

The fourth industrial revolution and labour market regulation in Singapore

The Economic and
Labour Relations Review
1–17

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DOI: [10.1177/1035304620941272](https://doi.org/10.1177/1035304620941272)

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Abstract

The race to develop and implement autonomous systems and artificial intelligence has challenged the responsiveness of governments in many areas and none more so than in the domain of labour market policy. This article draws upon a large survey of Singaporean employees and managers (N=332) conducted in 2019 to examine the extent and ways in which artificial intelligence and autonomous technologies have begun impacting workplaces in Singapore. Our conclusions reiterate the need for government intervention to facilitate broad-based participation in the productivity benefits of fourth industrial revolution technologies while also offering re-designed social safety nets and employment protections.

JEL Codes: J88, K31, O38, M53

Keywords

Artificial intelligence, autonomous technologies, government intervention, labour market regulation, labour market restructuring, Singapore, technological change

Introduction

The race to develop and implement autonomous systems and artificial intelligence (AI) has challenged the responsiveness of governments in many areas and none more so than

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in the domain of labour market policy. The societal and productivity benefits of such technologies have been widely documented (see Tegmark, 2017), but so has the capacity for disruption and job destruction (see Frey and Osborne, 2013). Indeed, contemporary commentary tends to be bifurcated between optimistic visions of the impact of fourth industrial revolution (4IR) technologies and dystopian predictions (Tegmark, 2017). Among the concerns raised are the likelihood that the rising tide of technologies is displacing tasks and potentially whole occupations (see Frey and Osborne, 2013), as well as the potential for AI and automation to accentuate existing labour market inequalities (Ernst et al., 2019; Korinek and Stiglitz, 2017). In addition, there are other challenging questions raised by these technologies that concern workplace privacy and surveillance, skill development, acquisition and utilisation, conflict and resistance, work/life balance, the need for anthropocentric job design and corporate social responsibility.

This article draws upon a large survey of Singaporean employees and managers (N=332) conducted in 2019 to examine the extent and ways in which AI and autonomous technologies have begun impacting workplaces in Singapore. It also reveals employee and manager perspectives on the degree to which government has prepared for the impact of new technologies and the extent to which employees and managers hold optimistic or dystopian views of the impact of 4IR technologies. Our data inform the article's narrative on the nexus between the technological re-shaping of employment and the need for novel labour market regulatory and policy approaches.

The rest of the article is organised as follows. The subsequent section presents an overview of Singapore's policy initiatives as it seeks to harness the potential of new technologies. The section entitled, 'The 4IR and the future of work implications' presents the research of the article presents the research design, methodology and key findings from our survey of 300 employees and managers in Singapore. The final section discusses the role of labour market regulation and strengthening social safety nets to facilitate broad-based participation in the productivity benefits of 4IR technologies.

Singapore 4IR policy platform

Recent policy efforts in Singapore have focused on technology as an engine to drive growth and play a central role in service delivery. The connotations of a smart economy, smart buildings and smart mobility are often synonymous with references to Singapore. Its position at number one among other Asian economies in the 2018 Asian Digital Transformation Index is testament to its prowess when it comes to infrastructure and industry innovation (The Economist, 2018). This is not surprising given Singapore's long-standing national focus around technology starting with the 'National IT Plan' in 1986 to grow the IT sector, the 'IT 2000 Plan' to harness IT in industry, the 'Infocomm 21 Plan' in 2000 to enable a tech-savvy society, the 'Connected Singapore Plan' in 2003 to drive value through IT, the 'Intelligent Nation 2015' plan to match the people software with advancements in technology hardware to the more recent 'Infocomm Media 2025' plan that encapsulates its 'Smart Nation' platform that was announced in 2014 to harness advanced technologies, improve lives and create new opportunities. It was through this process that significant administrative restructuring occurred that resulted in the

formation of SkillsFuture Singapore and Workforce Singapore and the subsequent policy announcement in 2016 of the Industry Transformation Maps (ITMs) (Hoe, 2016).

Through the ITMs, 23 sector-specific plans were launched and aggregated into six clusters – built environment, essential and domestic sectors, lifestyle, manufacturing, modern services (incorporating financial services) and trade and connectivity. The focus of these reforms was to build capabilities in complementary sectors, for example, lifestyle cluster incorporates the hotels, food and beverage, and tourism sector. In the digital technology arena, Singapore's InfoComm Media Development Authority (IMDA) has gone beyond ITMs to develop sector-specific Industry Digital Plans (IDP). Through the IDPs, the Digital Tech Hub operated by the association of small and medium enterprises (SMEs) aims to help businesses assess their digital readiness, access grants and consulting solutions among other initiatives. For example, in the logistics industry, SMEs can access tools that improve fleet and inventory management and connect with businesses that provide complementary services (e.g. business to business (B2B) e-payments, B2B trade facilitation platforms). These efforts are slated to value-add SG\$8 billion to the economy and create 2000 new professional and technical jobs by 2020 (InfoComm Media Development Authority, 2019). There are, however, limited studies in the public domain that evaluate the efficacy of these reforms.

At the industry level, the government has long been supportive of technology adoption to drive growth and expansion. For instance, the Government's multi-agency GET-Up (Technology for enterprise capability upgrading) policy initiative that was launched in 2003 targeted high-performing manufacturing firms to further boost its capabilities through technology road-mapping, high-skill technical manpower secondment and provision of technology advisory services (Ho et al., 2016). These efforts have been boosted in recent government budgets. For instance, the 2016 *Research, Innovation and Enterprise (RIE) 2020* plan set aside 17% of the SG\$19 billion for the development of advanced manufacturing and engineering (National Research Foundation, 2016).

In more recent years, skill development, too, has explicitly manifested itself through the government's SkillsFuture policy platform (see Waring et al., 2017). Beyond the funding of national training institutions, the Government has also opened up funding of digital courses, for example, data management and visualisation, business metrics for data-driven companies, Internet of things and others available through online learning platforms such as Coursera, and the development of industry-partnered programmes, for example, Digital Workplace in partnership with Microsoft, to future-oriented individuals, deepening an appreciation of technology, data and ultimately the future of work (Bali et al., 2020). Furthermore, to boost Singapore's capabilities in AI, in 2017, the Government through the National Research Foundation (NRF) launched AI.SG, a pan-institution national programme, to enhance the AI knowledge base creating tools and furthering the individual AI capabilities. The AI.SG, funded to the tune of SG\$150 million over 5 years to 2021, was set up with key objectives to tackle industrial and societal challenges using AI (AI Innovation), gearing up for the next wave of industrial revolution (AI Research) and to develop new AI-based products through at least 100 AI projects and proof-of-concepts (AI Technology) (AI Singapore, 2019; National Research Foundation, 2019). The AI.SG initiative aims to deliver an AI for Everyone (AI4E) programme targeting non-tech-savvy working professionals, managers and executives in

Singapore to enrol in a workshop that introduces them to AI technologies, applications, products and services and a competitive 9-month AI Apprenticeship Programme (AI Singapore, 2019). In 2019, Singapore introduced the Model Artificial Intelligence Governance (MAIG) framework governed by the need for AI systems-driven decisions to be transparent and for AI solutions to be human-centric.

Despite these government-led efforts, it is imperative to assess how Singaporean society has responded and how prepared or digitally mature society feels with regard to the emergence of the 4IR advancements in technology, particularly AI. Even with Singapore experimenting with autonomous vehicles (AV) for many years, societal impacts and readiness are still under assessment. It is no surprise why Singapore's Ministry of Transport suggests that full AV adoption will only occur in about 15 years but that a focus on job displacement and re-skilling, impacts on revenue collection (road tax) and incident management concerns requires consideration now to drive policy changes and prepare citizens to be less fearful when it comes to adoption (Huilin and Goh, 2017). Clearly, firm-level comprehension of AI impact on organisations, jobs and the labour force is needed. The empirical research presented in the next section overcomes the current challenge of scant academic literature, shedding light on critical aspects while also providing a basis for socio-economic policy analysis.

The '4IR' and the future of work implications

Design framework

This research study investigated the perspectives of Singaporeans with respect to the nature, characteristics, implications and planning responses to the impacts of the 4IR on a range of industries, occupations and workplaces. It attempted to obtain a comprehensive understanding of the associated issues and to develop a set of planning principles and illustrative case studies to respond to the challenges. Two central research questions drove the focus of this study:

1. Where do organisations/ industry in Singapore currently stand on the road to Industry 4.0?
2. What organisational conditions must be created for the successful implementation of Industry 4.0 and what circumstances must change?

To inform this line of research investigation, the research was situated in the Industry 4.0 Readiness Framework which captures the degree of willingness and capacity of organisations to implement the ideas pertaining to 4IR. The framework, based on six key dimensions – motivation, strategic importance, levels of automation, trust between people and automation, socio-technical congruence, information system effectiveness and inter-organisational information systems integration – informed the design of the 40 survey questions which were categorised under the following eight themes:

1. Smart organisation and smart employees;
2. Strategy, process and effectiveness;

3. Perceived technological impacts on performance;
4. Attitudes, job satisfaction and insecurity;
5. Innovative leadership;
6. Future of work;
7. Change management;
8. Job changes.

Methodology

This research was pursued as part of an Asia Pacific effort that covered multiple jurisdictions. In Singapore, the data collection was driven primarily through a survey instrument design and deployed using the survey platform, SurveyMonkey. The study secured ethics approval from the lead university partner based in Australia and the host research university associated with the Singapore-leg of the study. The survey was anonymous with no personal data being collected, and the data analysis was conducted by chief investigators associated with the research.

Results and discussion

The Singapore survey was sent via email link to a database of 18,000 Singaporeans who are alumni of the University. The survey yielded 332 responses with 39.5% of the respondents employed at the level of manager and above, including 13% employed in Director, CEO or owner positions. Male and female participants were almost equally represented in the survey. Sixty-five percent of the respondents were aged between 18 and 35 and approximately 28% were aged between 36 and 50. Sixty-seven percent held a bachelor's degree, while just under 22% held a postgraduate qualification. The key industries that were represented in the study were as follows:

- Education and training (17%);
- Finance and insurance services (13%);
- Info, media and telecom (12%);
- Professional, scientific and technical (9%);
- Manufacturing (6%);
- Healthcare (5%);
- Retail (5%).

As Table 1 indicates, 43% indicated that they were 'staff', while 'managers' and 'senior managers' accounted for 20% of the responses, respectively.

The subsequent section discusses some of the key findings emerging from this research as it relates to the focus of this article which is to discuss preparedness within organisations for the 4IR era, its impact on the workforce and why there is a heightened need for the Singapore government to further enhance its labour market and industry policy to ensure broad-based participation.

Table 1. Position level of respondents (answered: 329 – skipped: 3).

Answer choices	Responses	
Staff	43.16%	142
Team leader/Supervisor	12.16%	40
Manager	20.67%	68
Senior manager	5.17%	17
Director/CEO/General Manager	7.60%	25
Business owner/Entrepreneur	6.08%	20
Other (please specify)	5.17%	17
TOTAL		329

Smart organisations

Across the sample, just about a quarter of respondents identified their organisation as being a participant in the 4IR, while a large number, 56%, identified as being at the stage of the 3IR. Notwithstanding the dominance of service sector firms in the study, mobile technologies were found to be in predominant use (80%) followed by cloud technologies (70%) and embedded IT systems (65%). Data security, storage, and exchange were dominant technology drivers for organisations, while 3D printing, AI, robotics and automation are slated to be key technologies for the future. The survey data also revealed that 70% of organisations had their business strategies drive IT strategies, and where there was a misalignment, IT strategies were adapted and realigned.

Organisational and government leadership

Despite this level of technological appreciation and understanding, the survey data indicate that only 36% of organisations had a high level of leadership support towards AI-related technology adoption. Furthermore, only 30% of organisations indicated that adequate resourcing was in place to support AI adoption. This is supported by the finding that points to 60% of the survey respondents indicating that leaders were not clear about the benefits of AI-related technologies. Beyond organisational leadership, only a third of the respondents in this study were impressed with the leadership demonstrated by the Singaporean government through its policies and programmes to aid industry transition and preparation for 4IR (Table 2).

Innovation impact

The views on leadership support are in stark contrast to the overwhelming respondents, over 60%, having a clear sense that 4IR technologies will aid in better internal management and control of organisational processes and performance, and improved levels of customer experiences through the design of new processes, products and services. In addition, it is clear from the research that organisations are paying close attention to all things data, but the findings suggest that only 41% of respondents are skilled in this new area of growth. To tackle such new innovative areas of organisational growth, there is overwhelming support

Table 2. Respondents' perception of government policy (answered: 250 – skipped: 82).

	Not impressed at all	Not impressed	Undecided	Impressed	Very impressed	Total
From your observation, how impressed are you by the policies of your government in preparation for the impact of Artificial intelligence (AI) on jobs?	4.00%	19.60%	38.80%	31.60%	6.00%	
	10	49	97	79	15	250

for ongoing learning built upon two key skills – critical thinking and teamwork. As a result, over 65% felt that innovative learning and development programmes had to be put in place. Over 50% of the respondents agreed that emerging technologies, such as those related to AI, will not only be easy to use but also that learning these technologies will be easy and interaction will be flexible. These data points suggest that a disconnect most likely exists between organisational leadership, as discussed in the earlier section, and employees, where willingness to adopt new technologies and risk-taking seems to be higher at the employee level than at the senior levels of the organisation.

Job displacement and skill transition

At the individual level, 70% of the respondents indicated that productivity on the job would improve through the use of 4IR technologies, as a consequence lifting overall job performance, employee satisfaction and employee focus. Despite this positive outlook, the study suggests that deployment of 4IR technologies is going to either partly or fully displace existing roles. Only 30% of respondents indicated that automation would replace jobs and over 60% of the survey respondents concurred with the view that role redundancies and new job creation were to be a likely outcome. Clearly, there is a need to rethink current career trajectories, skills transition and how to prepare the workforce with the advent of new roles. In relation to employee-level preparation (see Table 3) for such changes, about a quarter of the respondents suggested that employee skills were low and preparation was needed in the areas of application development, with over 70% also suggesting that in the next 5 years data analytics and data security will be the two key areas of skill need within organisations. Thirty percent indicated that employees are better prepared with automation technology, and 36% indicate the same in the area of data analytics.

As a result, over 65% felt that new learning and development programmes had to be put in place for existing staff and that new forms of job design and new competencies would have to drive the selection and attraction of staff.

Job growth

Findings from the survey also suggest that four organisational areas are likely to be the winners in the 4IR era – information technology, marketing and sales, manufacturing and

Table 3. Respondents' impressions of employee skill levels.

	Very low	Low	Moderate	High	Very high	Total
IT infrastructure	1.71% 4	5.13% 12	23.93% 56	48.29% 113	20.94% 49	234
Automation technology	1.71% 4	8.12% 19	26.07% 61	42.31% 99	21.79% 51	234
Data analytics	2.59% 6	3.45% 8	21.98% 51	44.83% 104	27.16% 63	232
Data security/ Communications security	1.28% 3	3.85% 9	18.38% 43	44.87% 105	31.62% 74	234
Development of application of assistance systems	3.43% 8	6.87% 16	28.33% 66	43.78% 102	17.60% 41	233
Collaboration software	2.14% 8	8.97% 21	29.06% 68	40.17% 94	19.66% 46	234
Non-technical skills such as systems thinking and process understanding	1.71% 4	7.69% 18	28.63% 67	42.74% 100	19.23% 45	234

production, and research and development. Just as with any transformation process, there are winners and losers, this research study suggests that business functions are likely to resist the introduction of 4IR technologies. The survey results also indicated that most respondents expected some level of resistance to these technological changes but suggested that the level of resistance would be moderate. However, respondents suggested that accounting and human resource management would be the departments most likely to resist the introduction of AI/Robotics.

Discussion

Labour market regulation

As Bray and Waring (2019) have noted, at its essence, labour regulation is a normative state which 'reflects an ordered set of decisions and points of consensus of how the social, economic and political relationships between human beings at work ought to be organised'. A key question to consider, therefore, is what should be the 'ordered decisions and points of consensus' in the era of Industry 4.0? The very term 'order' connotes a stability and rationality which appears contrary to the disruptive impacts of 4.0 technologies. In this section, we examine the challenges that 4IR poses for labour regulation and propose some ways in which it might evolve to re-balance equity and efficiency objectives.

Labour regulation is often simply characterised as the formal and informal rules which regulate the employment relationship and this has tended to reflect an industrial era in which rule making by the state and its legislative and judicial branches was focused on the traditional tripartite industrial parties – large employers, unions and their members and government. The 4IR arguably ushers in a technological age which not only fragments this traditional focus but also introduces a need for more responsive labour

regulation that incorporates regulatory developments from other spheres. For example, the heightened efficiency of facial recognition, global positioning and tracking systems and human resource (HR) analytics provides new opportunities for surveillance and control on a scale and precision that requires a closer fusion of labour regulation and privacy law.

Workplace health and safety and more generally liability law is another domain of labour regulation which may need to rapidly evolve as a result of AI and automated systems. If, for example, a workplace injury or fatality occurs as a result of an autonomous digital system, the question of liability is likely to prove complex. If a fatality is caused by an AV for instance, establishing who should be blamed is difficult given the various levels of vehicle autonomy and the possibility of such systems being the subject of malicious cyber-attacks (Peterson and Glancy, 2019).

Labour regulation might also need to adopt new mechanisms to protect at-risk workers including those of the so-called ‘gig’ economy. These include owner-drivers, delivery operators, food suppliers, freelancers and many others for whom technology has enabled atomised contracting arrangements with few rights or protections. Gig work serves to further blur traditional legal distinctions between employees and contracting with, as De Ruyter et al. (2019) state, implications for taxation, welfare and insurance (p. 46). However, it is also important not to overstate the capacity of gig work to supplant standard employment relationships. As Stanford (2017) notes, some form of ‘gig work’ has existed since the ‘putting-out’ system of textile production prior to the first industrial revolution. While new technology has enabled previously unimagined gig work in different industries, it seems unlikely that the bulk of firms would view such arrangements as being appropriate for cultivating the long-term commitment, motivation, skill and knowledge needed to build sustainable enterprises.

The 4IR, arguably, also introduces a strong need for ethics and AI governance frameworks to be considered in the context of labour regulation. In Singapore, for instance, the authorities have developed a governance framework to assess and manage the probability of harm to individuals as a result of automated systems and AI. The governance framework proposes a matrix to classify the probability and potential harm to an individual as a result of a decision made by an organisation using AI about the individual. For example, if both the probability and degree of harm to an individual are considered low, then it is appropriate for automated decision-making in which a human being is out of the loop. If, on the other hand, both the probability of harm and the degree of harm are considered high, the matrix recommends active intervention in which human beings are involved in decision-making. The utility of this model can be viewed through a series of examples related to employment relations. Consider, for instance, an automated recruitment process in which a ‘Narrow AI’ system reviews submitted applications for a position. The system might review dozens of applications, examining ‘candidate fit’ against the selection criteria and compiling a short list. Such a system improves the efficiency of the recruitment process and eliminates (un)conscious bias. The probability and degree of harm to an individual are low and, thus the matrix would suggest, that human intervention need not be part of such a system. By contrast, consider an AI-driven performance management system in which individual performance data (both quantitative and qualitative) is judged through an algorithm and where the outcomes could result in reduced

pay or termination. The matrix would suggest that there is a probability of a reasonable level of harm to individuals and that therefore there is a need for human intervention in the AI system. In other words, it would be unethical for the system to be left to its own devices. As this illustration indicates, it is important for labour regulation to reflect such ethical considerations and seek to regulate some automated systems where there is a possibility that such systems, might harm workers in their employment.

The need to regulate managerial prerogative to introduce workplace change may also need to be revisited in the context of 4IR technologies. The capacity of such technologies to displace tasks, and in some cases, whole occupations, places at risk stable employment, and potentially the economic and social fabric of societies. Thus, there needs to be improved consultation over the introduction of technologies where it might potentially raise these risks. In addition, regulation should encourage a commitment to upgrade the skill sets of employees impacted by this type of change in a way which also supports the successful integration of novel technologies.

Finally, as has been noted elsewhere, the adoption of both narrow and broad-based AI is likely to erode employee bargaining power and accentuate inequalities. This is particularly evident where machine learning works to incorporate and then perfect worker knowledge or skill. For instance, think of a customer service officer at a Bank whose record of advice to customer enquiries is entered into an AI-driven chat bot. The chat bot is then able to reliably learn and build on this expertise through further client interactions.

The labour regulation challenge in responding to technological disruptions and the 4IR are accentuated by technology-specific issues that policymakers and the larger community that engages with these technologies do not have adequate clarity on. This includes, and is not limited to, (1) asymmetries in information across different stakeholders, (2) uncertainty around the true impact of these technologies on the labour market, (3) structural power dynamics in the labour market and, finally, (4) errors in policy intervention.

Asymmetries in information

The policy environment is characterised by asymmetries in information across agents and at multiple levels. First, at a relatively simple level is the notion of decisions being made on the basis of “uninformed ignorance” rather than “informed awareness” (Howlett et al 2018). Second, similar to asymmetries that exist in complex sectors such as healthcare, there are gaps in the information possessed by different agents (Bali and Ramesh, 2015). For instance, healthcare providers and patients have a relative information advantage over health insurance companies. Third, there are asymmetries in intent: consumers (employees in labour markets) and regulators do not have complete information on what the next steps are, nor how a given technology will be scaled up, nor the ultimate goal of the agent that is introducing a ‘technology’. This is particularly relevant given that technologies are continually scaled and improved through an iterative process and are unlike other services that government has to regulate which tend to be relatively discrete products or services.

Policy uncertainty

This is the most significant challenge that policymakers have to contend with and it manifests at several levels. At the most fundamental level, regulators are not entirely aware of the nature of the technological disruption (Walker et al., 2010). There is lack of awareness, let alone understanding, on what the specific challenges are. This is compounded by inadequate causal relationships across variables. The next is the question of magnitude of impact. Take, for example, the first death caused by an autonomous vehicle: a cyclist was killed by a driverless Uber vehicle in March 2018 in the United States. The report released by the National Transport Safety Board, the federal agency investigating the accident, noted that the AV detected but misclassified the victim, and the emergency braking system which received a trigger alert 1.6 seconds prior to the collision was deactivated by Uber to reduce false positives during the test runs (National Transportation Safety Board (NTSB), 2018). The Prosecutors office decided against filing criminal charges. This example brings to the fore the types of uncertainty at play: (1) the ability of the technology to accurately detect, classify and respond to objects on the road; (2) who was responsible for the accident; and (3) the magnitude of the impact. The magnitude is important because it is challenging to measure the impact in the case of sophisticated technologies such as generative adversarial networks (GANs). These different kinds of uncertainties require differentiated policy responses (Figure 1). The key argument here is that not only are we designing labour regulations for unknown-unknowns but also taking into account capacities of regulators and their knowledge of the phenomenon.

Structural power dynamics

In addition to the challenges of uncertainty and information asymmetry, technological disruptions affect different members of society differently. For example, the proliferation of the gig economy and platforms such as Uber and Sharetasker has brought to the fore issues such as whether Uber drivers are independent contractors or employees. If the latter, they are subject to stringent regulatory requirements around contributions to social security programmes, unemployment insurance and other such statutory requirements. The Fair Work Commission in Australia recently ruled that Uber drivers were independent contractors and not considered employees as per the Fair Work Act 2009 in Australia. However, the Unemployment Insurance Appeal Board of the State of New York has ruled to the contrary, making Uber liable to pay for unemployment insurance. The labour regulation challenge here is to ensure that adequate safety nets are in place to protect those that are vulnerable in society.

Errors in intervention

Miller et al. (2011) offer a useful framework to conceptualise regulation of pharmaceuticals that offers insights to the regulatory challenges discussed above. They argue that in approving 'new' technologies or regulating a technology, or deciding whether the state should intervene, the regulator is faced with a trade-off between Type 1 and Type 2 errors.

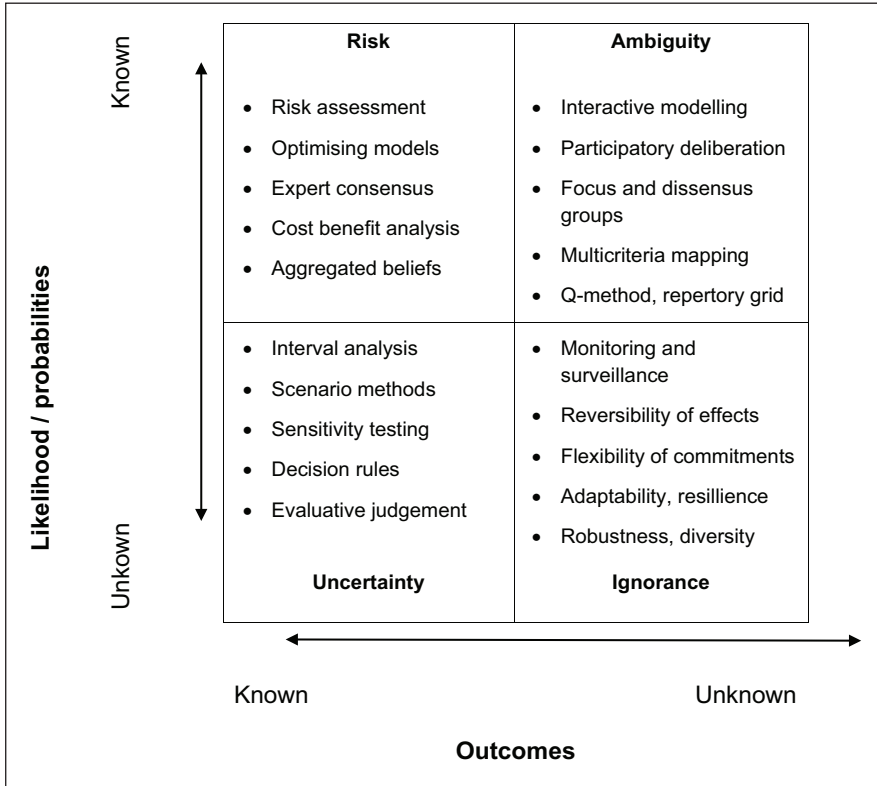


Figure 1. Types of uncertainties.
Source: Stirling (2010).

The regulator has to negotiate and balance the economic interests of agents that drive these innovations with those of citizens and members of societies that are affected by the outcomes of these innovations. If we assume that the null hypothesis is that disruptive technologies are harmful to citizens, there are two possible options. The first is that the government does not intervene or immediately approves the technology. The second is that the government intervenes aggressively, establishes safeguards and delays the technology. Given the null hypothesis, the regulator’s decision is subject to two types of errors:

- *Type 1 error: The technology is ‘harmful’ to society, and the government does not intervene.*
- *Type 2 error: The technology is ‘friendly’ to society, and the government intervenes.*

Figure 2 illustrates the trade-off between these errors. The vertical axis measures the probability and the costs of these errors, and the horizontal axis measures the level of scrutiny, or

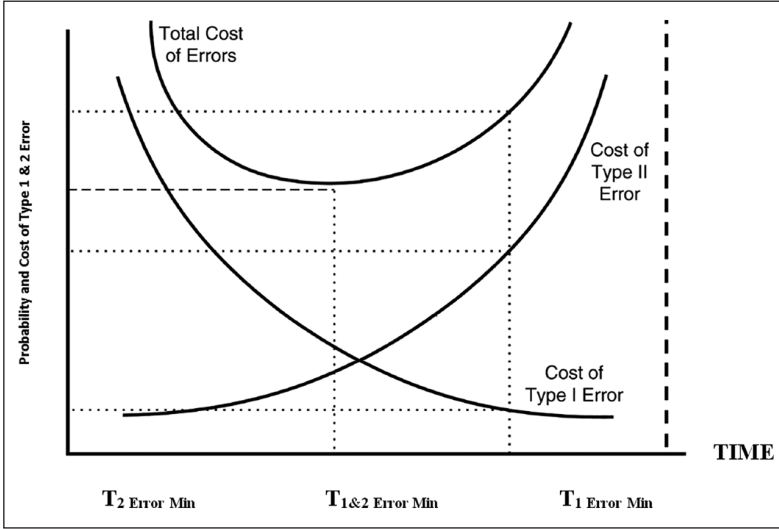


Figure 2. Probability and cost of Type 1 and 2 errors.
Source: Adapted from Miller et al. (2011).

testing, performed by the regulator (proxied by time). At 0% scrutiny, the government does nothing, and in this situation, the probability of a Type 1 error is at its highest, as is the potential cost to society of such an error. Alternatively, at 100% scrutiny, the regulator exhaustively scrutinises every aspect of the technology to the point where a Type 1 error is (virtually) impossible but the probability (and expected cost) of a Type 2 error is enormous.

This hypothetical example resonates with the labour regulation challenge. Given the uncertainty, the absence of causal relationships, and structural power dynamics labour market regulations that govern disruptive technology can create two possible errors. These are under-regulating ‘harmful’ disruptive technologies (e.g. not establishing labour market safe guards) and over-regulating ‘friendly’ technologies (e.g. unnecessary interventions). Policymakers would have to navigate and manage Type 1 and Type 2 errors. The appropriate policy response may be to reduce the combined incidence and cost of both types of errors – Type 1 and Type 2. Responding to only Type 1 or Type 2 errors would not address the problems that the technology disruptions pose. This in turn requires balancing the interests of different stakeholders in the labour market.

Social safety nets

Singapore’s policy responses to the 4IR must be viewed in the larger context of its labour market dynamics and city States growth and development strategy. While Singapore has enjoyed high employment rates fuelled by robust economic growth (Pang and Lim, 2015), its labour market has been characterised by low productivity growth, a relatively lower share of wages in national income and low growth in real wages especially in the bottom deciles of the income distribution (Asher et al., 2015; Hui and Toh, 2014; Waring et al., 2017).

These trends have been, at least in part, attributed to Singapore's growth and development strategy which focused on (1) developing flexible labour markets, (2) relying heavily on foreign labour, (3) creating a conducive environment for businesses by lowering taxes on capital and income and (4) developing complementary policies to crowd-in investments such as developing public infrastructure (Asher et al., 2015). Such policies collectively place downwards pressure on wages. The impact of this strategy on Singapore's labour market has been further entrenched by the absence of strong labour market protections under the Employment Act 1968 (Singapore) that governs the skilled workforce, the Industrial Relations Act 1960 (Singapore) that governs collective bargaining and governance relationships in the labour market and the Employment of Foreign Manpower Act 1990 (Singapore) in Singapore that governs foreign labour (Waring et al., 2017). Current legislation is characterised by an absence of minimum wage levels or robust social safety nets (especially for migrant workers). It allows large sections of the workforce (i.e. foreign workers) or employees earning more than S\$4500 per month to remain outside the purview of the statutory Employment Act 1968 (Singapore).

Current social safety nets in Singapore – programmes to pay for healthcare expenditure, public pension programmes and unemployment insurance – are relatively weak, especially compared with other societies at similar levels of economic development (Kwan and Asher, 2019). Singapore's current social safety nets, particularly the Central Provident Fund (CPF) which aims to provide retirement adequacy, are a defined contribution programme wherein the density of contributions (frequency over life-time employment) and wage levels are primary determinants of the benefits received. The absence of institutionalised risk-pooling through a tax-funded social pension in Singapore, for example, akin to the 'zero-pillar' in the conventional frameworks of social protection (e.g. Asher and Bali, 2013; Holzmann et al., 2008), accentuate the impact that disruptive technologies have on Singapore's labour market.

Advances in longevity, higher medical costs and the absence of adequate social protection systems have contributed to the increase labour force participation rates among the elderly in Singapore (Thang, 2011). This manifests in part-time contractual employment within the service sector and plays a role in providing retirement adequacy to elderly Singaporeans, particularly those in lower end of the income distribution (Government of Singapore, 2019). To harness the long-term benefits of disruptive technologies and ensure that a majority of Singaporean citizens can participate in their benefits, policymakers will have to re-examine current social protection systems. The absence of large scale and institutionalised societal risk-pooling to pay for healthcare expenditure or mitigate poverty in old-age or periods of unemployment increases the precarity associated with disruptive technologies in the labour market.

The combination of low productivity growth, low wages and weak social safety nets raise important concerns on the impact of disruptive technologies on Singapore's labour market. They point to a series of fault lines which require immediate attention, particularly the need for institutionalised social risk-pooling to cushion the impact of such labour market disruptions.

Conclusion

This article has contended that the 4IR poses significant challenges for policymakers to take advantage of the promise of its technologies, while also protecting society's social fabric. The analysis of Singaporean efforts in this regard demonstrates a thoughtful and sophisticated policy design. Yet the results of our empirical study suggest that these concerted policy efforts were not matched by a similar level of industry preparedness. In particular, our survey results showed that respondents felt that the majority of employers had not shown sufficient leadership in putting into place adequate resourcing to support 4IR initiatives. Moreover, the data reveal a concern that the bulk of industry leaders were not working towards ensuring that employees had the right skills to cope with 4IR. This is an interesting finding given Singapore's widely regarded 'SkillsFuture' initiative and the many supported opportunities available to employers to upgrade workforce skills.

As we have discussed, the 4IR is characterised by deep uncertainty, asymmetric information and a tendency to accentuate existing power imbalances. These characteristics enhance the risk that even the most carefully calibrated policy interventions will fail to adequately inspire industry to adequately prepare for change. More broadly, such characteristics also make it more likely that policymakers may fail in their ultimate goal to produce reasonable living standards and protect the vulnerable. To avoid the dystopian future that some have argued may result from 4IR technologies, Governments will need to develop novel and responsive regulatory approaches which have at their core, a strong set of ethical guiding principles.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

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