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Economic complexity and the globalization of services

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ABSTRACT

Economic complexity has emerged as an important metric to measure nations' inherent capabilities that are embodied in the structure of economic production. However, traditional measures of complexity only capture manufacturing-based capabilities, ignoring the growing importance of services in global trade. Technological innovations are increasingly splintering and disembodying services so they can be produced, transmitted, and consumed globally. This paper incorporates the role of service globalization to present a more complete picture of the economic complexity of nations. Using a non-linear iterative algorithm, this paper ranks the *'fitness'* of countries based on the diversity and *'complexity'* of specialization patterns. Modern technology-enabled service exports are fairly complex specializations but becoming increasingly ubiquitous. Developing countries show greater economic strength accounting for the growing tradability of services. A framework to aid decision-making about product/service export diversification strategies is proposed.

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1. Introduction

Economic complexity has emerged as an important metric to measure nations' inherent capabilities embodied in the structure of economic production. These capabilities—physical and human capital, institutions, organizational abilities– are reflected in the ability to produce and export sophisticated products. Using this idea of "revealed comparative advantage" (RCA), in conjunction with network theory, and data on world trade, scholars have measured the economic complexity of an economy's product space. They find that nations that specialize in traded goods that are associated with higher productivity perform better economically. Indeed, a strong correlation between income and complexity emerges. Developed countries like Germany, Italy, and Switzerland show higher GDP per capita and also high complexity. Less-developed countries like Angola, Haiti or the Bahamas are typically at the bottom of the rankings of GDP per capita and also the least fit. Economic development, then, can be viewed as the process of learning how to produce more complex products.

Existing complexity measures, such as those in Hidalgo et al. (2007), Hidalgo and Hausmann (2009), Tachella et al. (2012), Cristelli et al. (2015) are based primarily on trade in manufactured goods, which are assumed to be the key indicator of a country's development. Services are typically viewed as a low-productivity sector, and a passive input into the production of physical goods. The lack of disaggregate data on services has made this a convenient assumption, and thus empirical literature has been silent on the role of services. This omission of services is particularly glaring in light of current trends in globalization and emerging technologies that are making services a larger portion of global output and trade– the share of service value added is over 60 percent of global GDP and service exports over 6 percent of world GDP (UNCTAD, 2019; Loungani et al. 2018). The changing nature and growing importance of the services sector continues to challenge the conventional wisdom that suggests manufacturing-led growth is the primary route to economic growth (MacMillan and Rodrik, 2015; Romer, 2012, UNIDO, 2009). However, it is difficult to derive concrete policy

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implications about the potential of services without the incorporation of modern services data into the analysis. A deeper understanding of complex service exports may offer an alternative route to economic growth and development.

This paper takes a data-driven approach to integrate service sector exports with goods exports to provide a more complete picture of national specialization patterns and inform strategic diversification opportunities. We construct a measure called "universal fitness" which captures a nation's capabilities, not just in goods, but also services.[1] The Fitness-Complexity (FC) algorithm is applied to a bipartite network called the "universal space." The algorithm is used to define the complexity of goods and services and the universal fitness of countries. Thus, the algorithm can be used to rank more complex goods or services at the global level and rank the fitness (or competitiveness) of countries based on the structure of their export capabilities.

The evidence provides two novel insights. First, modern service exports are the most complex exports in the network of universal specializations. ICT-enabled "modern" services like research and development, financial intermediation, or information services tend to be more "complex" than traditional services like construction or transport. These traditional services are more ubiquitous in the universal space and exported by non-diverse countries– they are relatively less complex. Second, the results provide a more complete picture of emerging markets (EM's) competitiveness when services are included to assess their competitiveness. In particular, the fitness ranking of two types of economies -middle-income countries and resource-rich countries-improve with the inclusion of services. While advanced economies remain the most competitive in exporting complex services, the rankings of middle-income countries change significantly. For example, Brazil, Indonesia, or Philippines often characterized as losing competitiveness when focusing only on goods, are "more fit" once we account for increased adoption of new technology-driven service export sectors (like Research & Development, Computer and Information Services). This result applies to several developing economies. Taken together, these results show that specialization in complex services play a prominent role to increase the overall economic fitness of a country, especially for middle-income and natural resource-rich countries.

The addition of service exports to the world trade network offers a more comprehensive view of inter-and-intra sectoral resource reallocation dynamics and opportunities for diversification in global production networks. With this in mind, we present an analytical framework to operationalize the universal fitness approach and guide strategic diversification opportunities. The framework provides country case studies based on segmenting the feasibility and complexity of a sector in a simple 2×2 matrix. This framework can inform policymakers on which services (or goods) would be feasible (easy or difficult) based on the complexity of given specializations.

Our paper builds on and contributes to the emerging stream of work studying the links between an economy's inherent capabilities that cause economic growth, and how these capabilities are manifested in measures of economic complexity. The idea is that an economy's growth potential lies in its innate capabilities that are rooted in its production structure can be attributed to the early ideas of Lewis (1955), Hirschman (1958), Kuznets (1966), Kaldor (1967), amongst others that viewed growth and development as a process of structural transformation in the productive structure of the economy i.e. the reallocation of resources from low productivity to high productivity activities.

Based on the idea that a country's exports reflect underlying capabilities, Hausman, Hwang and Rodrik (2007) spurred an influential line of empirical work that has sought to study the links between these inherent capabilities and income growth. They construct a quantitative index to rank traded goods in terms of their implied productivity. Each good has an associated productivity (or income level), and a weighted average of this productivity level constitutes each country's export basket or a measure of the productivity level associated with that particular country's specialization or revealed comparative advantage.[2] They find that GDP per capita and export-productivity are closely correlated, but with some discrepancies in high-growth countries like China. Hidalgo and Hausman (2009) further quantify the concept of an economy's product space and introduce the idea of economic complexity. Their measure of complexity is correlated with income levels, but they also show that deviations from the relationship predict future growth. Thus, the complexity structure embedded in a country's productive structure dictates the income level that the country will eventually converge to build on this work by ranking over five thousand products and over a hundred countries based on complexity. Using panel data from Chinese cities, Pocent and de Waldemar (2012) show that locations with productive structures geared towards complex products will have higher economic growth, but this does not hold for firms in processing-only trade. Recognizing the growing importance of services in global economic activity and to aid diversification strategies, there have been only a few attempts to include services data. Stojkowski, Utkovski and Kocarev (2018) include aggregated one-digit service exports with goods exports. Zaccaria et al. (2018) also document the heterogeneity in the ranking of countries integrating services in the universal matrix of world trade. Complex services and complex manufacturing are clustered closely together, implying that gaining specialization in one (or the other) can directly aid discovering other nearby specializations (Zaccaria et al., 2018). Our paper uses highly disaggregate services data verifying this finding, but also providing additional insights into the types of services that boost growth. Moreover, we provide a framework that operationalizes the quantitative findings with policy implications based around more specific sectors.

The rest of the paper is organized as follows: Section 2 outlines the dataset and methods. Section 3 motivates the results with key stylized facts on the growing importance of services in the world economy. Section 4 reports our findings. Section 5 proposes an operational framework that can guide diversification and market-entry strategies. Section 6 concludes with policy implications.

2. Data and methods

Traditionally, economic complexity analysis has been conducted with goods exports statistics. In this paper, we add estimates from the International Monetary Fund's Balance of Payments Statistics (BOPS) to account for service exports as well. The one, two, and three-digit classification are merged to obtain more detailed data for around twenty-three services exports for almost one hundred and fifty countries.

[1] The term "universal fitness" was first used in Stojkoski et al. 2016 Zaccaria et al. 2018.

[2] A few other works that give insight into structural transformation, exports and development are: economic diversification is known to follow a non-monotonic path over the stages of economic development (Imbz and Wacziarg, 2003, Henn et al. 2015) and there is a positive relationship between structural shifts and per capita income (Gutierrez de Pineres and Ferrantino, 2000; Herzer and Nowak-Lehmann, 2006, Al-Marhubi, 2000, De Ferranti et al. 2001). Diversification of exports (in terms of products and destinations) helps in stabilizing export earnings in the longer run, with benefits analogous to the portfolio effect in finance (Ghosh and Ostry, 1994, Bleaney and Greenaway, 2001)

2.1. Universal matrix dataset

In the spirit of Stojkoski et al. (2016) and Zaccaria et al. (2018) the combined goods and services dataset of world trade will be referred to as the *universal matrix* of world trade. The main source of the analysis relies on BPM6 classification of disaggregated data on credit accounts of services. The BPM6 provides credit, debit and net accounts for services between 1948–2015. The coverage of trade in services data is still very limited and often unbalanced. Services, in contrast to goods, are characterized by a number of features, such as intangibility and non-storability, which complicate the collection of accurate international trade in services statistics (Spinelli and Miroudot 2015).

The detailed goods export data is originally obtained in HS6 classification from BACI CEPII. The data is originally compiled by the United Nations Statistical Division (COMTRADE database), and BACI reconciles the declarations of the exporter and the importer by harmonization procedure that enables to extend considerably the number of countries for which trade data are available, as compared to the original dataset. BACI provides bilateral values and quantities of exports at the HS 6-digit product disaggregation, for more than 200 countries with over 5000 products for a country (in its most detailed version) between 1995–2014. Since the trade data on goods and services are combined to produce the universal matrix, and since there are only 23 categories of services, the BACI data is used in its "chaptered" format that instead has only 96 categories. This is especially important, since the rest of the analysis uses the relative value of the exports of each category; hence, the two data should be made as compatible as possible before being combined with each other. Note that we have done robustness tests with different service categories, and the results can indeed depend on the specific categorization used for goods and services. However, it seems far away before super disaggregated service statistics are available, which is probably still a decade away.

The universal matrix (Zaccaria et al., 2018) of world trade consists of 96 categories for the goods (the BACI "chaptered" data) and 23 categories of services. This was done as a compromise between the level of detail of the categories, and the meaningfulness of the analysis.

While the formation of a universal matrix based on both goods and services has been presented before (cf. Zaccaria et al., 2018, Stojkoski et al., 2016), we improve upon existing work by using a more detailed categorization of goods and services. Using this detailed data on world trade in goods and services, we extract information on diversity of a country, ubiquity of a given activity, and also present comprehensive rankings of economic fitness of nations based on the universal matrix of specialization. In the methodology described below, the matrices of products are notated as (P), services as (S) and the universal matrix that incorporate both goods and services denoted as (U). Appendix 1 provides more details on the data, sources, and definitions.

2.2. Economic fitness-complexity (FC) algorithm

Economic "complexity" of a product or "fitness" of a country incorporate the entire trade data to measure which products are more "complex" to make and which countries are more "fit" economically. The idea is simple: if a product is made by only the most advanced countries, it is probably because it is more complex to make, and many of the less advanced countries do not have the required technology for making that product. Similarly, if one country is an active exporter of a large number of products, including more complex ones (say airplanes or nuclear reactors), while the other country only exports a few of the less complex products (e.g., crude oil), the former country is most probably more economically "fit", than the latter.

Table. 1
A summary of different measures used in this study.

Measure	Notation	Definition
RCA	$RCA_{c,u,t}$	$\frac{X_{c,u,t}/\sum_c X_{c,u,t}}{\sum_u X_{c,u,t}/\sum_c\sum_u X_{c,u,t}}$
Binary RCA	$M_{c,u,t}$	$\begin{cases} 1, & RCA_{c,u,t} \geq 1 \\ 0, & otherwise \end{cases}$
Diversity	$d_{c,t}$	$\sum_u M_{c,u,t}$
Ubiquity	$k_{u,t}$	$\sum_c M_{c,u,t}$
Fitness	$F_{c,t} = \lim_{n\to\infty} F_{c,t}^{(n)}$	$\begin{cases} \tilde{F}_{c,t}^{(n)} = \sum M_{c,u,t} Q_{u,t}^{(n-1)} \\ \tilde{Q}_{u,t}^{(n)} = \frac{1}{\sum M_{c,u,t}\frac{1}{F_{c,t}^{(n-1)}}} \end{cases} \rightarrow \begin{cases} F_{c,t}^{(n)} = \frac{\tilde{F}_{c,t}^{(n)}}{\tilde{F}_{c,t}^{(n)}} \\ Q_{u,t}^{(n)} = \frac{\tilde{Q}_{u,t}^{(n)}}{\tilde{Q}_{u,t}^{(n)}} \end{cases}$
Complexity	$C_{u,t} = \lim_{n\to\infty} C_{u,t}^{(n)}$	
Proximity	$\phi_{u,u',t}$	$\min\{P(M_{u,t}\|M_{u',t}),\ P(M_{u',t}\|M_{u,t})\}$ #
Density	$\omega_{c,u,t}$	$\frac{\sum_{u'} M_{c,u',t}\phi_{u,u',t}}{\sum_{u'}\phi_{u,u',t}}$

Note: The subscripts in each of the quantities show if that quantity is a function of the country ($_{.c}$), product ($_{.u}$), year ($_{.t}$), or any combination of these. $X_{c,u,t}$ is the total export value of product u, at year t, by country c. $P(A|B)$ is the conditional probability of A given B. See text for more details.

There are two measures of economic complexity used in the literature. The first method called the Method of Reflection (MR) (cf. Hidalgo and Hausmann, 2009), is a linear algorithm that defines competitiveness in terms of diversification and shows that more competitive economies were more diverse and poorly diversified economies tend to be specialized in few products which are exported by almost all other countries. The second method is commonly called Fitness-Complexity (FC) and is a highly non-linear algorithm where the export data reveal a structure usually defined as nested (; Cristelli et al., 2013; Tachella et al. 2013; Pugliese et al., 2015). Although each of these have their merits, and their relative performance in different situations has been the subject of many studies (Pugliese et al. 2014; Mariani, 2015), for the purpose of the present study we favor the nonlinear FC coupling algorithm. Our argument for this choice is two-fold: (i) there are shortcomings associated with the method of reflection (Hidalgo et al., 2007; Hausmann and Hidalgo 2011), and (ii) due to the strong coupling between the complexity of each of the products with the fitness of the countries and therefore complexity of all other products, nonlinearity appears to be a fundamental mathematical property that is unavoidable in view of the economic diversification challenges (cf. Tacchella et al., 2012). This algorithm describes the level of advancement and competitiveness of a country by a single number called *Fitness*, and the level of technology and advancement required to export a product (or service) by its associated *Complexity*.

The Fitness-Complexity (FC) algorithm uses the specialization of a country in exporting a set of products to define its fitness (and the fitness of the countries specialized in a product to quantify the product fitness). This is done by first computing the Revealed Comparative Advantage (RCA), that informs whether a country's share of an item in the world market is larger or smaller than the items' share of the entire world market (Balassa, 1965), then converting the RCAs to binary values (i.e., 0/1) based on whether they are above a threshold or below it, and finally to use this binary matrix to perform an iterative algorithm that simultaneously computes the complexity of the products and the fitness of the countries. The procedure is summarized in Table 1, along with some of the other measures used in this study.

A threshold of unity (i.e., 1) is used throughout this work when computing the binary RCA, $M_{c,u,t}$. This is justified in the work of Tacchella et al. (2012) by relying on the meaning of RCA (the share of the country c in global exports of product u, divided by the country's total share in the total global export); however, it is important to note that the final results are highly sensitive to the set

RCA threshold value. The results from lower thresholds of 0.75 or 0.5 can also be used based on the degree of specialization of interest.

A country is considered to be specialized in an item if it has an $M_{c,u,t} = 1$ for the country-item pair. Diversity of countries, measuring how many products they are specialized in, and ubiquity of products, measuring how many countries export a certain product, are defined based on the binary RCA information. Analyzing the FC algorithm based on diversity/ubiquity, the general observation is that less ubiquitous items are usually exported by more diverse countries, and conversely less diverse countries are exporting more ubiquitous items. Thus, the more diverse countries are usually those who have well established economies, or, if a country is specialized in a wide range of goods and/or services it means that it is a competitive country in the world, or more fit. Similarly, if an activity (good or service) is being exported by only a few of these fit countries it acquires a higher complexity in our analysis.

The iterative nature of the FC algorithm is due to the fact that we do not know *a priori* how fit a country and how complex a product is, and since these two are in fact strongly connected. The initial conditions we have used for this work are $\tilde{Q}_{u,t}^{(0)} = 1 \ \forall u, t$ and $\tilde{F}_{c,t}^{(0)} = 1 \ \forall c, t$ (i.e. we started out by assuming that all countries are equally fit and all products are equally complex). Nevertheless, we note that the algorithm converges to the "fixed points" of the map, meaning that no matter what the initial guess is it always converges (or supposed to converge) to the same values (Tachella et al. 2012, Cristelli et al. 2015). In this study, all reported values for fitness and complexity are converged to 1e-6, in the sense of the infinity norm of both complexity and fitness values. In other words, the iteration is terminated if the largest change in the fitness and complexity values, between two consecutive iterations, are below 1e-6. This is justified by the fixed-point nature of the convergence, assuming that the algorithm has converged if the values no longer change with iteration number n.

For both fitness and complexity, the minimum value is 0, and they are normalized such that the average of the fitness for all countries and the average of complexity for all products have a value of 1. As a result, the maximum value of fitness and complexity are less than the total number of countries and items in the sample, respectively. Furthermore, a fitness of 1 can be thought of as an average country in the world trade, and similarly, a complexity of 1 is for a product with the average level of sophistication required. One could also look at the median (instead of the mean) of the of population to get an idea of how fit a middle country or how complex a middle product is. Annex Table A2.2 provides the mean universal fitness value between 2010–16 with summary statistics. The standard deviation, max, and min, and the average gain (or loss) by adding services (universal - goods fitness) are also provided.

2.3. Feasibility of exporting a product: proximity and density

Another useful variable for the purpose of our study is called "proximity". Proximity (ϕ) is a measure of closeness of a pair of two exports in the product space (Hidalgo et al., 2007; Hausmann and Hidalgo 2011); in other words, it gives a rough measure of how easy it is to become an active exporter of product u being an active exporter of product u'. Proximity does not depend on the country, and is simply defined as the conditional probability of having an RCA above the threshold in the item u', by having an RCA above the threshold in item u, $P(M_{u,t}|M_{u',t})$, where we consider all the country-product pairs in estimating that probability. A simple example could be the computer's mainboard, product u, and electronic chips, product u': quite possibly, all exporters of the mainboard also export electronic chips (i.e. a proximity near unity), while maybe only 40 percent of countries who export electronic chips have developed the technology to manufacture the entire motherboard (a proximity of 0.4). Although this could depend on the countries (maybe slightly), we take this as a measure of how close two products are in the product space. This measure could also be used to judge the complexity of the products (perhaps the most complex item could be the one where sum of the unidirectional proximities given the country is an active exporter of that product is largest), although we have not used it as such for the purpose of this paper. Here, we take the slightly easier version of the proximity, where we take the minimum of the two probabilities, defined in Table 1. We have allowed the proximity to be a function of the year as well, although it would not change the results significantly if we have not.

Having access to the proximity, the general idea is that the countries are more probable to develop specialization in a given activity that is close to their current set of capabilities (at least it is easier for them). To quantify this, a country-specific measure can be defined using the proximity and the structure of the county's production portfolio. This is simply the sum of the proximity of the specific item of interest for that specific country to all other items where the country is specialized in, $\sum_u M_{c,u,i}\phi_{u',u,t}$, divided by the sum of all proximities to that product $\sum_u \phi_{u',u,t}$ (see Table 1). This measure is called "density", $\omega_{c,u,t}$, and can be formally thought of as a measure of log likelihood of developing an RCA above threshold in a future export (Hausmann and Hidalgo 2011). A high-density value indicates that a country has developed capabilities that surrounds the export of product u. In other words, if the country does not have an RCA above threshold for that specific item, but has a large density $\omega_{c,u,t}$, there is a high chance that it becomes specialized in that item in the future, while if the density value is small the chances are lower. It also means that probably a country would start gaining comparative advantage in items with the highest densities, although it is not necessarily always the case.

The higher value of density $\omega_{c,u,t}$ generally means that it is more "feasible" for country c to develop a higher RCA in product u, compared to other products with lower densities. This notion of "feasibility" is used extensively in the rest of this paper.

3. The growing importance of services in the world economy

Traditionally, the development of a labor-intensive goods manufacturing has been regarded as a prerequisite to rapid employment and GDP growth while services were viewed as a passive input into manufactured goods. Higher productivity, more opportunities for capital accumulation, spillovers and linkages and demand effects in manufacturing are the conventional arguments supporting manufacturing as an engine of growth (typically over agriculture). In this work, services are in the background, considered as low-skill and low-innovation (Baumol, 1967, Kaldor, 1966, UNIDO, 2009, McCredie and Bubner, 2010). The global slowdown in manufacturing exports has sparked academic, political and media attention, leading experts to view limited hope for developing countries, especially in Africa (Collier, 2007, Rodrik, 2015, Fort et al. 2018).

This pessimism is unwarranted given the dramatic evolutions of the service sector in the past two decades. While the global technology frontier manufacturing has stagnated, it is still shifting out for services (Ghani and Kharas, 2010). Emerging technologies like the automation, artificial intelligence, big data are changing the characteristics of service. Service activities can be unbundled, disembodied, and splintered in a value chain just like goods (Bhagwati, 1984). Technological changes are driving up demand for world trade in services. Technological innovations provide a wide array of services to be carried out in one location and consumed in many other places. Historically buyers and sellers needed to be

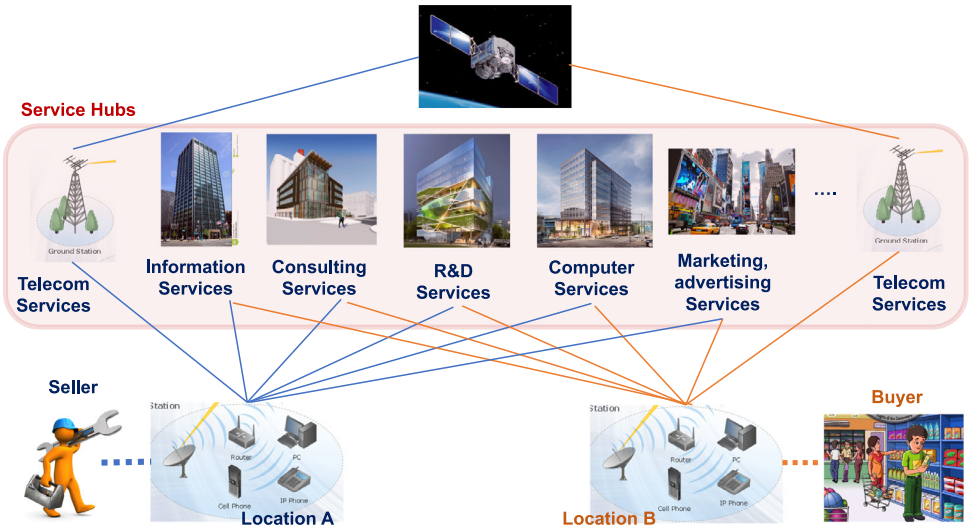

Fig. 1. System of service ecosystem.
Note: The abstraction shows that the digital infrastructure is reducing the cost of production, delivery, and consumption of service activities between buyers and sellers across locations.

face to face. However, increasingly many services between buyers and sellers can be traded globally across and within borders almost instantly through satellite networks. A system of services, as shown in Fig. 1, ecosystem enables tradable hi-technology services between buyers and sellers in different locations. The internet and other systems of network technologies like mobile phones, big data, industrial robotics, and artificial intelligence are providing technical changes to production techniques and business processes. Software has become the main component of all hardware systems. This has given services a physical presence like goods; they can be produced, stored, and consumed across borders.

The virtual capabilities of services, such as being transported cheaply and swiftly in binary bits, makes it more desirable than exported goods. Such services are called *modern* services like computer, information, or research and development services versus *traditional* services like haircuts, restaurants that require face to face contact (Baumol 1967; Ghani and Kharas, 2012, Mishra et al., 2011). Similar to high value-added products, modern services may yield greater knowledge spillovers, have a greater potential for backward and forward linkages, or offer an easier pathway toward discovering new specializations with similar characteristics (Anand et al., 2012). These structural changes are putting services at the center of world commerce, perhaps heralding a new wave of globalization (Loungani et al., 2017).[3]

Emerging economies like India, China, Bolivia, Nigeria and Brazil in particular have been affected by this services revolution. They have seen fast increases in consulting, analytics, design, knowledge-processing, transportation, financial and accounting services as multinational firms increasingly shifting parts of their activities abroad. Furthermore, rapid urbanization and growth in city clusters, characteristic of EMs, reduces demand for physical goods and increases demand for services. Agglomeration and economics of scale in service cities are incentivizing service hubs of exports in EM's, similar to the factory driven industrialization of China and other East Asian economies.

It should not be surprising then, that measures of complexity that fail to capture the growing importance of tradable services may underestimate (or over-estimate) the economic strength of emerging markets (EM's). Segments of EM's in the low-middle income status are unable to generate sufficiently high-growth growing economies stagnate at middle-income levels and fail to transition into a high-income economy. These countries may remain stuck in a "middle-income" trap and require new sources of growth (Agenor et al. 2012, Gabriel and Rosenblatt, 2013, Flaaen et al., 2013). Similarly, another segment of EM's may be trapped by a "resource-curse" with limited opportunities for diversification, for example many African countries are not competitive in any sectors that are not based on natural resources. (Gelb, 2010, Battaile and Mishra, 2015).

The following three key stylized facts about the growing importance of the service sector in the world economy should be noted as we explore our main findings. First, service value added accounts for over 70 percent of world GDP and leading engine of GDP growth across countries (Anand et al. 2013). Second, services account for over 50 percent of the world's formal employment (World Development Indicators, 2019). Services account for even a bigger proportion of informal labor markets in developing countries (ILO, 2018). Third, services are increasingly tradable. World service exports have grown to over $5 trillion in 2015. The share of service exports in total world trade has increased from below 1 percent in 1970 to over 20 percent in 2015.[4] The growing tradability of services has led to a gradually increasing share of services

[3] Recognizing this interdependence, companies are shifting from "selling products to selling an integrated combination of products and services that deliver value," a development that the academic literature refers to as the "servitization of manufacturing" (Baines, Lightfoot, and Smart, 2011). A common pattern is the "smile" of value creation in which companies break up the location of high value–added and low value–added activities (Mudambi, 2008). The success of many supply chains depends on an underpinning of services, from research and development at the inception of the product to distribution and repair at completion. There are many examples. For example, General Motors (GM) has kept its Pontiac LeMans alive by placing design and marketing in advanced economies and assembly in emerging market economies (Loungani and Mishra, 2016). Similarly, over 70 percent of returns per unit sale of Apple products go back to the "Designed in Cupertino" brand for the Research and Development (R&D) and Intellectual Property (IP) services (Maglio et al. 2010). Many of the largest space and advanced engineering companies like AIRBUS or Lockheed Martin do not just sell jet-engines for aircrafts but a host of finance, insurance, maintenance services as a core part of their business.

[4] The share of services rises to almost 50 percent if transactions are measured in terms of direct and indirect value-added content—that is if measured in terms of processing of imported components into final products for export (Hubert Escaith 2008). Adding the sales of services by foreign affiliates of multinational firms, then the value of trade in services rises further (WTO 2009, Hoekman et al., 2010).

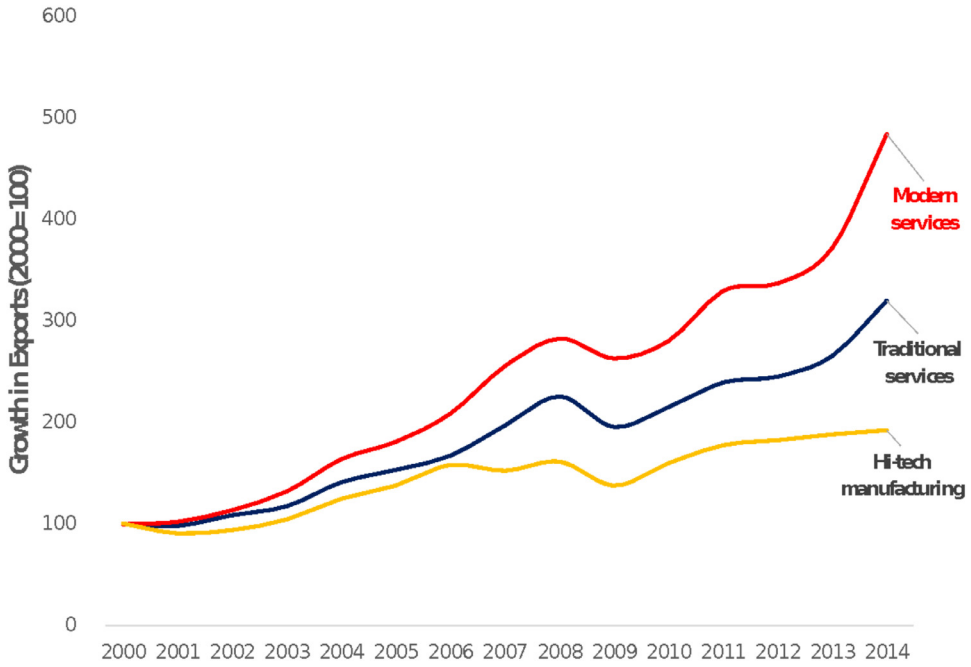

Fig. 2. Modern service exports are one of the fastest growing sectors of the global economy.
Note: For left panel, the numbers indicate the decadal growth rate of service exports for the world. The right panel shows subset of service and manufacturing exports. Modern services include research and development, business, computer and information, financial intermediation services.
Source: authors' calculations using IMF BPM6, 2016. .

in world GDP from negligible in late 1970′s to over 6 percent in recent years (World Trade Organization, 2019).

Especially interesting is the dynamics of *modern* services. This paper defines *modern* services as financial, telecommunications, computer and information, charges for IP and business services such as R&D services; *traditional* services are travel, transportation, construction, personal, cultural and recreation, and government services (Flaaen et al., 2013; Mishra et al., 2011).[5] Fig. 2 shows the components of world exports - modern services, traditional services, and high-technology manufacturing exports, where the year 2000 is indexed to 100. The chart shows that modern service exports have grown five-folds since 2000, whereas hi-technology manufacturing exports are decelerating. The figure highlights that trade in services sectors cannot be ignored in the universal world trade matrix if a more complete picture of trade globalization is to be captured accurately. In the subsequent analysis, we show that modern services are some of the most complex activities in world trade networks. The growth in modern service exports are an increasingly important driver of growth and economic competitiveness (Lewis et al., 1992; Raush, 1998).[6]

Before moving on to presenting our main finding, we show how our main variable of interest —country fitness correlates with the level of development. Fig. 3 plots the log GDP per capita on y-axis against the goods, services and universal fitness on the x-axis. The plots represent the average values between 2010–14. The chart can be interpreted in the following manner – countries that are on the lower-right quadrant have high fitness and will converge to higher levels of income. The countries in the upper-left quadrant are resource rich countries that have concentrated export portfolios and have per capita income levels higher than predicted by their fitness. The relationship is equally robust for service fitness as goods. For example, Iceland that has high service fitness will converge to much higher income levels. Others like Kuwait, Turkey, or Oman have higher per capita income levels than predicted by their fitness. Countries like India will converge to much higher income per capita levels (such as Poland) based on their inherent production capabilities.

4. Main findings

In this section we address three main questions: 1) are modern services more complex than traditional services? 2) are modern services more complex than hi-technology goods exports? and 3) how does our perception of emerging markets shift, in particular, for middle-income and resource-rich countries, accounting for services to measure economic fitness?

4.1. Complexity of modern services

Many modern services like R&D, Information, Finance and Computer and Business Services are found to have higher complexity than traditional services. Fig. 4 plots the complexity of service exports ranked by their high-low complexity ranking in 2015. The results show that modern services such as intellectual property, research and development, financial, information, and maintenance services are more complex than traditional services such as travel or transportation.

4.2. Economic fitness of nations in goods and services

In order to benchmark the relative performance in goods and service fitness between countries, the fitness country ranks are shown on vertical and horizontal axis respectively in Fig. 5. Four

[5] *Modern services* are ICT enabled services which is a growing part of world trade that takes place without proximity of buyer and seller. Many other services still require the mobility of people and capital across borders. Services where the proximity of buyer and seller is crucial are called *traditional services*.

[6] This structural shift driven by modern services is not an advanced economy story alone. Developing countries are taking over global market share of service exports. Developing countries occupied three percent of world service export market in 1970, rising steadily to over 20 percent of world service export market. The share of advanced economies in world service export market has declined from over 95 percent in 1970's to around 80 percent in 2015.

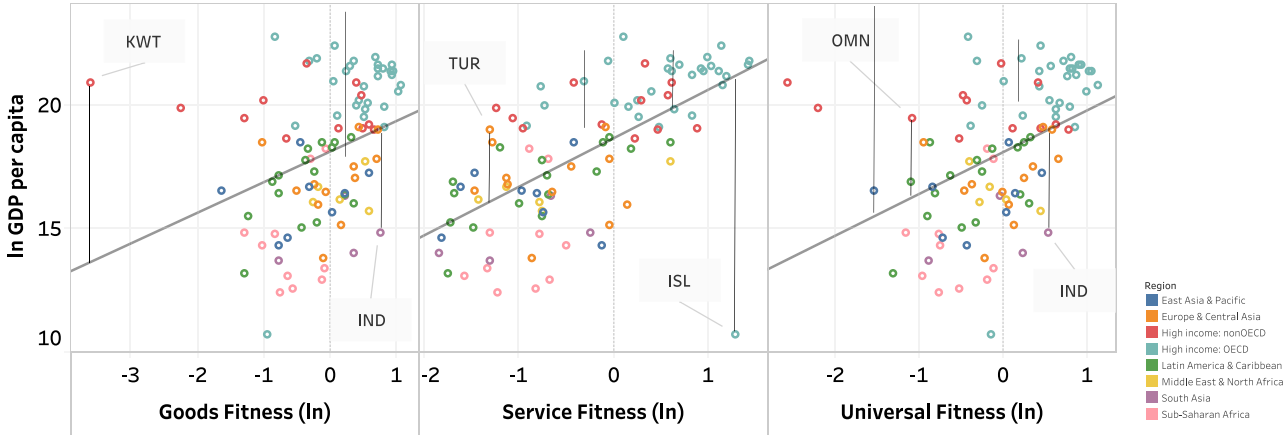

Fig. 3. Economic fitness and development.
Note: The countries that are below the regression line can be interpreted as countries that are fit and it is expected that they will converge to higher per capita income levels as predicted by their fitness value (see Cristelli et al., 2013 for details). These countries include Ethiopia, India, Moldova. Countries above the regression line are higher per capita income levels than would be predicted by their fitness, these countries are Qatar, Kazakhstan, Oman.
Source: authors' calculations based on P, S, and U matrix of world trade, 2019.

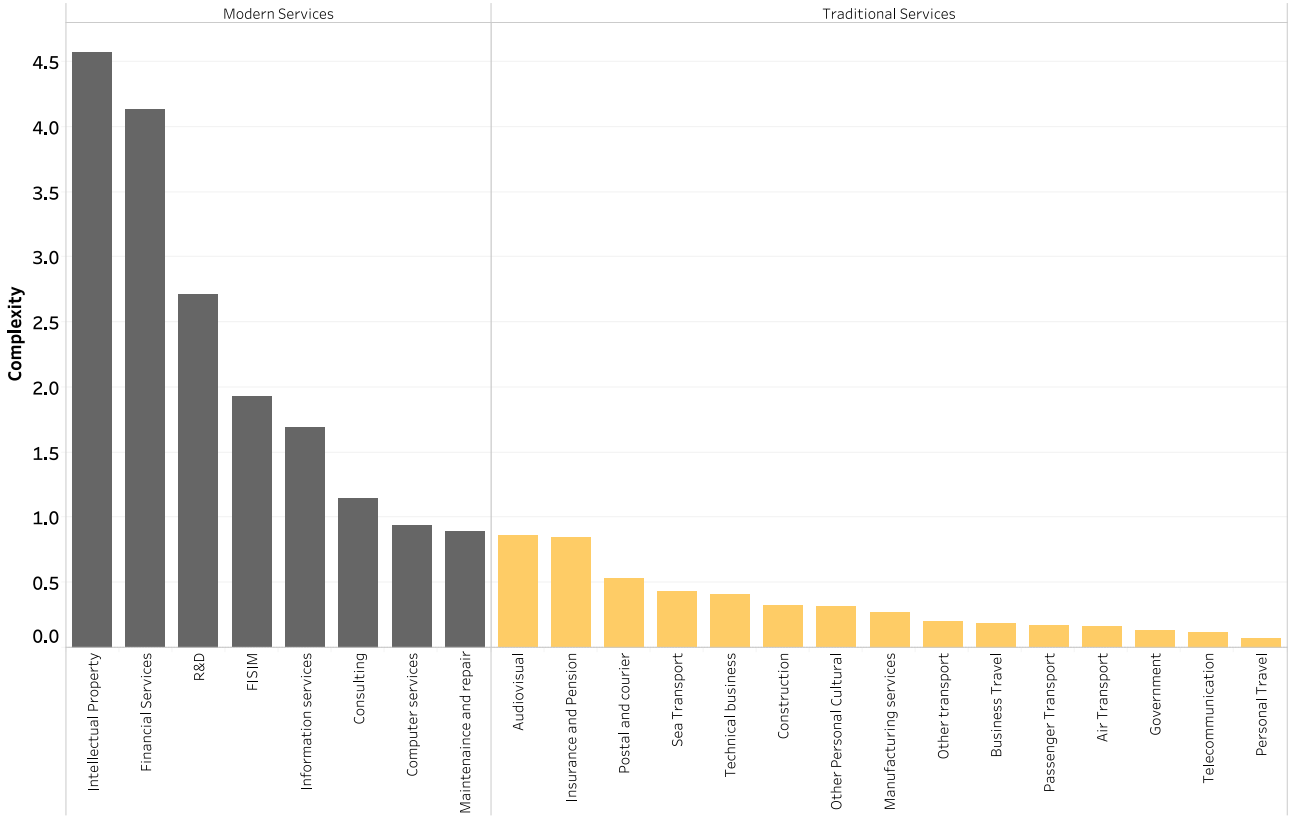

Fig. 4. Modern service exports are more complex than traditional services.
Note: The data presented is based on the service-only matrix of world trade.
Source: authors' calculations based on service-only matrix of world trade, 2019.

quadrants of countries are identified. Countries in the North-East (NE) quadrant are fit in both goods and services, or countries in the South-East (SE) quadrant are relatively more fit in services only, and so forth. Norway, Chile, or Kuwait are relatively more fit in services than in goods. Similarly, countries like Austria, Thailand, Turkey, or Korea are more fit in goods than in services. Countries like the US, Switzerland, or Germany are relatively fit in both goods and services. Lastly, countries such as Nigeria, Saudi Arabia, or Tanzania are in the lower range for fitness in both goods and services.

4.3. Middle income countries

The performance of emerging markets based on universal fitness is assessed next. Often, a tipping-point for developing countries is crossing the middle-income threshold. In the last half century though, very few countries that achieved middle-income status also achieved the status of a high-income country. Only one country (the Republic of Korea) out of the seven countries that

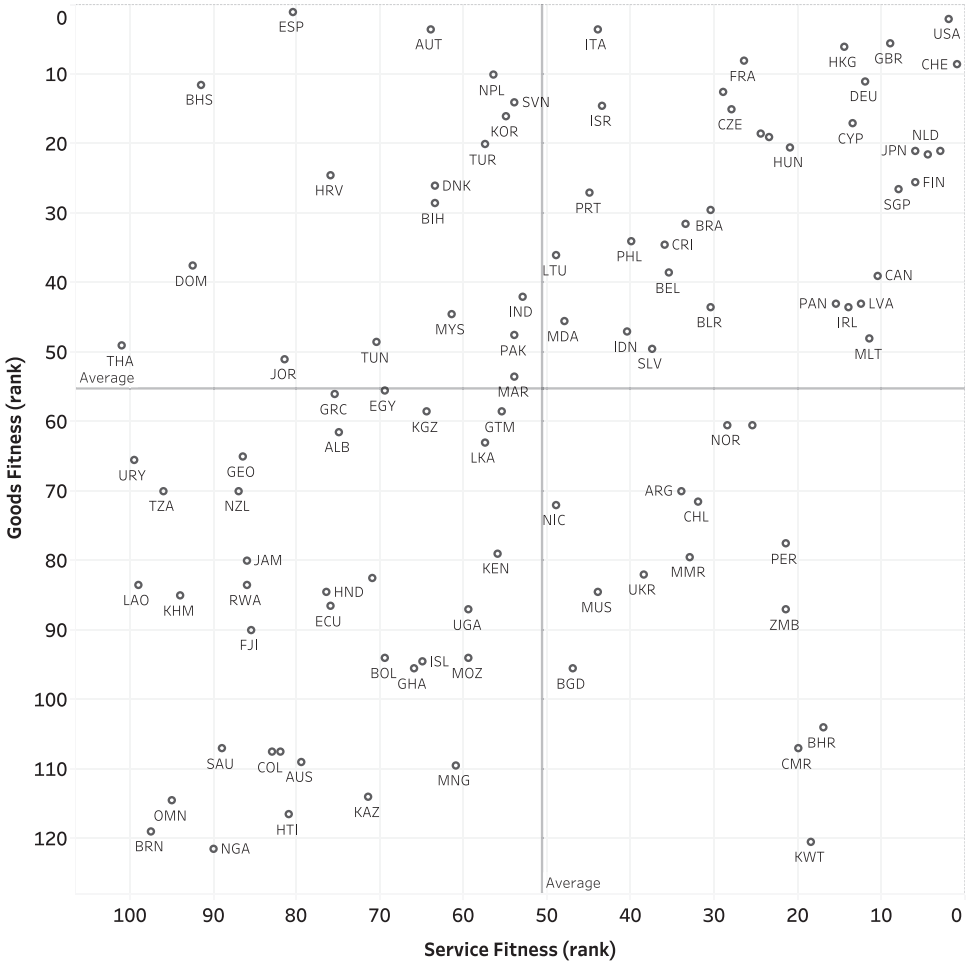

Fig. 5. Benchmarking goods and service fitness performance of countries, 2014–16
Source: authors' calculations based on goods-only and service-only matrix of world trade, 2019.

could be classified as middle income in 1975 managed to reach high-income status by 2005.[7]

Adding services improves the competitiveness of selected developing countries. In a similar vein as Zaccaria et al. (2018) we show the gain (or loss) in economic fitness integrating services, here the income and regional benchmarking for relative gain (or loss) in economic fitness is presented, incorporating services in the economic fitness approach. Fig. 6 plots the difference in fitness for developing countries and can be interpreted in the following manner. The vertical axis is universal fitness minus good fitness. Countries that have higher universal fitness as compared to goods fitness have positive values, and countries that have lower universal fitness than goods fitness have negative values. The labels show the income groups of developing countries and the geographic regions they belong to. The income groups correspond to the World Bank income grouping of countries. The following chart shows that many regions in developing countries improve fitness (positive values).[8]

4.4. Resource rich countries

Many observers have highlighted that structural transformation has stalled in resource rich countries. Resource rich economies are faced with unique transformation challenges.[9] Technological progress and specialization in trade in services may offer diversification options for the future in resource-rich countries (Gelb 2012; Anderson and Strutt 2013; Battaile and Mishra 2015). However, this claim pertaining to resource-rich countries competitiveness requires empirical validation. In the following analysis, resource-rich countries are defined as countries whose share of exports coming from non-renewables is more than 33 percent (IMF 2012).

The bar charts in Fig. 7 plot the gain (or loss) in fitness when services are added to assess fitness for broadly resource and non-resource rich countries. The positive bar indicates that resource rich countries have higher universal fitness than in goods

[7] By contrast, Brazil and South Africa, which had double the per capita income of Korea in 1975, have remained at roughly the same level. Cost advantages in labor-intensive sectors, such as manufacturing exports, that once drove growth, start to decline in comparison with lower-wage countries. Countries in the "trap" lack the institutions, capital markets, track record, or critical mass of highly skilled workers to grow through major innovations, like wealthier countries (Ma, 2016, Rasia and Chandran, 2015 Flaaen et al. 2013). Many middle-income countries tend to make two common mistakes: either they cling too long to past successful policies, or they exit prematurely from the industries that could have served as the basis for their specialization process (Kharas, Zeufack, and Majeed, 2010).

[8] We use the World Bank groupings and classify all countries as either Low Income Countries (LIC), Lower Middle-Income Countries (LMIC), Upper Middle-Income Countries (UMIC), OECD High Income Countries (HIC: OECD) or Non-OECD High Income Countries (HICs: Non-OECD). An example of a High-Income Non-OECD country oil-producing nation is the Saudi Arabia.

[9] For example, resource sectors tend to be highly capital intensive and offer limited employment opportunities to accommodate workers exiting sectors with lower average productivity, such as agriculture and informal services.

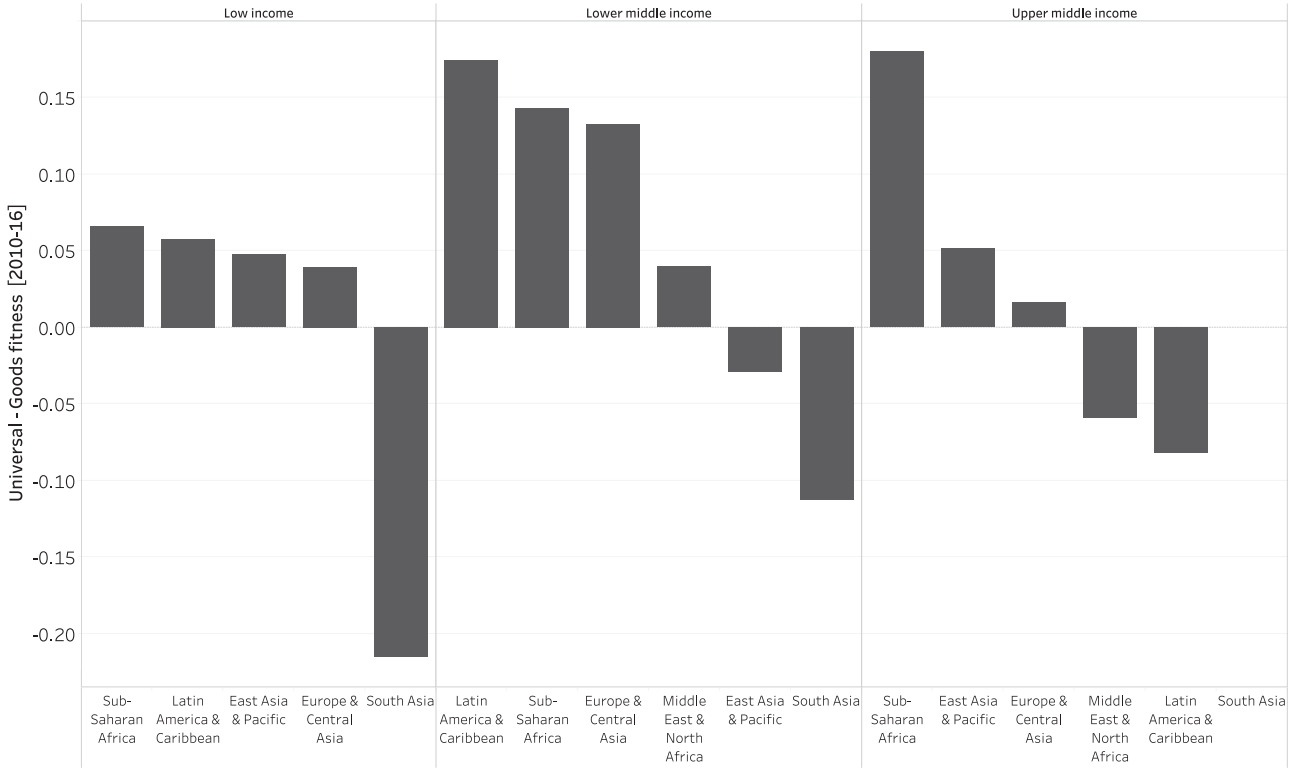

Fig. 6. Adding services improves the competitiveness of selected developing regions.
Note: The chart shows that many regions in developing countries improve fitness (positive values). In particular, Low income countries in East Asia, latin America and Caribbean, sub-saharan Africa, tend to do better. The detailed country bar chart shows specific countries by regions.
Source: authors' calculations based on universal matrix of world trade, 2019.

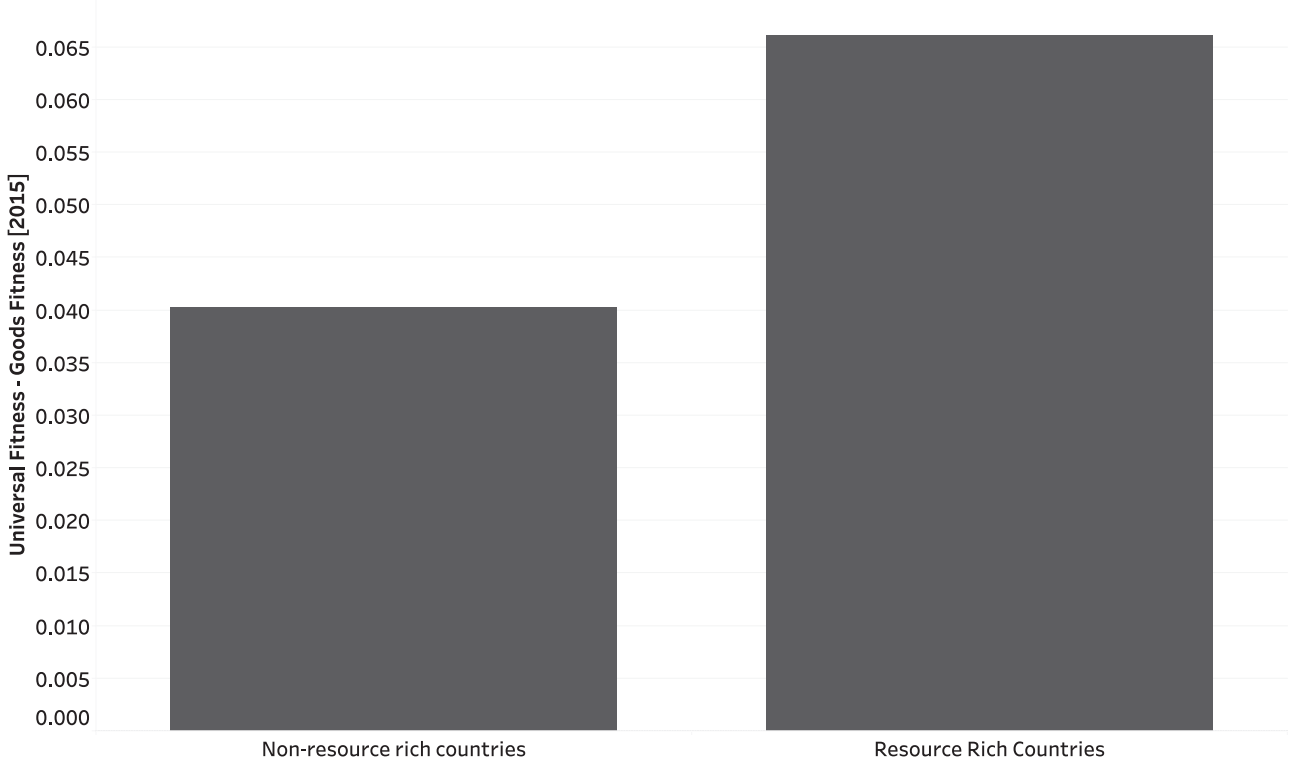

Fig. 7. Resource rich countries tend to do better when accounting for the globalization of the service sector.
Note: resource rich countries are a sample of 45 countries identified by the IMF (2012). The specific resource rich countries are plotted above as well. Resource rich countries like Bolivia, Mexico, Cameroon improve competitiveness when services are included to measure universal fitness. Others like Indonesia, Vietnam or Laos loose fitness adding services. Non-resource rich developing countries are a sample of 131 countries. Only developing countries are used in the sample presented above.
Source: authors' calculations based on universal matrix of world trade, 2019.

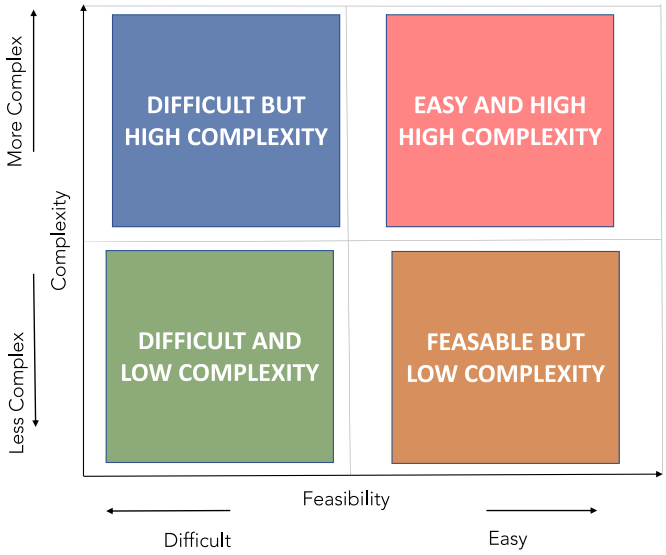

Fig. 8. Proposed framework to inform export diversification strategies.

alone. Non-resource rich countries tend to have substantially lower universal fitness when services are added to quantify their capabilities. More specifically, the list of resource rich countries ranked by the ones that gain competitiveness adding services are provided. Bolivia, Mexico, Cameroon, Kazakhstan, Ecuador, Mongolia are more fit when services are used to assess their fitness.

5. Framework to inform diversification and market-entry strategy

This Section describes a framework to use the metrics derived from the FC algorithm, as well as related measurements to devise data-driven export diversification strategy for specific countries. The universal matrix can be used in a predictive framework to assess future capabilities. To do this, we can look at the attractiveness of activities based not just on complexity but also on how easy or difficult they are to specialize in (Fig. 8). This gives us insight into the potential trajectory of overall specialization pattern (Hidalgo and Hausmann, 2009, Zacaria, 2016). In this framework, products and services from the universal matrix are segmented into four categories to identify relatively more complex specializations that can also be relatively easy to develop a comparative advantage in.

Complexity is plotted on the y-axis. A value of complexity above 1 indicates activities in the universal matrix that are less ubiquitous and made by countries that are more economically fit. Specialization in more complex activities will increase competitiveness and returns from exports as these activities are associated with higher value and productivity. Feasibility is plotted on the x-axis. Feasibility (i.e., density) is the (log) likelihood of specializing in a given sector (either goods or services). The feasibility measure can be interpreted as the relative difficulty or ease of gaining specialization (or RCA) in an activity. A higher number implies a relatively *easy* specialization opportunity and a lower number represents relatively *difficult* specialization prospect. The schematic provided in Fig. 9 illustrates the 2×2 matrix.

The four quadrants illustrate complexity and feasibility clusters. For a given country, each of the four clusters have implications for potential entry strategy accommodating for the complexity of the given activity. For example, the less complex and relatively difficult specialization will fall in the southwest (SW) quadrant. Activities in the SW quadrant may not be feasible and are not relatively complex.

Diversification strategies should be based on inherent specialization that are relatively more complex i.e. new specializations can be gained more easily in activities that are closer to the current set of capabilities and also more complex. The activities in the northeast (NE) quadrant provides the cluster of complex activities that can be of relative ease to gain specialization in for a given country.

There are three main points to note with this proposed framework. First, the framework should be used in conjunction with ground-truth realities. For example, if policymakers witness emerging specialization in complex information services from a low-income country, the companies providing such activities should be validated. Second, the decision-making with this framework can inform strategy in a highly modular and flexible manner by accommodating new metrics. This can help filter out and then zoom into specific product-service clusters that may not be visible in aggregated data. For example, policymakers can add additional dimensions in the NE quadrant to determine which complex-easy specializations that the given country has experienced the fastest growth or relatively lower degree of specialization. Third, a host of policy and environmental conditions could be important to support the specific diversification path. For example, the literature that has identified aspects of supply-side incentive structures, investments and policy reforms targeted at reducing trade costs (including business regulation, investment policy, and trade policy). Also, important to develop particular sectors would be effective policies to support adjustment and the reallocation of resources towards new activities as well as government institutions and support for entrepreneurship to guide young firms to innovate and build new specializations based on the proposed framework. Due to the breadth and depth of this proposed framework, the following case studies are a first step and more detailed discussions and nuances to run this strategy are presented in future work.

5.1. Case studies

To show the applicability of our framework, we provide case studies are provided for three developing countries. First, Angola, a low-income country and one of the most concentrated economies aspires to diversify from its natural resource base. Second, Ethiopia, currently a low-income country that aims to reach a lower-middle-income status by 2025. Third, India, currently a lower-middle income country that aspires to grow fast to converge with upper-middle income countries like China, Brazil, and Argentina in the coming decades.

The dots for country charts represent the items exported from the respective country based on the universal matrix. The slope (regression line not shown for simplicity) indicates the relationship between complexity and feasibility for a given country. The size of the dots represents the share of exports in total export basket for each country. The country charts provide a view of specialization patterns across exporting activities. The y-axis plots the complexity where cut-off point is defined as 1. The x-axis plots the feasibility with cut-off point has fixed at 0.3. Now the x-axis cut-off point can be adjusted based on the country; however, they have been kept the same across various countries to provide a comparable assessment between and within countries. The framework (as presented in Fig. 8) can be interpreted with the detailed country context in Fig. 9a, b, and c. These charts provide a basis to identify activities that are more complex with relative ease of gaining specialization. The figures provide operational examples for market-entry strategies in specific services (or goods) for country specific circumstances.

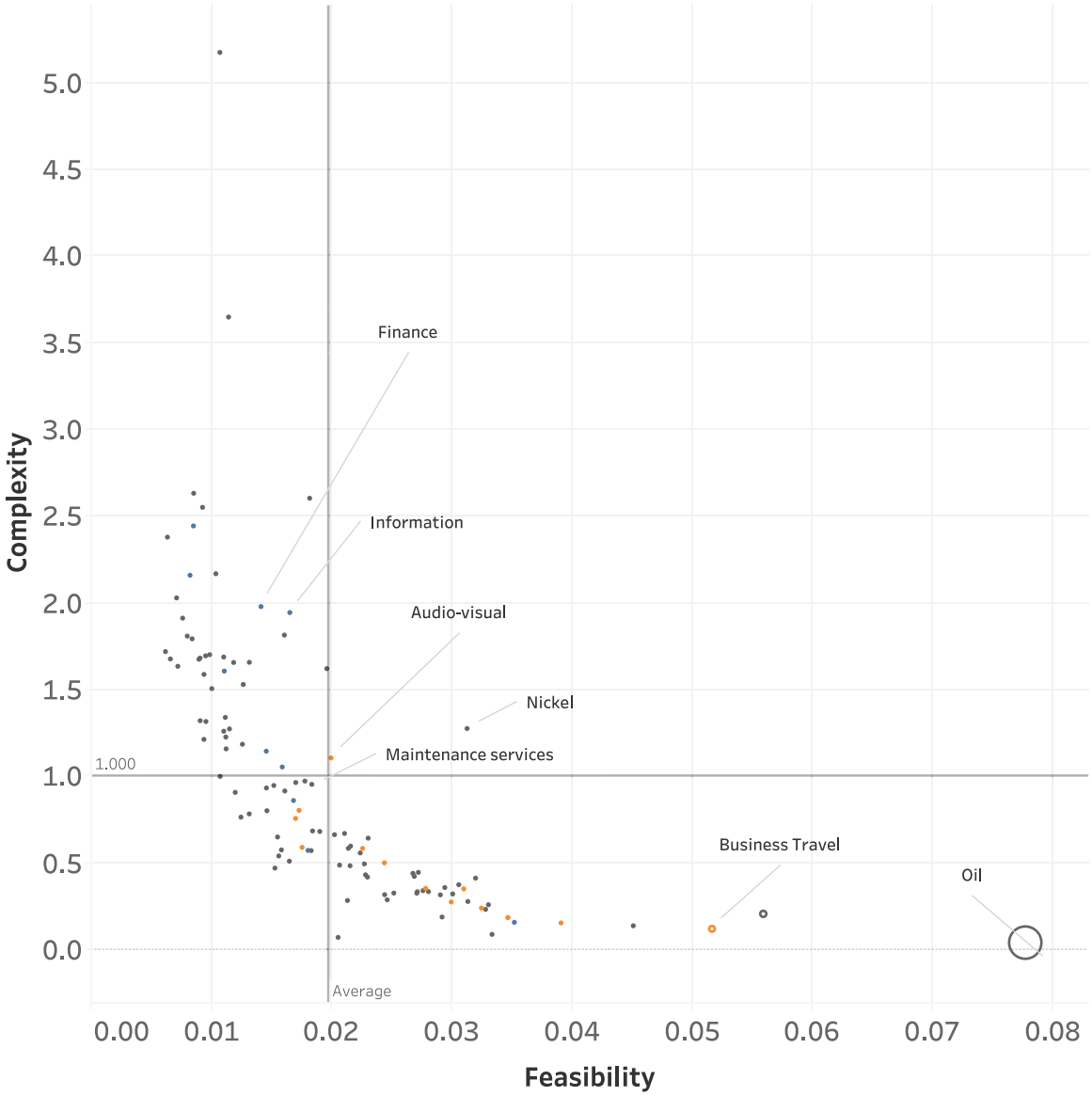

Fig. 9. (a) Angola - Proposed framework to inform export diversification strategies.
Note: The size of the bubble indicates the share of a given export in total exports (%). The color blue denotes modern services, orange denotes traditional services, and the gray dots represent goods exports. The chart represents an average for 2014–15. The x-axis constant at 0.3 has been relaxed for Angola and presented at an average of feasibility for Angola's export basket.
(b) Ethiopia - Proposed framework to inform export diversification strategies.
Note: The size of the bubble indicates the share of a given export in total exports (%). The color blue denotes modern services, orange denotes traditional services, and the gray dots represent goods exports. The chart represents an average for 2014–15.
(c) India - Proposed framework to inform export diversification strategies.
Note: The size of the bubble indicates the share of a given export in total exports (%). The color blue denotes modern services, orange denotes traditional services, and the gray dots represent goods exports. The chart represents an average for 2014–15.

5.1.1. Angola

Angola's economy is closely tied to oil, which is susceptible to global price shocks, declining global demand and competition from alternative sources of energy and suppliers. Unless Angola reduces its dependence on oil, continued volatility in Angola's income level will constrain it from reaching a high-income status. Angola has remained one of the most concentrated economies in the world (Chandra and Mishra, 2019); however, recent shifts in sources of comparative advantage could offer potential for future diversification.

Evidence of this opportunity is highlighted by the specific products-services that fall in each of the four quadrants the 2016 export statistics presented in the four quadrants. Angola could build upon its specialization in business travel to build a service ecosystem. Other services include sea, air, and other transportation services for Angola to gain deeper specializations. Similarly, Angola should build on its small telecommunications services to leap forward to computer and information services over the long run. For example, robotics technology is readily being deployed by multi-national corporations in offshore oil and drilling. Provided appropriate policy environment, specialized clusters in hi-tech service components embedded in such systems could be developed in Angola. Opportunities could also exist in complex minerals and derivate such as quarts, mica, particularly nickel is a rel-

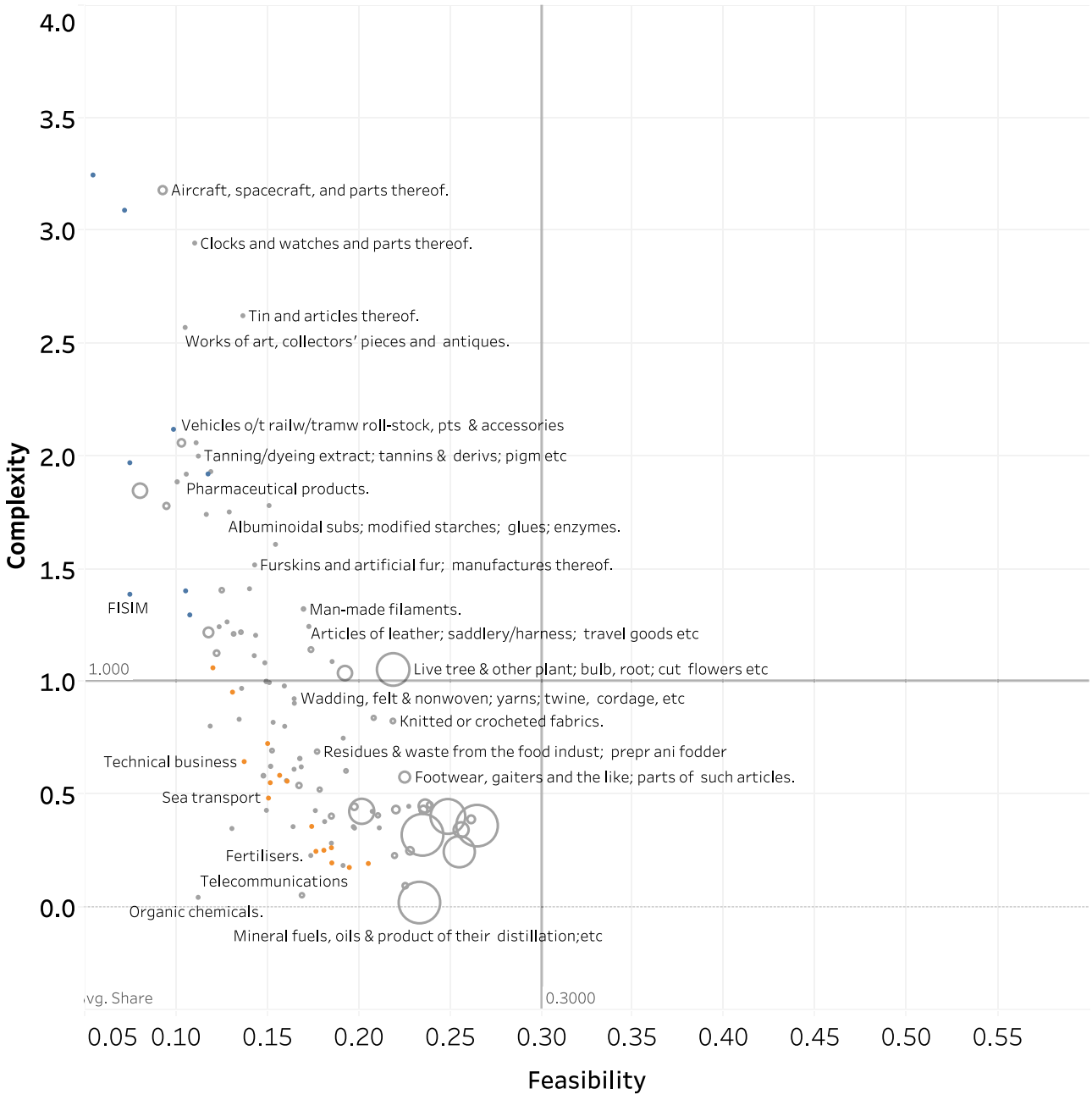

Fig. 9. Continued

atively complex and easy specialization to aid Angola's diversification. Similarly, financial services, business travel and other services are also relatively complex and within the sphere of Angola's capability structure.

5.1.2. Ethiopia

Ethiopia is one of the fastest growing countries in Africa. However, Ethiopia's export sector remains relatively small compared to peer African economies, with economic growth being led primarily by services and agriculture. There is a strong infrastructure pipeline that are supported by various transportation, cargo, communications. Ethiopia's Vision 2025 focuses on manufacturing capabilities but the role of services in designing competitive manufacturing base should be noted.

Fig. 9b shows the four quadrants of complexity-feasibility for Ethiopia. All capabilities in Ethiopia are below feasibility threshold of 0.3 indicating all complex activities are difficult. However, a deeper dive indicates specialization in diversified portfolio of primary and resource-based products such as coffee, tea, oils, minerals, vegetables. In the high-complexity segment, primary products such as leather, live tree and plant-based products, and in manufacturing mechanical products and nuclear industry. High-tech clusters that are relatively most feasible and consideration for diversification strategies include aircraft components, computer services

Given the stage of economic development in Ethiopia, upgrading global value chains (GVC's) is important through transportation, logistics and traditional services playing a key role in boosting diversification and improving efficiency of leather, horticulture, or coffee value chains. High technology service imports from countries could also play a role in acquiring new knowledge and discovery of new specializations by learning by doing.

Fig. 9. Continued

5.1.3. India

India's exports have been increasing since the early 1990s – both as a share of GDP and as a share of world exports. Total exports as a share of GDP have risen to almost 25 percent in 2013 from around 10 percent in 1995 (Anand et al. 2016). Likewise, Indian goods exports as a share of world goods exports have risen, with the share almost tripling to 1.7 percent during 1995–2013. A similar trend is visible in India's services export – the share tripling to over 3 percent of world service exports during 2000–2013. The Make in India movement started in 2014 aims to encourage manufacturing across the country

Fig. 9c shows the four quadrants from our framework for India. It is evident that most complex activities are in the NE quadrant implying that complex activities are relatively easy for India to gain specialization in. Even though Indian service exports are sophisticated (Mishra et al., 2011; Anand et al., 2015), India can benefit from overall diversification and uniqueness of service exports. Modern services are highly concentrated in computer services. Leveraging the available skill-base available in India and global trends in emerging technologies, India can move up the value-chain from computer to information services that can play a crucial role across industries.

As host of services underpin the modern manufacturing supply chain, India could build on its comparative advantage in high value services to discover niches in other critical service that will feed into successful operation of manufacturing supply chain networks. India's emerging comparative advantage in Research and Development Services is comparable to that of Australia, and other advanced economies like Germany, France, or the United States. This is evident through various fields in bioinformatics, aerospace, pharmaceuticals, management, chemical or mechanical engineering.

6. Conclusion and policy implications

The notion of international trade as involving only physical goods is eroding. Emerging technologies such as artificial intelligence, robotics, and big data are leading to a wide array of services to be carried out in one location and consumed in many other places. The data, methodology, and analysis presented in this paper contributed two new findings, in addition to a framework to guide policy decision-making regarding export diversification strategies. First, modern services are some of the most complex activities in the global trade networks, indicating that the knowledge spillovers from gaining specialization in complex services are higher than traditional industrialization-based model of growth and development. Second, emerging markets, and in particular low-middle income countries, show greater economic strength when adding services to measure the economic fitness. Resource-rich countries also improve ranking when services are added to measure the complexity. The proposed framework segments services and goods specialization for a given country on four quadrants based on complexity and ease (or difficulty) to aid economic policy decision-making concerning export diversification strategies.

The policy implications of our study include bringing attention to the spillovers of high-technology tradable services as critical engine for diversification and growth. Industrial policy could play an active role in the realization of new competitive specializations identified in this paper. In particular, traditional-manufacturing-based policy recommendations would entail capital-intensive fixed-cost investments; however, labor-saving technologies and their impact could have both positive and negative externalities. For example, a small cluster of strategic complex service specializations could lead to high growth, which may require different class of investment in compute capabilities, access to data, skills, and entrepreneurial ecosystem to realize the gains from trade in services. Similarly, a better understanding is required on how to make the service-led growth inclusive. The heterogeneity in various activities of specialization specific to a country provides an advantage to develop unique specialization patterns. Countries do not necessarily need to follow the growth pattern of previous nations but invent new paths to discovering new combination of specializations. It will be very interesting to further study the linkages between services and products to engage in new specializations.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.strueco.2020.03.002.

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