Education Reform for the Future of Work

The Shift to a Knowledge Society

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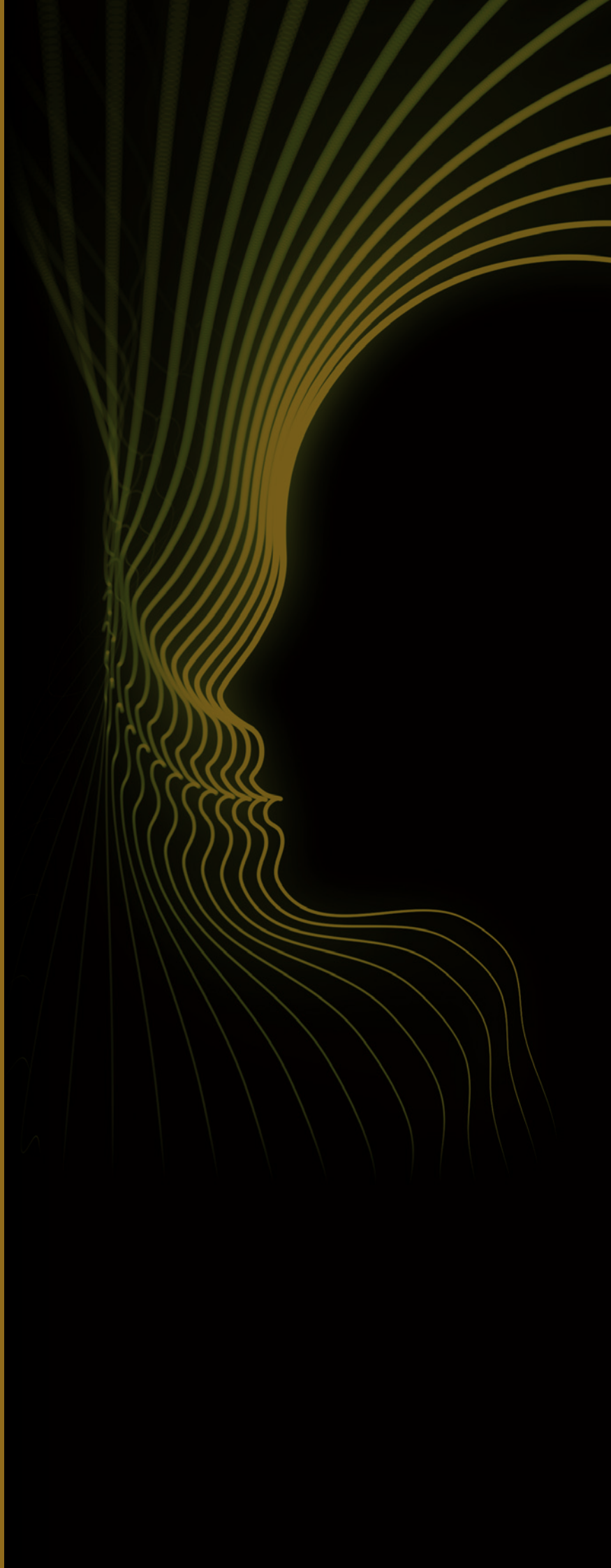

EDUCATION REFORM FOR THE FUTURE OF WORK

THE SHIFT TO A KNOWLEDGE SOCIETY

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FOREWORD

An economy's level of educational attainment reflects the quality of its human capital. It is also the main force behind the improvement of standards of living. The early 1950s was a period of unparalleled rapid economic growth, higher wages, increased labor productivity, improved health status, and lower infant mortality rates resulting from a better quality of education and more time devoted to it. Today's rapid technological advances have led to unprecedented changes in labor markets, particularly through the greater frequency of job automation. This necessitates a reexamination of the old mass production-based education model. Furthermore, ever-increasing school enrollment rates have been accompanied by a slowing in productivity gains, a narrowing base of economic growth, and widening income inequalities. These all indicate the need for new education models focusing on worker agility to meet changes in labor market requirements. Unless the socioeconomic contributions of human capital can be maximized, increases in living standards cannot continue.

This publication is a result of discussions among policymakers and experts at the Asian Productivity Organization Forum on the Impact of Education Policies on National Productivity Growth organized in collaboration with the Development Academy of the Philippines in Manila, 14–17 August 2018. It highlights the need for policymakers to revamp the education sector to benefit from rapid technological progress. It also discuss the types of education models which could cope with emerging challenges. One chapter emphasizes the integration of both general and job-specific skills into a new education model. Another advocates policies focusing on linkages between short-term policy responses such as tailor-made vocational training systems with medium- to long-term reskilling solutions such as lifelong learning for core competency development.

A recognizable pattern created by the IT revolution is that the rate of technological change always outpaces workers' skill development. When skill development lags, economic growth decelerates due to lower labor productivity. Workers incapable of adjusting to market demand for new skill sets are forced to accept low-skilled, low-wage jobs. This adjustment is usually accompanied by even more demand for higher-skilled, higher-wage jobs. Unemployment, labor market polarization, and inequality are the net effects on society. These are the main challenges for educational policymakers and governments as a whole.

It appears that the optimal policy responses will give humans the edge over technology in the perpetual competition between people and machines. A balance between the mastery of foundational and advanced

skills, which may also include social and emotional skills, is needed so that human labour can complement machines. The education sector can start by adopting a system-wide approach prioritizing nonroutine skills at all academic levels, while simultaneously emphasizing socioemotional development in early childhood. This balance would yield lasting benefits for countries in the Asia-Pacific region.

Dr. AKP Mochtan
Secretary-General

CHAPTER 1

EDUCATION AND PRODUCTIVITY: CLOSING THE GAP BETWEEN TECHNOLOGICAL ADVANCEMENT AND SKILLS

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Introduction

Education has long been recognized as a key driver of labor productivity and innovation. Investment in human capital was essential for East Asia's transition from the primary to the manufacturing sector and elsewhere from a manufacturing production-driven to a knowledge-intensive economy. Formal education was viewed as the primary source of human capital and vital for boosting labor productivity. However, education systems often fail to keep up with the demand for skills arising because of new technological developments. The shortfall is sometimes acute and often also holds back critical technological progress, leading to a low-skill, low-technology trap in developing countries. These two concerns are serious at a time of unprecedented changes in technological development beyond national boundaries and the rapid globalization of services and manufacturing production.

The way we organize work, mobilize labor, and deliver services is rapidly changing in the 21st century. The key to all of this is technological advancement and industrial revolution (IR) 4.0. For countries far from the global technology frontier, this has raised an important question: how can developing countries respond to the race between technology and skills? How should governments redesign the education sector in the era of robots, artificial intelligence, and machine learning? Additionally, rapid technological advancements raise two sets of policy questions related to labor demand and supply. First, how will technology respond and evolve so that it is adaptable to an aging workforce? Second, how will education and training change and adapt over the lifecycle of individuals so that they may stay longer in the labor market? This paper reassesses the role of education, asking how we can manage the race between education and technological development in the era of IR 4.0 where artificial intelligence is shaping developments such as self-driving cars, sewbots, retail drones, and virtual assistants.

This paper is organized as follows. The next section discusses the background of the study, i.e., IR 4.0, scrutinizing the available evidence on the possible impact of automation on employment and productivity around the world, with a particular focus on Asian countries. The third asks whether automation always implies job loss and deindustrialization and discusses the key features of

1 Dr. M Niaz Asadullah is the original author of this paper and APO shares the copyright with the author.

occupations that are "resilient" to automation. The fourth section discusses the interplay between education and technology, emphasizing the need for developing 21st century skill sets. Next is the section highlighting the main education policy challenges in the era of IR 4.0. Drawing on our research on schooling-learning gradients, we argue that most developing countries in Asia are behind the educational frontier in terms of ability to impart foundational and advanced skills, particularly in science, technology, engineering, and mathematics (STEM). The following section outlines a number of education reforms and policy suggestions to ensure adequate supply of New Economy (NE) skills. The final section outlines our conclusions.

Background: The 4th Industrial Revolution

The East Asian Miracle during the 1980s was mostly about the rise of manufacturing exporters through catch-up growth and rapid factor accumulation. Sustained educational investment was key to East Asia's subsequent transition from a manufacturing to a knowledge economy. The demand for education and skills has grown as production became more complex and sophisticated. However, automation may reverse the earlier pattern of globalization of jobs which benefited developing countries through the relocation of export-oriented manufacturing production [1].

IR 4.0 is transforming and affecting every aspect of industries and economic activities. There is an ongoing shift from digital computers to machine learning as the new general-purpose technology. Production processes today are defined by disruptive technologies such as smartphones, cloud computing, social networking, big data analytics, autonomous robots, and cybersecurity; additive manufacturing (3D printing); and the IoT. Technologies such as email, cell phones, laptop computers, mobile computing, smartphones, tablets, cloud computing, and social networking platforms disrupted the way we communicate, produce, deliver, and market services. Even the education sector is not immune to these changes, as evidenced by the rise of Massive Open Online Courses (MOOCs).

It is widely recognized that the world is fast approaching the inflection point where artificial intelligence outstrips that of humans, replacing huge swaths of jobs [2]. This has raised the concern that metal-collar jobs will replace millions of blue-collar jobs and some white-collar jobs as well. There are popular speculations about a world with 10 billion robots possessing intelligence surpassing that of the human brain. Advances in computing technology imply the declining capital cost of robots, making it increasingly affordable to replace human labor with robotic labor. AI has also opened the door to the development of cognitive robots (and cloud robotics), endowing machines with intelligent behavior and the ability to reason and understand how to behave in complex circumstances and develop capable autonomous systems.

Like previous technological breakthroughs such as the steam engine and electricity, ML facilitates additional innovations and capabilities [3]. Smart machines and AI also facilitate the interdependence of processes and increase demands for complex skills. Alongside genuine concerns over robotic labor and cognitive robots, there are reasons for optimism. Digitization and automation can be a source of sustained rise in productivity directly by boosting economic growth and indirectly by creating new high-productivity jobs. The next section elaborates on these issues by scrutinizing the available academic evidence.

Review of the Evidence on Automation

A number of studies have made grim predictions about the risks of automation [4–6]. The findings vary depending on the data and methodology used. The most frequently cited study, by Frey and

Osborne [4] of Oxford University, looked into the susceptibility to automation of 720 occupations, based on nine key skills. They define computerization as "job automation" and predict that 47% of American jobs will be automated by 2035. Their estimates for developing countries range between 55% and 85%. According to ILO [7] research on ASEAN-5 (Cambodia, Indonesia, the Philippines, Thailand, and Vietnam), the figure for the risk of automation is 56%. According to the McKinsey Global Institute, by 2030 automation will have replaced 800 million jobs. In Bangladesh, this shift is already being felt in manufacturing and other sectors. Bangladesh is home to a youth population of 100 million under the age of 30. Jobs become replaceable when an economy builds on replication, not innovation. The young face uncertainty in securing jobs and a higher rate of unemployment.

The predictions discussed above ignore the fact that most jobs consist of a bundle of tasks, some of which cannot be automated. If so, a task-based approach is more appropriate compared to an occupation-based analysis. The wide range of country- and occupation-specific predictions occurs for two reasons. First, the methodology relies on expert opinions on automation probabilities from the field of machine learning instead of on actual data on jobs being automated. Second, occupational categories in the USA are used to estimate possible job losses from automation in other countries [8].

The study by Arntz, Gregory, and Zierahn [5] conducted for the OECD therefore breaks down occupations by task and concludes that only 9% of jobs, on average, across 21 OECD countries are really at risk. For related reasons, another study on automatable jobs also produces a low estimate of 15% [6]. There are also additional country-specific heterogeneities. First, in the Republic of Korea, only 6% of jobs are automatable. Second, compared with administrative jobs, manager, director, and officer positions are less likely to be replaced by robots. Meanwhile, HR administrative jobs have a 90% chance of being automated [5].

Changing Jobs: Destruction or Growth?

From the supply-side perspective, the choice between man and machine is guided by the relative price of the latter. Human labor involves low capital expenditure but has a high operating cost. With advances in technologies, the cost of computation is declining, bringing down the capital-to-operating expenditure ratio, which is changing in favor of machines. Computerization of routine tasks/jobs (e.g., telephone answering, copying/typing, and the work of paralegals and legal assistants) is made possible by technologies such as bar-code scanners, self-service technology, and cash machines. At the same time, automation is also likely to lead to the creation of new tasks and jobs [9]. Machines would economize the use of manual labor while also increasing labor productivity and creating new uses for labor. But this would involve more abstract and creative services. Jobs that require cognitive and interpersonal skills are set to grow. Research also indicates a negative relationship between the probability of automation and the education level of workers [4]. Individuals in conventional high-skill occupations such as doctors, engineers, accountants, and lawyers will benefit from new technologies, while new occupational roles such as Zumba instructors and cloud specialists will emerge. In other words, man and machines can complement each other in the era of IR 4.0 instead of the latter being a perfect substitute for the former.

In sum, the anxiety over economy-wide automation risks may be premature. There is a lack of full agreement on the tasks where ML systems outperform humans. Although parts of many jobs may be suitable for ML, other tasks within those same jobs may not [3]. But regardless of the impact on job creation and destruction, there is a consensus that automation could boost global productivity growth by 0.8–1.4% annually [6]. Recent evidence for European countries suggests that technology

raises overall demand for labor [10].

Therefore, the main challenge for policymakers is to design an education system that will endow workers with NE skills. According to Autor, Levy, and Murnane [11], there are five broad categories of skills: cognitive analytical (lawyers, teachers, physicians, managers); cognitive non-routine interpersonal; cognitive routine (telephone operators, bookkeepers, meter readers, cashiers); manual non-routine (industrial truck operators, machine cutters); and manual routine (shoe machine operators, construction workers, carpenters). Work that involves repetitive tasks can be routinized using new technologies at a low cost. Resilient occupations will be those that are intensive in NE skills (i.e., analytical and interpersonal skills) [12].

Key Education Policy Challenges

In developing Asian countries, investment in schooling is important for poverty reduction through labor market channels [13–14]. Such investment is even more critical for innovation and the knowledge-based economy. In recognition of this view, education is a key component of the World Bank's Knowledge Economy Index. In developing countries, the largest number of new jobs will be those requiring secondary education or technical skills [6]. In emerging economies, the rate of job growth is highest for occupations that require a college degree or higher, but the absolute amount of job growth is highest for occupations requiring a secondary education diploma. This creates additional pressure on governments to increase the number of graduates. The race between education and technology is about how quickly and on what scale governments can provide workers with NE skills through the education system.

Beyond quantitative expansion, ensuring investment in 21st century skills will be critical. According to the World Economic Forum [15], there are 16 skills that students must have in the 21st century which go beyond the traditional skills and emphasize social emotional learning (SEL). Considering these aspects, the main policy challenge is twofold: to redesign the education system so that it helps break the vicious circle of technological stagnation and stagnating demand for graduates, is robust to radical unforeseen change, and prepares students for participatory lifelong learning, including disruptive technology; and to ensure quantitative expansion of the upper secondary segment of the education system.

For low and lower-middle income Asian countries, an additional challenge is that of addressing basic problems of mass illiteracy and innumeracy. Impressive growth in primary schooling during Millennium Development Goals campaigns significantly improved access but failed to meet the end objective, i.e., delivery of basic literacy and numeracy skills. In upper-middle income countries like Malaysia, coverage is high in terms of enrolment and completion rates [16]. Secondary school children in these countries also possess foundational skills in math and science. However, this is not the case for the vast majority of developing countries in Asia. There is an ongoing learning crisis that particularly affects lower-middle and middle-income countries [17–20].The education systems in those countries are characterized by flat learning profiles (i.e., a weak empirical relationship between schooling and learning).

To give a few examples, in Bangladesh, 30% of children are in grade 9 without acquiring grade 5 standard numeracy skills, even after accounting for household poverty [21]. The level of learning is also low across secondary school types in rural areas [22–23]. Similar evidence of flat learning profiles has emerged for Afghanistan, confirming a serious learning crisis in government schools. Empirical analysis of the schooling-learning gradient using Early Grade Reading Assessment

(EGRA), Early Grade Mathematics Assessment (EGMA), and Grade 5 standard oral and written numeracy scores of female students in government schools shows a very weak link between schooling and cognitive development [24]. The problem of schooling without learning is much more severe in India. India and Nepal perform worse than many African countries in terms of the percentage of grade 2 students who could not handle simple reading or math tasks [20].

In addition to the evidence of poor returns per year spent in school, in developing countries there is also emerging evidence of serious shortfalls in learning in the early part of the schooling cycle (e.g. primary school grades) [18]. This leaves the education system on a rickety foundation which is unable to bear the load of further cognitive development in complex skills. According to the child development and child intervention literature, these shortfalls therefore adversely affect skill formation in later stages.

The lifecycle framework for skill formation shows that inputs into the production of skills at different stages of childhood are complements, not perfect substitutes [25]. The stage-specific process of cognitive development is characterized by two features: self-productivity, i.e., skills acquired at one stage augmenting the skills attained at later stages; and complementarity, i.e., skills acquired at one stage raising the productivity of investment at subsequent stages. These combine to define skill multipliers i.e., skills begetting skills. Soft skills, people skills (e.g., leadership, communication, creativity, organizational skills) or SEL as emphasized by the WEF framework [15] are best acquired early in life. Early gaps in non-cognitive abilities lead to later gaps in cognitive skills.

Evidence from developing Asia shows that early stimulation through formal learning between ages 1 and 4 is important to prepare children for later education in primary school [26–28]. Children with preschool experience perform better in early-grade speaking, writing, and mathematics because preschool exposure boosts executive functions such as working memory, flexible thinking, and self-control. Evidence based on developed country data also confirms long-term labor market gains [29]. At the same time, low-quality preschool can do more harm to child development than no preschool at all [30].[2] Therefore, the "business as usual" approach to educational management is unlikely to work. Scaling up without quality will fail developing countries in the race against global technological advances and may lead to new challenges such as income inequality and graduate unemployment, and middle-income traps.

Education Reforms and Some Policy Suggestions

Our review of the evidence on educational systems in developing Asia highlights a dissonance between schooling and skills in education systems in that region: most developing Asian countries are still stuck with the basic challenges of low literacy and numeracy skills. This is deeply worrying, given that the demand for socio-behavioral skills is also on the rise in developing countries. For emerging Asian countries like Vietnam, there is evidence of higher market returns for interpersonal and non-routine analytical tasks (compared to non-analytical, non-interactive, and non-manual activities) [34]. In Asian countries such as Lao PDR, Malaysia, the Philippines, and Vietnam, the vast majority of employers report shortages of workers with specific socio-behavioral skills such as commitment to work [8]. Further adoption of digital technology will increase the importance of general cognitive skills and raise the demand for workers with interpersonal skills.

2 The low level of academic achievement and the existing inequalities therefrom also arise partly due to inequalities in health care at birth [31–33].

We also noted that most developing Asian countries have an underdeveloped preschool education system and also lack adequate quality child health care provisions (including neonatal care). Therefore, alongside policies affecting contemporaneous school inputs like good teachers, availability of books, and physical infrastructure of the schools, efforts to improve educational outcomes should also focus on strengthening preschool/early childhood infrastructure provisions. In this context, policy reforms in the region should tackle the following challenges.

- First, before diverting scarce resources to a higher (tertiary) level of education, gaps in the foundational stage need to be addressed. Alongside ensuring access to quality early childhood education, a competency- (or mastery-) based approach to learning should be adopted.

- Second, increase the supply of post-secondary graduates, particularly in STEM education. In this regard, reforms should also emphasize problem-based learning as a teaching method and, in general, closer interaction between theory and practice.

- Third, given the complementarities between non-cognitive and cognitive skills and the stage-specificity of skills formation, governments must prioritize development of a system-wide model to deliver 21st century skills. In school curriculums, SEL must be prioritized.

- Fourth, there are many examples of models and interventions that positively impact on enrolment, attendance, and school completion. But these interventions don't appear to systematically boost learning achievement. Review of the available evidence [35] highlights the need for developing context-specific solutions to improve the quality of education service delivery. Given the absence of a universal blueprint for affordable high-quality schools [35–36], home-grown country-specific innovations and experiments should be encouraged. Low-cost joyful learning models of non-formal education offered by NGOs such as BRAC are promising, although scaling up such models faces various challenges [37–38].

- Fifth, innovative use of ICTs to deliver and improve the quality of educational services should be explored. Simply replacing paper-based learning materials and textbooks with laptops can be counterproductive [39]. The focus should be on using technology to improve teacher productivity [40]. Models such as Bridge International Academies, while promising, may not be adequate for delivering SEL.

- Sixth, an optimal balance between sequential and dual track (a combination of general and practical education that is usually obtained through firm-specific employment) education needs to be ensured. Technical and vocational training (TVET) may be good for specific analytical skills and for ensuring school-to-work transition (i.e., youth employment), but questions remain about TVET's long-term impact. Gains in youth employment from TVET may be offset by less adaptability and diminished employment later in life [41] and long-term economic growth [42].

Concluding Remarks

One of the anxieties of our time is to how to prepare youths for the era of IR 4.0. Technology is changing the economy in multiple aspects, such as by altering the pattern of work and disrupting

the production process and the geography of jobs. However, our review of the available evidence suggests that the end of work is not imminent. While some jobs will be displaced and some skills will become obsolete, new roles and tasks will also emerge. Technological advancement is increasing market demand for workers with critical thinking skills while lowering demand for routine tasks. In developing Asia, the demand for socio-behavioral skills and SEL is also on the rise. Further adoption of digital technology will increase the importance of general cognitive skills and raise the demand for workers with interpersonal skills. Net effects on employment will depend on the policy response to automation risks: having an adequate supply of workers with critical thinking and socio-emotional skills can shield against the risk of technological unemployment. This calls for the state to take an active role in fostering skills development and educating the next generation.

The majority of low and lower-middle income countries in Asia are undergoing a learning crisis where the education system is struggling to offer conventional cognitive skills. Many of these countries also have a bias towards higher and STEM education as opposed to provisions for preschool stage development. In these countries, ignoring the problems of mass illiteracy and innumeracy and child poverty and only prioritizing training in high-order skills through tertiary education is unlikely to deliver 21st century skills and SEL. In order to win the race between man and machine using education, the main policy challenge remains getting the balance between foundational skills and excellence right so that human labor can complement robots. Adopting a system-wide approach that prioritizes non-routine skills at all levels and supports socio-emotional development in the early years of life will be critical.

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CHAPTER 2

EDUCATION IN PARTNERSHIP WITH THIRD PARTIES: LESSONS FROM HONG KONG[1]

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Abstract

Many societies, including Hong Kong, allow for outsourcing curriculum delivery to third parties using government funds (state-funded ed-outsourcing). Previous research conducted in other contexts at the respective levels of government and schools suggests that outsourced education perpetuates or even aggravates the educational inequity observed in overall education. However, empirical research documenting the interaction between government policies and school-level practices is very limited, especially in the Asian context. Considering the great role played by context in shaping the impact of a policy, there is a need for research that addresses this gap. This paper, drawing on government documents on relevant policies as well as reports on grant use allocated for ed-outsourcing from a third of Hong Kong secondary schools, shows that while the government is trying to ensure educational equity through ed-outsourcing, some equity-related issues have remained. It also identifies the factors contributing to the equity landscape around ed-outsourcing and presents policy suggestions to ensure the equity of education provided in partnership with third parties.

Background

Privatization of Education and Educational Outsourcing

Since the 1980s, different governments and societies have adopted privatization as a strategic response to the rapid changes caused by globalization [1]. Educational outsourcing, the focus of this paper, is a popular option among these strategies. This is a new strategy, in the sense that the core of schooling, that is, teaching itself, has been privatized, rather than traditional areas such as catering, which are peripheral. It involves the purchase of education-related services, materials, programs, or other activities by schools from a third party, including charities and education businesses.

Despite its potential to raise cost-effectiveness and diversity in curriculum delivery [2], doubts as to whether these benefits are achieved at the cost of educational equity, together with quality concerns, have been raised by different scholars [3–5]. These studies have found that educational outsourcing sometimes led to issues of equity and quality in public education, as the private sector would prioritize profit over addressing the needs of potentially marginalized students or ensuring

1 This is a reconstitution of Choi, T.H. English education in partnership with third parties: A case of equity in Hong Kong. In Kweon S.O. and Spolsky B., eds., The Asian EFL classroom: Issues, challenges and future expectations. Abingdon, Oxon: Routledge, 2018, pp. 169–188. Readers can find further extended discussion in that chapter.

the quality of the outsourced programs [6–7]. In Hong Kong, where the practice has been adopted extensively, these crucial issues have been under-researched, with just a few researchers studying specific but limited-scope issues, such as extra-curricular lessons [8]. This paper aims to address the research gap by analyzing school- and government-generated documents.

The Hong Kong Context

In Hong Kong, the condition of educational equity can be understood as interacting with, first, the educational system, and second, with English-language education (ELE)-related policies. Admission into secondary schools in Hong Kong has been governed by the Secondary School Places Allocation System from the start of the system. It allocates students with better academic results to higher-"band" schools, a local typology that describes the secondary school system, ranging from "Band One" schools to "Band Three" schools, "Band One" being the most highly regarded. Schools in a higher band have admitted more students with better academic results, who often come from a higher socioeconomic background [9].

In terms of ELE policy, following reversion to Chinese sovereignty, Hong Kong adopted a bi-literate and trilingual language policy, urging citizens to master written Chinese and English as well as spoken English and Chinese (both Cantonese and Putonghua). The government urged two-thirds of secondary schools to adopt Chinese as the MOI. In the context where all government-funded universities have adopted English as the MOI and English being a priority subject for college entrance with a higher requirement than other subjects such as math and science, the difference in MOI in schools created a new secondary impact: students who study in schools using English as the MOI have more opportunity to learn English and secure places in prestigious universities and desired professions. Against this background, schools using English as the MOI will typically be classified as "Band One," whereas schools where Chinese is the MOI will not. Taking into account the fact that learning outcomes in ELE in schools are highly correlated with students' socioeconomic status (SES) backgrounds [10], these factors together have worsened the life chances of students from a poor family background and with limited resources for learning English.

The Education Bureau's initiatives of providing public funds to address the needs of potentially marginalized groups were expected to help close this equity gap, as seen in the setup and guidelines for the grants provided to schools to purchase outsourcing services, such as, for instance, after-school learning and support programs for low SES families. However, despite detailed procedural guidelines, doubts about whether these initiatives have actually reduced the gap between haves and have-nots and about the quality of the services purchased to bridge the gap have yet to be understood.

The Study

English-language education was chosen as the case where equity-related issues are often more clearly observed in Hong Kong. The study was guided by an analytical framework the author developed for researching policy implementation and impact [11]. The data for this study consisted of documents collected from the government and the schools. At the government level, these included government policies and guidelines on outsourcing published by various government units. At the school level, documents capturing schools' state-funded ed-outsourcing practices and their alignment with relevant policies were collected. The study focused on educational equity in relation to students' SES backgrounds. Thematic content analysis [12–13] as well as simple statistical analysis, e.g., a Chi-square test, were conducted.

Equity in the educational context can be understood as providing equal life chances through education [14]. Reflecting this understanding and the study's focus on students' SES-related equity, school level data were collected from six out of 18 of Hong Kong's educational districts with contrasting SES profiles. That is, the three most affluent and the three most underprivileged districts were chosen, based on their median monthly domestic household income as identified by Hong Kong Census and Statistics Department [15] statistics. The practice of educational outsourcing was compared across the two groups of districts in terms of choice of programs and the implications of the choices on students' life chances. In investigating the implications for life chances, the practice was compared in terms of potential educational outcomes, i.e., obtaining English proficiency sufficient for securing higher education and desirable jobs, as well as access to the programs, drawing on previous research [16–17].

All 137 publicly-funded secondary schools in the districts studied, which had access to such ed-outsourcing funds, were investigated. These constituted a third of the total number of publicly-funded secondary schools in Hong Kong. A total of 333 school-level documents were collected, of which 128 were annual school reports and/or fiscal reports; the remainder were grant reports. The documents accessed reported on 1,240 English education-related programs run at the school level, of which 337 (27.2%) were outsourced. Both school-run and outsourced programs were analyzed to see whether identified student needs were addressed. To evaluate the quality of the outsourced programs, only purchased programs and services were analyzed.

Findings

Practice at Government and School Levels

To finance ed-outsourcing, the participant schools used 23 funds which explicitly allowed for the purchase of services and programs from third parties. Fund allocation was made mainly on the per capita principle, although some funds were set aside to address the needs of potentially marginalized students, e.g., students with special needs or migrant students. In addition, some funds could be used for all subjects while others were allocated for a single subject. For example, the "capacity enhancement grant" was for all subjects, whereas the "revised enhanced English scheme" was for subjects in English only. Notably, there were no specific laws or policies governing the quality of the programs and services to be purchased; the laws only concerned the procurement of services and programs [18–19]. There were fund-level guidelines to report on the quality of programs and services, but one-third of the schools studied did not report information for some of the programs, suggesting that the fund guidelines have a rather limited impact in terms of quality control.

At the school level, counting only English subject-related purchases, three quarters of the schools engaged in outsourcing English education, purchasing more than three items, on average, per year. Out of sixteen types of ELE programs and services, the most frequently purchased were foundational programs (i.e., for developing the four core skills of reading, writing, speaking, and listening). Schools tended to purchase one-off, independent programs while directly running those which require systematic changes and coordination, e.g., English across the curriculum, showing a developing division of roles between schools and the outsourcing parties such as education businesses and post-secondary educational institutes.

Educational Outsourcing and Educational Equity

The equity landscape with regard to educational outsourcing is rather complex. In terms of educational access, the extra funds seem to have contributed to educational equity. Fund allocation

made possible more exposure to English among benefitting students, which proved valuable especially when they came from homes where English was not used. Students from less affluent backgrounds were often allowed to pay a lower fee or were completely exempted from paying, although when resources were limited, they had to compete for the benefits. The study also found that, when comparing across schools with different SES profiles, schools serving low SES communities tended to invest more in purchasing English subject-related items by as much as 50%. However, in terms of potential educational outcome, the funds do not seem to have much impact on levelling the field for students from low SES communities. Content purchased by the schools serving high and low SES communities did not show statistically meaningful differences when overall provision of English programs showed significant difference ($p<.05$). Schools in low SES districts prioritized building basic English skills, while their counterparts focused on elite and showcase programs (e.g., to demonstrate students' achievements), providing their students with a competitive edge for admission to prestigious universities.

Equity interacts with the quality of education; if quality is not ensured, learning opportunities are missed [6–7]. However, in terms of reporting and levels of control of the practice studied, equity seems to be subject to varying practices across schools and programs. It is worthwhile mentioning once more that one-third of the schools did not follow the guidelines, either fully or in part. Some followed the guidelines exactly by reporting all details required, while others reported only the name of the programs and amounts spent; still others did not even make any information accessible about their ed-outsourcing, despite the grant guidelines requiring them to do so. In terms of quality control, most schools showed a serious and responsible attitude toward ensuring the quality of the programs, suggested by the finding that the most frequently used measure was direct monitoring (e.g., observation and reviewing learning outcomes). But despite this, the study also revealed the difficulty in managing quality and filling the gaps between the regulations and the actual practices at the schools.

Discussion

Practice and Equity Implications

The findings show that although considerable efforts have been made at the government level, such as providing regulations and guidelines for the practice of ed-outsourcing, their effectiveness was undermined by a lack of appreciation of the specificity of education, their focus being on financial transparency but not on whether learning aims are achieved. At the school level, the practice of ed-outsourcing has been pervasive and wide-ranging and has taken diverse forms. Division of labor has been observed between the schools and the service and program providers. Discrepancies between regulations and the programs outsourced suggest that schools face some challenges.

In terms of equity in relation to students' SES backgrounds, both the government and the schools have made efforts to provide and support extra initiatives, with the aim of closing the gaps in opportunities and outcomes between haves and have-nots. These efforts are especially important in the case of ELE, considering that English is important social capital in Hong Kong society. Concerns remain whether these supports are enough, considering the findings that schools in high SES districts are providing programs that promise better life chances than those provided by schools in low SES districts, whether they are purchased or provided by the schools.

Factors Shaping Ed-Outsourcing Practice and Equity

In this section, the factors that have shaped ed-outsourcing and may contribute to or hinder

educational equity are discussed. They are organized around the three dimensions of the policy process, namely policy features, people, and contextual features, drawing on the analytical framework.

In terms of policies on ed-outsourcing in Hong Kong, the findings have suggested that ed-outsourcing appears to both promote and hinder educational equity, considering the fact that the needs of potentially marginalized students are covered by the per capita principle of grant distribution complemented by needs-based fund allocation, and that quality management of the overall practice has been addressed only through grant guidelines but excluded in legislation. Other policies discussed in relation to ELE, such as the trilingual and bi-literacy policy, which set a relatively high English-language ability requirement, adversely affect the life chances of students from less affluent backgrounds. This is because the relevant policies on university entrance prioritize English proficiency over most other subjects and students who belong to this group tend to have less exposure to English.

Although the study did not go into detail concerning the various people involved in ed-outsourcing in ELE and how they impact educational equity, it confirms that service providers in this regard involve not only education businesses and companies but also other types of organizations, such as government entities, charity organizations, and institutes of higher education, which blurs the line between for-profit and non-profit organizations in ed-outsourcing in ELE. This follows a global trend in the corporatization of education [5] and demands further investigation of the role of public schools in an era when third parties contribute to public schooling.

Lastly, the SES profiles of the communities that the schools serve have proved to affect equity. Despite the significantly larger investment in English by schools serving low SES communities, overall, when both purchased and school-provided programs were compared, most of the schools' programs focused on building the foundation of ELE, compared with their counterparts providing significantly more at the level which would effectively assist their students to perform competitively in exams, the outcomes of which are weighed during college admittance procedures.

Concluding Remarks

This paper explored the government-funded practice of ed-outsourcing in Hong Kong. The practice is varied and diverse, with room for improvement in terms of quality control and issues of equity. The findings highlight the complexities involved in determining equity around ed-outsourcing, given that schools' efforts to promote greater educational equity have focused mainly on equity in terms of access but not in terms of educational outcomes. Also, the equity landscape has, in fact, been complicated by interactions between the practice itself and other policies and contextual factors.

To further increase educational equity, governments may want to consider borrowing successful case examples of setting laws and regulations for ed-outsourcing, such as in Japan [20], as an attempt to reduce the discrepancy between written guidelines and actual practices. In addition, the government could consider differential distribution of support, allocating more resources to schools serving low SES communities, to ensure equity in terms of improved learning outcomes. Related policies may need to be revised after their interactions with other policies and contextual features have been reviewed, as these interactions may curtail the effectiveness of those policies and even create unintended impacts.

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CHAPTER 3

HIGHER EDUCATION AND DEVELOPMENT IN ASIA

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This short article describes the contribution of higher education to various facets of development, focusing on the contribution of higher education to economic growth and how it is measured; the development of higher education in Asia; and the financing of higher education. All these issues are interrelated.[1]

Higher Education and Development

Conventionally, higher education is regarded as a public or quasi-public good, benefiting not only individuals but also all of society by producing a wide variety of externalities or social benefits. It is also a merit good, i.e., a social merit good. As the UN Declaration of Human Rights stated in 1948, education is a human right. Higher education is a unique good/service that boosts economic growth by making people more efficient and that simultaneously contributes to reducing inequality by providing opportunities for upward mobility and for occupational, economic, and social betterment. It is both efficient and equitable.

The contributions of higher education to development are varied: higher education helps economies rapidly industrialize by providing human resources with professional, technical, and managerial skills. In the current context of the transformation of society into a knowledge society, higher education contributes not only educated workers, but also knowledge workers, to the growth of the economy. It creates attitudes and makes possible the attitudinal changes needed to socialize individuals and modernize and transform society. Most importantly, through teaching and research, higher education helps create and disseminate knowledge and facilitate its absorption. Higher education also helps create strong nation-states and speed globalization. Finally, higher education allows individuals to enjoy an enhanced life of the mind and brings cultural and political benefits to wider society.

Recent research has also shown that higher education is significantly related to many aspects of human development; it is positively related to the human development, gender development, and gender empowerment indexes. A higher level of higher education in a society, whether as stock or flow, directly correlates to a higher level of human development through its impact on two of the main components of the human development index, namely, life expectancy and per capita GDP. Infant mortality is another measure of health significantly influenced by higher education. Higher education helps greatly reduce infant mortality rates, as more educated parents are likely to be more aware of the need for preventive health care and the availability of general healthcare

1 These are the three aspects covered in the three lectures that were delivered at the Forum.

facilities, leading to sound decision-making within households regarding healthcare. Higher education can also influence the health of the population in a different way, by providing more and higher-skilled medical professionals to society.

Similarly, higher education may have a two-fold effect on fertility rates. Higher education helps create awareness of the need to reduce fertility rates for development on the one hand, and on the other, more time spent in education, i.e., enrolment in higher education, can delay marriage and reduce fertility rates. For example, Japan and the Republic of Korea (ROK), which have the highest levels of higher education, have some of the lowest total fertility rates. By contrast, Nepal and Cambodia, where barely 1% of the population has higher education, have high total fertility rates. Finally, there is a relationship between higher education and poverty. It has been found that poverty is inversely related to the level of higher education. Higher education reduces poverty and raises people above the poverty line, minimizing the possibility that they will fall back into poverty in the future.

It is thus obvious that higher education plays a significant role in the development of societies, in terms of economic growth and development, human development, gender-based development, improvements in health and life expectancy, and reductions in fertility, infant mortality, and poverty. It is generally true that there is a two-way relationship between higher education and development, and empirical analysis of methods and aspects of development in numerous studies has clearly confirmed the significant contribution of higher education to economic growth and development.

Higher Education and Economic Growth

Although some of these aspects of higher education may have been understood but not necessarily quantified for many years, the economic value of higher education has been clearly and widely recognized since the middle of the last century.

According to the human capital theory proposed by Theodore Schultz in 1960, higher education is an important form of investment in human capital. It transforms human beings into valuable human capital by imparting skills and knowledge, thereby raising individuals' employability and productivity and leading to higher individual earnings and higher national economic growth. Higher education, along with research, in fact, can be regarded as an advanced or specialized form of human capital which contributes significantly to economic growth. It is rightly regarded as the engine of development in the new world economy because of its specific contribution to technological advancement.

The level of achievement in technology in an economy is critically dependent on the level of higher education in that economy. After all, it is higher education and research that help develop new technologies and that contribute to innovations and their dissemination. Hence, in any society, higher education will have a very strong effect on the development of technology. In fact, the level of achievement in technology may be a close indicator of economic growth itself. Most countries with high enrolment ratios in higher education became leaders in technological achievement. The converse is also true: a large number of countries with low enrolment ratios, of, for example, under 10%, are marginalized in the area of technology. Economies with a medium level of enrolment ratios of close to 20%, as in Singapore and Hong Kong, have emerged, indeed, as potential leaders in technology.

Rates of Return to Education

While production functions are used extensively to estimate the contribution of higher education to economic growth, one of the most popular tools used to measure the productivity, or the external efficiency, of higher education has been the rate of return. The rate of return measures the productivity of education, measured in terms of labor market benefits over individual lifetimes. The rate of return, an improved version of the earlier estimated net present value and benefit-cost ratio, based on the discounted value of lifetime benefits (earnings) and costs associated with education, is an important tool in investment decision-making. This is generally regarded as a comprehensive approach, since it considers both the benefits received from and the investments made in education by individuals and society as a whole and also takes into account the full life span of individuals. It also makes several important adjustments, such as for unemployment, mortality, etc., on the one hand and for economic growth on the other.

The rate of return can also be estimated using the Mincerian earnings function, where the rate of return to education is estimated based mainly on the earnings of the educated workforce and years of schooling as the investment made, and on-the-job experience. This is normally considered a shortcut.

Despite some inherent limitations the method of estimating rate of return based on discounted lifetime earnings and costs is associated with, its simple logic has wide appeal and as a result, the rate of return to education is estimated in many countries, as summed up by George Psacharopoulos in a series of studies and updates on this subject. The voluminous evidence on rates of return to education in Asian countries may be summarized as follows: investment in higher education yields positive rates of return to the individual and also to society at large; in several countries, social rates of return are high, above 10%, which can be considered an alternative rate of return; and rates of return seem to be increasing over the years. Generally, declining rates of return over time are often expected, but this is not the case in some Asian countries. This may be due to the rapid increase in the demand for more highly educated manpower.

While many estimates of rates of return are based on lifetime earnings as the only benefits of education, Walter McMahon [1] showed through his voluminous research that total returns to higher education can be estimated which include the value of externalities that higher education produces. In actual policymaking, the implications drawn from the estimates of rates of return need to be supplemented by other considerations rather than depending exclusively on rates of return.

Development of Higher Education in Asia

Despite increasing awareness of the contribution of higher education to development, many developing countries in the Asian region have not expanded their higher education systems adequately, due to a variety of social, economic, political, and cultural factors. Higher education has expanded well in some East Asian countries, apart from Japan, and in Australia and New Zealand in the Pacific region. But several countries in South Asia, Indochina, and Western Asia lag far behind. Unequal levels of development in higher education also lead to unequal levels of economic development.

Higher education has expanded well in the East Asian tiger economies and a few Central and Western Asian countries, with the gross enrolment ratio comparable to that of some developed

countries. The gross enrolment ratio in the ROK, Singapore, Hong Kong, Thailand, Australia, and New Zealand far exceeds 50%. Countries like Indonesia and Malaysia are rapidly expanding their systems, but enrolment ratios are still much lower. In contrast, all countries in South Asia and those in Southeast Asia like Cambodia and Vietnam have very low enrolment ratios, except for India where the enrolment ratio is about 25%. Vietnam and Myanmar have had universal primary education for a long time. Even in the 1980s, the gross enrolment ratios in primary education in these countries were above 100 and literacy rates among adults are also very high (above 80%), but these countries have not been able to progress economically, essentially because of the low level of higher education development. Similarly, although Sri Lanka has been able to attain a high level of performance in school education, it is still poor in economic terms. This may be because Sri Lanka and the other countries have not paid adequate attention to higher education. For example, higher education in Sri Lanka is extremely restricted and secondary school graduates must wait for two to three years for admission to higher education. Higher professional and technical education is even more restricted.

Private higher education institutions have been growing rapidly in all countries of the region, not only in the transition economies of Central Asia but also in South Asia and East Asia, including in the People's Republic of China (PR China) and in the Pacific. In Japan, the ROK, and the Republic of China (ROC), the private sector meets a large part of the demand for higher education. The share of enrollment in private higher education in Japan, the ROK, and the ROC is among the highest in the world; other economies in the region, such as Singapore and Hong Kong, do not rely on the private sector and financing by the private sector to the extent that the ROK and Japan do. However, private sector education is also growing rapidly in other countries of the region, including in South Asia.

A major area of public policy worth examining in this context relates to the financing of higher education, since this determines the growth of higher education in any country.

Financing of Higher Education

Conventionally, higher education, including higher professional education, is heavily subsidized by the state in almost all countries, including in countries in Asia. This has been justified by the recognition of education as capable of producing externalities, as a public good (or at least as a quasi-public good in the case of higher education), as a merit good, as a social investment for human development, and as a major instrument of equity, in addition to it being a measure of quality of life itself. It is well known that markets cannot ensure an optimum supply of education, and that left to individuals or to market mechanisms, social investment would be below optimum or socially desirable levels. Therefore, education, including higher education, was formerly financed by the government out of general direct and indirect, and specific (or earmarked), taxes and non-tax revenues. Other sources of revenue are used only to marginally supplement government budgetary resources. This has been the practice in many countries, since funding out of tax revenues has some specific advantages over other methods of funding.

However, there have been significant changes in recent years in the approach to higher education, and one of those is financing. Recent trends in funding higher education are associated with changing perceptions of the role of higher education. As a result, modern approaches have begun to replace long-cherished traditional and time-tested approaches, and business models have been adopted in setting up and operating universities. The many basic characteristics of higher education,

such as higher education as a public good, a merit good, a social investment, and a human right, are under attack. In the current wave of market reforms, the long-held and well-established role of the state in higher education is being increasingly questioned. Most importantly, the launch of neo-liberal economic reforms in most developing and developed countries of the world, including in Asia, has led to shrinking public budgets for higher education. Reform policies have involved drastic cuts in public expenditures across the board, including for higher education, and the introduction of neo-liberal approaches to financing higher education. Questions are being raised concerning the rationale for public subsidies, and some argue that it is both desirable and feasible to reduce, if not eliminate altogether, public subsidies in the education sector. This author has critically reviewed many of these arguments in his earlier works.

There has been a steady decline in public expenditure on higher education and many changes in the pattern of funding education are taking place all over the world, such as introducing or increasing student tuition, student loans, and other similar cost-recovery measures, and privatization. One major trend in recent years has been the increased effort to recover costs by introducing tuition fees in societies where no-fee higher education used to be provided, and steep increases in fees in others where fees already existed. Additionally, loans as a method of financing higher education have been introduced in recent years in many countries such as PR China and Thailand where they had not existed earlier, and were reinvigorated in many other countries where they had previously existed, with a view to increasing loan recovery rates. In New Zealand, income-contingent loans were introduced, and in India, government-operated loan schemes were replaced by commercial bank-operated loan schemes. Recent evidence shows that many universities are experimenting with cost recovery measures, generating resources from student fees and other non-governmental sources. Finally, initiatives are being made to mobilize private finance and more importantly, to encourage the private sector to set up higher education institutions. As a result, private universities, commercial universities, corporate universities, and entrepreneurial universities are becoming the order of the day, as they tend to dominate the higher education scene in many countries. In many Asian countries, the profit syndrome is no longer uncommon.

In most countries, higher education receives less than 1% of GNP from the public purse. The levels of cost recovery in higher education, specifically in the form of fee revenues as a proportion of total expenditure of universities, are higher in developing countries in Asia than in many advanced countries. Student loans have replaced scholarships in policy discourses regarding financing higher education. Higher education in some developing countries in Asia is more privatized than in economically advanced countries in the West.

For sound policy-making, the effects of these cost recovery measures on the quantity, quality, and equity of higher education need to be examined. Specifically, the relative effect of each cost recovery measure on generating additional resources, equity, quality, access, efficiency, and feasibility must be examined critically before it is adopted. In other words, various effects, positive and negative, of high cost recovery measures must be analyzed and understood. Even if some measures can raise resources to higher levels and can be easily implemented, it is necessary to examine whether they are desirable from the point of view of equity in higher education on the one hand and the manpower needs of developing economies on the other. However, the bottom line is that basically, any method of cost recovery restricts demand for education, and as education is a social merit good, there is the argument that it should not be rationed on the basis of ability to pay by consumers, as Burton Weisbrod [2] eloquently maintained long ago.

The best method of financing higher education is financing by the state out of its tax and non-tax revenues. Developing countries in Asia which have miles to go to expand their higher education systems in order to catch up with advanced countries have much to learn from other countries. Given the historical and contemporary experience of many countries that developed strong higher education systems, it seems imperative that the state should shoulder a major responsibility for financing higher education. Progressive taxation and funding higher education out of general tax revenues may still be the best option. All other sources of finance, including fees and private funds, should at best be viewed only as peripheral to supplementing public expenditures.

The level and method of financing determine the level and nature of development of higher education in a society, and the level of development of higher education in a society determines its contribution to national development. What we learn from history is first, that strong, vibrant, and widely spread higher education systems were developed with state finances and not by relying on student fees and other non-governmental sources. Second, nations with strong and widely spread higher education systems of high quality and excellence have emerged as strong developed economies and are socially progressive and politically stable; and that the reverse is also true.

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CHAPTER 4

HELPING THE WORK FORCE FACE THE CHALLENGES OF IR 4.0

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Abstract[2]

This paper addresses the directions to follow when reforming educational systems and school-to-work transition regimes to help the workforce face the challenges posed by industrial revolution (IR) 4.0. Although a high level of general education will be important for developing adaptability, it is not the only component to develop. Work-related skills, both general and job-specific, will be increasingly important and need, therefore, to be developed through on-the-job training. This will require important educational reforms to favor an ever-better integration between educational institutions and the world of work. Otherwise, young people and their families will be unable to adapt on their own to the new human capital requirements of production. A new framework for integrated action by governments, companies, educational institutions, and families is needed to smooth the school-to-work transition in the future. The duality principle is the basis for strongly diversifying education provision.

Introduction

IR 4.0, which is still ongoing, is a multifaceted process involving a number of concurrently occurring innovations in the fields of robotics, artificial intelligence, renewable energy sources, and digitalization of production and consumption patterns, etc. These changes are and will continue to be pervasive in every area of the economy and society.

The consequences for labor markets are already important and visible but will become even more apparent in the future. According to a famous study by Frey and Osborne [1], almost half of all existing jobs will be destroyed. This prediction, which sounds alarming, is not exaggerated if we look at it in perspective. Just think of the jobs that have evaporated in the last several years. Many have already gone and others will also disappear quite soon. In addition, all the remaining jobs will be done in a completely different way.

Robots are already substituting labor in an increasing number of jobs, not only the most repetitive ones but also for some creative endeavors as well. For example, vehicle drivers and airplane pilots will disappear to a large extent. Other examples include telemarketing, tax preparation, sports

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refereeing, fast-food preparation, including pizza chefs, long-term caregiving, children's tutoring, and even some surgery. The main novelty of recent robotics and artificial intelligence is that some robots are learning skills from humans. One example is RoDyMan, which has learned activities considered to be the result of human creativity and dexterity, such as making pizza: in fact, RoDyMan is the robot that became a pizza chef.

At the same time, new products, new consumption patterns and, therefore, new jobs, will appear. At the moment, it is impossible to foresee the exact number of and fields in which new jobs will be created. However, we can try to guess what new jobs will be created, based on skills that are being challenged now and those that will be still in demand in the future.

Our educated guess is that the jobs that will survive and even become more common will be those applying creativity to production and consumption. This means that they are jobs that will need to incorporate an increasingly high level of human capital. Human capital, in fact, is made up of not only general education but also and, perhaps more importantly, work-related skills, including both general and job-specific ones.

The overall number of jobs destroyed and created should balance out in the long run, although we do not know when that long run will come. Much will also depend on the ability of educational systems to develop the right skills in the shortest possible time. Education policy is, therefore, at the heart of the ongoing process of structural change.

In order to ease the process of human capital formation and, in particular, the formation of work-related skills, educational systems should implement the dual education principle on a scale never attempted before to replace the sequential principle. The dual education principle involves developing work-related skills in tandem with general education, rather than after completing education. It requires that education systems focus on generating all-round human capital rather than on education alone.

This paper is about education policy, but the government must also play a role in other areas, such as providing public infrastructure that might solve some market failures and, at the same time, favor implementing private investment and innovation in the economy. Financial incentives for firms in specific sectors might also help accelerate structural change and therefore the creation of new jobs, which should reduce the unemployment rate. The state should also provide completely new labor regulations to define new forms of organization of labor and new rights of workers in the new context.

This paper is structured as follows. The first section summarizes the main features of the industrial revolution. The next underlines the main directions of labor market change and tries to determine which skills will be most in demand. The third section examines the role of enterprises by distinguishing between what they will be likely to do and what they will have to do. The fourth section summarizes the main types of governmental intervention needed. The fifth section focuses on industrial policy directions and guidelines for new legislation and a new education policy, followed by some concluding remarks.

The 4th Industrial Revolution

Over the past few centuries, the economy has gone through a number of dramatic processes of structural change in the organization of production. The main steps in this process are:

- Merchant capitalism (pre-1784)
- 1st industrial revolution (1784–1869)
- 2nd industrial revolution (1870–1969)
- 3rd industrial revolution (1970–2010)
- 4th industrial revolution (2011–)

Merchant Capitalism

Using his own capital, a merchant paid highly skilled self-employed artisans by the piece. The more the artisans worked and produced, using their own means of production, the more they were able to sell and earn. In the words of Karl Marx, these artisans owned the product of their work. The merchant capitalist then brought the products to the market and earned the difference between purchase and sale prices.

1st Industrial Revolution

Industrial capitalism. Mechanical production replaced the traditional one-man textile machines. Production was organized around complex machines, often in the textile sector, which represented the most important manufacturing sector. Many less skilled manual workers were involved in production. A process of deskilling of the labor force from artisans to laborers took place. Alienation was the name used by Marx to describe the loss of workers' control over the product of their labor, who were paid a fixed wage based on a given number of hours worked in a factory.

2nd Industrial Revolution

Mass production and automation of production. Mass production became possible thanks to dramatic automation of the production process. The production chain could use increasingly less skilled manual workers, who were paid much less than earlier. However, this allowed for much higher productivity and reduced production costs, which in turn meant lower prices on the market. This made it easier for a larger number of people to acquire consumption goods which had earlier been inaccessible to the so-called middle class of blue- and white-collar workers employed in emerging executive tasks in large enterprises.

3rd Industrial Revolution

Almost full automation of manual work. The driving forces were the spread of ICTs, increased demand for skilled labor, and fossil fuel energy. This industrial revolution implied a deepening of the previous processes of automation and, at the same time, the spread of new ICTs in the production system. The overall process has sometimes been called skill-biased technical change. In fact, it encouraged polarization of workers between a small number of very skilled knowledge workers and an ever-increasing number of unskilled manual and executive white-collar workers. This led to increasing skill-based wage inequality.

4th Industrial Revolution

Complete automation of production, digitalization of consumption, and progressive spread of robotics. This latest revolution implies wider use of clean and renewable energy as well as the completion of digitalization in consumption and production; extreme diversification of production, with possible extreme customization of consumption; and robotization of many jobs, especially in manufacturing but also increasingly in services, with some jobs also requiring some form of creativity for the first time. With 3D printers, the process of innovation is likely to further develop to an extent that is not yet fully clear.

Artificial intelligence is expected to be pervasive not only within manufacturing but also in the service industry. Examples of famous robots that will become common include Sophia, a robot designed to serve in healthcare, education, and customer services. Designed to look very human-like, Sophia is capable of natural-face expression and at the same time understands human speech and facial expressions. Fortunately, at least up to now, she is not considered a legal person and cannot go to school, study, create art or start a business, at least not yet. She is already famous though, having been featured on the cover of *Cosmopolitan* magazine.

Another robot is RoDyMan, who has become a pizza chef. In fact, RoDyMan can learn tasks which had not been envisioned in the first place. In fact, RoDyMan started doing a job that was supposedly "creative" and therefore not reproducible by robots. This was true until recently, but now, RoDyMan has changed this situation: he can learn by observing real workers. He memorizes the pizza chefs' movements by having the latter wear a special apron that enables him to learn the physical movements necessary for making pizza. Working to make pizza, RoDyMan can reduce the cost of pizza and free money up to spend on other consumption goods.

The da Vinci system[3] performs robot-assisted surgery on a level of precision that no human being can achieve. The iPal[4] is a robot that specializes in playing with children and helping them with homework. Other robots can take care of the elderly. Self-driving cars already run without a driver, although experimentation is ongoing. Similar robots will drive trucks, pilot aircraft, and operate other means of transportation.

Just like any other very important person, all these robots have dozens of pages on YouTube and other easily accessible online repositories.

Lastly, globalization is an important part of IR 4.0. Economies are continually becoming more integrated, a trend that will continue in the future. Globalization per se is an important engine of change, since it increases the degree of competitiveness in any market and therefore contributes to instability in every economic activity. More importantly, as several observers have noted, globalization is also indirectly a driver of technological innovation. Globalization pushes firms in the direction of favoring the introduction and dissemination of new, skill-biased technologies, meaning a type of technological change that uses an ever-increasing share of skilled labor as a way of facing international competition. This is true especially in the most advanced economies but is also increasingly becoming so in emerging economies. In turn, skill-biased technological change is increasing the earnings of skilled relative to unskilled workers.

Dissemination of New Technologies

Information on the actual dissemination of new technologies in production and consumption is still partial and incomplete. New statistical sources will need to be defined and data collected more systematically, but we already have a vivid picture of the main features of this phenomenon. Because of space constraints, we will mention only a few indicators.

Let us look first at robots. The use of robots shows large variations across countries. In 2016, the average number of robots per 10,000 workers in manufacturing was 137 worldwide. For example, the Republic of Korea (ROK) drove the race with 631 per 10,000 workers (a factor of 4.6 to the

3 https://www.theguardian.com/technology/2016/sep/29/ipal-robot-childcare-robobusiness-san-jose
4 Ibid.

world average), with Singapore following with 488, and Germany and Japan with about 300 each.

In 2016, a total of over 294,000 new robots were installed, 16% more than in the previous year and more than 250% more compared to 2007, only 10 years before. If the growth rate remains the same, the number of robots worldwide will increase dramatically in the next few years.

In terms of the stock of robots by continent, Southeast Asia leads the game. The EU is a distant second and North America is still further behind. In Australia and Africa, the number of robots remains close to zero.

However, these numbers essentially refer to the use of AI in manufacturing, where it is already widespread. More dramatic changes will happen in services and consumption in the future.

Moreover, the biggest changes in consumption patterns and consumption style are already taking place, with online shopping becoming more and more widespread, to the detriment of traditional retail trade, which is disappearing, as well as, more recently, shopping at malls.

Effects on Employment and Skills

The new technologies will dramatically diminish labor requirements for the production of the old goods and commodities that will survive the evolution of consumption patterns. This would, in principle, cause unemployment, but fortunately, lower production costs, the availability of new technologies, and the emergence of new needs will allow the production of new consumption goods and the creation of new businesses, which will generate new jobs.

Among the jobs more at risk of disappearance or simply of dramatic changes are telemarketing, tax preparation, sports refereeing, fast-food preparation, long-term caregiving, children's tutoring, surgery, and others. As this shows, not only executive jobs involving repetitive tasks but also jobs requiring some creativity or dexterity are among those threatened.

The more at-risk jobs include those that are on some level routine, repetitive, and predictable, but some creative jobs too. The only ones that will not be reproducible are those that require a great deal of creativity and, simultaneously, job-specific competences. Work requiring genuine creativity, such as being an artist or a scientist, or a developer of new business strategies, will also be safe, as will occupations that involve building complex relationships with people: nurses, for example, or people in business roles requiring them to build close relationships with clients. Work with highly unpredictable demand, such as plumbers called out to handle emergencies in different locations, will also be spared.

To sum up, the likely consequences of new technologies will be a reduction in the labor required for all production; the increasing instability of labor faced with the ever-increasing volatility of any economic activity; the changing nature of work itself, with a smaller proportion of lifetime jobs; more people self-employed and in the liberal professions; and more entrepreneurs. Self-employment and entrepreneurship will become much more common, reviving the forecasts of neoclassical economists pondering the evolution of perfect competition.

The social structure will also change dramatically. The digitalization of consumption is one example. It reduces the number of blue- and white-collar jobs because production is automated and consumption and distribution of goods are digitalized; leads to the re-emergence of low-skill,

precarious jobs, including being paid for piecework, something that had disappeared with merchant capitalism; causes dramatic, unprecedented income inequality between billionaires and low-wage, low-skill workers; and stimulates the emergence of a small middle class of innovators, technicians, and entrepreneurs.

Will there be enough aggregate demand, or will unemployment grow indefinitely? A very interesting paper by Vivarelli [2] provides an answer to this question by surveying the theoretical literature. The classical view of economists on this matter is based on what is sometimes called the Nickell [3] principle of the irrelevance of technical change for labor markets in the long run, which is based on the observation of the unemployment rate over a very long span of time. Technological unemployment increases during some periods of exceptional dissemination of new technologies, especially those that are frequently labor-saving. Several previous technologies were also labor-saving, but although millions of jobs were lost, even more jobs were created. The overall impact will depend on an algebraic sum of two opposite effects. In particular, the impact of the changes will depend on whether the reduction in wage employment and labor's share of GDP will be lower, higher or equal to the increase in professional jobs and incomes. Much will depend on whether the reduction in labor costs and the ensuing increase in productivity will make enough new products and businesses possible. If we look at the unemployment rate over the last 150 years, we can see that it increased at the beginning of the Industrial Revolution and declined again later. The prediction of an ever-increasing unemployment rate has always proven to be wrong.

The Role of Enterprises

Enterprises are expected to behave in the traditional way, because their aim will continue to be profit maximizing. They will have to implement a (labor) cost-reduction strategy to face ever increasing competition from global markets and the volatility of business activity due to globalization. They will also continue to replace labor with machines, wherever possible, to become as flexible as possible to cope with the necessary changes and increasing globalization. As a consequence, companies will continue to reduce the share of permanent employment in favor of temporary employment for more standard tasks and use professional workers in the liberal professions as external labor resources.

In order to favor the creation of new jobs necessary for reducing the effects of technical change on the labor market, businesses will have to develop new entrepreneurial activities to exploit the opportunities offered by the new technologies. Enterprises are important knowledge centers which should drive change and produce an ever-increasing share of new businesses. Paradoxically, this strategy will determine whether there will be enough increase in labor demand to absorb all the emerging unemployment, particularly among young people.

Enterprises, and especially their human resources management centers, will understand that in order to obtain the labor they need, namely a workforce well-endowed with creativity and very high levels of job-specific competence, they will need to partly change their mission and become a training ground for workers; collaborate closely with education and training systems; and become part of an education and training system based on the dual principle. The new-model enterprise will resemble the guild model of merchant capitalism. In fact, it will involve production, labor, and training in one place and at the same time. School and university classrooms will no longer be the only place for building knowledge.

Moreover, in order to better exploit better the advantages of the new technologies, enterprises will

have to introduce smart working environments and teleworking. New labor regulations are needed in this field. A critical issue in the new regulations will be the so-called "right to disconnect". Teleworkers no longer have fixed work hours and work around the clock, reducing the time they can devote to their families or other pursuits. This is why the right to disconnect at least some part of the day should be guaranteed to smart workers.

New Labor Regulations

As described above, IR 4.0 carries the risks of increasing inequality, contributing to the disappearance of the middle class, reorganizing work within firms, and escalating the precariousness of the labor market. Moreover, a new category of workers, so-called platform workers, namely workers whose activity depends on a platform, will need regulation because of the specific, atypical nature of their work. New labor legislation will be needed to accommodate these changes.

Three broad directions should be followed. First is reducing the cost of permanent work to make it less costly than temporary work. Second is introducing new rights and forms of guarantees for low-skill workers, especially those involved in platform work. Third is regulating new types of work relationships, such as smart working.

Globalization has also made labor relations more unstable than ever. Entrepreneurs' horizons are shorter and shorter, pushing them to hire on a temporary, not a permanent, basis. It is very important to guarantee stable economic growth to favor permanent work, but it is not easy to understand how this should be done. Countries everywhere are trying to identify ways to guarantee that economic activities will be more stable for enterprises.

It is also important to reduce the relative cost of permanent versus temporary work. In many advanced economies, this is done by reducing the stability of open-ended contracts, therefore cutting hiring and firing costs, and by increasing the cost of temporary work. The latter can generally be accomplished by increasing the tax wedge and social security contributions on the wages of temporary workers.

The gig economy implies the spread of new types of low-skill jobs, such as bellboys or delivery workers. All these workers have been called platform workers by Eurofound [4–5]. In Italy, they are also known as "bike riders"or simply"riders," and their numbers have grown to about 50,000 in a few months. Platform work is often the only job opportunity available to many young people. Some of the companies using riders are Foodora, Glovo, Deliveroo or Just Eat. This is a worldwide phenomenon that is common in advanced economies around the world.

Representatives of delivery workers have agreed on a new charter of rights. From the legal point of view, the charter demands that workers be treated as wage employees rather than as self-employed if the work is "related to an online platform and algorithm decided by the firm," independent of whether workers use their means of production (e.g. a bicycle) or not, and an acceptable minimum wage (higher than the actual GPB2–4/hour they earn) defined within specific collective agreements as for workers in traditional sectors. The charter also asks that workers be guaranteed the right to disconnect (for at least 11 hours out of 24), the right to paid holidays, health insurance, and maternity protections, as for any other workers. Finally, the charter requires that firms provide proper bicycles (as wage employees rather than self-employed workers), pay for worker's compensation insurance, and pay for third-party insurance. These rights will likely increase the cost of online products. One possible risk is that businesses will be driven out of the

market unless consumers accept paying a surcharge for the service requested.

Smart working is becoming more and more common and is changing the structure and organization of enterprises. Labor rights must to be reformulated to include innovations such as the right to disconnect.

Government Intervention

There are three approaches to government policy: the liberalist approach, prevalent in Anglo-Saxon and EU countries; the dirigistic approach, used in China, India, and the ROK; and the balanced approach, which is still to come.

According to the liberalist approach, institutions (educational institutions, businesses, and governments) will find the right way on their own. Private firms will conduct all the R&D necessary, based on market convenience. The government's role is simply to create better conditions for firms to operate in the best possible way. The main shortcoming of this approach is that markets are often shortsighted.

In the dirigistic approach, to overcome the shortcomings of market mechanisms the government provides massive investment in a number of fields, such as infrastructure, education, and R&D, to stimulate innovation within production. The main shortcomings of this approach are that predictions may be wrong and that huge investments are sometimes made which are not profitable in the long run.

Finally, a more balanced approach holds that the government should suggest guidelines and provide financial incentives for enterprises to act as an important engine of the innovation process themselves. The state should step in, by investing in infrastructure and in research in which there is a shared interest, including, above all, basic R&D and other fields with economies to scale, to remedy market failures which exist.

There are at least four areas for state intervention. One, provide public goods and intangible infrastructure. Two, provide financial incentives to train staff to produce and transfer new technologies, develop new technologies through applied research, and transfer new technologies. Three, establish new labor regulations. And four, introduce in-depth reforms of every aspect of the education system.

Where IR 4.0 is concerned, an increasing number of scholars are returning to the old dirigistic approach of state intervention. For instance, Mazzucato [6] supports the idea of an entrepreneurial state that invests directly in innovation and the production of new goods and commodities. In this model, the state provides the main public infrastructures that private companies will never produce on their own. Examples of this include creating a national system of innovation; building wired networks; supporting the flow of information and debate about the importance of new technologies; and positive advertising, i.e., advertising the value of innovation.

In addition, the entrepreneurial state provides incentives for firms investing in innovation and new technologies and creates different institutions involving collaboration between academia, industry, and government [7]. Examples involving collaboration of this type are programs for creating an environment conducive to innovation, Digital Innovation Hubs (DIH), and Competence Centers (CC).

Financial and fiscal incentives for investing in innovation include super-amortization, iper-amortization[5], and tax credits. The advantages of these systems are that they favor the most innovative businesses, accelerate planned investments, are needs-based (bottom-up) rather than planned from above, and provide automatic incentives with co-financing to prevent gaming. The risks include creating dependence on public spending, favoring already-planned investment, and impacting only a limited number of companies.

Many countries advocate institutions called CCs, often called by different names (as is the case in Japan, Singapore, ROK, etc.). In Denmark, CCs are called RoboClusters. CCs are generally set up by the government and involve selected universities, polytechnic schools, and firms operating in a given or in multiple sectors. CCs provide resources to companies for worker training as future employees in DIHs, business incubators, and digital innovation labs.

DIHs are different. They are spontaneously organized by enterprises working together with the government and are intended to provide training in new technologies and specific solutions for businesses operating in given sectors, and to develop structures for disseminating and transferring technological change and innovation to companies.

Education Reforms

Finally, the government should conduct in-depth reform of the educational system and the entire school-to-work transition. As noted earlier, the skills less at risk as a consequence of the spread of new technologies are those that involve wide general and technical knowledge applied to the world of work, namely production and consumption. Such skills, unlike general education, cannot be inculcated in school or university classrooms but must be learned on the job. They are called work-related competencies or skills and are of two types, general and job-specific. General work-related competencies may be learned in any kind of job and transferred to any other kind of job. According to Nobel prize winner Gary Becker [8], there is a market failure in the production of these skills because firms are not interested in generating such skills, which can eventually be used in any kind of job. Workers generally pay for gaining these competencies in the form of lower than market-clearing wages. Job-specific training can be acquired only during a prolonged spell of employment in a given type of job. Job-specific competencies require time to acquire and can only be used in a specific type of job. According to Becker [8], job-specific skills or competencies require an investment which firms may or may not transfer to workers and consumers, depending on the degree of competition in labor and product markets [9–10].

A solution to market failures could be to implement the dual principle, as opposed to the sequential principle, at all levels of the education system. A sequential school-to-work transition system is one where work-related competencies are acquired after completing general education. In a dual education system, both general education and work-related competencies are acquired during the school and university period [11–12]. The mission of the education system should be to provide not only general education but also general and job-specific work-related competencies. That's why the Ministry of Education should be called the Ministry of Human Capital instead.

The main components of systematic reform of the education system should include increasing spending on education and training systems; moving from a sequential to a dual educational system; diversifying the supply of skills; favoring an increasing degree of integration between

5 https://www.logicalsystem.it/en/news/_2

educational institutions and the world of work; and developing well-functioning and comprehensive systems of lifelong learning.

The dual principle is key to the development of the work-related skills increasingly in demand with IR 4.0. Implementing the dual principle at all levels of the educational track will make it possible to diversify the education system.

The following reforms should be implemented at the various levels of education.

In upper secondary school

- Work-related learning (WRL)
- Vocational Education and Training (VET)
- Apprenticeship (the most developed type of VET)

At the university level

- Professional or vocational universities
- High level apprenticeship for university students

Post-university:

- MBAs and other master's programs
- Business incubators and training for entrepreneurship and self-employment
- Industrial Ph.D. programs
- Lifelong learning

WRL is the blandest form of VET. It aims to develop work-related competencies sooner than before, at the upper secondary school. WRL is a traditional mode of education in Scandinavia but is now becoming more common in Germany and other EU countries [13].

WRL is part of the upper secondary school curriculum and involves short periods (from 200 to 400 hours) of on-the-job training for students. It is compulsory for all students, including students at gymnasia [in the German school system], which can be useful, in fact, for gymnasia graduates who opt not to continue on to university studies. WRL should not be confused with apprenticeship. WRL has a lower skill content and aims only to impart the general component of work-related competencies.

Ducati, the Italian motor manufacturer now part of the Audi-Volkswagen group, created a good system, called DESI (Dual Education System in Italy).[6] The company invested half a million euros to build a laboratory for teaching mechanical concepts inside one of its factories. The concepts learned in the training area are implemented directly in the production of motorbikes, just outside the training area.

Why was this project implemented? Perhaps for cultural reasons, considering that Ducati has a German general management and industrial culture. In Germany, producing skills through apprenticeship is viewed as one of the missions of private companies and is considered a form of social responsibility. Or perhaps it is more a consequence of economic convenience for certain types of firms. Motorbike production is not automated; it is still handicraft production, with work done manually by a large number of mechanical workers. Through the DESI project, Ducati is

6 https://motorvalley.it/en/ducati-education-training-young-people/

ensuring that it will have a continuous supply of the skills necessary for building motorbikes.

VET (Vocational Education and Training) systems develop manual and practical skills and, as such, require both classroom and on-the-job training. Unfortunately, VET is not very common, except in a few Central and northern European countries.

VET education is not inferior to that offered in gymnasia; it is simply different. It is especially designed to equip young people with manual skills, which does not mean with no skills. It meets part of the demand for labor services which would otherwise be unmet.

Technical and professional knowledge is very important and will be even more so in the future. VET works if it also involves work-related learning and in the short run allows young people to protect themselves from precarious work, poverty, informal labor, and unemployment.

The main disadvantage of VET is that it is very specific and that if the skills learned are no longer in use, VET students are less able to adapt because they lack general skills. Hence there is a trade-off between outcomes over the short and long term. This is why VET students should acquire some general education before entering VET. The German case is problematic exactly because the choice between gymnasium and apprenticeship has already taken place by the age of 10. It would be better to start an apprenticeship after having acquired more general education, although some young people who choose an apprenticeship are not interested in general education.

Apprenticeship is the extreme form of VET, since it involves a high degree of on-the-job training. It is more widespread in Germany that elsewhere. In other EU countries and also in non-EU countries, where apprenticeship is not necessarily school-based, only about 5% of any cohort of students is in an apprenticeship, in contrast to Germany, where apprenticeship takes place at school and extends to 60% of every cohort. This share seems quite high and there are increasing demands for more general education, partly because it is difficult to find good venues for training all the students in apprenticeships. With apprenticeship, there is maximum development of job-specific skills but poor development of general skills [14–15].

Again, like VET education, apprenticeship is associated with a higher likelihood of employment probability, but there is also a higher risk of individuals being trapped by their skills. Workers with a professional qualification acquired at school through an apprenticeship are hard to retrain if unemployed, especially if they are middle-aged.

In the German dual system, professional schools, rather than universities, are a way to provide university education to people with an apprenticeship diploma who cannot access academic education otherwise. Many people in Germany have acquired highly technical and specific education. Professional schools such as those for public servants in specific sectors, provide applied instruction rather than teaching academic subjects.

Speaking of graduate programs, master's programs covering fields of study university graduates did not go into during their university studies could be very important for helping them complete their education. The late Sergio Marchionne, former Fiat Chrysler CEO, graduated in philosophy, so he was not well equipped to become a top manager of a major corporation. But his philosophy studies helped him understand that he wanted to pursue a business career, so he obtained further degrees, including a master's in business administration, and reached the top rungs of management.

Master's programs should be open to providing work-related knowledge and skills to well-educated people. This requires that academic education at the university level be neither too slow nor too specific. Students should be allowed the flexibility to move from one type of education to another.

Competence centers should be created at universities, to teach students willing to become self-employed or entrepreneurs. Education programs should be devised by the universities working with corporate managers. Entrepreneurs can be created; they do not come out of a black box or hop out of a hat like a rabbit. Business incubators funded by the state should be available in every state or province and at every university to support young people willing to start new businesses. Young people should be helped to develop their business ideas in detail, from both the financial and the technical perspectives.

Lastly there are the so-called industrial PhDs, which train students to implement innovation at private firms or in public administration. Most PhD holders tend not to work in academia but in the world of business or in the public sector. In Italy, only 2,000 out of 14,000 PhD holders remain in academia. Many of them are overeducated and also experience a wage penalty because of the mismatch between their academic knowledge and the knowledge required on the job [16]. They could be trained to do research applied to the world of work.

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CHAPTER 5

NEW TECHNOLOGIES, CHANGING WORK, CHANGING EDUCATION

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Most countries advocate and promote industrial revolution 4.0 (IR 4.0) to bolster industrial competitiveness and improve the social environment. Related to these technological changes, much attention has been paid to how the future employment structure of society will change. It has been pointed out that the future employment structure is not merely a change in the scale (increase or decrease) of employment but a qualitative change in the tasks involved. HR policy should provide for the quantitative and qualitative prospects of labor force supply and demand. Based on the idea that skill needs can be identified from technical information, patent analysis may be applicable for exploring future skill needs. In IR 4.0, the ability to work with data and make data-based decisions will be very important. Therefore, there will be increasing demand for complex problem-solving ability that encompasses various fields. In addition, the number of small businesses will increase, which will increase collaboration among firms.

During the process of catch-up development in the Republic of Korea (ROK), acquiring existing knowledge through simple memorization and functional training was enough. Today, the creation of new knowledge is expected, but inertia, i.e., excessive emphasis on acquiring existing knowledge, is becoming a constraint. The most urgent issue prior to general education reform is to reach a consensus that no further development will be possible without identifying and responding to the new needs of the future. Although a tailor-made vocational training system is a short-term direction, it does not offer enough linkage to areas that should be improved over the mid- to long-term. Over that time, mid- to long-term policy continuity for lifelong learning centered on core competency development should be ensured. On the other hand, a mid- to long-term strategy to respond to digital polarization should also be drawn up.

Changing Technologies

Technological Competition

Intelligent information technology and communication technology such as AI, IoT, and big data are converging with other technologies. This convergence is expected to bring about a shift in manufacturing as well as in overall socioeconomic conditions.

Patterns in US patent registrations present an intuitive snapshot of technology competition. In this paper, the time trends for patents between 1991 and 2016 are reviewed by patent assignee country in the relevant technology. For instance, a total 16,369 patents were registered between 1991 and 2016, broken down as 113 patents in 1991, 1,036 patents in 2010, and 1,908 patents in 2016. Comparing by country of assignee, the United States leads overwhelmingly with 11,777 patents, followed by 909 for Japan, 238 for Canada, 204 for Germany, 197 for the UK, and 177 for the

ROK. Patents for other core technologies, including IoT, cloud computing, big data, mobile internet, 3D printing, intelligent robots, self-driving vehicles, new energy, and synthetic biology were also reviewed. These technologies can be tracked according to their respective fields, and the following core technologies were grouped as ICT convergence technologies: AI, IoT, cloud computing, big data, and mobile internet; 3D printing, intelligent robots, etc.; self-driving vehicles for transportation, drones, etc.; new energy; and synthetic biology.

Patents for big data, AI, and robots account for 50% of patents when comparing patents issued in the last five years (2012–2016) to total patents issued from 1991 to 2016. Meanwhile, patents for cloud computing, IoT, and synthetic biology have a more than 75% share over the last five years. In the case of big data, AI, and robots, innovation continued from the previous period, but cloud computing, 3D printing, and synthetic biology are viewed as relatively new technologies. Overall, comparing the US, Germany, Japan, and the ROK over the past five years (2012–2016), the jump in patents issued to the ROK is remarkable compared with the longer period of 1991–2016 shown on previous graphs.

TABLE 5.1

PATENTS FOR TEN TECHNOLOGIES REGISTERED WITH THE US PATENT AND TRADEMARK OFFICE

(unit: %)

Class of technology		Proportion of the past five years (2012– 2016) to total (1991–2016)	Country proportion in the past five years (2012–2016)			
			US	Germany	Japan	ROK
ICT convergence technologies	AI	49.5	74.2	1.2	3.3	1.3
	IoT	75.1	57.4	1.5	3.0	12.3
	Cloud computing	96.3	84.9	2.1	2.9	0.7
	Big Data	47.0	70.6	2.7	9.9	2.4
Manufacturing	3D printing	79.9	61.8	4.1	3.0	0.9
	Robots	53.5	35.6	2.9	11.8	22.2
Transportation	self-driving vehicles	68.7	75.2	3.5	1.6	2.0
	Drones	70.1	79.2	0.7	0.6	0.6
Energy	Energy management in factories and buildings	58.7	68.4	1.9	8.8	2.7
Bio	Synthetic biology	76.7	79.5	0.8	3.4	1.1

Source: Author's calculations based on USPTO [1].

The US overwhelmingly dominates in all areas, even taking into account that the figures are based on USPTO data and that there is a large gap with the next three countries (Germany, Japan, and the ROK). Typically, Japan shows relative strength in the big data, energy management, and synthetic biology areas, the ROK in the Internet and robots, and Germany in 3D printing. In the emerging areas of cloud computing, 3D printing, and synthetic biology, Japan and Germany are relatively prolific, and the ROK seems to be relatively strong in areas where progress has been made in existing R&D.

Dissemination of New Technologies[1]

Expansion of Platform Companies

As digital platform technology evolves, platforms create new forms of goods, services, and markets that have never been connected to each other before. As the economic power of network platforms expands, the global economy is being reorganized around a handful of digital giants which have taken control of platforms. Current Internet giants such as Google, Amazon, and Alibaba and Tencent in the People's Republic of China (PR China) generate economic benefits from the contributions of users who create value within their own platforms.

Platform companies are moving beyond dominating their respective markets, taking over entire networks of economies, and expanding their monopoly position to other areas. Google, Amazon, Facebook, Alibaba and others have access to billions of users that every company wants to own. This pathway not only makes it easy to collect information and data but also has the power to connect new users, manufacturers, and distributors to enable new businesses.

TABLE 5.2

LIST OF PUBLIC CORPORATIONS BY MARKET CAPITALIZATION ON MARCH 31, 2018

(Unit: billion USD)

Company	Market value	Business	Country
Apple Inc.	851,317	IT	USA
Alphabet Inc.	717,404	IT	USA
Microsoft	702,760	IT	USA
Amazon.com	700,672	IT	USA
Tencent	507,990	IT	PR China
Berkshire Hathaway	492,019	Investment holdings	USA
Alibaba Group	470,930	IT	PR China
Facebook	464,189	IT	USA
JPMorgan Chase	377,410	Financial services	USA
Johnson & Johnson	343,780	Pharmaceutical	USA

Source: [3].

Successful platform companies are emerging in Asia, including in PR China and India. Among Asian companies, Alibaba and Tencent, PR China's leading platform companies, are competing for top place in market capitalization. Platform companies such as Japan's e-commerce company Rakuten and the electronic payment company PayTech in India are also expanding.

Block Chain Technology

The super-connected society born from the pervasive dissemination of the Internet has created a network economy and a platform economy. Meanwhile, block chain technology for security issues, the dark side of a hyperlinked society, highlights one aspect of the block chain economy. In the network economy, the value of information grows in importance, while trust in information and information security are central to the network. The introduction of block-chain technology ensures trust in transactions, enabling trusted parties to interact. Block chain technology distributes data in real time to network participants' PCs rather than centralizing the data on a central server.

1 Taken from [2].

Changes in Financial Services

The development of network technology has great potential for transforming traditional financial businesses. As mobile devices themselves become mobile solutions, settlement methods will be simplified and various forms of non-bank payment systems will emerge. With increasing use of block chain technology in the mid- to long-term, the trading, clearing, settlement, and record-keeping roles and functions of centralized service providers will be reduced. Furthermore, applying block chain technology will have a major impact on the economy not only through a micropayment system but also through financial market infrastructure, for example, the real-time total payment system and central depository institutions.

Transition from Manufacturing to Services

Global companies such as General Electric (GE) and Siemens have promoted business structure and business model innovation by making manufacturing a service. GE has transformed itself from a global conglomerate into a digital industry or software company. GE creates digital profiles of industrial machines through the Industrial Internet of Things (IIoT) to provide new opportunities for customer growth and productivity. Thanks to adopting new emerging technologies in line with the overall trend of IR 4.0, GE has succeeded in moving away from conventional manufacturing to the service sector.

Changing Work

Changing Skill Needs

Much attention has been paid to how recent technological changes will transform the future employment structure. Early discussions, including at the World Economic Forum in 2016 [4], focused on the changing occupation-based employment structure. Predictions were that many occupations would disappear within the next 20 years and that the number of employees would shrink considerably. However, the basis for these claims was simply based on existing companies and existing occupations, and new companies and new occupations were systematically overlooked.

On the other hand, it is held that the future employment structure will not merely be a change in the scale (increase or decrease) of employment but a qualitative change in the tasks involved. According to the OECD's task-based approach, only 9% of all individuals in the US face jobs that will be at least 70% automated [5]. Similarly, focusing on work activities, McKinsey [6] showed that fewer than 5% of occupations will be 100% automated; for about 60% of occupations, at least 30% of the tasks can be automated.

Exploring Future Skill Needs

HR policy calls for exploring the quantitative and qualitative aspects of labor supply and demand, especially demand in terms of the qualitative aspect. Organizations like the ILO and the European Centre for the Development of Vocational Training (Cedefop) have discussed how to identify future skill needs, but talks have not progressed beyond considering using labor market information or proposing employer surveys.

Alternatively, based on the idea of deriving skill needs from technical information, Hwang et al. [7] attempted to analyze patents to explore future skill needs and examine the adaptability of this methodology. They analyzed 174,155 patents in the information security sector applied for and registered with the Korea Patent and Trademark Office by September 2013. The International Patent Classification (IPC) code was mapped to the job codes derived from job analyses and the time trend of the number of patents mapped to the job codes was examined. After deriving a

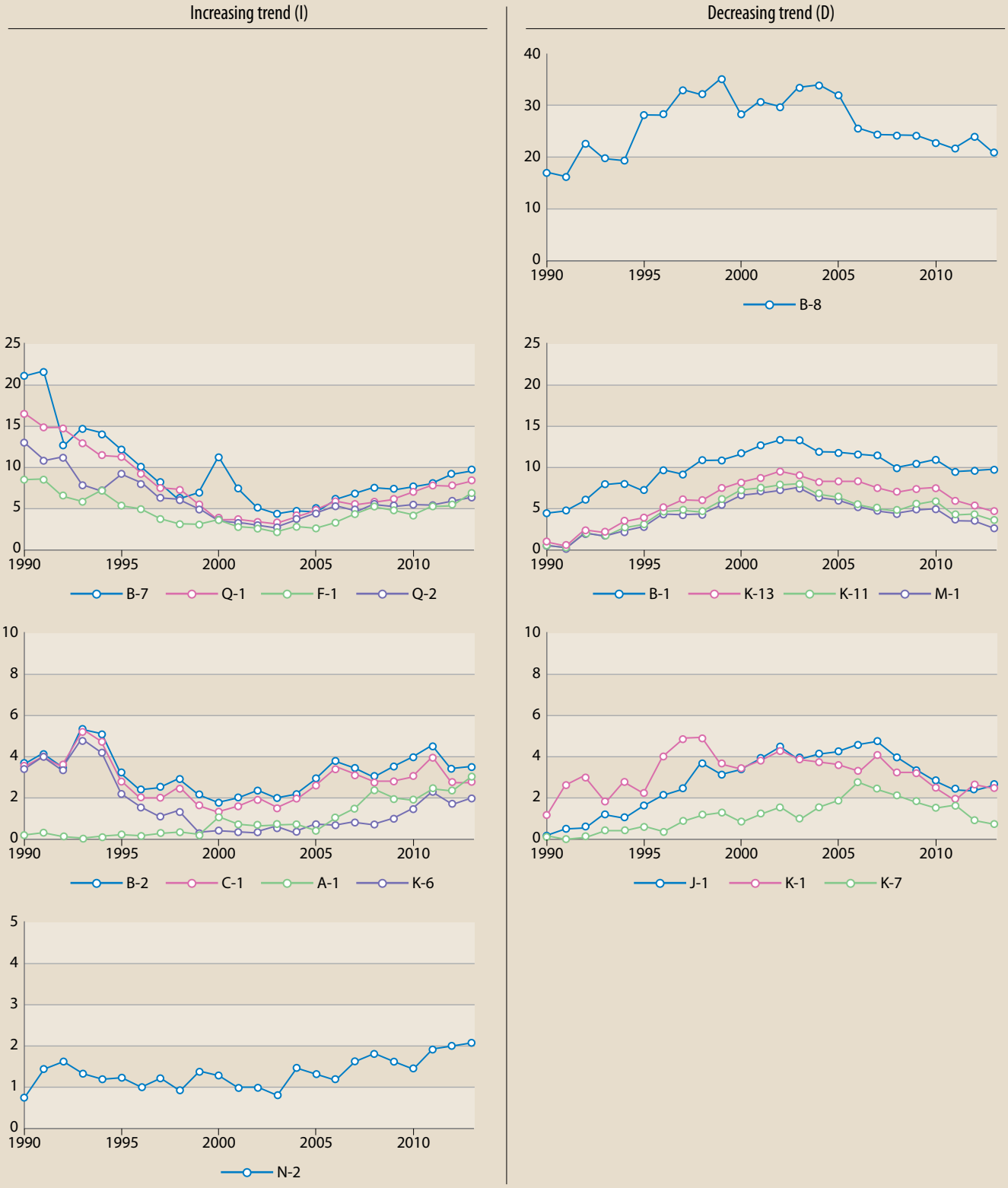
projection of skill needs for 2015 based on trends from 2005 to 2010,[2] an expert survey tested for confirmation.

The following patterns were categorized, with certain interpretations (Figure 5.1): in B-8 (network security), a very large share of skill needs, even though showing a slightly decreasing trend, was regarded as "stably important skills"; in B-7 (data security, etc.), the significant size of the rising trend in skill needs indicated "skills more in demand"; and in B-1 (information security management systems, etc.), the significant size of the declining trend for skill needs indicated that such skills were "becoming general skills." These propositions were verified by an expert survey, with statistical significance validated by a validity test.

2 Rapid technological change in the field of information security allows for the appearance of new technology within 5 to 10 years

FIGURE 5.1

TRENDS IN SKILL NEEDS BASED ON IPC TIME PATTERNS



Source: [7]

Growing Platform Work

IR 4.0 is expanding the on-demand economy and bringing about changes in forms of labor. This includes part-time or temporary work, freelance work, self-employment, and on-demand work. All of these can be called platform work, because they rely on digital platforms. In contrast to being hired to work on a regular basis, platform work is temporary work chosen on the basis of time, place, and work volume.

Due to the complexity of job subdivisions, platform labor makes it possible for a business with traditional employment relationships to do what could previously only be done through intermediary sites. This changes business opportunities and the way people recruit. Since jobs are subdivided, firms can increase productivity. To do this, firms and workers must re-establish the elements that make up the work.

As businesses' functions such as logistics, manufacturing, and marketing cross boundaries through a digital platform, employability is shifting from industrial expertise to functional expertise. In addition, given the increase in short-term employment, the transition will likely be accelerated by providing contract work or project-based work. In other words, the concept of full-time work is becoming blurred, and most jobs are likely to change into contracts (short-term employment), with self-employed or professional freelancers becoming more common.

There are concerns that platform work will create blind spots in employment and strengthen the polarization of labor. Unlike conventional employment relationships, platform work is problematic, since labor standards, minimum wages, and other social protections in facing consumers without employer mediation do not apply. In particular, job instability can be a serious threat to income stability.

In general, platform workers earn less for the work they perform. One of the reasons for this is that there are no organizations to protect individual platform workers in negotiating wages. Platform workers will meet the demand for simple and repetitive tasks on a global basis, keeping wages for simple repetitive tasks at the bottom.

However, despite the negative aspects of platform labor, this type of employment and the on-demand economy underlying it are likely to be the essence of IR 4.0. The expansion of the on-demand economy and the spread of platform labor are not only products of IR 4.0 but are also part of the socioeconomic system that drives IR 4.0.

Changing Education

The Need for Innovative Human Resources Development

Rapid changes in technology will lead to changes in tasks undertaken within existing jobs rather than complete substitution of existing jobs or occupations. What this means for labor market participants is that they need to strengthen existing competencies or acquire new competencies. The lifespan of knowledge will become shorter and qualifications and hard skills that were useful in the past will gradually lose their usefulness. Core skills, widely used in many industries, are expected to change significantly in the near future.

As the debate about the types of talent required by the IR 4.0 era becomes heated, major countries

around the world are establishing and implementing innovative educational policies in order to improve human resources. The McKinsey Global Institute [6] suggests that the skills gap has emerged as a major social issue. In the US, 40% of employers have difficulty finding talent with the desired capabilities, and 60% of the time, the reason is lack of adequate preparation for job performance. This is not a problem just in the US. The situation is similar in the ROK [8].

Innovating in Human Resources Development

In IR 4.0, the ability to work with data and make data-based decisions will be very important. Accordingly, there will be increasing demand for complex problem-solving abilities encompassing various fields. Also, the number of small businesses will increase, which will boost collaboration among businesses.

As AI develops in the future, collaboration and network-based businesses will spread from businesses to individuals as cognitive tasks are automated. There will be more network enterprises supporting individual business activities, business will be possible on a variety of scales, and one-person startups and brands will increase. Thus, the demand for skills to manage resources will also increase.

The EU and other developed countries, as well as global corporations, are investing in research, especially in the core competencies required in future society. One such example is the Assessment and Teaching of 21st-Century Skills (ATC21S) Project, sponsored by global companies such as Cisco, Microsoft, Intel, and others. At ATC21S, it was suggested that evaluation methods be changed to achieve leverage for innovation in education by developing a method to measure the core competencies required in the 21st century's future society. ATC21S divides the required competencies for the 21st century into four areas: Ways of Thinking, Ways of Working, Tools for

TABLE 5.3

21ST CENTURY CORE COMPETENCIES PROPOSED BY THE ATC21S PROJECT

Ways of Thinking	Ways of Working	Tools for Working	Living in the World
1. Creativity and innovation 2. Critical thinking, problem-solving, decision-making 3. Learning to learn, metacognition	4. Communication 5. Collaboration (teamwork)	6. Information literacy 7. Information and communication technology literacy	8. Citizenship – local and global 9. Life and career (including adapting to change; managing goals and time; being a self-directed learner; managing projects; working effectively in diverse teams; being flexible; producing results; guiding and leading others) 10. Personal and social responsibility (including cultural awareness)

Source: [9]

Challenges for Innovating Human Resources Development in the ROK

During the process of catch-up development in the ROK, acquiring existing knowledge through simple memorization and functional training was enough. Today, the creation of new knowledge is expected, but inertia, i.e., excessive emphasis on acquiring existing knowledge, is becoming a constraint. In order to preemptively respond to changes in future society, innovation must take

place on at least two fronts, the formal education system and reeducation and retraining.

The ATC21S project suggestions concerning formal education should be fully applied in the ROK. However, despite their validity, excessive school competition, heated over-education, and lack of jobs after graduation from college make it doubtful that they will be accepted. The problems in education in the ROK cannot be treated solely as educational issues, given their close connection to social status acquisition and economic compensation issues. Therefore, a consensus is needed concerning the innovative human resources development required in IR 4.0 in terms of a broader social reconstruction.

In the ROK, the most urgent issue before embarking on general education reform is reaching a consensus that no further development is possible without identifying and responding to the new needs of the future. This view should spread not only among students but also among ordinary citizens. Unless the new needs of the future can be identified and responded to, there will be no realization of new business opportunities, no emergence of new companies, and no further social development.

Let's look at the second issue of reeducation and retraining. In recent years, there has been continuous emphasis on better training and retraining to meet the demands of future society. There has been constant emphasis on upskilling and reskilling to acquire competencies such as the transferable skills and complex problem-solving abilities that future society will need. In addition, demand is growing for acquisition of new competencies and for convergence of various competencies in the form of hybrid jobs. The challenges of relearning in new fields to cope with changes in occupations or jobs due to technological change are increasing.

The Korean government is formulating mid- to long-term HR policies. For the short term, the government is establishing a tailor-made vocational training system in response to technology convergence, and for the longer term, it is promoting the transition to lifelong education centering on core competencies. This direction is not a problem in itself, but some improvements are needed. The short-term measure of setting up a personalized vocational training system responding to technology convergence is a step in the right direction, but not all the necessary components, such as teachers, etc. are in place. Further, although a tailor-made vocational training system is a short-term measure, there is insufficient linkage with mid- to long-term programs. Continuity with mid- to long-term policies providing for lifelong learning centered on developing core competencies should be ensured.

On the other hand, a mid- to long-term strategy to respond to digital polarization is also needed. In recent years, many people have been concerned that factors such as intelligence information technology and the IoT, etc. will lead to job loss and changes in the employment structure. Their main concern is a change in income rather than changes in or the disappearance of jobs themselves. In particular, older or less educated individuals are more likely to feel alienated or excluded because they are less receptive or responsive to change than those who are not.

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CHAPTER 6

NATIONAL EDUCATION AND TRAINING POLICY AND FUTURE JOB OPENINGS BY OCCUPATION AND INDUSTRY

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Introduction

A national education and training policy has many strands. The foundation of any such policy ought to be the education and health of mothers and early childhood education. Much research has shown the strong positive link between mothers' education and the development of young children. A national policy must also focus on preparing young people to participate successfully in a civil and democratic society and on preparing them for a smooth transition into further education and training and the labor market. Finally, it must include the principles of lifelong learning to meet the changing demand for skills in an evolving labor market. Equal education and training opportunities for all, irrespective of their socioeconomic status, overarches any good policy. The implementation of policies is, however, constrained by budgets, which necessitates making choices and setting priorities by individuals and institutions.

Individuals make choices about jobs, education, and training. Students, often with guidance from their parents and school counselors, make choices about the post-school education and training to undertake. Education and training authorities make decisions about whether to revise vocational education and training (VET) programs and whether to offer incentives to attract students into specific fields. Countries make decisions on how to support workforce development and whether to invest in more education to attract direct foreign investment. Information about the structure of the labor market, particularly the prospective labor market, often informs many of these decisions. Job seekers and migrants also use such information to assess their prospects of finding jobs in different occupations and to make decisions on whether to retrain. Similarly, firms use the information to make decisions on recruitment and human resources management. Many of these decisions are for the medium to long term: individuals, firms, and authorities are not preparing themselves for the current labor market but for several years into the future.

Labor market information is thus important for the efficient operation of dynamic and complex labor and training markets and, as discussed in a later section, this information can play an important role in reducing skills imbalances, which research has shown to have an adverse effect on productivity growth. While the future can never be certain, the experience of a number of countries suggests using the information we currently have to anticipate what a prospective labor market may look like is highly valued public information [1–6].

Future employment patterns reflect the structural changes of a dynamic economy as it adjusts to changes in technology,[1] business investment decisions, government spending, consumer preferences,[2] and international trade. The outsourcing[3] of services by firms, globalization, the 'gig economy,' and the offshoring of jobs have an additional effect on the structure, as does the reorganization of firms and the adoption of new human resource management practices.[4] Structural adjustment often means the elimination of old jobs and the creation of new ones, as well as changes in the industrial and occupational distribution of employment.

For many, the main concern is whether the broad trends in labor demand observed in recent years will continue and, if not, where to expect significant changes. Of particular interest are answers to the following specific questions about the labor market:

- What will the level of employment be over the medium to long term?
- In which industries and occupations will employment grow?
- What will be the impact of permanent job separations, including retirements, on job openings for new entrants?

The answers to these questions provide information on the job opportunities arising from future growth and replacement needs in each industry and occupation. Replacement needs are often a larger source of job opportunities than growth in many occupations but are often unaccounted for when assessing job opportunities. The information supplements other information describing the labor market. It is to assist individuals and institutions in their decision-making about jobs, education, and training, including what training should receive public subsidy.

This paper describes international practice in producing labor market information, particularly the use of quantitative modelling for forecasting job openings for new entrants in Australia. The next section briefly reviews the literature on the association between labor market information, skills imbalances, and productivity. Following this, we describe the method for forecasting job openings in Australia before finally providing some concluding remarks.

Skills Imbalances and Productivity

In a perfectly competitive, neoclassical labor market, price and quantity adjust until the market clears and imbalances in the supply and demand for skills do not persist. Firms adapt production processes to the available stock of human capital and workers seek the amount and type of training currently required (or foreseen) in an economy [7]. Underpinning this model is the assumption of perfect information, including that relating to the future structure of employment.

1 Changes in technology, such as the use of machines or software, have the potential to increase worker productivity so that the same amount of work requires fewer or no workers. Technology can also generate a demand for workers with different types of skill sets.
2 Changing consumer preferences for one product or service over another can affect the occupational share of employment in an industry. For example, as demand for carpeting decreases because of the rising popularity of other types of flooring materials, the demand for carpet installers will decrease in the construction industry.
3 Firms sometimes contract support functions to other firms instead of hiring their own workers. This can drive down the use of those workers in the firms that outsource the work but may increase use in another industry if the work is outsourced domestically, for example, schools outsourcing cleaning services to firms specializing in providing cleaning services.
4 Any type of change in job duties that produces the same output may increase or decrease the utilization of some occupations relative to others; for example, law firms hiring paralegals to do some of the tasks of lawyers, as well as legal secretaries.

Labor markets are, however, rarely perfect and labor market information is imperfect and often asymmetrical. Furthermore, tasks performed within occupations also change with advances in technology, which adds to the changing supply and demand for skills. The labor market is thus perpetually in a state of flux and at any point in time the supply and demand for skills will be in imbalance.

Skills imbalances are thus a reflection of the imperfections in the functioning of the labor and training markets, which include factors that impede the market clearing function of wage adjustment.[5] Lack of transparency in the labor and training markets, including in the links between education and training and job opportunities, is another important source of inefficiency and leads to skills imbalances. In reality, students, workers, employers, and training institutions may lack information about prospective skills requirements in the labor market. In the presence of incomplete information, and the time lag between the decision to enter education or a worker training program and that of entering the labor market, individuals may under- or over-estimate employment prospects, leading to skills imbalances [10, 5].

Perfect matching between skills demand and supply is neither feasible nor necessary, especially when a one–to-one relationship often does not exist between the skill sets people have and jobs [1].[6] Nevertheless, public access to high quality and timely labor market information is a key factor for ensuring individuals and enterprises adapt to changing demand for skills [11]. Effective adaptation reduces the risk of skills imbalances persisting, as the longer the imbalances exist, the higher the cost to the economy.

The investigation of the economic cost of skills imbalances tends to make a distinction between skills shortages and skills mismatches. Skills shortage occurs when there is an insufficient supply of appropriately qualified workers willing to work under prevailing employment conditions, particularly current wage rates [5]. Persistent skills shortages can affect labor productivity[7] growth [12–13]. Skills surplus arises when there is an excess of supply, but most research tends to focus on the shortage even though persistent skills surplus also has an economic cost.

Skills mismatches, on the other hand, occur when existing workers' current skills do not match the skills required in jobs [3].[8] Skills shortages can be a cause of skills mismatch when employers hire workers without the required skills for jobs because appropriately skilled workers are unavailable. Employers may, however, invest in on-the-job training to address the skills deficiency of these workers. Conversely, when there is a shortage of jobs, workers may accept jobs for which they are over-qualified.

The investigation of skills mismatch on productivity uses both indirect and direct methods. The indirect method uses workers' wages and other correlates of workers' productivity (e.g. job satisfaction, absenteeism, and turnover). The results from using wages as a measure of productivity

5 The time lag associated with wage adjustment can be affected by contracts of employment between employers and employees, centralized wage setting arrangements, wage controls and social welfare provisions and other institutional rigidities [8]. Delays by employers in accepting the need for wage adjustment and the reluctance to disturb existing wage structures in order to raise the rates for new employees with the required skills can also retard the process of wage adjustment [9].

6 A perfect match may in fact be detrimental, particularly when it is low-skills equilibrium, which then prevents further skills development and results in constraints to country competitiveness and social prosperity.

7 The measure of labor productivity is hours per unit of output.

8 Skills mismatch is generally defined using skills (e.g. literacy, numeracy, and problem solving) or education (e.g. years of education, qualification level, and field of study). The former is a more robust measure. OECD [14] shows that one-third of workers in OECD countries experience qualification mismatch and one-sixth skills mismatch, and that only 10% are mismatched on both measures.

show under (over)-educated workers' wages, and hence productivity, to be lower (higher) than those of workers' who are adequately educated. The research is, however, inconclusive about the link between mismatch and productivity when other correlates of workers' productivity are used as proxy.[9]

Mahy, Rycx, and Vermeylen [15] and Kampelmann and Rycx [16] both show the direct effect of mismatch on productivity at the firm level. They show a positive effect of over-qualification on firm-level productivity among firms in Belgium and a negative effect of under-qualification. Over-qualification had a stronger effect for firms with a higher share of high-skilled jobs in high-tech or knowledge-based industries. Adalet McGowan and Andrews [17] investigated the direct effect of mismatch on productivity at the industry level. They found that a higher level of skills and qualifications mismatch is associated with lower productivity at the industry level.[10] The research also showed that a higher skills mismatch is associated with lower labor productivity through a less efficient allocation of resources.[11]

Modeling Labor Demand: International Practice

The detail, quality, and type of labor and training market information available can vary significantly across countries. This is because approaches to producing such information varies, reflecting the perceptions of what is desirable, as well as the practical limitations (financial, expertise, and data) of what is feasible [19, 3]. With better data collection and advances in economic modelling, both approaches and limitations have changed substantially since the end of the Second World War.

Some of the main approaches to anticipating future demand for labor and skills include:

1. Surveys of employers
2. Qualitative methods
3. Sectoral studies
4. Quantitative modelling at the national, and sometimes the regional, level.

Table 6.1 shows the strengths and weaknesses of the different approaches.

9 For a review, see [15].
10 The effect on productivity was larger due to over-skilling and under-qualification. Allen and van der Velden [18] suggest that skills and qualification mismatch can have different implications for productivity.
11 Adalet McGowan and Andrews [17] suggest that when the share of over-skilled workers is higher in an industry, the more productive firms find it more difficult to attract skilled labor and gain market share at the expense of less productive firms.

TABLE 6.1

ADVANTAGES AND DISADVANTAGES OF DIFFERENT APPROACHES TO ANTICIPATING FUTURE SUPPLY AND DEMAND FOR LABOR AND SKILLS

Approach	Advantages	Disadvantages
Surveys of employers	Direct assessment of demand, recruitment difficulties, skills gaps and shortages	May be subjective and inconsistent; may focus on the present rather than the future; understanding of concepts may vary across respondents; requires careful interpretation of results; only represents the formal economy
Qualitative methods	Holistic, direct involvement of users, fewer initial set-up costs and data needs	Inconsistent; can be subjective; high risk of being non-systematic
Sectoral studies	Focused on the specific sector or occupation; focus on a single sector means that it is easier to combine qualitative and quantitative approaches	Partial; may not cover all sectors; inconsistent across whole economy; ignores interactions between sectors
Quantitative modelling	Comprehensive; consistent; multi-sectoral; systematic; transparent; provides a quantitative base for other approaches; provides a solid basis for qualitative approach	Data intensive; costly; may provide misleading impression of precision; requires expert modelers; can only include variables that can be quantified and for which data are available

Source: [19]

Surveys of Employers

Scientifically conducted employer-based surveys can be a source of important information about employers' perspectives on labor and skills demand within firms. While they provide information about the present, and perhaps the short-term future, they are generally not suited for medium- to long-term forecasting, and consequently their use for the purposes of providing prospective information about the labor market is uncommon. Green, Machin, and Wilkinson [20] show that employers can be inconsistent in their interpretation of the various notions of skills shortages such as skills gaps, recruitment difficulties, and hard-to-fill vacancies in self-reported employer surveys.

Qualitative Methods

Qualitative methods are an alternative to collecting information about the likely future trends in the labor market. The methods can include focus groups, roundtables, scenario development, and "Delphi-type" approaches. The success of qualitative methods in providing useful foresight depends on the quality of the inputs from key experts and stakeholders and the way in which these are integrated. The potential outcomes include participants developing future scenarios, including those they wish to commit themselves to implementing.

Sectoral Studies

Sectoral studies focus on a specific industry sector or an occupation for the analysis. Interactions

with the rest of the economy are often difficult to incorporate in these analyses. The studies sometimes combine qualitative and quantitative methods and include sector or occupation details that are difficult to incorporate in an economy-wide model. Examples of sectoral studies in Australia include Shah and Long [21] for nursing and caring occupations; Shah and Long [22] for the service industries; and Weldon, Shah, and Rowley [23] for teachers.

Quantitative Modeling

Quantitative labor market forecasting for education and planning purposes dates back to the 1920s in the old Soviet Union [24]. After the Second World War, the Bureau of Labor Statistics (BLS) began to conceive the idea of producing labor market forecasts in order to offer career guidance to returning war veterans, with the first set of forecasts produced not until 1960 [4]. Growing recognition of the role of human capital in economic development within the theoretical and empirical literature of the late 1950s and early 1960s further encouraged policy interest in models for education and labor force planning.

At the beginning, the development was characterized primarily by an emphasis on the labor demand side, i.e., manpower requirements. Typically, the process involved calculating labor requirements by occupation and qualification to meet specific, pre-determined macro and/or sectoral targets. An important criticism of the approach was the use of fixed coefficients in moving from the macro to industrial, occupational, and qualification-specific forecasts.

Advances in economic modelling over the past 25 years have attempted to address some of these criticisms. Most development has occurred in two areas:

1. Dynamic multi-sectoral macroeconomic models that extend basic input-output analysis with econometric relationships estimated using time series and panel data [25–29] and

2. Dynamic computable general equilibrium models [30–33].

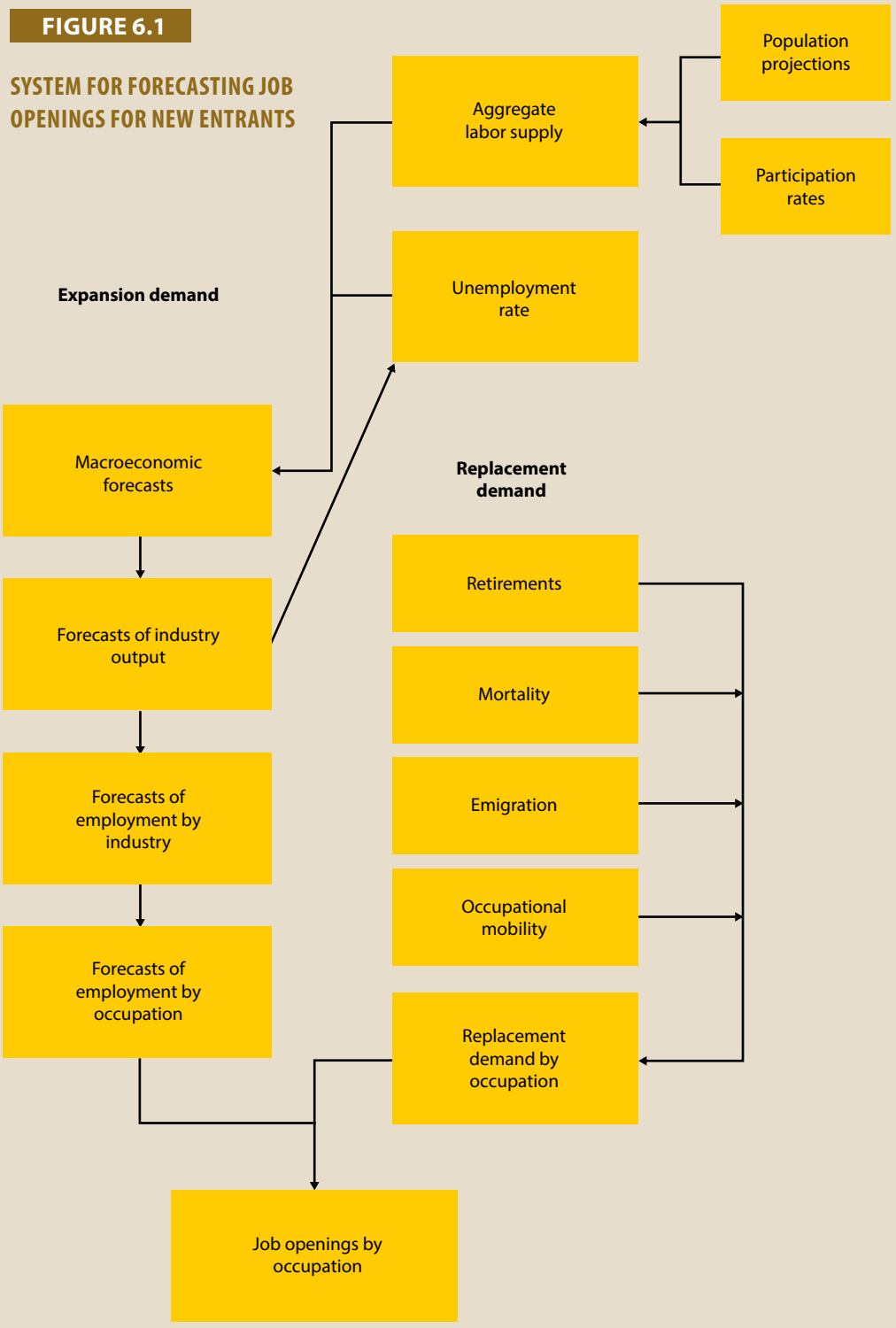
Both these developments address the fixed coefficients problem of earlier methods. They use economic and social theories to model the behavior of key actors in the economy, capturing trends in the past as well as factors that may influence future behavior. The models are more suitable for medium- to long-term forecasting than models that extrapolate linear (or more complex) trends in individual variables. Bakule et al. [19] notes that most trend patterns eventually end and, therefore, are not suitable for medium- to long-term forecasting.

Modern quantitative modelling, in the context of labor and training market information, refers to large-scale multi-sectoral analyses of the national or a regional economy, the aim being to produce medium- to long-term forecasts by industry and occupation (and sometimes by qualification). The modelling incorporates a multitude of complex interactions among different parts of the economy. At various stages of the modelling there may be a need for qualitative expert input. Expert judgement may also play a role in tweaking model assumptions in the light of initial results.

Figure 6.1 shows the basic components for forecasting job openings for new entrants by occupation common to most systems, although the details may vary across countries, depending on each country's access to expertise and data.[12] It shows that the three main steps are forecasting expansion demand, forecasting replacement demand, and forecasting job openings.

FIGURE 6.1

SYSTEM FOR FORECASTING JOB OPENINGS FOR NEW ENTRANTS



12 Some systems have extensions that include forecasts of employment by qualification, supply of qualifications, and some method for reconciling the supply with the demand.

Expansion Demand

A key input to forecasting expansion demand is macroeconomic forecasts, including forecasts of the national gross domestic product and the major categories of demand and income. They are derived from macroeconomic models, often developed by external organizations (e.g., in the United States, Macroeconomic Advisers, in the European Union, Cambridge Econometrics, and in Canada, the Conference Board of Canada). Many hundreds of behavioral equations and accounting identities relating changes in major categories of demand and income to changes in the external and domestic economic environment constitute a macroeconomic model. Economic theory underpins the formulation of these equations, which may include many feedback loops and interactions among the multitude of variables.[13] The external environment consists of the economic wellbeing of the country's major trading partners. The domestic economic environment includes such things as the country's fiscal and monetary policy, inflation rate, the exchange rate, productivity growth, energy supply and prices, unemployment rate, rate of adoption of technology, and aggregate labor supply. The models are typically estimated using econometric methods. Output from the models includes forecasts for gross domestic product and its expenditure and income side components, and in some instances (e.g., U.S.), output forecasts for some broad industry sectors.

The next stage in Figure 6.1 converts the forecasts of economic output from the macroeconomic model into forecasts of output by industry, with the link between the two stages generally made using multi-sectoral models of the input-output type. These models can vary in sophistication from the simple, as used in some developing countries using data from a single input-output table, to the more complex, using econometric methods to estimate the model [19]. A number of countries model the two stages within a unified framework. For instance, the macro model for the European Union is a multi-sectoral dynamic model, combining econometric methods with input-output detail and structure [25]. It provides consistent macro and industry forecasts. The macro model for the United States, on the other hand, produces forecasts for broad industry groups, which are subsequently decomposed into detailed industries using input-output methods [4]. As we will show in the next section, in Australia too, a single framework (computable general equilibrium model) produces the macro and industry forecasts. The degree of disaggregation of the output by industry can vary from about a dozen in Japan [29] to more than one hundred in the U.S. [4] and Australia [34].

The third step in determining expansion demand is deriving employment by industry. The simplest method is to extrapolate past trends in industry shares in total employment [35–36]. A slightly more complex method is to use industry output and labor productivity as is done in, for example, the Republic of Korea (ROK) [37] and New Zealand [38]. Some systems estimate it as a function of industry output, industry-specific real producer wages, average hours worked, and in some cases energy prices and interest rates, and use econometric methods for the estimation [4, 25, 29]. The computable general equilibrium framework typically uses a nested production function linking employment by industry with output by industry [34–35].

The fourth step transforms employment by industry to employment by occupation, and most models do this by extrapolating past trends of the matrix of occupational shares by industry. Some systems make further adjustments to reflect anticipated changes in industry production mixes and technology [4, 25]. Expert judgement is an important final input in some systems.

13 The ability to estimate multiple relationships simultaneously with feedback loops and interactions in these models is a clear advantage over simpler methods such as univariate trend extrapolation.

Replacement Demand

Forecasts of job growth provide an insight into where to expect future job openings. Additional job openings arise when workers permanently leave an occupation (e.g., to retire or for other reasons) and need replacing. Except in occupations with large turnover (usually with large numbers of young workers, such as food preparation assistants), most replacement requirements result from age-related retirements from the occupation.

Job openings resulting from replacement needs exceed those due to growth in most developed countries. More than three-quarters of all job openings for new entrants in the U.S. from 2014 to 2024 were the result of replacement demand, with the proportion much higher in occupations requiring low entry requirements [39].

There are two concepts of replacement demand, total and net [40–41].

CONCEPTS OF REPLACEMENT DEMAND

Total replacement demand measures the total number of job openings resulting from flows of workers out of an occupation irrespective of the numbers entering over the same period. This measure provides an indication of all job opportunities in the occupation, but because experienced workers seeking to re-enter the occupation will also fill some of the jobs, it is not a good indicator of opportunities for new entrants.

Net replacement demand provides a measure of the number of new and relatively younger workers required in an occupation due to workers retiring or permanently leaving the occupation. From the perspective of education and training planning, it is a much more important measure as it indicates job opportunities for new entrants.

Figure 6.1 shows the four components of occupational separation that lead to total replacement demand. As experienced workers seeking to re-enter the occupation will also fill some of the jobs, it is not a good indicator of opportunities for new entrants to an occupation. For this purpose, net replacement demand, which is net of these re-entrants, and expansion demand, provide a more accurate measure of the number of new and generally younger workers required in an occupation. In Figure 6.1, replacing occupational mobility by net occupational mobility provides an approximation for net replacement demand.

A lack of appropriate data to estimate the four components of replacement demand often means that countries often do not report total replacement demand. In the literature, replacement demand thus generally refers to net replacement demand and henceforth, we will follow this convention. Furthermore, for the purposes of education and training markets, net replacement is a more important measure because, when added to job openings from expansion demand, they approximate the minimum number of workers to train in occupations generally requiring entry-level training.

Most systems, apart from the one used in Canada,[14] use some variant of the cohort-component method to estimate replacement demand by occupation [4, 25, 26, 28, 40, 44]. The method, which

14 For a review of the method used in Canada, see [42–43].

has many applications in demography,[15] captures demographic but generally not behavioral changes. Age and gender generally define the cohorts, although in the U.S. only age is used.

The cohort-component method compares the employment of a cohort, defined by age, and sometimes gender, in an occupation at two points five years apart (labor force data are usually available by five-year age groups) to calculate the net change in the size of the cohort. While a decrease in the size of the cohort indicates net separation from the occupation over the five-year period, an increase indicates zero separations. For example, if the size of the 20 to 25 years age cohort in an occupation increases from 2,600 in 2010 to 3,000 in 2015, then net separations from the occupation are zero.[16] On the other hand, if the size of the cohort decreases to 2,200 in 2015, then net separations would equal 400 over the five-year period. The sum of net separations across all cohorts provides an estimate of replacement demand in the occupation. If employment in an occupation declines, then net separations would be greater not only because more workers leave, but also because fewer enter the occupation. Replacement needs in these circumstances are less by the decline in employment [4].[17] These replacement demand estimates form the basis for calculating replacement demand rates, which are then used to project replacement demand for future periods. This method is popular because mobility data for directly estimating replacement rates are generally unavailable.

In most occupations, net separations occur only from the older age groups, usually above age 55 years,[18] a pattern typically reflecting retirements. In occupations that typically have relatively low entrance requirements and pay relatively low wages, net separations occur from younger age groups. Young workers often take jobs in such occupations while in education or training. On completion of their training, they often transfer to occupations related to their training, which generally pay more.

The cohort-component method provides a lower bound for the number of job openings from replacement demand. This is because in younger age groups, more workers are entering than leaving the occupation and, therefore, net separation for this age group will be zero. This means that replacement need estimates do not include a person in these age groups who dies even though such an event creates a replacement need.

Job Openings

Job openings in an occupation are a result of growth in the occupation and replacement demand. These are primarily job openings for new entrants. Many other job openings also arise, but experienced workers fill these openings. The measure provides a lower bound for training requirements in occupations generally requiring training. Some people who complete the specific training do not enter the occupation for which they qualify. As a result, more workers would need to train to ensure that the minimum number enters the occupation.

Replacement needs, when added to job openings due to growth, roughly approximate the opportunities for workers wishing to enter the occupation for the first time. In occupations with contracting employment, replacement demand is the only source of job openings. As new workers to an occupation often need training, job openings calculated in this way provide an indication of

15 For applications of the method in demography, see [45–49].
16 To estimate this, we compare the employment of 20 to 24 year-olds in 2010 with the employment of 25 to 29 year-olds in 2015.
17 For an alternative method of adjusting for declining occupations, see the details of the European Union method in appendix A.
18 Among female cohorts, net separations may also occur at ages when they generally bear and look after children.

the minimum number of workers to train.

Forecasting Job Openings in Australia

In this section, we describe the method used for forecasting job openings in Australia. The method is also in three stages: expansion demand, replacement demand, and job openings.

Expansion Demand

The demand for labor depends on a multitude of interrelated factors, including macroeconomic factors affecting the domestic economy, as well as those of the economies of Australia's major trading partners; level of capital investment and its allocation across industries; the rate of technological change; and changes in government policies. Developments in one industry thus have ripple effects in other industries. Modelling the demand for labor and all the interactions in the economy that affect it requires bringing all of these factors together in a rational and coherent way. We do this using the Victoria University (VU) model, a dynamic computational general equilibrium model of the Australian economy.[19]

Dynamic general equilibrium models are economy-wide models based on the concept that all economic agents exhibit optimization behavior. They build up to the macro economy from microeconomic foundations; for example, consumers are assumed to maximize utility, while firms are assumed to maximize profits, subject to resource constraints, preferences, and production possibilities. The model can also examine the effect of a policy shock in equilibrium, which is when supply equals demand in all markets.

Unlike ordinary computational general equilibrium models, which are only useful for analyzing the impact of policy "shocks" on the economy (for example, to study the economy-wide effects of reducing tariffs in the manufacturing industry), the dynamic versions of the models have additional strong forecasting capabilities. This is because they have more detailed specification of intertemporal (dynamic) relationships, greater use of up-to-date as well as historical trends, data, and enhancements that allow input of forecasts from specialist agencies [50].

While it is possible to configure the VU model to produce a range of employment forecasts by such characteristics as industry, occupation, region, and hours worked as the output, our focus for this paper is on forecasts of employment by industry and occupation.

The box on p.59 shows the main elements of the VU model. The solution of the VU model is recursive in the sense that the solution for one year forms the base data for the following year. In the model, the linkages between industries are not merely through transactions with one another, but also through competition for resources, in particular the national supply of labor.

Estimating the VU model requires extensive data from a variety of sources. At the core of these requirements are input-output tables[20] of the Australian economy from the Australian Bureau of Statistics (ABS). As the period between publications of these tables is rather long, they tend to lose their currency quite quickly. In the VU model, this problem is resolved by calibrating the tables

19 The origin of VU is the MONASH model, whose development goes back to 1993 in the Centre of Policy Studies (CoPS) at Monash University. In turn, the development of MONASH stems from the ORANI model, first developed in the mid-1970s. The current version of VU, however, includes significant advances over the MONASH model.

20 Input-output tables show the sale and purchase relationships between producers and consumers within an economy.

with the use of other recently released economic data.[21] As a by-product, the calibration process reveals the underlying structural changes in the economy, such as changes in productivity, consumer preferences, savings rates, willingness to invest, and conditions in the world economy.

The VU model produces forecasts by solving the model in response to likely structural changes or "shocks," updating the database from one financial year to the next through a series of simulations. The shocks result from:

- Expert opinion
- Assumptions about future productivity growth (based on recent Australian and international experience)
- Significant announcements affecting future economic activity (for example, the closure of local car manufacturing)
- Anticipated activity in the construction industry, indicated through data on building approvals
- Continuation of structural changes, identified through calibration of the database.

Expert opinion includes:

- Forecasts of the value and volume of commodity production and exports (Department of Industry, Innovation and Science)
- Projections of population (ABS and state and territory governments)
- Forecasts of taxation and government expenditure and projections of labor force participation rates (Australian Treasury).

Until about 2010, the MONASH model, the predecessor to VU, included unconstrained labor supply [34].[22] In its current version, the VU model links the supply of labor by occupation to exogenously determined supply of skills provided to the labor force [52–53].[23] It builds on VU's existing framework, whereby industry demand is the source of demand for labor. The supply side of the labor market is explicit now. The formulation enables feedback within the model from the consequences of labor supply shortages or surpluses.

The model produces relative wages between occupations because the supply of labor to occupations is constrained by partitioning the workforce by skill groups. Based on initial occupational shares, each skill group supplies labor to an occupation. These change in response to changes in relative occupational wage movements. While movements away from the initial shares are typically small,

21 These data include the national accounts; gross domestic product; private and public consumption; investment; international trade; the terms of trade and industry value added; population; participation and unemployment rates; the wage price index; and the consumer price index.

22 Dixon and Rimmer [51] introduced constraints on the composition of labor supply in the MONASH model by explicitly modeling the transition of workers from one labor force status to another over each period of the simulation, using information on relative wages and workers' occupational preferences.

23 Level and field of qualification define the skill groups. The VU model projects the growth in the number of people with particular skills in the labor force using historical data with adjustments for demographic changes.

in a dynamic setting large changes may accumulate over time.[24]

The model assumes that industry demand for labor from a particular occupation will increase with a decline in the relative wage but that the supply of labor to the occupation will also decline. The market achieves equilibrium when supply matches demand. This formulation introduces a key rigidity, whereby workers' capacity for changing occupations is limited.

To estimate the VU model requires a large, consistent and up-to-date database, which the Centre of Policy Studies (CoPS) maintains.

MAIN ELEMENTS OF THE VU MODEL FOR EMPLOYMENT FORECASTS

Macroeconomic forecasts of the Australian economy are a major input into the model. The CoPS uses an in-house macro model to produce these forecasts. Input for this model includes population projections (sourced from the ABS and state and territory agencies); projections of labor force participation rates and unemployment rates (sourced from the Australian Treasury); household consumption data; government budget information; and data on investment, trade, exchange rate, and technological change.

Disaggregation of final demand (gross domestic product) into demand by various decision-making agents, such as producers (over one hundred industries), investors, households, government, and export (overseas firms), is the next step in the modelling. In the model, the agents make optimal decisions on the supply and use of commodities (corresponding to the industries) and factor inputs (land, labor, and capital), and whether to source commodity purchases from the domestic economy or imports. These include cost minimization by producers, utility maximization[1] by households, and allocation of investment funds in response to risk-adjusted rates of return. Policy generally drives government decisions on purchases. Another set of relationships in the model describes the price system. The condition of zero profit[2] on producers drives basic prices. Adding relevant margins and taxes generates purchaser prices. Finally, the model includes a set of market clearing relationships to ensure equilibrium in the supply and demand for each commodity produced. These relationships are sufficient to determine the price and quantity of every produced commodity within the system.

For non-produced commodities, i.e., factor inputs and imports sourced from outside Australia, the relationships are sufficient to explain price or quantity, but not both. In relation to these commodities, the model assumes the supply of land is fixed (may shift between uses); labor supply is determined through a series of relationships with links to Australia's population; industry-specific supply of capital is determined by links to lagged values of capital stock and investment; and foreign currency prices of imports are determined outside the system.

Macroeconomic accounting identities involving the gross domestic product, terms of trade[3], the real exchange rate, and other key macroeconomic indicators are part of the

24 The model provides a solution in between two extremes of fixed relative wages and fixed occupational shares.

model specification.

Exogenous[4] variables, besides those in factor markets[5], determined outside the system of relationships described above are also included in the model. These variables relate to changes in production technology; changes in household tastes; changes in preferences between imported and domestic goods; changes in government policy relating to taxation, the budget, and composition of expenditure; changes in international trading conditions (shifts in export demand schedules and foreign currency prices of imports); and changes in investor risk premium[6].

Aggregate demand for labor by industry is a function of total industry output (which in turn is a function of the demand for the industry's output); the industry's capital stocks; changes in productivity; and the labor cost to the industry relative to other inputs.

Occupational labor demand is a function of aggregate demand for labor, changes in the occupational wage relative to the average wage, and changes in relative occupational productivity.

Source: [54]

Notes: 1 Utility maximization refers to a household's objective of maximizing the total value from a given amount of money.
2 In competition theory, the zero profit condition occurs when an industry (or type of business) has near zero cost of entry. Many people thus tend to join the industry, seeing the opportunity to make profit, until supply exceeds demand and no more profit-making is possible. Competition limits each entity's share of the profit, as well as their profit margin. This situation represents almost perfect competition.
3 Terms of trade measures a country's ratio of an index of a country's export prices to an index of its import prices.
4 Exogenous variables are variables that are independent of the model and are determined outside the system.
5 In economics, a factor market is a market for the services of a factor of production. It facilitates the buying and selling of services of factors of production, which are inputs like labor, capital, land, and raw materials that a firm uses to make a finished product. A factor market is distinct from the goods and services market, which is the market for finished products or services.
6 A risk premium is the expected return in excess of the risk-free rate of return of an investment.

Replacement Demand

The cohort-component method also underpins the calculation of replacement demand by occupation for Australia. Our method, however, exploits the fact that we have available time series data on the labor force going back to 1987. The method, first, creates time series of cohort-level flow rates. A negative flow rate indicates net separation from the occupation. The rates show the change in the relative size of the cohort over time. We then use time series methods to forecast future values of these rates, which when combined with base period employment provide forecasts of net separations. The use of the time series method smooths the business cycle as well as other sources of volatility in the data, such as sampling error. Net separations result from a negative flow rate, otherwise net separations are zero. When summed over all cohorts, net separations give us the forecast of net replacement demand in the occupation. As the oldest age category is 70 years or older, we assume all workers retire at this age. In other words, net separations from this cohort will always equal the cohort employment.

As the definition of age cohorts is five years, the method generates five-year forecasts of replacement demand. The five-year replacement demand rate for each occupation is the ratio of replacement demand and base period employment, which when divided by five gives us the annual replacement demand rate.[25] This, together with forecasts of employment from the VU model described above, allows us to forecast replacement demand for each occupation.

Job Openings

The calculation of job openings for new entrants in an occupation follows the method described above. Finally, we estimate job openings by industry on the basis of observed matrix of industry-occupation employment shares.

Conclusion

This paper has provided a brief review of the international practices in forecasting labor demand. It has also described in more detail a method Australia uses for forecasting job openings for new entrants by occupation and industry. These forecasts indicate the type of skills that would be in demand in the future. Many countries that produce detailed forecasts of labor demand have a long history of such activity. Consequently, a rich body of literature exists describing the development of sophisticated economy-wide models for forecasting the labor market.

This paper argues the importance of detailed forecasts of labor demand by industry and occupation in the context of making informed decisions about investment in the development of national human capital. The decision-making is at a number of levels: individual, firm, training provider, and government. A variety of information, sourced from both quantitative and qualitative research, goes into making these decisions. Labor demand information, as discussed in this paper, however provides a consistent and coherent framework to cross-validate other information.

As demand for skills by industry evolves with advances in technology and improvements in human resource management practices, any national education and training policy also needs to have built-in flexibility to adjust to this changing demand. Without this flexibility, there is a higher risk of developing an imbalance in the supply and demand for skills as well as skills mismatches. This then reduces the efficiency of the training and labor markets. It can also have a negative effect on productivity growth and on innovation.

There are two main modeling strategies for forecasting economy-wide demand for labor: dynamic multi-sectoral macroeconomic models and dynamic computable general equilibrium models. The latter has the added advantage of being able to model the effect of policy shocks to the system. These models generate forecasts of employment growth in highly disaggregated industry and occupation groups. A separate, independent model generally provides forecasts of replacement demand, which in many occupations is a higher source of job openings than growth.

In summary, it is prudent to know the nature of future demand for skills when developing plans to develop human capital. The type of models described in this paper can help to assess this demand in a consistent and coherent manner, but to estimate these models requires a large amount of reliable data, which some developing economies may currently not have. The first step for these economies, therefore, is to set up systems to collect reliable economic data. This is a long-term investment decision with benefits wider than for just labor market forecasting. Organizations such as the Asian Productivity Organization (APO) can play a crucial coordinating and knowledge-sharing role in this respect.

25 This assumes the replacement demand rate remains unchanged over the forecast period.

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ABBREVIATIONS

ABS	Australian Bureau of Statistics
AI	Artificial Intelligence
APO	Asian Productivity Organization
ATC21S	Assessment and Teaching of 21st-Century Skills
BLS	Bureau of Labor Statistics
CC	Competence Centers
CEO	Chief Executive Officer
CoPS	Centre of Policy Studies
EDB	Education Bureau
EGMA	Early grade mathematics assessment
EGRA	Early grade reading assessment
ELE	English language education
DESI	Dual Education System in Italy
DIH	Digital Innovation Hubs
EU	European Union
GDP	Gross Domestic Product
GE Company	General Electric Company
GNP	Gross National Product
HR	Human resources
HRD	Human Resource Development
ICTs	Information and Communication Technologies
ILO	International Labour Organization
IoT	Internet of Things
IPC	International Patent Classification
IR	Industrial Revolution
ISMS	Information Security Management System
IT	Information Technology
Lao PDR	Lao People's Democratic Republic
MDGs	Millennium Development Goals
ML	Machine Learning
MBA	Master programs in Business Administration
MOOC	Massive Open Online Courses
MOI	medium of instruction
OECD	Organisation for Economic Co-operation and Development

Ph.D.	Doctor of Philosophy
R&D	Research and Development
SEL	Social and Emotional Learning
TVET	Technical and vocational training
U.S.	United States
VET	Vocational Education and Training
VU	Victoria University
WEF	World Economic Forum
WRL	Work related learning

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