Automation, Computerisation and Future Employment in Singapore

King Fuei Lee

Schroder Investment Management

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LEE King Fuei[1]

Schroder Investment Management

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Abstract

Digitalisation is expected to radically change the prospects of the types of occupations that will be needed in the future. This report examines the susceptibility of jobs to computerisation and automation in Singapore by drawing on the methodology and initial data in Frey and Osborne (2013). We find that about one-quarter of Singaporean employment is at high risk of computerisation. This places the country as having one of the lowest proportion of jobs under high risk internationally. Within this high-risk category of workers, a significant number of them have non-tertiary educational qualifications and tend to be older adults, making them less likely to be re-employed if they lose their jobs.

JEL Classification: E24, J24, J62, J64, O33

Keywords: Singapore, automation, computerisation, industry employment, technological unemployment

[1] Lee King Fuei, Schroder Investment Management, 138 Market Street #23-01 CapitaGreen Singapore 048946, Tel: (+65) 6800 7000, Fax: (+65) 6535 3486, Email: king.lee@schroders.com

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Introduction

The confluence of previously disjointed fields, such as robotics, artificial intelligence, nanotechnology, big data, machine-learning, genomics and biotechnology, is forecasted to inflict rampant disruption to labour markets and current business models, with massive changes predicted in the human skill sets required to succeed in the new landscape. In fact, at the launch of the 99% SME campaign in Singapore in 2015, Senior Minister of State (Trade and Industry and National Development) Lee Yi Shyan warned that "as new technologies come on board, many of the intelligent functions, predictive functions, repetitive functions … (such as) recording, filing, documenting, data collection, can be automated. Once that happens, a lot of the jobs will disappear." He further urged employers to reconsider how workers can be retrained to acquire the skills needed in the new economy.

Given the far-reaching impact of technological disruption on employment, it is not surprising that there have been considerable discussions about the types of jobs which are most at risk of being displaced. In their seminal paper, Frey and Osborne (2013) answered the question by employing a novel methodology to estimate the probability of computerisation of 702 occupations in the US using a Gaussian process classifier. They first identified three major engineering bottlenecks that limit the ability of computers to mimic human tasks, these being perception and manipulation, creative intelligence, and social intelligence. They then used data from O*NET, a database that evaluates US occupations, to categorise the tasks of these occupations in respect to the three bottleneck skills. The probabilities of computerisation for the detailed occupations in the database are then calculated. According to their study, about 47% of total US employment is at high risk. Pajarinen, Rouvinen and Ekeland (2015, p.1) applied the Frey-Osborne estimates to Finland and Norway, and calculated the share of jobs that are susceptible to automation to be around 35% and 33% respectively, while Bowles (2014) finds that number to be about 54% in Europe.

This paper aims to provide an estimate of the susceptibility of jobs in Singapore to computerisation and automation over the next ten to fifteen years by drawing on the methodology and initial data in Frey and Osborne (2013). In particular, we find that around 25% of employment in Singapore is at high risk of computerisation. This places the country as having one of the lowest share of jobs at high risk, compared to the estimates of other countries in various international studies. Within this group of Singaporean workers who are more susceptible to automation, the majority of them are in the Services industry, and slightly more than half of them are females. A significant proportion of them also have educational qualifications that are Secondary and below, and are aged 50 years and above, making them less likely to be re-employed if they lose their jobs.

There are several motivations for this paper. The key objective is to try to understand and quantify the impact of emerging technology on jobs and employment in Singapore. While there has been much debate about the existence of John Maynard Keynes' "technological unemployment", economic history has shown that major innovations such as the steam engine and electricity can result in substantial job losses in the short-term, even if this is more than offset in the long-term by the creation of more productive and fulfilling jobs with greater improvements in standards of living. A quantitative estimate of the possible job losses due to automation is therefore of interest. In addition, our analysis of the worker characteristics of the high-risk category of jobs also has important policy implications. Wanberg et al. (2016, p. 400) and studies by the Singapore Ministry of Manpower and the US Bureau of Labor Statistics have found strong relations between the likelihood of re-employment with age, as well as with educational qualification. Our findings can be used to augment current policy directions to mitigate the potential societal impact from those less likely to be re-employed after they lose their jobs.

Methodology and Data

This section gives a brief description of the methods and data sources that are used to extend the work of Frey and Osborne (2013) on US employment automation to Singapore. In their study, the O*NET data and the Standard Occupational Classification (SOC-2010) by the US Department of Labor was used to consider 702 US occupations.

Following the methodology of Pajarinen, Rouvinen and Ekeland (2015, p. 1) and Bowles (2014), we transfer the features of the US study to Singapore by performing two crosswalks. In the first crosswalk, we map the 702 SOC-2010 job codes used in Frey and Osborne (2013) to the International Standard Classification of Occupations (ISCO-2008) job codes using the crosswalk table provided by the US Bureau of Labor[i]. We then map the ISCO-2008 job codes to the Singapore Standard Occupational Classification (SSOC-2015) job codes in the second crosswalk using data provided by the Department of Statistics Singapore[ii]. In both instances, we average the probabilities of computerisation where there is a many-to-one correspondence. Due to differences in the two classification systems as well as the level of detailed employment statistics for various job codes provided by the respective departments, the number of occupations with relevant probabilities falls to thirty-eight in Singapore. There are some occupations in SSOC-2015 that do not have equivalent ISCO-2008 or SOC-2010 classifications, which we exclude from our dataset. Our data nevertheless covers 93% of the employed residents with a valid occupational code in Singapore. Only 153,600 out of the 2,147,900 Singaporean jobs were omitted.

The mapped probabilities of computerisation for each SSOC-2015 occupation is then matched with the Singapore employment counts from the latest Labour Force in Singapore 2014 study[iii] provided by the Ministry of Manpower. Because worker characteristics are only provided for major occupational groups, we therefore also calculate the probabilities for these major groups as cohort-weighted averages of the probabilities of the unit groups.

As consistent with Frey and Osborne (2013) and other studies, we define occupations with under 30% probability of computerisation as being low-risk, with over 70% as being high-risk, and the rest as being medium-risk.

Findings

Figure 1 shows the key results of our study. We find that about 25% of Singaporean employment is at high risk of computerisation. This compares to 47% in US (Frey and Osborne, 2013), 35% in UK (Knowles-Cutler, Frey and Osborne 2014), 35% in Finland and 33% in Norway (Pajarinen, Rouvinen and Ekeland 2015, p. 1). In contrast to all three studies where there are distinct peaks at both ends of the distribution for all three countries, almost half of the Singaporean jobs (46%) fall in the medium-risk category where the occupations have between 30% to 70% probabilities of being automated.

Table 1 shows our calculated probabilities of computerisation for each occupation and the corresponding number of employed residents. The large occupations that are most susceptible to computerisation in Singapore are General & Keyboard Clerks and Sales Workers, totaling 244,800 workers. The other large occupation Drivers & Mobile Machinery Operators lies at the boundary of the high-risk breakpoint, with a total of 114,700 workers (or 5.8% of Singaporean employment). At the other end of the spectrum, large occupations that are least susceptible to computerisation in Singapore include Managers & Administrators and Science & Engineering Professionals, totaling 363,400 employees.

There are two caveats to our analysis. Firstly as pointed out by Frey and Osborne (2013), the predictions from this methodology are based on the expanded premise of the tasks that computer-controlled equipment can be expected to perform, and therefore the focus is on estimating the potential job automatability over some unspecified number of years rather than on the number of jobs that will actually be automated. The actual extent and speed of computerisation will depend on several factors including regulatory considerations, the pace of technological progress, as well as the access to and price of labour and capital.

In addition, some have argued that because occupations typically consist of performing a suite of tasks of which not all can be easily automated, therefore the potential for automating entire occupations may be lower than that suggested by the approach used in Frey and Osborne (2013). Arntz, Gregory and Zierahn (2016) instead applied a task-based approach to estimating the job automatability, and concluded that the share of jobs at risk in the US is closer to 9%. There is clearly scope for further work to be done in this area using their methodology that will not be pursued in this paper.

Despite these caveats, our findings suggest that major future changes in the labor market are still afoot in the near term. We therefore delve into the high-risk category of jobs by breaking it down further according to worker characteristics. Our results are shown in Figure 2.

In terms of gender, there appears to be a larger proportion of females within the high-risk category at 55%, compared to males at 45%. The industry breakdown shows that the majority of these high-risk jobs are in the Services industry and stands at 84%. While significant, this is perhaps more representative of the broader employment landscape in the country where in general 83% of employees work in the Services industry. Within the industry, the high-risk jobs are found in the sub-industries of Wholesale & Retail Trade (329,700 workers) and Public Administration & Education (288,900 workers).

When we break down the high-risk category by age groups, we find that almost half of the workers, around 48%, are aged 50 years and over. This is important as a recent US study by Wanberg et al. (2016, p. 400) have found that after losing their jobs, older adults tend to remain unemployed 10.6 weeks longer than those aged between 20 and 29, with the odds of being re-employed falling by 2.6% for each one-year increase in age. This is similarly observed by the Ministry of Manpower (MOM) in Singapore. In their Redundancy and Re-entry into Employment 2015 report, they found that the rate of re-entry into employment within twelve months of redundancy is the lowest for workers aged 50 and above, standing at only 57.6%. This compares to 76.7% for those aged below 30 years old, and 72.4% for those aged between 30 to 39. Our finding therefore has important societal and policy implications for Singapore as it suggests that a large proportion of these workers who are at risk of being displaced by automation are also at risk of being structurally unemployed. In addition, there may also be a temptation by companies to push these older workers in the high-risk category into early retirement before they reach the minimum retirement age of 62. This temptation, however, will likely be partly mitigated by the Retirement and Re-employment Act (Chapter 274A) of Singapore (the "Act") which prohibits employers from dismissing employees below the prescribed minimum retirement age for a reason that is solely on the ground of their age. Indeed for employees close to retirement age who are being terminated, the onus of proving that the termination was not for reasons of age will fall on the employer, should the employee challenge the termination.

When we break down the high-risk category by the highest educational qualification attained, we find that a majority 81% of them have non-tertiary educational qualifications. According to the US Bureau of Labor Statistics, there is a direct correlation between the level of education one achieves and the likelihood of finding a job. For example when they examined their 2013 data, they found that high school graduates had an unemployment rate of 8.3% compared to university graduates of 4.5%. With a substantial proportion of the Singaporean workers in the high-risk group also having lower educational qualifications, this again implies that there is significant risk that they will be in disadvantageous positions when looking for new employment. We believe that the right policies will be required going forward to help reduce the impact of these challenges. Indeed, it looks like initiatives are already increasingly being put in place in Singapore. For example, the SkillsFuture initiative launched this year helps companies and workers identify and anticipate the new types of jobs that will be created under the new digital era, and is one of the ways that will support SMEs in facilitating their employees in developing new skills.

We further perform an international comparison by setting our results against those from other studies (Frey and Osborne 2013; Knowles-Cutler, Frey and Osborne 2014; Pajarinen, Rouvinen and Ekeland 2015, p. 1; Durrent-Whyte et al. 2015; World Bank 2016; Bowles 2014). When comparing these results, it is worth noting three points. Firstly, all the studies used here employ the same initial data from Frey and Osborne (2013) to calibrate their findings, and employ similar methodologies when transferring the SOC-2010 occupational classifications to their country's respective occupational classifications. Secondly, the estimates for different countries are calculated using data from different dates, so an international comparison assumes that the job structures of the economies have not changed significantly since their respective studies. Thirdly, because the application of the Frey-Osborne estimates for the US to other countries implicitly assumes that the risk of automation for a particular occupation in comparable across countries, therefore international comparisons of the estimated share of workers that are prone to automation will mainly be driven by differences in the occupational structures of the countries.

The results are presented in Figure 3. It can be seen that compared to the other countries, Singapore has one of the lowest proportion of workers in jobs that are at high risk of computerisation, and compares favourably to the UK at 35%, US at 47%, EU at 54% and the OECD average of 57%. In particular, it can be seen in Figure 4 that the proportion of workers in the high-risk category in Singapore has been falling for more than two decades from 46% in 1991 to 25% in 2014, while the proportion of low risk jobs has increased from 11% in 1991 to 29% over the same period of time. This likely represents the evolution of the country's economic model since the 1990s which "saw companies moving up the value chain and intensifying their use of technology", with the "Services industry [flourishing] to form one of the pillars of Singapore's economy, along with the field of biomedical sciences and emerging key industries.[iv]" This also meant that automation susceptibility in Singapore has fallen over time as highly susceptible jobs, particularly in the Manufacturing industries, were already being automated.

Conclusions

The global economy is on the cusp of a new industrial revolution and technology is going to dramatically reshape the labour market in the next two decades. Unlike previous industrial revolutions where technological innovation largely replaced repetitive and mechanical tasks, advances in fields such as artificial intelligence, computer data analytics and robotic technologies means that a much broader range of tasks that were previously considered to be non-automatable is now under threat.

In this paper, we estimate the susceptibility of jobs in Singapore by employing the methodology and initial data of Frey and Osborne (2013) and applying it to the domestic labour market. We find that 502,200 jobs – around 25 per cent of the workforce – are prone to automation and computerisation in the next ten to fifteen years, particularly in the sub-industries of Wholesale & Retail Trade and Public Administration & Education. While this number is lower than corresponding estimates in other countries, it still portends significant changes in the domestic labour force. We further find that within this category of high-risk jobs, a significant proportion of them are older adults and have lower educational qualifications. These workers typically find it harder to be re-employed after they lose their jobs. This has huge societal and economic implications, and the development of the right policies in future can help to mitigate the impact of these challenges. One solution will be for companies to pre-empt the disruptive impact of new technology on employment by sending these soon-to-be displaced workers for re-training and other educational enhancement initiatives such as part-time college programmes. Indeed, the setting up of the SkillsFuture movement by the Ministry of Manpower and the development of two Continuing Education and Training (CET) campuses represent very positive steps by the Singapore government towards addressing the disruptive impact of technological innovation on future employment.

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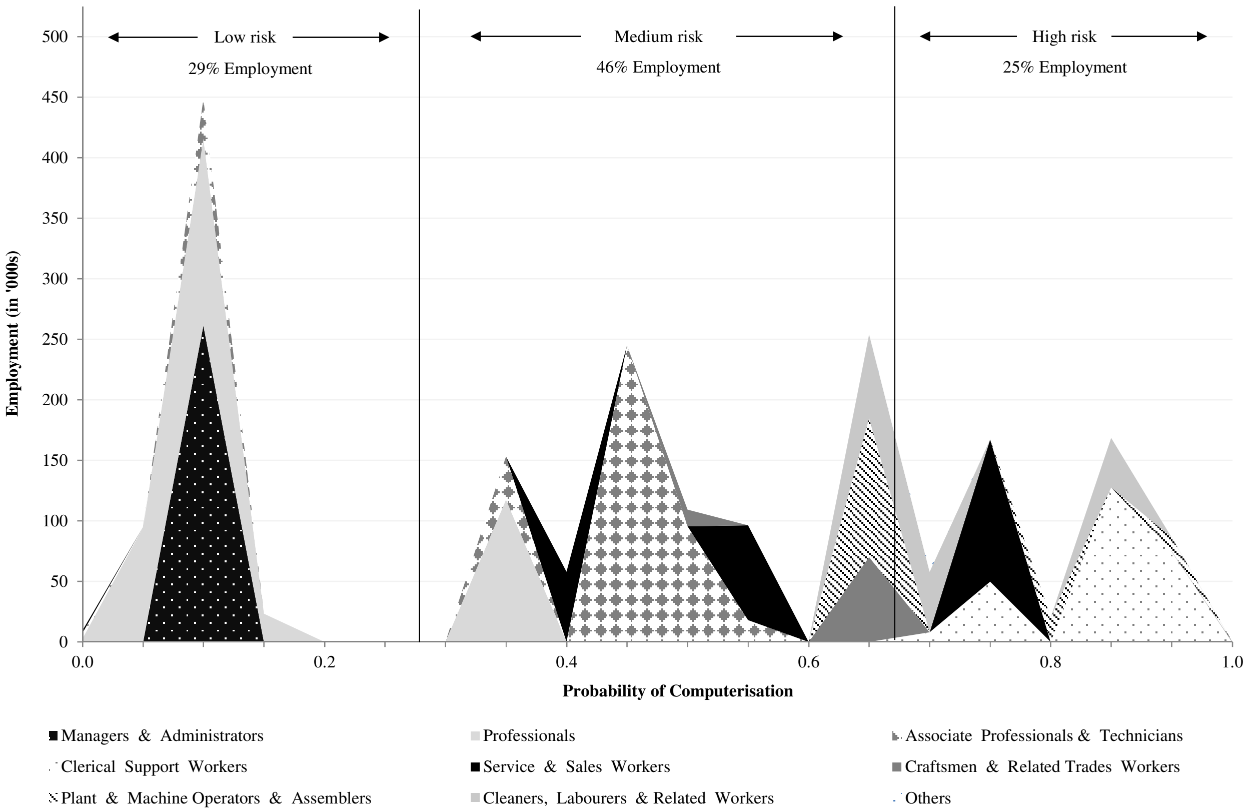
Table 1: Probability of Computerisation and Number of Employed Residents in Singapore by Occupation

Singapore Standard Occupational Classification (SSOC-2015)		Probability of computerisation	Employed Residents Aged Fifteen Years And Over, June 2015 (in '000s)		
Code	Description		Total	Male	Female
Major Group					
1	Managers & Administrators	0.140	261.3	167.8	93.5
2	Professionals	0.185	392.9	211.4	181.7
3	Associate Professionals & Technicians	0.470	427.2	218.1	209
4	Clerical Support Workers	0.868	264.6	61.8	202.8
5	Service & Sales Workers	0.629	256	116.7	139.3
7	Craftsmen & Related Trades Workers	0.657	83.8	74.4	9.7
8	Plant & Machine Operators & Assemblers	0.731	146.3	127.4	18.7
9	Cleaners, Labourers & Related Workers	0.753	160.2	65.5	94.7
6, X	Others	0.702	2	1.5	0.5
Unit Group					
11 -14	Managers & Administrators	0.140	261.3	167.8	93.5
21	Science & Engineering Professionals	0.146	102.1	76.5	25.6
22	Health Professionals	0.065	35	10.5	24.5
23	Teaching & Training Professionals	0.054	59.8	21.5	38.3
24	Business & Administration Professionals	0.364	117.5	54.1	63.5
25	Information & Communications Technology Professionals	0.105	52.3	36.9	15.5
26	Legal, Social & Cultural Professionals	0.175	23.3	10	13.3
29	Other Professionals Not Elsewhere Classified	0.017	2.9	1.9	1
31	Physical & Engineering Science Associate Professionals	0.538	95.5	80.3	15.2
32	Health Associate Professionals	0.351	13.4	4.1	9.3
33	Business & Administration Associate Professionals	0.499	244.9	99	145.9
34	Legal, Social, Cultural & Related Associate Professionals	0.371	22.4	15.1	7.2
35	Information & Communications Technicians	0.581	17.9	13.9	4
36	Teaching Associate Professionals	0.107	33.1	5.7	27.4
40	Clerical Supervisors	0.014	4.2	1.8	2.4
41	General & Keyboard Clerks	0.885	127.5	17.6	109.9
42	Customer Services Officers & Clerks	0.755	49.9	10.7	39.2
43	Numerical & Material-Recording Clerks	0.928	74.9	29	45.9
44	Other Clerical Support Workers	0.747	8.1	2.7	5.4
51	Personal Service Workers	0.560	78.5	33.5	45
52	Sales Workers	0.793	117.3	42.7	74.6
53	Personal Care Workers	0.441	14.1	1.6	12.5
54	Protective Services Workers	0.403	44	37.7	6.3
59	Service Workers Not Elsewhere Classified	0.049	2.1	1.2	0.9
61 - 62	Agricultural & Fishery Workers	0.702	2	1.5	0.5
71	Building & Related Trades Workers, Excluding Electricians	0.690	27.6	27.1	0.6
72	Metal, Machinery & Related Trades Workers	0.676	26	24.9	1.1
73	Precision, Handicraft, Printing & Related Trades Workers	0.671	4.7	3.1	1.7
74	Electrical & Electronic Trades Workers	0.549	13.7	13.3	0.5
75	Food Processing, Woodworking, Garment, Leather & Other Craft & Related Trades Workers	0.662	11.8	6	5.8
81	Stationary Plant & Machine Operators	0.821	20.1	11.2	8.8
82	Assemblers & Quality Checkers	0.908	11.5	3.8	7.6
83	Drivers & Mobile Machinery Operators	0.698	114.7	112.4	2.3
91	Cleaners & Related Workers	0.694	69.3	24.5	44.8
92	Agricultural, Fishery & Related Labourers	0.883	1.7	1.4	0.3
93	Labourers & Related Workers	0.732	26.9	15.6	11.3
94	Food Preparation & Kitchen Assistants	0.875	39.4	12	27.4
96	Waste & Recyclables Collection Workers & Other Elementary Workers	0.735	22.9	12	10.9

Figure 1: Distribution of Occupational Employment over Probability of Computerisation, along with Share in Low, Medium and High Probability Categories



Note: The total area under the all curves is equal to total Singapore employment.

Figure 2: Breakdown of Employed Residents at High Risk of Computerisation by Worker Characteristics

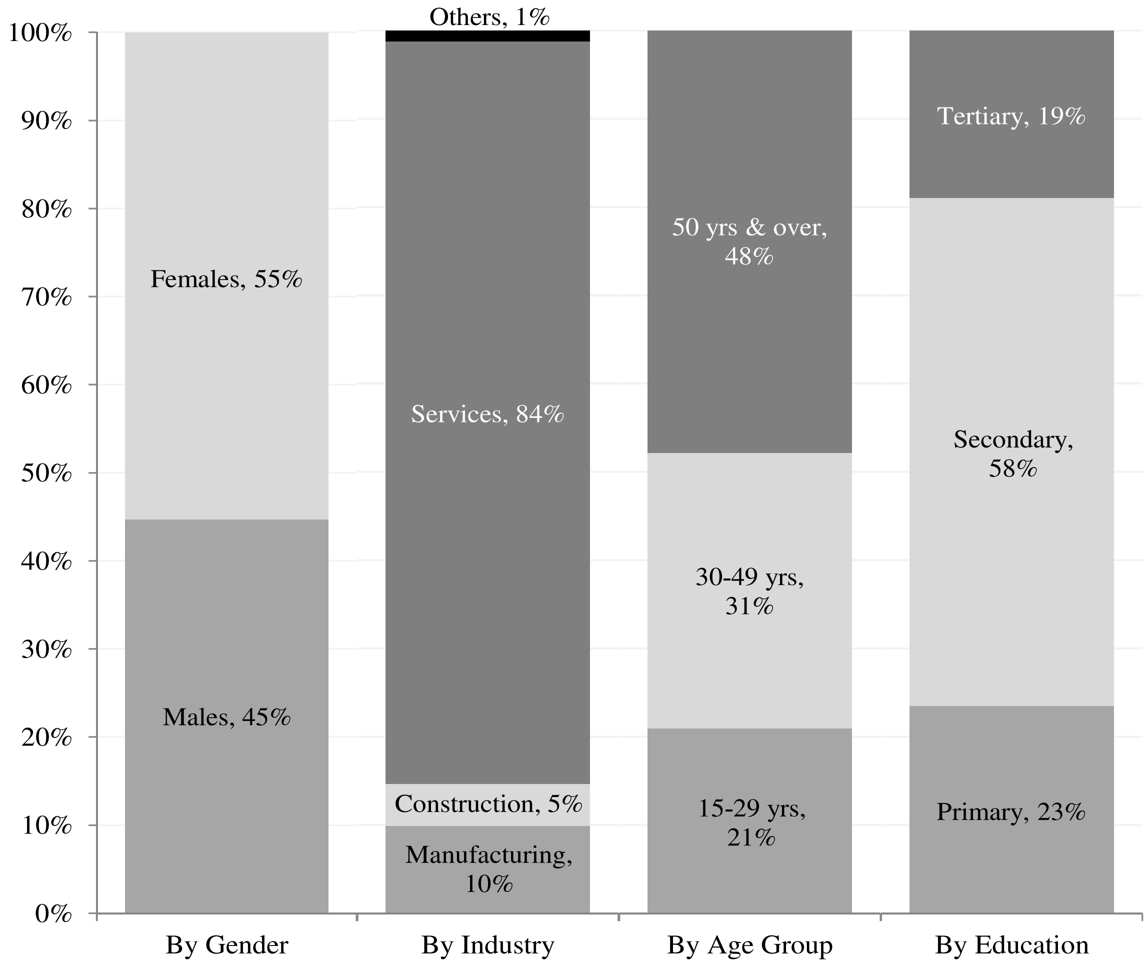
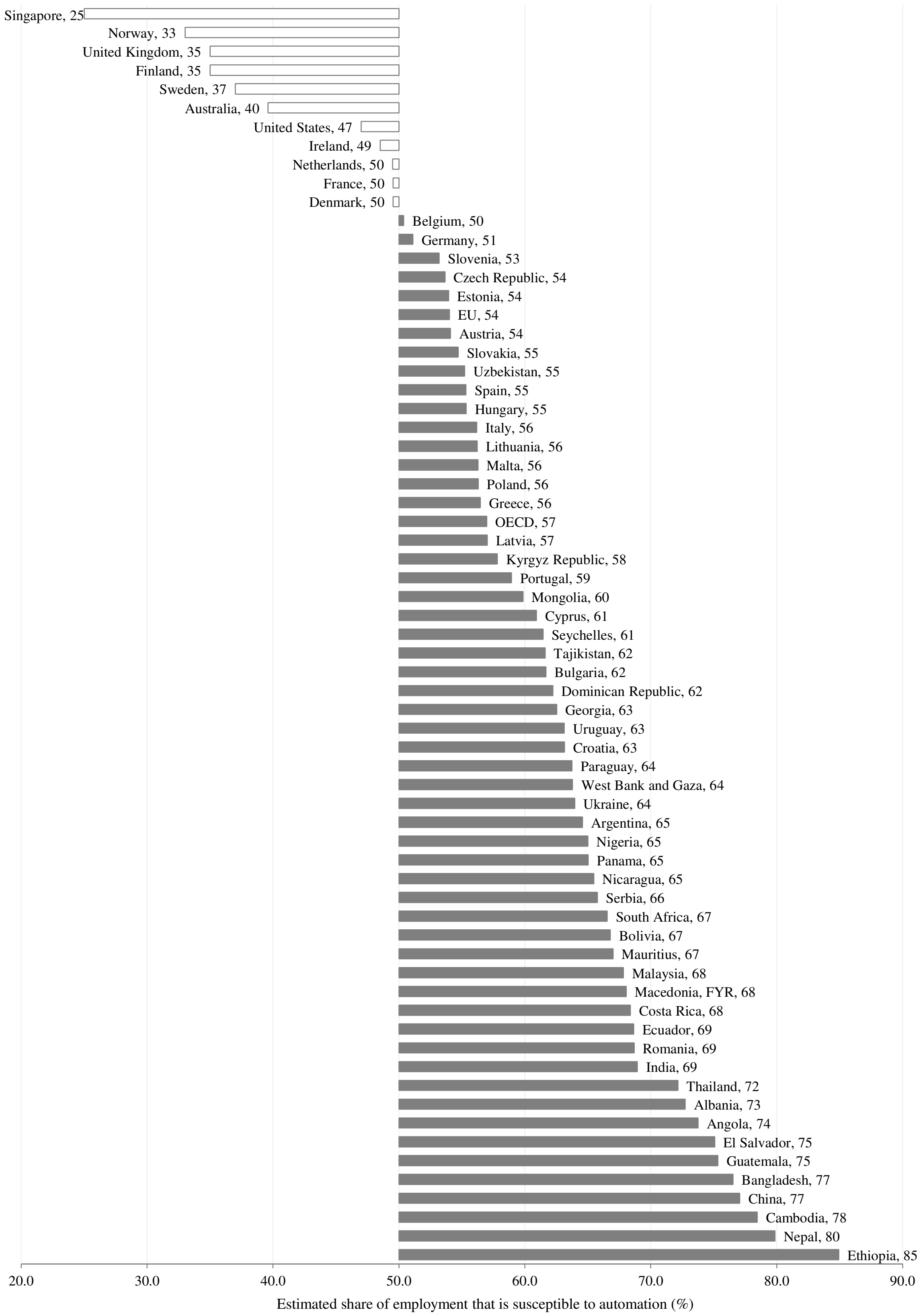
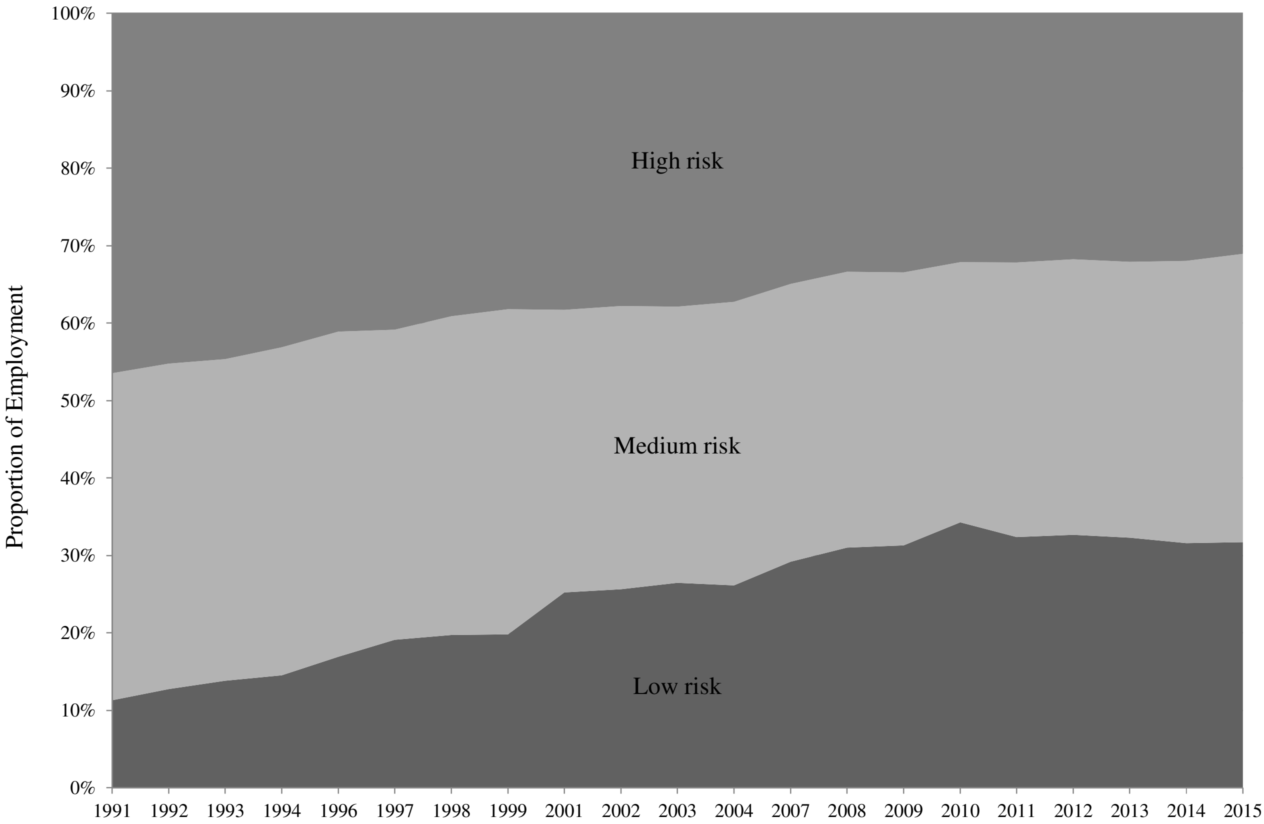


Figure 3: International Comparison of Proportion of Employment at High Risk of Computerisation Across Countries



Note: Estimates for countries are obtained from: US (Frey and Osborne, 2013), UK (Knowles-Cutler, Frey and Osborne, 2014), Australia (Durrant-Whyte et al, 2016), Finland and Norway (Pajarinen, Rouvinen and Ekeland, 2015), EU countries (Bowles, 2014), All other countries (World Bank, 2016)

Figure 4: Proportion of Singaporean Employment by Low, Medium and High Probability Categories Over Time



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