385	21,224
F	2.723**	43.87***

Table A43. Continued

Dependent Variables	Services Trade	Services Trade
	2012–2016	2000–2012
R ²	0.638	0.663
Adjusted R ²	0.624	0.661
Root MSE	1.328	1.333

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001; Robust standard errors are in parentheses.

Source: Author's own compilation

Executive Summary

AI-Powered Intelligent Automation and International Trade in Services: Implications for Service Jobs in APEC Economies

Min-Seok Pang • Gwanhoo Lee

The advances in intelligent automation enabled by artificial intelligence (AI) could make a wide range of service jobs obsolete at an accelerated speed. These jobs that are threatened by automation include not only routine low-skilled service jobs but also high-skilled, knowledge-intensive service jobs. The service producers in developed economies have been resorting to high-skilled workers in developing economies via service offshoring to take advantage of lower wages. However, intelligent automation could offer the service firms with an even cheaper alternative than service offshoring, threatening employment in the service industries in developing economies.

The objective of this study is to investigate the impact of intelligent automation on international trade in services. We posit that AI-powered intelligent automation reduces the demand for service offshoring, which, in turn, leads to a decline in international trade in services. To test this hypothesis, we use multiple data sets including the U.N. Comtrade trade data over the period from 2000 to 2016, the O*NET data, the World Bank Open Data, and ITU's ICT Development Index (IDI). We run a series of regression analysis to take a deep dive into the temporal patterns of international trade in services.

We find that the annual growth of international trade in services over the period from 2000 to 2016 was 1.67%. However, we observe that the annual growth rate significantly declined from 2014 after healthy growth between 2008 and 2014. However, whereas highly automatable service industries such as financial services, information services, and professional services experienced a negative annual growth rate from 2014, other less automatable services industries did not experience a significant decrease in their annual growth over the same period. Therefore, we could infer that intelligent automation replaced service offshoring of highly automatable services and as a result, international trade in those services declined.

Our further analysis shows that the exports in highly automatable services from developing economies to developed economies witnessed a significant decline since 2014. However, we did not find the same pattern in less automatable service industries. We also see that, over the period from 2000 to 2016, the annual growth in the service exports from countries with a low level of ICT development to countries with a high level of ICT development was significantly lower than that from countries with a high level of ICT development to other countries. This finding is consistent with prior findings that ICT facilitates international trade. However, since 2014, we are witnessing a decline in both the exports and the imports in services in countries with a high level of ICT development. This decline was more significant in highly automatable service industries. We could infer that countries with a high level of ICT development have more advanced intelligent automation technologies, which reduce the demand for service offshoring.

When we limit the scope of our data analysis to 21 APEC member economies only, we still find the same results. While highly automatable service industries experienced a decline in international trade since 2014, less automatable service industries did not experience such a fall. Another interesting finding is that the exports from the developing economies within APEC to the developed countries within APEC decreased more significantly than the

exports from the developed to the developing, from the developed to the developed, or from the developing to the developing economies. Finally, it is found that China, India, Korea, and Russia experienced growth in service exports until 2012 but since then witnessed a decline in service exports starting from 2012.

We discuss the implications of these findings and offer policy recommendations. We present five guiding principles for regulations and policies for intelligent automation technologies, ten policy directions, and six specific policy recommendations for APEC member economies. Finally, we discuss how South Korea can serve as a model and contribute to promoting shared prosperity in APEC member economies.

국문요약

AI-Powered Intelligent Automation and International Trade in Services: Implications for Service Jobs in APEC Economies

(AI 기반 지능형 자동화와 국제 서비스무역:
APEC 지역 경제의 서비스 일자리에 미치는 영향과 시사점)

방민석 • 이관후

2016년 알파고와 이세돌의 역사적 대국 이후 AI(인공지능 artificial intelligence)에 대한 관심과 우려는 국내뿐만 아니라 전세계에서 크게 상승하였다. AI로 인한 새로운 가치 창출과 경제발전에 대한 기대와 더불어 기존의 많은 일자리들이 AI에 의해 대체될 수 있다는 두려움이 고조되었다. 그런데 기술혁신의 역사를 보면 기술혁신으로 인해 많은 일자리가 사라지는 경우 반대급부로 더 많은 새로운 일자리가 창출되어 왔다. 따라서 AI도 예외가 아닐 것이라는 예측도 있으나 많은 기업인, 경제학자, 경영학자, 과학자, 정책입안자들은 AI 혁명은 과거 기술혁신과는 다르게 새로 창출되는 일자리보다 사라지는 일자리가 훨씬 더 많을 것으로 보고 있다. 이러한 예측의 근거는 딥 러닝과 머신러닝이라는 AI의 알고리즘이 빅데이터를 이용하여 지속적인 학습을 함으로써 지식노동의 거의 모든 분야에서 인간의 능력을 추월할 것이라는 논리 때문이다.

과거 ICT와 산업로봇을 기반으로 한 산업자동화 기술로 제조업의 많은 일자리들이 기계로 대체되었고 이러한 현상은 가속될 전망이다. 하지만 AI

기반의 지능형 자동화는 제조업을 넘어서 서비스업의 일자리에도 큰 영향을 미칠 수 있다고 예측되고 있다. 지능형 자동화로 인해 위협을 받는 직업들은 저숙련 기술을 요하는 단순한 서비스뿐 아니라 회계사, 금융전문가, 정보처리사, 법조인, 의료전문가와 같은 고도의 지식과 숙련을 요하는 지식 집약적인 서비스까지도 포함된다. 그러나 이러한 예측들이 실증적 연구를 통해 실제 경제 및 산업 데이터로 검증 및 확인된 것은 아직 없다.

본 연구의 목적은 AI 기반의 지능형 자동화가 과연 서비스 일자리에 영향을 미치는지를 경제 및 산업 데이터의 분석을 통해 검증하는 데 있다. 보다 구체적으로 말하자면, 본 연구에서는 지능형 자동화가 서비스의 해외 아웃소싱을 대체하여 해외 아웃소싱의 수요가 줄어들고 이것은 국제 서비스무역의 감소로 이어진다는 가설을 검정한다. 과거에 선진국의 기업들은 해외 아웃소싱을 통해 개발도상국 서비스 노동자의 낮은 임금을 활용해 낮은 가격으로 서비스를 구매해 왔다. 하지만 지능형 자동화는 해외의 값싼 노동력보다도 더 저렴한 비용을 제공할 수 있게 되어 필리핀이나 인도와 같은 개발도상국 서비스 노동자의 일자리를 위협할 수 있다. AI 기반 지능형 자동화가 국제 서비스무역에 미치는 영향을 실증적으로 검증한 연구는 기존문헌에 없으며 본 연구가 세계 최초이다.

본 연구의 가설 검증을 위해 유엔(UN)의 Comtrade 무역 데이터베이스를 사용하였는데 여기에는 2000년부터 2016년까지 236개국의 62개 서비스 산업별 국제무역 데이터가 포함되어 있다. 또한, 서비스 산업별 자동화 가능 정도를 정량화하기 위해서 미국 노스캐롤라이나 주정부의 O*NET 데이터베이스를 사용하였으며, 각국의 ICT 인프라 수준을 측정하기 위해서 ITU(International Telecommunication Union)의 ICT 개발 인덱스(IDI)를 사용하였다. 마지막으로 각국의 경제적, 사회적, 산업적 특성에 관련된 데이터를 세계은행(World Bank)의 오픈 데이터로부터 수집하여 통제변수로 사용하였다.

4장에 데이터 분석 결과가 상세히 나와 있다. 4.1장에서는 국제 서비스

무역의 연간 성장률 추이를 보여주는데, 전세계 국제 서비스무역은 2000년부터 2016년까지 연 평균 1.67% 성장한 것으로 나타났다. 그런데, 2008년부터 2014년 사이에 가장 급속한 성장을 하였으나 2014년을 기점으로 급격한 감소를 보여주고 있다. 4.2장에서는 자동화 가능성이 비교적 높은 서비스산업(금융서비스, 정보서비스, 전문지식서비스)의 연간 성장률 추이를 보여준다. 전체적으로 볼 때, 자동화 가능성이 높은 서비스산업 분야의 2000년부터 2016년 사이의 연평균 성장률은 4%를 상회하여 다른 서비스산업 분야보다 높은 성장률을 보여주고 있다. 하지만, 기간을 세분하여 분석해 보면, 자동화 가능성이 높은 서비스산업 분야 모두가 2008년에서 2014년 사이의 고도성장 후 2014년을 기점으로 마이너스 성장세를 보이고 있다. 이 시기는 AI를 기반으로 한 지능형 자동화기술이 급속한 발전을 시작한 시기와 일치한다. 그런데, 자동화 가능성이 상대적으로 낮은 다른 서비스산업에서는 2014년부터 특별한 감소세가 나타나고 있지는 않았다. 따라서, 자동화 기술로 인해서 금융서비스, 정보서비스, 전문지식서비스 산업의 해외아웃소싱이 자동화 기술로 대체되고 이에 따라 이 산업들의 국제무역이 감소세로 전환되었다고 추론할 수 있다.

4.3장에서는 유엔이 지정한 37개 선진국과 개발도상국 간 서비스무역의 변화 추이에 대한 분석 결과를 보여준다. 흥미롭게도, 2000년부터 2016년 사이에 개발도상국에서 개발도상국으로의 서비스 수출이 가장 낮은 마이너스 성장률을 보이고 있다. 특히 정보서비스와 금융서비스 분야의 성장률이 가장 낮게 나타났다. 하지만, 기간을 세분해서 분석해 보면 개발도상국에서 선진국으로의 서비스 수출에 있어서 정보서비스, 금융서비스, 전문지식서비스 등 고도의 자동화가 가능한 산업은 2014년을 기점으로 급격히 감소하고 있으나 자동화가 상대적으로 어려운 다른 서비스 분야에서는 이러한 급격한 감소 현상은 나타나고 있지 않았다.

4.4장에서는 각국의 ICT 인프라 수준 차이가 서비스 무역에 어떠한 영향을 미치는지에 대한 분석 결과를 보여주는데 2000년부터 2016년 사이에

ICT 인프라의 수준이 낮은 국가에서 인프라 수준이 높은 국가로의 서비스 수출의 연 성장률은 ICT 인프라 수준이 높은 국가에서 다른 국가로의 서비스 수출의 연 성장률보다 현격히 낮은 것으로 나타났다. 또한, 2014년부터는 ICT 인프라 수준이 높은 국가들의 서비스 수입 및 수출이 감소하고 있는 것으로 나타나고 있다. 이러한 감소세는 자동화 가능성이 높은 산업에서 더욱 두드러지게 나타났다. 이것은 ICT 인프라 수준이 높은 국가들이 AI 기술을 활용한 지능형 자동화로 기존에 해외 아웃소싱하던 서비스들을 기계로 대체하였기 때문이라고 추론할 수 있다.

4.5장에서는 선진국과 개발도상국으로 분류하는 대신 유엔에서 지정한 고소득 국가와 저소득 국가로 분류했을 때 국제 서비스 무역 분석 결과를 보여주는데 4.3장에서 선진국과 개발도상국으로 분류했을 때와 같은 패턴의 결과를 얻었다.

4.6장에서는 분석의 범위를 21개 APEC 회원국으로 국한하였을 때의 결과를 보여주는데 이는 앞서 전세계 236개국을 대상으로 한 분석 결과와 같은 패턴으로 나타났다. 즉, 금융서비스, 정보서비스 및 전문지식서비스 산업의 경우 2008년부터 2014년까지의 지속적 성장세 이후 2014년을 기점으로 감소세로 돌아섰는데 특히 금융서비스의 감소세가 가장 두드러졌다. 이에 반해 자동화 가능성이 낮은 산업의 경우 2014년 이후에 별다른 변화가 나타나고 있지 않았다. 특히 주목할 것은 2011년을 기점으로 APEC 지역 경제내 개발도상국에서 선진국으로의 서비스 수출 감소가 선진국에서 선진국 또는 선진국에서 개발도상국 또는 개발도상국에서 개발도상국으로의 서비스 수출에 비해서 더욱 컸다는 점이다.

4.7장에서는 APEC 회원국 중 8개국(중국, 러시아, 한국, 인도, 필리핀, 인도네시아, 브라질, 멕시코)을 심층 분석한 결과를 보여준다. 중국, 러시아, 한국 및 인도의 경우 2012년까지는 서비스 수출이 성장세를 보였으나 2012년을 기점으로 성장세가 멈추거나 마이너스 성장세로 돌아섰음을 발견했다. 하지만, 다른 국가들에서는 통계적으로 유의한 변화는 발견되지 않았다.

5장에서는 지능형 자동화로 인한 서비스 일자리 및 국제무역의 감소에 따른 정책적 시사점 및 정책제언을 논의한다. 5.1장에서는 지능화 자동화에 대응한 정책이나 규제를 수립하는 데 있어서 고려해야 할 다음의 5가지 기본 원칙들을 제시한다: (1) 지능형 자동화 규제는 실증적 데이터 및 증거에 기반해서 수립한다 (2) 규제 샌드박스과 같은 개방형 혁신 어프로치를 채택한다 (3) 규제는 가급적 light-touch (최소한의 규제) 어프로치를 채택한다 (4) 정부는 특정 기술이나 업체를 선호하지 않는다 (5) 정책과 규제가 부처간 일관성이 있도록 한다.

5.2장에서는 지능형 자동화로 인한 서비스 일자리 및 무역의 감소에 따른 대책으로 다음의 10가지 정책을 제언한다: (1) 서비스 노동자의 재교육 및 훈련을 통해 자동화 가능성이 낮은 서비스 일자리로 전환하는 것을 지원한다 (2) 중고등학교와 대학에서 미래형 서비스 일자리에 필요한 지식과 기술을 교육한다 (3) 서비스 노동자와 기업을 연결해주는 디지털 플랫폼을 개발한다 (4) 기본소득 제공 및 전직시 필요한 지원을 한다 (5) 기업가 정신과 혁신을 부양하여 새로운 일자리를 창출한다 (6) 국내 서비스 산업의 재편을 통해 미래를 대비한다 (7) 5G등의 첨단 디지털 인프라에 투자한다 (8) 정부 부처간의 정책 조율을 한다 (9) 민관 협력 (Public-private partnership)을 장려한다 (10) 국제협력을 강화하여 상호 학습 및 혁신에 도움을 준다.

5.3장에서는 앞서 제시한 10가지 정책외에 APEC 회원국을 위한 다음의 6가지 정책을 제안한다: (1) 2020년까지 APEC 지역경제를 위한 지역 전략을 수립하여 지능형 자동화 발전에 따른 경제적 사회적 이슈들에 대비한다 (2) APEC 회원국들간의 공동 연구 프로그램을 만들어 지능형 자동화에 관련된 경제적, 기술적, 노동적, 사회적 측면의 다양한 이슈들을 연구한다 (3) APEC 회원국들을 위한 온라인 교육 프로그램을 개발하여 재교육 및 직업훈련에 활용한다 (4) 서비스 노동자의 디지털 숙련도를 공식적으로 인정하는 인증 프로그램을 만든다 (5) 기업과 정신과 혁신을 고취하기 위해 지역경제내에 혁신센터(center of excellence)를 설립한다 (6) APEC 회원

국간의 정책 및 규제를 논의하고 협력할 워킹그룹을 창설한다.

마지막으로, 5.4장에서는 한국이 APEC 지역 경제의 상생과 공유된 번영을 위해서 할 수 있는 역할들이 무엇인지에 대한 제언한다. 첫째, 한국의 우수한 대학 및 교육 기관들이 개발도상국 서비스 노동자들의 재교육을 도와줄 수 있다. 둘째, 정보통신 강국인 한국은 개발도상국이 유무선 통신 네트워크 인프라를 구축하는 데 필요한 기술적 지원을 할 수 있다. 셋째, 개발도상국의 모델이 될 정책의 청사진을 개발하고 공유한다. 마지막으로, 지식교류 프로그램 등을 통해 한국의 디지털경제 개발과정을 거치면서 체득한 노하우와 경험을 개발도상국에 전수한다.

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