

Smart Cities: Digital Solutions to a Green Future

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Abstract

Cities are major contributors to climate change, while climate change poses significant threats to urban development. In seeking solutions, urban digitalization, as exemplified by smart cities, may offer viable solutions for achieving sustainable development. Analyzing a sample of 1,843 Chinese A-share listed companies from 2005 to 2021 using the time-varying difference-in-difference (DDD) technique, we find a positive effect of smart city construction on firms' green innovation. The event study approach verifies the parallel trend assumption of DDD and shows that the smart city policy has a long-term effect on green innovation patents and a short-term effect on green utility patents, an immediate impact on independently filed green patents and a delayed impact on jointly filed green patents. Further analysis from the perspective of innovation ecosystem reveals that green innovation benefits from the synergistic influence of smart city policies and relationships with universities or governments, particularly when the university has a substantial and direct stake in the firm, or the firm is state-owned. These results remain robust across various tests, including an extension using subsamples, substitution of proxy variables for green innovation, inclusion of additional control variables, examination of other policy influences, placebo tests, re-estimation after propensity score matching or entropy balancing method, and instrumental variable estimation. Our findings offer actionable insights for policymakers and practitioners, highlighting how digitalization can transcend the conflict between urbanization and climate change into a harmonious and mutually beneficial symbiosis. This transformation can be effectively facilitated through collaborative efforts among governments, companies, and academic institutions, working together to develop and implement innovative solutions.

Keywords: Smart City; Green Innovation; Innovation Ecosystem

Research Question:

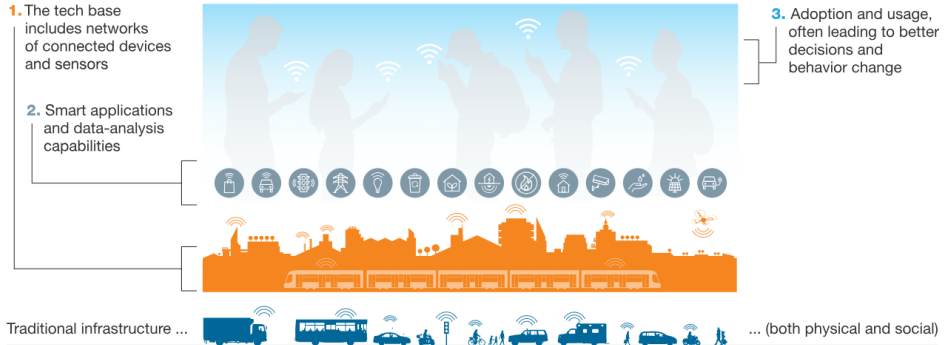
Does the development of a "smart city" drive green innovation in local firms?

What is a city smart? What makes a city smart?

Exhibit 1

Smart cities add digital intelligence to the urban world and use it to solve public problems and achieve a higher quality of life.

3 layers of "smartness" will elevate life in cities of the future



Quasi-natural experiment and main results

- ▶ Smart city pilot projects by the Ministry of Housing and Construction in China
- ▶ Rolled out over three batches in 2012, 2013, and 2014
- ▶ Main result: Positive effect of smart city construction on firm green innovation
 - ① Long-term effect on green invention patents
 - ② Short-term effect on green utility patents
 - ③ Immediate impact on independently filed green patents
 - ④ Delayed impact on jointly filed green patents
 - ⑤ Stronger effect for firms with university shareholdings and state-owned enterprises
- ▶ Large data-collection effort and an interesting empirical setting

This discussion in three parts

- ① How exactly does the Chinese smart city pilot program work?
- ② What kind of innovation do smart cities facilitate?
- ③ Perfect setting for the staggered DiD methodology

1. How exactly does the Chinese smart city pilot program work?

What I can learn about the pilot program from reading the paper:

- ▶ Top-down organised by the Chinese government
- ▶ Smart city development began with the issuance of policy documents that provided guidance and objectives
- ▶ Regional distribution skewed to coastal provinces with higher GDP per capital and population density

Good, but I want to know more to better judge the timing of the impact, possible selection in the sample, and unintended consequences:

- ▶ How were cities selected to be part of the pilot program?
- ▶ How long was the implementation phase of the program?
- ▶ Were there certain milestones to be achieved by certain dates?
- ▶ What exactly has changed in these pilot cities? Was the program successful?

1. How exactly does the Chinese smart city pilot program work?

- ▶ Cities become part of the pilot program (*are treated*) in 2012, 2013, and 2014 with the sample period lasting from 2003 to 2021
 - ▶ Page 14: *Since the Ministry of Housing and Urban-Rural Development of China announced the smart city construction list in three batches in 2012, 2013, and 2014, we construct the independent variable based on this list.*
- ▶ What happened after 2014? Were all cities "treated" after 2014? Is there more variation to be explored after 2014?
 - ▶ Page 6: *The first batch of 90 national smart city pilots in 2012 [...] Subsequently, the number of pilot projects expanded to 103 and 97 in 2013 and 2014. [...] From 2013 to 2016, smart cities were rapidly promoted. According to UN-Habitat (2020), there were 572 pilot projects led by central ministries, in addition to numerous local plans by the end of 2017, and the focus of smart city development in China has now shifted from concept to practice and from the central leadership to local implementation.*

2. What kind of innovation do smart cities facilitate?

- ▶ The authors hypothesize that smart cities...
 - ① ... create better ICT which enhances a firm's functional flexibility
 - ② ... foster a collaborative ecosystem and synergies
 - ③ ... set an institutional environment that incentivizes and pressures firms to innovate
- ▶ Smart cities are about technology & people and aim to improve the quality of life
- ▶ Quality of life has many dimensions:
Commuting time, health, safety, sustainable environment, ...
- ▶ What kind of innovation do smart cities facilitate?
 - ① green innovation
 - ② any innovation
 - ③ any but green innovation in particular
 - ④ some specific type of innovation that correlates with green innovation

3. Perfect setting for the staggered DiD methodology

- ▶ Staggered role-out of pilot cities suits the staggered DiD methodology
 - ▶ Current "time-varying DID" specification:
$$pat_{i,j,c,t} = \theta_0 + \beta did_{i,j,c,t} + \rho X_{i,j,c,t} + \zeta_j + \tau_c + \mu_t + \varepsilon_{i,j,c,t}$$
 - ▶ Staggered DiD literature (e.g. Callaway & Sant'Anna (2021), Sun & Abraham (2021), Roth, Sant'Anna, Bilinski & Poe (2023)) suggests something like:
$$pat_{i,t} = \sum_{e \in \{2012, 2013, 2014\}} \sum_{\ell=-8, \neq -1}^9 \delta_{e,\ell} \mathbb{1}\{E_i = e\} \dot{D}_{i,t}^{\ell} + \alpha_i + \mu_t + \varepsilon_{i,t}$$
- ▶ Dependent variables are patent counts:
 - ▶ Current specification OLS with Log + 1
 - ▶ Log + 1 estimates have no natural interpretation and can have the wrong sign in expectation (Cohn, Liu, & Wardlaw, 2022)
 - ▶ Poisson model produces consistent and reasonably efficient estimates for count variables

Good luck with the paper

- ▶ Great data background work and an interesting empirical setting that thinks about the interconnectedness of agents in an economy and its impact on green innovation
- ▶ My suggestions:
 - ① Provide more background on the "Chinese smart city pilot program"
 - ② Discuss in more detail what kind of innovation smart cities affect
 - ③ Chinese smart city pilot program suits itself for the popular staggered DiD methodology (e.g. Callaway & Sant'Anna (2021), Sun & Abraham (2021), Roth, Sant'Anna, Bilinski & Poe (2023))