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Lessons of eco-transition of a rural small town: The case of Manzhuang China from raw material processing industries to a circular economy

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ABSTRACT

Eco-transition has been a national priority policy in China. However, underdeveloped areas, such as small towns in rural areas, may face challenges in pursuing this policy due to a shortage of resources and externalities. This research, based on ecological modernisation theory, carried out a case study of *Manzhuang*, China, to explore how comparatively underdeveloped areas cope with the requirement of eco-transition to a circular economy from raw material processing industries. The research found that eco-transition guided by the concept of eco-modernisation requires integrated social, institutional, technological, and various sub-systems transformation as a whole. It is also necessary to take into account changes in the market. It is not enough to consider the improvement of technology alone. The research also showed that the socio-economic bottleneck relating to middle-stage industrialisation and fierce regional competition for investment has led to a dilemma in implementing such a policy agenda. This situation is particularly acute in underdeveloped areas. It is argued in the research that the local application of a circular economy as a means of implementing sustainable development may lose its significance without macroeconomic restructuring and regional coordination if it is to be achieved in comparatively underdeveloped areas.

1. Introduction

The circular economy has been promoted worldwide over the last two decades, with notable adoption in countries like Denmark, Germany, the Netherlands, the UK, Japan, and China (Geissdoerfer et al., 2017). The circular economy proposes a paradigm change from the traditional linear model to closed-loop systems that emphasise resource circulation (Lieder and Rashid, 2016). This approach aims to achieve an ecological economy by minimising waste and pollution through product life extension strategies such as reuse, remanufacture, and recycling (Lieder et al., 2017). As a sustainable development initiative, the circular economy focuses on decoupling economic growth from finite resource depletion. It accomplishes this by promoting material cycles and a transition towards renewable and cascading energy flows, thereby minimising the overall material and energy throughput within societal production-consumption systems (Korhonen et al., 2018a). As an innovative model, the circular economy maximises the utility and value of products, components, and materials, the process of which shows a commitment to sustainability (Awan et al., 2022). Implementing a circular economy fosters economic growth while reducing costs, natural resource consumption, and environmental pressures (Kalmykovaa et al., 2018). Moreover, the circular economy intends to minimise costs by recovering and reusing materials, developing better processes, and reducing the need for landfills (Awan et al., 2023). The European Commission (2015) advocated for a circular economy to retain the value of products, materials, and resources within economic operations and minimise waste generation.

China, a country with the largest population in the world but with a relative scarcity of natural resources, has shifted its development trajectory away from its former reliance on resource consumption in the last 10 years (Yu, 2014a). In 2006, China initiated an eco-transition policy in its Eleventh Five Year Plan for National Economic and Social Development. The Plan emphasised adopting a circular economy to protect the ecological environment and establish a resource-saving and

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environmentally friendly society, ultimately promoting sustainable development (The State Council, 2020). The development path has shifted, driven by environmental reforms that aim to foster green GDP and a circular economy alongside economic growth, a process seen as ecological modernisation (Boksh and Islam, 2015; Mol, 2006; Zhang et al., 2007).

Several studies have explored eco-transition, focusing on direct factors such as policy (Ma et al., 2022), environmental technical standards (Wan et al., 2022), and the significance of technology (Zhang et al., 2021; Zhao et al., 2023). They also consider other contextual settings, employing a statistical approach (Shi et al., 2010; Yu et al., 2014). The assumption seems to be that eco-transition can be achieved by influencing supply factors, seemingly ignoring external factors. However, it overlooks various factors including the disparities in research and development (R&D) capacity among regions, cities, and towns in China. Small towns and underdeveloped areas are likely to face significant resource constraints, including finance, professional talent, and skilled labour. Addressing these constraints and supplying the required resources require more comprehensive and systemic reform. These factors may be crucial in determining the success of eco-transition or ecological modernisation. Despite these limitations, many small towns have become home to highly polluting industries due to the relocation of such industries from prosperous large cities, particularly those in East China. This industrial relocation is propelled by metropolitan efforts to foster high-value service sectors and adhere to stringent environmental regulations mandated by the central government. As a result, many polluting industries have re-established themselves in small towns or West China. This phenomenon is similar to the process of technology transfer and foreign direct investment (FDI) from developed to developing countries (Kheder and Zugravu, 2012; Raman and Fumio, 2000; Hasan, 2018). Yet, these underdeveloped small towns are expected to achieve eco-transition or ecological modernisation to reduce carbon emission and pollution and increase energy efficiency alongside more resource-rich cities to meet national targets when China's economy plays a critical role in the world, and the average income of its people has increased significantly. This places small towns at a significant disadvantage. Understanding the constraints that may hinder eco-transition and the challenges of achieving ecological modernisation in underdeveloped areas, like small towns in China, is both valuable and necessary. The research outcomes offer valuable lessons for developing countries.

This research explores the complex challenges of eco-transition encountered by rural small towns in their efforts to achieve ecological modernisation and implement a circular economy. By examining the case of *Manzhuang,* a small town in China, the research identifies and investigates the specific barriers that impede the transition from traditional raw material processing industries to a more sustainable, circular economic model. *Manzhuang* was chosen as a case study due to its severe pollution caused by industrialisation, which adversely affected local villagers and residents. Local people had repeatedly protested to the local government against the destructive effects of raw material processing on their production, livelihoods, and health. Under the pressure of the central government's environmental protection and low-carbon and energy-efficiency policies, as well as the pressure from local residents, *Manzhuang* was forced to implement an eco-transition. *Manzhuang*'s eco-transition is a representative case of an underdeveloped region. Undoubtedly, industrial eco-transition, including the delivery of a circular economy, plays a positive role in promoting economic growth, energy saving, emission reduction, efficient use of resources, and cost reduction. However, there is still a research gap in understanding the decision-making process in eco-transitions, including the related incentives and regulatory decision-making to promote a circular economy (Awan et al., 2022) as a type of transition. The specific problems and challenges encountered in regions with low levels of economic development have not been extensively explored in the literature. Understanding these challenges and finding ways to address them is crucial for effectively implementing eco-transitions for sustainable development. Otherwise, eco-transitions may end up being just an empty strategy. This paper makes a significant contribution by researching, observing, analysing, and discussing the impacts of policies. Additionally, the theory of ecological modernisation, an important theory of eco-transitions, faces similar challenges. While it is recognised as a theory to support strategy at global and national levels to promote economic growth while controlling pollution and emissions, the implementation problems at the local level are rarely analysed and discussed. This paper addresses the gap between the theoretical promises of ecological modernisation and the practical difficulties in underdeveloped areas. It focuses on the constraints and challenges encountered in *Manzhuang* and aims to offer insights into sustainable development in developing countries, too.

The authors utilised a thorough mixed-method approach to data collection and analysis to conduct this research. The data collection took place over three months before the pandemic (between May and August 2019) and began with participant observation, allowing the researchers to deeply engage in the local context and witness the dynamics of the eco-transition. This was complemented by unstructured interviews, which facilitated open dialogues with various stakeholders, including local government officers and entrepreneurs from various industrial sectors. Thirty-four local government officers were interviewed to gain insights into environmental protection policies and the promotion of eco-transition, while twenty-three entrepreneurs, including managers and owners from seven different industrial companies, were interviewed to understand the challenges and constraints of eco-transition from an entrepreneurial perspective. These interviews provided a detailed account of the viewpoints, difficulties, and revelations surrounding the eco-transition initiatives. A comprehensive assessment of all available papers was also carried out, including a broad range of sources such as industry reports, government documents, meeting minutes, and internet sites that provided a broad overview of the policy and business environment. A thematic approach was used to analyse the qualitative data gathered from observations and interviews. This process involved coding the data, searching for themes, and conducting a critical review to ensure that the findings were robust and representative of the participants' experiences. To identify important trends, policy changes, and issues relevant to the eco-transition, the information was synthesised as part of the document review analysis. The study was based on the ecological modernisation theory, which provided a conceptual framework for analysing the data and comprehending how environmental sustainability and economic development interact.

This study uses *Manzhuang,* a rural small town as a case to examine the transition towards a circular economy in rural areas, highlighting the challenges of implementing ecological modernisation. The research identifies several obstacles, including market dynamics, regional competitiveness, and a shortage of skilled labour, which often overshadow the long-term environmental benefits of eco-transition efforts. By addressing an underexplored gap of eco-transition in underdeveloped areas and market dynamics in ecological modernisation theory, this study emphasises the need for a more context-sensitive approach to ecological transitions. The authors advocate for integrating market mechanisms to balance economic and environmental interests, institutional support to promote sustainable practices, and technological innovations to improve resource use and efficiency.

This paper is structured into five parts. Building upon this introduction, the next section delves into a comprehensive review of the literature on ecological modernisation, setting the stage for our case study analysis. Section 3 explores the constraints faced by a small-town government and local entrepreneurs in their efforts to respond to eco-transition at the *Dawenkou* Industrial Park (DIP) in *Manzhuang.* Section 4 presents a discussion of ecological modernisation based on the research findings. The final section encapsulates our findings, offering insights into the barriers and challenges of ecological modernisation in underdeveloped regions.

2. Review of debates on ecological modernisation

Ecological modernisation (EM) transforms modern industrial production into environmentally friendly activities through advanced industrial practices (Huber, 1982; Morad, 2007), and fits well with the policies that emphasise economic growth while reducing environmental risks and facilitating adaptation to climate change in the world. This social theory, which was proposed in the 1980s, claims that continuing economic growth, environmental improvement and climate change mitigation (Baer and Singer, 2022), can be compatible with the capitalist system (Baer and Singer, 2022; Dorn et al., 2022) if it utilises technology and if social institutions are modernised as an integral part of industrialisation (Hajer,1995; Rinkevicius, 2000; Mol, 2001).

When ecological modernisation (EM) was at its initiative stage, Huber (1982) argued the transition towards EM requires a switchover in the industrialisation process by replacing early, dirty technology with the latest modern and improved technology. The requirement is what Jänicke and Jörgens (2004) calls a forward escape rather than a backward escape which would incorporate radical green ideas for example anti-productivity measures, de-modernisation, and de-industrialisation that have been claimed by some to be the only way to reverse environmental deterioration (Mol, 1999). EM aims to achieve a win-win situation with a balanced realisation between environmental protection and economic growth (Machin, 2019; Mastrangelo and Aguiar, 2019). Initiatives for promoting a circular economy and eco-industrial parks that make use of the latest technology and the adoption of close-loop industrial systems with notions for example, energy cascading and by-product exchange are regarded as a practical EM approach to eco-transition that is compatible with economic growth (Mol, 1999; Cohen, 2000; Gibbs, 2003; Koppen and Mol, 2009). Moreover, EM policies aim at delinking GDP growth and consumption of primary industrial products as the root of reducing pollution in the process of industrialisation (Simonis,1989; Dorn et al., 2022; Awan et al., 2023). Other preventive environmental policies and market tools, such as instrumental-level solutions, are equally important, especially as governments and corporations increasingly focus on EM as a symbolic gesture of environmentalism in their policies (Dorn et al., 2022). Gouldson and Murphy (1997) recommend that the political way to achieve this de-linkage is through promoting macroeconomic restructuring. It refers to the sectoral shift of industrial society from energy and resource-intensive production to knowledge and service-intensive production, such as high-tech and tertiary industries. Therefore, eco-transition initiatives need to be more combined with high-tech manufacturing rather than industries with high material and energy inputs.

However, it is necessary to distinguish the weak form and the strong form of EM especially in its use as a political discourse because not all the so-called EM political accommodation can bring about eco-transition in a sustained manner. Christoff (1996) criticises the EM process that overemphasises technological, and techno-corporatist change and calls it a weak form of EM. Technology-based methods can be both solutions to problems and problems themselves. (Dorn et al., 2022). As suggested by Dryzek et al. (2003), a weak form of EM only treats economic development as a priority. Nevertheless, a weak form of EM cannot bring real eco-transition because the scrutiny of a set of state political reforms as crucial components to influence eco-transition is absent. Luke (2003) comments that a weak form of EM confines itself only to instant managerial solutions to ecological problems. It is obvious that the weak form of EM merely stays focused on niche policy learning, and technological innovations while avoiding touching issues of broader social and institutional change of the current regime of industrialism and industrialisation.

The success of EM requires strong political will to adopt a strong form of ecological modernisation that facilitates competition for production and distribution, rather than a weak approach to EM. (Hasan, 2018). Christoff (1996) elevates ecological modernisation theory to view eco-transition as not only focusing on technology as an instrument but also as a more systematic and open mechanism. He (Ibid) indicates that it is required to have a broad institutional change that can be formed as a strong form of EM to promote fundamentally a long-term embedded eco-transition. It is also suggested by Dryzek et al. (2003) that the contrast between technical style and structural style solutions in the policy process determines weak and strong forms of EM. The arguments indicate that what tends to bring about the long-term eco--transition is through policy reforms and arrangements that focus on comprehensive issues and barriers instead of only on technology. However, as soon as technical policy measures are applied and begin to deliver a certain degree of transition, their intervention tends to be easily offset by the implications of other variables.

This understanding stimulates a discussion of ecological modernisation (EM), with a focus on identifying the mechanism for formulating a systematic policy agenda on the key comprehensive issues. Before undertaking an eco-transition in line with EM principles, it is essential to establish environmental capacity, which refers to a society's ability to identify and address environmental issues effectively. For instance, Weidner (2002) and Jänicke and Jörgens (2004) believe that eco-transition as policy/political discourse is ultimately the improvement of environmental capacity and argue that the centrality to view the building of such capacity is to analyse the prerequisites, development, effects, and changes of the environmental policy/political agenda. Environmental capacity is determined by the abilities of a society to identify and solve environmental problems in which the building of the environmental capacity relates to the multifactorial processes to develop those abilities (Ohiorheunuan and Wunker, 1995). Therefore, environmental capacity building can be understood as a specific process of creating the basis of eco-transition through a systematic set of policies beginning with political adjustment, institutional arrangements and interactions among actors under certain external temporal-spatial settings. Environmental capacity building is the key indicator to signify eco-transition. However, it is difficult to build the environmental capacity required by strong EM because there are many lock-ins, inertia and institutional impediments (Jänicke, 1990).

Yet much of the existing literature on EM focuses on its application in developed regions, particularly within Europe and North America, where technological capacity and institutional frameworks are more robust. Studies in these contexts emphasise the benefits of transitioning to closed-loop systems, where waste is minimised and resources are reused (Geissdoerfer et al., 2017; Lieder and Rashid, 2016). However, while ecological modernisation has been extensively explored in developed countries, there is a noticeable gap in understanding how the theory applies to underdeveloped areas, particularly rural small towns in developing nations. It is critical at a time when all countries and regions, regardless of their size, stage of development, or economic capacity and income levels, are faced with the same challenges of increasing energy efficiency to reduce pollution and carbon emissions. Underdeveloped countries and regions are unlikely to be able to emit pollution and carbon indiscriminately to promote their economic growth. Nevertheless, ecological modernisation theory rarely deals with the problems faced by the specific practices of underdeveloped countries or regions. This is of paramount importance.

It should be realised that underdeveloped countries and regions are at a great disadvantage in addressing the world's common problems of reducing environmental pollution and adapting to climate change. This is because economic development, poverty eradication, and modernisation through industrialisation remain their focus, while environmental degradation is a by-product of traditional industrialisation. EM, which has a significant influence on development discourse (Hasan, 2018), is considered an alternative path. The successful cases of EM in some affluent developed countries, achieved by applying environmentally benign technology and reorganising institutions to encourage economic growth while decoupling from the throughput of raw materials, energy consumption, and waste production, have stimulated

developing countries to follow suit. However, the present EM pattern may not be fully applicable to underdeveloped countries and regions, since their business, political, economic, and social landscapes diverge significantly from the developed countries (Hasan, 2018).

This research gap in the literature highlights a critical need to understand how the principles of EM can be applied in underdeveloped regions and what adaptations are necessary to make such transitions successful. This research contributes to the field by providing an empirical analysis of the circular economy's implementation in an underdeveloped rural context to address the gap.

3. Findings and results

3.1. Overview of Manzhuang

The town of *Manzhuang* is located in the *Dawenkou* basin, at the southern end of *Daiyue* District, Tai'an, Shandong Province in China, with a total land area of 113 km^2 (MTG, 2018). (Fig. 1).

Manzhuang is abundant in mineral resources, including high-grade, easily extractable deposits of gypsum, rock salt, natural sulfur, and coal. In particular, gypsum reserves are estimated at 36.651 billion tonnes, with an annual mining scale of 1.2 million tonnes. Rock salt reserves are approximately 7.521 billion tonnes, with 100,000 tonnes mined annually. Sulfur reserves total 3.189 billion tonnes (Manzhuang Statistical Station, 2003).

Before the 21st century, *Manzhuang* was mainly a rural area with only a small population and underdeveloped production industries. After the 21st century, *Manzhuang* started its industrialisation. Capitalising on these plentiful mineral resources, *Manzhuang* has developed construction materials, gypsum mining and processing, and agricultural product processing as leading industries. Major industrial enterprises include *Huaxin* Gypsum Products Co., Ltd., *Wenchang* Casting Co., Ltd. and *Zhendong* Co. In 2003, the total industrial output value reached 400 million yuan (Manzhuang Statistical Station, 2003).

3.2. Catalyst for transition and establishment of Dawenkou Industrial Park (DIP)

Urban renewal of Tain'an has significantly propelled *Manzhuang*'s industrialisation, prompting the relocation of industries to this resource-rich area. Tain'an Central City faced restrictions on urban development land, while its industries needed renewal, replacement, and upgrading to increase clean, high-value industries and tertiary sector development. These pressures prompted some industries, especially polluting raw material processing industries, to relocate to the southern hinterland, where *Manzhuang* is located.

The Tai'an municipal government seized this opportunity by issuing Administrative Decree 74 in 2001, which directed *Manzhuang*'s parent administrative body, the *Daiyue* District Government, to establish a management mechanism and to allocate necessary land for the proposed industrial park. In 2002, the *Daiyue* district government formed the *Dawenkou* Industrial Park Committee (DIPC). *Dawenkou* Industrial Park (DIP), with a total area of 46.8 km^2, was established adjacent to *Manzhuang* Town Industrial Park. The *Daiyue* district government required the DIP to promptly "allocate a number of manufacturing enterprises, take advantage of mineral resources and develop mineral resource economy" (Ibid., p.15). In line with the government's policies, the industrial development strategy of DIP was mainly focused on raw material processing, to accommodate enterprises relocated from the city centre. Major enterprises and projects include *Xinwen* Mining Group's RMB 600 million, 43-ha gypsum products project, and their RMB 2 billion, 74-ha salt chemical project, *Dawenkou Liyuan* Cogeneration Company Limited's RMB 50 million, 10-ha light steel and wood flooring production project, and a 66.7-ha logistics project (Manzhuang Statistical Station, 2003).

Thus, *Manzhuang* experienced large-scale industrial development. However, as numerous production lines were established, industrial pollution and waste, especially those from the gypsum mining and processing, and chlor-alkali chemical industry increased.

3.3. National policy of eco-transition and countermeasures of the local governments

After more than 30 years of rapid economic development, the income of the Chinese people has generally increased. Reducing pollution and carbon emissions, as well as increasing energy efficiency for low-carbon development, has become an important agenda for the Chinese government. (Yu, 2014b). In 2012, the 18th National Congress of the Communist Party of China (CPC) formally adopted the concept of "Ecological Civilization" as the highest national strategic policy. The concept of ecological civilization is defined as "integrated into all aspects and the entire process of economic development, political construction, cultural development, and social development." (CPC, 2012, p. 5).

Central Commission of CPC and the State Council (2015)

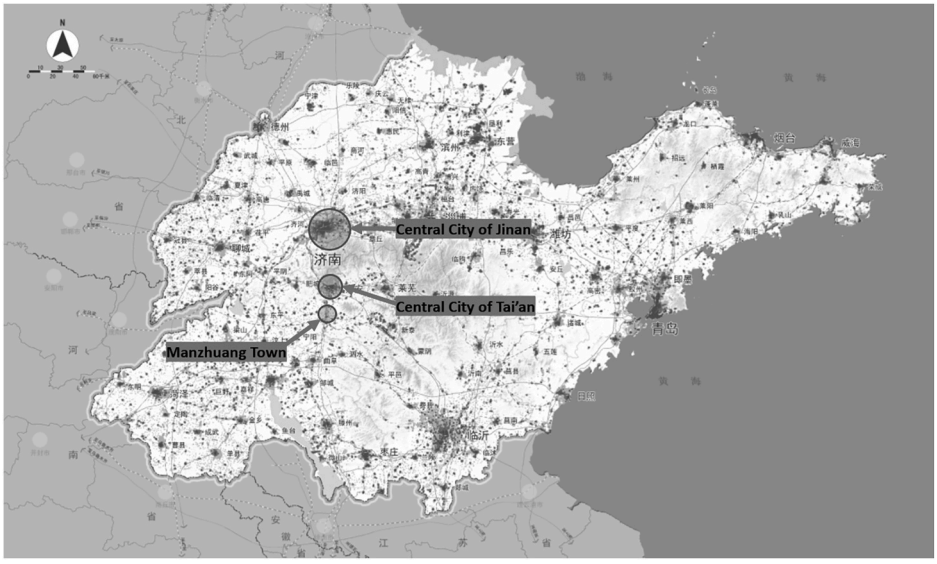

Fig. 1. *Manzhuang* town in shandong province, east China.
Source: Adopted from Shandong Urban & Rural Planning and Design Institute, 2016, Master Plan of Shandong Peninsula Urban Agglomeration 2016–2030.

subsequently issued a document stating that Ecological Civilization should pursue green, recycled, and low-carbon development, prioritising energy efficiency, environmental protection, and economic restructuring. Ecological civilization seeks practical solutions for ecological transformation by promoting economic growth while protecting the environment to achieve a win-win situation. The underlying principle is the same as EM (Gibbs, 2003; Koppen and Mol, 2009; Mastrangelo and Aguiar, 2019). Under the guidance and pressure of the national government's policy to promote a circular economy for sustainable development (CPC, 2012), *Manzhuang* needed to transition its industry to reduce pollution emissions, despite its economic and research and development (R&D) disadvantages in the region.

Aiming for ecological modernisation, the DIPC has committed to transforming the industrial park into a circular economy model, focusing on high technology and sustainability (DIPC, 2012). The 2012 Master Plan for *Manzhuang* town proposed a functional division based on the concept of an "eco-industrial park (town)". In 2017, the DIPC adopted an approach to EM by imposing a circular economy programme to facilitate the ecological transformation of the industry after pollution levels rose to unacceptable levels (Mol, 1999; Gibbs, 2003; Koppen and Mol, 2009), sparking protests from the local population (DIPC, 2017a). *Manzhuang*'s industrialisation began transforming towards a circular economy. However, it was a weak form by only emphasising technologies (Christoff, 1996; Dryzek et al., 2003; Luke, 2003).

Depending on the technology, *Manzhuang* leveraged the advantages of its nearby brine resources and the existing chlor-alkali industry by using its byproducts to expand the industrial chain downstream, generating economic and ecological benefits. It was determined that the most suitable downstream industry to consume the byproducts of the chlor-alkali industry is polyvinyl chloride (PVC), which requires large amounts of chlorine and chloride (CPCPI, 2017). *Manzhuang* planned to create a circular industrial chain with chlor-alkali as upstream and PVC as downstream by 2030 (ibid.).

3.4. Changing market conditions

Unfortunately, this research found that the plan of *Manzhuang* was impossible to achieve due to external constraints. Despite voluntary agreements for by-product utilisation, the DIPC faced insurmountable challenges in establishing a complete circular industrial chain due to industry limitations and market saturation.

This situation was because China's industrial development has moved beyond the stage of establishing simple primary process links into the more complex middle stage of industrialisation. Economic growth in China has been slowing annually since 2010, from 10.64% to 6.1% (DBSC, 2020). The market for most basic bulk industrial products has become saturated in terms of supply and demand, leading to a prominent and structural overcapacity. Statistics from 2018 to 2019 indicate that the market for basic bulk industrial products has peaked. For example, the production of iron and steel, crude oil, coal, chemicals, electrolytic aluminium, machine tools, automobiles, household appliances, textiles, and food products all fell from their peaks between 2011 and 2017 (Huanzhong, 2020).

The overcapacity problem affects the production of sodium hydroxide, the main chlor-alkali product. In 2016, China's total domestic sodium hydroxide capacity was 39.45 million tons per year, an increase of 9.62 million tons per year from 2010. Since 2007, the operating rate of sodium hydroxide production has decreased. In 2009, the utilisation rate of industrial units fell below 70% of production capacity (CEVSN, 2017). However, the three companies operating in *Manzhuang* remain reasonably profitable despite this production situation.

In 2000, the continuous growth of the national economy led to soaring demand for building construction, which in turn drove demand for the development of the PVC industry. As a result, domestic PVC production expanded rapidly before 2007. However, since 2007, the growth rate of PVC demand has declined, and some enterprises have withdrawn from production. The operating rate of the PVC industry began to drop to 55% from 70% (CEVSN, 2017). By 2016, China's total PVC production capacity reached 23.26 million tons, but the actual output was only 16.69 million tons (Ibid.). Although the utilisation rate increased to 80% in 2019, this increase in utilisation was not sustained. Survey interviews revealed that the profits from PVC production in the *Manzhuang* chlor-alkali industry were unsatisfactory due to a number of factors, including market demand and product prices.

To comply with the national government's policy of promoting a circular economy and eco-transition, the DIPC proposed adding a 500,000-ton acetylene PVC production line to use fluid chlorine. One *Manzhuang* company also built a 100,000-ton PVC production line using the calcium carbide method. However, due to the current volatility of the PVC market, entrepreneurs believe that adding new PVC production lines to the existing industrial structure would pose a significant risk of loss (Mr. Guo, interview on June 12, 2019). In fact, due to overcapacity in the PVC market, a chlor-alkali enterprise with PVC production incurred a cumulative loss of 1.02 billion yuan from 2007 to 2016 (Mr. Biao, interview on June 18, 2019). This indicates that PVC production is not very profitable at this time.

Developing a circular economy, similar to other traditional economic models, requires a deep understanding of market dynamics, considering supply and demand. The circular economy should also consider the business perspective with remanufacturing activities to assess the supply chain profitability (Lieder and Rashid, 2016). This is an issue that has not been explored in debates on EM.

3.5. Regional competition as the consequence of entrepreneurialism

China's reform and opening-up policy, initiated in 1978, emphasised three key principles: globalisation, marketisation, and decentralization (Yu, 2014a). This policy aimed to foster competition among all entities, including local governments, to boost efficiency and economic growth (Yu, 2014a). As a result, "Chinese urban entrepreneurialism" emerged, where local governments compete to attract investment, promote growth, and create jobs (Yu and Zhu, 2009). This competitive landscape extends to attracting new material industries and promoting the circular economy.

Market pressures forced the DIPC to revise its plans for downstream chlorine consumption. Interviews conducted during our survey suggested the local government explored partnerships with the pharmaceutical or new materials industries, offering potentially higher value-added products. This highlights the strategic shift in industrial development driven by the central government's focus on "strategic emerging industries". These industries, including pharmaceuticals and new materials, are viewed as replacements for outdated industrial units (Li, 2018). Local governments, including *Manzhuang*, actively pursue these projects, as evidenced by the DIPC's efforts of the dispatch of seven working groups to recruit projects in the chlorine-related chemical field, including chlorine-related pharmaceuticals and chlorine-related new materials. However, the DIPC recognised its disadvantage compared to more developed, research-intensive municipal-organized industrial parks in attracting pharmaceutical companies, particularly in terms of R&D resources. *Manzhuang* and DIPC offered attractive incentives, such as "one-stop service" and preferential government policies, to entice these new industries, including the most preferential tax and land policies allowed by national policies (DIPC, 2017b).

Manzhuang's biggest advantage in attracting investment was its low land prices for industrial development. According to our survey, the average price of industrial land in *Manzhuang* at the end of 2018 was 3.15 million yuan per hectare, compared to 4.5–6 million yuan in Tai'an, the central city and 6–15 million yuan in Jinan, the provincial capital. To attract investment in pharmaceutical and new material industries, the DIPC even tentatively offered land prices as low as 50% off the standard 3.15 million yuan per hectare. However, since these prospective industries require relatively little land, the land price advantage

was minor.

3.6. Restrains and limitations of Manzhuang in eco-transition

Industries prioritise locations with robust R&D capabilities, an educated workforce, and well-connected industrial parks. These factors offer better visibility, growth opportunities, and increased profiles for businesses, as well as significant possibilities for further development and marketing. Unfortunately, these essential characteristics are scarce in rural small towns like *Manzhuang*.

The R&D capacity supported by higher educational professions and a skilled labour force, which are the preconditions for the development of these prospective industries, can be easily supplied in well-developed regions like large cities. Underdeveloped regions, including rural small towns like *Manzhuang*, are at a disadvantage due to their lack of high-quality R&D capabilities and skilled labour.

Moreover, Chinese industrial parks are ranked and operate in a hierarchical system. In the Jinan Metropolitan Area, for example, there are three national development parks, two national high-tech parks, 50 provincial development parks, and six provincial high-tech parks, for a total of 61 (SDUP, 2019) (Fig. 2). Pharmaceutical and new material industries can be appropriately placed in either higher-level development parks or high-tech parks. The DIPC in *Manzhuang* is listed as a provincial development park under the administration of the district-level government, which is the lowest government administrative hierarchical system. This lower status ranking restricts its appeal to investors. For example, Tai'an High-Tech Park, which is directly adjacent to *Manzhuang*, is ranked as a national high-tech park under the administration of the higher and more important prefectural-municipal level government. For this reason, it is preferred by entrepreneurs (Mr. Si, Interview on July 19, 2019). Industrial parks in rural areas, such as the DIPC in *Manzhuang*, lack this advantage and fail to achieve their goal of attracting inward investment for pharmaceutical and new material industries.

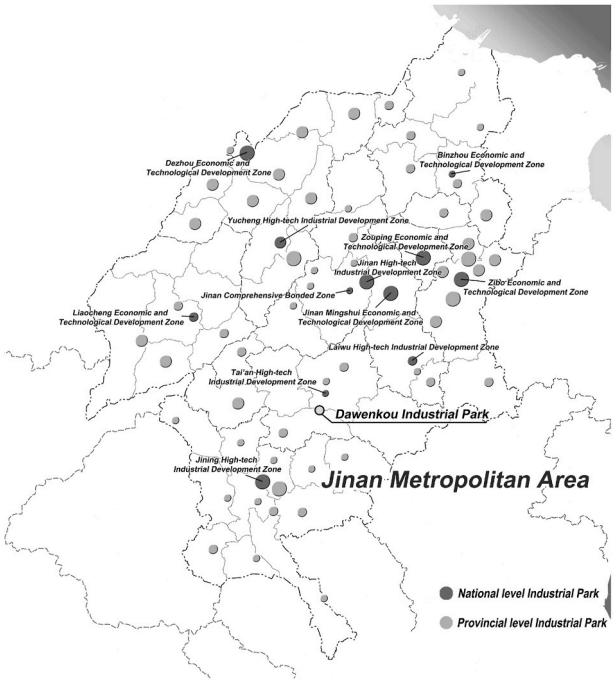

Fig. 2. The spatial distribution of the development-oriented parks in Jinan Metropolitan area.
Sources: Adopted by the authors based on Shandong Urban & Rural Planning and Design Institute, 2019. Research on the development strategy of the Jinan Metropolitan Area

4. Discussion

4.1. An unaddressed gap in ecological modernisation theory in eco-transition practice

Sustainable development has gradually become the main policy of development for all countries, especially as human beings face the threat of climate change and needs to adapt to it, since the publication of the UN Brundtland Report in 1986. Ecological modernisation, a socio-technical transition that attempts to explore a path of further promoting economic growth while reducing pollution and carbon emissions, is regarded as a solution for sustainability (Baer and Singer, 2022).

This research reveals that the resources needed for industrial eco-transition vary by region, highlighting a fundamental gap between the theoretical promises of ecological modernisation (EM) and its practical implementation in underdeveloped regions. The findings illustrate that while EM proposes a harmonious balance between economic growth and environmental sustainability, the successful transition to a circular economy remains uncertain in regions like *Manzhuang*, where resource constraints, technological limitations, and institutional weaknesses restrain progress. This raises critical questions about the general applicability of EM in diverse socioeconomic contexts, especially in rural small towns within developing countries.

The transition to the latest and improved options proposed by EM (Huber, 1982), including a circular economy in *Manzhuang* through increased industrialisation (Huber, 1982; Morad, 2007) reveals that while there is a policy-driven push for a circular economy, the actual transition is hindered by a lack of systemic integration, which is one of the crucial elements for realising the theoretical promises of EM (Mol, 2006). While *Manzhuang*'s case indicates that without a robust technological and institutional foundation, the theoretical promises of a circular economy remain unattainable (Korhonen et al., 2018a,b), it also shows that the mere availability of technology is not sufficient; there must also be the capacity for adaptation and absorption, which is often constrained by local conditions (Boksh and Islam, 2015). Moreover, the lack of local R&D capacity and skilled labour constrains the ability to implement and sustain the technological innovations required for eco-transition (Boksh and Islam, 2015). It echoes the EM theory's emphasis on the importance of advanced industrial practices (Huber, 1982). However, the research outcomes highlight the critical need for an integrated approach that considers social, institutional, technological, and market changes, rather than focusing solely on technological improvements (Korhonen et al., 2017). From this perspective, the eco-transition is particularly challenging for relatively economically underdeveloped regions compared to developed regions and/or countries.

The findings from *Manzhuang* underscore the need for a more context-sensitive approach to EM. Unlike more economically developed regions, underdeveloped areas like *Manzhuang* are further burdened by institutional inertia, which impedes progress. *Manzhuang* was previously a small town with mainly agricultural production with relatively backward economic development. In the 21st century, due to the adjustment and transformation of industries in big and central cities, many polluting enterprises were moved to underdeveloped rural small towns like *Manzhuang*. The transfer of industries did play a positive role in increasing the economy of underdeveloped areas, promoting the development of the local economy. However, it has also brought serious pollution problems. When environmental protection and pollution control requirements are upgraded to explore and promote a circular economy for low carbon and sustainable development, underdeveloped regions appear to face more challenges.

In the 2010s, China's central government enacted strict environmental protection, energy conservation, and emission reduction policies. Although *Manzhuang* had only experienced a few years of traditional industrialisation, it was forced to transform along with the rest of China as the country's economy became the second largest in the

world, the middle class grew significantly, and Chinese people became more sensitive to environmental issues. Consequently, pollution reduction has become a top priority of the Chinese government's policy. Additionally, the challenge of climate change, which all countries face, has become a crucial political issue worldwide.

However, the findings of this research indicate that the lack of local R&D capacity and skilled labour hinders the absorption of new technologies, which is a critical gap in the eco-transition process (Boksh and Islam, 2015), significantly influencing *Manzhuang*'s eco-transition.

Manzhuang, as an underdeveloped town in China, like many other rural areas, lacks the highly educated talent pool needed for EM. Education levels of residents in rural small towns in China may not be sufficient to support emerging high-tech and new material industries, such as pharmaceuticals. There are no universities in small towns, and rural Chinese education levels (see Fig. 3), where these towns are located, are not adequate to meet the demands for capacity in R&D and a well-educated workforce for the development of prospective industries for eco-transition. Most educated people in *Manzhuang* choose to live and work in economically developed areas, such as big cities or central cities, where they can earn higher incomes and have a better quality of life. Lack of knowledge and talent constrains the development of *Manzhuang* and other disadvantaged regions. It evidences that implementing EM in underdeveloped regions requires not only technological innovation, but also systemic reforms, including environmental governance, and other comprehensive systemic changes, such as the general upgrading standards of education, R&D capacity, which is a sustained effort.

The study of *Manzhuang* reveals crucial insights for policymaking. In a global or national effort to support the transition to an eco-transition, the authors suggest that development objectives and specific approaches must be tailored to support the transition to an eco-transition in underdevelopment areas, including the operation of a circular economy. This requires practical policies and measures, such as investing in education and skills development, providing financial incentives for eco-friendly practices, and developing regulations that promote resource efficiency and environmental protection.

4.2. Regional disparities and socio-economic impacts in eco-transition

One of the most significant findings in the study is the stark regional disparities that affect eco-transition efforts. Hasan (2018) argues that the regional disparities in eco-transition capacities emphasise the unique challenges faced by underdeveloped areas. In the context of Chinese urban entrepreneurialism, the central government has undertaken a policy of decentralization, granting local governments greater autonomy to pursue exogenous growth through competition. While competition in a market economy can foster efficiency and economic growth, it may also raise concerns about sustainability. The oversaturation of industrial markets, as revealed in the PVC and sodium hydroxide production sectors, illustrates how regional competition can impede the creation of closed-loop industrial systems. The competitive dynamics of a market economy can lead to a "Matthew effect",[1] where regions with pre-existing advantages continue to prosper while underdeveloped areas struggle (Yu, 2014a).

In the case of *Manzhuang*, this research illustrates that the "Matthew effect" impedes the implementation of ecological transition in underdeveloped regions and countries that adopt EM approaches. Underdeveloped regions and countries often lack the resources to attract high-tech, high-value industries, placing them at a disadvantage in competitive endeavours, leading to further decline. Moreover, intense inter-locale competition can result in a rapid oversupply in industrial markets, hindering the development of (green) industrial chains at the local level. In the case of *Manzhuang*, the addition of PVC downstream production lines aimed to create a presumed closed-loop industrial system for chlor-alkali. However, both PVC and chlor-alkali production quickly reached a ceiling around 2013. The current market oversupply has rendered the ideal path of the (green) industrial chain in *Manzhuang*, based on adding PVC production (and processing), unfeasible.

The rapid industrial market oversupply is also a result of China's "administrative regional economy" (Liu and Shu, 1996; Liu, 2004), in which localities create self-contained economic landscapes within their jurisdictional boundaries. This creates a "boundary mismatch" (Cheshire and Gordon, 1996), where administrative boundaries cover a significantly smaller area than the larger functional economic region. Local governments tend to fragment the coherence of the broader spatial economic system based on their borders and accommodate economic activities fully within their jurisdiction.

From this perspective, the spatial mismatch in production (Yi et al., 2014) is the consequence of local governments focusing only on maximizing economic activities within their administrative areas, regardless of whether the spatial expansion of industrial capacity contributes to efficient regional and national economic performance. In the short term, expanded industrial production increased economic growth, but in the long term, resulting in industrial isomorphism and repetition reduced total factor productivity (TFP) (Deng et al., 2019). This is because some enterprises lost rationality as they dealt with distorted markets and factor signals caused by various preferential policies offered by local governments in an attempt to undercut their competitors (Dunford, 1994; Cheshire and Gordon, 1998) and prisoner's dilemmas (Huang et al., 2018).

The implications of this finding are critical for policymakers. It suggests that eco-transition policies must consider the uneven economic and institutional capacities of different regions. The "boundary mismatches" in the "administrative regional economy" should be avoided. Regional cooperation and coordination, and resource-sharing mechanisms could help mitigate these disparities, allowing underdeveloped areas to participate more fully in national eco-transition initiatives, while avoiding the "Matthew effect".

4.3. Impacts of the market

Another critical finding is the role of market constraints in shaping the feasibility of eco-transition. The interplay between market forces and environmental sustainability is central to integrating supply and demand dynamics within the framework of EM. Market forces can either facilitate or obstruct the transition to a circular economy, highlighting the need for market-oriented strategies that complement EM efforts (Lieder and Rashid, 2016). The case of *Manzhuang* exemplifies the challenges of aligning market dynamics with EM goals. This illustrates a key issue that is often overlooked in the EM literature—the importance of aligning market dynamics with environmental sustainability (Korhonen et al., 2018a,b).

On the supply side, EM theory emphasises technological advancements and improved industrial practices as drivers of cleaner and more efficient production processes (Huber, 1982; Morad, 2007). Yet, successful implementation hinges on the market's capacity to absorb these changes and industries' ability to adapt without jeopardizing economic viability (Gouldson and Murphy, 1997). *Manzhuang*'s attempt to establish a circular industrial chain illustrates this. Oversupply and market saturation hindered the initiative, highlighting the importance of broader market considerations when promoting eco-innovations (Korhonen et al., 2018a,b). Demand dynamics are equally critical. EM necessitates a corresponding increase in demand for environmentally friendly products and services (Baer and Singer, 2022). However, market demand is shaped by various factors, including price and market

[1] The Matthew effect refers to the phenomenon of the rich getting richer and the poor getting poorer because wealth or credit is distributed according to how much one already has. As a result, it is difficult for low-ranked groups to increase their totals because they have fewer resources to risk over time, while it is increasingly easy for high-ranked groups to preserve their large totals because they have more to risk.

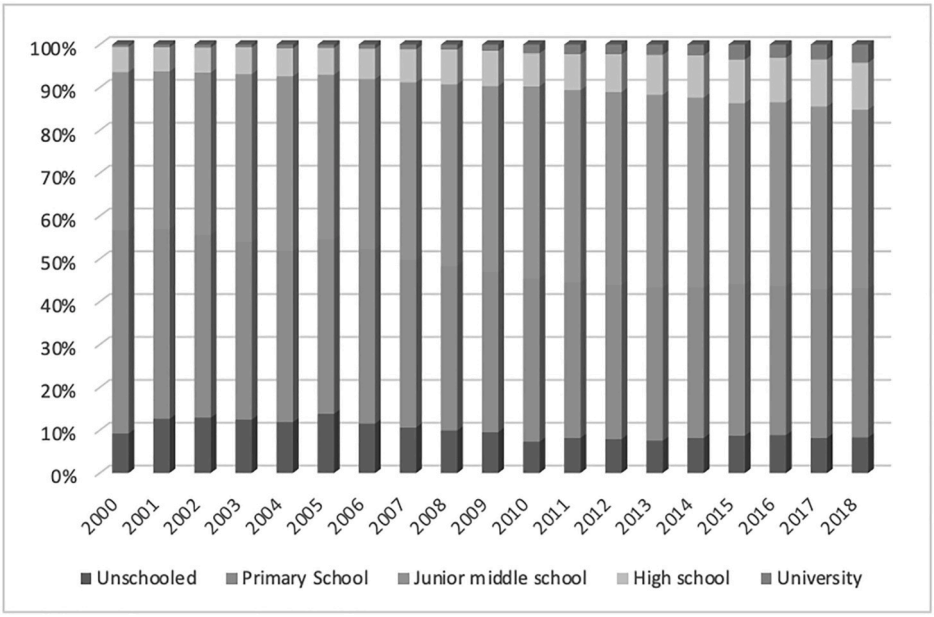

Fig. 3. The education levels in rural China (2000–2018).
Source: Produced by the authors from the "Statistics Yearbook of Chinese Population and Employment"

saturation, which can conflict with EM objectives (Lieder and Rashid, 2016). The declining demand for PVC in *Manzhuang* underscores the need for understanding market trends for a successful green economic transition. It further highlights the need for market-oriented strategies that align with EM goals.

Given a saturated and unprofitable market, it was no longer economically viable for localities to easily establish more production and processing plants to consume upstream waste and by-products as part of a (green) industrial chain. Thus, EM (circular economy) became infeasible, as the industrial market no longer justified adding extra downstream production lines. A decline in demand would significantly impact the green transition. However, while EM theory emphasises the importance of delinking economic growth from environmental degradation through technological innovation, it pays insufficient attention to the market forces that determine the success of such innovations (Lieder and Rashid, 2016).

The implication here, especially for policymaking, is that eco-transition policies must incorporate market-oriented strategies that take into account supply and demand dynamics. Simply promoting technological innovations without ensuring their market viability is unlikely to result in sustained ecological modernisation.

4.4. *Institutional reform and long-term eco-transition*

Based on the case of *Mangzhuang*, this research reveals a critical distinction in the locational preferences of pharmaceutical firms compared to traditional manufacturing industries. Flexible accumulation relies less on large labour pools and freight costs, increasing the flexibility of location selection, pharmaceutical companies have higher requirements for place-specific milieus than mass production units, making them more selective in site selection (Scott, 2014; Scott and Storper, 1987). This means that only localities with sufficient territorial competitiveness can win in competing for pharmaceutical investors, whether categorized as comparative advantages (Jessop, 1998; Begg, 1999), urban bundle assets (Docherty et al., 2004), or (quasi) public goods (Zhang, 2011). The findings of this research also underscore the critical role of institutional reform in achieving long-term eco-transition. The *Manzhuang* case demonstrates that technological solutions alone cannot drive the green transition without the support of strong, flexible institutions capable of adapting to new environmental and economic challenges. The failure of the *Dawenkou* Industrial Park (DIP) to establish a robust circular economy despite policy support and local initiatives points to the requirement of institutional reform to reduce the negative impacts on eco-transition efforts in underdeveloped regions.

As the debates on EM have indicated, a weak form of EM focuses on niche policy learning and technology while ignoring the demand for broader institutional change, is unlikely to ensure a successful industrial eco-transition. Even a stronger form of EM that incorporates a more systematic, open, and democratic approach to environmental challenges (Christoff, 1996; Dryzek et al., 2003) may prove insufficient. A comprehensive strategy is required, potentially involving macroeconomic restructuring, regional coordination, improvements in education quality and R&D capacity of the entire society, increased R&D investment, and systematic policy interventions. This research supports the view that EM may not be successful without a fundamental institutional change (Christoff, 1996) to promote long-term EM and transition. A long-term transition to eco-friendliness requires social, economic and political institutional reforms and arrangements, which is a strong form of ecological modernisation (Dryzek et al., 2003) rather than focusing solely on technology. It is because that technological advancement is primarily aimed at maintaining the status quo, which is why technology-based approaches to green transition or EM, can actually reinforce social and environmental disparities (Dorn et al., 2022). The *Manzhuang* study demonstrates these inequalities in the acceptability of necessary resources. Successful implementation of EM must rely on a more systematic and open mechanism to solve complex issues, including market conditions, institutional reform, technical capacity, and the availability of skilled labour forces. It is the view of the authors that more critically the spatial disparities in required resources must be considered which has not been fully considered in the debates of EM. These barriers reduce the likelihood of successful EM in underdeveloped areas such as rural Chinese small towns.

Systematically, the solution requires political reorientation and re-institutionalisation through a sectoral shift to emerging high-tech industries and a proper consideration of how to fit by-products into a closed-loop industrial chain. Well-organized regional coordination for industrial project allocation would facilitate this development.

EM advocates for a comprehensive and systemic approach to fostering sectoral transitions from traditional industries to new high-tech ones. It underscores the importance of carefully considering how

by-products can be integrated into closed-loop chains, as well as the necessitates for political restructuring and institutional reorganization. We believe that well-structured regional coordination of industrial project allocation will expedite this development. However, it must be acknowledged that the systematic approach to EM requires time to overcome existing suboptimal linkages, inertia, and institutional embeddedness. Understanding the uncertainties inherent in a dynamic national economy is crucial. Compared to decoupling and cooperation, eco-transition guided by a simple circular production process is still the most common policy orientation adopted by local governments to solve industrial pollution. This suggests that local governments almost always tend to avoid major structural changes in order to achieve eco-transition. The easy approach is very appealing, even if it is second-best.

4.5. Implications for global sustainable development

Drawing on the findings of this research, the authors argue that this study has important implications for the broader field of global sustainable development. The challenges faced by *Manzhuang* are not unique to China; many developing countries and underdeveloped regions face challenges similar to those encountered by *Manzhuang*, as discussed in this paper. Primarily, underdeveloped regions need increased financial and technical support to overcome resource limitations and develop eco-transition capabilities. From this perspective, the global community needs to recognise the challenges faced by underdeveloped regions, such as the limited availability of trained personnel and a restricted capacity for research and development. Therefore, it is crucial to provide a support strategy to address these challenges in the target regions. In addition, it should be realised that the influence of market forces, particularly the efforts of industry stakeholders, plays an even more significant role on the global stage. Industry stakeholders should prioritise innovation and collaboration in their transition to circular economy models. This can be achieved by investing in R&D, forging partnerships with academic institutions and research organisations, and engaging with local communities to develop inclusive business models. Moreover, businesses should actively participate in policy dialogues and collaborate with policymakers to create an enabling environment for the circular economy. Businesses contribute to eco-transition by engaging in corporate social responsibility initiatives that promote environmental sustainability and community well-being. This could involve collaborating with government organisations to establish public-private partnerships promoting eco-innovation or partnering with nearby educational institutions to provide relevant training programs. Finally, since eco-transition encompasses both social and technical dimensions, it necessitates the alignment of various actors' behaviours with prevailing social institutions, norms, regulations, and cognitive standards (Chen and Yao, 2012). From this perspective, ensuring sustained communication and information exchange between businesses and policymakers is crucial. This collaborative approach can help overcome socio-economic bottlenecks and achieve sustainable development in underdeveloped areas.

5. Conclusion

The ecological modernisation (EM) theory has been regarded as a promising approach to environmental protection and carbon emission reduction while maintaining economic growth. Its influence has extended to policy frameworks in numerous countries, including China. However, this research conducted in the rural town of *Manzhuang*, China, which has been and is still in the process of eco-transition from the raw material processing industry to a circular economy, has highlighted the challenges of applying this approach to underdeveloped areas. In line with the research findings, the authors argue EM, originating in Germany, required adaptation to local conditions based on socio-economic development levels. Implementing EM in underdeveloped areas like *Manzhuang*, presents unique challenges compared to more developed regions. Instead of direct replication from Western industrialised nations, EM should ensure its effectiveness and applicability in diverse settings.

Western developed countries have significantly advanced their eco-transition by strategically relocating polluting industries to developing countries. This allows them to retain high-value, low-emission sectors. Consequently, these nations benefit from a broader market demand that facilitates the flexible formation of closed-loop industrial systems, effectively managing industrial pollution. In contrast, developing countries and underdeveloped areas, including the rural small town of *Manzhuang* in this study, face challenges in reducing industrial pollution and carbon emissions by upgrading their production and implementing a circular economy. Critically, traditional resource-intensive industries often form the backbone of local economies, providing vital employment opportunities, especially for less-skilled workers, and contributing to socio-economic stability. Simply forcing a green transition guided by EM without fully considering local realities may adversely affect local situations, despite potential benefits for environmental risk mitigation, climate change adaptation, and ultimately, the protection of the ecological environment, natural resources, and the international community.

Therefore, developing countries may need to maintain resource-intensive primary processing production while simultaneously developing high-end emerging industries incrementally that can consume a portion of the harmful by-products. This strategy can help control pollution within the existing industrial system while promoting economic growth and diversification. From this perspective, eco-transition in developing countries should not be viewed as a direct r replication of the Western model. China, as evidenced by the case study of *Manzhuang*, a typical rural town, is likely to experience continued pollution within its local industrial system for some time. This emphasises the necessity for customised eco-transition strategies that consider the specific socio-economic and industrial structures of developing countries.

A deeper understanding of China's eco-transition necessitates an examination of the underlying mechanisms that shape the spatial distribution of global production (Harvey, 1985). This research would not only explore China's position within the global capital-space system but also illuminate pathways for restructuring the Chinese macroeconomy towards high-tech industries subject to international comparative advantage and Western technological hegemony. Concurrently, it is essential to explore the feasibility and extent to which rural small towns like *Manzhuang* can develop environmentally friendly economies that can compete effectively within China's domestic and global markets. Success in this endeavour will be vital for China's future urbanisation and economic development.

The eco-transition of *Manzhuang* provides valuable insights applicable to the international community, particularly developing countries that struggle to balance environmental sustainability and economic growth. This case study emphasises the importance of tailoring EM strategies, as a universal solution might not work well in all cases. Furthermore, the *Manzhuang* case emphasises the necessity for a multimodal approach encompassing institutional, social, and market reforms alongside technical innovation.

The *Manzhuang* scenario emphasises the critical role of market considerations and regional competition in the eco-transition process. Market regulations and trade agreements should be designed to encourage fair competition and prevent polluting industries from developed to underdeveloped countries.

Furthermore, the lessons from *Manzhuang* highlight the necessity of long-term strategy and a holistic approach to eco-transition. This involves not only investing in green technologies but also reforming social institutions, improving education and skills development, as well as promoting regional coordination and collaboration. *Manzhuang*'s experience serves as a valuable case study, offering transferable knowledge to promote sustainable development on a global scale.

In terms of the contribution of this paper, it lies in its in-depth,

operational case study of *Manzhuang*, a Chinese rural small town. By examining *Manzhuang*'s transition from raw material processing to a circular economy, the study offers an understanding of the challenges faced by underdeveloped regions in this process. Utilising EM theory, this research provides new perspectives on the institutional and socio-economic obstacles hindering such transitions. It emphasises the critical role of local conditions, market dynamics, and regional competition in formulating effective eco-transition strategies, thus enriching the theoretical discourse on sustainable development.

The study does, however, have certain limitations. Firstly, the single-case design may restrict the generalizability of the findings. The unique economic, political, and social institutions of *Manzhuang* may not be representative of all underdeveloped regions, particularly those in different countries undergoing eco-transitions. Secondly, while the qualitative data-gathering methods provide rich insights, the absence of quantitative metrics limits the corroboration of the findings.

To address these limitations and guide future research, several directions are proposed. A longitudinal study tracking the long-term impacts of the eco-transition on *Manzhuang* and its residents would offer a more comprehensive understanding of the process's evolution. Additionally, comparative studies involving multiple regions with diverse socio-economic conditions would provide a broader perspective on the factors influencing successful eco-transitions. Incorporating quantitative data, such as economic indicators and environmental metrics, would offer a more robust analysis and support the qualitative findings.

CRediT authorship contribution statement

Li Yu: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Ning Jia:** Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **L. Mo:** Writing – review & editing, Investigation, Funding acquisition.

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Data availability

Data will be made available on request.

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