World Bank Group | LinkedIn

DATA INSIGHTS:

JOBS, SKILLS AND MIGRATION TRENDS METHODOLOGY & VALIDATION RESULTS

Tingting Juni Zhu Alan Fritzler Jan Orlowski

WORLD BANK GROUP

LinkedIn

ACKNOWLEDGEMENTS

Authors:

Tingting Juni Zhu (TTL, Private Sector Specialist) and Jan Orlowski (Economist) at Finance, Competitiveness and Innovation Global Practice, World Bank Group, Washington, DC, and Alan Fritzler (Senior Data Scientist) at LinkedIn Corporation, San Francisco, CA, prepared this methodology and validation report. For questions and comments, please contact Tingting Juni Zhu at tzhu@worldbank.org.

People we thank:

We would like to thank the broader team, Ramin Aliyev, Rajan Bhardvaj, J. Ernesto Lopez Cordova, Dina Elnaggar, Elena Gex, Anh Le, Une Lee, Jiemei Liu, Renzo Massari, Jeffrey Mccoy, Moira Mckerracher, Rodimiro Rodrigo, David Satola, Nika Soon-Shiong, Nina Vucenik, and Douglas Zhihua Zeng from WBG, and Hannah Brown, Pei Ying Chua, Nick Eng, Nicole Isaac, Paul Ko, Mariano Mamertino, Di Mo ,Kevin Morsony, Akshay Verma, Tony Vu, and Jenny Ying from LinkedIn for their helpful comments and support of the project. In addition, task team leaders of the World Bank Group's operations helped configure the research and provide feedback during the team's work, including Carli Blunding-Venter (Sub-Saharan Africa), Cesar A. Cancho (Europe and Central Asia), John Gabriel Goddard (Sub-Saharan Africa), Marco Antonio Hernandez Ore (Europe and Central Asia), and Marcin Miroslaw Piatkowski (East Asia and Pacific). We would also like to acknowledge the comments and feedback from Ana Paula Cusolito, Mary C. Hallward-Driemeier, Victoria Levin, Espen Beer Prydz, and Hernan Winkler. Finally, we would like to thank the seed funders of this project in a big data competition at the World Bank Group exploring nontraditional datasets for public policy-making in developing countries: Prasanna Lal Das, Trevor Monroe, Victor Mulas, and Klaus Tilmes. Without their entrepreneurial spirit, the project would not have become what it is today.

ABBREVIATIONS

BLS	U.S. Bureau of Labor Statistics
ECA	Europe and Central Asia
EAP	East Asia and Pacific
ICT	Information and Communications Technology
ILO	International Labor Organization
ILOSTAT	International Labor Organization Statistics
ISIC	International Standard Industrial Classification
LAC	Latin America and the Caribbean
MENA	Middle East and North Africa
OECD	Organization for Economic Cooperation and Development
PIAAC	Program for the International Assessment of Adult Competencies
PS-TRE	Problem solving in technology-rich environments
NAC	North America
SA	South Asia
SSA	Sub Saharan Africa
WBG	World Bank Group

Table of Contents

FIGURES 2
TABLES 3
BOXES 3
EXECUTIVE SUMMARY 4

I. Introduction 15

A. Using Online Data for Policy Research 15
B. Quality Control and Limitations of LinkedIn Data 16
C. Innovative Applications of LinkedIn Data 18
D. Overview of WBG-LinkedIn Partnership and Data Update Plan 18

II. Data Sources 19

A. Age and Sex 20
B. Industry Employment Size 20
C. Industry Employment Growth 21
D. Skills 21
E. Talent Migration 25

III. LinkedIn Data Representativeness 27

A. Age 27
1) Age Distribution Globally 27
2) Age Distribution According to Income Group 28
3) Age Distribution According to World Bank Region 28

B. Sex 30
1) Sex Distribution Globally 30
2) Sex Distribution According to Income Group 30
3) Sex Distribution According to World Bank Region 30

C. Industry 32
1) Industry Coverage Globally 32
2) Industry Coverage According to Income Group 34
3) Industry Coverage According to World Bank Region 34

IV. LinkedIn Metrics Validation Results 37

A. Industry Employment Metrics 37
1) Industry Employment Location Quotient 37
a) Overview 37
b) Methodology 37
c) Validation Results 40
(1) Industry Employment Location Quotient Globally 40
(2) Employment Location Quotient According to Industry 40
(3) Industry Employment Location Quotient According to Income Group 41
(4) Industry Employment Location Quotient According to World Bank Region 41
2) Industry Employment Growth 43
a) Overview 43
b) Methodology 44
c) Validation Results 44
(1) Industry Employment Growth in All BLS Super-Sectors 44
(2) Industry Employment Growth According to BLS Super-Sector 45

B. Skills 49
a) Overview 49
b) Methodology 49
(1) Industry Skills Needs 49
i. Identifying the Top Represented Skills 49
ii. Aggregating Skills to Groups of Skills 50
(2) Skill Penetration Rate 51
2) Validation Results 52
(1) PIAAC ICT Skills Score of Problem Solving in Technology-Rich Environments 52
(2) ICT Development Index Data 52
(3) Correlation Results 53

C. Talent Migration Metrics 54
a) Overview 54
b) Methodology 54
c) Validation Results 56
(1) Talent Migration Globally 56
(2) Talent Migration According to Income Group 56
(3) Talent Migration According to World Bank Region 56

V. Sample Visual Outputs and Country Applications 59

A. Industry Employment Dynamics 59
B. Skills 65
C. Talent Migration 65

VI. Conclusions 69

VII. References 70

Appendix A. External vs. LinkedIn Data Matching Methodology 71
1) Age and Sex 71
2) Industry Employment Size 71
3) Industry Employment Growth 73
4) Skills 74
5) Talent Migration 74

Appendix B. LinkedIn Data Country List (100,000+ members) n=140 75

Appendix C. LinkedIn to International Standard Industrial Classification 4 Industry Mapping 78

Appendix D. Migration Data Summary Charts 83

Appendix E. Migration Validation Other Data Sources Evaluated 84

Appendix F. Skill Group Classification 86

FIGURES

Figure 0-1: World Bank Group (WBG)-LinkedIn Collaboration Schedule 5
Figure 0-2: Three Objectives of this Methodology Report 6
Figure 0-3: LinkedIn Industry Coverage According to (A) Income Group and (B) World Bank Region 7
Figure 0-4: Growth from Industry Transitions according to Income Group Annual Average 2015-2017 12
Figure 0-5: Global Artificial Intelligence Skill Penetration 2015-2017 13
Figure 0-6: Skills with the Largest Increase in Penetration Across Industries 2015-2017 13
Figure 0-7: Global Talent Migration 2015-2017 14
Figure II-1: Sample LinkedIn Profile 19
Figure II-2: Sample LinkedIn Profile Work Experience 21
Figure II-3: Sample LinkedIn Profile Skills Section 25
Figure II-4: Sample LinkedIn Profile Location Information 25
Figure III-1: Global Age Distribution (LinkedIn vs. International Labor Organization (ILO)) 27
Figure III-2: Age Distribution According to Income Group (LinkedIn vs. International Labor Organization (ILO)) 28
Figure III-3: Age Distribution According to World Bank Region (LinkedIn vs. International Labor Organization (ILO)) 29
Figure III-4: Global Sex Distribution (LinkedIn vs. International Labor Organization (ILO)) 30
Figure III-5: Sex Distribution According to Income Group (LinkedIn vs. International Labor Organization ((LO)) 31
Figure III-6: Sex Distribution According to World Bank Region (LinkedIn vs. International Labor Organization (ILO)) 31
Figure III-7: Global LinkedIn Industry Coverage (LinkedIn as Percentage of Total International Labor Organization (ILO) Workforce, 2016) 32
Figure III-8: LinkedIn Industry Coverage According to Income Group 35
Figure III-9: LinkedIn Industry Coverage According to World Bank Region 35
Figure IV-1: Country -Industry Pair Location Quotients 40
Figure IV-2: Global Industry Location Quotient Correlation (LinkedIn vs. International Labor Organization) 41
Figure IV-3: Global Industry Location Quotient Correlation According to Income (LinkedIn vs. International Labor Organization) 42
Figure IV-4: Global Industry Location Quotient Correlation According to World Bank Region (LinkedIn vs. International Labor Organization) 42
Figure IV-5: Super-Sector Industry Employment Growth Correlation (LinkedIn vs. Bureau of Labor Statistics) 46

Figure IV-6: Monthly Growth of Super-Sectors with Significant Correlation Between LinkedIn and Bureau of Labor Statistics (BLS), Jan 2015 – Apr 2018) 47
Figure IV-7: Monthly Growth of Super-Sectors with Nonsignificant Correlation Between LinkedIn and Bureau of Labor Statistics (BLS), Jan 2015 – Apr 2018) 48
Figure IV-8: Example of Aggregating Detailed Skills into Skill Groups 50
Figure IV-9: Log-Transformed Outflow Migration Rate: Organization for Economic Cooperation and Development (OECD) vs. LinkedIn Data 56
Figure IV-10: Migration Correlation Results According to Income Group (Log-Transformed) 57
Figure IV-11: Migration Correlation Results According to World Bank Region (Log-Transformed) 57
Figure V-1: Industry Employment Size Location Quotient for the Finance and Insurance Sector in China, Macedonia, Mexico, and South Africa 60
Figure V-2: Growth from Industry Transitions in the Information and Communication Sector Annual Average 2015-2017 61
Figure V-3: Growth from Industry Transitions Worldwide in 100+ Countries Annual Average 2015-2017 62
Figure V-4: Growth from Industry Transitions According to World Bank Region Annual Average 2015-2017 63
Figure V-5: Growth from Industry Transitions According to Income Group Annual Average 2015-2017 64
Figure V-6: Most-Representative Skill Groups for the Online Media Industry Globally 65
Figure V-7: Top Industries Using Artificial Intelligence Skill, Globally 2015-2017 65
Figure V-8: Net International Talent Migration (per 10,000 LinkedIn Members in Country of Interest, Annual Moving Average 2015-2017) 66
Figure V-9: Middle East and North Africa (MENA) Net Migration Rate per 10,000 LinkedIn Members, 2015-2017 67
Figure V-10: Middle East and North Africa Largest Skills and Industry Loss Associated with Talent Movements, 2015 – 2017 67

TABLES

Table 0-1: Summary of Metrics: Methodology and Validation Results 8
Table 0-2: Sample Policy Questions Using LinkedIn Metrics 11
Table II-1: LinkedIn Industry Employment Growth Data Extraction Methods 22
Table II-2: Summary of External Datasets Considered for Skills Metrics Validation Exercises 23
Table II-3: Summary of Other Major External Migration Datasets Considered 26
Table III-1: Summary of Other Considered External Datasets 33
Table IV-1: Correlations between skills and development outcomes (US as the benchmark) 53
Table IV-2: Correlations with Software Engineer in Section J skills vector (US as the benchmark) 53

BOXES

Box 1: Pilot Country 1–Identifying Comparative Advantage and Skills Development Needs in South Africa 38
Box 2: Which Benchmark to Choose When Calculating Location Quotient 39
Box 3: Why we construct a balanced panel data from LinkedIn 44
Box 4: Why correlating industry employment growth of the International Labor Organization (ILO) with that of LinkedIn does not yield the expected result 45
Box 5: Calculating digital marketing skill group's penetration rate in information and communications technology (ICT) and services industry 51
Box 6: Pilot Country 2–Talent and Skill Migration, Macedonia 54
Box 7: Pilot Country 3–Intercity Migration Trends in China 55
Box 8: Should We Weight the LinkedIn Data to Obtain a Representative Sample When Conducting Global Benchmarking? 61
Box 9: How to Compare Migration Flows Between Countries Fairly 66

EXECUTIVE SUMMARY

The World Bank Group-LinkedIn partnership pilots the use of private company data for generating insights on development trends. This partnership is a three-year effort between the WBG and LinkedIn to investigate the extent to which LinkedIn's data can inform policy (figure 0-1). The first phase of the partnership evaluates LinkedIn data covering 100+ countries with at least 100,000 LinkedIn members, distributed across 148 industries and 50,000 skills categories. The second and third phase focus on automating and scaling insights, and expanding joint research.

This methodology report describes the construction and validation of metrics on skills, industry employment, and talent migration in over 100 countries. This report has three objectives: (1) document the characteristics and coverage of LinkedIn data; (2) report the methods used to develop new metrics; and (3) showcase examples of policy questions that can be answered with this non-traditional data (figue 0-2). Because this is the first time that LinkedIn has shared a nontraditional dataset with a third-party organization globally as a public good (strictly unremunerated), it is important that we make these methodology and validation results available so that researchers and policy-makers can build on this initial effort by the WBG and LinkedIn.

The metrics generated from LinkedIn's data differ from traditional government indicators in important ways. As new development opportunities emerge, especially in the digital economy around the globe, WBG is seeking new data sources that can capture the latest development trends. Traditional government surveys often cannot keep up with this demand. Making LinkedIn real-time data available for development use, especially in developing countries, can be useful for policy-makers. For example, LinkedIn data can help answer pressing questions such as "What skills are gained or lost in association with talent migration in my country?" and "What are the most recent sectoral employment trends, and which skills are most relevant to them?" Nonetheless, because of the granularity and sheer amount of user-generated data, the industry and skills classifications that LinkedIn taxonomy uses are not standard and may not always conform to commonly used standards such as the International Standard Industrial Classification (ISIC); European Skills/Competences, Qualifications, and Occupations (ESCO); and the Occupational Information Network (O*NET). Part of the contribution of this methodology report is to match LinkedIn's taxonomies to these international standards to allow for easier matching of LinkedIn data with external datasets for further analysis. These efforts are central to the continued use of LinkedIn data as a valuable complement to traditional data sources.

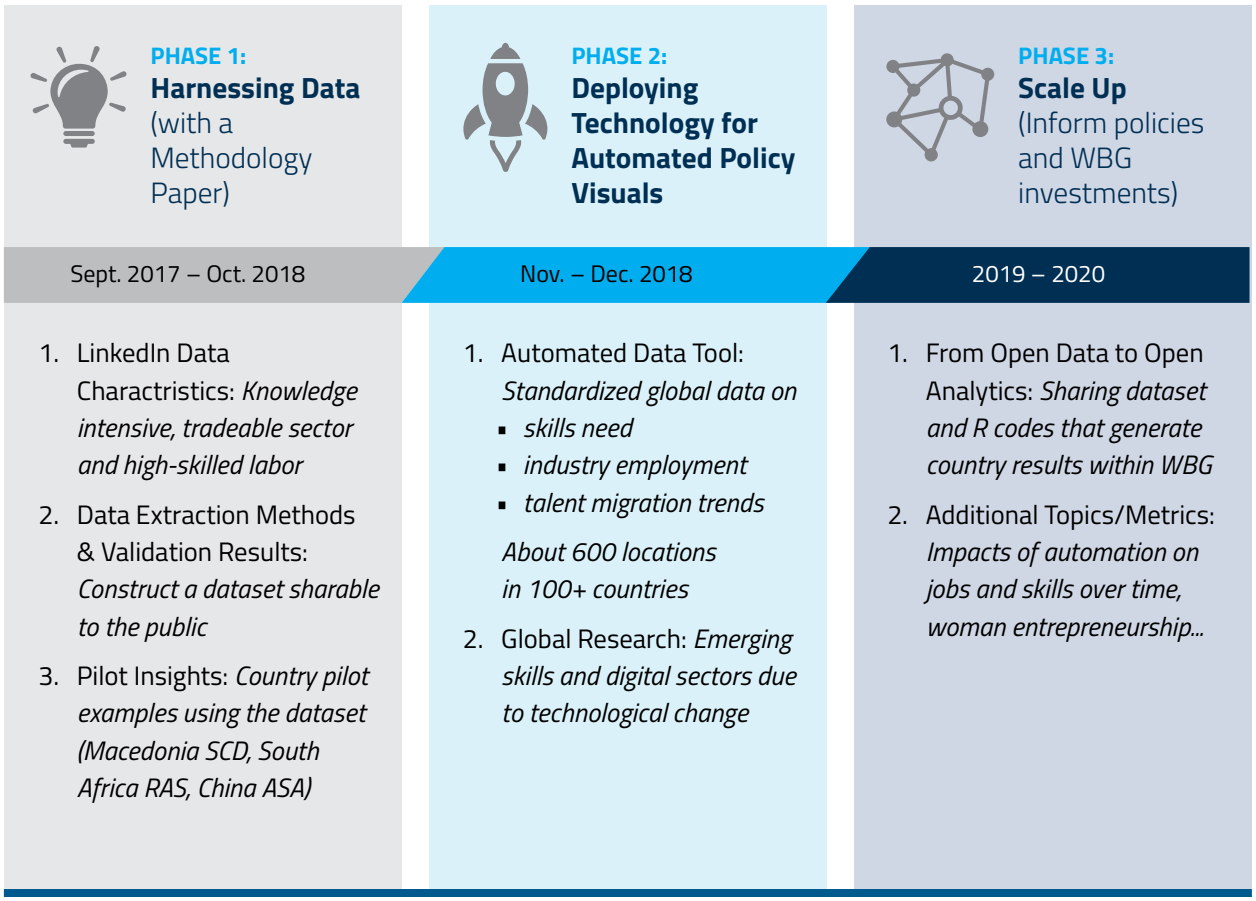
LinkedIn data are best at representing skilled labor in the knowledge-intensive, and tradable sectors. The LinkedIn metrics were compared and validated against 23 internationally standardized data sources on industry, skill, and migration trends.[1] Although LinkedIn may have better coverage in developed than developing countries, there are certain knowledge-intensive and tradable sectors, such as information and communication; professional, scientific, and technical activities; financial and business services; arts and entertainment; manufacturing; and mining and quarrying, that have good LinkedIn coverage globally (figure 0-3).[2] This allows for benchmarking of performance across locations globally in these six sectors.

1 See Table II-3 and Appendix E (Migration), Table II-2 (Skills), and Table III-1 (Industry Employment) for all the external data sources that the team evaluated

2 The strong LinkedIn coverage of the mining and quarrying sector is partially due to companies on LinkedIn incorrectly identifying themselves as oil and energy companies rather than as utilities and hence being misclassified in ISIC sector B instead of D. An example of this is EDF Energy in the United Kingdom. See section II-C-1 (Industry Coverage Globally). Manufacturing has significantly lower coverage, however it is a an important tradable sector for inclusion.

FIGURE 0-1:

World Bank Group (WBG)-LinkedIn Collaboration Schedule



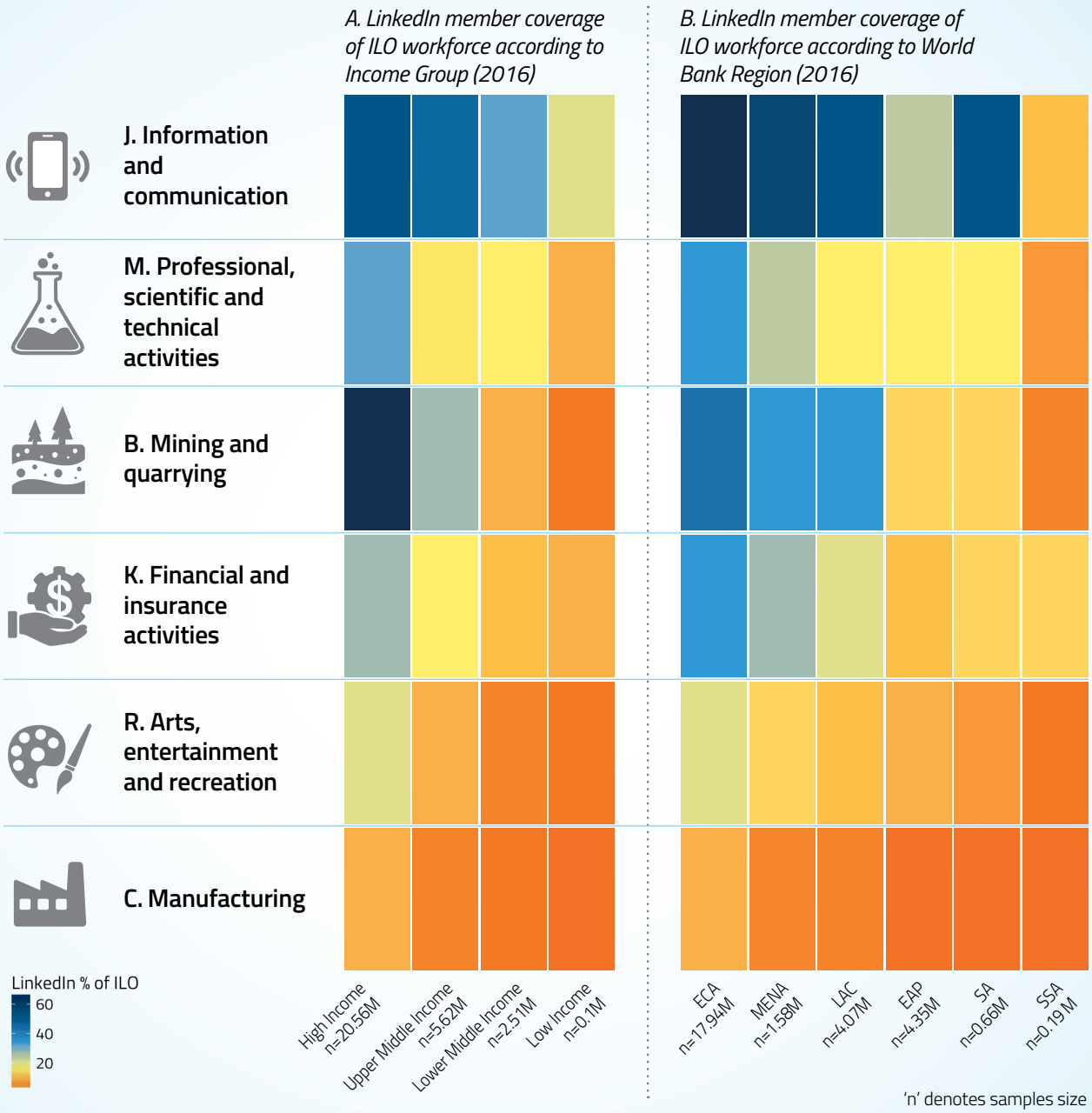
In addition to certain sectoral skewness, young, skilled individuals with at least a bachelor's degree are more likely than those with less education to be on LinkedIn, and women are more likely to be captured in LinkedIn than national statistics. In general, although LinkedIn data are not representative of the entire economy and are self-reported, they can uniquely capture segments of the economy that are among the most innovative, dynamic and high-value add. In addition, because these data are updated more frequently than traditional government statistics, they have the unique ability to capture the latest employment and industry skills needs, which government statistics often miss—especially in the digital and disruptive technology sectors. Industry employment, skills, and talent migration metrics comprise the first phase of this partnership (table 0-1).

FIGURE 0-2:

Three Objectives of this Methodology Report

FIGURE 0-3:

LinkedIn Industry Coverage According to (A) Income Group and (B) World Bank Region



Note: See Section III.C for more information on LinkedIn industry representativeness. Because of lower penetration rates of some sectors, the first phase of the World Bank Group-LinkedIn collaboration will share data only from the six knowledge-intensive and tradable sectors to ensure data quality and minimize risks of misinterpretation of the LinkedIn data due to small sample size; the remaining sectors not shows are: : L. Real estate activities; D. Electricity; gas, steam and air conditioning supply; N. Administrative and support service activities; P. Education; O. Public administration and defense; compulsory social security; S. Other service activities; Q. Human health and social work activities; H. Transportation and storage; G. Wholesale and retail trade; repair of motor vehicles and motorcycles; F. Construction; I. Accommodation and food service activities: A. Agriculture; forestry and fishing.

Source: Authors' calculation using LinkedIn and International Labor Organization (ILO) data in 92 countries

TABLE 0-1:

Summary of Metrics: Methodology and Validation Results

METRIC NAME	METHOD TO DERIVE THE METRICS[a]	CONFIDENCE LEVEL (REASONS)
1) Industry Employment		
Industry employment location quotient (LQ) Captures the employment size of an industry in a particular locale, relative to the same industry in other locales.	For a given country *c*, industry *i*, and time *t*, $Industry\ LQ_{c,i,t} = \frac{industry\ size_{c,i,t}}{average\ industry\ size\ of\ all\ countries\ in\ country\ c's\ income\ group_{i,t}}$ where with industry size measured as a relative term: $Industry\ size_{c,i,t} = \frac{member\ count_{c,i,t}}{member\ count_{c,t}}$	High (good global coverage, good validation results)
Industry employment growth[b] Captures the transitions among industries over time by LinkedIn members as a proxy for industry employment growth. Based on the industries declared by the companies in a member's work history.	Growth is given as rate of employment-level change (e.g., 2015-2017) for country *c* and industry *i*, $Industry\ growth_{c,i} = \frac{member\ count_{c,i,t+1} - member\ count_{c,i,t}}{member\ count_{c,i,t}} * 100$	Medium (good global coverage, good validation results but external data source covers only specific countries)
2) Skills		
Industry skills needs Captures the most-distinctive, most-represented skills of LinkedIn members working in a particular industry. Based on the skills section of the LinkedIn profile.	For each country, the weight ($w_{i,s}$) denotes how distinctive and representative each skill s is in industry *i* as: $w_{i,s} = m_{i,s} * \ln\left(\frac{N}{n_s}\right)$ with $m_{i,s}$ indicating the number of members in industry *i* having skill *s*, *N* the total number of industries, and n_s the total number of industries having skill *s*. The first term gives greater weight to skills that have high membership penetration, and the second term gives less weight to "common" skills that appear in all industries (e.g., Microsoft Office). In this sense, the most important skills for each industry are those that have high member penetration but are also unique.	Medium (good global coverage for knowledge-intensive and tradable sectors, good validation results but external data source covers only specific countries)

continues

TABLE 0-1: continued

Skill penetration Measures the time trend of a skill across all occupations within an industry. Based on skill addition rates, and the number of times a particular skill appears in the top 30 skills added across all of the occupations within an industry.	There are four steps to compute skill penetration: 1. Use the industry skills needs framework above to calculate the weight for each skill *s* for each occupation *o* in industry *i*: $$w_{i,o,s} = m_{i,o,s} * \ln\left(\frac{N}{n_s}\right)$$ 2. Construct a list of the 30 top represented skills for each occupation *o* in industry *i*, based on the values of $w_{i,o,s}$: $$[(s_1, w_1), (s_2, w_2) \cdots, (s_{30}, w_{30})]$$ 3. Calculate the skill group penetration rate at the occupation-industry level $p_{i,o,S}$ by counting the number of skills *s* belonging to each skill group S and dividing by 30: $$p_{i,o,S} = \frac{\sum_{s=1}^{30} s \in S}{30}$$ 4. Get the average skill group S penetration rate $p_{i,S}$ across all occupations *o* for the industry *i*: $$\bar{p}_{i,S} = \frac{\sum_{o=1}^{n} p_{i,o,S}}{n_i}$$	Medium (good global coverage for knowledge-intensive and tradable sectors, good validation results but external data source covers only specific countries)
3) Talent migration		
Inter- and intra-country talent migration Based on user-reported location. When a user's updated job location is different from their former location, LinkedIn recognizes this as a physical migration.	Given as net migration, with country *a* the country of interest, and country *b* the source of inflows or destination of outflows, at time *t*, $$Net\ migration_{a,b,t} = \frac{net\ flows_{a,b,t}}{member\ count_{a,t}} * 10{,}000$$ (net flows = arrivals – departures)	High (good global coverage for knowledge-intensive and tradable sectors, good validation results)
Migration – industries gained and lost Based on the industry associated with a member's company at the time of migration.	Given as net migration, with country *a* the country of interest and country *b* the source of inflows or destination of outflows, both considered for a given industry *i* at time *t*, $$Net\ industry\ migration_{a,b,i,,t} = \frac{net\ industry\ flows_{a,b,i,,t}}{member\ industry\ count_{a,i,t}}$$ (This formula is used to calculate the top gaining and losing industries associated with talent migration flows.)	Low (good global migration data for knowledge-intensive and tradable sectors, but migration industry movements have no comparable global external data for validation)

continues

Migration – skills gained and lost Based on the skills associated with a member's profile at the time of migration.	Given as net migration, with country *a* the country of interest and country *b* the source of inflows or destination of outflows, both considered for a given skill *s*, at time *t*, $$Net\ skill\ migration_{a_s,b_s,t} = \frac{net\ skill\ flows_{a_s,b_s,t}}{member\ skill\ count_{a_s,t}}$$ (This formula is used to calculate the top gaining and losing skills associated with talent migration flows.)	Low (good global migration data for knowledge-intensive and tradable sectors, but skills migration has no comparable global external data for validation)

Notes: Confidence level is evaluated against two criteria: 1) *global coverage* (High: good for global, Medium: good only for certain sectors, Low: limited coverage at the moment but expected to improve over time as LinkedIn membership grows and diversifies, and hence worth including in the dataset and dashboard) and 2) *validation results against other independent data sources* (High: highly positively correlated with various government or international organization data sources, Medium: highly positively correlated with one other source that has data on a specific region or country only, Low: the project team was unable to find a comparable dataset for validation). This last point also demonstrates the value of LinkedIn data in that they expand the information available on the topic and can be complementary to traditional survey or administrative data and low confidence level is not a reflection of the quality of the metric.

a All metrics at the city level were calculated in the same manner as at the country level, except for Industry location quotient, because we did not have city-level income for calculation; instead we used country average for the denominator—how a city compares with its own country average.

b Because of rapid LinkedIn membership growth around the globe, the team constructed the balanced panel data to isolate LinkedIn membership growth from industry employment growth, so the growth rate captured here is an employment transition rate for experienced employees who report jobs on the LinkedIn platform across years. For details, see Section IV-A-2.

To protect user privacy and permit comparability of metrics, LinkedIn metrics are normalized. Because user behavior is different in different countries (e.g., overreporting of work experience; not updating profile if unemployed; LinkedIn membership growing exponentially in developing countries and hence the data potentially capturing LinkedIn business growth instead of industry headcount growth), in addition to validating against other data sources, we used statistical methods to normalize and standardize metrics to ensure they can be compared fairly across countries and industries. For example, we normalized most metrics according to LinkedIn membership size in each country so that countries with more workers on LinkedIn did not artificially rank higher.

Based on feedback from three World Bank Group pilot projects in South Africa, Macedonia, and China, sample policy questions that LinkedIn metrics can answer are listed in table 0-2. In addition to determining descriptive trends, another useful application of the LinkedIn metrics is to triangulate across the three categories of metrics. For example, to nurture certain growing industries, one can further explore what skills are needed or whether there is a risk of talent outflow. Furthermore, to conduct analytical and empirical research, the datasets are structured so they can be easily merged with external data sources. For instance, because all the LinkedIn data on industries made available through this partnership are equivalent to the two- to three-digit ISIC level, and the project team has mapped these LinkedIn industry classifications against ISIC 4 standards, merging industry employment and skills needs data with data from economic censuses, such as wage and productivity data, can help in understanding private sector growth and the productivity and human capital components that drive that growth.

TABLE 0-2:

Sample Policy Questions Using LinkedIn Metrics

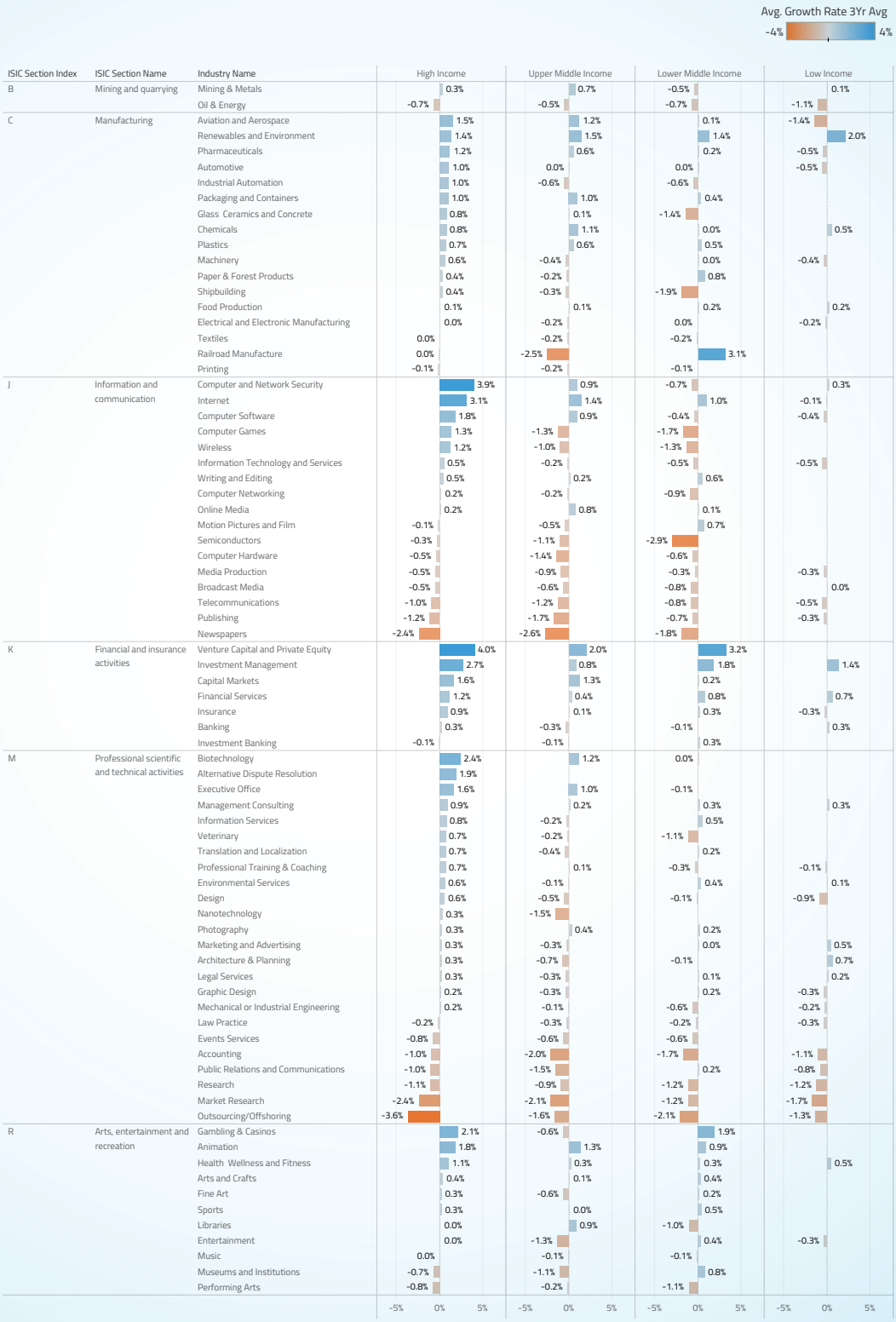
METRIC NAME	SAMPLE POLICY QUESTIONS
1) Industry employment	
Industry employment location quotient	Which industries are more concentrated in my country or city than in an average country in the same income group?
Industry employment growth	What are the most recent employment growth trends in my country or city, especially in knowledge-intensive and tradable sectors?
2) Skills	
Industry skills needs	For the industries I am interested in, what are the latest, most important skills?
Skill penetration	Are particular skills (e.g. Artificial Intelligence) being applied across industries ? How is this changing over time?
3) Talent migration	
Inter- and intra-country talent migration	Am I (net) losing talent? With which countries do I compete for talent?
Migration – industries gained and lost	To which industries are these talents moving?
Migration – skills gained and lost	What skills are gained or lost in association with talent migration?

To further demonstrate how the above metrics can be used to inform policies for World Bank projects, we provide some sample visuals in this report. One is the top growing and declining sectors globally in 100+ countries (figure 0-4). Emerging sectors, such as renewables and environment and Internet have registered rapid employment growth in the past three years, whereas newspaper and outsourcing are in decline in countries in all income groups. This type of insight can be generalized across World Bank regions or specified to a particular country as well (see Section V: Sample Visual Outputs and Country Applications).

FIGURE 0-4:

Growth from Industry Transitions according to Income Group

Annual Average 2015-2017



Note: Industries where N<5 countries are removed

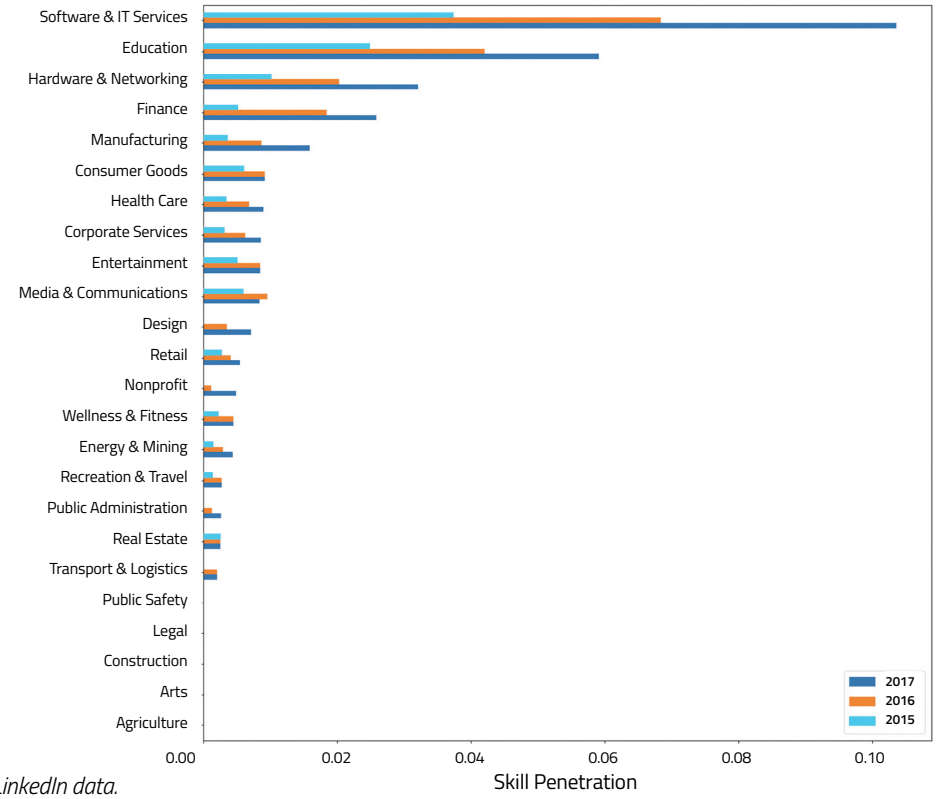
Source: Authors' calculation using LinkedIn data.

Another value that the LinkedIn metrics add is in the emerging skills and industries that official statistics often do not capture. LinkedIn's skill metrics allow the World Bank Group to measure how new technologies—such as artificial intelligence—are spreading across industries and changing labor markets around the globe. For example, artificial intelligence skills are among the fastest-growing skills on LinkedIn, with a 190% increase from 2015 to 2017 across all industries (figure 0-5).

The current round of technological advancement (aka Industry 4.0) seems more pervasive than the previous rounds and is being transmitted to developing countries more quickly. Around the globe, disruptive technology skills have appeared in many developing countries in the past three years, although typically "human" skills (e.g., those related to sociobehavioral characteristics, interpersonal communication, and cognitive skills) are also on the rise (figure 0-6).

FIGURE 0-5:

Global Artificial Intelligence Skill Penetration 2015-2017



Source: Authors' calculation using LinkedIn data.

FIGURE 0-6:

Skills with the Largest Increase in Penetration Across Industries 2015-2017

1. **Leadership**
2. **Development Tools**
3. **Oral Communication**
4. **Web Development**
5. **Business Management**
6. **Digital Literacy**
7. **People Management**
8. **Data Science**
9. **Graphic Design**
10. **People Management**

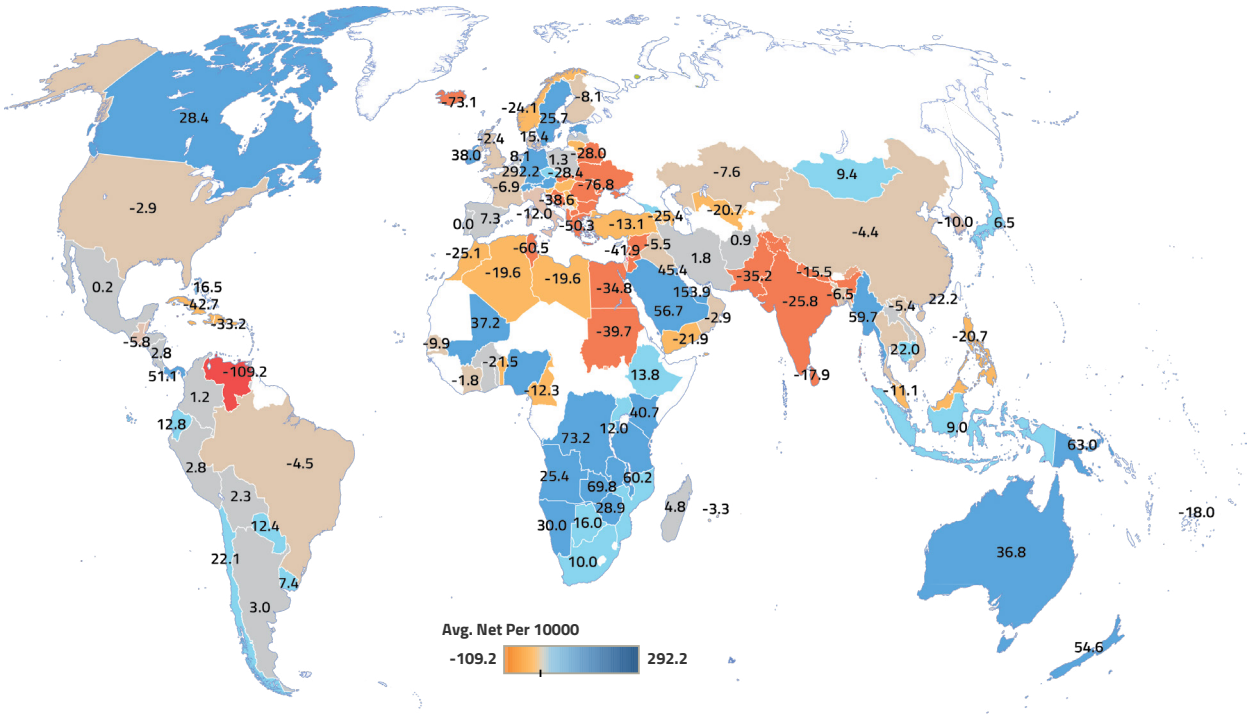
Source: Authors' calculation using LinkedIn data.

Near-real-time global talent migration trends can also be captured through LinkedIn data to allow developing country policy-makers to assess the health of their countries' talent pipelines. The Middle East and North Africa, Latin America and the Caribbean, and South Asia have seen the greatest talent loss in recent years, whereas Organization for Economic Cooperation and Development (OECD) countries such as Australia, New Zealand, and Canada are attracting the most talent (figure 0-7).

All the visuals will be automated and updated annually[3] until June 2020 under this three-year WBG-LinkedIn partnership on linkedindata.worldbank.org. The underlying dataset, as well as other resources that are helpful for policy-makers around the world, will also be updated and made available for free at the same URL as a public good.[4] Subject to demand and user feedback, more metrics may be added later.

FIGURE 0-7:

Global Talent Migration 2015-2017



Source: Authors' calculation using LinkedIn data.

3 There will be a minimum of an annual refresh by LinkedIn. The online visuals can be updated more frequently if there is strong user demand

4 The aggregated datasets and visuals are available to all for the public good under the Creative Commons Attribution 3.0 IGO license with attribution to both LinkedIn Corporation and the World Bank Group. The World Bank Group and LinkedIn Corporation (including its affiliates) do not take responsibility and are not liable for any damage caused through use of data and insights through this website, including any indirect, special, incidental or consequential damages.

I. Introduction

The objectives of this methodology report are to document LinkedIn data characteristics worldwide in terms of age, sex, industry, and skills distribution; the methodology and assumptions that go into developing the LinkedIn datasets that LinkedIn Corporation shares with the World Bank Group and our best attempt to compare these LinkedIn metrics with other government administrative and survey data; and sample analytical and visual examples using these metrics to answer policy questions related to industry growth, skills gaps, and talent attraction and retention.

A. USING ONLINE DATA FOR POLICY RESEARCH

There has been considerable research interest in the use of web-based data for economic analysis in recent years (Antenucci et al. 2014; Askitas and Zimmermann 2009, 2015; Chancellor and Counts 2018; Kuhn and Mansour 2014; Guerrero and Lopez, 2017; Tambe 2014). In particular the reports by Tambe (2014) and Antenucci et al. (2014) consider labor markets and how online data-driven research may facilitate policy-making and correlate with "on-the-ground" indicators. In general, research in this field has been focusing on extracting a limited number of metrics in selected countries to answer specific research questions. This WBG-LinkedIn dashboard and the underlying dataset cover hundreds of locations worldwide and allow for benchmarking for policy-makers.

Data projects of this nature are often referred to as labor market information based, and their value depends heavily on the type and availability of the data. A handful of private companies and organizations have pursued ambitious domestic and limited global projects, primarily from the U.S. perspective. Groups pursuing these projects, including Burning Glass, Wanted Analytics, Glassdoor, and Career Builder, rely unsurprisingly often on web-based data. These organizations primarily aggregate various sources of online data on employment. Glassdoor and Career Builder are online companies with their own proprietary job posting data that have acquired external economic research arms or created inhouse research teams to analyze the data. In other cases, private firms share data with international organizations to analyze job postings, such as a recent World Bank report on job postings in India (Nomura et al. 2018).

The richness of LinkedIn data, which cover a range of topics from skills to migration and are available on a granular level, arguably exceeds that of data from the above projects. Furthermore, the initiatives mentioned above have relied almost solely on job posting data, whereas LinkedIn takes advantage of detailed member profiles in addition to job postings and hires. A 2016 RTI International publication discusses the above projects and defines general limitations of labor market information according to timeliness of data, accuracy of surveys and questionnaires, capacity to conduct analysis, integration of various data sources, use by nongovernment agencies (accessibility to data), and cost of acquiring data (Johnson 2016). The LinkedIn data and the joint WBG-LinkedIn collaboration address each of these limitations. As will be discussed in detail in this report, LinkedIn data allow for near-real-time updates. Furthermore, LinkedIn facilitates comparisons between countries (or cities or regions) by having a single data structure and taxonomy. Finally, the aim of the collaboration is to offer a public good in the form of a transparent, publicly accessible dashboard presenting insights in addition to the underlying datasets.

The rising use of online data to answer far-ranging societal questions in a wide array of disciplines not only comes with tremendous insights (Boyd and Crawford, 2012), but also marks a shift in quantitative and qualitative analysis. Tufekci (2014) describes this shift and calls for a close inspection of this dramatic change in how we analyze data and the methodologies and interpretations and interpretations we use. That report primarily addresses concerns about bias found in online data from a single social network or platform (e.g., Twitter). Similarly, when using LinkedIn data, with one structure and platform used to derive insights, one must

openly address and measure the inherent bias found in the user base and interaction between users and the platform. Other research on the use of online data calls into question the use of traditional statistical techniques, in which statistical significance (for example) may be inapplicable to the huge datasets that are built using online data (Gandomi et al. 2015). The authors address concerns about data heterogeneity, noise accumulation, and spurious correlation. LinkedIn metrics and validation exercises presented in this report occur at country *aggregate* levels. Thus, although concerns about excessively large samples for correlation (dimensionality) are not major concerns, attention should be paid to concerns about heterogeneity arising from many individual members and noise accumulation. Another report on the use of online data for health care warns of identifying patterns where none exist because of the complex nature of data connections (European Commission Directorate General for Health and Consumers 2014).

LinkedIn data meet the online data description above and exceed it on a variety of levels. LinkedIn data not only allow for comparison of diverse geographic regions (100+ countries and hundreds of cities) in the form of one unified structure and comparable data points, but are also updated in real time by members. The importance of frequently updated data is emphasized in a report by Aslett and Abott (2018) stating that the "time value of data is a significant driver for Pervasive Intelligence." In this sense, LinkedIn offers an unconventional source of labor market data in that it describes the latest employment and skills trends as motivated by real-time observations of labor market outcomes and user behavior. More precisely, all data are provided voluntarily and from the perspective of what the labor force views as most relevant. As with all data collection methodologies, various questions arise. Can user-generated inputs be trusted? Can they be aggregated in a meaningful way? Can a relevant and applicable economic message be derived from the noise? Although unique, are LinkedIn insights in line with trusted measures of the labor market? These are important questions, vital for identifying where LinkedIn data can be most valuable and how they should be positioned to have the greatest effect on policy decisions. It is the purpose of this report to address these unknowns and to better understand the data strengths and limitations, hence informing interpretation of results.

B. QUALITY CONTROL AND LIMITATIONS OF LINKEDIN DATA

Before analyzing bias, we impose a number of basic rules on the data. First, spam and other inactive profiles are removed from the sample so that it includes only active LinkedIn members.[5] Second, each dataset is filtered to display an aggregated number with at least 50 observations per the most granular data-point. For example, for a given skill in a given industry and city to be displayed in the dataset, at least 50 members must have reported the skill in their LinkedIn profile. This rule is consistent across all datasets and is imposed to ensure the accuracy and privacy of user data. Such procedures are increasingly important in online data and are referred to as "data forensics" in a report on use of online data in economics (Horton et al. 2015). In the industry employment-related metrics, instead of using a member's self-reported industry, we use the company that the member worked for and the industry that the company reported that it belonged to on LinkedIn. This dramatically shrinks the sample size because not every company has a profile on LinkedIn and reports which industry it belongs to. Nonetheless, using this filter helps increase the accuracy of industry employment data because members can have different understandings of which industry the company is in based on their position, experience, and daily work routine.

After these rules are imposed, the remaining sources of bias and limitations of LinkedIn data come from different LinkedIn usage and uptake in different countries, industry bias, and occupation bias. The first bias—regarding differences in LinkedIn usage—is generally addressed by normalizing against total country LinkedIn membership or other totals or averages. Nonetheless, varied usage patterns may take other forms, such as differences in propensity to include skills or share work experience between cultures and regions[6] see section II-C. Finally, the third bias regarding occupations adds an additional layer to the two previously discussed. Given a defined industry bias, the type of occupation most represented on LinkedIn in each industry in a country may be biased itself. Occupational bias on LinkedIn drives some industry bias, when, for example, an industry such as financial services is composed mostly of white collar managers and analysts—occupations that are well represented on LinkedIn—whereas in the agriculture sector, managers, analysts, and economists make up a smaller portion of the occupational pool, resulting

5 Individuals who had logged in within the past 12 months and had the basic section filled out, such as skills, work history, and education.

6 To decrease bias due to different usage patterns in different countries, especially if certain cultures, race, or sexes tend to over- or underreport their job duties and experience, we include standardized taxonomy on job titles and skills, school and degree names, and company-reported industries for this dataset instead of trying to infer members' work and education experience from their profiles' detailed descriptions.

in low LinkedIn representation of this sector (on average) and capturing only a segment of the workforce in the sector. A strength emerges in that LinkedIn offers strong representation in various industries for given occupations, for example, ICT workers working in various industries, not just in the information and technology industry.[7]

An additional dimension of bias regards skills and how information on them is extracted from member profiles on LinkedIn. This analysis uses only self-reported skills data, and these skills listed in profiles are included because the member wants to be considered for a certain position. This raises a question of when skills are added, because members may include skills during initial completion of their profile and fail to update them as they move to different locations and positions. Finally, a user may have multiple skills, so measures must be given as relative values, and the number of total skills (including skills in a given skill category) may not be representative of a given number of individuals, because individuals can list multiple skills.

In sum, LinkedIn is self-reported and subject to typical challenges with this type of data: it is a nonrandom sample of LinkedIn members (people familiar with the Internet who have basic digital literacy will be more likely to use LinkedIn); people who want to network and promote themselves professionally are more likely to have a LinkedIn profile and keep the profile updated; those who have just lost their jobs are unlikely to update their LinkedIn profile saying they are unemployed; and members might inflate their skills or present them differently in different cultures and sexes (e.g., women tend to have shorter job descriptions). We deployed different strategies to address these problems when deriving the methodology for metrics from LinkedIn's raw data, and we show the advantages and disadvantages of each methodology and explain why we chose one over another. It is important that researchers keep in mind these limitations when they interpret results using LinkedIn data.

7 These relationships should be regarded as hypothetical until a systematic validation of occupations is conducted in future research.

C. INNOVATIVE APPLICATIONS OF LINKEDIN DATA

LinkedIn may not only complement existing labor force data, but also take the lead in measuring factors essential to today's economic landscape, such as the digital economy, rising automation, and job displacement. Because of LinkedIn's unique strength in tracking emerging skills and digital technology–enabled jobs, the platform is well suited to measure emerging trends in important skills and job composition in specific industries due to automation (and can potentially be expanded to measure the effect of other disruptive technologies). Some of the analytical visuals in Section V provide examples of this.

D. OVERVIEW OF WBG-LINKEDIN PARTNERSHIP AND DATA UPDATE PLAN

The WBG-LinkedIn partnership contributes to a wider WBG initiative using digital platform data (private and public) to improve the WBG's understanding of market efficiency, social inclusiveness, and environmental sustainability. These objectives are supported through strategic partnerships such as with leaders in digital tourism, use of blockchain technology in global value chains, and digital skills and sector development. The LinkedIn collaboration addresses the last of the three research objective tiers with a focus on the digital economy and skill trends. By leveraging the WBG's institutional knowledge and expertise, LinkedIn data can generate insights into pressing economic challenges that can be acted on in the rapidly changing economic landscape.

This is the first year of a three-year memorandum of understanding signed between the WBG and LinkedIn Corporation. When more derived metrics on other topics of interest become available, they will be added, and the validation results will be updated in this report, as will validation results for the existing metrics, subject to demand. As we gain access to more comparable global datasets on areas related to skills, industry employment, and migration for validation, we will continue to improve this report. In sum, we intend this document to track our latest efforts in extracting, cleaning, and validating LinkedIn metrics for development use.

The three categories of derived metrics in this first phase of collaboration focus on industry employment, skills needs, and talent migration trends. The selection of these three categories is based on feedback from World Bank pilot projects in South Africa and Macedonia on which derived metrics are most relevant for policy-makers; the feasibility of extracting, cleaning, and validating metrics, especially as to whether a globally harmonized dataset from other sources is readily available to conduct validation; and applicability in multiple locations (e.g., if a specific metric is good for only certain regions or income groups, it receives less priority in the first phase). Sensitivity of the metrics, especially those that might have implications for ethics and privacy, is also considered.

All derived metrics are reported at the city or country level and cover hundreds of worldwide locations in 100+ countries with at least 100,000 LinkedIn members (see Appendix B).[8] We used LinkedIn member profile information on education, work experience, and skills over time to construct these datasets. It is envisaged that this dataset will keep improving and will be updated at least annually from 2018 to 2020 as a trial collaboration between the WBG and LinkedIn. Historical data from 2015 to 2017, from which the validation results here are drawn, will be made available as well.[9]

The remainder of the document is structured as follows. Section II reviews the data sources and data merging methods. Section III provides an analysis of LinkedIn data distribution according to age, sex, and industry. Section IV presents validation results for the methods used to derive metrics related to industry employment, talent migration, and skills. Section V discusses how these metrics were applied to World Bank country pilot projects, the assumptions behind the visuals, and sample analytical visuals.

8 Based on our pilot experience in South Africa, a sample size of 100,000 is close to the threshold of having reliable derived metrics because, for certain metrics (e.g., industry employment growth), the sample size might drop dramatically if there are not enough entries into and exits from industries that these 100,000+ members record.

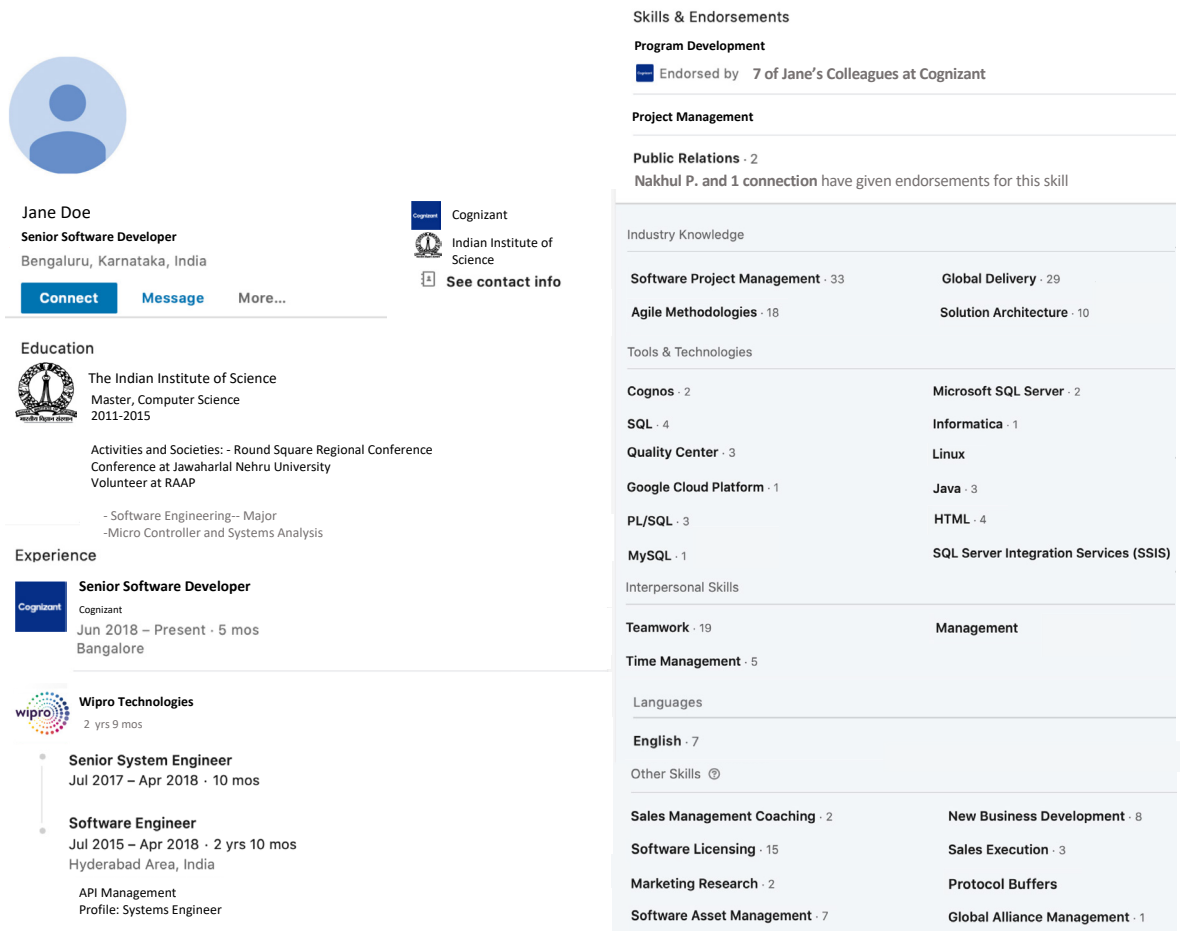
9 Historical LinkedIn data are less reliable and representative globally because they depend heavily on whether members can recall their work history accurately.

II. Data Sources

As described above, the advantage of this LinkedIn dataset is that it is near real time and is granular, with 148 industries, 50,000 detailed skills categories, and global coverage of 100+ countries and hundreds of cities, drawing from a user base of 560 million LinkedIn members worldwide. Each data point is acquired from anonymized LinkedIn member profiles. A sample LinkedIn profile is shown in figure II-1, with the individuals' company and industry of employment, location, work and education history, and self-reported skills extracted and aggregated for analysis.

FIGURE II-1:

Sample LinkedIn Profile



In addition, new members are joining LinkedIn at a rate of roughly two per second, and membership is growing exponentially in developing countries. More than 46 million students and recent college graduates are on LinkedIn as well. More than 70 percent of LinkedIn members are outside the United States, using the platform in 24 languages, and LinkedIn data science teams are merging and standardizing taxonomies and languages into a single coherent dataset.

This WBG-LinkedIn dataset makes heavy use of a member's curriculum vitae. Members list their education and employment history in the Education and Experience sections of their profile, including current and previous positions. For example, when members add work experience to their profiles, some of the primary inputs include job title, employer, and the dates they were employed, which are captured and standardized. Furthermore, members are motivated to include their skill set and location in their profile. It is through this profile structure that key variables for insights and analysis are extracted.[10] The project team then looks for similar metrics that other sources collect, such as government administrative and survey data and other nontraditional sources, such as Google trends and job posting data—because globally comparable data at such a granular scale are rare—to determine whether these metrics contain genuine, strong signals of the markets. The section below describes the data sources used for validation.

A. AGE AND SEX

LinkedIn data have member count totals according to sex and age for 126 countries from 2016. Explicit information on sex and age is unavailable on the LinkedIn platform, so the data are deduced from member profiles (e.g., male or female name, first year of full-time experience after graduation from college). Data on these variables therefore do not reflect total LinkedIn membership (because not every member provides complete profile information).

International Labor Organization (ILO) labor force age and sex data are downloaded[11] from their database—ILOSTAT. The data's country count varies according to reference year. Country selection for matching with LinkedIn data is discussed in Appendix A, Section 1.

B. INDUSTRY EMPLOYMENT SIZE

LinkedIn industry data have industry member count for 148 industries (roughly mappable to the ISIC two-digit level) for 100+ countries with at least 100,000 members. As described, industry is derived from the referenced company's name in a user's profile and the industry this company belongs to (figure II-2).

ILO data on industry are taken from the ILO Database of Labor Statistics—Employment by sex and economic activity.[12] Based on definitions from ISIC 4, ILO data are provided at the ISIC one-digit level for 92 countries. ILO data from 2014, 2015, and 2016 are used because not all countries have data updated annually;[13] data continuity and harmonization are maximized because there were no changes to survey methodology or definitions. The matching framework for these two datasets is given in Appendix A, Section 2.

10 **Job title:** Members are required to include a job title for each position listed on their profile. LinkedIn standardizes this information by mapping these member inputs against a comprehensive taxonomy of more than 22,000 job titles that can be further aggregated based on job occupation or function. **Occupation or function:** Job functions provide broad groupings of common job roles based on the title the member inputs. The classification of the job title in LinkedIn's title taxonomy determines the function a member performs in his or her job. **Industry:** Members indicate the name of their employer for each position on their profile, which LinkedIn then maps to a standardized company entity. The classification of the company in LinkedIn's taxonomy of industries determines the industry in which a member works. **Skill acquisition:** Members indicate their expertise in the skills section of their profile. LinkedIn clusters the tens of thousands of individual skills that members choose to display on their profile into categories for analysis. **Migration:** We determine a LinkedIn member's location according to the location they indicate in their profile summary. When this location changes, we measure that change as a migration.

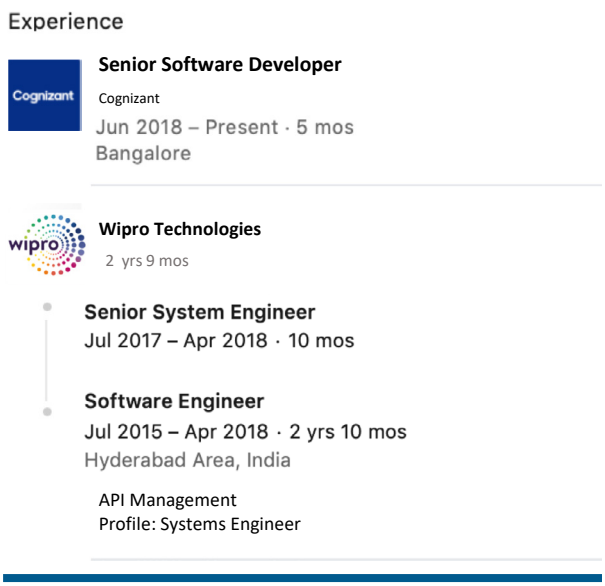
11 ILO Labour Force Age and Sex data downloaded from: **http://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=EAP&indicator=EAP_TEAP_SEX_AGE_NB&datasetCode=A&collectionCode=YI&_afrLoop=729967134259350&_afrWindowMode=0&_afrWindowId=jszc0tnev_1#!%40%40%3Findicator%3DEAP_TEAP_SEX_AGE_NB%26_afrWindowId%3Djszc0tnev_1%26subject%3DEAP%26_afrLoop%3D729967134259350%26datasetCode%3DA%26collectionCode%3DYI%26_afrWindowMode%3D0%26_adf.ctrl-state%3Djszc0tnev_45**

12 The ILO industry database was downloaded from: **http://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?indicator=EMP_TEMP_SEX_ECO_NB&subject=EMP&datasetCode=A&collectionCode=YI&_adf.ctrl-state=42zyhjcu2_45&_afrLoop=2107626251049 69&_afrWindowMode=0&_afrWindowId=42zyhjcu2_1#**

13 For example, EU countries are required to provide updated labor force survey data for at least one quarter annually.

FIGURE II-2:

Sample LinkedIn Profile Work Experience



C. INDUSTRY EMPLOYMENT GROWTH

LinkedIn industry growth data are calculated by LinkedIn panel data between 2014 and 2017. We capture new industry hires and losses by counting active LinkedIn members (who have logged in at least once in the past year) who move from one industry to another (experienced hires). We use a separate dataset to capture whether recent graduates are entering the market and finding jobs in an industry (table II-1). Because of the characteristics of LinkedIn data, multiple approaches were tried in building an industry employment growth dataset for analysis, and the single-position LinkedIn panel data approach was adopted. The advantages and disadvantages of each approach are outlined in table II-1.

Two external data sources are used in industry employment growth validation. First, ILO data are taken from the dataset described previously in the industry employment size data source section. Second, LinkedIn industry growth is compared with monthly employment according to industry in the United States from the Bureau of Labor Statistics (BLS);[14] BLS data are given as non-seasonally adjusted monthly industry employment count between 2015 and April 2018 to match with the LinkedIn dataset that the team constructed. A detailed data-matching framework of the two datasets can be found in Appendix A, Section 3.

D. SKILLS

LinkedIn is able to provide skills data at a very granular level (and for each industry in a given country or city). As with all the metrics, a constraint is imposed on extracting data; to protect member privacy and ensure that the results are not biased because of small sample size, a cell is reported with a value only if it does not fall below 50 observations for a particular self-reported skill.[15] Members may have more than one associated skill in their profile (figure II-3).[16]

A variety of sources are used in validating LinkedIn skills data, even though there are no comparable global skills data at such a granular scale as LinkedIn captures (table II-2). The team hence tried some other nontraditional sources such as Google Trends, Job Posting on LinkedIn, and European Center for the Development of Vocational Training Panorama skills data for validation.[17] In addition, the derived skill metrics (e.g., most-important skills for each industry presented in section IV-B) were validated against proxy indices such as, information and communications technology (ICT) skill rankings (Program for the International Assessment of Adult Competencies (PIAAC), and ICT development indices.[18] The dataset matching method can be found Appendix A, Section 4.

14 BLS Current Employment Statistics downloaded from **https://data.bls.gov/PDQWeb/ce**

15 LinkedIn records skills in three places: self-reported in the skills section of the profile, text in other sections of the LinkedIn profile extracted using a skill-tagger, and inferred from all member data (e.g., their network). We used self-reported skills only from the skills section in our analyses because this is a basic source that does not use additional predictive models, although it has its own limitations.

16 A skill is not necessarily associated with a particular industry, which allows for a larger data sample if for any reason a member is not associated with a classifiable industry.

17 Panorama data, given for 2016, offer skills data for 28 European countries. Countries vary in number of observations available, but each country offers data on identical skills, facilitating cross-country comparison. The data are based on a survey of employed individuals, online or over the telephone. (**http://skillspanorama.cedefop.europa.eu/en**)

18 Value add data are from the OECD (**https://data.oecd.org/natincome/value-added-by-activity.htm**)

TABLE II-1:

LinkedIn Industry Employment Growth Data Extraction Methods

APPROACH	ADVANTAGES	DISADVANTAGES	TEAM DECISION ON THIS APPROACH
Single-position LinkedIn panel data	Given as a balanced panel for a given set of members over time, with each member associated with one position and industry in each year.	Concerns over selecting "main"[a] position but no significantly better result than with multiple-position LinkedIn dataset.	This balanced-panel dataset was used for validation and analysis in the end. In U.S. industry employment growth validation, this dataset takes the form of monthly observations between 2015 and early 2018 for comparison with U.S. Bureau of Labor Statistics data. Strong correlations were found between LinkedIn and Bureau of Labor Statistics data, especially for high-penetration-rate sectors. Detailed findings are discussed in section IV.A.2 of this report.
Multiple-position LinkedIn panel data[b]	Captures more than one active position of a member.	By capturing multiple positions for a member in a single year, the dataset takes on the structure of a weakly balanced panel, meaning that there are one or more observations per member per year.	The dataset did not achieve better results than the single-position LinkedIn panel dataset, and it is likely that inclusion of multiple positions added noise.
Recent graduate LinkedIn data[c]	Captures recent graduates (new additions to workforce).	Data are given as annual cross-sections, giving only the number of graduates moving to work positions in an industry, as well as total number of graduates for that year.	This dataset provides a glimpse of an important source of industry employment growth; new entrants and recent graduates are treated as a different group for analysis from the single-position balanced panel, which provides data on experienced hires.
Employment transitions LinkedIn data[d]	Dataset filters only industry movements across years, eliminating bias associated with new members signing up.	Membership is not held constant throughout years, meaning that bias due to LinkedIn membership growth is not accounted for.	Because this dataset had greater biases than the single-position balanced panel, it was not used.

a Because a member can list several positions at the same time (e.g., volunteer service), "main" position is defined as the highest level at which a position has been held or the longest time a position has been held. If a member has held multiple positions at the same level, the one added first is selected as the "main" position.

b LinkedIn members with at least one active position in December of 2014, 2015, 2016, and 2017 are included in this dataset, which means that the dataset has information on the same sample of members for the four years. At the same time, all members on the platform are considered, including those who listed internship positions, for example. Members can list one or more active positions at each point in time, and in the multiple-position panel dataset, we allow each LinkedIn member to be associated with one or more positions each year. This makes the dataset a weakly balanced panel, with one or more observations per member per year.

c The dataset includes data only on recently graduated LinkedIn members. Each member's highest level of education is identified, as well as the year of graduation. Individuals are counted in the dataset if they have moved to a job (for which an industry can be identified) within one year of graduation.

d Transitions dataset identifies only member movements in and out of industries, not holding a constant set of members over the years (unlike panel sets), and hence can capture LinkedIn membership growth (e.g., when a new member is registered in this dataset, we cannot determine whether this is a genuine new entry or a member who was already working in the industry but is signing up on LinkedIn for the first time, and hence we register growth.

TABLE II-2:

Summary of External Datasets Considered for Skills Metrics Validation Exercises

DATASET	ADVANTAGES	DISADVANTAGES	TEAM DECISION
World Bank I2D2 International Income Distribution Data Set data[a]	Allows for comparison of occupation and industry distribution between countries; particularly useful in industry employment and occupation validation.	Limited number of countries available with industry and occupational data (e.g., 8 countries in 2015, 3 in 2016, 0 in 2017).	International Income Distribution Data Set data are unusable in LinkedIn comparison over desired years because of extremely limited country observations.
World Bank STEP (Skills Measurement Program) data[b]	Provides composition of skills on country level in 17 countries; derived from household and employer surveys.	STEP and LinkedIn have different skill[c] definitions and concepts, which does not allow for comparison.	Data were not pursued further because of poor matching of skills measures and definitions between sources.
Europe Skills Panorama (CEDEFOP)[d]	Provides skill data for 28 European countries. Skills are given in 11 categories.[e] Data are derived from surveys for large working population sample.	Imprecise mapping of LinkedIn skills to Panorama categories. Specifically, LinkedIn has several hundred skills matching to the CEDEFOP technical skills category but only a few for team work, which results in small sample size and variation in this category.	Skill mapping differences between the two sources led to counterintuitive results. Limited observations (28 per skill) also led the team not to pursue the data further.
Google Trends Data[f]	Allows for comparison of skill flows over time, serving as a good source of matching with the wide variety and specificity of LinkedIn skills and skill categories.	Difficulties comparing countries because of language barriers (LinkedIn has unified conversion to English, not true for Google trends).	Difficulties in cross-country comparisons because of language barriers and the inability to obtain a clear skill signal on Google search trends limited the scope of the exercise (e.g., need to capture Java the skill but not Java the place or java coffee).
LinkedIn job postings	Premium job posting data on LinkedIn used exclusively, allowing required skills to be captured directly from standardized LinkedIn skills classification. This approach minimizes noise in the data from approaches such as using algorithms to extract skills from text.	LinkedIn job postings can be considered an external data source, driven by company postings rather than member profiles. Nonetheless, shared bias toward certain industries and occupations on the platform as a whole may fail to validate against a representative sample when using this dataset for validation.	This dataset is used for early skill demand metric development (proxied by hiring rate) in validation exercises.

continues

TABLE II-2: continued

DATASET	ADVANTAGES	DISADVANTAGES	TEAM DECISION
ICT Development Index[g]	Index is available over relatively long time period (2009–2017) and for 176 countries. It combines 11 indicators into one benchmark measure for correlation exercise.	Individual indicator value and weights to use to arrive at a single quantitative measure can be subjective.	Used in validating skill metrics with regard to relationship to ICT development level.
PIAAC score[h]	Provides measures of proficiency in information technology skills of the 'problem-solving in technology-rich environment' section.	Only data from 2015 and limited to 35 OECD countries.	Used in validating skill metrics with regard to relationship to PIAAC score.
Value Added (OECD, World Bank Group, International Labor Organization)	Metric allows theoretical concept of skill similarity of developed and developing countries to be compared with difference in value added per worker.	Final value-added measure derived from multiple sources, with data for 27 countries. Additionally, comparing skill composition to value add introduces too many confounding factors for clear interpretation of correlation results.	Used in validating skill metrics with regard to relationship to value added per worker.

a A global harmonized household survey database providing a basic set of harmonized variables that are comparable across countries and time. The dataset is only available selectively within the World Bank.

b Available at **http://microdata.worldbank.org/index.php/catalog/step**. Survey-based data from households and employers in 17 countries.

c Skills Towards Employability and Productivity (STEP) given in three categories: cognitive, behavior and personality types, job-relevant skills.

d European Center for the Development of Vocational Training (CEDEFOP) Skills Panorama provides the most comprehensive landscape of skills and labor data in Europe, also using sources such as the Organization for Economic Cooperation and Development (OECD) and Eurostat. The data are downloaded from **http://skillspanorama.cedefop.europa.eu/bg/datasets**

e These categories include technical, communication, team-work, foreign language, customer handling, problem-solving, learning, planning and organization, literacy, numeracy, and information and communications technology skills.

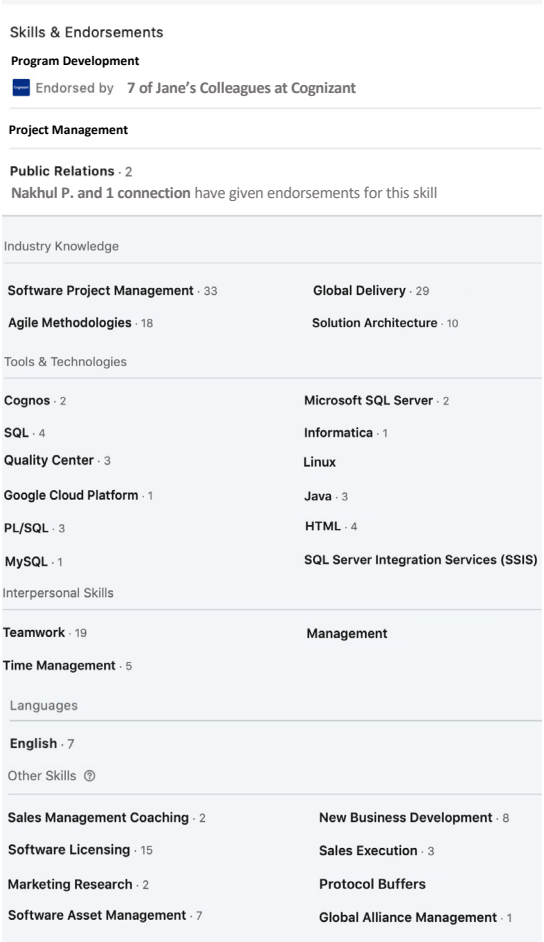
f Available at **https://trends.google.com/trends/?geo=US**. Offers data on frequency of a term's searches relative to total searches for a given period of time. Data are available since 2004 across countries and regions.

g International Telecommunications Union Information and Communications Technology Development Index (**http://www.itu.int/net4/ITU-D/idi/2017/index.html)**

h OECD Program for the International Assessment of Adult Competencies (PIAAC) score (**http://www.oecd.org/skills/piaac/**)

FIGURE II-3:

Sample LinkedIn Profile Skills Section



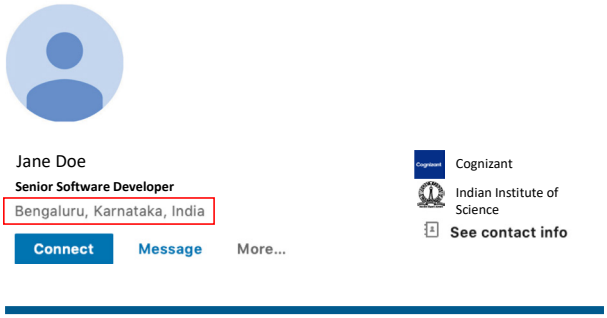
E. TALENT MIGRATION

LinkedIn migration rates are derived from the self-identified locations of LinkedIn members on their profile (figure II-4). For example, when a LinkedIn member updates his or her location from Nairobi to London, this is counted as a migration. The LinkedIn rates are compared with international migration flow data from the OECD.[19]

The OECD estimates migrant inflows into OECD countries using population censuses, population registers, and nationally representative surveys. We limit the sample to those data points that had at least 30 observed migrations each from the OECD and LinkedIn in a LinkedIn country with more than 100,000 members. This results in a total of 1,447 country pairs (country A to country B, C, D, etc.) with 5.46 million migrations to OECD countries in OECD data and a corresponding 1.16 million migrations in LinkedIn data. This translates to LinkedIn covering roughly 21.4% of all migration flows in the OECD dataset. Coverage is best for migration between high-income countries. Reference charts can be found in Appendix D, and the detailed dataset matching framework can be found in Appendix A, Section 5 (table II-3 provides a summary of other major datasets considered).

FIGURE II-4:

Sample LinkedIn Profile Location Information



19 OECD migration data downloaded from: **http://www.oecd.org/els/mig/keystat.htm**

TABLE II-3:

Summary of Other Major External Migration Datasets Considered

MAJOR ALTERNATIVE DATA[a] SOURCES CONSIDERED FOR MIGRATION METRICS VALIDATION	ADVANTAGES	DISADVANTAGES	TEAM DECISION
United Nations Department of Economic and Social Affairs	Shows number of migrants residing in each country according to country of origin from 1990 to 2017 (every 5 years, except for 2017).	United Nations captures foreign-born individuals residing in a country, which are different from LinkedIn's migrant flow estimates.	Many factors contribute to the changing level of migration stock data—not just talent flow (e.g., reason for decreasing number of migrants from Mexico to United States can be attributed to various reasons). We do not think this is a fair comparison dataset for talent migration metric validation.
International Labor Organization	Similar to above, covering 2003-2015.	Same disadvantage as UN data.	Same disadvantage as UN data.

a The team evaluated 13 alternative sources of data for migration validation and decided to use the Organization for Economic Cooperation and Development dataset for migration validation results mainly because it is the only data source that shows flows of migration (not foreign-born individuals), which is a direct comparison to LinkedIn data. See Appendix E for details of the 13 datasets.

III. LinkedIn Data Representativeness

Before we report validation results, it is important to document which segment of the workforce and economic activities LinkedIn data have better representativeness for.[20] We compare LinkedIn data with other representative government data in three dimensions: age, sex, and industry.

A. AGE

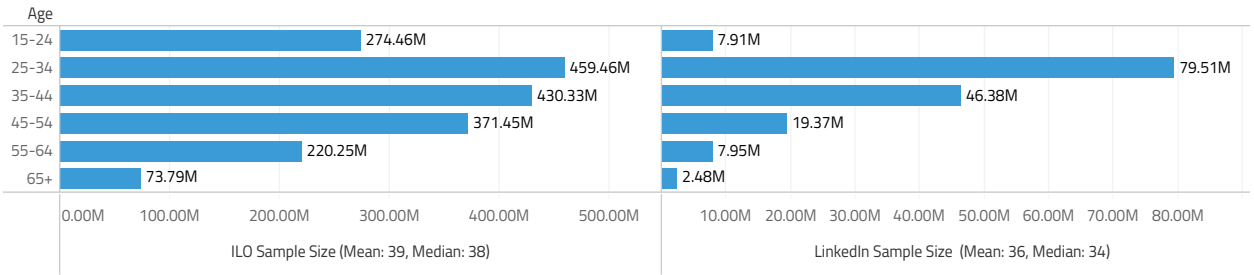
Mean and median age are presented for all cross-sections (global, income group, World Bank region), with 98 countries included in the analysis. Income group analysis classifies the 98 countries into four income group categories. Income group is defined according to the World Bank List of Economies as of June 2017 according to gross national income per capita.[21]

1) Age Distribution Globally

Age information from LinkedIn for 98 countries matched that of ILO, with a three-year difference in mean age (39 years and 36 years, respectively) and a four-year difference in median age (34 years and 38 years, respectively) (figure III-1). The LinkedIn distribution is skewed toward capturing a younger sample of the workforce, a trend seen throughout income groups and World Bank regions. The Welch two-sample t-test (unequal variance) showed that age in LinkedIn was statistically significantly different from that in ILO in all countries ($p < 0.01$).

FIGURE III-1:

Global Age Distribution (LinkedIn vs. International Labor Organization (ILO))



20 We use the term 'representativeness' loosely because we do not have detailed representative global datasets for comparison with LinkedIn data for age, sex, and industry dimensions. Ideally, we would compare LinkedIn members' education and occupation representation within industries as well to understand true 'representativeness'.

21 Economies are defined according to per capita gross national income calculated using the World Bank Atlas method in 2016, with $1,005 or less considered low income; $1,006 to $3,955 considered lower middle income; $3,956 to $12,235 upper middle income; and $12,236 or more high income.

2) Age Distribution According to Income Group

The tendency for LinkedIn Data's skewness towards younger population is also seen across WB income levels (figure III-2). Lower-middle-income countries have the greatest disparity in mean age (7 years). Low-income countries have a 4-year mean difference between ILO and LinkedIn. The smaller member sample size in low-income countries should be taken into consideration with regard to the better match in those countries (LinkedIn data covers <2% of ILO).

3) Age Distribution According to World Bank Region

The largest age difference between sources (7 years) was seen in East Asia and the Pacific. The greatest similarity between sources is seen in Sub-Saharan Africa, with only a 3-year mean age difference (figure III-3).

FIGURE III- 2:

Age Distribution According to Income Group

(LinkedIn vs. International Labor Organization (ILO))

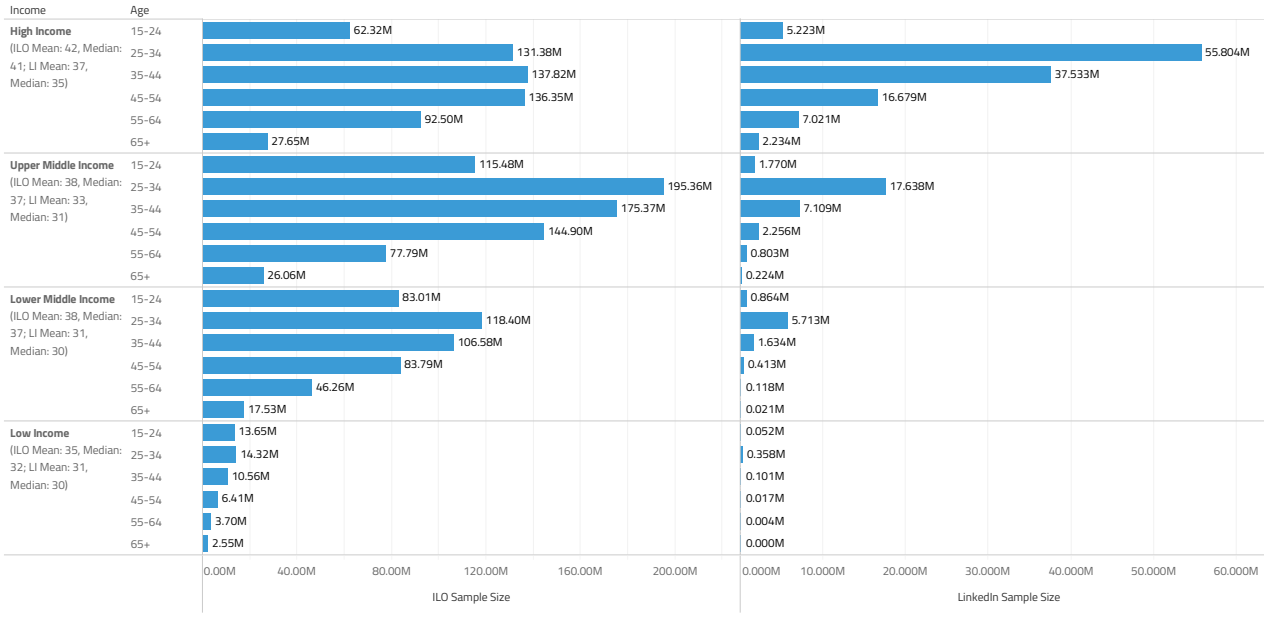


FIGURE III-3:

Age Distribution According to World Bank Region

(LinkedIn vs. International Labor Organization (ILO))

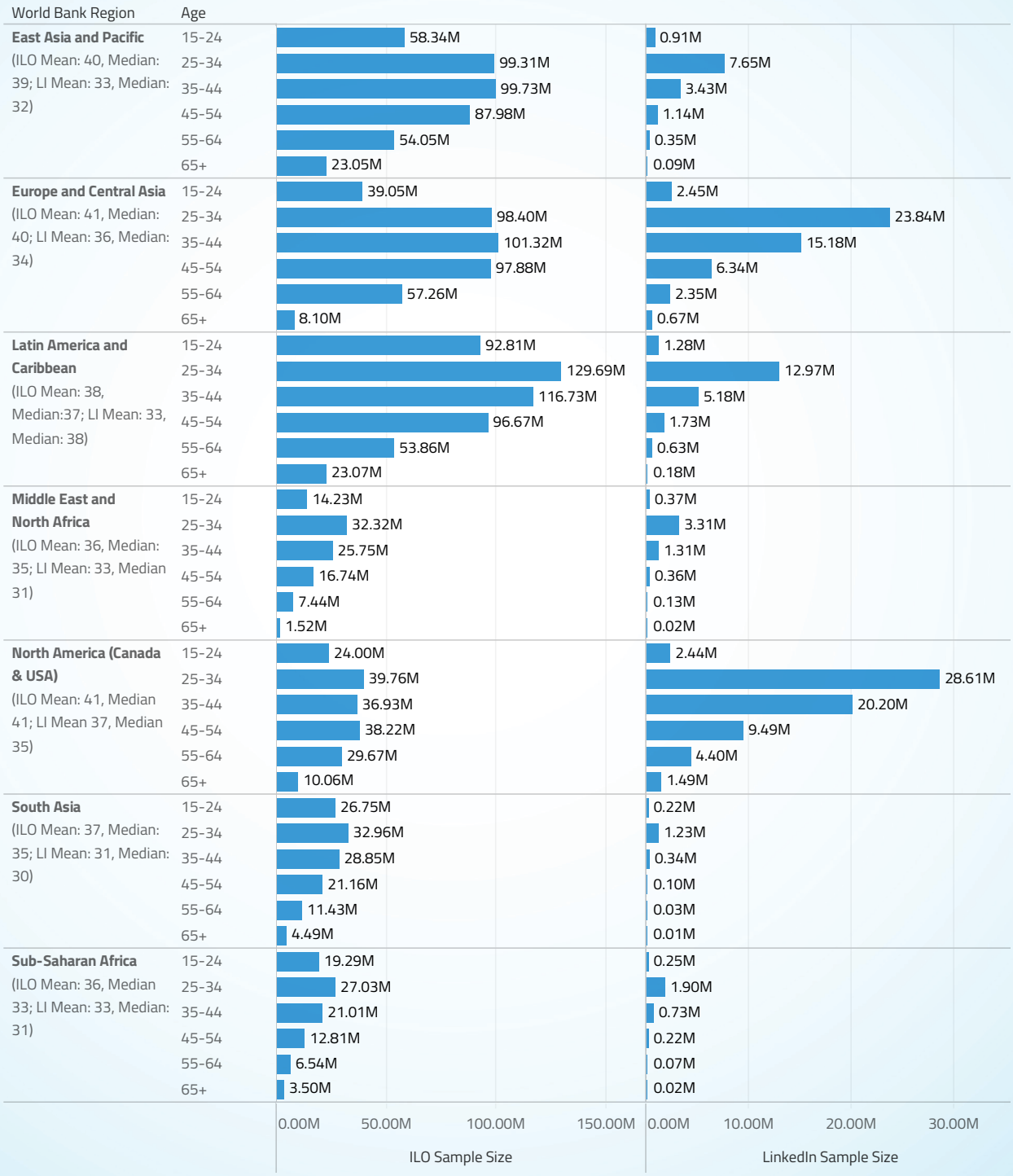
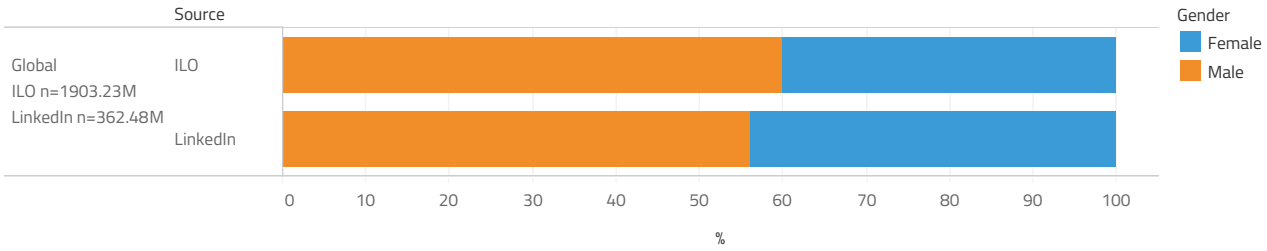


FIGURE III-4:

Global Sex Distribution (LinkedIn vs. International Labor Organization (ILO))



Note: where 'n' represents sample size

B. SEX

1) Sex Distribution Globally

LinkedIn captures a larger proportion of women in the labor force than does the ILO for 64 countries (of 110) (figure III-4). Of all member profiles on LinkedIn globally for which sex could be estimated, 45% were female and 55% were male. Of the ILO, with significantly larger sample size, 42% were female and 58% male. Using a Welch two-sample unequal-variance t-test, the female ratio between LinkedIn and ILO was not statistically significantly different globally ($p = 0.72$).

2) Sex Distribution According to Income Group

Low-income countries had the lowest proportion of women to men in the labor force (32% women) according to LinkedIn (figure III-5), whereas the ILO data showed that low-income countries had the highest proportion of women to men (49% women). Men's greater access to technology, which is required for LinkedIn use, in low-income countries and underrepresentation of women in industries that LinkedIn data cover (e.g., LinkedIn data has better coverage in ICT, which is traditionally male dominated) may explain this. LinkedIn has a higher percentage of women in high-income countries than in lower-income countries.

There was only a one-percentage-point difference between ILO and LinkedIn in sex distribution in lower-middle-income and high-income countries, with LinkedIn having a higher representation of women (lower middle income: LinkedIn 37%, ILO 36%, high income: LinkedIn 46%, ILO 45%).

3) Sex Distribution According to World Bank Region

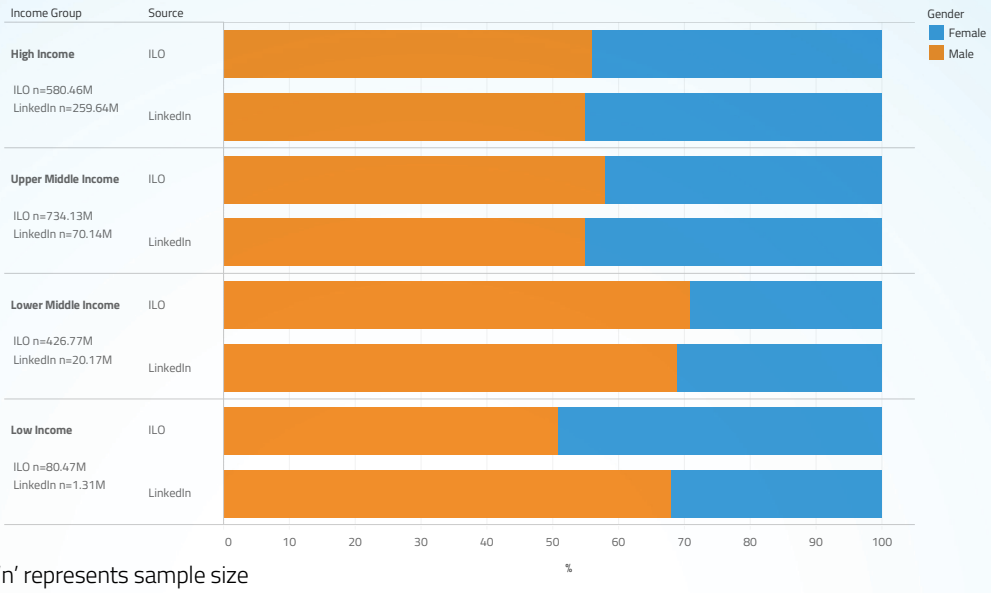
According to both sources, North America has the highest percentage of women in the workforce (LinkedIn 48%, ILO 47%), and South Asia and the Middle East and North Africa have the lowest (figure III-6).

There was a dramatic difference between the LinkedIn and ILO data in percentage of women in the workforce in South Asia (LinkedIn 18%, ILO 27%). The greatest similarity was seen in North America (one-percentage-point difference) and Latin America and the Caribbean (two-percentage-point difference).

FIGURE III-5:

Sex Distribution According to Income Group

(LinkedIn vs. International Labor Organization (ILO))

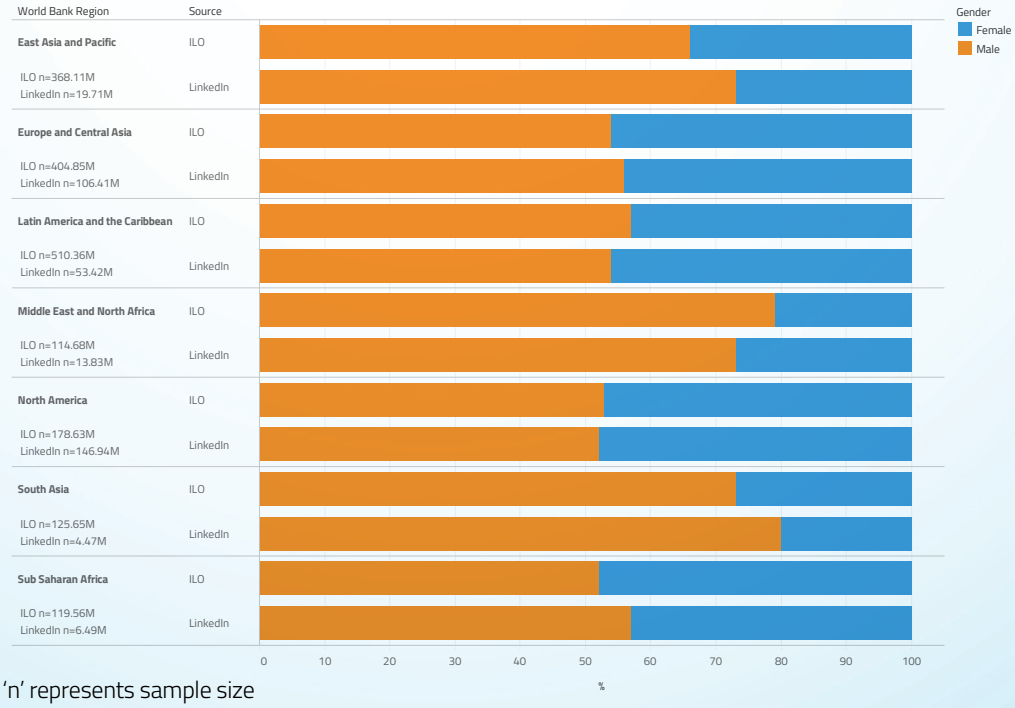


Note: where 'n' represents sample size

FIGURE III-6:

Sex Distribution According to World Bank Region

(LinkedIn vs. International Labor Organization (ILO))



Note: where 'n' represents sample size

C. INDUSTRY

LinkedIn coverage of the workforce according to ILO data is measured in 92 countries, and results are presented at the global, income group, and World Bank region levels.

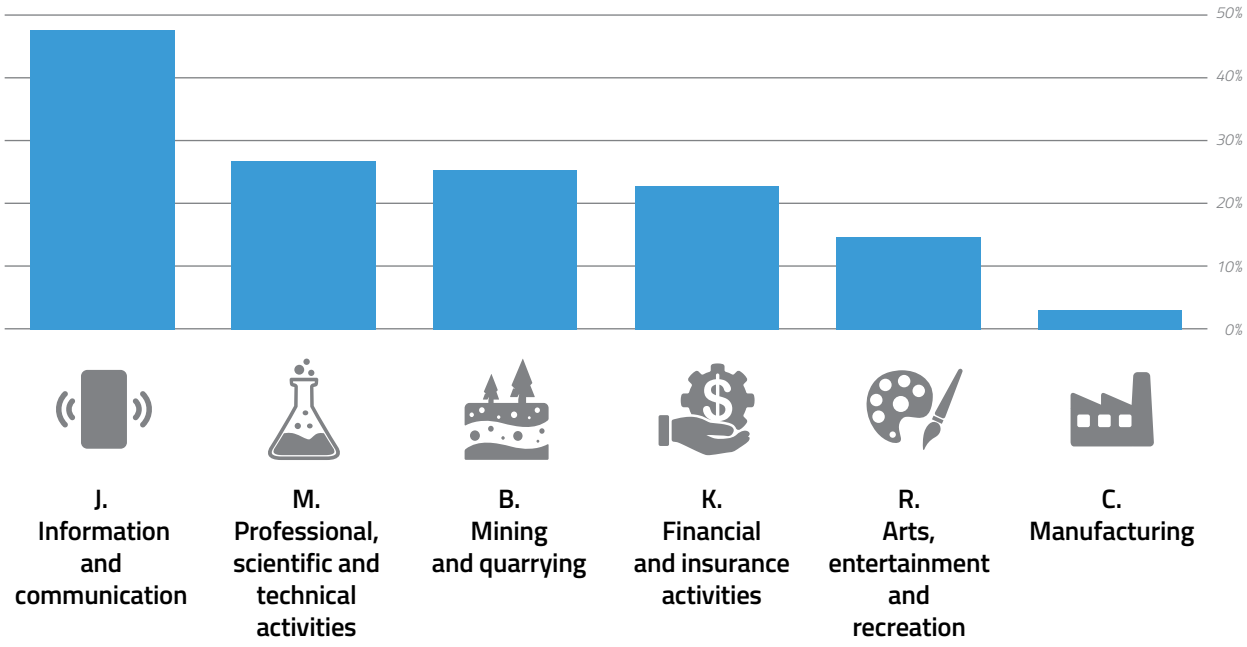
1) Industry Coverage Globally

The greatest industry coverage by LinkedIn data[22] is in the knowledge-intensive and tradable sectors (figure III-7), specifically ICT[23] (~48%); professional, scientific, and technical activities (~26%); mining and quarrying (~25%);[24] financial and insurance activities (~22%); arts, entertainment, and recreation (~14%); and finally, manufacturing (~3%), with lower coverage.

FIGURE III-7:

Global LinkedIn Industry Coverage

(LinkedIn as Percentage of Total International Labor Organization (ILO) Workforce, 2016)



Note: Because of lower penetration rates of some sectors, the first phase of the World Bank Group-LinkedIn collaboration will share data only from the six knowledge-intensive and tradable sectors to ensure data quality and minimize risks of misinterpretation of the LinkedIn data due to small sample size; the remaining sectors not shown are: : L. Real estate activities; D. Electricity; gas, steam and air conditioning supply; N. Administrative and support service activities; P. Education; O. Public administration and defense; compulsory social security; S. Other service activities; Q. Human health and social work activities; H. Transportation and storage; G. Wholesale and retail trade; repair of motor vehicles and motorcycles; F. Construction; I. Accommodation and food service activities: A. Agriculture; forestry and fishing.

Source: Authors' calculation using LinkedIn data.

22 Measured as percentage of LinkedIn membership in the labor force defined according to ILO in 92 countries.

23 ISIC sector J. Information and communication

24 The representativeness of LinkedIn in the mining and quarrying sector is partially due to companies on LinkedIn incorrectly identifying themselves as oil and energy companies rather than utilities (hence being classified in ISIC category B rather than D). For example, EDF Energy, a major employer in the United Kingdom, categorizes itself under oil and energy but specializes in electricity and gas sales to homes and business (activities that fit in the utilities sector).

TABLE III-1:

Summary of Other Datasets Considered

ALTERNATIVE DATA SOURCES CONSIDERED FOR ASSESSING INDUSTRY REPRESENTATIVENESS	ADVANTAGES	DISADVANTAGES	TEAM DECISION
International Labor Organization ISIC 3 classification.	Ability to capture additional countries that use ISIC 3 classification (e.g. United States).	ISIC 3 introduces different levels of industry classification than ISIC 4. The alternative classification is problematic on two levels: 1) Industries are aggregated in an outdated manner (e.g. lack of standalone information and communications technology industry).[a] 2) ISIC 3 tends to group well-represented and underrepresented LinkedIn industries together, making the LinkedIn-ILO industry representativeness comparison problematic. also dilutes LinkedIn data level of detail (e.g., ISIC 3 real estate, renting, and business activities are classified together).	For the reasons listed, as well as in the interest of preserving consistent mapping, ISIC 3 classification is not included. Efforts to re-map ISIC 3 to ISIC 4 did not yield results that we had confidence in.
World Bank International Income Distribution Data Set data.	Allows for comparison of occupation and industry distribution between countries.	Few countries with industry and occupational data (e.g., 8 countries in 2015, 3 in 2016, 0 in 2017).	These data were not included in the analysis because of the small number of countries with industry and occupational data in recent years and greater confidence in LinkedIn data quality from 2015 on.

a For example, International Standard Industrial Classification (ISIC) 4 includes standalone section on information and communications technology.

2) Industry Coverage According to Income Group

In all industries, the greatest industry coverage was found in high-income countries, followed by upper-middle-income, lower-middle-income, and low-income countries (figure III-8).

In countries in all income groups, the highest coverage is seen in ICT, followed by professional, scientific, and technical activities and financial and insurance activities. Arts, entertainment, and recreation has considerably higher coverage in high-income countries than in others.

3) Industry Coverage According to World Bank Region

LinkedIn member coverage of the workforce according to World Bank region, benchmarked by ILO, is given in figure III-9. The knowledge-intensive and tradable sectors have the greatest coverage in all World Bank regions.[25] Trends across World Bank regions are the same as across income groups—higher income regions tend to have better LinkedIn coverage. Regions are ordered from left to right according to decreasing LinkedIn coverage in figure III-9.

On the regional level, ICT is the industry with highest coverage in all regions. Second highest penetration is mining and quarrying for all regions except Sub-Saharan Africa. Professional, scientific, and technical activities and financial and insurance activities are the third- and fourth-highest-coverage industries across all regions.

25 With the exception of manufacturing sector.

FIGURE III-8:

LinkedIn Industry Coverage According to Income Group

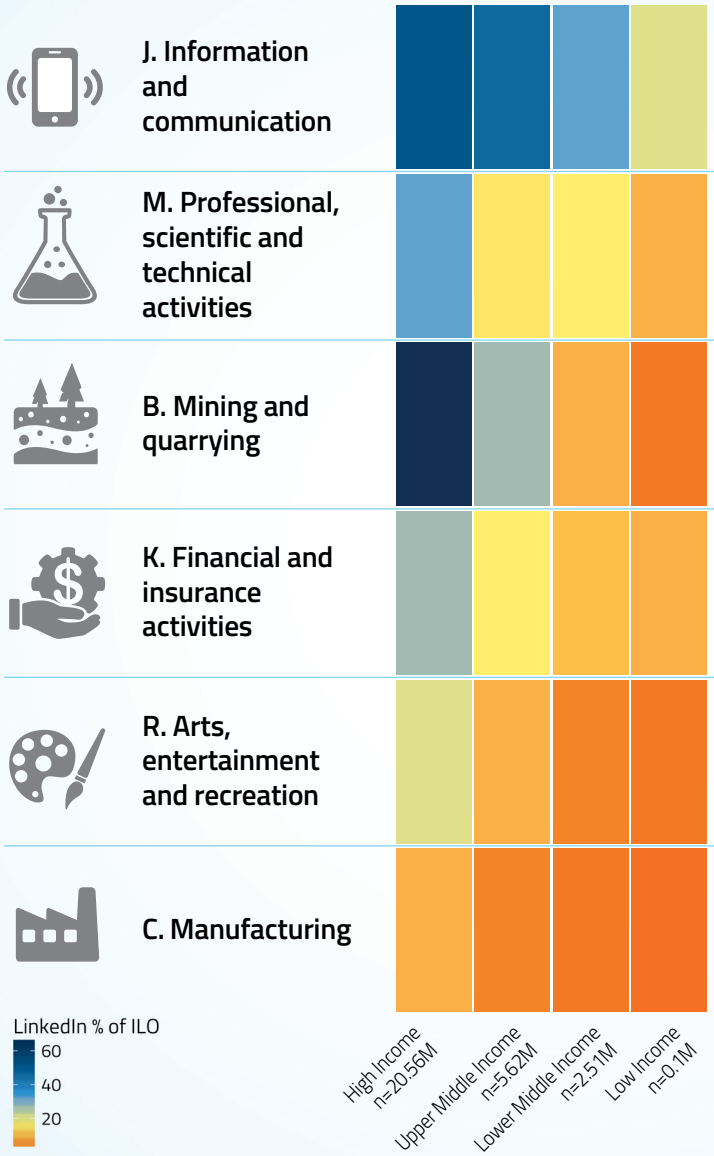
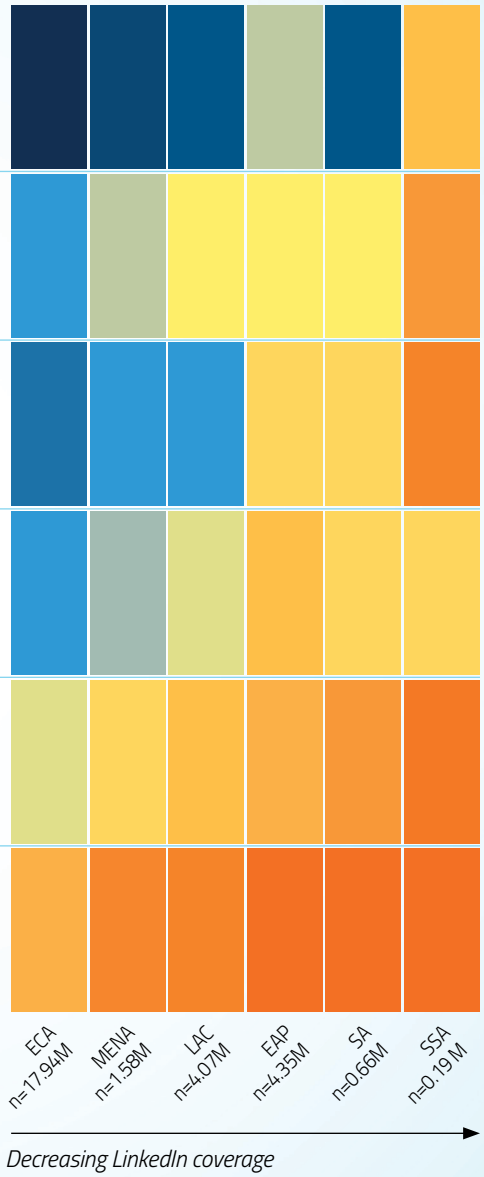


FIGURE III-9:

LinkedIn Industry Coverage According to World Bank Region



'n' denotes samples size

Note: Because of lower penetration rates of some sectors, the first phase of the World Bank Group-LinkedIn collaboration will share data only from the six knowledge-intensive and tradable sectors to ensure data quality and minimize risks of misinterpretation of the LinkedIn data due to small sample size; the remaining sectors not shown are: : L. Real estate activities; D. Electricity; gas, steam and air conditioning supply; N. Administrative and support service activities; P. Education; O. Public administration and defense; compulsory social security; S. Other service activities; Q. Human health and social work activities; H. Transportation and storage; G. Wholesale and retail trade; repair of motor vehicles and motorcycles; F. Construction; I. Accommodation and food service activities: A. Agriculture; forestry and fishing.

Source: Authors' calculation using LinkedIn and International Labor Organization (ILO) data in 92 countries


A
100
90
80
70
60
50
40
30
20
r = 0.87
60
100
120
300
day 5
day 6

IV. LinkedIn Metrics Validation Results

The objective of this section is to determine whether the online social media data extraction methods that we used to derive LinkedIn metrics contain genuine signals, as compared with other data sources. Three categories of metrics are assessed: industry employment size and growth, talent migration, and skills. Results are presented according to the global, income group, and World Bank region[26] levels to help readers determine which metrics are more relevant for certain regions or income levels and which are relevant for cross-country comparison.

A. INDUSTRY EMPLOYMENT METRICS

1) Industry Employment Location Quotient

a) Overview

Understanding which industries hire the most workers in a location and having the ability to benchmark this industry employment concentration (captured according to location quotient) against that of peers gives policy-makers a summary of the major (tradable) economic activities at a location (see Box 1, as an example of how this may be applied), although as mentioned before, LinkedIn data are skewed toward the knowledge-intensive and tradable sectors. To ensure comparability, we first need to ascertain whether relative industry employment size according to LinkedIn is at least similar to size according to the ILO and to identify which industries allow for cross-country comparisons within the same industry (e.g., ICT sector very likely) and which do not (e.g., agriculture) because sample coverage in under-represented sectors varies considerably across countries.

b) Methodology

The methodology involves two steps. First, industry employment size (distribution of members across industries) is calculated for each country. Given as,

$$Country\ industry\ size_{c,i,t} = \frac{member\ count_{c,i,t}}{member\ count_{c,t}}$$

where industry employment size is given for country *c* in industry *i* for year *t* =2016 (because ILO data are most complete for 2016, see section II-B).

An income group's industry employment size for income group *I* for industry *i* for year *t* is calculated by treating each country in the group as one observation (regardless of country size, hence no weighting is applied) and then taking an arithmetic mean of countries in the income group:

$$Income\ group\ average\ industry\ size_{I,i,t} = \frac{\sum_{c=1}^{n} country\ industry\ size_{c,i,t}}{n}$$

where n denotes the number of countries in an income group.

Second, we obtain a country's industry employment location quotient by comparing a country's industry size with the income group average:

$$Country\ industry\ size\ location\ quotient_{c,i,t} = \frac{country\ industry\ size_{c,i,t}}{income\ group\ average\ industry\ size_{I,i,t}}$$

26 Income group and region are defined as averages of all countries in this group rather than aggregating all members in the region as a whole and calculating the average. For example, industry size in high-income countries is given as an average of industry size for all high-income countries, treating each country as one unit of (unweighted) observation. The same method was used to calculate World Bank region averages.

BOX 1:

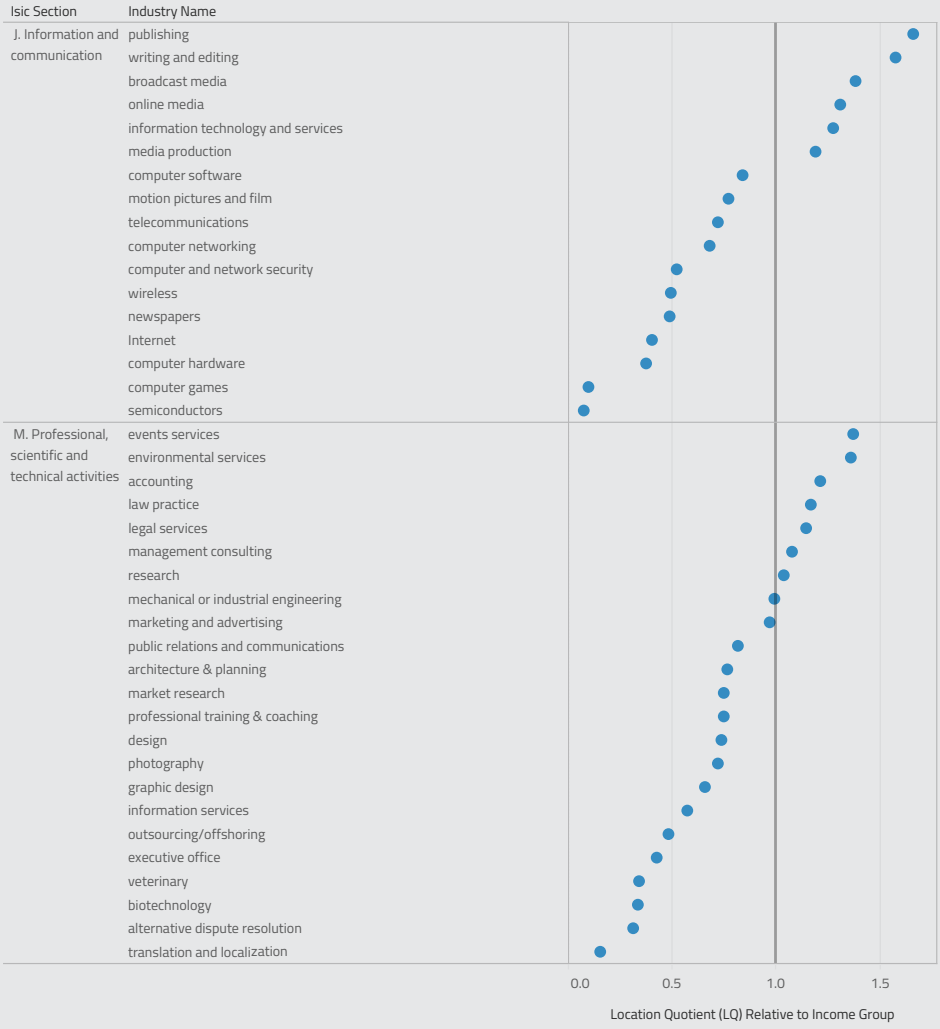
Pilot Country 1—Identifying Comparative Advantage and Skills Development Needs in South Africa

The World Bank Group—LinkedIn partnership was able to provide city- and country-level insights for South Africa, one of the first pilot countries. LinkedIn data were harnessed to identify the stand-out industries (location quotient above 1) in terms of national and subnational employment concentration to understand a location's comparative advantage, using the location quotient methodology described in section IV-A-1.

The analysis shows that South Africa has a strong global comparative advantage in areas of traditional strength such as energy and mining and transport and logistics and is slowly expanding as a regional leader in finance. Nonetheless, South Africa lags in sectors requiring digital skills (e.g., computer software and semiconductors, in the ICT sector, with a location quotient below 1), with stand out industries covering non-digital industries such as publishing and broadcast media. Considered in tandem with signs of low supply combined with strong demand for digital skills, these results may inform policymakers in South Africa on potential upskilling and reskilling opportunities for the local workforce, especially if the country wants to take advantage of the growth of the digital economy.

Moreover, LinkedIn data allow for analysis at the subnational level. Cities in South Africa reflect a changing landscape and unique growth capabilities in each region. For example, Cape Town's workforce is competitive in areas related to business services, tourism, and creative work, because the location quotient of these industries is above one.

The insights generated support the importance of supporting South Africa in acquiring the skills necessary to drive future industry growth. Developing digital and information and communications technology skills will be important for economic transformation and productivity growth, because it can have a multiplier effect on employment and income through value chains or consumption.



Note: Location quotients above 1 and below 1 denote industry employment size above and below income group average, respectively.

Source: Authors' calculation using LinkedIn data.

BOX 2:

Which Benchmark to Choose When Calculating Location Quotient

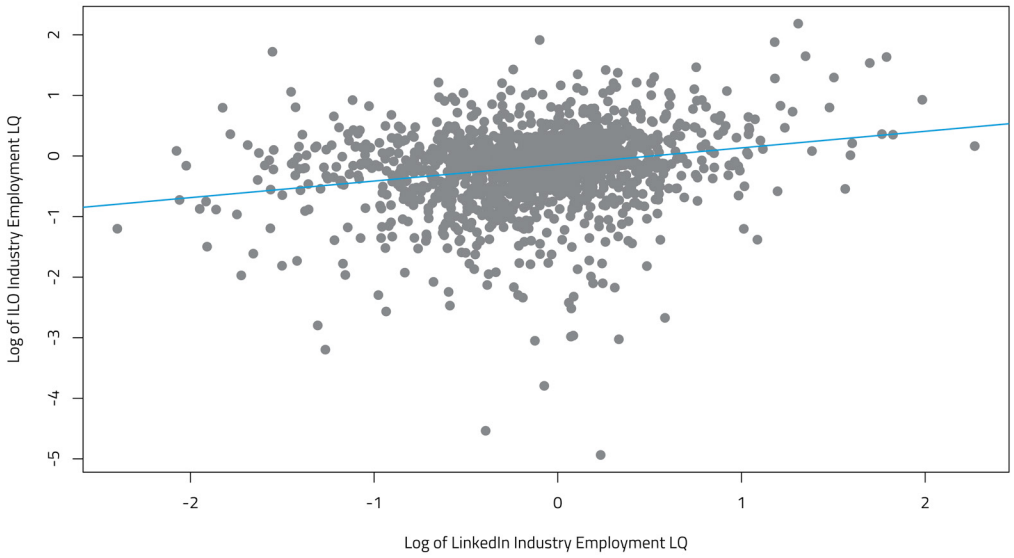
Because LinkedIn coverage rates are different in developed and developing countries, the team realized that that location quotient cannot be calculated by comparing country industry size with global average industry size, because developed countries would systematically underindex because their user base covers more, and more-diversified, industries, which "dilute" the industry size (in percentage of total membership). The team examined a variety of benchmarking groups from an economics perspective and considering the validation results (validating against International Labor Organization industry employment). It was decided to use income group because it was fairer to compare economies in similar stages of development and the validation results were better. Using other benchmarking groups so as to calculate results according to global average, World Bank region, and other regions (e.g., Western Europe) was also explored, but because of the varied stages of development of countries in these groups, along with inferior validation results, such benchmarking was not pursued.

After a suitable benchmark group applicable to all countries in the dataset was developed, another question arose on how best to compare a country with an aggregate of countries (e.g., income group). Three options were considered: First, an income group could be treated as a whole, with industry size defined according to absolute member count in an industry over total member count in this income group. Second, a weighted mean of each country's industry size could be calculated based on each country's workforce size. Third, a simple average could be calculated of each country's industry size, with each country in the income group treated as an equal-weight economy regardless of the size of the country. The team chose the third approach because it prevents a country with a large LinkedIn member count (e.g., United States) from overpowering the results.

Finally, although income group is selected as the benchmark for defining location quotient measures on the country level, this does not prevent comparison of location quotient measures of diverse country groupings, depending on the analytical question being asked.

FIGURE IV-1:

Country–Industry Pair Location Quotients



Note: The fitted line shows a positive relationship between International Labor Organization (ILO) industry employment location quotient and LinkedIn industry employment location quotient.

c) Validation Results

The location quotient for a given industry of a specific country derived from LinkedIn data was compared with that derived from ILO data. We first present these correlation results for all countries and all industries globally so that readers have a sense of the overall level of confidence—whether LinkedIn data can capture the relative concentration of major industry employment activities. We then disaggregate the results according to income group and region to determine whether we have a higher confidence level in certain income groups and regions.

(1) Industry Employment Location Quotient Globally

We find that, for all countries and industries (1,512 country-industry pairs), there is a positive and statistically significant correlation at a 99% confidence interval between LinkedIn industry location quotient and ILO industry location quotient, controlling for income group (Pearson correlation coefficient=0.307). This means that the way we constructed the industry location quotient metrics in general captures genuine industry employment concentration (figure IV-1), resulting in a positive linear relationship across all location quotient country-industry pairs.

(2) Employment Location Quotient According to Industry

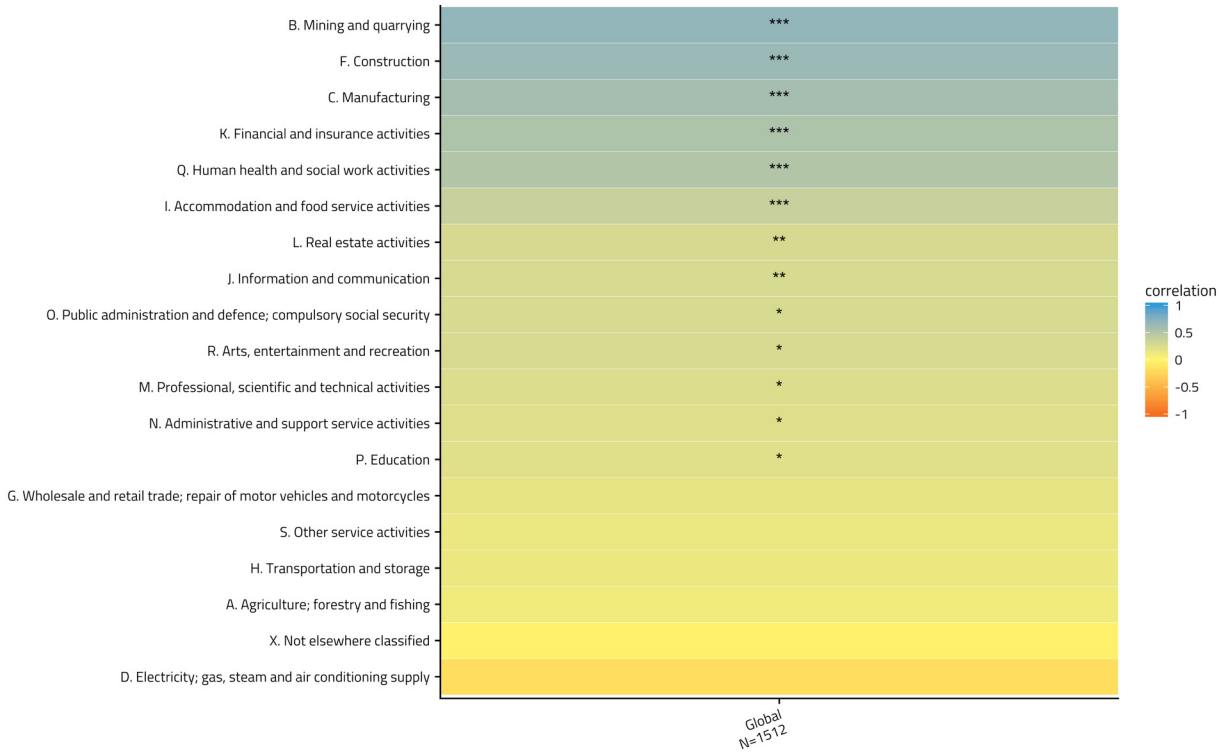
There is a positive correlation between LinkedIn and ILO data for the majority of industries, with more than half of the correlations being statistically significant, although the correlations were not as strong as expected for knowledge-intensive industries (figure IV-2). For example, although financial and insurance activities has a correlation coefficient of 0.58, ICT has a correlation coefficient of less than 0.28, probably because the latter is the highest penetrated industry on LinkedIn in all countries, which leads to it being overrepresented.[27] This explains the lower correlation between LinkedIn and ILO in this sector.

27 i.e. Compared with the penetration rate of ICT sector in ILO data, LinkedIn's ICT penetration rate is probably higher because it is calculated as a percentage of total LinkedIn members.

FIGURE IV-2:

Global Industry Location Quotient Correlation

(LinkedIn vs. International Labor Organization (ILO))



Note: Industries are ranked according to global correlation coefficient in ascending order. N = number of country-industry pairs.

(3) Industry Employment Location Quotient According to Income Group

When the global results are disaggregated according to income group (figure IV-3), a decreasing trend in the significance and strength of the correlations is seen as one moves from high- to low-income countries (left to right). Knowledge-intensive sector correlations, in particular, are higher as income group level rises probably because of fairer industry representation in high-income countries. It appears that high- and upper-middle-income countries drive the positive global correlation results presented in the section above, with a sharp drop in correlation strength and significance in the lower two income groups. Again, the ICT sector yields poor results even in the high-income countries, for reasons discussed above.

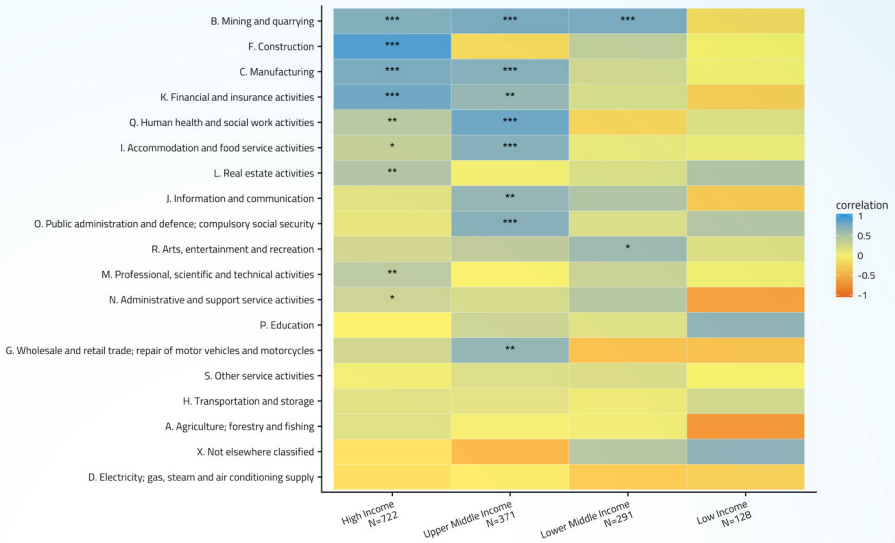
(4) Industry Employment Location Quotient According to World Bank Region

The situation is similar when grouping observations according to World Bank region (figure IV-4). Generally, the higher the LinkedIn coverage in a region (those with at least 20% LinkedIn coverage rate of total workforce), the stronger the correlation between the location quotients. For example, in Europe and Central Asia, LinkedIn location quotients are closely and positively correlated with those of the ILO in nearly all industries.

FIGURE IV-3:

Global Industry Location Quotient Correlation According to Income Group

(LinkedIn vs. International Labor Organization (ILO))

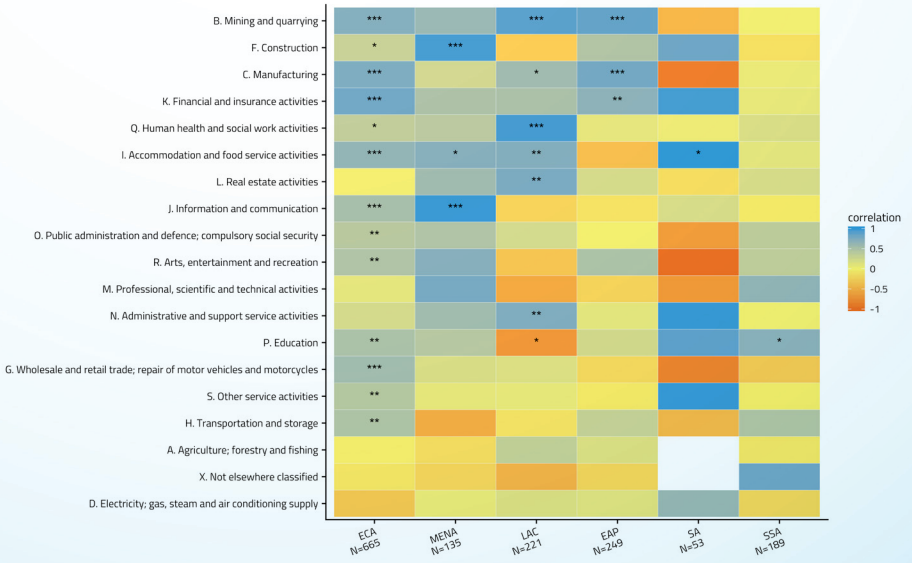


Note: Industries are ranked according to global correlation coefficient in ascending order. N = number of country-industry pairs.

FIGURE IV-4:

Global Industry Location Quotient Correlation According to World Bank Region

(LinkedIn vs. International Labor Organization (ILO))



Note: Industries are ranked according to global correlation coefficient in ascending order. N = number of country-industry pairs.

2) Industry Employment Growth

a) Overview

Capturing industry employment movements over time provides vital information on past and current trends of industry development. We constructed a metric based on transitions between industries over time by LinkedIn members as a proxy for industry employment growth. This metric is derived from a balanced panel of members who have continuously held positions over a three-year period, which does not take into account members who enter or exit an industry and those with employment gaps. It is likely that this metric reflects transitions between industries of experienced workers with deep attachment to the labor market. The purpose of the validation exercise below is to better understand whether the near-real-time LinkedIn employment transitions between industries can pick up signals of industry employment growth that government data show. The exercise shows that, despite limitations of a balanced panel, the LinkedIn balanced panel-derived transition rates (henceforth referred to as growth rate) correlate reasonably well with external employment growth rate signals.

The team explored two external time series of industry employment data in this validation exercise: ILO and U.S. BLS Current Employment Statistics. As described in the Data Source section and Appendix A, the ILO offers data for multiple countries, albeit with considerable limitations on the available length of the time series and varying precision[28] of data across countries. These factors move the focus of this section to the U.S. market, where time series industry employment data are more readily available than in other countries. The United States is also the largest, best-represented market for LinkedIn. Using this advantage, together with greater access to fine-scale employment statistics, is likely to yield a fairer validation result, even though it is not a global-level validation.

28 Precision is composed of factors such as coverage of industries, survey sample size, and variation in surveys between countries and years (e.g., 2014 and 2016).

BOX 3:

Why we construct a balanced panel data from LinkedIn

LinkedIn membership has been growing consistently (if not exponentially) since its establishment in 2002. Examining industry employment growth simply by calculating differences in industry employment levels over years can be problematic because new members signing up for a LinkedIn account may be the primary reason for a headcount increase in a particular location. This is especially true in developing countries, where LinkedIn is experiencing exponential growth.

To isolate real industry employment growth from LinkedIn business growth, we freeze membership at any given point in time and construct members' work experience backward. This creates a balanced panel on which members are the same across years, and we compare the size of employment in an industry over time as a proxy for industry employment growth.

One of the drawbacks of this approach is that we have to limit the balanced panel to include only members with a job in all years and therefore are essentially capturing industry transition of experienced hires but no new entrants or exits. (LinkedIn is less likely to pick up exits because members do not have an incentive to report that they have lost a job and are unemployed.) Because the panel is balanced, some industries will experience a net gain in employment, and some will experience a net loss. In other words, we are measuring how well industries are performing in terms of employment relative to each other. For a detailed explanation of the advantages and disadvantages of using the balanced panel data and alternative datasets considered, see table II-1.

To capture new entrants, we must separately construct another repeated cross-section dataset for recent graduates looking for their first job after graduation; the balanced panel dataset mentioned above should capture their subsequent industry transitions. This recent graduate dataset is noisier than the balanced panel in the sense that there is no way to separate growth of LinkedIn membership of recent graduates from overall growth in the number of recent graduates.

By constructing a balanced panel dataset, we can separate to some extent real industry employment signals from noise that the exponential growth of LinkedIn's business creates—an intrinsic feature of social media platforms.

b) Methodology

Given monthly BLS Current Employment Statistics data at the national level, a LinkedIn balanced panel data set is constructed for January 2015 through April 2018 for comparison. Both datasets are given as an absolute count of individuals within each industry, from which monthly growth rates are derived as

$$Growth\ rate_{i,m+1,y} = \frac{industry\ size_{i,m+1,y} - industry\ size_{i,m,y}}{industry\ size_{i,m,y}} * 100$$

where *i* is BLS industry super-sector,[29] *m* is month, and *y* is year, with a total of 39 monthly growth observations per industry.[30] Monthly growth rates from LinkedIn are compared with those from BLS by running Pearson correlation tests and simple linear regression models[31] on the entire data set and according to industry.

c) Validation Results

(1) Industry Employment Growth in All BLS Super-Sectors

Taking the employment growth value for a given industry in a given month for all 429 observations in the 11 BLS super-sectors for LinkedIn and BLS data yields a correlation of 0.30 at a 99% confidence interval. The results are promising, considering the inclusion of industries with particularly low LinkedIn penetration and the potential noise due to time lag

29 BLS super-sectors are composed of multiple NAICS sectors and are roughly equivalent to the ISIC 1-digit level. See **https://www.bls.gov/sae/saesuper.htm** for more information on BLS super-sector mapping:

30 We multiply this by 11 BLS super-sectors, yielding 429 observations from each source.

31 Simple linear specification of BLS monthly growth as a function of LinkedIn monthly growth.

BOX 4:

Why correlating industry employment growth of the International Labor Organization (ILO) with that of LinkedIn does not yield the expected results

The team has made considerable effort to understand the best way to construct a panel dataset that accurately captures industry employment movements. A key lesson learned is that it is difficult to find an apples-to-apples comparison for validation. For example, in the ILO, industry employment growth (*G*) is given as *G= X + Y + Z (new entrants, existing employees changing jobs, and exits*), whereas LinkedIn growth may be mainly given as *G = Y (existing employees changing jobs).* In addition, global industry growth over time in the ILO dataset requires strong assumptions, extrapolation, and harmonization methods over time for multiple countries, which adds more noise to the ILO industry employment growth data.

Correlating industry growth of all country-industry pairs of LinkedIn with that of the ILO (between 2014 and 2016 because ILO data are available for these two years) resulted in a correlation coefficient of 0.138 at the 99% confidence interval. Low, statistically insignificant correlations were seen even for well-represented industries on LinkedIn (e.g., ICT), whereas unexpectedly strong results were seen for manufacturing (International Standard Industrial Classification section C). It is difficult to determine whether the unexpected validation results are due to methodological challenges or noise from the external data source. Therefore, the team has focused on looking for more comparable, high-quality external data (U.S. Bureau of Labor Statistics monthly data) for this validation exercise.

of LinkedIn members updating their LinkedIn profiles to reflect industry transition. In addition, modelling BLS growth as a function of LinkedIn growth yields a positive coefficient at a 99% confidence interval—reaffirming the directional relationship and correlation between sources.

(2) Industry Employment Growth According to BLS Super-Sector

When the merged dataset is broken down according to super-sector, the correlation between LinkedIn and BLS is positive in all sectors (with 7 of the 11 sectors having a statistically significant correlation of 0.25 and higher). In the knowledge-intensive and tradable sectors, where LinkedIn has particularly strong coverage, we find that the trade, transportation, and utilities; mining and logging; education and health services; information, professional, and business services; and financial activities are also statistically significantly correlated. A summary of correlation and statistical significance according to super-sector is shown in figure IV-5.

FIGURE IV-5:

Super-Sector Industry Employment Growth Correlation

(LinkedIn vs. Bureau of Labor Statistics (BLS))

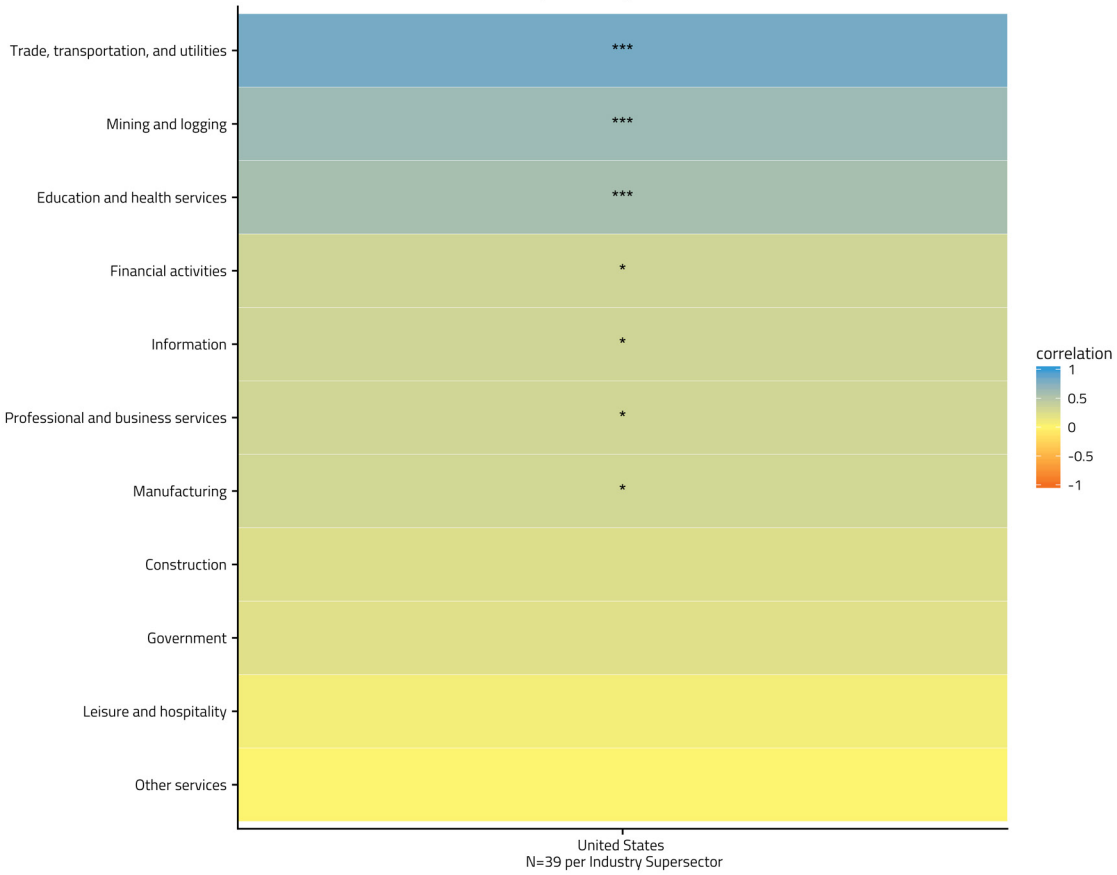


Figure IV-6 and figure IV-7 show month-by-month industry movements from both sources.[32] Figure IV-6 displays a subset of 7 industries that show positive statistically significant correlation. In general, LinkedIn appears to track BLS closely. Furthermore, LinkedIn displays a "smoothing average" and less dramatic jumps than BLS, probably reflecting the time lag of LinkedIn members updating their profile information when they change industries. This effect is particularly prominent in the financial activities sector.

32 The magnitude of the growth rate is considerably different between LinkedIn and the BLS. In figures IV-6 and IV-7, the axis scale for the BLS and LinkedIn are adjusted and unique to each source in order to discern co-movement patterns more easily.

FIGURE IV-6:

Monthly Growth of Super-Sectors with Significant Correlation Between LinkedIn and Bureau of Labor Statistics (BLS), Jan 2015 – Apr 2018

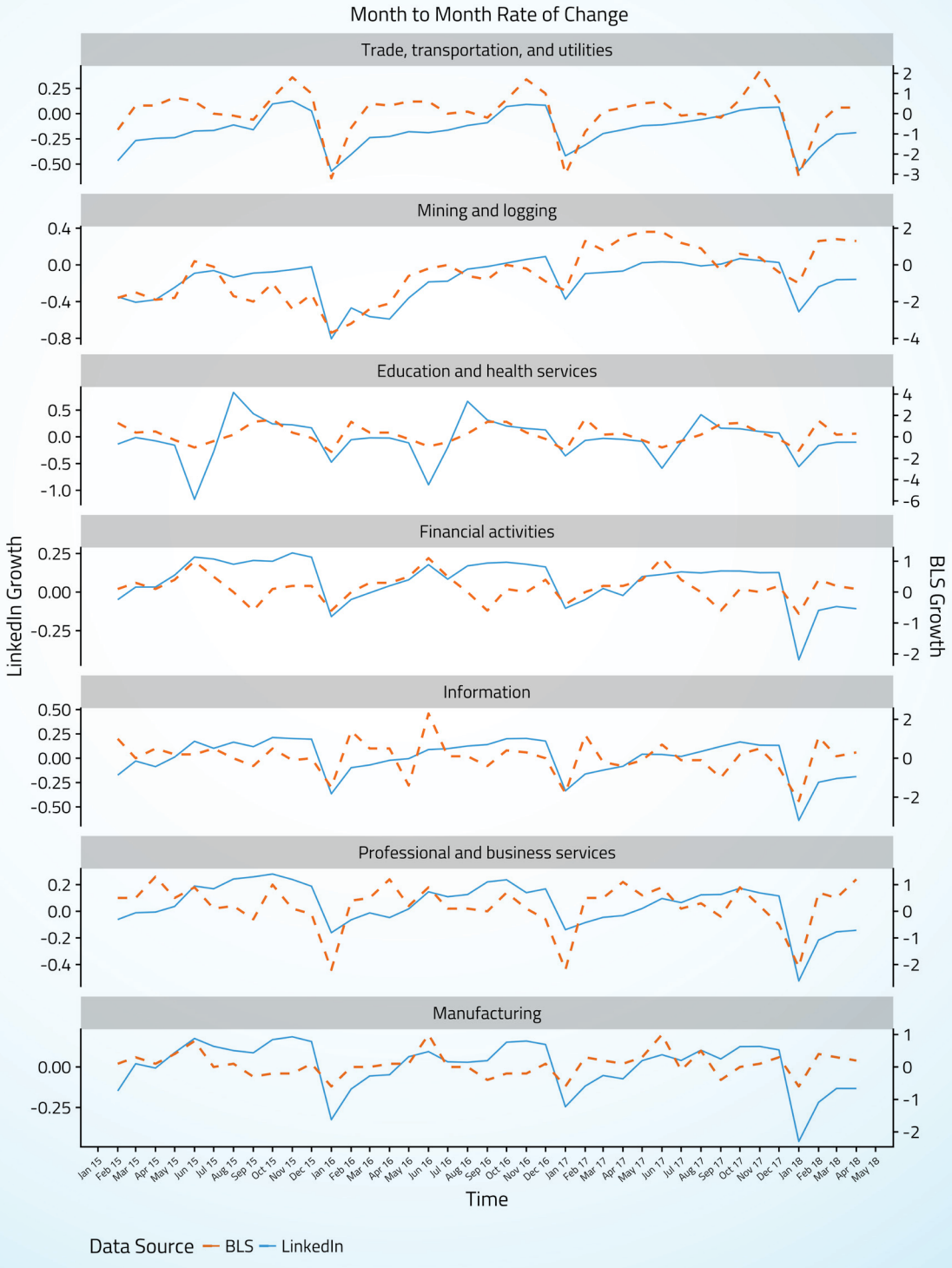
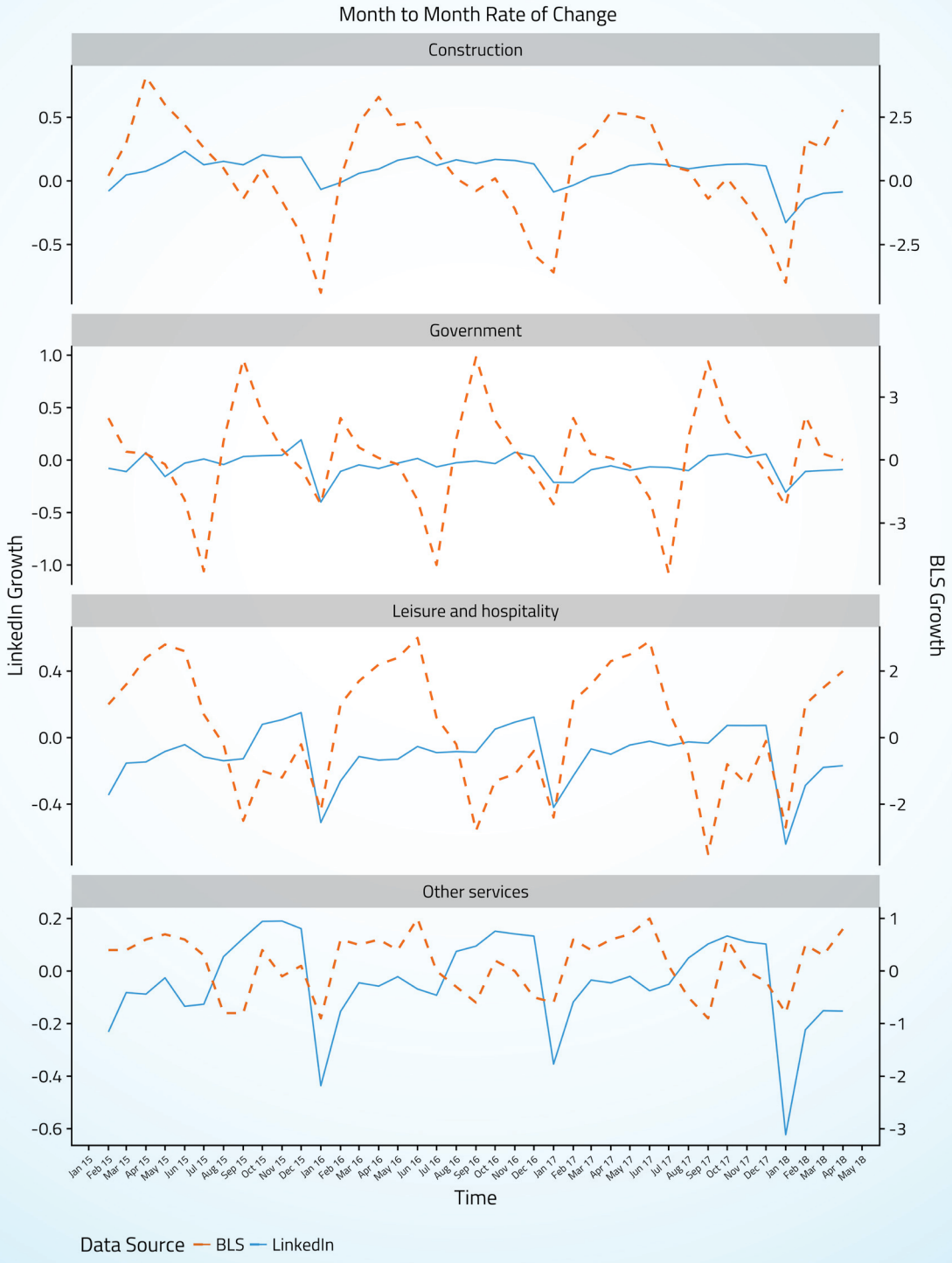


FIGURE IV-7:

Monthly Growth of Super-Sectors with Nonsignificant Correlation Between LinkedIn and Bureau of Labor Statistics (BLS), Jan 2015 – Apr 2018



B. Skills

a) Overview

Measuring skills is central to identifying opportunities that are needed for effective skill development policies to promote a competitive labor force that in turn fosters private sector growth and job creation. This section discusses how to derive skills needs in each industry and the respective metrics' validation results.

To compare skills needs of different industries, taking into account different occupation composition within the same industry in different countries, as well as the different timing and frequency with which a member would update his or her skill profile (e.g., after creating a LinkedIn profile vs. after changing to a new job), requires carefully extracting reliable skills metrics that describe genuine industry skills needs.

Two skill metrics were derived: industry skills needs and skill penetration rates in an industry. Industry skills needs are the most-distinctive, most-represented skills of members working in the industry. Skill penetration rates measure the time trend of different skills from among the industry skills needs in different occupations in an industry.

Both metrics aim to provide a picture of the skills needs of an industry globally and over time, but they approach the industry skills needs from different angles. The selection of industry skills needs gives a general idea of skills that members working in the industry report. In contrast, skills penetration rates show how skills are associated with different jobs across industries and show the time trend of the change. In other words, they measure how the representativeness of skills changes for occupations in an industry over time.

b) Methodology

(1) Industry Skills Needs

i. Identifying the Top Represented Skills

To identify the top represented skills for an industry in a country, we map the industry into a vector space in which each skill is a dimension. The top represented skills are the ones that have the greatest weights (w):

$$[(skill_1, w_1), (skill_2, w_2), ..., (skill_n, w_n)]$$

where n is the total number of skills in an industry and a country.[33] Taking the Internet industry in the United States as an example, we illustrate how we calculate the weights below.

To compute weights for each skill in an industry, we select all members who work in the industry and then count the number of times each skill appears in the LinkedIn profile under the Skills sections of these members. For example, if we are interested in identifying the top represented skills of the Internet industry in the United States, we find all members working in the industry, extract the skills from their profiles, and compute the weight for each skill as the count of members having that skill. This initial approach results in the following skill vector (showing the top 10 skills with the highest weights):

Microsoft Excel	*Microsoft Office*	*Data analysis*	*SQL*	*Microsoft Power-Point*	*Microsoft Word*	*Python*	*Research*	*Leader-ship*	*R*

The problem with the member count approach, as evident from the above example, is that a set of generic, cross-functional skills such as Microsoft Excel and Microsoft Office occupy the top spots in the skills vector. These skills are hardly representative of the group of people under consideration. We find this is often the case for all industries. We address this in two ways.

First, we match positions with skills added during the period that a position is held because we find that members are likely to include generic and cross-functional skills in their profile even if these skills are not representative of the industry they work in. Such skills are often not added as they are acquired or as a result of experience on the job. We call the approach of associating skills only with positions during

33 A skill vector includes all the skills that are relevant to an industry in a country. This ensures that all skill vectors have the same length so that skill vectors for different industries and different countries can be compared. If a particular skill is not relevant to an industry in a country, the weight would be 0.

which the skills are added a "skills flow" approach, versus a "skills stock" approach, in which we associate all the skills on a member's profile added before and during the time that a job title or position was held with that or a previous job. Career trajectory is often nonlinear; when members switch occupations or industries, skills acquired in previous jobs are not necessarily associated with future jobs. The "skills flow" approach is more likely to discern changes in skills composition over time than the "skills stock" approach because emerging skills are less likely to be buried in the large number of historical skills that members have from long ago. In the illustrative case above, matching positions with skills added on the job results in the following skill vector.

Data analysis	*SQL*	*Python*	*Tableau*	*Microsoft Excel*	*Microsoft Office*	*R*	*Microsoft Power-Point*	*Microsoft Word*	*Hive*

We further adjust the weight to downweight skills that are common in many industries. For each skill *s* in industry–country pair *i*, the weight is computed as:

$$w_{i,s} = m_{i,s} * \ln\left(\frac{N}{n_s}\right)$$

where $m_{i,s}$ indicates the number of members in the industry–country pair *i* having skill *s*, *N* is the total number of industry–country pairs, and is the total number of industry–country pairs having skill *s*. The second logarithmic term downweights skills that are common in many industries. For example, if a skill appears in every industry and country, then *N* equals n_s. The second term and the final weight would both be close to 0. In other words, the skill is not representative of any particular industry in any country. This weighting scheme is one form of the term frequency–inverse document frequency (TF-IDF) technique commonly used in text mining.

After applying the TF-IDF technique, we have the new weighted skill vector:

SQL	*Tableau*	*Python*	*Data Analysis*	*Hive*	*R*	*Machine learning*	*Data mining*	*Post-greSQL*	*Data visu-alization*

We use skills added in 2015, 2016, and 2017 separately to compute the top represented skills for each year. This provides a time series to discern changes in skills needs of an industry over time. For each industry-country pair, we rank the top represented skills according to the descending order of their weight to derive the top represented skills for each industry and each country.

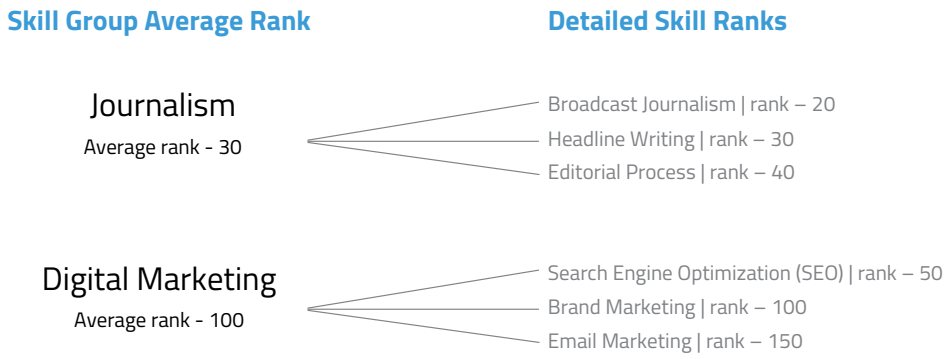
ii Aggregating Skills to Groups of Skills

LinkedIn has an enormous library of individual skills. For ease of analyzing meaningful general trends of skills, we group individual skills into broader categories. For example, Python and C++ are grouped into a development tool skill group, and online marketing and search advertising are grouped into a digital marketing skill group. To construct the skill groups, skills are clustered based on the likelihood of co-occurrence of skills on LinkedIn profiles. A detailed list of skills and their corresponding skill groups can be found in Appendix F.

For an industry-country pair, based on the list of top represented skills, we average the ranking of all the skills in a given skill group to arrive at the average ranking of the skill group. We perform this exercise for each skill group. As a dummy example, for the online media industry in a country, we would compute the skill group average rank for two skill groups—journalism and digital marketing—as shown in figure IV-8.

FIGURE IV-8:

Example of Aggregating Detailed Skills into Skill Groups



BOX 5:

Calculating digital marketing skill group's penetration rate in information and communications technology (ICT) and services industry

We illustrate how skill group penetration is calculated using the digital marketing skill group and the ICT and services industry as an example. The digital marketing skill group includes 77 skills, such as online marketing and search engine optimization. The global ICT and services industry includes more than 1,300 occupations, such as software engineer and digital marketing specialist in 2015.

Of the 30 top represented skills of a digital marketing specialist in the ICT and services industry, 13 belong to the digital marketing skill group, which as a result, has a 43% (13/30) penetration rate for digital marketing specialists in the ICT and services industry. By the same means, we can calculate the digital marketing skill group penetration rate for software engineers, which, not surprisingly, is 0%.

Lastly, we perform the same digital marketing skill group penetration calculation for all the other occupations in the ICT and services industry and then average penetration rates for these occupations to arrive at a 1.4 percent skills penetration rate for the digital marketing skill group in the ICT and services industry in 2015.

To identify the top represented skill groups for each industry globally, for each skill group–industry pair, we take an average of the ranking of the skill group across all the countries. Then, for each industry, we rank the skill group according to its average ranking.

(2) Skill Penetration Rate

There are four steps in computing the penetration rate of a skill group for an industry. First, we use the industry skills needs framework developed above to calculate the weight for each skill *s* for each occupation o in industry i:[34]

$$w_{i,o,s} = m_{i,o,s} * \ln\left(\frac{N}{n_s}\right)$$

We then construct a skill vector of the 30 top represented skills for each occupation *o* in industry *i*, based on the values of $w_{i,o,s}$:[35]

$$[(s_1, w_1), (s_2, w_2) \ldots, (s_{30}, w_{30})]$$

Second, we measure how prevalent a skill group is in an industry–occupation pair. For the top 30 skills, we count the number of skills for each of the skill groups. In the top 30 skills, the more skills showing up for a skill group, the more important that skill group is for an industry–occupation pair. We limit to the top 30 skills to make sure that we focus on the part of the skill vector that is of better quality and has less noise.

Third, we calculate the skill group penetration rate at the occupation-industry level $p_{i,o,S}$ by dividing the number of skills *s* in the skill vector that belong to the same skill group S according to the total length of the vector. Because the skill vector is cut off at the top 30 skills, the denominator is 30 for all industry–occupation pairs:

$$p_{i,o,S} = \frac{\sum_{s=1}^{30} s \in S}{30}$$

Lastly, we take an average of the skill group S penetration rate $\bar{p}_{i,S}$ for all occupations o in each industry *i* to generate the industry-level skill group penetration rate:[36]

$$\bar{p}_{i,S} = \frac{\sum_{o=1}^{n} p_{i,o,S}}{n_i}$$

We do this for different time periods to generate the time trends for skill penetration.

34 We do not create skill profiles at the occupation–industry–country level because we do not have sufficient skills data to do so. Instead, we create skill profiles at the occupation–industry level.

35 We restrict the dataset to industry–occupation pairs that have more than 30 most-represented skills to maintain sufficient skill data to compute skill penetration rates.

36 For example, the accounting skills group can appear in many occupations in the finance industry; hence we need to average across occupations within the finance industry to calculate the accounting skill penetration rate.

2) Validation Results

Because there is no direct measure of skill penetration rate by industry for each country, we validate the metric by comparing skills similarity of country A and the United States and country A's development outcomes with those of the United States; this requires the assumption that, if a country has a skills composition similar to that of the United States in the same industry, it should generate development outcomes similar to those of the United States, such as ICT development level. To limit this validation exercise to a workable scope, we focus on the ICT sector.

Having skills vectors for two industry–country pairs (G_1 and G_2), we can compute skill similarity between the countries by computing cosine similarity between the two vectors:

$$Skill\ similarity = \frac{G1.G2}{|G1| * |G2|}$$

Where, for each industry *i* and a total of *n* skills, each G is $[w_{1i}, w_{2i} \ldots w_{nj}]$ Cosine similarity is invariant to country size, and thus neither country size nor LinkedIn membership size biases it.[37]

Then, we collect information on two development outcomes[38]—PIAAC problem-solving skills score and ICT development index—and correlate these outcomes with the skills similarity index for each country. A description of each of the two development outcomes are as follows:

(1) PIAAC ICT Skills Score of Problem Solving in Technology-Rich Environments

We correlate the skill similarity of ICT industries around the globe with the test scores of these same set of countries in the problem solving in technology-rich environments (PS-TRE) section of PIACC 2016. The PIAAC is an international assessment of adult skills that the OECD manages, with data available for 34 countries in 2015. It focuses on three kind of skills: literacy, numeracy, and PS-TRE.[39]

PS-TRE is divided into four levels of proficiency (Levels 1 through 3 plus below Level 1). The features of the tasks at these levels are described in detail in Table 2.3 of an OECD skills study.[40] We used two indicators for the validation exercise: PSL11, which is the proportion of individuals aged 16 to 65 scoring at Levels 2 and 3 in PS-TRE, and the mean score of the Level 3 performers (IT Level 3). To test the correlation of these indicators with our skill similarity measure, we used the United States as the benchmark country.

(2) ICT Development Index Data

The ICT Development Index,[41] is available from 2009 to 2017 for 176 countries. It combines 11 indicators into one benchmark measure[42] and is used to monitor and compare developments in ICT between countries and over time and the extent to which countries can make use of them to enhance growth and development in the context of available capabilities and skills. To test the correlation of these indicators with our skill similarity measure, we used the United States as the benchmark.

37 For example, if a country doubles in size, as long as the number of skills members have increases proportionately, the cosine similarity will remain the same.

38 We also consider value added per worker (OECD, ILO, and WBG data) at the industry level to correlate with the skills similarity index as an additional validation check. Although correlation results are positive (yet insignificant), there are too many confounding factors for clear interpretation of correlation results. For example, if the elasticity of output with respect to materials is different, or if there are frictions such as adjustment costs in capital that prevent the efficient use of capital to generate output, even though countries may have the same skill composition, their value added per worker may differ.

39 In PIAAC, PS-TRE is defined as using digital technology, communication tools, and networks to acquire and evaluate information, communicate with others, and perform practical tasks. PS-TRE assesses the cognitive processes of problem solving—goal setting, planning, selecting, evaluating, organizing, and communicating results. The core aspects of the PIAAC PS-TRE assessment requires mastery of foundational computer (ICT) skills, including skills associated with manipulating input and output devices (e.g., mouse, keyboard, digital displays), awareness of concepts and knowledge of how the environment is structured (e.g., files, folders, scrollbars, hyperlinks, menus, buttons), and ability to interact effectively with digital information (e.g., commands such as save, delete, open, close, send). It involves familiarity with electronic texts, images, graphics, and numerical data and the ability to locate, evaluate, and critically judge the validity, accuracy, and appropriateness of accessed information.

40 See **https://www.oecd-ilibrary.org/education/skills-matter_9789264258051-en**.

41 See **http://www.itu.int/net4/ITU-D/idi/2017/index.html**

42 The ICT development process and a country's evolution toward becoming an information society can be depicted in three-stages: readiness, intensity, and impact. Based on this conceptual framework, the ICT Development Index is divided into three subindices and 11 indicators: **the access subindex** captures ICT readiness and includes five infrastructure and access indicators (fixed-telephone subscriptions, cellular telephone subscriptions, international Internet bandwidth per user, households with a computer, households with Internet access); the **use subindex** captures ICT intensity and includes three intensity and usage indicators (individuals using the Internet, fixed broadband subscriptions, mobile-broadband subscriptions); and the **skills subindex** captures capabilities or skills that are important for ICT and includes three proxy indicators (mean years of schooling, gross secondary school enrollment, gross tertiary school enrollment). Because these are proxy indicators of ICT-related skills, they are given half the weight of the other two subindices.

(3) Correlation Results

We find evidence that skill differences could explain differences in ICT-related development measures between countries for members working in the information and communication industry. We correlated a skill similarity measure with indicators of the PIACC skills score in a technology-rich environment and ICT development (relative to the United States). This contributes to the literature on the economics of education that investigates the role of human capital in economic performance and typically references education and standardized test rankings.

For each subindustry within the ICT sector, we found a positive correlation between the skills similarity index and ICT skills scores in the PS-TRE section of the PIAAC (table IV-1).

For skills difference and the ICT development difference, the correlation was significant for four subindustries within the information and communication sector (r=0.41–0.64), with subindustries such as programming and information services scoring highest.

Once we control for a specific occupation within the ICT sector, our correlation results improve. Looking at the skill vector of software engineers in the entire information and communication sector, we found that our measure of skill similarity to the United States is positively correlated with the proportion of individuals aged 16 to 65 scoring at Levels 2 and 3 in PS-TRE (PLS11) and the mean score of the Level 3 performers (ICT Level 3); both correlations are statistically significant ($p< 0.05$) (table IV-2).

TABLE IV-1:

Correlations Between Skills and Development Outcomes

(United States as the Benchmark)

VARIABLE	ITLEVEL3	OBS	PSL11	OBS	ICT-DI	OBS
Section J						
Programming	0.504**	21	0.406*	21	0.638***	53
Information services	0.407*	21	0.319	21	0.480***	53
Comunication	0.105	21	0.026	21	0.449***	52
Telecommunications	0.218	21	0.087	21	0.412***	53
Broadcasting	0.354	21	0.253	21	0.211	52
Publishing	0.138	21	0.144	21	0.115	53

TABLE IV-2:

Correlations with Software Engineer in Section J Skills Vector

(United States As the Benchmark)

VARIABLE	ITLEVEL3	OBS	PSL11	OBS	ICT-DI	OBS
Section J						
Software Engineer	0.612	22	0.608	22	0.518	53
T-stat	3.460		3.428		4.329	
P-value	0.002		0.003		0.000	

C. TALENT MIGRATION METRICS

a) Overview

Monitoring international flows of migrants is critical to designing effective talent attraction and retention policies, but migration data tend to be coarse, inconsistent between countries, expensive to gather, and available only with considerable delay. This section presents LinkedIn profile data as an alternate source for measuring migration and how these data compare with OECD migration flows data. A natural derivation of the talent migration metric is an examination of skills gained and lost, as well as the industries associated with these talent movements. Although there is no equivalent dataset for validation of these latter two derived metrics, their formulas are presented in the methodology section below.

b) Methodology

We compare migration outflows for 2015, normalized for LinkedIn country member counts at the end of 2015 (for calculating migration rate using LinkedIn data) and OECD population figures for 2015 from the country of origin (for calculating migration rate using OECD data), which is denoted as country A below, interpreted as flows from country A to country B normalized for country membership per 10,000 members.

$$Normalized\ migration\ outflows_{a,b} = \frac{Total\ outflows_{a,b}}{Member\ count_{a,2015}} * 10{,}000$$

LinkedIn data allow a country to identify the skills and industries gained or lost in association with migration trends. Although these metrics are not validated against external sources at this stage, because there are no equivalent official data for validation, the specifications are presented below.

BOX 6:

Pilot Country 2–Talent and Skill Migration, Macedonia

The World Bank Group–LinkedIn partnership was able to provide the Macedonia Systemic Country Diagnostic team with insights into skills gap and migration trends across knowledge sector industries in Macedonia. In Macedonia, analysis of LinkedIn data was able to shed light on the skills, especially managerial and other high-value added skills, that Macedonia has been losing to western European countries in recent years.

LinkedIn data migration metrics indicate that, of the 24 Eastern European and Balkan countries, Macedonia ranked fourth in terms of net outflow of talent from 2015 to 2017 (after Moldova, Armenia, and Bosnia). Of these workers, the most likely to emigrate are high-skilled workers, in particular those with management, research, and leadership skills. Further analysis showed that these skills are also highly desirable domestically. This makes the workforce development and retention program in Macedonia difficult, and the problem is likely to worsen as Macedonia becomes more integrated with the European Union. The analysis showed that, as Macedonians acquire desirable skills, workers with these skills have stronger incentives to emigrate.

Skills with highest rate of emigration among LinkedIn users in FYR Macedonia, 2014-2016

1. Management
2. Research
3. Leadership
4. Training
5. Government
6. Supervisory Skills
7. Customer Service
8. Teamwork
9. Project Planning
10. Analytical Skills

Source: Authors' calculation using LinkedIn data.

Industry migration for country A as the country of interest and country B as the source of inflows and destination for outflows, both considered for industry *i* at time *t*, are calculated as follows,

$$Net\ industry\ migration_{a,b,i,,t} = \frac{Net\ industry\ flows_{a,b,i,,t}}{Member\ industry\ count_{a,i,t}}$$

Net flow is defined as arrivals minus departures.

Similarly, skill migration is considered for skill *s* at time *t* for country A as the country of interest and country B as the source of inflows and destination for outflows.

$$Net\ Skill\ migration_{a_s,b_s,t} = \frac{Net\ skill\ flows_{a_s,b_s,t}}{Member\ skill\ count_{a_s,t}}$$

All three of the above metrics may be applied to LinkedIn data at the country and city level as long as sample size allows. Validation results for talent migration at the country level are shown in the validation results section.

BOX 7:

Pilot Country 3—Intercity Migration Trends in China

The World Bank Group—LinkedIn partnership supported the World Bank *Mid Term Assessment of Beijing's 13th 5-Year Plan: Note on Innovation and Local Economic Development* (World Bank 2018). The analysis focused on using LinkedIn data to determine talent movements within China, in particular with respect to Beijing, and the skill composition of the workforce in relation to frontier industry development, such as artificial intelligence.

The analysis shows that Beijing is net losing talent to other first-tier cities in China and globally, which can prevent Beijing from achieving its structural transformation target of becoming an innovation-driven economy. For example, when examining talent migration between Beijing and Shanghai from 2015 to 2017, the data show that absolute departures from Beijing to Shanghai were consistently higher than arrivals, with Beijing losing a net of approximately 90,000 people to Shanghai on average each year from 2015 to 2017. Examining the data to determine which industries this talent loss affects most shows that the software and information and communications technology (ICT) industry in Beijing seems consistently to lose talent to other cities.

While more research is needed to explore the reasons behind these trends, this result is probably expected because of Beijing's unique function as the capital and political center of China; Shanghai and other cities have more commercial functions that are conducive to private sector growth. Nonetheless, to reach Beijing's goal of transforming the economy into an innovation-driven model, retaining specific groups of top talent in the priority sectors with more senior positions will be a challenge going forward.

Top Five Industries in Which Beijing Had a Net Loss of Talent to Other Cities (2015-2017)

Shanghai	Shenzhen	New York City
1. Finance	**1. Software and ICT Services**	1. Education
2. Software and ICT Services	2. Finance	**2. Software and ICT Services**
3. Manufacturing	3. Hardware and Networking	3. Public Administration
4. Corporate Services	4. Consumer Goods	4. Media and Communications
5. Media and Communications	5. Manufacturing	5. Nonprofit

Source: Authors' calculation using LinkedIn data.

c) Validation Results

(1) Talent Migration Globally

The correlation of all 1,447 country pairs (figures IV-9), without removing outliers, is positive with a coefficient of 0.304 (p=0.001). Many of these outliers correspond to inflows middle-income countries in Eastern Europe and from countries such as Syria, Turkey, and others in Northern Africa and the Middle East (driven by the refugee crisis) to Germany and from middle-income countries in Latin America and the Caribbean to the United States. Removing these increases the correlation (Pearson product-moment correlation=0.439, p=0.001). We also address these outliers and differences in scale by log-transforming both outflow rates. These log-transformed rates are highly correlated (Pearson product-moment correlation=0.804, p=0.001).

(2) Talent Migration According to Income Group

Considering the data in subsets by income group leaves four of 16 subsets with at least 30 country pairs to correlate (figure IV-10). The data limitations are due to lack of OECD data availability, because the OECD offers inflow data only for OECD countries. Using the data available, LinkedIn best tracks migrations between high-income countries, probably because economic migration of skilled workers (a group that LinkedIn is more likely to capture) makes up a larger share of the migration between those countries than between low-income countries, where it is more likely that migration is forced.

(3) Talent Migration According to World Bank Region

Considering the data according to World Bank region leaves 13 of 49 possible subsets with at least 30 country pairs to correlate (figure IV-11). Migration rates correlate best in markets where LinkedIn is widely adopted in the origin and destination regions. For example, correlations of migration rates between LinkedIn and OECD data of North Americans moving to Europe and Central Asia (0.91) or Latin Americans moving to North America (0.92) are among the strongest. Conversely, correlations of migration rates from countries in the Middle East and North Africa (0.43), where LinkedIn is less prevalent, to North America are weaker.

FIGURE IV-9:

Log-Transformed Outflow Migration Rate: Organization for Economic Cooperation and Development (OECD) vs. LinkedIn Data

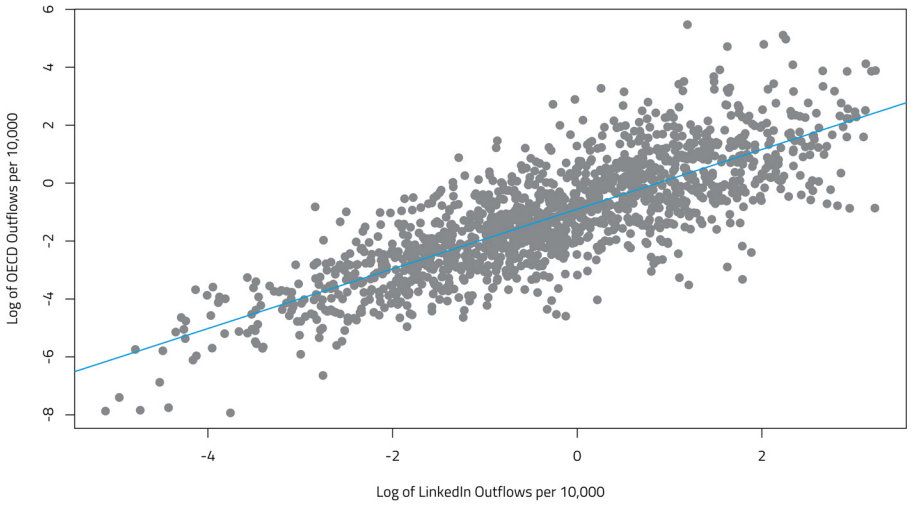


FIGURE IV-10:

Migration Correlation Results According to Income Group

(Log-Transformed)

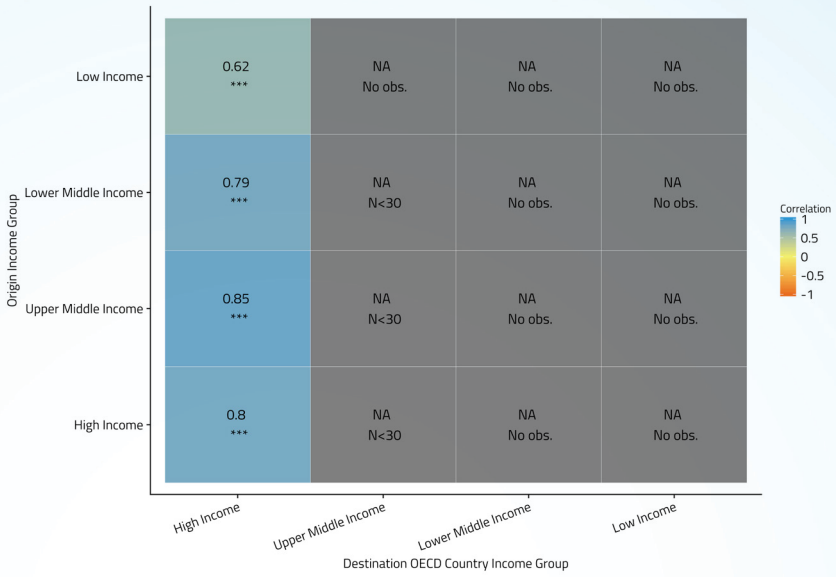
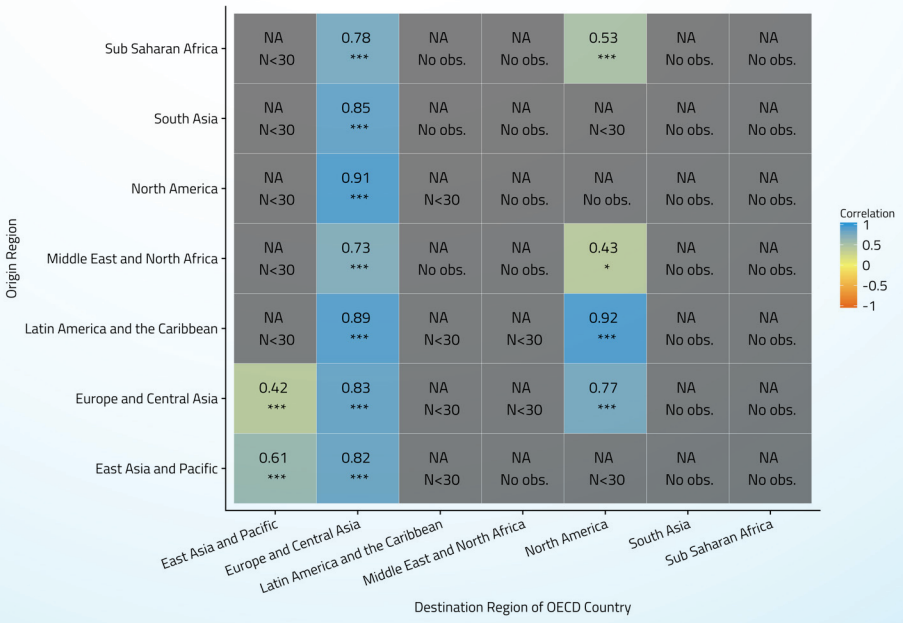


FIGURE IV-11:

Migration Correlation Results According to World Bank Region

(Log-Transformed)



V. Sample Visual Outputs and Country Applications

Now that we understand LinkedIn data's main characteristics and the derived metrics that are made available under this WBG-LinkedIn partnership, in this section we provide some examples of how we transform these metrics into benchmarking visuals and apply them to World Bank projects. All these visuals and the underlying dataset are available at **linkedindata.worldbank.org**.

The full range of metrics is available at the country and city level. Country-level examples are shown in this report, with similar methodologies applied at the city level. Furthermore, given the intended audience, use, LinkedIn data characteristics, and global workforce coverage rate, all visuals are limited to six knowledge-intensive tradable sectors[43] to ensure that global benchmark results are based on a large-enough sample size, with fair sample representativeness for all countries. Finally, to control for noise and make the skills metric more useful for policy makers, skills are reported at the skills group level. This maintains some level of detail but ensures a large enough sample to conduct skills analysis. (For example, we report the robotics skill group instead of mechatronics skill, which is one of the detailed skills within robotics.) The LinkedIn data have approximately 250 skill groups, which include approximately the 10,000 most-reported detailed skills on LinkedIn. As new skills emerge on the LinkedIn platform, the skills taxonomy will be updated to reflect the latest skills trends.

The sample visual outputs are presented in the following sections. Section A provides insight into the comparative advantage of a country in industry employment concentration and the latest industry employment shifts. Section B covers the latest skills metrics to inform workforce planning and training policies. Section C covers talent migration trends and the associated skills and industries that are gained and lost. To ensure fair and ethical use of LinkedIn member profile data, each metric in the visual outputs is based on aggregated measures—the most-detailed level of observation in the dataset must reach at least 50 observations to report an aggregated value, and a minimum of 100,000 members in a country is necessary for inclusion in the dataset and analysis.

A. INDUSTRY EMPLOYMENT DYNAMICS

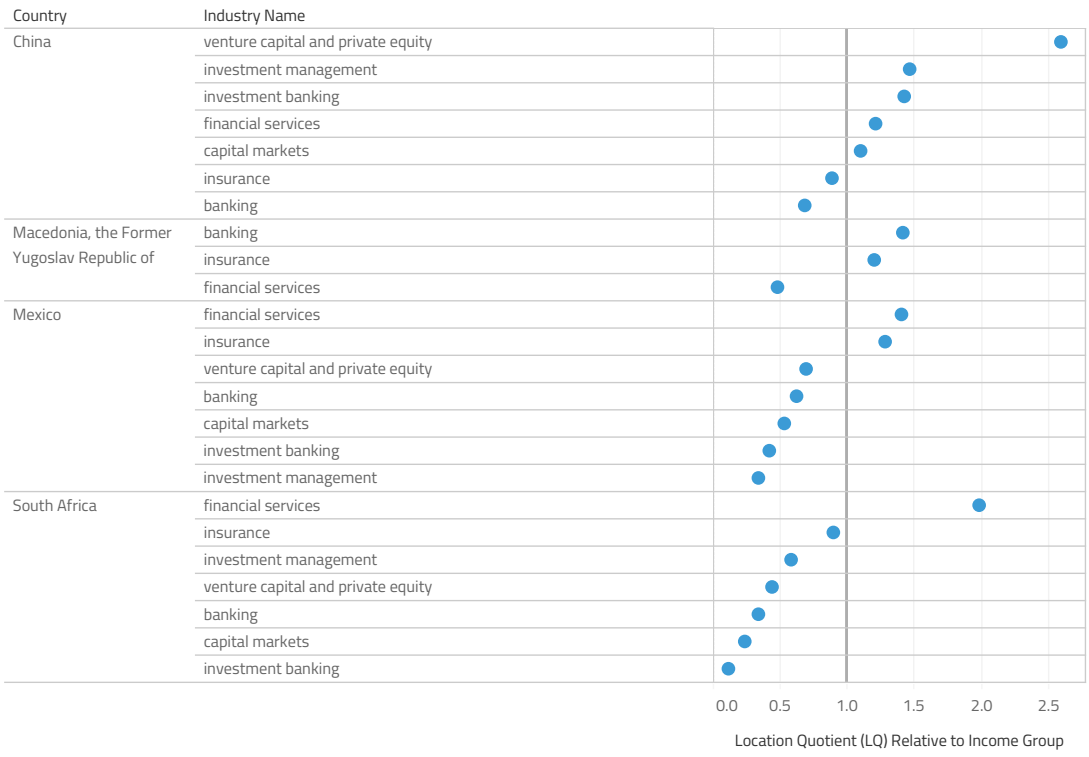
Sample visual outputs begin with an overview of sectoral employment concentration in a country, given as a summary of sectoral employment location quotient. This allows policy-makers to gain a quick understanding of a country's employment composition and comparative advantage with regard to industry employment concentration in the six knowledge-intensive and tradable sectors that this LinkedIn dataset captures.

Sample standout industry outputs in the finance and insurance sector are shown for four pilot countries (figure V-1). This overview of industry employment location quotient serves as a quick sector scan that can inform subsequent

43 These six knowledge-intensive and tradable sectors, using ISIC 4 classification, are: B-mining and quarrying; C-manufacturing; J-information and communication; K-financial and insurance activities; M-professional, scientific, and technical activities; and R-arts, entertainment and recreation.

FIGURE V-1:

Industry Employment Size Location Quotient for the Finance and Insurance Sector in China, Macedonia, Mexico, and South Africa



Source: Authors' calculation using LinkedIn data.

industry deep dives. The visual shows industries that fall below or above the income group average employment size (1.0) and the magnitude to which they fall behind or surpass their income group peers. For example, in China, the relative employment size in the venture capital and private equity industry is substantially larger than the average of all upper-middle-income countries. Only subindustries that have at least 50 observations[44] are included (which explains why Macedonia has fewer subindustries in the finance and insurance sector).

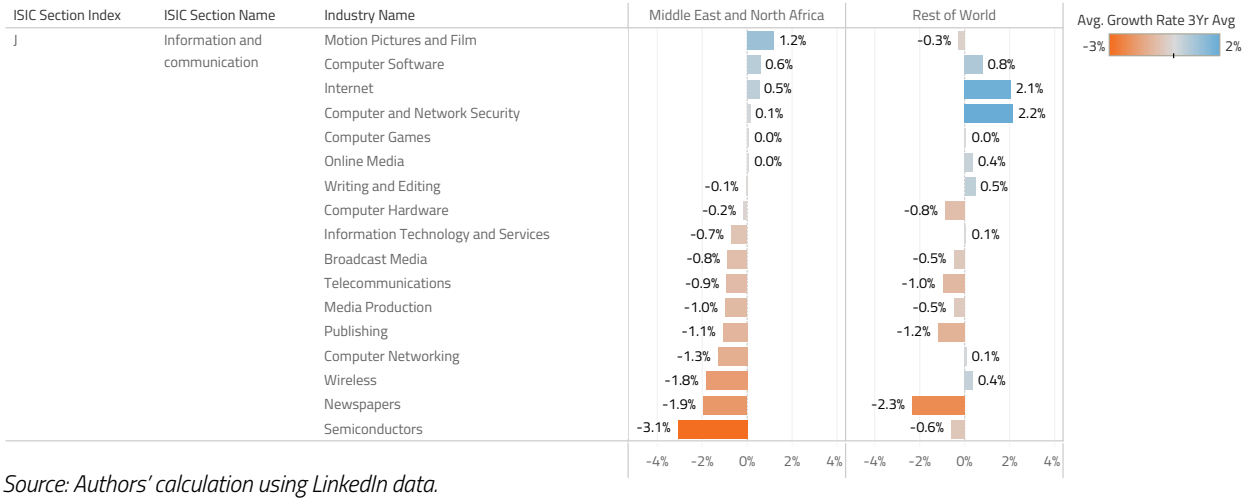
After examining static comparative advantage in industries, one important value addition of the LinkedIn data is that they can reflect intra- and interindustry headcount change in near real time; we translate this dynamic into an industry employment growth visual. This visual can be particularly useful for policy-makers who need to decide on and track the performance of strategic industries in a country, in a region, or globally (figures V-2, V-3, V-4, and V-5). For example, one can compare information and communication sector growth in the Middle East and North Africa with global growth trends (figure V-2). The results show that the Middle East and North Africa largely tracks global employment trends in this sector. For example, the online media industry is growing at approximately 10 percent in the Middle East and North Africa, versus approximately 5 percent globally, but still lags in some important emerging sectors, such as the Internet and computer network and security.

44 To ensure data quality, the more-stringent industry categorization method was applied for this visual; instead of the self-reported industry that a member says she or he belongs to in her or his profile, we examine the company this person works for and which industry it belongs to. This dramatically decreases the sample size because many companies cannot be easily mapped to an industry.

FIGURE V-2:

Growth from Industry Transitions in the Information and Communication Sector

Annual Average 2015-2017



Source: Authors' calculation using LinkedIn data.

BOX 8:

Should We Weight the LinkedIn Data to Obtain a Representative Sample When Conducting Global Benchmarking?

As described in the LinkedIn data description and validation sections of this report, LinkedIn data should not be treated as a random sample of a country's workforce. With regard to industry employment, the LinkedIn user base presents a definable bias in industry distribution and varied levels of market coverage in different countries and regions (See Section III).

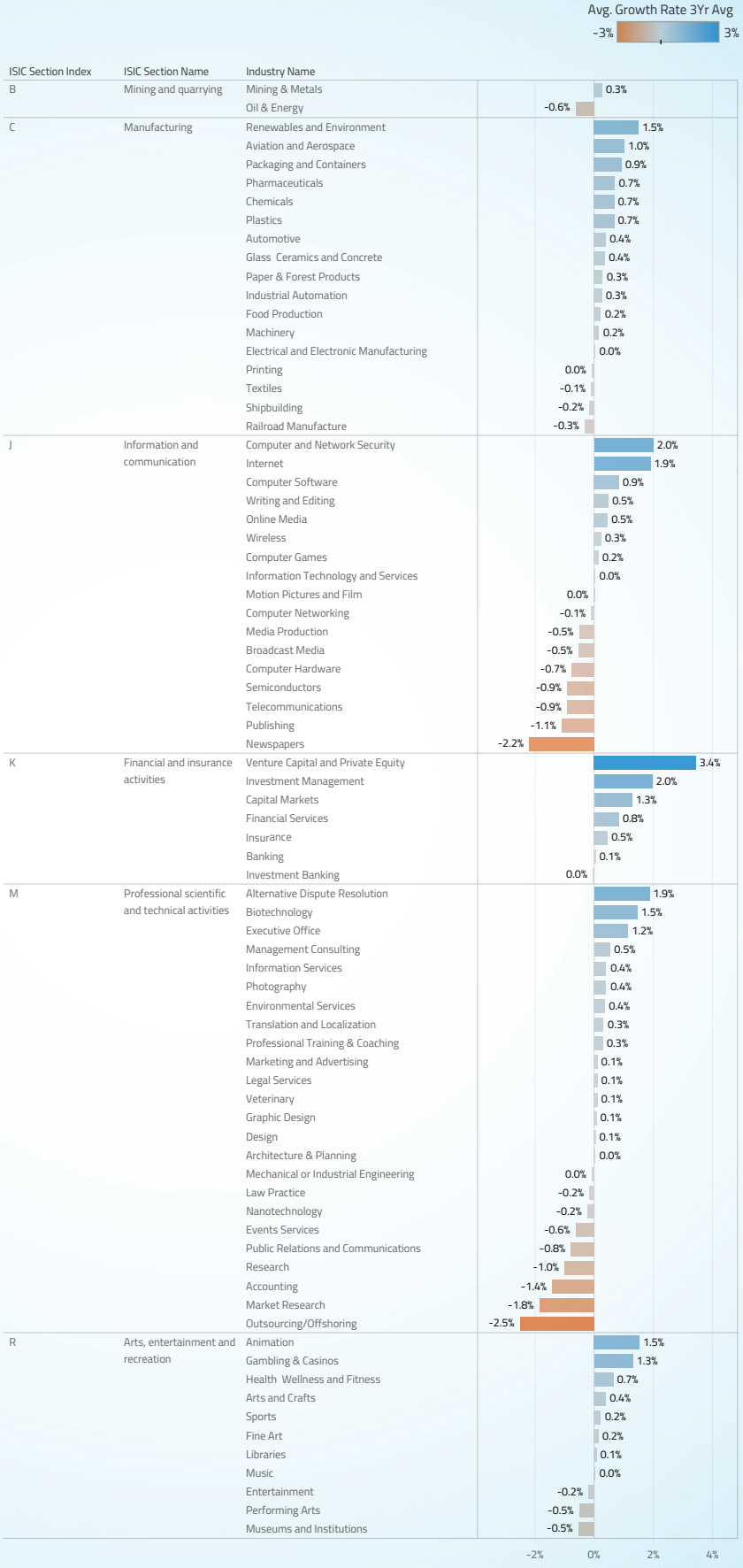
To address varying sample size and skewed industry distribution, the use of weights, given according to country population, and industry employment count (from local government or international statistics) to reweight LinkedIn data was explored. This would allow the LinkedIn member base to be rescaled to a representative sample. A critical obstacle to this approach is lack of sufficient government data on industry employment distribution for the wide range of countries available in the LinkedIn dataset. Furthermore, to impose weights on LinkedIn data, the LinkedIn classification of industries (two- to three-digit International Standard Industrial Classification equivalent) would require restructuring and matching with external sources and their varied definitions of industry activities according to country. Such an approach would be unlikely to address the full complexity of skewness (e.g., occupation skewness: management, technical, and sales occupations in the manufacturing sector are more likely to be on LinkedIn than factory floor workers).

In the interest of avoiding excessive manipulation of the data, LinkedIn data are not reweighted. Instead all industry employment metrics are reported as relative measures based on a country's membership size (as a percentage of total LinkedIn members in a country).

FIGURE V-3:

Growth from Industry Transitions Worldwide in 100+ Countries

Annual Average 2015-2017



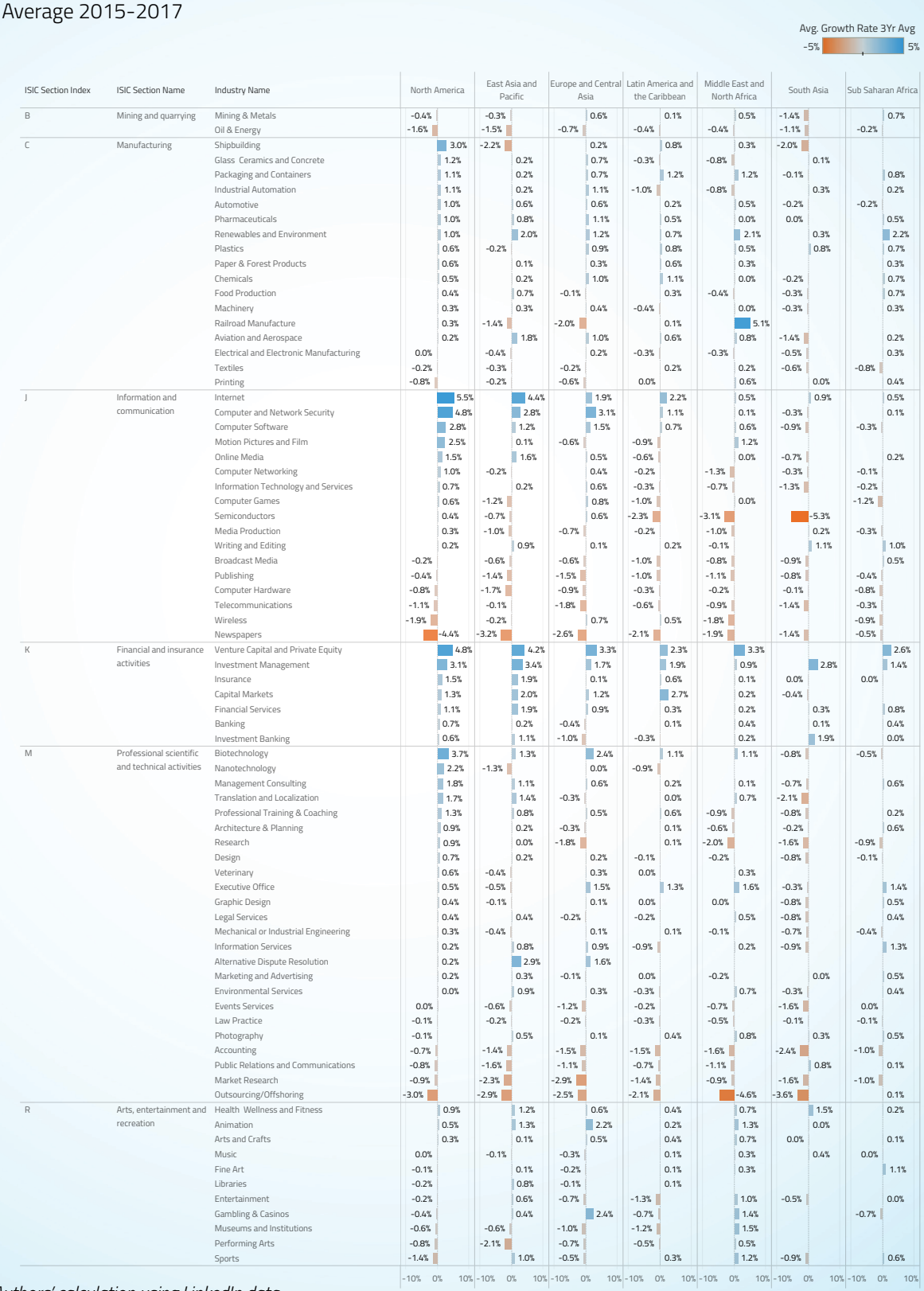
Note: Industries where N<5 countries are removed

Source: Authors' calculation using LinkedIn data.

FIGURE V-4:

Growth from Industry Transitions According to World Bank Region

Annual Average 2015-2017

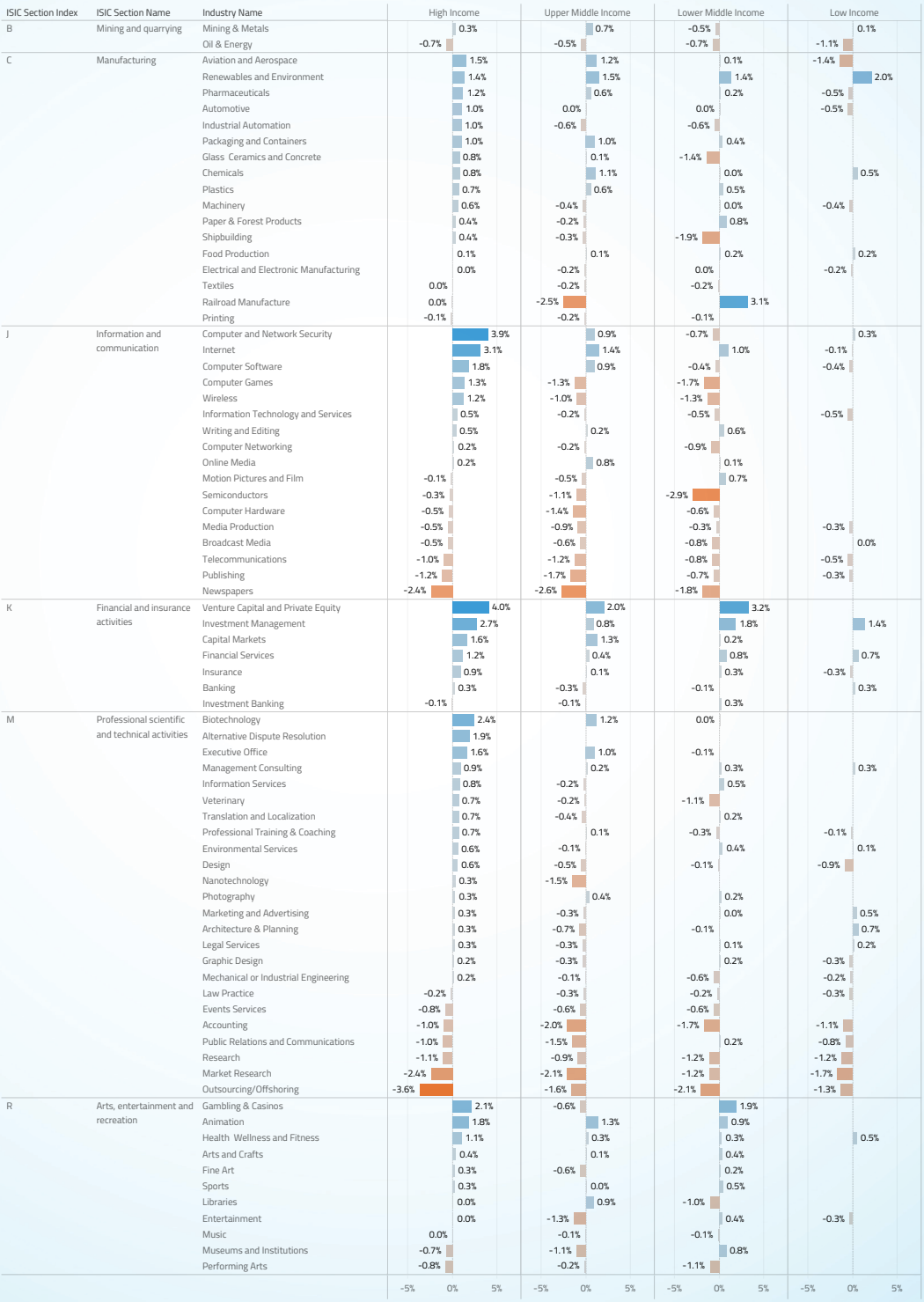


Source: Authors' calculation using LinkedIn data.

FIGURE V-5:

Growth from Industry Transitions According to Income Group

Annual Average 2015-2017



Note: Industries where N<5 countries are removed

Source: Authors' calculation using LinkedIn data.

B. SKILLS

After examining the latest industry employment dynamics, this section explores the latest skills insights according to industry. All visuals are reported at skill groups level that covers the 10,000 detailed skills most commonly seen on LinkedIn. For example, the output below shows the 10 most-represented skill groups in the online media industry globally (figure V-6).[45]

Readers will be able to choose a skill group and see which industries are currently applying these skills in developed and developing countries. One advantage of LinkedIn skills data is the ability to track emerging skills. For example, disruptive technology skills are widely reported in developing countries; almost all 100+ countries in the LinkedIn dataset possess some type of disruptive technology skills, although they are more concentrated in a small number of industries in developing than developed countries. The example below shows the industries with the highest artificial intelligence skill penetration globally (figure V-7) .

FIGURE V-6:

Most-Representative Skill Groups for the Online Media Industry Globally

1. **Social Media**
2. **Journalism**
3. **Editing**
4. **Writing**
5. **Digital Marketing**
6. **Advertising**
7. **Graphic Design**
8. **Photography**
9. **Oral Communication**
10. **Digital Literacy**

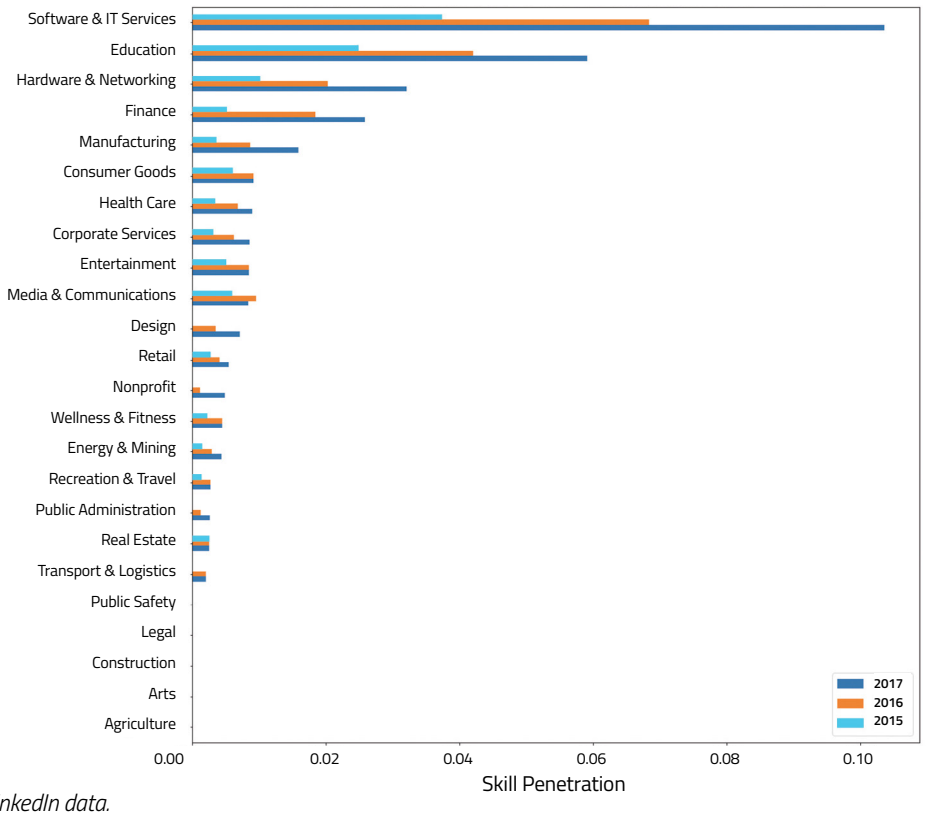
Source: Authors' calculation using LinkedIn data.

C. TALENT MIGRATION

The use of LinkedIn data to monitor international flows of talent allows policy-makers to shape their talent attraction and retention programs and assess the health of a country's talent pipeline. A key value addition of LinkedIn data is the

FIGURE V-7:

Top Industries Using Artificial Intelligence Skill, Globally 2015-2017



Source: Authors' calculation using LinkedIn data.

45 A detailed classification of individual skills into categories and groups can be found in Appendix F.

BOX 9:

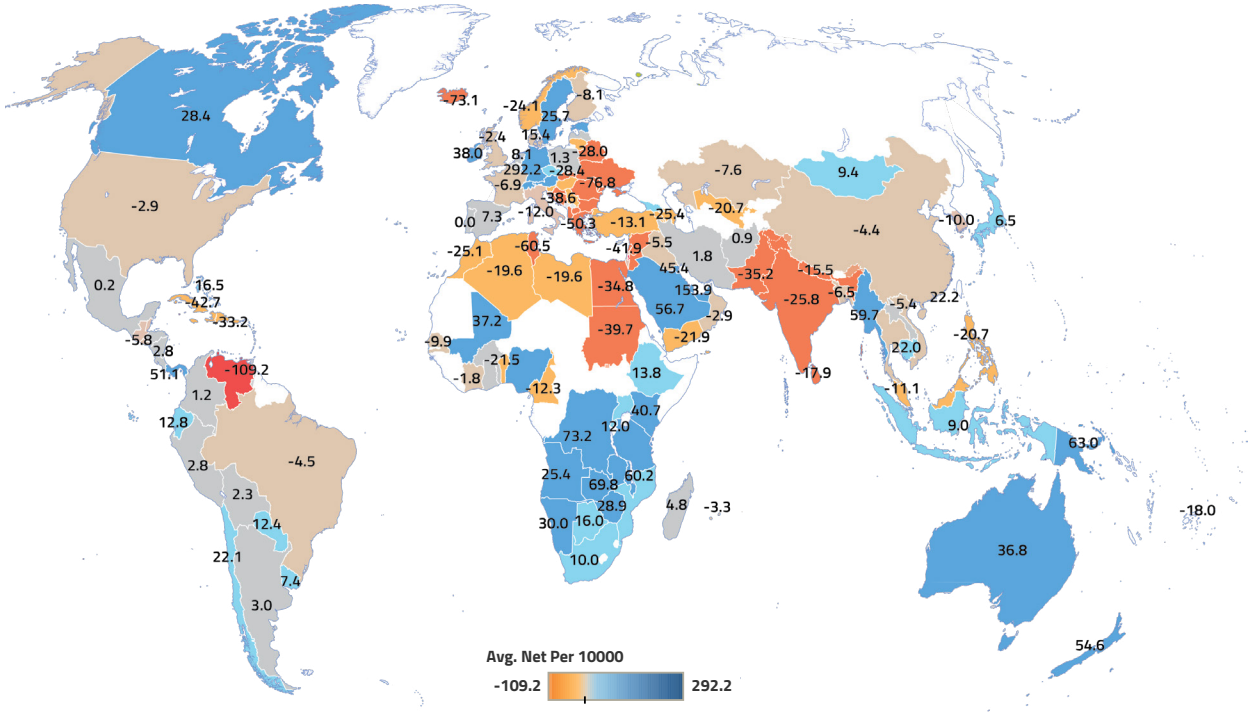
How to Compare Migration Flows Between Countries Fairly

LinkedIn membership varies considerably between countries, which makes it difficult to interpret absolute movements of members from one country to another. For example, comparing an absolute inflow from country X of 1,000 LinkedIn members to Mexico with an inflow from county Y of 100,000 LinkedIn members to Mexico is misleading. Given various levels of LinkedIn membership, the appropriate question is how to compare migration flows between countries fairly using a normalization method.

The first strategy that the team considered was weighting LinkedIn membership in each country according to the population or workforce from official statistics, but official statistics are not sufficient to address the various sources of bias (industry bias, occupation bias). An alternative is to construct migration flows normalized according to country of interest. For example, if Mexico is the country of interest, all absolute net flows into and out of Mexico, regardless of origin and destination countries, are normalized according to LinkedIn membership in Mexico (and multiplied by 10,000). Hence, this metric gives readers the relative scale of the effects of talent migration from all countries on Mexico. It is likely that the net outflow from Mexico to the United States is larger than to any other country, because it is normalized according to Mexican and not U.S. LinkedIn membership.

FIGURE V-8:

Global Talent Migration 2015-2017



Source: Authors' calculation using LinkedIn data.

ability to track talent movements in near real time, as well as the type of industries and skills that are gained or lost in association with these movements. For example, figure V-8 shows that, the OECD on average has a net gain in talent and that some developing countries in the Middle East and North Africa, Latin America and the Caribbean, and South Asia have the greatest net talent loss. Figure V-9 provides an in-depth regional look at Middle Eastern and North African migration rates to and from other countries. Policy-makers in the Middle East and North Africa may want to see whether countries in their region are retaining the talent needed to support their growing industries. Such policy questions can be informed by examining the greatest net gain and loss of skills and industries associated with these talent movements (figure V-10).

FIGURE V-9:

Middle East and North Africa (MENA)

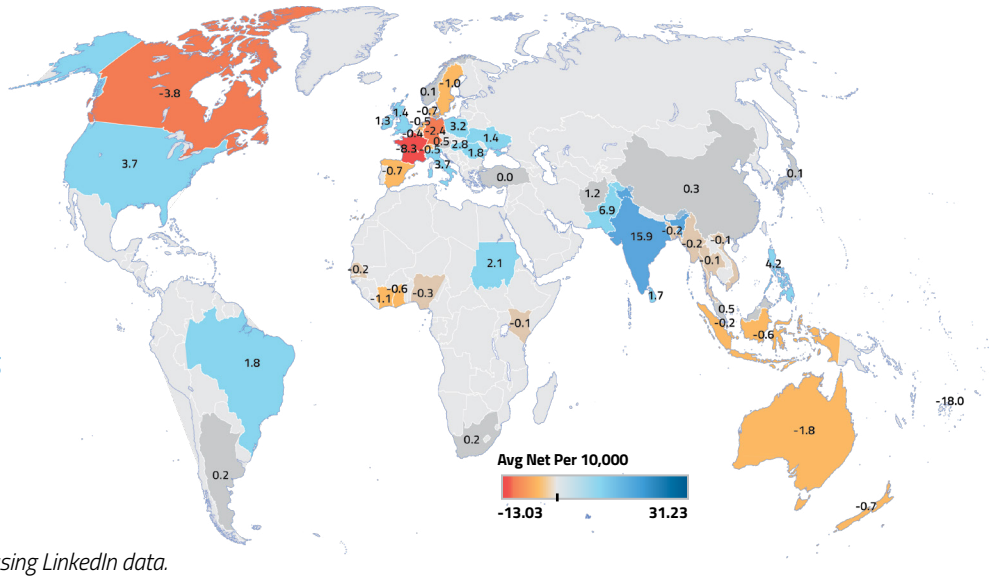
Net Migration Rate per 10,000 LinkedIn Members, 2015-2017

Countries MENA is Losing the Most Talent To:

1. France
2. Canada
3. Germany

Countries MENA is Gaining the Most Talent from:

1. India
2. Pakistan
3. Philippines



Source: Authors' calculation using LinkedIn data.

FIGURE V-10:

Middle East and North Africa Largest Skills and Industry Loss Associated with Talent Movements, 2015 -2017

1 Research	1 Compensation & Benefits
2 Architecture & Planning	2 Partner Development
3 Civil Engineering	3 Artificial Intelligence
4 Info Technology & Services	4 Operational Efficiency
5 Writing & Editing	5 Management Consulting

Source: Authors' calculation using LinkedIn data.

VI. Conclusions

This methodology and validation report is the first attempt to harness the dynamic, fast-growing LinkedIn dataset, which covers more than 100 countries, to support the analytical, advisory, and operational work of the WBG. Although it is promising, it also has limitations because of the low penetration of LinkedIn membership in many developing countries, especially in the nontradable, nontechnology, and nondigital sectors.

The validation results presented here, ranging from industry employment to skills to migration trends, show moderate but positive (~0.30) correlations with LinkedIn data metrics and external sources. Throughout these exercises, metrics derived from LinkedIn data mirror the penetration of LinkedIn membership, favoring middle- to high-income countries and knowledge-intensive and tradable sectors in technology and business occupations—a reflection of LinkedIn member demographic characteristics.

Setting these caveats aside, LinkedIn data have unique strengths in that they enable new insights into the emerging digital sectors and skills, with near real-time updates that are unlikely to be reflected in government statistics. Certain tradable and knowledge-intensive sectors also have good coverage across income levels and geographic locations, which allows for global benchmarking. In this manner, it may from the outset serve as a complementary dataset to other government statistics. With the growing use of LinkedIn, these data can become increasingly relevant for developing countries around the globe. The next step for this partnership is to continue efforts to expand the list of metrics and validation if there is demonstrated user demand for this dataset. The case studies and programming codes using the data for policy analysis will be documented in a central repository on the World Bank github account and serve as a growing reference of the scope and applicability of this innovative, constantly developing dataset.

VII. References

Antenucci, D., M. Cafarella, M. Levenstein, C. Ré, and M. D. Shapiro. 2014. "Using Social Media to Measure Labor Market Flows" No. w20010. Cambridge, MA: National Bureau of Economic Research.

Askitas, Nikolaos, and Klaus F. Zimmermann. 2009. "Google Econometrics and Unemployment Forecasting." *Applied Economics Quarterly* 55 (2): 107-120.

Askitas, Nikolaos, and Klaus F. Zimmermann. 2015. "The Internet As a Data Source for Advancement in Social Sciences." *International Journal of Manpower* 36 (1): 2-12.

Aslett, Matt, and John Abott. 2018. "As Intelligence Becomes Pervasive, Data Becomes the Ultimate Asset." 451-Research.

Boyd, Danah, and Kate Crawford. 2012. "Critical Questions for Big Data: Provocations for a Cultural, Technological, and Scholarly Phenomenon." *Information, Communication & Society* 15 (5): 662-679.

Chancellor, Stevie, and Scott Counts. 2018. "Measuring Employment Demand Using Internet Search Data." *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems.* ACM.

European Commission, Directorate-General for Health and Consumers. 2014. "The Use of Big Data in Public Health Policy and Research."

Gandomi, Amir, and Murtaza Haider. 2015. "Beyond the Hype: Big Data Concepts, Methods, and Analytics." *International Journal of Information Management* 35 (2): 137-144.

Guerrero, Omar A., and Eduardo Lopez. 2017. "Understanding Unemployment in the Era of Big Data: Policy Informed by Data-Driven Theory." *Policy & Internet* 9 (1): 28-54.

Horton, John J., and Prasanna Tambe. 2015. "Labor Economists Get Their Microscope: Big Data and Labor Market Analysis." *Big Data* 3 (3): 13-137.

Johnson, Eric. 2016 . "Can Big Data Save Labor Market Information Systems." Research Triangle Park, NC: RTI International

Kuhn, Peter, and Hani Mansour. 2014. "Is Internet Job Search Still Ineffective?" *The Economic Journal* 124 (581): 1213-1233.

Nomura, Shinsaku, Saori Imaizumi, Ana Carolina Areias, and Futoshi Yamauchi. 2017. "Toward Labor Market Policy 2.0: The Potential for Using Online Job-Portal Big Data to Inform Labor Market Policies in India."

Tufekci, Zeynep. 2014. "Big Questions for Social Media Big Data: Representativeness, Validity and Other Methodological Pitfalls." *ICWSM* 14: 505-514.

Tambe, P. 2014. "Big Data Investment, Skills, and Firm Value". *Management Science* 60 (6): 1452-1469.

Appendix A. External vs. LinkedIn Data Matching Methodology

Comparing LinkedIn data with data from external sources requires careful, structured matching of taxonomies. The approach is outlined for each validation exercise. Particular attention was paid to industry and age comparison, where matching of sources involves explicit assumptions and references to LinkedIn data storage structure.

1) Age and Sex

LinkedIn age data are given as months of a member's experience. Transformed into annual experience, 1 year of experience translates to an age of 23, with the assumption that the majority of full-time employment (excluding internships and apprenticeships) begins after completion of undergraduate tertiary studies because 80 percent of LinkedIn members possess at least a college or equivalent degree. Selecting age 23 as a starting point facilitates capturing variation in length of undergraduate studies (e.g., 4 years in the United States versus 3 years in most of Europe). Following this approach, 2 years of experience translates to 24 years of age, 3 to 25, and so forth.

International Labor Organization (ILO) age data are selected in 10-year age bands.[46] The first category (<15 years old) was removed because of low count and lack of comparability with LinkedIn data. The 65+ age band was renamed 65 to 75 when calculating mean and median values. Finally, mean and median were calculated for matching to LinkedIn data. Mean and median age values were matched according to country for 2016 because that was the latest complete year for the ILO age sample.[47]

Data on sex are structured similarly in the LinkedIn and ILO data (female, male, total/unknown; excluding missing data). In both data sets, the total/unknown category was removed for all countries LinkedIn derives sex from individuals' names in their profiles using an algorithm that identifies which sex a name is most likely to be associated with. LinkedIn and ILO data on sex are matched according to country for 2016.[48]

2) Industry Employment Size

LinkedIn data are categorized according to 148 industries (roughly International Standard Industrial Classification (ISIC) two- to three-digit equivalent), which are further classified into 22 higher-level industry groups (roughly ISIC 1-digit equivalent). The 148 industries that are mapped to ISIC 4 can be found in Table III-1. The detailed LinkedIn–ISIC industry matching, including how LinkedIn industry is mapped to ISIC two digits, can be found in the detailed LinkedIn to ISIC Rev. 4 in Appendix C.

Three LinkedIn industries that are not mapped to any of the ISIC categories were labelled as X, "Not elsewhere classified." ISIC Section E: water supply; sewerage waste management and remediation activities has no corresponding industry in the LinkedIn data and so was excluded from mapping.

Data from 2016 were used for the mapping exercise; if countries had no 2016 data in the ILO labor statistics, 2014 or 2015 data were used, whichever was the latest available, yielding a final country count of 92 for the industry employment size representativeness exercise.[49]

46 <15, 15-24, 25-34, 35-44, 45-54, 55-64, 65+

47 Out of 98, 9 countries were included from 2015 and 7 from 2014 for ILO data to maximize coverage.

48 Out of 110, 11 countries were included from 2015 and 10 from 2014 for ILO data to maximize coverage.

49 Out of 92, 16 countries were included from 2015 and 6 from 2014 for ILO data to maximize coverage.

INTERNATIONAL STANDARD INDUSTRIAL CLASSIFICATION SECTOR (1 DIGIT)[a]	LINKEDIN INDUSTRY (ROUGHLY 2-DIGIT EQUIVALENT)[b]
A. Agriculture; forestry and fishing	farming; ranching; dairy; fishery
B. Mining and quarrying	mining & metals; oil & energy
C. Manufacturing	defense and space; pharmaceuticals; food production; aviation and aerospace; automotive; chemicals; machinery; shipbuilding; textiles; paper & forest products; railroad manufacture; printing; electrical and electronic manufacturing; plastics; renewables and environment; glass, ceramics and concrete; packaging and containers; industrial automation
D. Electricity; gas, steam and air conditioning supply	utilities
F. Construction	construction; building materials; civil engineering
G. Wholesale and retail trade; repair of motor vehicles and motorcycles	cosmetics; apparel and fashion; sporting goods; tobacco; supermarkets; consumer electronics; consumer goods; furniture; retail; food & beverages; consumer services; wholesale; wine and spirits; luxury goods and jewelry
H. Transportation and storage	package/freight delivery; transportation/trucking/railroad; warehousing; airlines/aviation; maritime; logistics and supply chain; import and export
I. Accommodation and food service activities	hospitality; restaurants
J. Information and communication	computer hardware; computer software; computer networking; Internet; semiconductors; telecommunications; motion pictures and film; broadcast media; newspapers; publishing; information technology and services; writing and editing; computer games; online media; computer and network security; wireless; media production
K. Financial and insurance activities	banking; insurance; financial services; investment banking; investment management; venture capital and private equity; capital markets
L. Real estate activities	Real estate; commercial real estate
M. Professional, scientific and technical activities	law practice; legal services; management consulting; biotechnology; veterinary; accounting; architecture & planning; research; executive office; marketing and advertising; information services; environmental services; market research; public relations and communications; design; professional training & coaching; translation and localization; events services; nanotechnology; alternative dispute resolution; outsourcing/offshoring; mechanical or industrial engineering; photography; graphic design
N. Administrative and support service activities	leisure, travel & tourism; recreational facilities and services; fundraising; staffing and recruiting; security and investigations; facilities services; human resources; business supplies and equipment
O. Public administration and defense; compulsory social security	military; legislative office; judiciary; international affairs; government administration; law enforcement; public safety; public policy; political organization; government relations
P. Education	primary/secondary education; higher education; education management; e-learning
Q. Human health and social work activities	medical practice; hospital & health care; medical device; alternative medicine; mental health care
R. Arts, entertainment and recreation	entertainment; gambling & casinos; sports; museums and institutions; fine art; performing arts; libraries; arts and crafts; music; health, wellness, and fitness; animation
S. Other service activities	individual and family services; religious institutions; civic & social organization; non-profit organization management; international trade and development
X. Not elsewhere classified	Unknown; program development; think tanks; philanthropy

a ISIC section E. Water supply; sewerage, waste management and remediation activities was removed because there were no corresponding LinkedIn industries.

b LinkedIn industries program development, think tanks, and philanthropy (sk(id): 102, 130, 131, respectively) did not match ISIC section definitions and hence were mapped to ISIC section X: Not elsewhere classified

3) Industry Employment Growth

Because the ILO provides limited time series observations for calculating industry employment growth, LinkedIn industry employment data were mapped to U.S. Bureau of Labor Statistics data using the North American Industry Classification System. LinkedIn industry mapping to each of the 11 super-sectors of the North American Industry Classification System is summarized in the table below.

BUREAU OF LABOR STATISTICS SUPERSECTOR (NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM AGGREGATE)	LINKEDIN INDUSTRY[a]
Construction	construction; building materials
Education and health services	biotechnology; medical practice; hospital & health care; pharmaceuticals; veterinary; medical device, primary/secondary education; higher education; education management; alternative medicine; e-learning; mental health care
Financial activities	banking; insurance; financial services; real estate; investment banking; investment management; venture capital and private equity; commercial real estate; capital markets; international trade and development
Government	military; legislative office; judiciary; international affairs; government administration; executive office, law enforcement; public safety; public policy
Information	computer software; telecommunications; motion pictures and film; broadcast media; marketing and advertising; newspapers; publishing; printing; information services; public relations and communications; translation and localization; computer games; online media; wireless; media production; animation
Leisure and hospitality	entertainment; gambling & casinos; leisure; travel & tourism; hospitality; restaurants; sports; museums and institutions; fine art; performing arts; recreational facilities and services; music; health; wellness and fitness
Manufacturing	defense & space; computer hardware; semiconductors; cosmetics; apparel and fashion; sporting goods; tobacco; food production; consumer electronics; consumer goods; furniture; food & beverages; aviation and aerospace; automotive; chemicals; machinery; shipbuilding; textiles; paper & forest products; railroad manufacture; electrical and electronic manufacturing; plastics; mechanical or industrial engineering; wine and spirits; luxury goods and jewelry; renewables and environment; glass; ceramics and concrete; packaging and containers; industrial automation
Mining and logging	mining & metals; oil & energy
Other services	libraries; individual and family services; religious institutions; civic & social organization; consumer services; non-profit organization management; fundraising; program development; political organization; events services; outsourcing/offshoring; philanthropy
Professional and business services	computer networking; internet; law practice; legal services; management consulting; accounting; architecture & planning; civil engineering; research; environmental services; information technology and services; market research; design; writing and editing; staffing and recruiting; professional training & coaching; nanotechnology; computer and network security; alternative dispute resolution; security and investigations; facilities services; think tanks; photography; human resources; graphic design; government relations
Trade, transportation, and utilities	supermarkets; retail; utilities; package/freight delivery; transportation/trucking/railroad; warehousing; airlines/aviation; maritime; arts and crafts; logistics and supply chain; wholesale; import and export; business supplies and equipment

a Four LinkedIn industries could not be mapped to the North American Industry Classification System: farming, ranching, dairy, and fishery. The Bureau of Labpr Statistics super-sector does not include the agriculture sector, and it is not well represented in the LinkedIn user base.

4) Skills

Similarities between skill composition were measured at the industry level, where LinkedIn and external data sources use the ISIC 4 industry classification, to facilitate comparison. The skill similarity index that the team derived is compared with an external information technology skills proficiency index (Program for the International Assessment of Adult Competencies) and information and communications technology (ICT) development level (ICT Development Index) at the industry and occupation level.

5) Talent Migration

LinkedIn migration data were matched to Organization for Economic Cooperation and Development migration data at the country level according to country name. The dataset was filtered before correlation analysis for a minimum sample of 30 observations in each country pair.

Appendix B. LinkedIn Data Country List

(100,000+ members) n=140

COUNTRY (A-K)	WORLD BANK INCOME GROUP	WORLD BANK REGION	COUNTRY (L-Z)	WORLD BANK INCOME GROUP	WORLD BANK REGION
Afghanistan	Low	South Asia	Latvia	High	Europe and Central Asia
Albania	Upper middle	Europe and Central Asia	Lebanon	Upper middle	Middle East and North Africa
Algeria	Upper middle	Middle East and North Africa	Libyan Arab Jamahiriya	Upper middle	Middle East and North Africa
Angola	Lower middle	Sub-Saharan Africa	Lithuania	High	Europe and Central Asia
Argentina	Upper middle	Latin America and the Caribbean	Luxembourg	High	Europe and Central Asia
Armenia	Lower middle	Europe and Central Asia	Macedonia, FYR	Upper middle	Europe and Central Asia
Australia	High	East Asia and Pacific	Madagascar	Low	Sub-Saharan Africa
Austria	High	Europe and Central Asia	Malawi	Low	Sub-Saharan Africa
Azerbaijan	Upper middle	Europe and Central Asia	Malaysia	Upper middle	East Asia and Pacific
Bahamas	High	Latin America and the Caribbean	Mali	Low	Sub-Saharan Africa
Bahrain	High	Middle East and North Africa	Malta	High	Middle East and North Africa
Bangladesh	Lower middle	South Asia	Mauritius	Upper middle	Sub-Saharan Africa
Belarus	Upper middle	Europe and Central Asia	Mexico	Upper middle	Latin America and the Caribbean
Belgium	High	Europe and Central Asia	Moldova, Republic of	Lower middle	Europe and Central Asia
Benin	Low	Sub-Saharan Africa	Mongolia	Lower middle	East Asia and Pacific
Bolivia	Lower middle	Latin America and the Caribbean	Morocco	Lower middle	Middle East and North Africa
Bosnia and Herzegovina	Upper middle	Europe and Central Asia	Mozambique	Low	Sub-Saharan Africa
Botswana	Upper middle	Sub-Saharan Africa	Myanmar	Lower middle	East Asia and Pacific
Brazil	Upper middle	Latin America and the Caribbean	Namibia	Upper middle	Sub-Saharan Africa
Bulgaria	Upper middle	Europe and Central Asia	Nepal	Low	South Asia
Burkina Faso	Low	Sub-Saharan Africa	Netherlands	High	Europe and Central Asia
Cambodia	Lower middle	East Asia and Pacific	New Zealand	High	East Asia and Pacific
Cameroon	Lower middle	Sub-Saharan Africa	Nicaragua	Lower middle	Latin America and the Caribbean
Canada	High	North America	Nigeria	Lower middle	Sub-Saharan Africa
Chile	High	Latin America and the Caribbean	Norway	High	Europe and Central Asia
China	Upper middle	East Asia and Pacific	Oman	High	Middle East and North Africa
Colombia	Upper middle	Latin America and the Caribbean	Pakistan	Lower middle	South Asia

continues

APPENDIX B continued

COUNTRY (A-K)	WORLD BANK INCOME GROUP	WORLD BANK REGION	COUNTRY (L-Z)	WORLD BANK INCOME GROUP	WORLD BANK REGION
Congo, the Democratic Republic of the	Low	Sub-Saharan Africa	Palestinian Territory, Occupied	Na	Middle East and North Africa
Costa Rica	Upper middle	Latin America and the Caribbean	Panama	Upper middle	Latin America and the Caribbean
Côte d'Ivoire	Lower middle	Sub-Saharan Africa	Papua New Guinea	Lower middle	East Asia and Pacific
Croatia	Upper middle	Europe and Central Asia	Paraguay	Upper middle	Latin America and the Caribbean
Cuba	Upper middle	Latin America and the Caribbean	Peru	Upper middle	Latin America and the Caribbean
Cyprus	High	Europe and Central Asia	Philippines	Lower middle	East Asia and Pacific
Czech Republic	High	Europe and Central Asia	Poland	High	Europe and Central Asia
Denmark	High	Europe and Central Asia	Portugal	High	Europe and Central Asia
Dominican Republic	Upper middle	Latin America and the Caribbean	Puerto Rico	High	Latin America and the Caribbean
Ecuador	Upper middle	Latin America and the Caribbean	Qatar	High	Middle East and North Africa
Egypt	Lower middle	Middle East and North Africa	Reunion	High (france)	Sub-Saharan Africa
El Salvador	Lower middle	Latin America and the Caribbean	Romania	Upper middle	Europe and Central Asia
Estonia	High	Europe and Central Asia	Rwanda	Low	Sub-Saharan Africa
Ethiopia	Low	Sub-Saharan Africa	Saudi Arabia	High	Middle East and North Africa
Fiji	Upper middle	East Asia and Pacific	Senegal	Low	Sub-Saharan Africa
Finland	High	Europe and Central Asia	Serbia	Upper middle	Europe and Central Asia
France	High	Europe and Central Asia	Singapore	High	East Asia and Pacific
Georgia	Lower middle	Europe and Central Asia	Slovakia	High	Europe and Central Asia
Germany	High	Europe and Central Asia	Slovenia	High	Europe and Central Asia
Ghana	Lower middle	Sub-Saharan Africa	South Africa	Upper middle	Sub-Saharan Africa
Greece	High	Europe and Central Asia	Spain	High	Europe and Central Asia
Guatemala	Lower middle	Latin America and the Caribbean	Sri Lanka	Lower middle	South Asia
Haiti	Low	Latin America and the Caribbean	Sudan	Lower middle	Sub-Saharan Africa
Honduras	Lower middle	Latin America and the Caribbean	Sweden	High	Europe and Central Asia
Hong Kong	High	East Asia and Pacific	Switzerland	High	Europe and Central Asia
Hungary	High	Europe and Central Asia	Syrian Arab Republic	Lower middle	Middle East and North Africa
Iceland	High	Europe and Central Asia	Taiwan, Province of China	High	East Asia and Pacific
India	Lower middle	South Asia	Tanzania, United Republic of	Low	Sub-Saharan Africa
Indonesia	Lower middle	East Asia and Pacific	Thailand	Upper middle	East Asia and Pacific

continues

APPENDIX B continued

COUNTRY (A-K)	WORLD BANK INCOME GROUP	WORLD BANK REGION
Iran, Islamic Republic of	Upper middle	Middle East and North Africa
Iraq	Upper middle	Middle East and North Africa
Ireland	High	Europe and Central Asia
Israel	High	Middle East and North Africa
Italy	High	Europe and Central Asia
Jamaica	Upper middle	Latin America and the Caribbean
Japan	High	East Asia and Pacific
Jordan	Lower middle	Middle East and North Africa
Kazakhstan	Upper middle	Europe and Central Asia
Kenya	Lower middle	Sub-Saharan Africa
Korea, Republic of	High	East Asia and Pacific
Kuwait	High	Middle East and North Africa

COUNTRY (L-Z)	WORLD BANK INCOME GROUP	WORLD BANK REGION
Togo	Low	Sub-Saharan Africa
Trinidad and Tobago	High	Latin America and the Caribbean
Tunisia	Lower middle	Middle East and North Africa
Turkey	Upper middle	Europe and Central Asia
Uganda	Low	Sub-Saharan Africa
Ukraine	Lower middle	Europe and Central Asia
United Arab Emirates	High	Middle East and North Africa
United Kingdom	High	Europe and Central Asia
United States	High	North America
Uruguay	High	Latin America and the Caribbean
Uzbekistan	Lower middle	Europe and Central Asia
Venezuela	Upper middle	Latin America and the Caribbean
Vietnam	Lower middle	East Asia and Pacific
Yemen	Lower middle	Middle East and North Africa
Zambia	Lower middle	Sub-Saharan Africa
Zimbabwe	Low	Sub-Saharan Africa

Appendix C. LinkedIn to International Standard Industrial Classification 4 Industry Mapping

ISIC SECTION	ISIC SECTION NAME	ISIC DIVISION	ISIC DIVISION NAME	LINKEDIN INDUSTRY SK	LINKEDIN INDUSTRY NAME	LINKEDIN INDUSTRY GROUP SK	LINKEDIN INDUSTRY GROUP NAME
A	A. Agriculture; forestry and fishing	1	Crop and animal production, hunting and related service activities	63	farming	1	Agriculture
A	A. Agriculture; forestry and fishing	1	Crop and animal production, hunting and related service activities	64	ranching	1	Agriculture
A	A. Agriculture; forestry and fishing	1	Crop and animal production, hunting and related service activities	65	dairy	1	Agriculture
A	A. Agriculture; forestry and fishing	3	Fishing and aquaculture	66	fishery	1	Agriculture
B	B. Mining and quarrying	5	Mining of coal and lignite	56	mining & metals	16	Energy and Mining
B	B. Mining and quarrying	6	Extraction of crude petroleum and natural gas	57	oil & energy	16	Energy and Mining
C	C. Manufacturing	25	Manufacture of fabricated metal products, except machinery and equip	2	defense and space	10	Manufacturing
C	C. Manufacturing	21	Manufacture of pharmaceuticals, medicinal chemical and botanical products	15	pharmaceuticals	12	Healthcare
C	C. Manufacturing	10	Manufacture of food products	23	food production	10	Manufacturing
C	C. Manufacturing	30	Manufacture of other transport equipment	52	aviation and aerospace	10	Manufacturing
C	C. Manufacturing	29	Manufacture of motor vehicles, trailers and semi-trailers	53	automotive	10	Manufacturing
C	C. Manufacturing	20	Manufacture of chemicals and chemical products	54	chemicals	10	Manufacturing
C	C. Manufacturing	28	Manufacture of machinery and equipment n.e.c.	55	machinery	10	Manufacturing
C	C. Manufacturing	30	Manufacture of other transport equipment	58	shipbuilding	10	Manufacturing
C	C. Manufacturing	13	Manufacture of textiles	60	textiles	10	Manufacturing
C	C. Manufacturing	17	Manufacture of paper and paper products	61	paper & forest products	10	Manufacturing
C	C. Manufacturing	30	Manufacture of other transport equipment	62	railroad manufacture	10	Manufacturing
C	C. Manufacturing	18	Printing and reproduction of recorded media	83	printing	11	Media & Communications
C	C. Manufacturing	26	Manufacture of computer, electronic and optical products	112	electrical and electronic manufacturing	10	Manufacturing
C	C. Manufacturing	22	Manufacture of rubber and plastics products	117	plastics	10	Manufacturing
C	C. Manufacturing	32	Other manufacturing	144	renewables and environment	10	Manufacturing
C	C. Manufacturing	32	Other manufacturing	145	glass, ceramics and concrete	10	Manufacturing
C	C. Manufacturing	32	Other manufacturing	146	packaging and containers	10	Manufacturing
C	C. Manufacturing	32	Other manufacturing	147	industrial automation	10	Manufacturing
D	D. Electricity; gas, steam and air conditioning supply	35	electricity; gas, steam and air conditioning supply	59	utilities	16	Energy and Mining
F	F. Construction	41	Construction of buildings	48	construction	3	Construction
F	F. Construction	43	Not_mapped	49	building materials	3	Construction
F	F. Construction	42	Civil engineering	51	civil engineering	3	Construction

continues

APPENDIX C continued

G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	18	cosmetics	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	19	apparel and fashion	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	20	sporting goods	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	21	tobacco	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	22	supermarkets	24	Retail
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	24	consumer electronics	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	25	consumer goods	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	26	furniture	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	27	retail	24	Retail
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	34	food & beverages	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	91	consumer services	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	46	Wholesale trade, except of motor vehicles and motorcycles	133	wholesale	24	Retail
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	142	wine and spirits	4	Consumer goods
G	G. Wholesale and retail trade; repair of motor vehicles and motorcycles	47	Retail trade, except of motor vehicles and motorcycles	143	luxury goods and jewelry	4	Consumer goods
H	H. Transportation and storage	53	Postal and courier activities	87	package/freight delivery	15	Transportation & Logistics
H	H. Transportation and storage	49	Land transport and transport via pipelines	92	transportation/ trucking/railroad	15	Transportation & Logistics
H	H. Transportation and storage	52	Warehousing and support activities for transportation	93	warehousing	15	Transportation & Logistics
H	H. Transportation and storage	51	Air transport	94	airlines/aviation	14	Recreation and Travel
H	H. Transportation and storage	50	Water transport	95	maritime	15	Transportation & Logistics
H	H. Transportation and storage	52	Warehousing and support activities for transportation	116	logistics and supply chain	15	Transportation & Logistics
H	H. Transportation and storage	52	Warehousing and support activities for transportation	134	import and export	15	Transportation & Logistics
I	I. Accommodation and food service activities	55	Accommodation	31	hospitality	14	Recreation and Travel
I	I. Accommodation and food service activities	56	Food and services activities	32	restaurants	14	Recreation and Travel
J	J. Information and communication	62	Computer programming, consultancy and related activities	3	computer hardware	19	Hardware & Netwoking
J	J. Information and communication	62	Computer programming, consultancy and related activities	4	computer software	8	Software & IT Services
J	J. Information and communication	62	Computer programming, consultancy and related activities	5	computer networking	19	Hardware & Netwoking
J	J. Information and communication	61	Telecommunications	6	Internet	8	Software & IT Services
J	J. Information and communication	62	Computer programming, consultancy and related activities	7	semiconductors	19	Hardware & Netwoking
J	J. Information and communication	61	Telecommunications	8	telecommunications	19	Hardware & Netwoking

continues

APPENDIX C continued

J	J. Information and communication	59	Motion picture, video and television programme production, sound recording	35	motion pictures and film	18	Entertainment
J	J. Information and communication	60	Programming and broadcasting activities	36	broadcast media	18	Entertainment
J	J. Information and communication	58	Publishing activities	81	newspapers	11	Media & Communications
J	J. Information and communication	58	Publishing activities	82	publishing	11	Media & Communications
J	J. Information and communication	63	Information service activities	96	information technology and services	8	Software & IT Services
J	J. Information and communication	58	Publishing activities	103	writing and editing	11	Media & Communications
J	J. Information and communication	58	Publishing activities	109	computer games	18	Entertainment
J	J. Information and communication	63	Information service activities	113	online media	11	Media & Communications
J	J. Information and communication	62	Computer programming, consultancy and related activities	118	computer and network security	8	Software & IT Services
J	J. Information and communication	62	Computer programming, consultancy and related activities	119	wireless	19	Hardware & Netwoking
J	J. Information and communication	59	Motion picture, video and television programme production, sound recording	126	media production	19	Entertainment
K	K. Financial and insurance activities	64	Financial service activities, except insurance and pension funding	41	banking	7	Finance
K	K. Financial and insurance activities	65	Insurance, reinsurance and pension funding, except compulsory social	42	insurance	7	Finance
K	K. Financial and insurance activities	64	Financial service activities, except insurance and pension funding	43	financial services	7	Finance
K	K. Financial and insurance activities	64	Financial service activities, except insurance and pension funding	45	investment banking	7	Finance
K	K. Financial and insurance activities	64	Financial service activities, except insurance and pension funding	46	investment management	7	Finance
K	K. Financial and insurance activities	64	Financial service activities, except insurance and pension funding	106	venture capital and private equity	7	Finance
K	K. Financial and insurance activities	66	Activities auxiliary to financial service and insurance activities	129	capital markets	7	Finance
L	L. Real estate activities	68	Real estate activities	44	Real estate	22	Real estate
L	L. Real estate activities	68	Real estate activities	128	commercial real estate	22	Real estate
M	M. Professional, scientific and technical activities	69	Legal and accounting activities	9	law practice	9	Legal
M	M. Professional, scientific and technical activities	69	Legal and accounting activities	10	legal services	9	Legal
M	M. Professional, scientific and technical activities	70	Activities of head offices; management consultancy activities	11	management consulting	5	Corporate Services
M	M. Professional, scientific and technical activities	72	Scientific research and development	12	biotechnology	12	Healthcare
M	M. Professional, scientific and technical activities	75	Veterinary activities	16	veterinary	12	Healthcare
M	M. Professional, scientific and technical activities	69	Legal and accounting activities	47	accounting	5	Corporate Services
M	M. Professional, scientific and technical activities	71	Architectural and engineering activities; technical testing and analysis	50	architecture & planning	17	Design
M	M. Professional, scientific and technical activities	72	Scientific research and development	70	research	6	Education
M	M. Professional, scientific and technical activities	70	Activities of head offices; management consultancy activities	76	executive office	5	Corporate Services
M	M. Professional, scientific and technical activities	73	Advertising and market research	80	marketing and advertising	11	Media & Communications
M	M. Professional, scientific and technical activities	70	Activities of head offices; management consultancy activities	84	information services	5	Corporate Services
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	86	environmental services	5	Corporate Services
M	M. Professional, scientific and technical activities	73	Advertising and market research	97	market research	11	Media & Communications
M	M. Professional, scientific and technical activities	70	Activities of head offices; management consultancy activities	98	public relations and communications	11	Media & Communications

continues

APPENDIX C continued

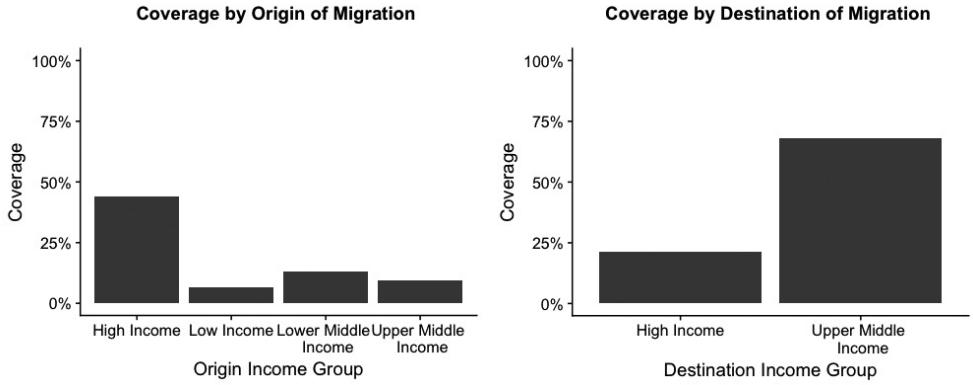
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	99	design	17	Design
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	105	professional training & coaching	5	Corporate Services
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	108	translation and localization	11	Media & Communications
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	110	events services	5	Corporate Services
M	M. Professional, scientific and technical activities	72	Scientific research and development	114	nanotechnology	19	Hardware & Networking
M	M. Professional, scientific and technical activities	69	Legal and accounting activities	120	alternative dispute resolution	9	Legal
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	123	outsourcing/ offshoring	5	Corporate Services
M	M. Professional, scientific and technical activities	72	Scientific research and development	135	mechanical or industrial engineering	10	Manufacturing
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	136	photography	2	Art
M	M. Professional, scientific and technical activities	74	Other professional, scientific and technical activities	140	graphic design	17	Design
N	N. Administrative and support service activities	79	Travel agency, tour operator, reservation service and related activities	30	leisure, travel & tourism	14	Recreation and Travel
N	N. Administrative and support service activities	81	Services to buildings and landscape activities	40	recreational facilities and services	14	Recreation and Travel
N	N. Administrative and support service activities	82	Office administrative, office support and other business support activities	101	fundraising	13	Nonprofit
N	N. Administrative and support service activities	78	Employment activities	104	staffing and recruiting	5	Corporate Services
N	N. Administrative and support service activities	80	Security and investigation activities	121	security and investigations	5	Corporate Services
N	N. Administrative and support service activities	81	Services to buildings and landscape activities	122	facilities services	5	Corporate Services
N	N. Administrative and support service activities	78	Employment activities	137	human resources	5	Corporate Services
N	N. Administrative and support service activities	82	Office administrative, office support and other business support activities	138	business supplies and equipment	5	Corporate Services
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	71	military	21	Public safety
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	72	legislative office	20	Public Administration
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	73	judiciary	20	Public Administration
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	74	international affairs	20	Public Administration
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	75	government administration	20	Public Administration
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	77	law enforcement	21	Public safety
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	78	public safety	21	Public safety
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	79	public policy	20	Public Administration
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	107	political organization	20	Public Administration
O	O. Public administration and defence; compulsory social security	84	Public administration and defence; compulsory social security	148	government relations	20	Public Administration
P	P. Education	85	Education	67	primary/secondary education	6	Education
P	P. Education	85	Education	68	higher education	6	Education

continues

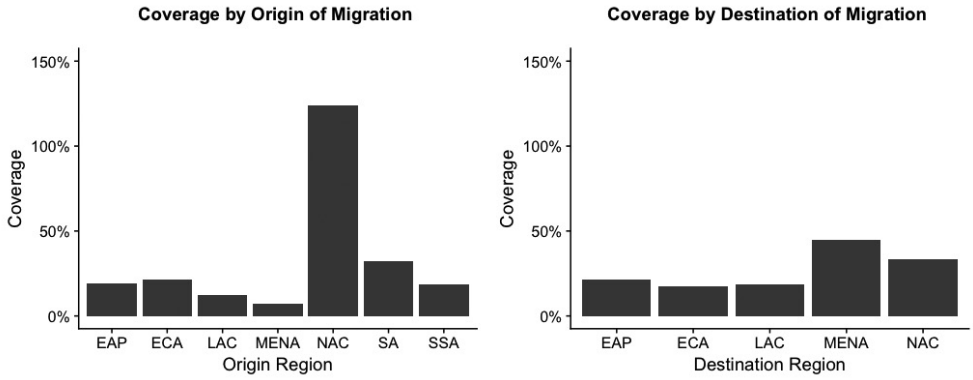
APPENDIX C continued

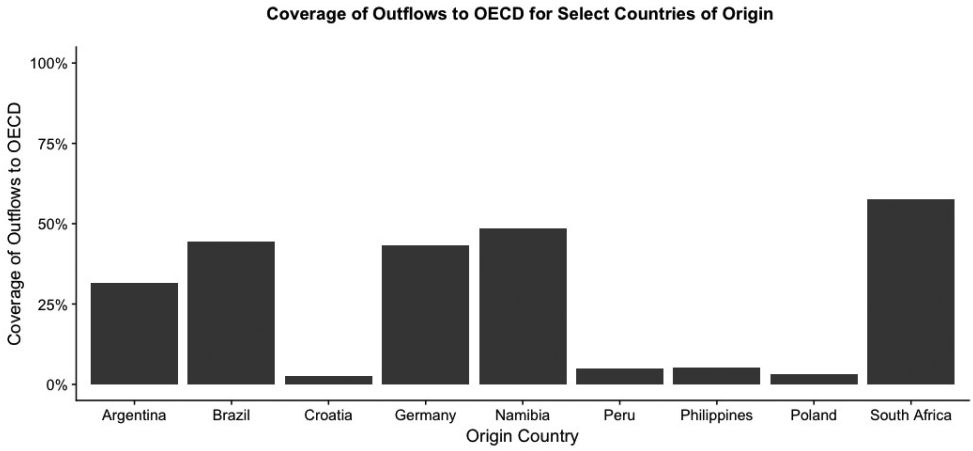
P	P. Education	85	Education	69	education management	6	Education
P	P. Education	85	Education	132	e-learning	6	Education
Q	Q. Human health and social work activities	86	Human health activities	13	medical practice	12	Healthcare
Q	Q. Human health and social work activities	86	Human health activities	14	hospital & health care	12	Healthcare
Q	Q. Human health and social work activities	86	Human health activities	17	medical device	12	Healthcare
Q	Q. Human health and social work activities	86	Human health activities	125	alternative medicine	23	Wellness and Fitness
Q	Q. Human health and social work activities	86	Human health activities	139	mental health care	12	Healthcare
R	R. Arts, entertainment and recreation	90	Creative, arts and entertainment activities	28	entertainment	18	Entertainment
R	R. Arts, entertainment and recreation	92	Gambling and betting activities	29	gambling & casinos	14	Recreation and Travel
R	R. Arts, entertainment and recreation	93	Sports activities and amusement and recreation activities	33	sports	14	Recreation and Travel
R	R. Arts, entertainment and recreation	91	Libraries, archives, museums and other cultural activities	37	museums and institutions	13	Nonprofit
R	R. Arts, entertainment and recreation	90	Creative, arts and entertainment activities	38	fine art	2	Art
R	R. Arts, entertainment and recreation	90	Creative, arts and entertainment activities	39	performing arts	2	Art
R	R. Arts, entertainment and recreation	91	Libraries, archives, museums and other cultural activities	85	libraries	13	Nonprofit
R	R. Arts, entertainment and recreation	90	Creative, arts and entertainment activities	111	arts and crafts	2	Art
R	R. Arts, entertainment and recreation	90	Creative, arts and entertainment activities	115	music	18	Entertainment
R	R. Arts, entertainment and recreation	93	Sports activities and amusement and recreation activities	124	health, wellness and fitness	23	Wellness & Fitness
R	R. Arts, entertainment and recreation	90	Creative, arts and entertainment activities	127	animation	18	Entertainment
S	S. Other service activities	96	Other personal service activities	88	individual and family services	13	Nonprofit
S	S. Other service activities	94	Activities of professional membership organizations	89	religious institutions	13	Nonprofit
S	S. Other service activities	94	Activities of professional membership organizations	90	civic & social organization	13	Nonprofit
S	S. Other service activities	94	Activities of professional membership organizations	100	non-profit organization management	13	Nonprofit
S	S. Other service activities	94	Activities of professional membership organizations	141	international trade and development	13	Nonprofit
X	X. Not elsewhere classified	-9	Not_mapped	-9	Unknown	-9	ERR
X	X. Not elsewhere classified	-9	Not_mapped	102	program development	13	Nonprofit
X	X. Not elsewhere classified	-9	Not_mapped	130	think tanks	13	Nonprofit
X	X. Not elsewhere classified	-9	Not_mapped	131	philanthropy	13	Nonprofit

Appendix D. Migration Data Summary Charts



** All Organization for Economic Cooperation and Development (OECD) countries are high income except for Mexico. (This is driving the high coverage of upper middle income in the Coverage According to Destination of Migration chart).





Appendix E. Migration Validation Other Data Sources Evaluated

SOURCE	LINK	GEOGRAPHY LEVEL	YEARS	DATA STRUCTURE	NOTES
United Nations Department of Economic and Social Affairs	International migrant stock 2015	Major area Region Country	1990 1995 2000 2005 2010 2015 2017	XLS file	Shows number of migrants from specific country to major area, region and country of destination by totals and by gender
Organization for Economic Cooperation and Development	International migration database	Country	1975-2015	Self-service chart that can be exported as XLS or CSV file	Presents data showcasing flows and stocks of the total immigrant population and immigrant labor force, together with data on acquisition of nationality List of databases found here
International Labor Organization	Migrants according to country of origin (thousands)	Country	2003-2015	Table that can be exported as XLS file	Sources: Labor force survey, Official estimate, Other administrative records and related sources, Other household survey, Other official source, Population census
United States Department of Homeland Security	Table 3. Persons Obtaining Lawful Permanent Resident Status By Region And Country Of Birth: Fiscal Years 2013 To 2015	Country Region	2013-2015	Table online that can be converted into an XLS file	Shows number of immigrants who are: granted green card, admitted as temporary nonimmigrants, granted asylum/refugee status, naturalized
*Migration Policy Institute	Immigrant and Emigrant Populations by Country of Origin and Destination	Country	Mid-2015	Tableau map (can be configured into text file – source found here)	Source: UN Department of Economic and Social Affairs – "Trends in International Migrant Stock: Migrants by Destination and Origin" (see above)
*International Organization for Migration	World Migration	Country	2015	Interactive map	Source: UN Department of Economic and Social Affairs – "Trends in International Migrant Stock: Migrants by Destination and Origin" (see above) Migration Data Portal aims to serve as access point for timely and comprehensive migration statistics (coming December 2017)

SOURCE	LINK	GEOGRAPHY LEVEL	YEARS	DATA STRUCTURE	NOTES
Wittgenstein Centre for Demography and Global Human Capital	Global Flow of People	Country Region	1990-1995 1995-2000 2000-2005 2005-2010	XLS file	Bilateral migration flows at region and country levels for 5-year periods (mid-year to mid-year) Estimates reflect migration transitions and thus cannot be compared with annual movement flow data published by United Nations or Eurostat (because of differences in definition, measurements, and data collection procedures)
United Nations Economic Commission for Europe	UNECE Statistical Database – Migration	Country (former USSR)	2001-2014	Self-service dashboard that can be exported as XLS file	Focuses on former Soviet countries Data based on population censuses provided by national statistical offices
*Pew Research Center	Origins and destinations of European Union migrants within the European Union	Country (European Union)	2015	Interactive map	Figures refer to total number (cumulative "stocks") of migrants born or living in European Union countries
Migration Observatory at University of Oxford	Home Office Control of Immigration Statistics	Inner UK data	2011	XLS file	Home Office publishes data collected in process of managing entries into the United Kingdom and other changes of legal status of persons subject to immigration control Data collected through UK Border Agency Main types of entry data: entry clearance visas issued, passenger entries recorded
Eurostat	Migration and migrant population statistics	Country (European Union)	2016	XLS file	Table 6: Main countries of citizenship and birth of foreign and foreign-born population, 1 January 2016
United States Department of State	Report of the Visa Office 2017	Country (immigrant visas to United States) City (visa issuing office)	2013-2017	Statistical tables in PDF files	Table III. Immigrant Visas Issued (by Foreign State of Chargeability or Place of Birth): Fiscal Year 2017 Table IV. Summary of Visas Issued by Issuing Office: Fiscal Year 2017

* Data from UN Department of Economic and Social Affairs

continues

Appendix F. Skill Group Classification

SKILL GROUP	SAMPLE DETAILED SKILLS
Accounts Payable	Accounts Payable, Invoicing, Cash Collection, JD Edwards, Purchase Orders, Invoice Processing, Expenses, Billing Systems, Billing Process, Client Billing
Active Learning	E-Learning, Distance Learning, Moodle, Needs Analysis, Self Learning, Passionate about work, Professional Learning Communities, Active Learning, Quick Study, Learn New Software Quickly
Administrative Assistance	Data Entry, Office Administration, Administration, Process Scheduler, Phone Etiquette, Typing, Scheduling, Filing, Receptionist Duties, Clerical Skills
Advertising	Advertising, Online Advertising, Copywriting, Brand Management, Web Analytics, Creative Strategy, Sponsorship, Media Planning, Sports Marketing, Direct Mail
Aerospace Engineering	CATIA, ANSYS, Avionics, Aeronautics, Airworthiness, Helicopters, Aerospace Engineering, Abaqus, CAE, Flight Test
Affiliate Marketing	Trade Marketing, Relationship Marketing, Affiliate Marketing, Network Marketing, Local Marketing, Destination Marketing, Influencer Marketing, Consumer Marketing, Web Marketing Strategy, Marketing Operations
Agricultural Production	Agribusiness, Farms, Sustainable Agriculture, Animal Husbandry, Animal Nutrition, U.S. Department of Agriculture (USDA), Irrigation, Horses, Crop Protection, Organic Farming
Agronomy	Agronomy, Soil Sampling, Plant Breeding, Soil Science, Plant Pathology, Soil Fertility, Seed Production, Hydrologic Modeling, Plant Propagation, Soil Management
Air Force	Aerospace, Military Operations, Defense, Weapons Handling, Force Protection, Intelligence Analysis, Intelligence, Air Force, Radar, Electronic Warfare
Air Traffic Control	Airport Management, Air Traffic Control, International Flight Operations, Airspace Management, ADS-B
Aircraft Management	Aircraft Maintenance, Aircraft Systems, Business Aviation, B737, A320, Helicopter Operations, Aircraft Leasing, Aircraft Management, Flight Management Systems, Cockpit
Airlines	Airlines, Commercial Aviation, Airports, Flight Safety, Civil Aviation, Piloting, Flight Planning, Air Charter, Aviation Security, IATA
Analytical Reasoning	Critical Thinking, Technical Analysis, Independent Thinking, Analytical, Analytical Reasoning, Logical Approach, Systems Thinking, Information Analysis, Reasoning Skills, Scientific Analysis
Anesthesiology	Anesthesiology, Mechanical Ventilation, Regional Anesthesia, Sedation, Intubation, Conscious Sedation, General Anesthesia, U.S. Federal Communications Commission (FCC), Intraoperative Monitoring
Animation	DES, After Effects, 3D Studio Max, Animation, 3D Modeling, 3D, Rendering, Maya, Motion Graphics, Storyboarding
Anthropology	Archaeology, Cultural Anthropology, Cultural Resource Management, European Studies, Cultural Studies, Historical Archaeology, Social Anthropology, Latin American Studies
Apparel	Fashion, Apparel, Textiles, Fashion Design, Sewing, Fashion Illustration, Footwear, Fashion Shows, Sportswear, Wovens
Architecture	AutoCAD, Computer-Aided Design (CAD), SketchUp, Enterprise Architecture, Architectural Design, Revit, Sustainable Design, Design Research, AutoCAD Architecture, Green Building
Army	U.S. Department of Defense, Army, Counterterrorism, Military Training, Tactics, Military Logistics, Veterans, Special Operations, Combat
Art History	Contemporary Art, Museums, Art Education, Curating, Gallery Administration, Cultural Heritage, Museum Collections, Museum Education, Historical Research, World History
Artificial Intelligence	Machine Learning, Data Structures, Artificial Intelligence, Computer Vision, Apache Spark, Deep Learning, Pattern Recognition, OpenCV, Artificial Neural Networks, Neural Networks
Auditing	Auditing, Internal Controls, Internal Audit, Sarbanes-Oxley Act, External Audit, Assurance, Consolidation, Accountants, Preparation, Statutory Audit
Automotive	Automotive, Automotive Aftermarket, Automotive Engineering, Automotive Sales, Dealer Management, Powertrain, Motors, Motorsports, Automotive Electronics, Aftersales
Bartending	Wine, Bartending, Wine Tasting, Alcoholic Beverages, Beer, Beverage Industry, Wine & Spirits Industry, Cocktails, Craft Beer, Champagne
Biomedical Engineering	Medical Devices, Biomedical Engineering, Electronic Data Capture (EDC), Biomaterials, Medical Technology, Medical Equipment, Bioanalysis, Medical Device R&D, Biomedical Devices

continues

APPENDIX F continued

Bookkeeping	Accounts Receivable, QuickBooks, General Ledger, Bookkeeping, Peachtree, Accounts Payable & Receivable, MYOB, Expense Reports, Petty Cash, Record Keeping
Botany	Gardening, Botany, Habitat Restoration, Plant Physiology, Native Plants, Plant Ecology, Plant Genetics, Ethnobotany
Business Management	Management, Strategic Planning, Business Process Improvement, Change Management, Strategy, Team Management, Business Planning, Vendor Management, Business Process, Small Business
Capital Markets	Portfolio Management, Due Diligence, Financial Risk, Equities, Capital Markets, Trading, Derivatives, Financial Markets, Fixed Income, Bloomberg
Cardiology	Cardiology, Vascular, Interventional Cardiology, Hypertension, Catheters, Echocardiography, Cardiovascular Disease, Vascular Surgery, Cardiac Surgery, Pacemakers
Carpentry	Carpentry, Woodworking, Cabinetry, Roofers, Wood, Millwork, Joinery, Kitchen Cabinets, Finish Carpentry, Engineered Wood Products
Central Banks	Interest Rates, Monetary Policy, Inflation
Chemical Industry	Chemical Engineering, Polymers, Coatings, Formulation, Aspen HYSYS, Fragrance, Adhesives, Paper Industry, Resin, Chemical Industry
Childcare	Child Development, Early Childhood Education, Working With Children, Childcare, Early Intervention, Early Childhood Development, Babysitting, Early Childhood Literacy, Preschool, Safeguarding Children
Collaborative Style	Collaborative Leadership, Collaboration Solutions, Cross-functional Collaborations, Build Strong Relationships, Collaborative Environment, Collaboration Tools, Collaborative Work, Cross-Organization Collaboration, Team Environments, Collaborative Style
Commercial Photography	Commercial Photography, Fashion Photography, Studio Photography, Studio Lighting, Headshots, Architectural Photography, Still Life, Product Photography, On Location, Food Photography
Communication Disorders	Speech, Speech Therapy, Traumatic Brain Injury, Language Disorders, Aphasia, Audiology, Assistive Technology, Apraxia, Augmentative and Alternative Communication (AAC), Hearing Aids
Compensation & Benefits	Relocation, Benefits Administration, Deferred Compensation, PeopleSoft, Benefits Negotiation, Compensation & Benefits, SAP HR, Incentives, Compensation, Benchmarking
Competitive Strategies	Competitive Intelligence, Global Delivery, Thought Leadership, Market Intelligence, Positioning, Pricing Analysis, SWOT analysis, Future Trends, Global Strategy, Strategy Execution
Composites	Composites, Carbon, Composite Structures, Prestressed Concrete, Fibre, Polymer Composites, Aircraft Structures, Fiberglass, Carbon Fiber, Mould Design
Computer Graphics	Computer Graphics, AutoCAD Mechanical, OpenGL, Qt, GIMP, Digital Image Processing, Engineering Drawings, Adobe Freehand, 2D graphics, MEL
Computer Hardware	Computer Hardware, Servers, Microcontrollers, Printed Circuit Board (PCB) Design, VHDL, Verilog, Field-Programmable Gate Arrays (FPGA), PLC Programming, Application-Specific Integrated Circuits (ASIC), IBM iSeries
Computer Networking	Networking, Windows Server, Active Directory, Software as a Service (SaaS), Network Administration, Voice over IP (VoIP), Cisco Systems Products, Internet Protocol Suite (TCP/IP), Network Design, Switches
Conceptual Art	Mixed Media, Conceptual Art, Artistic Vision, Installation Design, New Media Art, Interactive Art
Constitutional Law	Constitutional Law, Discrimination Law, Election Law, First Amendment, Supreme Court
Construction Engineering	Construction Management, Contractors, Concrete, EPC, Value Engineering, Construction Safety, HVAC, Submittals, Primavera P6, Construction Drawings
Contract Law	Civil Litigation, Dispute Resolution, Arbitration, Joint Ventures, Contract Law, Contractual Agreements, Construction Law, Company Law, Software Licensing, Breach Of Contract
Cooking	Cooking, Culinary Skills, Food Preparation, Baking, Dairy Products, Pastry, Bakery, Seafood, Cake Decorating, Flavors
Corporate Communications	Media Relations, Strategic Communications, Press Releases, Corporate Communications, Newsletters, Internal Communications, Corporate Identity, Corporate Branding, Corporate Social Responsibility, Crisis Communications
Cosmetology	Styling, Cosmetics, Beauty Industry, Skin Care, Makeup Artistry, Hair Cutting, Spa, Hair Care, Cosmetology, Waxing
Crafts	Printmaking, Jewelry Design, Embroidery, Floral Design, Weaving, Crochet, Knitting, Pottery, Yarn, Quilting
Creativity Skills	Creativity Skills, Creative Arts, Creative Work, Creative Merchandising, Creative Visualization, Creative Conception, Creative Content Production, Creative Campaign Development, Creative Content Creation, Creative Industries
Criminal Law	Criminal Law, Anti Money Laundering, Criminal Defense, Business Litigation, Wrongful Death Claims, Expert Witness, Forensic Accounting, Automobile Accidents, Crime Scene Investigations, Conveyancing
Customer Experience	Customer Satisfaction, Customer Retention, Contact Centers, Customer Experience, Customer Support, Customer Engagement, Service-Level Agreements (SLA), Client Services, Consumer Insight, Complaint Management
Customer Service Systems	Customer Service Management, IVR, CRM Integration, Call Routing, Service Processes, Queue Management, Customer Service Systems, Service Automation, Call Flow Design, Customer Portal
Cyber-security	Security, Network Security, Firewalls, Information Security, Computer Security, Information Assurance, Information Security Management, IT Audit, Security Audits, Vulnerability Assessment
Dance	Dance, Choreography, Contemporary Dance, Ballet, Dance Education, Modern Dance, Classical Ballet, Zumba, Dance Instruction, Tap Dance

continues

APPENDIX F continued

Data Science	Data Analysis, Forecasting, Statistics, Analytics, SPSS, R, Trend Analysis, Data Mining, SAS, Modeling
Data Storage Technologies	SQL, Microsoft SQL Server, MySQL, Databases, Cloud Computing, Oracle Database, Oracle HR, Data Center, Virtualization, PL/SQL
Data-driven Decision Making	Decision Support, Decision Analysis, Business Decision Making, Ethical Decision Making, Decisiveness, Data-driven Decision Making
Debt Collection	Debt Collection, Debt Restructuring, Debt Management, Credit Control, Debt Settlement, Debt Consolidation, Debtors, Debtor/ Creditor, Vendor Finance
Delivery Operations	Freight, International Logistics, Third-Party Logistics (3PL), Freight Forwarding, Air Freight, Forwarding, Freight Transportation, Direct Store Delivery, Freight Brokerage, Lean Logistics
Dentistry	Dentistry, Cosmetic Dentistry, Restorative Dentistry, Oral Surgery, Teeth Whitening, Periodontics, Prosthodontics, Endodontics, Dental Care, Veneers
Dermatology	Dermatology, Skin Care Products, Plastic Surgery, Microdermabrasion, Chemical Peels, Acne, Laser Hair Removal, Botox Cosmetic, Hair Removal, Juvederm
Development Tools	Java, C++, C, Linux, C#, Python, Unix, .NET Framework, ASP.NET, Git
Digital Literacy	Microsoft Office, Microsoft Excel, Microsoft Word, Microsoft PowerPoint, Microsoft Outlook, Microsoft Access, Visio, Mac, Computer Literacy, Microsoft Products
Digital Marketing	Digital Marketing, Online Marketing, E-commerce, Search Engine Optimization (SEO), Email Marketing, Digital Strategy, Direct Marketing, Google Analytics, Search Engine Marketing (SEM), Google Adwords
Documentation	Software Documentation, Technical Writing, Documentation, Technical Documentation, Confluence, Manuals, Document Imaging, Technical Communication, FrameMaker, SnagIt
Drilling Engineering	Pipelines, Offshore Drilling, Upstream, Drilling, Oilfield, Completion, HAZOP Study, Front End Engineering Design (FEED), Subsea Engineering, Offshore Operations
Earth Science	Renewable Energy, Geographic Information Systems (GIS), ArcGIS, Geology, Global Positioning System (GPS), Geological Mapping, Mineral Exploration, Remote Sensing, Geophysics, Logging
Economics	Financial Modeling, Valuation, Stata, Econometrics, Quantitative Analytics, Macroeconomics, EViews, Energy Markets, Economic Research, International Economics
Editing	Editing, Copy Editing, Proofreading, Text Editing, English Grammar, Fact-checking, Web Editing, Punctuation, Formatting Documents, Spelling
Educational Administration	Staff Development, Educational Leadership, Student Affairs, Student Development, Academic Advising, Admissions, Technology Integration, Student Engagement, Technology Needs Analysis, Educational Consulting
Educational Research	Educational Technology, Educational Research, Assessment, ADDIE, Action Learning, Evidence-Based Practice (EBP), Cognitive Science, Transcripts
Electronic Control Systems	Programmable Logic Controller (PLC), Control Systems Design, Distributed Control System (DCS), Building Automation, Allen-Bradley, Building Management Systems, Variable Frequency Drives, Lighting Control, Control Logic, WinCC
Electronics	Electronics, Electrical Wiring, Embedded Systems, Semiconductors, Arduino, Integrated Circuits (IC), Consumer Electronics, Sensors, Semiconductor Industry, Soldering
Emergency Medicine	Cardiopulmonary Resuscitation (CPR), First Aid, Emergency Medicine, Emergency Services, Life Support, EMT, Paramedic, Emergency Nursing, Ambulance, First Aid Training
Employee Learning & Development	Training, Leadership Development, Organizational Development, Employee Training, Employee Engagement, Instructional Design, Training Delivery, Executive Coaching, Organizational Effectiveness, Training & Development
Employment Law	Employment Law, U.S. Family and Medical Leave Act (FMLA), Employment Contracts, Equal Employment Opportunity (EEO), I-9 Compliance, Union Avoidance, Employment Law Compliance, Employment Litigation, U.S. Equal Employment Opportunity Commission (EEOC), Union Agreements
Enterprise Software	SAP Products, Enterprise Software, SAP ERP, SAP Implementation, High Availability, SAP Netweaver, Microsoft Dynamics CRM, Cognos, Magento, Microsoft Dynamics NAV
Entrepreneurship	Entrepreneurship, Start-ups, Social Entrepreneurship, Lean Startup, Angel Investing, Start-up Ventures, Entrepreneurship Development, Small Business Development, Early-stage Startups, Growth Hacking
Environmental Consulting	Sustainability, Environmental Compliance, Environmental Consulting, Hazardous Materials, Remediation, Incident Investigation, OHSAS 18001, Environmental Permitting, Environmental Auditing, HAZWOPER
Environmental Engineering	Environmental Engineering, Waste Management, Stormwater Management, Hazardous Waste Management, Waste, Erosion Control, Municipalities, Traffic Management, Redevelopment, Green Technology
Environmental Science	Life Sciences, Environmental Awareness, Sustainable Development, Environmental Management Systems, Environmental Science, Environmental Impact Assessment, ISO 14001, Environmental Policy, Ecology, Climate Change
Event Planning	Event Planning, Event Management, Corporate Events, Live Events, Festivals, Meeting Planning, Weddings, Party Planning, Event Production, Wedding Planning
Evolutionary Biology	Evolutionary Biology, Natural History, Paleontology, Synthetic Biology, Species Identification, Flora & Fauna
Family Law	Family Law, Juvenile Law, Elder Law, Prenuptial Agreements, Divorce Law, Family Mediation, Paternity, Preparation of Wills, Legal Separation, Juvenile Delinquency

continues

APPENDIX F continued

Family Medicine	Medical Education, Home Care, Internal Medicine, Diabetes, Pain Management, Medical-Surgical, Immunology, Infectious Diseases, Wound Care, IV Therapy
Financial Accounting	Financial Analysis, Financial Reporting, Financial Accounting, Corporate Finance, Financial Statements, International Financial Reporting Standards (IFRS), Financial Audits, Generally Accepted Accounting Principles (GAAP), U.S. Generally Accepted Accounting Principles (GAAP), Financial Forecasting
Fishing	Fishing, Fly Fishing, Ecotourism, Commercial Fishing
Flexible Approach	Easily Adaptable, Diplomacy, Adaptation, Flexible Schedule, Flexible Approach, Agility, Can Do Approach, Constructive Feedback, Open-mindedness, Lateral Thinking
Fluid Dynamics	Computational Fluid Dynamics (CFD), Fluid Mechanics, Aerodynamics, Fluid Dynamics, Fluids, Dynamic Simulation, Turbulence Modeling
Food Manufacturing	Food Safety, Food Industry, Hazard Analysis and Critical Control Points (HACCP), Food Processing, Food Science, Food Technology, Food Manufacturing, Food Microbiology, Food Packaging, Food Chemistry
Food Service Operations	Restaurant Management, Catering, Nutrition, Menu Development, Pre-opening, Banquet Operations, MICROS, Fine Dining, Recipe Development, Sanitation
Foreign Languages	English, Spanish, French, Dutch, Portuguese, German, Foreign Languages, Italian, Multilingual, Chinese
Forestry	Forestry, Trees, Forest Management, Forest, Renewable Resources, Sustainable Forest Management, Forest Products, Urban Forestry, Forest Carbon
Game Development	Video Games, Game Development, Unity3D, Game Design, Online Gaming, Mobile Games, Gaming Industry, Gaming, Perforce, Unity
Gastroenterology	Gastroenterology, Digestive Disorders, Hepatology, Gastrointestinal Disorders, Gastrointestinal Surgery
General Surgery	Surgery, Operating Room, Working with Surgeons, General Surgery, Surgical Instruments, Disposables, Aseptic Technique, Laparoscopic Surgery, Endoscopy, Reconstructive Surgery
Genetic Engineering	Molecular Biology, Polymerase Chain Reaction (PCR), Genetics, Real-Time Polymerase Chain Reaction (qPCR), Genomics, Molecular Cloning, Gel Electrophoresis, DNA, Protein Expression, DNA Extraction
Geotechnical Engineering	Highways, Geotechnical Engineering, Earthworks, Foundation Design, Excavation, Tunnels, Seismic Design, Pavement Engineering, Slope Stability, Rock Mechanics
Graphic Design	Adobe Photoshop, Adobe Illustrator, InDesign, Web Design, Adobe Creative Suite, Art Direction, Logo Design, Drawing, Illustration, Graphics
Ground Transportation	Shipping, Road, Forklift Operation, Rail Transport, Trucking, Fleet Management, LTL Shipping, Truckload Shipping, Dispatching, Shipping & Receiving
Growth Strategies	Mergers & Acquisitions, Restructuring, Customer Acquisition, Financial Structuring, Corporate Development, Acquisitions, Acquisition Integration, International Business Development, LBO, Market Entry
Healthcare Management	Hospitals, Healthcare Management, Healthcare Information Technology (HIT), Electronic Medical Record (EMR), Patient Safety, U.S. Health Insurance Portability and Accountability Act (HIPAA), Medical Terminology, Managed Care, Medicare, Healthcare Consulting
Higher Education	Higher Education, Curriculum Development, Program Development, Program Evaluation, Adult Education, Lecturing, English as a Second Language (ESL), Intercultural Communication, Online Research, International Education
History	American History, European History, Oral History, Critical Reading, Ancient History, Social Change, Film History, Local History, Public Records, Cultural History
Hosting Services	Web Hosting, Internet Services, Managed Hosting, Email Hosting, Hosting Services
Human Computer Interaction	User Experience, User Interface Design, Bootstrap, Interaction Design, User Experience Design, Usability, Usability Testing, Human Factors, Wireframing, Experience Design
Human Resources	Performance Management, Employee Relations, Talent Management, HR Consulting, HR Policies, Human Resources Information Systems (HRIS), Succession Planning, New Hire Orientations, Workforce Planning, Labor Relations
Industrial Design	Sketching, Concept Development, Concept Art, Design Thinking, User-centered Design, Model Making, Rapid Prototyping, Design Strategy, Ergonomics, Design Engineering
Information Management	SharePoint, Content Management, Content Management Systems (CMS), Document Management, Knowledge Management, Records Management, Laboratory Information Management System (LIMS), Symfony, Enterprise Content Management, SharePoint Designer
Inorganic Chemistry	Inorganic Chemistry, Catalysis, Physical Chemistry, Surface Chemistry, Precious Metals, Organometallic Chemistry, Heterogeneous Catalysis, Inorganic Synthesis, Silicones, Adsorption
Inside Sales	Account Management, Direct Sales, Sales Process, Solution Selling, International Sales, Cold Calling, Sales Effectiveness, Consultative Selling, Telemarketing, Territory Management
Instrumentation	Instrumentation, Calibration, Industrial Control, Data Acquisition, Measurements, Meters, Electronic Instrumentation, Instrument Control
Insurance	Risk Management, Insurance, Health Insurance, Underwriting, General Insurance, Property & Casualty Insurance, Commercial Insurance, Life Insurance, Claims Management, Liability

continues

APPENDIX F continued

Intellectual Property	Intellectual Property, Licensing, Patent Law, Trademarks, Copyright Law, Trade Secrets, Patent Litigation, Patent Prosecution, Trademark Infringement, Patentability
Interior Design	Interior Design, Space Planning, Furniture, Interior Architecture, Building Materials, Flooring, Refurbishments, Furnishings, Lighting Design, Retail Design
International Law	International Business, International Trade, International Law, Export, Human Rights, European Union, Cross-border Transactions, Immigration Law, European Law, International Arbitration
Inventory Management	Inventory Management, Enterprise Resource Planning (ERP), Inventory Control, Warehouse Operations, Materials Management, Warehouse Management Systems, Distribution Center Operations, SAP Sales & Distribution, Stock Management, Order Management
Investment Banking	Investments, Financial Services, Financial Planning, Asset Management, Investment Banking, Private Equity, Wealth Management, Mutual Funds, Retirement Planning, Hedge Funds
Investor Relations	U.S. SEC Filings, Investor Relations, Capital Raising, U.S. Securities and Exchange Commission (SEC), SEC Financial Reporting, XBRL, Public Companies, Securities Offerings, Board of Directors Reporting, Stock Compensation
Journalism	Journalism, Magazines, Newspapers, Online Journalism, Broadcast Journalism, AP Stylebook, Digital Publishing, Breaking News, Reporting, Sports Writing
K-12 Education	Tutoring, Lesson Planning, Teacher Training, Classroom Management, Elementary Education, Special Education, Differentiated Instruction, Literacy, K-12 Education, Secondary Education
Kinesiology	Exercise Physiology, Kinesiology, Biomechanics, Low Back Pain, Musculoskeletal Physiotherapy, Corrective Exercise, Bodybuilding, Gait Analysis, Musculoskeletal Injuries, Group Exercise
Landscape Architecture	Landscaping, Landscape Design, Horticulture, Landscape Architecture, Landscape Maintenance, Garden Design, Garden, Tree Planting, Lawn Care, Plant Identification
Law	Legal Research, Litigation, Legal Writing, Corporate Law, Legal Advice, Commercial Litigation, Corporate Governance, Legal Assistance, Regulatory Affairs, Appeals
Leadership	Leadership, Team Leadership, Team Building, Cross-functional Team Leadership, Organizational Leadership, Strategic Thinking, Strategic Leadership, Technical Leadership, Situational Leadership, Business Innovation
Legislation	Legislative Relations, Legislation, Regulations, Legislative Research, State Government, Policy Development, Legislative Affairs, Citizenship, Legislative Policy, Government Administration
Library Science	Library Services, Cataloging, Information Literacy, Archives, Collection Development, Library Management, Library Instruction, Library Research, Digital Libraries, Metadata
Linguistics	Grammar, Applied Linguistics, Computational Linguistics, Phonetics, Discourse Analysis, Phonology, Syntax, Pragmatics, Language Testing, Psycholinguistics
Literature	Literature, Poetry, English Literature, Short Stories, Novels, Book Reviews, Literary Criticism, Memoir, Essays, Narrative
Lodging	Hospitality Industry, Hotel Management, Front Office, Rooms Division, Hotel Booking, Property Management Systems, Guest Service Management, Opening Hotels, Reservations, Housekeeping
Machining	SolidWorks, Welding, Metal Fabrication, Autodesk Inventor, Machining, Geometric Dimensioning & Tolerancing, Machine Tools, Machinery, Computer Numerical Control (CNC), CAD/CAM
Maintenance & Repair	Maintenance, Maintenance Management, Maintenance & Repair, Preventive Maintenance, Computer Repair, Hydraulics, Heavy Equipment, Computer Maintenance, Plant Maintenance, Mechanics
Management Accounting	Budgeting, Account Reconciliation, Managerial Finance, P&L Management, Cash Flow, Cash Management, Cost Accounting, Variance Analysis, Bank Reconciliation, Management Accounting
Management Consulting	Business Analysis, Management Consulting, Business Intelligence, Market Analysis, Strategic Consulting, Business Process Mapping, Business Case, Business Modeling, Process Consulting, Client Presentation
Manufacturing Operations	Operations Management, Continuous Improvement, Lean Manufacturing, Six Sigma, Project Engineering, 5S, Inspection, Commissioning, Process Engineering, Quality Management
Materials Science	Materials, Materials Science, Design of Experiments, Characterization, Spectroscopy, Metallurgy, Thin Films, Scanning Electron Microscopy, Raw Materials, Metrology
Mathematics	Numerical Analysis, Mathematica, Fortran, Operations Research, Applied Mathematics, Calculus, Numerical Simulation, Monte Carlo Simulation, Algebra, Mathematical Analysis
Mining	Minerals, Gold, Coal, Mineral Processing, Iron Ore, Base Metals, Mining Engineering, Underground Mining, Copper, Coal Mining
Mobile Application Development	Android, Mobile Applications, Android Development, iPhone, Android Studio, Android SDK, Mobile Internet, Blackberry, Mobile Application Development, Windows Phone
Music	Music, Music Production, Singing, Music Industry, Sound, Audio Recording, Music Composition, Songwriting, Music Education, Musical Theatre
Nanotechnology	Nanotechnology, Nanomaterials, Molecular Modeling, Carbon Nanotubes, Nanostructures, Nanomedicine, Mechanical Properties, Nanoelectronics
National Security	National Security, Homeland Security, Counterinsurgency, Government Relations, Coalitions, Interagency Coordination, Government Liaison, Federal Government Relations, NSA

continues

APPENDIX F continued

Natural Language Processing	Information Retrieval, Natural Language Processing, Text Mining, Speech Recognition, Text Analytics, Semantic Technologies, Sentiment Analysis, NLTK, Parsing, Natural Language Understanding
Navy	Command, Navy, Maritime Security, Marine Operations, Ship Management, Diving, Seamanship, Vessel Operations, Docking, Submarines
Negotiation	Negotiation, Mediation, Conflict Resolution, Strategic Negotiations, Cooperation, Conflict, Priority Management, Union Relations, Collaborative Law, Adjudication
Neurology	Neurology, Neuroscience, Neurosurgery, Stroke Rehabilitation, Central Nervous System, Spinal Cord Injury, Neurological Disorders, Brain Injury, CNS disorders, Movement Disorders
Nonprofit Management	Nonprofit Organizations, Community Outreach, Fundraising, Grant Writing, Community Development, Capacity Building, Non-Governmental Organizations (NGOs), Community Engagement, Economic Development, Accountability
Nuclear Engineering	Nuclear, Radiography, Reactor, Nuclear Safety, UV, Digital X-ray, Dosimetry, Nuclear Energy, Radiation Monitoring, Radiochemistry
Nuclear Physics	Radiation Safety, Nuclear Power Plants, Radiation, Nuclear Physics, Nuclear Proliferation, Radioactive Materials, Reactor Physics, Radiation Effects, Radioactivity, Linear Accelerators
Nursing	Nursing, Basic Life Support (BLS), Inpatient Care, Critical Care Nursing, Advanced Cardiac Life Support (ACLS), Patient Education, Acute Care, Working with Physicians, Patient Advocacy, Vital Signs
Obstetrics	Obstetrics and Gynecology, Pregnancy, Women's Health, Obstetrics, Gynecology, Fertility, Prenatal Care, Infertility, Midwifery, Maternity
Ocean Transportation	Maritime, Maritime Operations, International Shipping, Container Shipping, Ocean Transportation, Ports, Navigation, ISM Code, Sailing, Boat
Oceanography	Scuba Diving, Marine Biology, Meteorology, Oceanography, Climate, Underwater, Marine Survey, Marine Conservation, Physical Oceanography
Oil & Gas	Petroleum, Oil & Gas, Gas, Onshore Operations, Petrochemical, Piping, Oil & Gas Industry, Refinery Operations, Natural Gas, Piping and Instrumentation Drawing (P&ID)
Oncology	Oncology, Cancer, Cancer Research, Chemotherapy, Oncology Clinical Research, Breast Cancer, Cancer Screening, Cancer Treatment, Molecular Oncology, Gynecologic Oncology
Operational Efficiency	Operational Planning, Supply Chain Optimization, Operational Excellence, Key Performance Indicators, Demand Planning, KPI Reports, Operational Efficiency, Inventory Planning, Operational Strategy, Cost Effective
Ophthalmology	Ophthalmology, Contact Lenses, Optometry, Eyewear, Glaucoma, Eye Exams, Ocular Disease, Dry Eye, Lenses, LASIK
Oral Communication	Public Speaking, Communication, Presentations, Presentation Skills, Interpersonal Communication, Presenter, Technical Presentations, Presentation Development, Professional Communication, Oral Communication
Oral Comprehension	Learning Disabilities, Educational Assessment, Listen, Assistive Listening Devices, Oral Comprehension
Organic Chemistry	Biochemistry, High-Performance Liquid Chromatography (HPLC), Analytical Chemistry, Good Laboratory Practice (GLP), Organic Chemistry, ELISA, Chromatography, Protein Purification, UV/Vis Spectroscopy, Protein Chemistry
Orthopedic Surgery	Orthopedic Surgery, Sports Injuries, Musculoskeletal System, Chronic Pain, Spine, Neuromuscular Therapy, Knee, Outpatient Orthopedics, Orthotics, Podiatry
Paediatrics	Paediatrics, Neonatal Intensive Care, Neonatal Nursing, Neonatology, Adolescent Health, Pediatric Surgery, Child Health
Painting	Painting, Visual Arts, Oil Painting, Art Exhibitions, Restoration, Watercolor, Acrylic, Paint, Acrylic Painting, Murals
Partner Development	Partner Management, Business Alliances, Partnerships, Strategic Alliances, Partner Development, Partnership-building, Partner Programs, Channel Programs, Partner Support
Pathology	Flow Cytometry, Laboratory Medicine, Toxicology, Pathology, Biomarkers, Biomarker Discovery, Anatomic Pathology, Medical Microbiology, Cancer Biology, Veterinary Pathology
Payroll Services	Payroll, ADP Payroll, Payroll Taxes, Payroll Processing, Payroll Administration, Time & Attendance, Kronos, Payroll Services, Kronos Timekeeping, Payroll Analysis
People Management	Teamwork, Supervisory Skills, Personnel Management, People Management, Team Motivation, Conflict Management, Distributed Team Management, Workforce Management, Organizational Structure, Staff Training
Personal Coaching	Coaching, Personal Development, Mentoring, Career Counseling, Personal Training, Motivational Speaking, Life Coaching, Business Coaching, Job Coaching, Lifestyle Coaching
Pharmaceutical Manufacturing	Pharmaceutical Industry, Biotechnology, GMP, Laboratory Skills, Standard Operating Procedure (SOP), U.S. Food and Drug Administration (FDA), Clinical Development, Good Clinical Practice (GCP), Technology Transfer, CRO Management
Pharmaceutics	Clinical Research, Clinical Trials, Pharmaceutical Sales, Pharmacy, Pharmaceutics, Pharmacology, Market Access, Pharmacovigilance, Biopharmaceuticals, U.S. Title 21 CFR Part 11 Regulation
Photography	Photography, Digital Photography, Image Editing, Portrait Photography, Lightroom, Event Photography, Fine Art Photography, Photojournalism, Wedding Photography, Travel Photography
Physical Medicine and Rehabilitation	Rehabilitation, Fitness Training, Physical Therapy, Sports Medicine, Injury Prevention, Weight Training, Manual Therapy, Strength & Conditioning, Functional Training, Exercise Prescription
Physical Security	Physical Security, Security Management, Surveillance, Security Operations, Closed-Circuit Television (CCTV), Industrial Safety, Workplace Safety, Firefighting, Executive Protection, Corporate Security

continues

APPENDIX F continued

Physics	Optics, Thermodynamics, Nuclear Magnetic Resonance (NMR), Heat Transfer, NMR Spectroscopy, Dynamics, Photonics, Biophysics, Astronomy, Experimental Physics
Physiology	Cell Culture, Cell Biology, Western Blotting, Microscopy, Assay Development, Confocal Microscopy, In Vitro, Animal Models, Tissue Culture, In Vivo
Plastics	Plastics, Injection Molding, Extrusion, Thermoplastics, Blow Molding, Mold, Plastic Extrusion, Thermoforming, Plastics Engineering, Plastics Industry
Politics	International Relations, Politics, International Development, Political Campaigns, Foreign Policy, Public Affairs, Humanitarian, Political Consulting, Foreign Affairs, State Politics
Power Systems	Power Generation, Energy Efficiency, Power Plants, Solar Energy, Power Distribution, Power Systems, Photovoltaics, Wind Energy, Power Electronics, Energy Audits
Printing	Digital Printing, Pre-press, Offset Printing, Print Management, Wide Format Printing, Screen Printing, 3D Printing, Color Management, Variable Data Printing, Managed Print Services
Problem Solving	Problem Solving, Creative Problem Solving, Decision-Making, Collaborative Problem Solving, Ethics, Problem Analysis, Solution Focused, Analytic Problem Solving, Root Cause Problem Solving, Team Problem Solving
Procurement	Contract Negotiation, Logistics Management, Contract Management, Procurement, Subcontracting, Strategic Sourcing, Transportation Management, Supply Management, Global Sourcing, Import
Product Development	Product Development, Product Launch, Product Design, Innovation Management, Product Lifecycle Management, Product Innovation, Commercialization, Innovation Development, Mechanical Product Design, Product Engineering
Product Marketing	Marketing Strategy, Market Research, Product Marketing, Marketing Management, Competitive Analysis, Brand Development, Integrated Marketing, Market Planning, Customer Insight, Go-to-market Strategy
Product Testing	Testing, Quality Control, Validation, Quality Auditing, Corrective and Preventive Action (CAPA), Nondestructive Testing (NDT), Verification and Validation (V&V), Welding Inspection, Ultrasonic Testing, QA Engineering
Professional Cleaning	Carpet Cleaning, Professional Cleaning, Data Cleaning, Floor Cleaning, Window Cleaning, Commercial Cleaning, Industrial Cleaning, Upholstery Cleaning, Home Cleaning, Green Cleaning
Professional Sports	Sports Management, Athletics, Football, Athletic Training, Soccer, Golf, Swimming, Basketball, Martial Arts, Tennis
Project Management	Project Management, Project Planning, Program Management, Microsoft Project, Software Project Management, Project Estimation, Stakeholder Management, Project Coordination, Facilitation, Project Delivery
Property Law	Property Law, Property Damage, Estate Law, Ownership, Low-Income Housing Tax Credit (LIHTC), Evictions, Land Use Law, Personal Property, Trust Deeds, Property Rights
Property Management	Investment Properties, Property Management, Working with Tenants, Apartments, Dispositions, Lease Negotiations, Social Housing, Affordable Housing, Shopping Centers, Yardi
Psychiatry	Psychiatry, Dual Diagnosis, Mental Health Treatment, Child Psychiatry, Behavioral Disorders, Forensic Psychiatry, Geriatric Psychiatry, Addiction Psychiatry, Deconstruction, Psychiatrists
Psychology	Psychotherapy, Working with Adolescents, Stress Management, Counseling Psychology, Family Therapy, Cognitive Behavioral Therapy (CBT), Psychological Assessment, Interventions, Mindfulness, Elder Care
Public Health	Public Health, Health Education, Health Promotion, Epidemiology, Prevention, Health Policy, Global Health, Community Health, Medical Affairs, Health Economics
Public Policy	Public Policy, Government, Policy Analysis, Public Sector, Local Government, Government Contracting, Grassroots Organizing, Private Sector, Federal Government, Public Transport
Public Safety	Risk Assessment, Emergency Management, Safety Management Systems, Occupational Health, Law Enforcement, Investigation, Crisis Management, Public Safety, Criminal Justice, Private Investigations
Radio Production	Radio, Audio Editing, Radio Broadcasting, Adobe Audition, Audio Post Production, Radio Production, Audio Mixing, Radio Host, Radio Advertising, Radio Promotions
Radiology	Medical Imaging, Radiology, Digital Imaging, Picture Archiving and Communication System (PACS), Medical Ultrasound, X-ray, MRI, Medical Diagnostics, DICOM, Computed Tomography
Reading Comprehension	Reading Comprehension, Reading Intervention, Guided Reading
Real Estate	Residential Homes, Real Estate Transactions, Commercial Real Estate, Sellers, Mortgage Lending, Working with First-Time Home Buyers, Real Estate Development, Renovation, Short Sales, Buyer Representation
Recreation	Outdoor Recreation, Casino Gaming, Camping, Mountaineering, Theme Parks, Therapeutic Recreation, Golf Clubs, Camp, National Parks
Recruiting	Recruiting, Interviewing, Sourcing, Employee Benefits Design, Technical Recruiting, Hiring, Onboarding, Executive Search, Applicant Tracking Systems, Screening
Religious Studies	Preaching, Theology, Pastoral Care, Discipleship, Religion, Biblical Studies, Youth Ministry, Pastoral Counseling, Church Events, Missions
Research	Research, Qualitative Research, Research and Development (R&D), Quantitative Research, Research Design, Focus Groups, Primary Research, Secondary Research, Qualitative & Quantitative Research Methodologies, Financial Research
Retail Packaging	Packaging Design, Retail Packaging, Packaging Engineering, Packaging Artwork, Pharmaceutical Packaging, Packaging Machinery

continues

APPENDIX F continued

Retail Sales	Sales Management, Retail, Merchandising, Pricing Strategy, Visual Merchandising, Retail Sales, Store Management, Fast-Moving Consumer Goods (FMCG), Trade Shows, Loss Prevention
Revenue Analysis	Revenue Analysis, Yield Management, Revenue Cycle, Revenue Cycle Management, Revenue Forecasting, Revenue Modeling, Revenue Streams, Revenue Share
Robotics	Automation, Robotics, Control Theory, Process Automation, Machine Design, Electrical Controls, Mechatronics, Electro-mechanical, Motion Control, Machine Vision
Sales Leads	Lead Generation, Demand Generation, Inbound Marketing, Lead Management, Sales Leads, Inbound Lead Generation, Client Prospecting, Social Selling, Channel Partner Development, Building New Business
Sales Operations	Customer Relationship Management (CRM), Sales Operations, Business-to-Business (B2B), Salesforce.com, Strategic Partnerships, Pre-sales, Business Relationship Management, Sales Presentations, Channel Partners, Key Account Development
Scientific Computing	Matlab, Finite Element Analysis, Mathematical Modeling, Simulink, Bioinformatics, SASS, Scala, High Performance Computing (HPC), Scientific Computing, Maple
Sculpture	Sculpture, Clay, Stoneware, Statues
Shipbuilding	Marine Engineering, Shipbuilding, Yachting, Naval Architecture, Vessels, Maritime Safety, Marine Industry, Shipyards, Boat Building, Marine Systems
Signal Processing	Signal Processing, Image Processing, Digital Signal Processing, Audio Processing, Encoding, Video Processing, Speech Processing, Multiplexing, Analog Signal Processing, Speech Signal Processing
Social Media	Social Media, Social Media Marketing, Digital Media, Blogging, Facebook, Twitter, Social Marketing, YouTube, Instagram, Social Media Optimization (SMO)
Social Perceptiveness	Emotional Intelligence, Self-confidence, Interpersonal Relationships, Cross-cultural Communication Skills, Cultural Awareness, Social Justice, Intercultural Skills, Social Enterprise, Cross-cultural Teams, Social Innovation
Social Services	Mental Health, Social Services, Case Management, Crisis Intervention, Group Therapy, Mental Health Counseling, Behavioral Health, Youth Development, Motivational Interviewing, Clinical Supervision
Sociology	Cultural Diversity, Ethnography, Social Psychology, Social Research, Qualitative Data, Demography, Quantitative Data, Institutional Change
Software Development Life Cycle	Integration, Requirements Analysis, Agile Methodologies, Software Development Life Cycle (SDLC), Scrum, Solution Architecture, Requirements Gathering, Systems Engineering, Unified Modeling Language (UML), Software Design
Software Testing	Test Automation, User Acceptance Testing, Manual Testing, Test Planning, HP Quality Center, Regression Testing, Debugging, System Testing, Software Quality Assurance, Test Cases
Sports Coaching	Sports Coaching, Strength Training, Sports Nutrition, Fitness Instruction, Endurance, Golf Instruction, Sports Development, Performance Enhancement, College Football, Coaching Baseball
Structural Analysis	Structural Analysis, Engineering Design, Bridge, Calculations, Stress Analysis, Specifications, FEM analysis, Slabs, Structural Modeling, Structural Integrity
Structural Engineering	Structural Engineering, MathCAD, Reinforced Concrete, Retaining Walls, Earthquake Engineering, Autodesk Robot Structural Analysis, Concrete Materials, Marinas, Pile Foundations, Aluminum Alloys
Tax Accounting	Tax, Income Tax, Tax Preparation, Corporate Tax, Tax Accounting, Tax Advisory, Value-Added Tax (VAT), International Tax, Sales Tax, Tax Research
Tax Law	Tax Law, Revenue Recognition, Asset-Backed Security (ABS), Securities Lending, Commercial Mortgage-Backed Security (CMBS), Mortgage-Backed Security (MBS), Distressed Debt, FIN 48, Unsecured Loans, Use Tax
Teaching	Teaching, University Teaching, Language Teaching, Teaching English as a Second Language, English Teaching, Teaching English as a Foreign Language, Teaching Writing, Sales Trainings, Instructors, Assistant Teaching
Technical Support	Windows, Troubleshooting, ITIL, Technical Support, Operating Systems, System Administration, IT Service Management, IT Strategy, IT Management, Disaster Recovery
Telecommunications	Telecommunications, Mobile Devices, Wireless Technologies, Internet Protocol (IP), GSM, Unified Communications, 3G, LTE, Radio Frequency (RF), Mobile Communications
Television	Television, Broadcasting, Commercials, Broadcast Television, Camera, Avid Media Composer, TV Production, Streaming Media, Reality Television, Sony Vegas
Theatre	Theatre, Acting, Stage Management, Drama, Improvisation, Comedy, Theatrical Production, Stage Lighting, Set Design, Shakespeare
Time Management	Time Management, Organization Skills, Multitasking, Skilled Multi-tasker, Self-management, Tenacious Work Ethic, Prioritize Workload, High degree of initiative, Deadline Oriented, Time-efficient
Translation	Translation, Technical Translation, Localization, Language Services, Bilingual Communications, Legal Translation, Trados, Spanish Translation, Website Localization, Internationalization
Travel Management	Tourism, Travel Management, Leisure Industry, Business Travel, Leisure Travel, Travel Planning, Travel, Online Travel, Tour Operators, Sabre
Urban Planning	Urban Design, Urban Planning, Comprehensive Planning, Land Development, Transportation Planning, Land Use Planning, Zoning, Historic Preservation, Urbanism, Urban
Urology	Urology, Dialysis, Kidney Transplant, Pediatric Urology

continues

APPENDIX F continued

Utilities	Energy, Energy Industry, Pumps, SCADA, Energy Management, Electricity, Building Services, Boilers, Gas Turbines, Pneumatics
Veterinary Medicine	Microbiology, Veterinary Medicine, Animal Welfare, Animal Behavior, Pet Care, Dogs, Veterinary Surgery, Veterinary Technology, Veterinary Nursing, IACUC
Video	Video Production, Video Editing, Video, Film, Final Cut Pro, Film Production, Adobe Premiere Pro, Video Post-Production, Documentaries, Short Films
Volunteer Management	Volunteer Management, Volunteering, Youth Mentoring, Volunteer Recruiting, Volunteer Training, Community Service
Water Engineering	Water Resource Management, Water Treatment, Water Supply, Pump Stations, Water Engineering, Industrial Water Treatment, Drainage Systems, Activated Sludge
Web Development	HTML, JavaScript, Cascading Style Sheets (CSS), PHP, Web Development, XML, jQuery, HTML5, WordPress, Web Services
Wellness	Wellness, Fitness, Holistic Health, Wellness Coaching, Nutritional Counseling, Healing, Therapeutic Massage, Yoga, Meditation, Nutrition Education
Wholesale	Wholesale, Order Picking, Wholesale Operations, Invoice Discounting, Wal-Mart, Gross Margin, Rebates, Pick & Pack, Cross Merchandising, Discount
Writing	Writing, Creative Writing, Proposal Writing, Publishing, Report Writing, Web Content Writing, Storytelling, News Writing, Publications, Resume Writing
Zoology	Animal Work, Zoology, Entomology, Parasitology, Birds, Ornithology, Exotic Animals, Laboratory Animal Medicine, Reptiles, Aquariums

November 2018