The twin transition in Chinese regions: Joining green and digital transformations

Simone Maria Grabner[‡], Xiuping Hua[¶], Haolin Li[¶], and Xiaodan Yu[¶]

[‡]Institute for SME Research, Technology & Innovation Unit, Vienna, Austria
[¶]Nottingham University Business School China, University of Nottingham Ningbo China, Ningbo, China

Extended Abstract

In the current era of the global economy, especially after the COVID-19 pandemic, we are witnessing significant challenges like deep economic recession, income inequality, societal polarization, and unbalanced regional development. However, amidst these difficulties, we are also experiencing an accelerated and transformative process known as the 'twin transition' - a combination of digital and green technologies. The twin transition is a transformative journey, where our economies and societies embrace a digital and sustainable future. The digital transition is fueled by cutting-edge technologies of the 4th industrial revolution, like AI, big data, and IoT. These innovations also hold the key to tackling several global challenges, including climate change and poverty. Meanwhile, the green transition focuses on creating a sustainable economy by reducing fossil fuel reliance, boosting energy efficiency, and adopting circular practices. Innovation in green technologies plays an important role in the green transition.

The surge in the creation and adoption of digital and green technologies leads to the emergence of new markets and the replacement of existing ones. Hence, the twin transition has the potential to serve as a new engine of growth, driving the transformation of regional economic models towards smart, sustainable, and inclusive systems.The ongoing policy debate surrounding the twin transition highlights the potential for these technologies to create disruptions and opportunities beyond the existing techno-economic-social paradigm. Even previously lagging regions in terms of innovation, such as those slow to adopt information and communication technologies, have the chance to catch up and leapfrog technologically. This, in turn, may foster entrepreneurship, restructure established businesses (corporate entrepreneurship), and generate high-quality job opportunities. For China, embracing the twin transition

- incorporating digital and green innovations - offers a pathway towards achieving the policy agenda of "common prosperity" advocated by the government. However, despite the potential benefits, there is currently limited empirical evidence that combines the digital and green transitions. This knowledge gap is especially evident in emerging economies.

To address this issue, this paper aims to bridge the gap by providing empirical evidence and insights into if the twin transition can positively impact regions, especially in terms of addressing regional inequality in China. By studying the interplay between innovation in digital and green technologies, we hope to shed light on the opportunities and challenges that lie ahead in this transformative era.

This study aims to achieve two primary objectives. Firstly, we aim to identify green and digital patents in China, using them as indicators of green and digital innovations at the city level. Through descriptive statistics, we will paint a comprehensive picture of the geographical distribution of green and digital innovation across Chinese cities, and analyze the trends over time. We will particularly focus on regional inequality, examining leading, catching-up, and lagging regions to determine if there is a pattern towards equality or polarization. By differentiating between green and digital technologies, we can gain insights into the distinct geographies arising from the twin transition.

Secondly, we will investigate the driving factors behind green and digital innovation at the regional level, employing an econometric model and regression analysis. Past research has highlighted the path-dependent nature of innovation geography, where regions tend to diversify into technologies related to their existing capabilities. Additionally, we will explore how the complexity of technologies may influence local innovation, as more complex technologies might present greater challenges for regions to specialize in. Furthermore, we will examine the impact of other potentially important variables, such as population density, environmental protection measures, and investments in research and development. By pursuing these objectives, we seek to gain a deeper understanding of the dynamics of green and digital innovations in Chinese cities and their implications for regional inequality. The study aims to shed light on the driving forces behind these innovations, paving the way for informed policy decisions and strategies to foster a more equitable and sustainable development across China.

In this study, we use patent data from the INCOPAT database and the China City Database spanning 1985 to 2020. Our aim is to identify green patents, which encompass technologies related to controlling, reducing, or preventing greenhouse gas emissions. The identification process involves CPC codes and detailed subclasses within the Y02 class. For identifying digital patents, we adopt a two-step procedure recommended by the European Patent Office (EPO). The EPO's recent strategy EPO (2020) has been widely used in various studies (e.g. Capello and Lenzi (2021) and Benassi et al. (2022)). The EPO

defines digital inventions related to the fourth industrial revolution (4IR) as those involving "smart and connected devices" combining computing, connectivity, and data exchange features. Following the EPO approach, we first identify patents with CPC codes classified as 4IR technologies. In the second step, we conduct text analysis on patent documents (title, abstract, keyword) to further refine our identification process.

The preliminary descriptive findings reveal significant variations among Chinese cities concerning both green and digital technologies. Beijing stands out as the leading city in both domains, showcasing an absolute advantage in creating green technologies compared to other cities like Shanghai (2nd), Shenzhen (3rd), and Guangzhou (4th), which significantly lag behind. The dynamics of the geographical distribution of digital patents differ, being more concentrated than green patents. Shenzhen held the leading position in digital patenting until 2014 but was then surpassed by Beijing, which now holds a dominant position with the highest number of digital patents. In general, digital patents tend to be more concentrated than green patents, although both technologies display notable heterogeneity across Chinese cities. Another interesting trend is the distinct development paths of these technologies. The share of green patents in China remained relatively stable, fluctuating between 5% and 10% from 1985 to 2020. In contrast, the share of digital patents experienced substantial growth, rising from less than 2% in 2005 to over 27% in 2020. As a result, since 2015, digital innovation has played a much more significant role in China than green innovations. However, this focus on digital innovation and its strong dominance by Beijing could have implications for the catch-up potential of lagging cities. The concentration of digital technologies in certain areas may hinder the innovation and development prospects of regions striving to bridge the gap.

For the preliminary regression analysis, we employ a linear probability model with technology, period, and city fixed effects, a commonly used approach in the literature on technological diversification (Petralia et al., 2017; Balland et al., 2019). Our dependent variable is the entry of a new technological specialization in a city, either in the digital or green technology domain, that is not present in the city's current specialization portfolio. To determine technological specializations, we follow the empirical literature and use the relative technological advantage as a measure. The initial regression analysis reveals that cities tend to diversify into technologies that are closely related to their existing set of technologies, confirming the significant role of path dependence in innovation. Additionally, we find that the complexity of digital or green technologies affects a city's ability to diversify into them, with more complex technologies posing greater challenges for diversification.

Moving forward, the empirical analysis will involve developing a typology of cities based on their

patenting activities in digital and green technologies, categorizing them into leading, catching-up, and following cities. We anticipate that innovation and development patterns will differ among these groups, and the impact of explanatory variables will vary accordingly. For instance, technological complexity may not hinder innovation in leading cities with strong local capabilities, whereas follower cities with limited local capabilities might face difficulties in diversifying into complex green or digital technologies. Furthermore, we aim to explore potential differences in the driving factors behind digital versus green technologies. Additionally, we will include essential control variables such as population density, R&D investment, Foreign Direct Investment (FDI), education, and environmental variables to gain a comprehensive understanding of the innovation dynamics in Chinese cities.

Through this comprehensive analysis, we hope to shed light on the factors influencing technological diversification, understand the varying patterns across different city groups, and provide valuable insights for policymakers and stakeholders to foster innovation and sustainable development in China.

Keywords: Green patents, Digital patents, Twin transition, Chinese regions, Inequality

References

Balland, P.-A., R. Boschma, J. Crespo, and D. L. Rigby (2019). Smart specialization policy in the european union: relatedness, knowledge complexity and regional diversification. *Regional studies 53*(9), 1252–1268.

Benassi, M., E. Grinza, F. Rentocchini, and L. Rondi (2022). Patenting in 4IR technologies and firm performance. *Industrial and Corporate Change 31*(1), 112–136.

Capello, R. and C. Lenzi (2021). 4.0 technologies and the rise of new islands of innovation in european regions. *Regional Studies 55*(10-11), 1724–1737.

EPO (2020). *Patents and the Fourth Industrial Revolution: The Global Technology Trends Enabling the Data-Driven Economy*. European Patent Office.

Petralia, S., P.-A. Balland, and A. Morrison (2017). Climbing the ladder of technological development. *Research Policy 46*(5), 956–969.