Development economists have considered physical infrastructure to be a precondition for industrialization and economic development. Infrastructure investments play a particularly important role in expanding overall employment opportunities either directly by absorbing workers or indirectly by crowding in private investments, technology adoption, and production activities through which new jobs are created. As investments in infrastructure increasingly address the integration of technology and sustainability principles, the nature of jobs and skill requirements are also changing. On one hand, augmented public funding can favor infrastructure investments that have higher employment elasticity to ensure adequate job creation. On the other hand, the advent of the Fourth Industrial Revolution calls for a more skill-intensive workforce. Using findings from existing studies on infrastructure and data from Asian Development Bank, this paper discusses changing infrastructure investments in a rapidly changing technological environment and how developing countries can reap employment creation benefits through innovations.

**KEYWORDS**
Infrastructure; technology; employment; fourth industrial revolution; skill-intensive workforce

**Introduction**

Development economists have considered physical infrastructure to be a precondition for industrialization and economic development. Infrastructure investments play a particularly important role in expanding overall employment opportunities either directly by absorbing workers or indirectly by crowding in private investments and expanding the range of production activities and required tasks. These paper reviews and discusses the changing dynamics of infrastructure investments and required skill sets in production, as well as how developing countries in the Asia and Pacific region can reap employment creation benefits.

In general, physical infrastructure consists of two parts – economic infrastructure such as telecommunications, roads, irrigation, and electricity; and social infrastructure such as water supply, sewage systems, hospitals, and school facilities (Murphy, Shleifer, & Vishny, 1989). It has been demonstrated that physical infrastructure development improves the long-term production and income levels of an economy.
in both the macroeconomic endogenous growth literature (Barro, 1990; Futagami, Morita, & Shibata, 1993) and empirical studies (Calderón, Moral–Benito, & Servén, 2015; Canning & Pedroni, 2008; Canning & Bennathan, 2000; Easterly & Rebelo, 1993; Esfahani & Ramirez, 2003; Jimenez, 1995; Lipton & Ravallion, 1995). Moreover, a number of micro studies have shown that development of infrastructure is one of the indispensable components of poverty reduction (Gibson & Rozelle, 2003; Jacoby, 2000; Jalan & Ravallion, 2003; Lokshin & Yemtsov, 2005; Van de Walle, 1996).

According to the Asian Development Bank (ADB), economic growth in Asia and the Pacific, which accounts for more than 60% of current global growth, has been driven by continued investments in a variety of physical infrastructure (ADB, 2018b). Yet, over 400 million Asians still live without electricity, 300 million without safe drinking water, and a staggering 1.5 billion without basic sanitation (ADB 2017a, 2017b). Moreover, according to ADB (2017b), developing Asia will need to invest $26 trillion from 2016 to 2030, or $1.7 trillion per year, if the region is to maintain its growth momentum, eradicate poverty, and respond to climate change.

Currently, the region annually invests an estimated $881 billion in infrastructure for 25 economies with adequate data (Table 1), comprising 96% of the region’s population (ADB, 2017b). The infrastructure investment gap, i.e. the difference between investment needs and current investment levels, equals 2.4% of projected gross domestic product (GDP) for the period 2016–2020 when incorporating climate change mitigation and adaptation costs. Hence, there are two main challenges in Asia and the Pacific region’s infrastructure investments: first, to expand fiscal space for larger public investments in infrastructure; and second, to attract and mobilize private resources in financing the gap.

As investments in infrastructure increasingly address the integration of technology and sustainability principles, the nature of jobs and skill requirements are also changing. In general, sophisticated infrastructure is a prerequisite for innovative production processes (ADB, 2017b). For example, reliable and widely available electricity is central, for example, for any manufacturing requiring sophisticated machines. Broadband networks are vital tools for creating and disseminating knowledge and hence can facilitate the shift to knowledge-based, innovative economies. Infrastructure and technology are also closely related to job creation and maintenance. On one hand, augmented public funding can favor infrastructure investments that have higher employment elasticity to ensure adequate job creation. On the other hand, the advent of the fourth industrial revolution calls for a more skill-intensive workforce, generating adverse impacts on the employment prospects of unskilled workers. Indeed, the growing concern that new technologies could cause widespread job loss is endorsed by numerous empirical studies (Acemoglu &

| Table 1. Infrastructure investment needs, 2016–2030 ($ billion in 2015 prices). |
|---------------------------------|-----------------|-----------------|
| Asia and the Pacific            | 22,551          | 5.1             |
| Annual average                  | 1,503           |                 |
| Climate–adjusted                | 26,166          | 5.9             |
| Total                           | 1,744           |                 |

GDP = gross domestic product. Source: ADB (2017b)
Restrepo, 2018, 2019; Autor & Salomons, 2017; Frey & Osborne, 2017; Graetz & Michaels, 2018; McKinsey Global Institute, 2017). Yet, in the Asia and Pacific region, improved productivity and resulting demand increase from rising incomes offset job displacement driven by automation (ADB, 2018a; Bertulfo, Gentile, & de Vries, 2019). Especially when technology complements labor in the production process, workers’ higher incomes create positive spillover on other industries through increased demand for goods and services, generating overall net positive employments (ADB, 2018a; Bertulfo et al., 2019). Since infrastructure has been the core element of continued growth in Asia and the Pacific, continued investments in infrastructure are indispensable for sustainable job creations under the rapidly progressing technological environment in the region.

Using findings from existing studies on infrastructure and data from ADB (2018a), this paper will review and discuss dynamics of infrastructure investments in the rapidly changing technological environment, and how developing countries can reap employment-creation benefits out of such investments. The rest of the paper is organized as follows. The next section postulates a conceptual framework of the infrastructure investments and job creation nexus, and then calibrates the role of infrastructure in augmenting employment opportunities in Asia. The final section summarizes the paper and gives concluding remarks.

Calibrating the role of infrastructure in augmenting employment opportunities in Asia

In this section, we postulate a conceptual framework of the infrastructure investments and job creation nexus, upon which we perform a simple calibration of the model.

Conceptual framework of the infrastructure investments and job creation nexus

Following Acemoglu and Restrepo (2018), a labor demand function of an economy with task-based production activities and automation can be described in equation (1):

$$L = \frac{(N - I)Y}{w},$$

(1)

where $N$ captures the number of tasks, and $I$ is the extent of automation. Simply, employment size of the economy, $L$, is determined by three elements: the unautomated task varieties, $N-I$; production scale, $Y$; and wage rate, $w$. Confining our focus on the role of infrastructure, $F$, in expanding overall employment opportunities indirectly by crowding in private investments and production activities, the role of infrastructure can be demonstrated, as shown in Equation (2):

$$\frac{d\log L}{d\log F} = \frac{d\log Y}{d\log F} \left(\frac{d\log (N - I)}{d\log Y} + 1\right).$$

(2)

To illustrate the magnitude of the elasticity, $d\log L/d\log F$, Dinkelman (2011) quantifies the impact of household electrification on employment in South Africa. Since electricity infrastructure construction is constrained by geographical conditions, land gradient information is utilized as an instrumental variable for electrification. The
paper found that electrification significantly raises female employment within 5 years while reducing female wages and increasing male earnings. The estimated infrastructure elasticity of female employment ranges from 0.3 to 0.35. Several pieces of evidence also suggest that household electrification raises employment by releasing women from household-related tasks and enabling the formation of microenterprises, making household tasks obsolete economically.

To explore the overall mechanics behind the infrastructure and employment nexus, Equation (2) shows that the elasticity of infrastructure in creating labor demand can be decomposed into two elements shown in the right-hand side of this equation: the first part, $d\log Y/d\log F$, indicates an elasticity with which infrastructure promotes production growth. In this ‘reduced-from’ marginal effect, technologies play an important role implicitly because advanced infrastructure such as stable energy supply and infrastructure for information and communication technology is a necessary condition for innovative production processes (ADB, 2017b). The second part of Equation (2) in parentheses shows another elasticity of income growth generating a net increase in employment through the extensive margin of augmenting tasks, $N-I$, as well as the intensive margin given the set of existing tasks, which is unity under the Cobb–Douglas production function with a constant returns to scale assumption.

**Elasticity of infrastructure on production**

Several recent review articles cover a wide range of impact evaluations of infrastructure projects: Raitzer, Blöndal, and Sibal (2019a, 2019b); White and Raitzer (2017); Estache (2010); Hansen, Andersen, and White (2013); Sawada (2015); and World Bank (2012). Table 2 shows conventional estimates of aggregate overall infrastructure productivity captured by the elasticity of output with respect to infrastructure access, summarizing reviews by Jimenez (1995), Munnell (1992), World Bank (1994), and other recent studies. Except for one study using data from the United States (US) (Holtz–Eakin, 1992), the estimated elasticities are all positive, ranging from 0.01 to 0.39. In the latest comprehensive study on infrastructure impacts, Calderón et al. (2015) employed a panel time

| Economy          | Infrastructure type                                      | Elasticity | Source                        |
|------------------|---------------------------------------------------------|------------|-------------------------------|
| US               | Nonmilitary public capital                              | 0.39       | Aschauer (1989)               |
| US               | Nonmilitary public capital                              | 0.34       | Munnell (1992)                |
| States, US       | Public capital                                          | 0.15       | Munnell (1992)                |
| States, US       | Public capital                                          | 0.15       | Holtz–Eakin (1992)            |
| Regions, Japan   | Industrial infrastructure                               | 0.20       | Mera (1973)                   |
| Taipei, China    | Transportation, water, and communication                | 0.24       | Uchimura and Gao (1993)       |
| Republic of Korea| Transportation, water, and communication                | 0.19       | Uchimura and Gao (1993)       |
| Mexico           | Power, communication, and transportation                | 0.05       | Shah (1992)                   |
| Cross-country, OECD, & LDCs | Infrastructure capital stocks                 | 0.01–0.16  | Baffes and Shah (1998)         |
| Cross-country    | Transportation, power, and telecommunication           | 0.07–0.10  | Calderón et al. (2015)        |

LDCs = least developed countries, OECD = Organisation for Economic Co-operation and Development, US = United States.

Note: The Asian Development Bank recognizes ‘South Korea’ as the ‘Republic of Korea’ and ‘Taiwan’ as Taipei, China.

Source: Adapted from Box Table 1.1 in World Bank (1994).
series approach using a large cross-country dataset to estimate a long-run aggregate production function relating GDP to human capital, physical capital, and a synthetic measure of infrastructure comprising transport, power, and telecommunications. In their estimation results, the long-run elasticity of output with respect to the synthetic infrastructure index ranges from 0.07 to 0.10. In Table 3, aggregate elasticity estimates for an output with respect to transportation and irrigation infrastructure are presented. The point estimates are mostly positive, ranging from 0.07 to 1.62, and falling in the range of the estimated elasticities for aggregate infrastructure productivity reported in Table 2.

As to more recent studies on impacts of infrastructure, Hulten, Bennathan, and Srinivasan (2006) found that in India, from 1972 to 1992, highways and electricity accounted for almost half of the growth of the Solow residuals of the manufacturing industries. The positive productivity effects of physical infrastructure development can be found even in rural areas and agricultural sectors (Fan & Zhang, 2004; Jimenez, 1995; Zhang & Fan, 2004). Table 3 also includes estimates of positive production elasticities with respect to road and irrigation infrastructure in agriculture. More recent studies, such as Del Carpio, Loayza, and Datar (2011), Dillion (2011) and Strobl and Strobl (2011), used unique datasets to evaluate the impact of irrigation on production and consumption. Based on the findings of these existing studies on positive productivity impacts of infrastructure and a strong positive correlation between income growth and poverty reduction found in various studies, such as Besley and Burgess (2003), Dollar and Kraay (2002), and Ravallion (2001), it is evident that infrastructure development is likely to reduce poverty by enhancing growth.

Empirical studies have increasingly started to focus on the role of infrastructure in reducing poverty directly. Such studies include Brockerhoff and Derose (1996) and Jalan and Ravallion (2003) on the role of water supply and public health systems; Datt and Ravallion (1998) on state-level poverty in India; Gibson and Rozelle (2003), Jacoby (2000), and Jacoby and Minten (2008) on the effectiveness of road and transportation infrastructure; Jalan and Ravallion (2003) on the water supply system; Lokshin and Yemtsov (2004, 2005) on the poverty reduction effect of community-level infrastructure improvement projects on water supply systems in Georgia; and Van de Walle (1996) on the poverty reduction effect of irrigation infrastructure in Viet Nam.

Table 3. Conventional estimates of aggregate transportation and irrigation infrastructure productivity in elasticity of output with respect to infrastructure access ($\frac{\text{dlog}Y}{\text{dlog}F}$).

| Country          | Infrastructure type          | Elasticity | Source                        |
|------------------|-----------------------------|------------|-------------------------------|
| Cross-country    | Paved roads in agriculture  | 0.26       | Binswanger (1990)             |
| Cross-country    | Rural road density in agriculture | 0.12     | Binswanger (1990)             |
| Cross-country, OECD | Transportation            | 0.07       | Canning and Fay (1993)        |
| Cross-country, LDCs | Transportation        | 0.07       | Canning and Fay (1993)        |
| Cross-country, LDCs | Transportation and communication | 0.16  | Easterly and Rebelo (1993)    |
| Districts, India | Road                        | 0.20       | Binswanger, Khandker, and Rosenzweig (1993) |
| Cross-country    | Irrigation in agriculture  | 1.62       | Binswanger (1990)             |
| Districts, India | Irrigation                 | 0.00       | Binswanger et al. (1993)      |

LDCs = least developed countries, OECD = Organisation for Economic Co-operation and Development, US = United States.

Source: Adapted from Table 43.1 in Jimenez (1995) and Box Table 1.1 in World Bank (1994).
**Experimental and quasi-experimental studies**

However, such non-experimental studies are likely to involve upward biases in estimating elasticities because infrastructure is placed in areas where economic growth is expected and/or the hosting communities have appropriate capacities. To illustrate this problem, consider a framework of each outcome variable, \( Y \), and a dichotomous variable for infrastructure access, \( F \), which takes the value of 1 if there is access, and 0 otherwise. In other words, we postulate a model of ‘treatment’ of infrastructure access.

The level of an outcome variable with infrastructure is denoted by \( Y_1 \), and without infrastructure by \( Y_0 \). The average impact on outcome caused by infrastructure can be captured by the average treatment effects of the treated (ATT) as shown in Equation (3):

\[
E(Y_1 - Y_0|F = 1).
\]  

In Equation (3), the fundamental issue is the way to grasp the counterfactual outcome, \( E(Y_0|F = 1) \), which cannot be observed directly. We can write and expand the observable average difference between the treatment and control groups by the following Equation (4):

\[
E(Y_1|F = 1) - E(Y_0|F = 0) = \left[ E(Y_1|F = 1) - E(Y_0|F = 1) \right] + \left[ E(Y_0|F = 1) - E(Y_0|F = 0) \right].
\]  

Equation (4) shows that the observable average difference between the treatment and control groups, i.e. \( E(Y_1|F = 1) - E(Y_0|F = 0) \), deviates from ATT, \( E(Y_1 - Y_0|F = 1) \), by the amount \( E(Y_0|F = 1) - E(Y_0|F = 0) \). This discrepancy is called a selection bias, which basically shows the discrepancy between the average outcome of counterfactual situation \( E(Y_0|F = 1) \) and the average observable outcome of the control group \( E(Y_0|F = 0) \). If infrastructure is placed in the areas or for the groups that have a better outcome even without infrastructure, the selection bias will be positive, i.e. \( E(Y_0|F = 1) - E(Y_0|F = 0) > 0 \), generating upward bias in estimating ATT.

To mitigate these biases and to accurately identify the causal impacts of infrastructure, it is more appropriate to employ experimental or quasi-experimental methods that carefully utilize situations in which there is no selection bias. In fact, analytically robust evaluation of infrastructure has been an emerging field in development economics and policymaking recently. If random placement of infrastructure is possible, we can set \( E(Y_0|F = 1) - E(Y_0|F = 0) = 0 \) intentionally. Yet, such randomization will be difficult for infrastructure projects due to their large-scale aggregate nature. Even in this case, when infrastructure placements are determined by factors which cannot be manipulated by humans, they provide researchers with natural experiments similar to those discussed in DiNardo (2008), in which people are exogenously assigned into treatment and control groups. We assume that such a natural experiment gives us a serendipitous situation where the selection bias \( E(Y_0|F = 1) - E(Y_0|F = 0) \) converges to zero. We can also work with a weaker condition, under which given the same set of observables \( X \), the selection bias becomes zero, as shown in Equation (5):
This assumption is called ignorability, or selection on observables (Lee, 2005).

Table 4 shows experimental estimates of outcome elasticity with respect to infrastructure access. As a notable example of an impact evaluation of infrastructure using a quasi-experimental method, Duflo and Pande (2007) performed impact evaluation of dams in India on poverty reduction, using river gradient variables as instrumental variables for placements of dams for engineering reasons. Using district-level data from India, they found that in districts located downstream from a dam, agricultural production increases, and rural poverty and vulnerability to rainfall shocks decline. In the district where the dam is located, agricultural production shows an insignificant increase, while poverty increases and its volatility increases. These results suggest that neither markets nor state institutions have alleviated the adverse distributional impacts of dam construction.

Jensen (2007) evaluated the impact of mobile phones in India’s Kerala state on the price of sardines, which is a perishable good formerly lacking appropriate cold chain networks. He utilized a nature of the mobile phone network development in which the timing of introduction of mobile phones in each fishing community is different and is exogenously given to fishermen. Using micro data, he showed that the adoption of mobile phones by fishermen and wholesalers is associated with a dramatic reduction in price dispersion, the complete elimination of waste, near-perfect adherence to the Law of One Price, and significant increases in both consumer and producer welfare.

Banerjee, Duflo, and Qian (2012) used historical data from cities and counties in the People’s Republic of China on transportation networks to estimate the effect of access to transportation networks on regional economic outcomes in the People’s Republic of China over a 20-year period of rapid income growth. This paper addressed the problem of the endogenous placement of networks by exploiting the fact that these networks tend to connect historical cities, showing that proximity to transportation networks have a moderate positive causal effect on per capita GDP levels across sectors, but no effect

### Table 4. Experimental estimates of outcome elasticity with respect to infrastructure access ($\frac{\text{dlog}Y}{\text{dlog}F}$).

| Country                      | Infrastructure type         | Outcome measure                  | Elasticity | Source                                      |
|------------------------------|-----------------------------|-----------------------------------|------------|---------------------------------------------|
| Kerala, India                | Mobile phone network        | Consumer and producer welfare     | Positive   | Jensen (2007)                               |
| Acayucan, Mexico             | Road asphalting             | Durable and home ownership        | 0.12–0.50  | Gonzalez-Navarro and Quintana-Domeque (2016) |
| Quintana-Domeque (2016)      |                              |                                   |            |                                             |
| Cities and counties,         | Road network                | GDP                               | 0.07       | Banerjee et al. (2012)                       |
| People’s Republic of China   |                              |                                   |            |                                             |
| Districts, India             | Dams                        | Agricultural production           | 0.3 (downstream) | Duflo and Pande (2007)                        |
|                              |                              |                                   | 0 (upstream)|                                             |

GDP = gross domestic product.

Note: The Asian Development Bank recognizes ‘China’ as the People’s Republic of China.
on per capita GDP growth. Based on a simple theory, the authors argue that their results are consistent with factor mobility playing an important role in determining the economic benefits of infrastructure development.

Gonzalez-Navarro and Quintana-Domeque (2016) used a first-time street asphaltling randomized experiment to provide experimental evidence on the role of infrastructure in reducing poverty for the urban poor. Within 2 years of the intervention, households whose streets were finally paved, and which were present both before and after its implementation, increased their consumption of durable goods and acquired more motor vehicles. These impacts were driven in part by the street paving, which boosted housing wealth and fueled a rise in collateralized credit use; and also by an increase in the marginal utility of vehicles.

Experiments can be performed based on economic theories, an approach taken in the fields of international and interregional trade (Donaldson, 2015). We summarize findings from three existing studies in Table 5. Based on ex ante counterfactual experiments developed by Eaton and Kortum (2002), Allen and Arkolakis (2014) estimated the aggregated impact of highways. According to their study, welfare losses of removing the US interstate highway system would have been 1.1–1.4% (Table 5).

Donaldson (2018) employed a general equilibrium trade model and archival data from colonial India to investigate the impact of India’s vast railroad network. The study found that railroad infrastructure reduced trade costs and interregional price gaps, increased interregional and international trade, increased real income levels, and generated substantial gains from trade. Donaldson and Hornbeck (2016) take an alternative approach based on the gravity model to quantify the gains from market integration brought about by US railroads. They found that removal of all US railroads in 1890 would have reduced the total agricultural land value by 60.2%, leading to annual economic losses equal to 3.22% of US gross national product.

**Elasticity of income on job creation**

While there is a growing concern that arrivals of new labor-saving technologies could cause widespread job loss, we can be optimistic about job prospects in Asia and the Pacific region due to few reasons (ADB, 2018a). First, new technologies usually automate only subcomponents of a job, not the whole job. Second, job automation through a new technology materializes only where it is also profitable enough. Third, technological progress and resulting productivity improvements almost always generates new occupations and industries. More importantly, rising income and demand due to higher

| Country | Infrastructure type | Outcome measure | Elasticity | Source |
|---------|---------------------|-----------------|-----------|--------|
| US      | Interstate highway system | Welfare | 0.011–0.014 | Allen and Arkolakis (2014) |
| Districts, India | Railway network | Agricultural income per acre | 0.164–0.258 | Donaldson (2018) |
| Counties, US | Railway network | Annual GNP | 0.322 | Donaldson and Hornbeck (2016) |

GDP = gross domestic product, US = United States.
productivity offsets job displacement effects driven by automation. This whole process is usually facilitated by infrastructure investments. Moreover, it is important to notice that such an income and market augmentation effect can be magnified through global value chains (GVCs): an increase in demand and production in one industry heightens demand for other interconnected industries as well.

We can quantify the overall elasticity of income on job creations through technological progress along by combining multiregional input–output tables developed by ADB (a.k.a., ADB multiregional input–output tables) with employment data from labor force surveys from various countries, and world input–output database – socioeconomic accounts from Timmer, Dietzenbacher, Los, Stehrer, and de Vries (2015) and (ADB, 2018a). We employ multiregional input–output tables, which track supply chains in 12 economies in developing Asia, covering 35 sectors from 2005 to 2015 and 90% of employment in developing Asia in 2015. Then, applying the analytical framework developed in ADB (2018a), Bertulfo et al. (2019), and Reijnders and de Vries (2017), we perform structural decomposition analysis, quantifying changes in labor demand associated with technological change and task relocation and examining the relative magnitude of these GVC-specific channels with respect to conditions globally and within an economy.

According to the results reported in ADB (2018a) and Bertulfo et al. (2019), jobs created by rising income and demand more than compensated for job losses to technological advances in Asia and the Pacific region (Table 6). On one hand, the combined impact of efficiency gains at the country level and technological advances within the GVC, holding all other components constant, is a notional 66% decrease in employment, equal to 101 million jobs per annum. Higher demand for goods and services generated by higher incomes more than offsets this negative employment effect with an 88% increase in labor demand, equal to 134 million jobs per annum. As can be seen from Table 6, the net job creation effect due to the arrival of new technologies can be as large as 0.63 in terms of income elasticity. This can be interpreted as an extensive margin of job creation from overall technological progress along with the supply chain networks.

**Table 6. Job creation elasticity with respect to income.**

| Effects                                                                 | Figures          | Data source     |
|------------------------------------------------------------------------|------------------|-----------------|
| (1) Labor-saving effect of technologies per annum (dI)                 | 101 million      | ADB (2018a)     |
| (2) Employment creation effect of income and demand expansion per annum (dN) | 3.0 million      | ADB (2018a)     |
| (3) Net job creation rate per annum [(dN-dI)/N]                        | 22%              | ADB (2018a)     |
| (4) dlog(N-I) assuming dN/dI = N/I                                   | 89.33%           | ADB (2018a)     |
| (5) GDP growth rate of developing economies in Asia and the Pacific (current USD and PPP) | 141.5%           | ADB (2018b)     |
| (6) Job creation elasticity with respect to income along the extensive margin: dlog(N-I)/dlogY | 0.63             | Rows (4) and (5) |

*Source:* Author’s compilation using ADB (2018a) and Bertulfo et al. (2019) based on ADB multiregional input–output tables, labor force surveys from various countries, and world input–output database – socioeconomic accounts (Timmer et al., 2015); and ADB (2018b).
Based on the framework of equation (2) and the income elasticity of employment along the intensive margin given the set of existing tasks which is unity, the total income elasticity of employment on both internal and external margins will be 1.63. Considering the income elasticity of infrastructure investments ranges from 0.1 to 0.3 according to Tables 2, 3, and 4, the total net job creation elasticity with respect to infrastructure ranges from 0.163 to 0.489. In this elasticity, the job creation effects arising from increased income would be critical components of overall employment creation in Asia and the Pacific region. This highlights an importance of the income and demand expansion effect in Asia and the Pacific region due to higher productivity arising from innovation, which dominates job displacement effects driven by automation. Moreover, for this mechanism to materialize, it would have been indispensable for the region to gain continuous supplies of appropriate skills that match technological requirements.

Concluding remarks

This paper reviewed and discussed the existing evidence on the role of infrastructure investments in expanding overall employment opportunities by crowding in private investments and production, and facilitating technology adoption and innovation. The job creation effects arising from increased income and demand from the arrival of new technologies would have been critical elements of overall employment generation in Asia and the Pacific. Yet, such employment creation effects should be matched by expanded supplies of skilled workers who are equipped with suitable technical capabilities.

While arrivals of new technologies generate new jobs, those workers with ‘routine and manuals jobs’, as defined and analyzed by Acemoglu and Autor (2011); Autor (2015); Autor, Levy, and Murnane (2003); and Acemoglu and Restrepo (2018, 2019), may lose existing jobs or encounter stagnated wage growth, worsening overall income inequality (ADB, 2018a). To strengthen such workers’ skills, governments need to undertake education reform, promote lifelong learning, and provide technical and vocational education and training (TVET) programs (ADB, 2018a). Also, to maximize the potential benefits of new technologies, labor market flexibility needs to be accompanied by active labor programs and social protection systems such as effective unemployment benefits and minimum wage laws, expanded health insurance, public works programs, and income transfers. Also, effective egalitarian tax policies should be implemented to mitigate distributional consequences of technological inequalities.

Moreover, it is indispensable for governments to fill in infrastructure investments gaps particularly on information and communication technology, electricity supply, and transport (ADB, 2018a). Governments can increase public investments in infrastructure by raising more revenues through tax reforms, reorienting expenditures, borrowing prudently, and undertaking innovative approaches to expand public funds such as land value capture and brown-field capital recycling (ADB, 2017b). Also, expanded private financing of infrastructure investments will be necessary. The role of multilateral development banks such as ADB is crucial to catalyze and add value to private sector investment into infrastructure needs. Moreover, broader infrastructure such as market and institutional infrastructures are imperative to setting an enabling environment or ecosystem of infrastructure investments and skill development: Governments will need
to play a critical role to protect personal data and privacy as well as to maintain the norms of fair competition. Further exploration of these wider impacts of infrastructure investments and skills development should be pursued in future studies.

**Notes**

1. Here we assume that wage is not affected by infrastructure. In fact, the average wage of workers barely increased over several decades despite a dramatic increase in labor productivity in manufacturing (Bessen, 2015).
2. Strictly speaking, there is a third effect of the relocation of tasks across countries along supply chains globally. According to ADB (2018a), such an effect is a 2% increase in employment, equivalent to 3 million jobs per year. This suggests that so-called ‘reshoring’ may not be a major threat to employment in the region.

**Disclosure statement**

No potential conflict of interest was reported by the author.

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