Chapter 11

Managing the Transition to Industry 4.0 through Multilevel Governance Systems

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Chapter 11

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1. Introduction

A fourth industrial revolution may provide great opportunities for Southeast Asia as it combines managing growing pressures on resources and the environment and takes advantages of a transition to a resource-efficient and ultimately regenerative circular economy. This is increasingly being acknowledged by governments, the private sector, and civil society. However, leapfrogging to a circular economy is not trivial. A systemic transition is needed in the use and recovery of resources in the economy, ensuring future jobs and competitiveness; outlining potential pathways in innovation and investment regulation; tackling harmful subsidies; increasing opportunities for new business models; and setting clear targets.

This chapter outlines some of the opportunities for innovation policies using examples from Germany and the European Union (EU). In that context, the chapter will also highlight some barriers and opportunities in a multilevel governance system.

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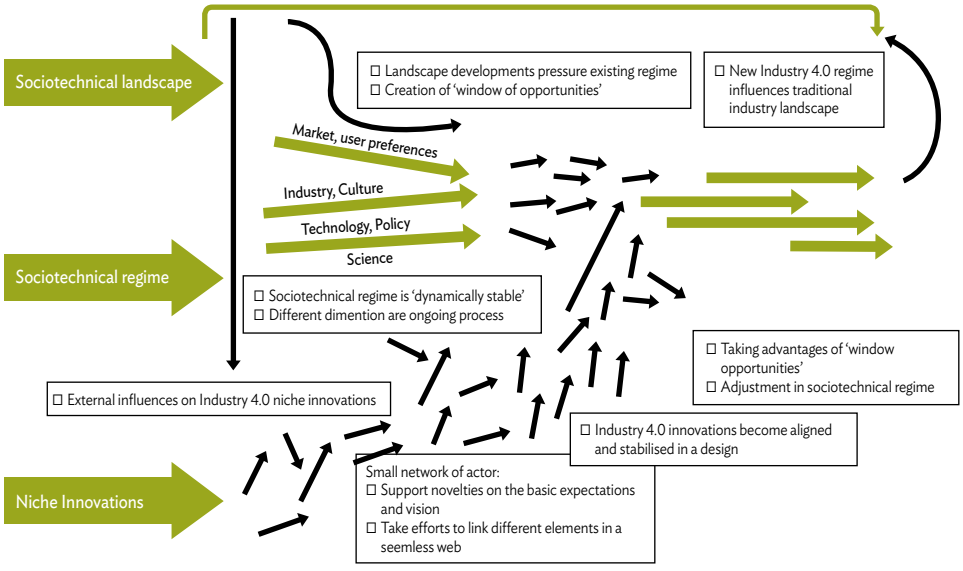
2. Transition towards a Sustainable Industry 4.0

Countries are different and the institutions that define these differences are described by several scholars using different approaches and definitions. This section explores some political science theories in innovation and industry policy. There are several studies examining the influence of the concepts of corporatism, coordinated market economy, consensus democracy, epistemic communities, and European integration on policy performance (Bernauer and Koubi, 2008; Haas, 1999; Neumayer, 2003; Scruggs, 1999). This section will compare some of the key institutional indicators with the ability of countries to move towards an Industry 4.0 approach. It aims to shed some light on the transferability of related innovation and industrial policies to Southeast Asia.

Transitioning from Industry 4.0 innovation niches to a mature circular economy landscape is a complex and challenging process that requires a policy and institutional environment that is dynamic, which is vital to enable innovations, but is also stable, which is essential to attract investments. Transition towards an Industry 4.0-led circular economy would be considered a radical shift towards a different economic system. The scope of the change requires innovations that range from technological breakthroughs to longer-term changes within the existing regime, all of which are gradually emerging through the sociotechnical system (Geels, 2002, 2011).

Figure 1. Transition Process of Industry 4.0 Innovations



Source: Based on Geels, 2002.

2.2 Consensus-focused Institutions as Enablers for Industrial Transitions

A central element of many consensus democracies is a corporatist institutional structure that allows a more coordinated approach to policymaking with a small number of large peak organisations (Goldthorpe, 1984). This closed-shop approach enables the formation of epistemic communities as it substantially limits the number of players that need to be convinced. The comparative advantage of consensus democracies also relates to a number of other elements that characterise these countries, such as the 'shadow of state regulation' (Scruggs, 1999) and a broad acceptance of government regulations due to a history of strong penetration of the state in areas such as the labour market and social policy (Woldendorp, 1997). The institutional structures of a consensus democracy are the primary drivers behind political stability and continuity that create better industrial and innovation policies over the long term, which are vital for a transition to Industry 4.0 (Lundqvist, 1980; McGuire and Olson, 1996). Corporatist institutional arrangements are characterised by a strong relationship between large encompassing groups that enable decision makers to negotiate policy in a way that is distinctively different from policymaking in pluralist, majoritarian democracies (Hall and Soskice, 2001). These groups are integrated into the policy process in a corporatist country and broaden the basis of policies, which create a high level of continuity that is required for long-term investments (Lehmbruch and Schmitter, 1982). This coalition building locks groups into certain policy directions that further enhance policy progress, which is almost self-reinforcing (Katzenstein, 1978).

The institutions that enable a broader consensus amongst political groups and societal actors are described by several scholars using different approaches and definitions. Democratic systems can largely be divided into two major categories: majoritarian and consensus democracies (Crepaz, 1995; Lijphard, 1999). Majoritarian systems are characterised by the concentration of power in one party and minimal winning majority cabinets, a two-party system, non-proportional election systems, interest organisation pluralism, centralised forms of government, unicameral parliaments, constitutional flexibility, absence of judicial review, and executive control of the central bank. Consensus democracies, on the other hand, are characterised by a coalition government, balance between executive and legislative powers, proportional representation, interest group corporatism, federalism, bicameralism, constitutional rigidity, judicial review, and independence of the central bank (Lijphart, 1999). Note that these combinations are not a definitive list of characteristics but an indication of typical elements of countries that can be described as majoritarian or consensus democracies. Due to its characteristics, it could be argued that majoritarian democracies, such as the United States, Australia, and the United Kingdom are decisive and are able to implement innovation policies faster than their consensus-focused counterparts (Lah, 2017a).

2.2 Reliability as a Factor of Success for Innovation Policy

A decisive factor of success for innovation policy is the reliability of the policy environment over the long term. This challenges the theory that majoritarian democracies are more effective and argues that consensus-orientated democracies are more likely to be successful in moving towards sustainable development and a circular economy over the long term. It is argued that consensus democracies are even more responsive and decisive than majoritarian systems, at least over the longer term, because of the more coordinated interaction with societal actors (Lah, 2017b). This positive impact on the stability of the policy environment depends on a number of elements that are characteristic of a corporatist country, for example, comparatively encompassing interest groups, the 'shadow of state regulation', and a broad acceptance of government regulations due to a history of strong penetration of the state in areas such as the labour market and social policy (Scruggs, 1999).

The institutional structures of a consensus democracy are the primary drivers behind political stability and continuity. Corporatist institutional arrangements are characterised by a strong relationship between large encompassing interest organisations that enables decision makers to negotiate policy in a way that is distinctively different from policymaking in pluralist, majoritarian democracies. There is still a debate about corporatism creating more positive impacts, particularly on socio-economic performance (Schmidt, 1982; Cameron, 1984), than negative impacts (Therborn, 1987). Corporatist institutional interaction is characterised by less collective protests and strikes (Schmitter, 1981), which indicate political stability, but no definitive answer can be translated into the Southeast Asian context. However, engagement and coordination of key societal actors clearly help create a lasting partnership and coalition on which transition to Industry 4.0 in Association of Southeast Asian Nations (ASEAN) member countries can be built.

It can be claimed that corporatism is beneficial for innovation policy development and outcomes, but here it is argued that it is only if the encompassing groups have vital interests that foster environmentally sustainable policies. These groups are integrated into the policy process in a corporatist country and broaden the basis of policies, which create a high level of continuity that is required for long-term investments. This coalition building locks groups into certain policy directions that further enhance policy progress, which is almost self-reinforcing (Katzenstein, 1977, 1987). A similar effect is expected from consensus democracies and coordinated market economies.

2.3 European Integration as a Driver of Industry 4.0

A high level of integration into a framework beyond the nation state acts as an additional factor for policy continuity, which helps in the transition towards Industry 4.0 in the case of the EU. It also results in policy action and may enhance policy implementation as outcomes are externally monitored. The interrelations between European and domestic politics and policies create a new dimension for societal and political actors. The European level opens new opportunities, but potentially also constraints, to pursue specific political interests. This provides societal actors with an opportunity to advocate for, for example, innovation policies, even if this issue has no or little priority in the domestic political agenda.

Even more importantly, there are formal institutions in the EU, which provide the opportunities for innovation policy initiatives. They also create a policy environment that is less dependent on national elections and hence, less likely to become subject to radical change after an election (Weidenfeld, 2010). The 'logic of appropriateness' (March and Olsen, 1998) and processes of persuasion in the EU are mediated by the influence of change agents who persuade others to adjust national interests to the overarching European framework and the European political culture, which aim for political consensus and cost-sharing (Börzel and Risse, 2009). The EU influences directly and indirectly the innovation and industrial policies of its member states (Jordan, 2001; Vogel, 2003; Boerzel and Risse, 2009). Due to its supranational character, the EU is a significant policy driver, which acts as a contributing factor to more political continuity. While the ASEAN framework has no supranational character, a common research and innovation framework for Southeast Asia may at least help pursue ideas collectively and on a more consistent and longer-term basis, which may eventually feed into national policy processes.

2.4 Institutions that Enable a Transition Towards Industry 4.0

Consensual political institutions as outlined by Lijphart and Crepaz (1991) cited in Lah (2017a) may lead to higher levels of policy continuity, which, in turn, would have positive effects on industrial transition processes. This approach also adopts the theoretical concept of 'encompassing organisations' (Olson, 1982) and examines the relationships between political and societal actors and their ability or inability to negotiate policies that are based on broad majorities in both politics and society. Crepaz (1991) cited in Lah (2017a) argues that multiparty coalition governments with proportional representation and negotiation power are more effective in lowering unemployment and inflation, hence creating a more favourable socio-economic environment. Crepaz (1995) and Lijphard (1999) provide conceptual frameworks and supporting evidence that governments with consensual, inclusive, and accommodative constitutional structures and wider popular cabinet support act more politically responsible than more majoritarian, exclusionary, and adversarial countries.

In countries with corporatist institutional structures, major policy issues are negotiated in a concerted effort by organised interests. Studies in this domain usually focus on the interaction between unions and employer organisations to negotiate socio-economic policies. Policy coordination amongst organised interests facilitates favourable policy outcomes, which, in this study, relates to high levels of energy efficiency and low levels of greenhouse gas emissions. According to this, a high level of corporatism may influence the implementation and improvement of policies with a long-term focus. There are several elements that may support this. For example, comparatively encompassing interest groups, a consensual social partnership, the 'shadow of state regulation', and a broad acceptance of government regulations due to a history of strong penetration of the state in areas such as the labour market and social policy (Scruggs, 1999). Interest groups are integrated into the policy process in a corporatist country and they broaden the basis of policies, which create a high level of continuity that is required for long-term investments. This coalition building locks groups into certain policy directions that further enhance policy progress, which is almost self-reinforcing (Katzenstein, 1977). As a response to the economic downturn, high unemployment, and inflation rates triggered by the oil price shocks in the 1970s, several countries with open economy used corporatist structures to cope with increasing policy pressures (Goldthorpe, 1984; Katzenstein, 1977; Woldendorp, 1997).

The concept of coordinated market economies is very similar to the general concept of corporatism, as it relies on formal institutions to regulate the market and coordinate the interaction of firms and firm relations with suppliers, customers, and employees (Hall and Soskice, 2001). Coordinated market economies can be characterised as having long-term relations between key actors in the economy. The focus in research has been the relationship between trade unions and employer associations. These long-term, cooperative relations provide coordinated market economies with a comparative advantage that positively affects the policy continuity and policy capability of a country as corporatist structures do.

Hall and Soskice (2001) argue that the hands-off policy approach and uncoordinated interaction between policymakers, and economic and societal actors, which characterise liberal market economies, put these countries on a relative disadvantage compared with coordinated market economies. The strong interlinks between industry, banks, government, and non-governmental organisations in coordinated market economies are considered to cause inertia, but also continuity and policy stability (Amable, 2003; Streeck and Yamamura, 2001). The analysis of the potential relationship between carbon intensity and continuity and coherence indicators gives some indications of clusters of countries that represent certain institutional arrangements and governance structures.

3. Industry 4.0 Innovation Policy: Examples from Germany

The concept of Industry 4.0 originated from Germany and it aims to generate greater productivity through resource efficiency and investments in people and technology (Buhr, 2015). The German approach to Industry 4.0 is to boost human-orientated development as much as technological development. Industry 4.0 is seen as a sociotechnical system that will not outsource workers but will broaden its work spectrum and offer access to knowledge and training. Technological innovation needs to focus on easy access and operation for consumers, interconnectedness, and individualisation of products. The efficiency of resources can be planned, developed, monitored, and optimised (BMBF, 2015). These areas of action are a priority for the German government – open standards for networking; automation of complex systems; widespread broadband infrastructure; safety, privacy, and security; clarification of work organisation for people; continued education; legal framework; and resource efficiency. A clear focus of the government on standards, legal regulations, and financial incentives or facilitations, is crucial for the successful implementation of Industry 4.0.

The German Federal Government sees Industry 4.0 as a central part of a future plan to lead the economy into a sustainable future and maintain Germany´s role as a global economic powerhouse. Several innovation policy and infrastructure initiatives started to enable this transition, for example, by investing in the interconnectedness of the virtual and physical worlds to a cyber-physical system (CPS). These CPSs will have intelligent sensors to interact with their environment and self-assess products, machines, and equipment to optimise and self-regulate (BMWE, 2014).

Germany is a place for innovation and industry, with about 15 million jobs that are directly linked to production. To keep businesses in the country, industry needs to evolve and change. The value of Industry 4.0 for the economy will lead to higher quality and productivity, increased flexibility, standardisation of development processes, as well as quicker production to bring products on the market (BMWE, 2014). The focus for the German government is on:

i. the expansion of high technology sectors, for which the federal government will promote the development of autonomous systems, smart services, and digitalisation of medical-related systems;
ii. the establishment of platforms to manage big data and make it more consumer friendly;
iii. the investment in people and their training in high technology sectors; and
iv. the investment in medium-sized companies (BMBF, 2016).

One of the main driving factors for the development and support for Industry 4.0 is the economic value that it can bring and the necessity to develop resource efficient production ways and products. For example, a BMBF-funded project develops a resource conserving production chain with zero-waste-production. This is one goal to keep the need for limited resources as low as possible and to create a circular economy in which all products can be produced efficiently and reused afterwards. Intelligent systems will be able to provide relevant data for life cycle management at any time and in any location, which will be necessary for increased efficiency and waste reduction. Intelligent systems will provide policymakers with reliable data to develop an optimised sustainable recycling circle (Velis and Brunner, 2013).[1] Government policies need to mirror this development and adapt existing policies to accommodate innovation and ensure sustainability safeguards.

3.1 Governance and National Innovation Systems in Germany

The German government sees an active role for itself in the transition to the fourth industrial revolution. It sees its role in creating an innovation-friendly environment and fair competition within the international actors, as well as 'financing possibilities' (Die Bundesregierung, 2016).

The German Federal Government sees the need to accelerate the launch of start-up companies to facilitate market access, which needs a regulatory framework and industry standard that enable innovation. Traditionally, Germany's industry works within a 'closed innovation' circle, which means that no technical invention will be spread outside the company. Yet, Industry 4.0 will change this towards an 'open innovation' strategy, which means to circulate ideas, innovations, and skills sets (Buhr, 2015). Cohen and Levinthal (1990) spoke about 'absorptive capacity', which means the power of policy instruments to promote this openness and enhanced networking (Cohen and Levinthal, 1990). This has to start with educational changes, promoting interaction, network building, and funding inter-disciplinary projects or the transfer of research from funded projects (Buhr, 2015). The German government is funding companies that can profit from the digitalisation of their industry and will especially support small and medium-sized enterprises to apply Industry 4.0 approaches.

[1] http://www.res-com-projekt.de/index.php/home_DE.html

3.2 Investing in Industry 4.0 Innovations, Examples from Germany

Investing in research and innovation can make a vital contribution to the transition to an Industry 4.0. The German Federal Ministry for Research and Education plays an active role in this by funding a range of research projects geared towards innovations for an Industry 4.0. The following section briefly summarises some of the recent projects in this area.

The research project BaZMod (component-specific machine configuration in production by cyber-physical additions) developed an integrated strategy, which can communicate between the tool and its environment (time frame: 3 years, volume: €4,040,000). The intelligent documentation of machines, which will, with increased digitalisation, only be done by machines in the future (time frame: 3 years, volume: €3,704,000). The intelligent network in production is another example of German government funding, which will be necessary with increased consumer requirement and the need for resource efficiency (time frame: 3 years, volume: €11,100,000). To achieve a timely knowledge of production to be able to influence events, the research project eApps4Production will provide knowledge and information in real time, which CPSs can access (time frame: 3 years, volume: €3,656,000). Intelligent cooperation and networking is important when working in production to create flexible and small-amount production parts (time frame: 3 years, volume: €4,234,000). To react flexibly to increased or decreased capacity needs, the KapaflexCy project will enable industry to plan in a timely and flexible manner the use of staff (time frame: 3 years, volume: €5,560,000). To react quickly to changes in production, the production machines must be changed. This will be done through a standardised system and developed by the research project KARIS PRO (time frame: 3 years, volume: €5,057,000). To be able to create CPSs, all disciplines of production must be synchronised, such as mechanics, electric, informatics, and the like (time frame: 3 years, volume: €4,364,000). The research project metamoFAB is creating the change towards an intelligent industry within the companies itself, which means the development of a connected industry with itself and others (time frame: three years, volume: €4,500,000) (BMBF, 2015). The development stages of Industry 4.0 vary from pilot-phase initiatives to market-ready companies. As part of a federal programme to support Industry 4.0 companies, 249 businesses identified themselves as taking an Industry 4.0 approach. The following sections show some illustrative examples.

F&M Maschinenbau in Berlin has started to use intelligent software solutions to enable employees to organise their work more efficiently and to prioritise the orders intelligently, taking third party deliveries into account. Barcodes at every station help further to deploy

personal, more efficient, and open-sourced hardware, which guarantee low cost.[2] Another example is PRO-OPT, a big data production optimiser for smart ecosystems. It helps to collect volumes of generated data and develop an integrative modelling approach, which models along with the restrictions on their use and quality. The secure data can be further analysed by the companies involved and integrated into its own processes.[3] The sHub for smart motors has been successfully integrated in the HIPERFACE DSL company in Baden-Wurttemberg. This element can be integrated at the motor of a production machine and predict the next necessary maintenance, hence avoid an unplanned machinery shutdown.[4] The company Bayer developed a management system for a modern light-emitting diode street lighting called 'Intelligent City 2.0', which works through an internet-connected cloud software CityTouch Light Wave and communicates with light-emitting diode light bulbs independently. The illuminance can be controlled according to the individual lighting situation. The intelligent software can find any fault in the light bulbs and automatically sends a report; it follows a programmed protocol to ensure the operation continues safely.[5]

3.3 Funding for Innovation Start-ups

It can be challenging for small start-up businesses with weak financial security or history to attract investment or find start capital. The German government wants to help these companies through a special funding strategy and tax exemption. Start-up businesses are necessary for a successful implementation of Industry 4.0 in Germany and they will get initial capital through various programmes like INVEST – Zuschuss für Wagniskapital (grant for venture capital), a start-up funding programme for science (EXIST) (BMWE, 2016). The German government is also exploring funding options from crowd investing or crowd funding and will support society to organise itself.

The first important step towards Industry 4.0 is to create a fast internet access because one core factor of Industry 4.0 is the connection between real and virtual realities to ensure smooth data exchange (Wirtschaftsrat Deutschland, 2013). This increased data exchange entails some pitfalls for data security for companies and individuals. It is especially important to secure personal data from third parties without the consent of the person,

2 http://www.plattform-i40.de/I40/Redaktion/DE/Anwendungsbeispiele/239-auftragsverwaltung-als-basis-zur-schrittweisen-einfuehrung-von-industrie-4-0-komponenten-f-m-maschinenbau-gbr/beitrag-auftragsverwaltung-als-basis-zur-schrittweisen-einfuehrung-von-industrie-4-0-komponenten-f-m-maschinenbau-gbr.html

3 http://www.plattform-i40.de/I40/Redaktion/DE/Anwendungsbeispiele/298-dsa-daten-systemtechnik-pro-opt/beitrag-dsa-daten-systemtechnik-pro-opt.html

4 http://www.plattform-i40.de/I40/Redaktion/DE/Anwendungsbeispiele/230-shub-enabler-for-smart-motors/beitrag-shub-enabler-for-smart-motors.html

5 http://www.plattform-i40.de/I40/Redaktion/DE/Anwendungsbeispiele/200-intelligent-city-2-0/beitrag-intelligent-city-2-0.html

as well as to secure business-related data. In such cases, the government must legally protect the security of data within the new area of Industry 4.0. The international uniform data protection laws create insecurity, and uniform laws, at least for the EU, have to be provided (Wirtschaftsrat Deutschland, 2013). However, these standards and laws must be enforced abroad as well. Security and intellectual property rights are also important considering the increased digitalisation and the potential security issue from manipulation or data loss. The government is responsible for providing secure infrastructure and formulating standardised data security for the EU or the international community (Wirtschaftsrat Deutschland, 2013).

3.4 Investing in Human Capital and Innovative Start-ups

The introduction of CPSs will permanently change the relationships between people, manufacturing, and the kind of work that people are used to. The change towards Industry 4.0 needs to address the quality of the products as well as the satisfaction of the people, their health, and the related knowledge and competence development of workers (Botthof and Bovenschulte, 2009). The digitalisation of production can potentially bring many positive results for workers: flexible work time, balance between family and work, and easier integration of elderlies or disabled people. Yet, without supervision and the right policies, Industry 4.0 could also become more stressful for people or a means to exclude many (Buhr, 2015).

One task of government and industry is to create an environment in which people's motor skills are not replaced by intellectual machines; they can also develop their thinking, association, and sensory skills. These human capabilities will never entirely be replaced by machines (Spath et al., 2013). Yet these skills must be developed, especially the necessary creative potential and systematic competences required to efficiently use it. Machines should primarily be employed to replace repetitive work to relieve the worker.

Labour organisations could be replaced in the process of digitalisation and new industrialisation. Which form they will take in the future is less clear. One scenario could be a small group of experts, which has the qualification and knowledge about the whole process to make all important decisions, while others suggest a swamp organisation in which workers act as a collective (Hirsch-Kreinsen, 2014). Both scenarios need trained and educated people at the centre and it is partly the government's responsibility to enhance people's abilities and knowledge through training and education.

5. Co-benefits and Coalitions to Support Innovation

5.1 Potential Co-benefits of Industry 4.0 Innovations

Industry 4.0 strategies that help achieve economic, social, and environmental policy objectives can have a far more extensive overall impact on sustainable development and rely on broader political support than business innovations that only deliver economic benefits. Only a few studies have examined the total cost of industry, including air pollution, environmental degradation, and social issues, and the total potential benefits of policies and programmes that reduce these negative impacts. When developing business cases for Industry 4.0 innovations, an assessment of the wider societal benefits that may be high on the agenda of important policy actors and stakeholders may help strengthen the case to find additional support for the implementation. Energy security, access to jobs and markets, affordability, air quality, health, and climate change are all powerful policy objectives that need to be considered when designing Industry 4.0 innovations that are geared towards a high level of synergies and co-benefits.

5.2 Coalition Building Potential of Circular Economy Approaches

Boosting Industry 4.0 innovations and supporting the transition towards a circular economy are complex and multifaceted activities. Policy interventions in this sector can have unintended positive and negative consequences as they rarely only affect one objective. For example, air quality measures may affect resource or energy efficiency negatively or vice-versa. Linking and packaging policies are therefore vital to generate synergies and co-benefits between measures. These provide a basis for coalitions that can align different veto players. An integrated policy approach can help overcome implementation barriers, minimise rebound effects, and create the basis for coalitions amongst key political actors and societal stakeholders.

There is a growing number of examples of successfully implemented Industry 4.0 innovations and policies that provide substantial economic opportunities and other sustainable development benefits. Only an integrated approach can achieve economic outcomes that benefit society entirely and help reach international climate change and sustainable development goals.

Different people, groups, and institutions may have different priorities. For example, some may be motivated by economic objectives and others by social equity or environmental objectives. The diverse benefits offered by a comprehensive or integrated measure can help build broad community support. The nature of integrated circular economy policies is that they address several objectives simultaneously, which generates synergies and helps create coalitions. The political and institutional contexts in which policies are being pursued are vital factors for the success or failure of implementation (Jänicke, 1992). Institutional aspects, such as the presence or absence of an environment ministry at the national level or an environment department at the local level and their respective roles in the process as well as their legal power, budget, and political influences are likely to affect the implementation of (primarily) sustainability-related measures (Jänicke, 2002).

Support from diverse businesses, political actors, stakeholders, and the public is vital for the success of innovation policies and circular economy strategies. A societal perspective and the incorporation of sustainable development objectives are vital steps in forging coalitions and building public support. The policy environment, the context in which decisions are made, is vital for the success of the take-up and implementation of Industry 4.0 measures (Justen et. al., 2014). This context includes not only socio-economic but also political aspects, considering the institutional structures of countries. The combination of business and policy objectives can help build coalitions but can also increase the risk of failure of the package if one measure faces strong opposition, which can be overcome if the process is managed carefully. A core element of success is the involvement at an early stage of potential veto players and the incorporation of their policy objectives in the agenda setting (Tsebelis and Garrett, 1996).

Veto players are political actors who have distinctive roles in the policy process and can put a hold on an initiative. Typical veto players are finance ministries and parliaments with legislative prerogatives. This is a substantially different role from stakeholders who have vested interests in a policy process but do not have the (legal) power stop it. However, both groups need to be involved in the process to successfully implement a measure. Public participation can help ensure stability and support beyond political parties. There is a causal relationship between policy objectives, agenda setting, institutional structures, and policy outcomes (Tsebelis, 2002 and Lijphart, 1984 cited in Lah [2017c]). The synergies explored in this paper provide a basis for the inclusion of veto players into the policy process, which is vital for the uptake of Industry 4.0 innovations.

6. Discussion and Conclusion

Transition towards Industry 4.0 requires a consensus on the need for policy intervention and a strategic, coherent, and stable operating environment. Policy interventions in the various sectors that make up Industry 4.0 require a clear political vision to drive change rather than to follow it. This requires a strong political commitment to bring Industry 4.0 on the policy agenda and to remain in place as transition relies on investments for long-term change. This policy environment prevails in the EU and some of its member states where a mixture of national and supranational institutional structures ensures a relatively high level of continuity that can mitigate political volatility to a certain extent and foster policy coherence through integration. Copying singular measures or adopting isolated technologies will not help in the transition towards Industry 4.0 in Southeast Asia. What is needed is a common approach amongst ASEAN countries and a commitment from each of the member states to bring a common vision into national policies. An ideal first step in that direction would be setting up a joint ASEAN research framework programme that identifies policies and technologies that can help Southeast Asian countries develop into sustainable societies with innovative and productive industrial economies.

Considering that significant and diverse benefits can be gained from Industry 4.0 innovations that increase resource efficiency, their uptake is far lower than economically justified. Shifting to a circular economy pathway requires substantial reforms and investments into innovations. Many of these are options that provide significant economic, social, and environmental co-benefits and can therefore conserve energy, resources, and reduce emissions cost effectively. Because of their significant and diverse benefits, they offer opportunities to build coalitions involving many different stakeholders with various interests. This is true for Europe and Southeast Asia. This can help build support and strengthen the political case for the shift towards a circular economy. Successful strategies need to be integrated across policy areas, regions, and levels of government in close cooperation with innovators, start-ups, and traditional industries.

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