Chapter 12

Managing the Transition through Multilevel Governance

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Chapter 12

Managing the Transition through Multilevel Governance

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1. The Circular Economy and Industry 4.0 – Towards a Sustainable New Industrial Paradigm

1.1 Transitioning to an Alternative Economic Growth Path

The discourse on the circular economy originated in the early 1970s[1] and it is now gaining significant traction as an alternative model that could alleviate and potentially even counteract major global environmental challenges, including climate change, natural resource scarcity, and critical ecosystem degradation. These environmental threats are largely the result of the proliferation of the linear economy – an industrial system that converts natural resources into waste via production (Murray, Skene, and Haynes, 2015).

Advanced economies, particularly in Europe, are now seriously considering the circular economy as they begin to encounter greater price volatility, scarcity, and vulnerability in natural resource supply chains. The World Economic Forum is advancing the circular economy as a new industrial system (World Economic Forum, 2014b) while the Ellen MacArthur Foundation foreshadows that it could be the next major European political economy project after the creation of its internal market (Ellen MacArthur Foundation and McKinsey Center for Business and Environment, 2015).

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[1] With the publication of the landmark Limits to Growth study by Meadows et al. and Walter Stahel articulating the 'cradle-to-cradle' concept and the first vision of a closed-loop economy (CIRAIG, 2015).

Its major proponents are also seriously considering its prospects in the developing world. Indeed, emerging economies could potentially leapfrog directly into this economic model, given their ripe opportunities to establish and implement circular systems in developing their manufacturing bases (World Economic Forum, 2014a).

1.2 The Circular Economic Model

The circular economy is a new and evolving school of thought that still requires careful debate and consideration in formulating a fitting definition that will allow real benefits for both the economy and society. In broad terms, this concept envisages an economy that has no net effect on the environment, restoring any damage in resource acquisition and minimising waste generation in manufacturing and the product life cycle (Murray, Skene, and Haynes, 2015).

Circular goods are either consumable or durable. Consumables are not environmentally harmful and can be safely returned to the biosphere. Durables contain technical nutrients that cannot biodegrade and must be designed for reuse. Ideally, recyclable products require limited redesign (if any) before they can be reused (harnessing the power of the inner circle); maximise opportunities for recycling and prolong each stage of reuse (the power of circling longer); diversify use across value chains to reduce demand for virgin materials (the power of cascaded use); and harness the collection of uncontaminated material streams (the power of pure inputs) (World Economic Forum, 2014b). Taken to its full conclusion, the circular economy could radically transform the built environment and transport our existing food systems (Ellen MacArthur Foundation and McKinsey Center for Business and Environment, 2015).

Transitioning towards a circular economy could have profound industrial and social implications, particularly in terms of providing an enabling environment for the pervasive emergence of new service, leasing, sharing, and collaborative business models. Product ownership gives way to product stewardship, and manufacturers will begin to resemble service providers. The circular economy will also create a new breed of 'prosumers' – consumers who are directly involved in lending, swapping, or selling their spare or idle capacity.

1.3 Harnessing the Circular Economy through Industry 4.0

Many leading circular economists regard the emerging Industry 4.0 revolution as a profound tool to mainstream the circular economy. Indeed, in our rapidly changing technological landscape, 'things that were products can become services ... Information that was impossible to know can now be tracked ... one of the greatest impacts will be in the 'circular economy', the idea that natural resources are used in an effective and sustainable manner'.[2]

The proliferation of intelligent assets and greater connectivity inherently complement the circular economy. They could reconfigure our existing energy infrastructure,[3] the built environment,[4] waste management,[5] and natural resource management.[6] They could also herald a more comprehensive transition towards a service or leasing-oriented economy as they provide platforms for the popular growth of these new business models.

1.4 The Role of Multilevel Governance in Driving a New Economic Transition

Convincing states, particularly emerging economies and developing countries, on the merits of transitioning to a the circular economy is a challenging task, particularly since no successful macroeconomic state precedent can be directly followed. In this regard, progressive multilevel governance will play a seminal role, as a shift of this kind requires strategic approaches to create linkages to overcome the existing system and its entrenched path dependencies (Grin, 2008).

Ostensibly, circular economy is normatively aligned with multilevel governance in that it requires implementation at all levels to function as intended, and warrants significant

2 Kenneth Cukier, Data Editor, cited in Ellen MacArthur Foundation, 2016.

3 Intelligent assets are already being used to improve efficiency in energy consumption and are now creating greater transparency in usage. They could improve renewable energy efficiency and have supported its growth in the developing world (Ellen MacArthur Foundation, 2016).

4 Intelligent assets can create a built environment that is flexible and modifiable. They are already being used to optimise energy efficiency in buildings. They can facilitate the predictive maintenance of the urban infrastructure and offer a platform for the secondary materials market (Ellen MacArthur Foundation, 2016).

5 Intelligent assets substantially advance the ability to track products worldwide as well as their condition, thereby optimising resource management on a global scale. Better data collection on waste could assist municipalities in launching successful incentives to reduce waste and improve recycling (Ellen MacArthur Foundation, 2016).

6 Sensing technology and precision agriculture could transform agricultural production, reducing the use of inputs that cause negative externalities and facilitate natural capital regeneration (Ellen MacArthur Foundation, 2016).

cooperation between governments, civil society, and private actors (CIRAIG, 2015). Multilevel governance is also instrumental for Industry 4.0 to be fully harnessed towards the circular economy. While the technology revolution, developing on its own, should improve resource productivity, it is not likely to generate systemic environmental solutions without intervention. Moreover, given the comparatively slow nature of systemic change (in contrast with rapid changes and innovation at product level), there is a very real risk that new technologies will not be integrated effectively towards the structural development of a circular economy (Ellen MacArthur Foundation and McKinsey Center for Business and Environment, 2015). The formulation of multilevel governance approaches must also be tailored to the specific challenges that emerging economies like India and countries within the ASEAN community face to enable them to leapfrog into a circular development path.

2. Existing Policy and Governance Approaches to The Circular Economy in Different Countries

2.1 An Emerging Public Policy Discourse in India

Although India has a low per capita consumption of natural resources, it ranks third in ecological footprint after China and the United States (WWF, 2016), strengthening the case even further for a macro-level circular transition. However, the circular economy still inhabits a relatively niche policy space in India and is generally considered in the context of new approaches towards waste management. In this regard, the status of the circular economy in India is similar to that of many other ASEAN countries that have not yet formulated a coherent vision for the circular economy and tend to approach it predominantly from a waste management perspective.

Fly ash utilisation is often cited as one of India's most significant circular policy initiatives as shown in the case study in Box 1.

Box 1. Fly Ash Waste in India: A Case Study

India generates enormous amounts of fly ash waste.[A] Its utilisation by the building and construction sector has mainly been promoted through government policy measures. The Fly Ash Notification of 1999,[B] originally established an ambitious 100% utilisation target within 9 years (or 15 years for old power plants), while power plants were required to make fly ash freely available for a minimum of 10 years.

This notification was amended in 2003, 2009, and 2016. In 2003, the radius capturing construction activities that should use ash-based products was expanded from 50 to 100 kilometres of a thermal power plant.[C] The 2009 amendments specified the minimum content of fly ash to be used in bricks and other construction materials. They also postponed the 100% utilisation deadline to 2014 (allowing a 5-year grace period to achieve full utilisation).[D]

The latest 2016 amendments further expanded the radius capturing construction activities to 300 kilometres. Power plants must now 'inventorise' and regularly update their fly ash stock online, and bear the cost of transportation to manufacturers within a 100-kilometre radius. They are also responsible for establishing ash production facilities within or near their premises. The use of ash-based products is mandated in cities with a population of 1,000,000 or more, as well as for government programmes with a built-up area over 1,000 square feet.[E]

These regulatory measures achieved 55% ash utilisation by 2015 (Central Electricity Authority, 2015). They were generally effective when fly ash is economical. For example, there has been a significant uptake from the cement industry, which currently represents half of the demand for fly ash-based products (Central Electricity Authority, 2015). Fly ash is generally a popular raw material for cement manufacturers as it is cheaper than limestone. However, there has not been much penetration within the brick-making industry. Although it is offered freely, it is difficult for brick makers to access as they must either bear the cost of transportation or purchase it through traders. In addition, these measures do not incentivise brick makers to invest in transitioning to the manufacturing of ash-based products. The 2016 amendments could improve existing utilisation levels by addressing the problem of transportation logistics, promoting the development of more power plant-based production facilities (particularly near cities), and expanding the requirement to use fly ash materials in smaller cities and government projects.

[A] Approximately 184 million tonnes were generated in 2014–2015, while 300 million tonnes are projected by 2021 (Bhushan et al., 2015).

[B] Utilisation of Fly Ash from Coal or Lignite -Based Thermal Power Plants, Notification under the Environment (Protection Act) 1986, Ministry of Environment and Forests, New Delhi, 14 September 1999, http://envfor.nic.in/legis/hsm/flyash.html

[C] Notification, Ministry of Environment and Forests, New Delhi, 27 August 2003, http://envfor.nic.in/legis/hsm/so979(e).pdf

[D] Notification, Ministry of Environment and Forests, New Delhi, 3 November 2009, http://dste.puducherry.gov.in/Flyash_notification2009.pdf

[E] Notification, Ministry of Environment, Forests and Climate Change, New Delhi, 25 January 2016, http://www.moef.nic.in/sites/default/files/fly%20ash%20amendment%202016.pdf

Source: Author.

Apart from fly ash, there have been other recent government initiatives in the direction of the circular economy, although these are being implemented in an ad hoc fashion (largely due to the absence of a consolidated national policy in this area). These include:

Clean India Mission: The national Clean India Mission has catalysed the development of circular waste management initiatives by local bodies. For example, the city of Pune in Maharashtra, India, has implemented Zero Garbage Pune, which is directed towards eliminating the need for landfills, adding value to waste, and creating a paradigm shift from mere disposal to the treatment of garbage as a renewable resource (Kumar, K., 2015).

Introducing the White Industries Concept: In March 2016, India's Ministry of Environment, Forest and Climate Change announced a new category of practically non-polluting white industries. This notification also re-categorises existing industries based on their pollution load. The purpose of the white categorisation is to dispense with the need for environmental clearances to foster the growth of non-polluting industries, and to assist them obtain finance from lending institutions. The re-categorisation of existing industries according to their pollution load seeks to encourage more progressive industries to adopt cleaner technologies and generate fewer pollutants.[7]

Zero Liquid Discharge: This policy (where industrial and municipal wastewater output is reused instead of disposed into a waterbody) is gradually being introduced in different industrial sectors (with a draft notification issued for the textiles industry in December 2015), and as part of the national strategy to rehabilitate the Ganga. In early 2016, the government also amended the power tariff policy to mandate the use of sewage wastewater by thermal power plants within 50 kilometres of a sewage treatment plant.[8] This policy should significantly improve the water efficiency of the thermal power sector, which consumes approximately 22 billion cubic metres of water, almost half of India's total domestic needs (Bhushan et al., 2015).

Amendments to the 2016 Waste Management Legislation: The government has introduced a suite of amendments to existing legislation advancing the circular economy in waste management. The most significant circular features of these new laws are shown in Box 2.

[7] Press Information Bureau, Government of India, Ministry of Environment and Forests, 5 March 2016, http://pib.nic.in/newsite/PrintRelease.aspx?relid=137373

[8] Press Information Bureau, Government of India, Cabinet, 20 January 2016, http://pib.nic.in/newsite/PrintRelease.aspx?relid=134630

Box 2. New Waste Management Legislation

E-Waste: Introducing the principle of extended producer responsibility (under which manufacturers and producers are responsible for collecting and channelising e-waste for disposal), and prescribing collection targets.[A]

Plastic Waste: Introducing the principle of extended producer responsibility (channelising recyclable plastic waste to a registered recycler) and encouraging urban local authorities to promote the use of plastic waste for the construction of roads and energy recovery.[B] The introduction of these new rules is timely, considering that India's plastic production is growing at 2.5 times the rate of India's gross domestic product (GDP) (Narain and Sambyal, 2016).

Municipal Solid Waste: Representing India's largest waste stream, the new rules mandate segregation at source, channelising waste to wealth through recovery, reuse, and recycling. They introduce a collect back scheme for non-biodegradable packaging waste. Biodegradable waste must be composted or treated through bio-methanation. Waste processing facilities should be set up in cities with a population of 1,000,000 or more (Sambyal, 2016). The new rules also promote the development of waste to energy plants, requiring that non-recyclable waste with high calorific value should be used directly for energy production or for preparing refuse-derived fuel (Narain and Sambyal, 2016).

Construction and Demolition Waste: This is a newly designated waste category. Local bodies must now use 10% –20% of this waste in municipal and government contracts. Large generators are responsible for segregating this waste, and must pay for its transportation, collection, processing, and disposal.

[A] E-waste (Management) Rules, 2016, Ministry of Environment, Forest and Climate Change, Government of India, 23 March 2016, http://www.moef.gov.in/sites/default/files/EWM%20Rules%202016%20english%2023.03.2016.pdf (accessed 22 April 2018).

[B] Plastic Waste Management Rules, 2016, Ministry of Environment, Forest and Climate Change, Government of India, 18 March 2016, http://www.moef.gov.in/sites/default/files/PWM%20Rules%2C%202016.pdf (accessed 22 April 2018).

Source: Author.

Existing Circular Initiatives in Business and Industry

Indian businesses and industrial sectors are now beginning to seriously consider the circular economy. In many respects, circular practices are attractive, not only because they are more sustainable but also because they make sound business sense.

Significantly, the Tata Group has announced a sustainability policy embedding a product life-cycle approach, which commits to natural and social capital valuation. Reduce, reuse, and recycle offer a competitive advantage and Tata companies are encouraged to explore the possibilities of product life-cycle management (with Jaguar Land Rover and

Tata Motors taking significant steps in this area).[9] The Mahindra Group is participating in The Climate Group's EP 100, committing to double its energy productivity by 2030. Each business within the group undertakes materiality analyses to formulate its own sustainability roadmap. The Birla Group has pledged to eliminate wood sourced from sustainable forests. Novelis, a Birla subsidiary, is now celebrated for rapidly dropping its dependence on bauxite mining and primary aluminium and using 53% of recyclable inputs. Novelis maintains that there is a strong business case for the circular economy. Indeed, the resource crunch has exposed the vulnerability of existing linear supply chains (Karunakaran, 2016).

Some Indian industries are voluntarily adopting circular practices. For example, since 2001, the paper industry has substantially reduced its need for virgin wood and chemicals and has improved its energy and water productivity (Bhati and Sangeetha, 2014). Apart from being the largest user of fly ash, the cement industry is also exploring co-processing different types and streams of waste material as fuel (Confederation of Indian Industry, 2011). The Indian sugar industry is now beginning to use integrated units in sugar mills, which enable the use of waste for co-generation, and ethanol and fertiliser production.

The Circular Economy: An Indian Cultural Tradition

Although advanced economies tend to approach the circular economy as a new economic model, it is already a familiar practice in many developing countries, including India. Indeed, despite the limited formal policy recognition of the circular economy, India, like many ASEAN countries, may already have a sociocultural ethos that, in contrast with advanced economies, is more inclined towards the circular economy.

India's Ministry of Environment, Forest and Climate Change recently documented existing, traditional climate friendly practices in India that are consistent with the circular economy (MoEFCC, 2015).[10] Significantly, India has a thriving informal recycling network. In fact, the concept of frugal innovation (developing scalable innovative low-cost solutions) that is now becoming popular in advanced economies originated in India where there is a strong

[9] Tata Sustainability Group, Waste, http://www.tatasustainability.com/waste.aspx

[10] Culturally, Indians are inclined towards needs-based consumption. Simple, sustainable consumption values are imbibed from a young age. Approximately 40% of households are vegetarian. Non-motorised transport (such as pedal rickshaws) is still prevalent in Indian cities (representing 40%–50% of the modal share in mega cities). Traditional building practices such as solar passive orientation, mud-based thermal insulation chequered windows, and large courtyards for natural ventilation are practices designed for comfort in harmony with natural surroundings. Traditional houses use materials such as bamboo, stones, and clay. These materials are not only suitable for the local climate but reduce cement consumption and material transport.

recycling tradition and where people are accustomed to doing more with less. However, the challenge will be to maintain this existing ethos, which is now at risk of becoming displaced as these countries pursue economic development through a linear pathway.

2.2 The Circular Economy in Other Emerging and Advanced Economies

Perhaps, one of the reasons the circular economy remains a peripheral discourse in India and the ASEAN region is the comparatively few and still evolving governance models to support its implementation.

2.2.1 The Circular economy in China

Ironically, although circular economy is predominantly an advanced economic discourse, China has the most sophisticated governance and implementation model. Amongst other things, China established a fund to convert industrial parks into eco-industrial agglomerations along with tax breaks for the reuse sector (Mathews and Tan, 2016). China also enacted the Circular Economy Promotion Law, which is designed to influence behaviour at the micro,[11] meso,[12] and macro[13] levels to achieve a recycling-oriented society (Murray, Skene, and Haynes, 2015). It was even upgraded to a national development strategy in China's 12th Five-Year Plan.[14]

In 2012, the National Development and Reform Commission called for 50% of national industrial parks and 30% of provincial parks to complete circular economy transformation initiatives by 2015, with the aim of achieving close to zero discharge of pollutants. In 2013, the State Council released a national strategy for achieving the circular economy – the first such strategy in the world – including establishing targets for energy productivity, water productivity, and for the recycling industry to reach CNY1 trillion (Mathews and Tan, 2016). The National Development and Reform Commission also invited academic and policy experts to develop circular economy indicators aimed at the macro and meso levels, which measure resource output, consumption and utilisation, waste, pollution, and emissions (Murray, Skene, and Haynes, 2015).

11 Wherein companies are encouraged to develop eco-design and cleaner production approaches (Murray, Skene, and Haynes, 2015).

12 Promoting regional development and the natural environment (Murray, Skene, and Haynes, 2015).

13 Promoting eco-cities and sustainable production and consumption (Murray, Skene, and Haynes, 2015).

14 Including objectives such as reusing 72% of industrial solid waste and raising resource productivity; and introducing 10 major programmes focusing on recycling industrial wastes, converting industrial parks, remanufacturing, urban mining, the development of waste-collection and recycling systems, 100 demonstration cities and 1,000 demonstration enterprises or industrial parks (Mathews and Tan, 2016).

2.2.2 The Circular economy in Germany and Japan

Although China is ostensibly the leader in circular economy implementation, it has been greatly influenced by both Germany and Japan (Mathews and Tan, 2016). Germany's National Sustainability Strategy of 2002 prescribes, amongst other things, ambitious targets to double its raw material productivity and its energy productivity by 2020 (with reference to 1994 and 1990 baselines respectively).[15] Germany has also implemented ProgRess, a national resource efficiency programme. ProgRess II is an updated version of the programme that was passed by the Cabinet in March 2016, which relevantly seeks to safeguard the sustainable supply of raw materials, enhance resource efficiency in production and consumption, and expand a resource efficient circular economy.[16] It also supplements the national raw material productivity target with additional indicators and includes a series of circular economy-related indicators and targets.

Diminishing solid waste landfill capacity initially catalysed Germany's waste management and recycling policies and legislation. In 1991, Germany passed the Ordinance on the Avoidance of Packaging Waste[17] (the first of its kind in Europe), which was followed in 1994 by the Closed Substance Cycle Waste Management Act, Germany's principal circular economy legislation (Davis and Hall, 2006). Significantly, it establishes the principles of the circular economy and waste hierarchy, and enshrines the prioritisation of waste prevention over reuse, recycling, energy recovery, and disposal, while setting specific recycling targets (Sum of Us, 2016).[18] However, although Germany is arguably the global leader in this area, it has not yet made significant inroads with respect to the recirculation of secondary materials and the promotion of circular product design (Wilts, 2016).

The circular economy also arose from resource scarcity in Japan. Its first transformation was to reduce its dependency on oil as its primary energy source and improve the energy efficiency of its industries (World Economic Forum, 2014b).

15 Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, General Information Sustainable Development, http://www.bmub.bund.de/en/topics/strategy-legislation/sustainability/general-information/

16 Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, The German Resource Efficiency Programme II Summary, http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Ressourceneffizienz/the_german_resource_efficiency_programme_summary_ii_bf.pdf

17 Imposing a system of extended producer responsibility for packaging waste, compelling producers and retailers to take back packaging waste, and pay for waste treatment via the Green Point system, wherein producers pay in advance for the treatment of their packaging waste (Sum of Us, 2016).

18 At least 65% of paper, metal, plastic, and glass, and at least 70% of construction and demolition materials should be recycled by 2020 (Sum of Us, 2016).

Like Germany, it has implemented a series of waste management legislation since the early 1990s. Its most significant is the Law for the Promotion of Effective Utilisation of Resources, enacted in 2000, which is aimed at waste minimisation by consumers and producers alike and covers the entire product life cycle.[19] It has also developed indicators and established targets with respect to material productivity, circularity usage rate, and landfilling amount (Ministry of Economy, Trade and Industry, 2016). Strong, complementary education and public awareness campaigns were also initiated, directed at changing not just economic behaviour but also social behaviour to reinforce and cultivate the circular economy as a social transition (Ji, Zhang, and Hao, 2012).

2.2.3 The Circular economy in the European Union

In December 2015, the European Union (EU) adopted a circular economy package. This package consists of an EU action plan and timelines addressing the full product life cycle from production, consumption, and waste management, and the market for secondary raw materials. It also includes revised legislative proposals on waste, establishing reduction targets and an ambitious and credible path for long-term waste management and recycling (European Commission, n.d.).

3. The Emergence of Industry 4.0 in India

3.1 A Nascent Public Policy Discourse

Although still an emerging concept, Industry 4.0 heralds a new industrial era where smart devices assume major control over manufacturing and distribution. Existing cyber-physical production systems are sophisticated enough to tell machines how they should be processed; processes now govern themselves in a decentralised, modular system; and smart embedded devices start working together wirelessly, either directly or via the internet cloud – the internet of things (IoT) – to revolutionise production. Rigid, centralised factory control systems give way to decentralised intelligence as machine-to-machine communication hits the shop floor (ABB, 2014).

[19] Ibid.

India was the official partner country for the Industry 4.0-themed Hannover Messe in April 2016. India's participation was based on the 'Make in India' theme (launched by the government of India)[20] and a joint Indo–German workshop was convened on Innovation Partnership through Industry 4.0. India's Ministry of Heavy Industry entered two memoranda of understanding with German entities to develop cooperation, technology transfer, and innovation in the manufacturing sector. India also announced that it would leverage its reputed information technology industry to transform manufacturing, not only in India, but also at the global scale, with new concepts such as smart factory, artificial intelligence and IoT, which is projected to be worth US$15 billion for India by 2020.[21]

Despite the inherent opportunities for Industry 4.0, its implementation faces several challenges in India and other ASEAN countries. For example, the cost of energy could be a deterrent to using technologies such as automation in heavy manufacturing (Ranjan, 2016). Significantly, India risks falling behind in terms of its international competitiveness, particularly as Gartner estimates that the global opportunity for IoT alone could reach US$1.9 trillion by 2020 (of which India's share will be relatively minor) (Gartner, 2013). India and many countries within the ASEAN community will need to prioritise building their domestic capabilities in Industry 4.0. This will include developing a domestic IoT industry, robust data security infrastructure, competent security services, as well as education and skills training (Lanvers, 2015).

3.2 Early Signs of Industry 4.0 Transition

India is now positioning itself as an attractive destination for foreign investment, providing international opportunities for setting up new plants and processes in line with Industry 4.0. Table 1 shows sectors that attract the inflows of the FDI Equity in India in the 2013-2016 period. Havells, Godrej, and Bosch are already shifting their operations to India (Lanvers, 2015). However, there are signs that the Industry 4.0 transition has already begun. Pertinently, foreign investment is increasingly directed at the information technology and services sectors (sectors which are ostensibly the most inclined towards Industry 4.0):

[20] A national initiative seeking to transform India into a global manufacturing and design hub, http://www.makeinindia.com/about

[21] Press Information Bureau, Government of India, Ministry of Heavy Industries and Public Enterprises, 26 April 2016, http://pib.nic.in/newsite/PrintRelease.aspx?relid=142220 India has already launched the Cyber Physical Systems Innovation Hub. The Ministry of Communication and Information Technology has committed ₹ 17.6 (1 crore = 10 million rupee, 17.6 crore = US$ 2.6 million) to develop prototypes and a hub for testing out projects, focusing predominantly on smart buildings.

Table 1. Sectors Attracting Highest FDI Equity Inflows
(Amount in ₹ [crore] and US$ in million)

Sector	2013-14	2014-15	2015-16
Services Sector*	₹ 13,294 US$ (2,225)	27,369 (4,443)	45,415 (6,889)
Construction Development: Townships, Housing, and Built-Up Infrastructure	7,508 (1,226)	4,652 (769)	727 (113)
Computer Software and Hardware	6,896 (1,126)	14,162 (2,296)	38,351 (5,904)
Telecommunications (Radio Paging, Cellular Mobile, and Basic Telephone Services)	7,987 (1,307)	17,372 (2,895)	8,637 (1,324)
Automobile Industry	9,027 (1,517)	16,760 (2,726)	16,437 (2,527)
Drugs and Pharmaceuticals	7,191 (1,279)	9,052 (1,498)	4,975 (754)
Chemicals (Other Than Fertilisers)	4,738 (878)	4,658 (763)	9,664 (1,470)
Trading	8,191 (1,343)	16,755 (2,728)	25,244 (3,845)
Power	6,519 (1,066)	4,296 (707)	5,662 (869)
Hotel and Tourism	2,949 (486)	4,740 (777)	8,761 (1,333)

FDI = foreign direct investment.

Note: *Services sector includes financial, banking, insurance, non-financial/business, outsourcing, research and development, courier, and technology testing and analysis.

Source: FDI Statistics, Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India, 2016. http://dipp.nic.in/English/Publications/FDI_Statistics/2016/FDI_FactSheet_JanuaryFebruaryMarch2016.pdf

Bosch is already planning to roll out Industry 4.0 in its Indian plants. It has more than 100 pilot projects underway and aims to implement connected production in its 14 manufacturing locations across India by 2018 (ETAuto, 2015). GE has opened its US$200-million multi-modal facility in Chakan (which can manufacture a wide range of products throughout all the company's divisions) that could completely revolutionise how its products are manufactured (Grunewald, 2016). Godrej is already using an intelligent plant framework to run its factory floors, while Mahindra & Mahindra and Tata Motors are using robots to build car body frames (Krishna, 2016). The Indian Institute of Science is developing India's first smart factory in Bengalaru. This project is expected to be revolutionary for India in terms of creating fully autonomous, thinking, and sensing factory operations (Kumar C., 2016).

3.3 Prospects for Integration with the Circular Economy

Policymakers at the highest level acknowledge the importance of Industry 4.0 for India. They believe that it will contribute to productivity gains, revenue growth, employment, and investment (Chitravanshi, 2016). In contrast, there is no equivalent recognition or willingness to evolve from a linear to circular growth path through Industry 4.0, even though both are potentially highly disruptive transformations. This swift embrace of Industry 4.0 is perhaps symptomatic of how the technology revolution does not warrant the same socio-economic paradigm shift that the circular economy does. Moreover, conventional national accounting mechanisms such as GDP are deficient in properly capturing the scope of economic growth opportunities inherent in the circular economy for policymakers to consider this model more seriously.

However, there are some discrete areas of convergence between Industry 4.0 and the circular economy in India. The most obvious example is the Smart Cities Mission. Arguably, this integration is an inherent feature of the smart cities concept, rather than a result of deliberate planning by policymakers. The apparent circular elements of this initiative include requiring solar power to deliver at least 10% of energy requirements, planning for solid waste management, waste water recycling and rain water harvesting, smart metering, the promotion of non-motorised transport, intelligent traffic management, and energy-efficient street lighting. In addition, at least 80% of buildings should be energy efficient and green buildings (Ministry of Urban Development, 2015).

Earlier, the government shortlisted 20 cities under this programme. In May 2016, 13 more cities were added. However, it remains to be seen how far these cities will authentically imbibe characteristics of a circular economy. Of the 33 smart city winners, 21 have already decided not to follow the requirement of 80% energy efficiency in buildings, while there has been an excessive emphasis on 24-hour water supply and comparatively little attention given to water efficiency and sufficiency (Somvanshi, 2016).

4. Facilitating Inclusive Growth?

While there is much excitement about the potential for Industry 4.0 to substantially unleash the circular economy, it is imperative to position this debate within the broader context of the principle of sustainable development in an emerging economy or developing country scenario. The principle of sustainable development consists of economic, environmental, and social aspects. Human well-being lies at the very heart of this principle. Ideally, rural communities and poor people should be the prime economic beneficiaries in developing countries (CIRAIG, 2015).

The circular economy originally emerged as a business- and industry-oriented discourse relating to resource efficiency. While it is often advanced as an important mechanism to promote sustainable development, it is not necessarily synonymous with inclusive growth. In fact, contemporary literature on the circular economy is virtually silent on the social dimension of sustainable development (Murray, Skene, and Haynes, 2015).

While current economic policies may enable the shifting of Industry 4.0-style manufacturing operations to India, it is questionable whether the proliferation of Indian smart factories will substantively promote the human aspect of sustainable development. Although they are economic and environmentally efficient models of production, they are not likely to deliver substantial employment opportunities in a country with a labour force that far exceeds its employment growth. The World Economic Forum predicts that the fourth industrial revolution could lead to the loss of over five million jobs worldwide in 15 major developed and emerging economies, including India and ASEAN countries (Cann, 2016).

This does not imply that India should discourage Industry 4.0. If anything, the prevailing linear model has only deepened existing inequalities. In this regard, there are huge merits in transitioning to an economic model that is more sustainable. However, policymakers will need to ensure that the economic growth delivered by Industry 4.0 is somehow harnessed towards uplifting the poor, considering that they represent a majority of India's population and are not likely to immediately benefit from this transition. They will also need to develop complementary policies on reskilling and retraining to better prepare its labour force for this transition.

Despite the general concern over the future of jobs, the enormous potential for the progressive deployment of Industry 4.0 should not be overlooked. Indeed, these technologies may be ideal for economies with aging populations, and in labour sectors

that traditionally have high occupational health and safety risks. Potentially, the use of intelligent assets in India to accurately inventorise its waste could radically catalyse the growth of India's recycling sector, a sector which remains largely untapped and lacks government recognition as an industry but which could be worth up to US$13 billion by 2025 (Dixit, 2016). Precision agriculture is another area where Industry 4.0 could substantially improve the livelihoods of small-scale farmers and the sustainability of existing agricultural practices (Rajvanshi, 2015). It could also create more jobs in the services sector for which obtaining the relevant skills may not be too demanding (such as the emergence of app-based car-riding services).

There are already some compelling examples of the deployment of Industry 4.0 to support inclusive growth in India. For example, Amul India (the world's largest dairy cooperative) has been using advanced automation and control systems since 2008 to enable the aggregation, processing, and distribution of milk, preventing millions of litres from perishing. This has supported both Amul's growth and improved the livelihood of its farmers, enabling them to keep pace with growing demand for milk produce (ABB, 2014). Similarly, the Akshaya Patra Foundation has leveraged technology to feed daily 1.3 million children in government-run schools across 10 states. This initiative has not only contributed to the alleviation of child hunger, but has improved school attendance (Seaver, 2012). Sigma Fraudenberg NOK has opened a state-of-the-art plant in Basma, Punjab, which will employ 2,000 skilled and semi-skilled workers, approximately 50% of them are women from nearby towns and villages (Mathur, 2015).

Intriguingly, the digital economy is also reviving traditional circular practices in India. For example, a substantial market has now emerged through e-commerce for cow dung cakes, which is providing a valuable source of supplementary income for women in villages (Ganesan, 2016). There is also a growing trend of philanthropic crowdfunding emerging in India (as donors can make a significant difference to people's lives by contributing even small amounts of money).[22]

Indian start-ups, which progressively combine Industry 4.0 with the circular economy, are now emerging. Below are a few of the kinds of progressive initiatives that have emerged in this space:

[22] For example, crowdfunding enabled farmers to build a canal in a village in Western India, provided boarding and education to children orphaned by farmer suicides, as well as refurbished old shoes to provide footwear for the underprivileged (Rai, 2016).

Box 3. Examples of Progressive Initiative for Industry 4.0 and Circular Economy in the Indian start-ups

Kabadiwalla Connect is an online information service that works with stakeholders in the informal waste ecosystem, using information technology to help collectors get better prices for their materials, connect to new customers and markets, and optimise logistics across the value chain. They connect communities to their local scrap dealer, helping them sell their recyclable waste easily. Going forward, they will explore new ways, through technology, to send more recyclable (and upcyclable) materials into local scrap-dealer networks, and track how much materials are being recycled at the neighbourhood level (Vardhan, 2015).

Protoprint is a social enterprise that empowers urban waste pickers with low-cost, distributed technology to produce 3D printer filament from the plastic waste they collect. It is currently pioneering an ethical, fair-trade filament production process, which aims to leverage the existing gap in the market for recycled filament (as most filament is produced from virgin polylactic acid plastic and acrylonitrile butadiene styrene plastic).

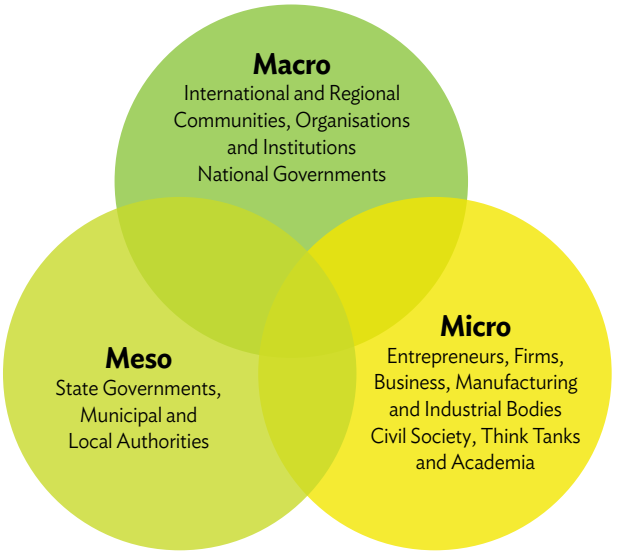
EM3 Agri Services makes high-end technology affordable and accessible to Indian farmers by offering its services on a pay per use basis. They are currently exploring the scope of offering even more cutting-edge technologies (such as soil testing, pest tracking, and other remote sensing technologies that can detect plant health) through the pay per use model (Goyal, 2016).

skyTran is a path-breaking public transport technology using levitating, pod-like vehicles on elevated guideways, which could increase the speed of travel sixfold. Co-founded by an Indian engineer, the technology is now being developed in collaboration with NASA. It is being proposed in many countries around the world, including India, where it will be piloted in a few states including Kerala. If successful, it could augur a new era in public transportation that alleviates air pollution and congestion.

5. Implications for Multilevel Governance in India and the ASEAN Region

While Industry 4.0 and the circular economy are complementary discourses, they may not always interact and combine organically. Accordingly, multilevel governance will play a crucial role in coordinating their strategic integration.

Figure 1. Multilevel Governance and Key Actors



Source: Author.

While relevant actors and change-makers are associated with different tiers of multilevel governance (as identified in Figure 1), Table 2 exemplifies how such transitions occur through dynamic interlinkages and interactions between multiple developments at all three levels (Grin, 2008).

Table 2. Multilevel Governance – Key Actors and Their Roles

Levels	Actors	Strategic Approaches, Measures, and Initiatives			
Macro	International and Regional Communities, Organisations, and Institutions	Promote a circular economy discourse. Encourage the formulation of regional and national policies on the circular economy and Industry 4.0.	Fund and implement strategic and replicable pilot projects.	Facilitate knowledge sharing and technology transfer.	Fund pioneering projects with the potential to scale up the circular economy.
	National Governments	Develop national circular economy policies and initiatives (including indicators) supported by Industry 4.0. Develop guidelines for the adoption of new technologies.	Strengthen domestic capabilities in Industry 4.0.	Support R&D and innovation. Establish research collaborations exploring the scope for the circular economy through Industry 4.0.	Incentivise the adoption of circular and collaborative practices in industry and business.
Meso	State Governments, and Municipal and Local Authorities	Develop complementary circular economy policies.	Educate the local community about the circular economy.	Fund and provide infrastructure support to local innovators.	Encourage and facilitate the implementation of strategic and replicable pilot projects.
Micro	Entrepreneurs, Firms, Corporate, Manufacturing, and Industrial Bodies	Drive innovation. Undertake R&D.	Establish and implement circularity practices.	Showcase and disseminate circular precedents supported by new technologies.	Participate in research collaborations with government and academia.
	Civil Society, Think Tanks, and Academia	Influence public policy development. Popularise the circular economy and its potential in the digital revolution.	Educate consumers about sustainable production and consumption.	Promote the deployment of new technologies to advance sustainable development and inclusive growth.	Harness the collective voice of consumers to reform linear production chains.

R&D = research and development.

Source: Author.

5.1 Raising the Profile of the Circular Economy at the National and Regional Levels

Circular economy remains a relatively niche policy discourse in the ASEAN region. This arguably contributes to the current lack of recognition of the opportunities for Industry 4.0 to catalyse circular growth. While ASEAN countries are no doubt developing progressive policies with respect to environmental management and resource efficiency, policymakers are not yet seriously regarding the circular economy as a new industrial paradigm.

Considering the experiences in other countries (particularly China, Germany, and Japan), ambitious efforts are required at the macro level to develop holistic national circular economy policies that can drive systemic transformations and encourage the participation of key actors. Comprehensive national circular economy policies and implementation strategies must ideally address the following key components identified in Box 1, and not simply focus on waste management.

Box 4. Key Features of a National Circular Economy Policy and Programme

- Encouraging a circular product design
- Positioning resource efficiency policies in manufacturing and industry within a circular economy framework
- Facilitating secondary materials recirculation throughout the economy
- Including the circular economy as an aspect of State national planning (with particular emphasis on the urban and industrial sectors)
- Developing a waste management hierarchy in accordance with the circular economy principles
- Creating public institutions dedicated to the circular economy
- Devising circular economy indicators to establish targets and map progress
- Fostering research and development and innovation
- Driving social change towards the principles of reuse, reduce, and recycle
- Establishing platforms and working groups, bringing together stakeholders across all sections of multilevel governance to contribute their expertise on the circular economy

To date, the countries and regions that have developed circular economy policies and programmes have done so largely because of natural resource scarcity and/or environmental pressures. However, India, like many other countries within the ASEAN community, is not yet experiencing the same level of resource and environmental pressures that force economic change. In the absence of such compelling external policy drivers, elevating the circular economy discourse to a national or regional priority may be a challenge, particularly as most of these countries are immediately concerned with their economic growth.

In this regard, the international community and institutions will play an important role in promoting and disseminating the circular economy discourse as an alternative and better economic growth path. This could include developing more studies about the scope and opportunity for the circular economy, specifically at a regional or country level; increasing bilateral or multilateral exchanges on the merits and potential for the circular economy

(such as the Indo–German Working Group on the Circular Economy that was established in 2015); and showcasing the circular economy as a prospective solution in international development discourse to realise the conventionally competing state commitments towards economic growth and the environment (for example, by leveraging the synergies between the circular economy and the recently adopted Sustainable Development Goals [23]).

Apart from devising new national circular economy policies, India and ASEAN countries will need to develop complementary public institutions and collaborative multi-stakeholder platforms to support its strategic implementation. For example, establishing an Office of Resource Management and relevant government postings could do much to widen awareness about circular economy opportunities and precipitate change (House of Commons Environmental Audit Committee, 2014). This will also require the creation of working groups, bringing together stakeholders across all levels to contribute their expertise to the formulation of circular economy policies. ASEAN could also develop a broad strategy and action plan to help stimulate a regional transition to the circular economy, similar to the approach taken by the EU. Currently, the circular economy is not formally recognised as a priority area with respect to ASEAN cooperation on the environment or in its action plans for key sectors such as energy, minerals, or the food, agriculture, and forestry sector (although these plans do exhibit some features that in some respects complement the circular economy).

A key aspect of developing a transformative state circular economy policy is the formulation of appropriate indicators that can establish targets and map progress, for which Industry 4.0 technologies can even be harnessed to develop more accurate and comprehensive measures. They can even be tailored to different governance levels, such as the approach taken in China.

These indicators should broadly address factors relating to the extraction and import of virgin materials, the current environmental load of economic activity and ultimate waste disposal rates, the recycling and recirculation of secondary materials throughout the economy, the uptake of circular life-cycle analyses in product design, resource efficiency in industrial and manufacturing operations, and the socio-economic transition towards a recycling-oriented society. Table 3 summarises the circular economy indicators that have been adopted in other countries and regions.

[23] In particular, the circular economy is highly relevant to Sustainable Development Goals 8 (Decent Work and Economic Growth); 9 (Industry, Innovation, and Infrastructure); 11 (Sustainable Cities and Communities); and 12 (Responsible Production and Consumption) http://www.un.org/sustainabledevelopment/sustainable-development-goals/

Table 3. Circular Economy Indicators Adopted by Other Countries and Regions

Country	Indicators
Japan	• Material productivity (material use as a proportion of GDP) • Circularity usage rate (measuring materials reused as a proportion of total materials used by the economy) • Landfilling amount (measuring how much waste is ultimately sent to landfills)
Germany	• Additional indicators have been formulated as part of ProgRess II, Germany's resource efficiency programme, supplementing the raw material productivity indicator. This will include input raw material productivity and total weight of all raw materials used in production. • In addition to recycling and recovery indicators and targets for different waste streams, two new virtual indicators are currently being developed including DERec (direct effects of recovery as a percentage of direct material input) and DIERec (direct and indirect effects of recovery as a percentage of raw material input). These indicators will be reviewed and improved in the future development of the programme, and further analyses will be developed with respect to the use of foreign natural resources to produce German imports.
China	China has introduced indicators for the meso-industrial park and macro levels, which include four categories broadly relating to: • Resource output • Resource consumption • Integrated resource utilisation • Waste disposal
European Union	• Resource efficiency • Eco innovation index • Recycling rates • Amount of municipal waste per capita • Amount of municipal waste per GDP output

GDP = gross domestic product.

Sources: Ministry of Economy, Trade and Industry, 2016; Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2016; University of West England, 2012; and European Parliamentary Research Service, 2016.

Social and well-being indicators should also be developed to ensure the human aspects of the circular economy are adequately addressed. These could address such factors as employment generation, education and skills development, improvements in the environmental quality of life, and benefits to public health. Indeed, one of the criticisms of the Chinese system is the lack of assessment indicators for the social aspects of the circular economy (University of West England, 2012).

5.2 Leveraging Industry 4.0 Towards the Circular Economy

India and the ASEAN countries are certainly aware of the impending changes that Industry 4.0 will likely precipitate. Governments will play a key role in enabling or holding back new

technologies (McKinsey Global Institute, 2014). In this emerging, new industrial era, Indian policymakers are preoccupied with ensuring that India remains globally competitive and exploring the synergies between key national initiatives such as Make in India and Digital India missions (which are particularly apparent in Indo–German collaboration and India's participation at the Hanover Messe in 2015).

At a macro level, it is certainly important for India and the ASEAN countries to strengthen their domestic capabilities to be competitive in the Industry 4.0 era (except, perhaps, Singapore[24]). These include developing policies and programmes that seek to bridge the digital divide; and strengthen the information and communications technology sector and data security environment (including instituting programmes in education and skills development). However, policymakers must also recognise and cultivate the profound opportunities that Industry 4.0 presents for transitioning towards a circular growth path. They must also ensure that this transition is specifically directed towards inclusive growth by establishing relevant guidelines or criteria for encouraging new technologies.[25] In this regard, micro-level actors, particularly the civil society sector, relevant think tanks, and academia (particularly circular economy and green growth advocates), will need to be proactively engaged to contribute to and help steer the national policy direction. Again, exploring Industry 4.0's inherent synergies with the Sustainable Development Goals may be a useful way of ensuring that this transition is harnessed progressively.

5.3 Establishing Compelling Circular Precedents

Perhaps, the biggest challenge in convincing emerging economies like India to transition towards a circular growth path is the lack of off-the-shelf models that they can emulate (Preston, 2012). In the absence of replicable economic models, it is imperative to establish and successfully demonstrate strategic pilot projects that leverage the synergies between Industry 4.0 and the circular economy.

Both macro-and meso-level actors, including international institutions and national and state governments, have an important role to play. For example, the International Finance Corporation's eco-cities programme (which is explicitly tailored towards using technology

[24] Singapore is the only country in the top 10 of the United Nations ICT Index, and in the top 20 of the Economist Intelligence Unit Digital Economy Ranking. It is also the only ASEAN country to have been considered a 'Stand Out Country' in the Digital Evolution Index (A.T. Kearney, 2016).

[25] This could include considerations such as the technology's potential for rapid adoption, how widespread the benefits and impacts will be (including impacts on people, institutions, products, and markets), whether it will have a significant economic impact, and whether it has the potential to address economic and social challenges (McKinsey Global Institute, 2014).

to support circular urban planning) could positively impact the future development of smart cities in India.[26] Similarly, the World Bank is funding the Efficient and Sustainable City Bus Service Project (which uses intelligent transport and management information systems).[27] While this project is currently being trialled in four cities, it has enormous potential for replication in smart city and urban transport planning if the trial is successful. National and regional initiatives can be taken to develop frameworks and implement replicable circular economy pilot projects such as the approach taken in China to develop eco-industrial parks circular economy pilot cities; and establish a National Pilot Eco-Industrial Park Program and National Pilot Circular Economy Zone Program (Su et al., 2013).

Appropriate technology transfer is certainly important in the demonstration and diffusion of successful circular precedents. While this aspect will be largely driven by micro-level actors at the firm level, national governments have a crucial determining role in deciding which technologies to promote. Currently, there is much interest in exploring opportunities for Industry 4.0 technology transfer between Europe (particularly Germany) and India. Arguably, a major criterion for supporting and facilitating technology transfer in Industry 4.0 should be its prospects for scaling up the circular economy and promoting inclusive growth.

The private sector will have a major role to play at the micro and meso levels. However, given the currently limited capabilities of Industry 4.0 in India and many other ASEAN countries, global corporations based in advanced economies (such as Japan) will be primarily responsible for showcasing Industry 4.0's circular economy potential. For example, Hitachi Ltd. is developing models for inter-manufacturing asset sharing as part of its broader research to develop factories of the future,[28] and is also creating a crowdsourcing platform wherein individual manufacturers can share their resources (including machinery, materials, and expert skills) as part of a symbiotic community of manufacturers.[29] The Japanese business community has also established the Industrial Value Chain Initiative, which is seeking to develop a comprehensive manufacturing ecosystem where factories no longer work in isolation but are connected to optimise production across an entire supply chain. The initiative is now seeking to promote global and borderless collaboration, extending beyond manufacturing to the services sector.[30]

26 Significantly, the city of Bhubhaneswar in Odisha is one of the five cities chosen to be modelled as an eco-city, while it was also shortlisted in the first phase of the government's Smart Cities Mission.

27 Efficient and Sustainable City Bus Services Project of India, Projects and Operations, The World Bank http://www.worldbank.org/projects/P132418?lang=en

28 A model that proposed the sharing of manufacturing assets between factories that ordinarily work in isolation to ensure optimal utilisation, save costs, and reduce energy. Source: Presentation given by Mr. Jun Kikuchi, Senior Engineer, Planning Department, Hitachi Ltd. at a meeting of the ERIA Research Project on 'Industry 4.0: Empowering ASEAN for Circular Economy' on 6 June 2016 in Bangkok, Thailand.

29 Ibid.

30 Yasuyuki Nishioka, President, Industrial Value Chain Initiative https://www.iv-i.org/en/

More generally, firms will play an important complementary role supporting macro-level efforts to mainstream the circular economy in business and industrial practices. Encouragingly, major corporate houses in India (e.g. the Tata Group, the Birla Group, and the Mahindra Group) are beginning to implement circular practices within their organisations. Moreover, since the 1990s, industrial practices have become much more resource efficient.[31] As the circular economy discourse gains more traction in business and industry, governments should now consider further incentivising measures to generate a culture of circularity in these sectors. However, to fully reap the circular economy benefits of the Industry 4.0 revolution, the corporate and business sectors must further evolve towards developing a collaborative business and manufacturing ecosystem (such as the case of Japan) to develop optimal solutions. Governments will be required to play a critical role to catalyse and drive collaboration within and across different value chains (through initiating cutting edge research projects, facilitating consortiums, and establishing working groups).

5.4 Investing in the Circular Economy

Both the circular economy and Industry 4.0 are innovation-driven transitions. However, India's emerging, new breed of high technology, circular economy innovators have received little, if any, funding from the government.[32] More support is required from the macro-level to catalyse innovation. The Indian government is now recognising the importance of developing a robust start-up ecosystem with the announcement of the Start-up India initiative, which establishes a fund of approximately US$1.7 billion and provides incubation support. Within the ASEAN region, Singapore and Malaysia have established multiple programmes to support local start-ups (A.T. Kearney, 2016).

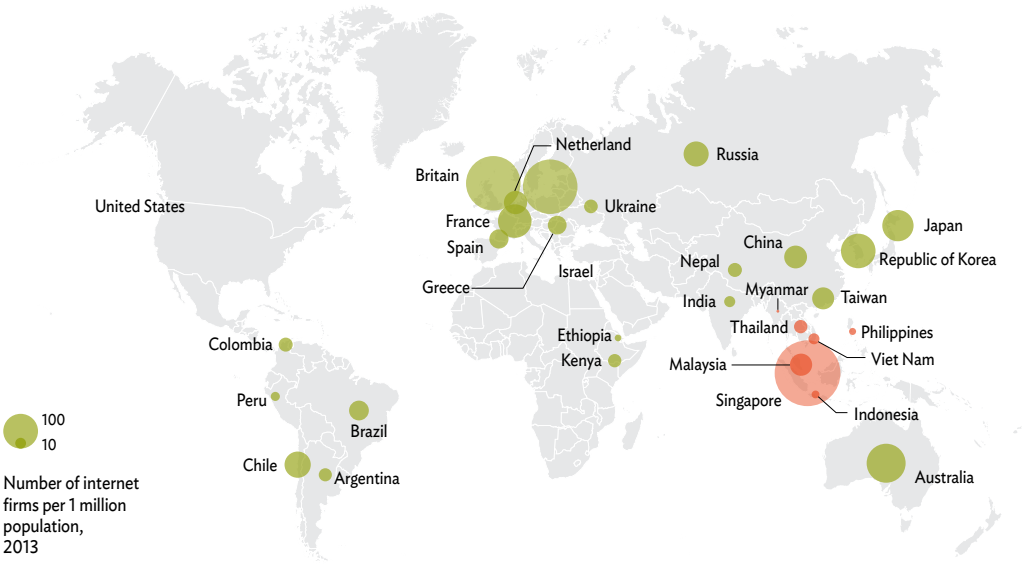
However, despite these various initiatives, the number of internet start-ups per capita in India and the ASEAN region (except Singapore) lag behind other tech hubs of the world (A.T. Kearney, 2016). While it is clearly important for governments to stimulate and support entrepreneurial activity in these countries, there should also be specific incentives for initiatives that advance the circular economy.[33] In addition, the international community should maintain and strengthen its role as an important source of seed funding, while ASEAN could consider establishing an innovation fund supporting pioneering technologies with the potential to scale up the circular economy in this region.

[31] For example, the installation of pollution control devices has now become the norm, and there have been significant improvements in water and raw material efficiency (Bhushan, 2016).

[32] For example, skyTran is backed by Eric Schmidt's Innovation Fund. Kabadiwalla Connect won a climate change grant from the World Economic Forum. Protoprint was supported by grants sourced from the United States of America.

[33] For example, the Start-up India Action Plan currently only prioritises biotechnology as a sector http://startupindia.gov.in/actionplan.php

Figure 2. Low Number of Internet Startups in ASEAN, except for Singapore



Source: A.T. Kearney, 2016.

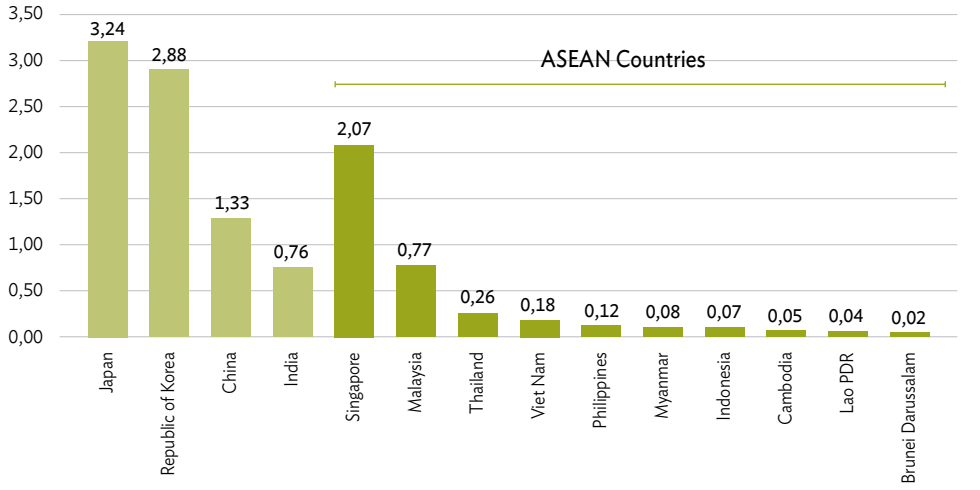
Meso actors, including states and local authorities, will also have a vital role as key enablers. For example, although the national government has recently announced the Start-up India initiative, some state governments have already played a significant role in providing support and infrastructure, stimulating the emergence of start-up ecosystems in cities such as Bengaluru and Hyderabad. However, more education and awareness about the circular economy is necessary to fully leverage the role of state and local government actors as enablers, particularly in terms of developing mindsets that are open to exploring new ideas and supporting innovation. For example, the founders of Banyan (a solid waste management high-tech start-up) encountered difficulties in dealing with urban authorities because of the general reluctance to support innovation and risk, despite the demonstrated need for an integrated solid waste management company (Vardhan, 2014). In contrast, the city of Pune designated land to Protoprint (the makers of recycled 3D filament) and its project partner SWaCH to support the development of their production lab.

Governments at all levels and micro actors (mainly civil society and think tanks) can also encourage innovation by announcing circular economy-themed competitions and challenges. Moreover, they can facilitate maker spaces and repair cafés, providing local spaces for innovation and to spread education about the circular economy. Pertinently, the repair cafés that have emerged in Europe function as important nodes for disseminating the circular economy and teaching its principles from the ground up

(Charter, 2016). While India has a growing makerspace movement (Sivaramakrishnan, 2014), it is generally focused on technological innovation rather than circular solutions.

There is also a need for more consolidated efforts between actors across all levels of multilevel governance (including government, industry, civil society, and academia) to fund and undertake research and development that explore the opportunities for leveraging Industry 4.0 towards the circular economy. Advanced economies have allocated substantial funds towards Industry 4.0 alone.[34] In contrast, no funds have been specifically dedicated by the government towards Industry 4.0 or the circular economy in India. India, like other middle-income ASEAN countries, spends only a fraction of its income on research and development (R&D).[35] These countries will need to attract more R&D investments from global corporations and the private sector, guided towards high-priority research areas relating to Industry 4.0 and the circular economy. They could also establish a public–private development fund for core technologies (McKinsey Global Institute, 2014).

Figure 3. Average Expenditure on Research and Development
(Selected Asian Countries' % Share of GDP, 1996–2013 Average)



ASEAN = Association of Southeast Asian Nations, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic.
Source: World Development Indicators, World Databank, The World Bank.

[34] For example, Germany has dedicated US$222 million to the Federal Ministry of Education on Industry 4.0, while the Obama administration has pooled together US$500 million towards smart manufacturing in the United States.

[35] In the latest Union Budget for the Government of India, R&D investment towards the Department of Scientific and Industrial Research and the Department of Electronics and Information Technology represents approximately 0.6% of India's GDP.

5.5 Educating and Leveraging the Digitally Empowered Consumer

The non-governmental organisation and civil society sector has a significant role in guiding the development and popularising the circular economy, undertaking consumer education (including making consumer preferences more sustainable), and promoting the deployment of new technologies to advance sustainable development. In Europe, the French l'Institut de l'Economie Circulaire has taken a leadership role in campaigning and organising events, and the Dutch non-governmental organisation Circle Economy has been developing research partnerships with public and private enterprises (Murray, Skene, and Haynes, 2015). The Ellen MacArthur Foundation has been instrumental in revitalising international discourse on the circular economy and exploring its potential in the digital economy. However, there are no equivalent institutions in India or the ASEAN region specifically dedicated to the circular economy or exploring the social implications of new technologies. It is imperative that civil society is strengthened in this area, considering how some of these countries are rapidly urbanising. There is now a pressing need to inculcate more sustainable consumption habits in this growing population.

Intriguingly, Industry 4.0 could be an industrial transition that significantly empowers consumers. If their collective power is properly harnessed, consumers have the profound potential to reform existing patterns of production. Considering the proliferation of social and digital channels, consumers now have a significantly larger audience with whom to express their concerns and opinions about a product. They are increasingly demanding more data and accuracy about a product's performance as well as its health, environmental, and social impacts. In this regard, traditional manufacturing will need to transform from linear value chains[36] to consumer-oriented collaborative value networks[37] to respond immediately and effectively to complex and varied demand signals (Capgemini and The Consumer Goods Forum, 2015). Given this unique opportunity, civil society should be proactive in making consumers aware of their digital empowerment, and effectively utilise their collective voice to catalyse a swifter transition towards more sustainable forms of production.

[36] Wherein products and information flow in a linear and sequential order from the supplier, manufacturer, retailer, and finally the consumer (Capgemini and The Consumer Goods Forum, 2015).

[37] Future value networks will be based on widespread collaboration and enabled by IoT; driverless cars; smart, mobile, and wearable devices; social networks; virtual and augmented reality; 3D printing; and robotics (Capgemini and The Consumer Goods Forum, 2015).

6. Conclusion

India, like countries within the ASEAN region, has initiated some progressive steps towards the circular economy. However, these measures (primarily directed at waste management) do not go far enough to catalyse a macroeconomic transition. Moreover, given the nascent state of the circular economy discourse in these countries, there is a very real risk that the profound circular economy opportunities inherent in Industry 4.0 will be overlooked.

Multilevel governance approaches for these countries should originate primarily at the macro level with the formulation of national circular economy policies and strategies (along with appropriate indicators). Policies should be directed not just at waste management but at circular product design and manufacturing processes and the creation of a recycling-oriented society as well. These policies can also be adapted at the meso and micro levels (such as the approach taken in China).

Policies and strategies will also need to be developed with respect to Industry 4.0. While developing countries must strengthen their capabilities in Industry 4.0, they should also ensure that it is effectively deployed to support circular and inclusive growth. Guidelines for supporting the adoption of new technologies could be developed, having regard to both their circular and inclusive growth potentials, amongst other things.

Governments at the macro and meso levels and international as well as national actors should fund and facilitate pioneering circular projects involving new technologies, convene research partnerships on new technologies and the circular economy, and support the creation of a robust entrepreneurial ecosystem in this area.

Firms at the micro level must be encouraged to develop and implement circular economy practices, support R&D, and participate in multi-stakeholder research collaborations in this field. They should also showcase and disseminate new technologies that enable circular practices and solutions. Significantly, a substantial shift in corporate culture is needed. Given the opportunities now being presented by new technologies, firms will need to move beyond working in isolation and participate more collaboratively towards realising circular solutions within and between supply chains and across sectors.

Governments at the meso and micro levels and civil society actors will play an important role in popularising the circular economy discourse in their communities. Civil society and academia will also be instrumental in influencing and contributing to the public policy debate, and conducting research exploring the social implications of an Industry 4.0-enabled circular transition.

Finally, civil society actors (particularly think tanks and non-governmental organisations) will need to create a groundswell of support for the circular economy, alerting the public to its potential to unfold as a digital revolution and advancing sustainable consumption preferences within society at large. Significantly, civil society is now uniquely positioned to harness and leverage the collective voice of consumers who, perhaps now more than ever, have the profound ability to progressively reform and reshape existing production chains in this digital era.

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