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| Institution: University of Cambridge | | |
| Unit of Assessment: UoA13 Architecture and the Built Environment | | |
| Title of case study: Changing policies, perceptions and perspectives through interdisciplinary modelling of city-regions and their transport systems | | |
| Period when the underpinning research was undertaken: 2004-2020 | | |
| Details of staff conducting the underpinning research from the submitting unit: | | |
| Name(s): | Role(s) (e.g. job title): | Period(s) employed by submitting HEI: |
| Dr Ying Jin | Reader in Architecture and Urbanism | 01.11.2008-present |
| Prof Marcial Echenique | Director of Research; Professor of Land Use and Transport Studies (till 2013) | 01.10.1967-31.12.2013 |
| Prof Pete Tyler | Professor of Urban and Regional Economics | 01.01.1981-31.03.1994 01.04.1995-present |
| Prof Colin Lizieri | Grosvenor Professor of Real Estate Finance | 01.10.2009-present |
| Nick Mansley | Senior Research Associate | 20.10.2014-present |
| Dr Li Wan | University Lecturer | 01.03.2017-present |
| Period when the claimed impact occurred: 2014-2020 | | |
| Is this case study continued from a case study submitted in 2014? N | | |
| 1. Summary of the impact (indicative maximum 100 words) This joint Architecture-Land Economy team at the University of Cambridge has developed an internationally unique methodology for modelling symbiotic inter-dependencies among production, trade, employment, real estate, consumer choices, lifestyles, infrastructure development and urban design. Their modelling work has been used as core evidence to change how jobs, housing and transport interventions are designed and coordinated in (a) UK local areas and city regions, (b) UK countries and regions, (c) mega-city regions outside the UK, with (d) worldwide dissemination, influence and thought leadership as a focal point for bringing together all the leading teams in the field of applied urban modelling. | | |
| 2. Underpinning research (indicative maximum 500 words) This research is a result of close collaboration between the Department of Architecture and Department of Land Economy at the University of Cambridge since REF2014, when the two departments jointly submitted for the first time. There is a common recognition in urban and regional studies of the importance to understand the symbiotic nature of policy interventions. For instance, the inter-dependencies among job creation, housing affordability and sustainable travel engender both virtuous and vicious cycles, magnifying policy effects. But in most cities in the UK and elsewhere, research on such policy interventions tends to be carried out in separate specialisms. Models representing such inter-dependent and cross-cutting relationships are challenging to develop and validate, particularly when they are required for convincing decision-makers and the public to make intensely contested, real-world decisions. The Architecture-Land Economy collaboration built on past land use and transport planning models developed at the Martin Centre for Architectural and Urban Studies, Dept of Architecture, and produced a new generation of models that have become the analytical backbone of major | | |

city-region and national development studies. Its interdisciplinarity also resulted in a particularly extensive and simultaneous reach to a wide range of government agencies, businesses, civic organisations as well as specialist researchers in multiple universities and research bodies. The fundamental research combines urban and regional economics (Tyler), dynamics of real estate markets (Lizieri, Mansley), digital cities (Jin, Wan) and systematic urban activity and infrastructure system modelling (Jin, Echenique, Wan).

This team's novel inclusion of agglomeration effects and use of log-linear equations for spatial interaction have enabled their new models to investigate and predict the above-mentioned symbiotic interactions in mega-city regions and nation states of 60-120 million people, a scale that is between three to six times larger than what was feasible with the past models, whilst retaining neighbourhood-level details for assessing social, economic, environmental and resource impacts of alternative policies and interventions.

R1 is the paper that broke the ground in the new modelling of dynamic inter-dependencies among jobs, housing and transport. This approach was further developed for mega-city region scale empirical applications in the PhD dissertations of Wan and eleven others, under the supervision of Jin and the advice of Echenique and others. The core contents of the model have transcended traditional urban land use and transport interaction to include a multiplicity of socioeconomic deprivation, green infrastructure, underrepresented transport modes (cycling, mobility-as-a-service, city logistics), a spectrum of infrastructure facilities (energy, water, sewage, waste disposal, digital, telecoms and media technology), and a more rigorous validation of model predictions. A key feature of their empirical modelling is the team's novel integration of new digital data sources (including Big Data) and machine-learning methods with cause-effect modelling, which has made it feasible to develop high quality new models where there is otherwise scarce data.

R2 presented a new spatial economic methodology to examine the degree of divergence across UK cities and analyse how far this has been driven by differences among cities in industrial structure, specialisation, tradable bases and productivity. This provided vital insights for representing the causes of the geographical disparities of economic and social development in the models. **R3** investigated rarely known real estate challenges in the Life Sciences sector, including locational decisions as well as aggregate supply and demand of floorspace for these new industries in the UK. **R4** used a joint structural equation and latent class method to capture key symbiotic influences (both direct and indirect) upon travel behaviour, and opened up an influential stream of theoretical and policy analyses on complex causal effects.

The resulting new modelling framework from the work above has made it possible to develop systematic policy modelling e.g. for the UK as a connected series of city regions of 67 million people (**R5**) and for the Beijing-Tianjin-Hebei region in northern China of 120,000,000 million people (**R6**).

3. References to the research (indicative maximum of six references)

R1: Y Jin, MH Echenique and AJ Hargreaves (2013). A Recursive Spatial Equilibrium Model for Planning Large-Scale Urban Change, in *Environment and Planning B*, 40:6, pp1027-1050, December. doi:10.1068/b39134.

R2: R Martin, P Sunley, P Tyler and B Gardiner (2016). Divergent Cities in Post-Industrial Britain. *Cambridge Journal of Regions, Economy and Society*, 9:2, pp269–299. doi:10.1093/cjres/rsw005.

R3: N Mansley (2017). Review of wet lab space and incubator space for the Life Sciences in the Cambridge area. Report commissioned and published by Cambridge Ahead. Cambridge Real Estate Research Centre, University of Cambridge. See https://www.cambridgeahead.co.uk/media/1408/ca_wet_lab_report_final-1.pdf.

R4: K Jahanshashi, Y Jin and IN Williams (2015). Direct and indirect influences on employed adults' travel in the UK: New insights from the National Travel Survey data 2002–2010. *Transportation Research Part A: Policy and Practice*, 80, pp288-306. See <http://www.sciencedirect.com/science/article/pii/S096585641500227X>.

R5: Y Jin, S Denman and L Wan (2019). UK2070 Futures Technical Report. UK2070 Commission. See <http://uk2070.org.uk/wp-content/uploads/2019/05/UK2070Commission-MODELLING-TECHNICAL-REPORT.pdf>.

R6: Y Jin, S Denman, B Deng, X Rong, M Ma, L Wan, Q Mao, L Zhao, Y Long (2017). Environmental impacts of transformative land use and transport developments in the Greater

Beijing region: Insights from a new dynamic spatial equilibrium model. *Transportation Research Part D: Transport and Environment*. 52:Part B, pp548-561. doi: 10.1016/j.trd.2016.12.009.

The underpinning research was conducted with funding support of interdisciplinary collaborative projects across planning, design, engineering, economics, physical sciences, real estate property and digital cities:

EPSRC Sustainability of Land Use & Transport in Outer neighbourhoods - SOLUTIONS 2004-2009 (Echenique as PI) GBP1,750,372

EPSRC ReVISIONS - Regional Visions of Integrated Sustainable Infrastructure Optimised for Neighbourhoods 2008-2012 (Echenique as PI) GBP3,225,933

EPSRC Energy Efficient Cities 2008-2014 (Echenique as Co-I; Jin as Coordinator) GBP2,758,533

Joseph Roundtree Foundation Area Regeneration and Localisation: Evidence and Policy Review 2013-2017 (Tyler as Co-I) GBP6,184

ESRC Structural Transformation, Adaptability and City Economic Evolutions 2015-2018 (Tyler as Co-I) GBP688,049

EPSRC Mistral 2016-2020 (Tyler as Co-I) GBP314,816

EPSRC Managing Air Green Inner Cities 2015-2021 (Jin as Co-I) GBP4,173,134

EPSRC Innovation Knowledge Centre for Smart Infrastructure and Construction (2011-2016) (Echenique and Jin as Co-I) GBP4,956,319

Cambridge Real Estate Research Centre (since 2013; Lizieri as Lead, Mansley as Executive Director) which is supported by sponsorships, donations and partnerships including:

Government Investment Corporation of Singapore 2016-2018 (Mansley as PI) GBP100,000 for research support and consultancy; Investment Property Forum and Bank of England 2018-2019 (Mansley as PI) GBP103,000; Investment Property Forum and Grosvenor projects on Hurdle Rates in the Investment Process and Hurdle Rate (Investment appraisal) (methods 2017 onwards (Lizieri and Mansley as PIs) GBP86,100); Beijing Institute of Architectural Design/Beijing Qinggai Consultancy on model-based planning policy analysis for Pengzhou City, Chengdu, China 2019-2020 (Wan and Lizieri as PIs) GBP100,000.

Digital Cities for Change Programme funded by the Ove Arup Foundation since 2017 (Wan and Jin as Co-I) GBP509,739

EPSRC Data and Analytics Facility for National Infrastructure (DAFNI) Hardware Fund Collection 2020-2021 (Jin and Wan as Co-I) GBP88,094

4. Details of the impact (indicative maximum 750 words)

The team's research has made real changes to policies, perceptions and perspectives in the UK and internationally, with extensive reach in terms of dissemination and thought leadership.

(a) Local and city-regional scale - UK

Jin, Echenique, Tyler, Wan and Mansley as a team conducted highly original modelling and associated research (known locally as the CF3 project) for Cambridge Ahead (a local business and civic group) and the Cambridgeshire and Peterborough Combined Authority during 2014-2021. In 2017-2018, the Chair of an independent commission for the Cambridgeshire and Peterborough Independent Economic Review (CPIER), used CF3 outputs to recommend (i) a very different employment growth trajectory from pre-existing plans (**E1**, p20, Figure 1) and (ii) a very substantial increase of housing growth in the area from existing expectations (**E1**, p69). CF3's outputs have since been used in the region by government, businesses and civic groups as "the most robust evidence to change the existing vision ... as well as the core assumptions for the policy debate (**E2**)". The Chair commented that CF3 "formed the backbone of our deliberations", enabled her review "to consider what the most vital infrastructure needs were" and "is a great example of complex modelling producing outputs of value" (**E4**).

Moreover, "[the] work that Dr Jin and colleagues produced ... has fundamentally contributed to [the] evidence base" of the Greater Cambridge Partnership, which is the UK's largest City Deal with GBP500,000,000 Government investment to the region over 15 years – specifically, the 'geographical differentiation of empirical evidence ... was made possible through the model that Dr **Jin** and team have developed" (**E3**).

The Greater Cambridge Shared Planning Service considers the CF3 model “especially important in relation to the evidence base for the new Greater Cambridge Local Plan in respect of future employment provision”, resulting in “critically important new growth and spatial options being added” in the new land use plan published for consultation in January 2020 (E2). “Civil servants from the Department for Business, Energy, and Industrial Strategy described this work as the ‘gold standard for an Industrial Strategy evidence base.’ ” (E2).

The East-West Rail Corridor Study by Network Rail and UK Department for Transport in 2019 “exceptionally recognised the new local growth perspective resulting from the team’s work as an additional growth scenario in their forward planning” for the regional railway network (E2). In sum, CF3 is “highly influential” and “among the best examples of cutting edge university research applied to real world issues” (E2).

(b) National scale - UK

Jin, Wan and team with advice from **Tyler** and **Echenique** have been working since 2017 with the UK2070 Commission, which is an independent inquiry into the long term future of UK’s cities and regions with contributions from top experts from all cogent fields to UK’s urban and regional development. They produced the UK2070 Futures reports for the Commission as an impact extension to their UKRI research. The Commission has since adopted the UK2070 Futures reports (R5) “as an essential piece of evidence for its new policy options to address the worsening social and economic disparities across the countries and regions in the UK – the model’s results constitute the very first substantiation of the quanta implied by government’s ‘Levelling-Up’ agenda ... This initiated a new policy perspective that had not previously existed in the UK” (E5).

The Commission considers the UK2070 Futures reports “genuinely new and original work on informing policy debate”, and “central to UK2070 Commission’s case for change and the influence it has had in national and local policy debates, i.e. in gaining acceptance of the magnitude of the challenge, the need for extra-long term planning and local action. In particular, the modelling work not only provides insights into the spatial balance of the economy, but also informed key social and environmental policy issues.... This cross-cutting work helped underpin a key message of the Commission, namely, that with the current pattern of development of the UK, no-one wins i.e. all regions, even the so-called prosperous ones, increasingly lose out” (E6). The work “has broken the mould of existing spatial modelling, and sparked off a paradigm shift”, thus filling “a persistent gap in the available evidence for making decisions on future developments” (E5).

“[T]he team has been working throughout the COVID-19 pandemic period to provide new scenarios, upon which the UK2070 Commission has made its current recommendations. This demonstrates the high relevance of the team’s work on one of the most critical issues the UK is grappling” (E5). The Commission’s findings have “now been accepted and reflected in the national conversation about levelling up” (E6) and “used in the discussions about the levelling up agenda through the panregional strategies for England, for the North, Midlands South West and London & the Wider South East mega-regions” (E5).

(c) Mega city regions outside the UK

In China, **Jin** and **Wan** used their model for Beijing-Tianjin-Hebei since 2016 to study strategic development and infrastructure investment of Tongzhou, Beijing’s designated subsidiary city centre of 4,000,000 people. This model application for the Beijing Municipality was “the first time in China to combine urban big data with urban modelling ... In August 2017 their study report received direct comments from the municipal government leadership, which concluded that ‘the report is convincing’ and recommended that ‘the city’s other districts should consider making this analysis’ ... All eight [districts] that were studying the relationship between employment, population and transport balance at the time carried out this project” during 2018 and as a result radically revised their pre-existing masterplan visions in the metropolis of 21 million people (E7). This model has “revealed really valuable policy insights into how land use, transport and economic planning interact to shape sustainable and low carbon development, which is otherwise unavailable in China. This fills the gap of comprehensive prediction of employment, population and transportation in Chinese cities” (E7). **Lizieri** and **Wan** further extended this model approach in 2020 for Pengzhou, a leading small city within the 14,000,000 Greater Chengdu region in Southwest China, and their model has “played an indispensable role ... in developing a new multi-level industrial-spatial strategy for Pengzhou” and “has provided new

evidence ... in terms of balancing jobs, housing and transportation investments” (E8). In both cases the policy makers think the model has significant potential for wider use in the next steps in their cities and other cities of a similar stage of development (E7 and E8).

In Chile, **Echenique** built on his prestigious series of model applications since the 1990s, and developed a novel model since 2018 to “forecast the use of proposed infrastructure in an integrated manner” for the new USD50 billion National Infrastructure Plan 2020-2050 that aims “to accelerate the economic growth of the country with consideration of territorial equity and with minimum environmental impact”. The Chilean Minister of Public Works acknowledges that the modelling provides “accurate evaluation of the impacts of government projects and policies leading to concrete economic, social and environmental benefits for the people of Chile” (E9).

(d) Wider dissemination

Besides continuous, in-depth policy applications, the team have established impactful channels for disseminating advanced modelling methods for practical use worldwide. **Jin** is one of the longest serving external experts at the British Standards Institution’s SDS/2, a committee for producing Publicly Available Specifications for smart and sustainable cities (PAS180-186), which in turn influences the standard-setting at the International Organisation for Standardisation (ISO). **Jin, Echenique** and **Wan** have led the Martin Centre’s wide network of collaborators and alumni who practise symbiotic urban and regional modelling in the US, Canada, India, Brazil, China, France, Belgium, Italy, Spain as well as the UK. The Martin Centre has also led the international Applied Urban Modelling (AUM) symposia in Cambridge with support of its Scientific Committee, not only to explain their own methods, but also to open up the intellectual debate to the whole spectrum of urban data sciences for maximum impacts. This has been highly appreciated by those modellers pursuing alternative methodologies. For instance, a global leader of an alternative modelling approach says that the opening up of the field to big data and machine learning methods “has been one of the most valuable and lasting contributions of the AUM conference series that was the idea of the Martin Centre”. For “leading and emerging scholars ... from every part of the globe ... the Martin Centre ... became a focal point for bringing together the best and brightest ... to applied urban modelling” (E10).

5. Sources to corroborate the impact (indicative maximum of 10 references)

E1: Cambridgeshire and Peterborough Independent Economic Review (CPIER) Report, 2018; see <https://www.cpier.org.uk/final-report/>.

E2: Testimonial letter from Cambridge Ahead (signed jointly by Chief Executive and Chair of CA Regional Economic Planning Group).

E3: Testimonial letter from Greater Cambridge Partnership, the local delivery body of the City Deal – a partnership of Cambridge City Council, Cambridgeshire County Council, South Cambridgeshire District Council, the University of Cambridge, and the business community (signed by Head of Strategy and Programme).

E4: Testimonial email from Commission Chair of the Cambridgeshire and Peterborough Independent Economic Review (CPIER).

E5: Testimonial letter from the UK2070 Commission (signed by Steering Group Chair).

E6: Testimonial letter from Chair of the UK2070 Commission.

E7: Testimonial letter from a People’s Deputy of the China National People’s Congress, who is also a Standing Council Member of Beijing Municipality People’s Political Consultative Conference, and a Beijing Municipal Strategic Scientist. (In Chinese with English translation).

E8: Testimonial letter from Director, Department of Spatial Planning and Management, Bureau of Planning and Natural Resources, City of Pengzhou Municipality in the Greater Chengdu Region, South West China. (In Chinese with English translation).

E9: Testimonial letter from Minister of Public Works of Chile.

E10: Testimonial letter from Professor of City and Regional Planning, College of Environmental Design, University of California, Berkeley, USA.