40 Years of Economic Reform – The Case of Pudong New Area Open Economic Zone in Shanghai

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Agenda

Introduction and Motivation I

- Economic reforms (especially open-door policy, gaige kaifang) initiated by Deng Xiaoping sparked unprecedented success story with regards to economic growth
- First wave of new policy leads to south-eastern coastal cities being granted status as special economic zones (SEZs), comprehensive reform experimenting cities or open coastal cities
- Cities and provinces along the Pacific coast spearheaded reforms, Shanghai not part of these pioneers
  - Shanghai had a higher per capita GDP than China (1981: CNY 2,780 vs CNY 493)
  - However, a lower average annual growth rate (1981–1991: 9.27% vs. 14.56%)
  - GDP per capita growth of Shanghai outpaced that of China for the first time since start of reform policies in 1992

Introduction and Motivation II

- Shanghai is one of the major cities in China (economic activity and population) but there is not much research on economic development of Shanghai
- Shanghai usually excluded from analysis (see e.g. Wang, 2013, and Alder, Shao and Zilibotti, 2016) as it significantly differs from rest of China with regards to main economic and socio-demographic indicators
- While early reform policies were targeted on manufacturing and international trade (i.e. FDI and exports; see Park and Prime, 1997, Yao, 2006, and Zhao, 2013), Pudong New Area Open Economic Zone is more geared towards the Chinese capital market

Introduction and Motivation III

- Our contribution is to fill this gap in the literature and assess the impact of Pudong New Area Open Economic Zone on economic development of Shanghai
- Using the augmented synthetic control method (ASCM) of Ben-Michael, Feller and Rothstein (2021), we find an effect of up to CNY 7,166 in GDP per capita per year
- Using the Bayesian structural time series (BSTS) approach of Brodersen et al. (2015), we find an effect of up to CNY 6,961 in GDP per capita per year

Methodology I – Augmented Synthetic Control Method

- Synthetic control method (SCM) of Abadie and Gardeazabal (2003) to construct counterfactual coined „the most important innovation in the policy evaluation literature in the last 15 years“ (Athey and Imbens, 2017, p. 9)
- SCM strongly relies on proper pre-treatment fit of counterfactual
- SCM constrains weights attached to units in the donor pool to be nonnegative and sum to one to safeguard against extrapolation outside the support of the predictors
- Given that Shanghai is the province with the highest values of some of the covariates during the sampling period (e.g. population density), it is not possible to perfectly reproduce Shanghai as a convex combination of the other Chinese provinces

Methodology II – Augmented Synthetic Control Method

- To overcome issue of infeasible pre-treatment fit, Ben-Michael, Feller and Rothstein (2021) suggest to augment SCM with an outcome model
  - Estimate bias due to divergence between treatment unit and synthetic counterfactual
  - Adjust original SCM estimate for this bias
- ASCM estimator of unobserved counterfactual $Y_{1T}(0)$ given as $\widehat{Y}_{1T}^{aug}(0) = \sum_{W_i=0} \widehat{\gamma}_i^{scm} Y_{iT} + (\widehat{m}_{1T} - \sum_{W_i=0} \widehat{\gamma}_i^{scm} \widehat{m}_{iT})$ $= \widehat{m}_{1T} + \sum_{W_i=0} \widehat{\gamma}_i^{scm} (Y_{iT} - \widehat{m}_{iT})$, where W_i indicates treatment of unit i in period $T_0 < T$, $\widehat{\gamma}_i^{scm}$ denotes the SCM weights and $\widehat{m}_{iT}$ is an estimator for the post-treatment control potential outcome $Y_{iT}(0)$
- ASCM explicitly takes imbalance of pre-treatment outcomes via $\widehat{m}(\cdot)$ into account ($\widehat{m}_{iT} = const.$ yields traditional SCM as special case)

Methodology III – Bayesian Structural Time Series Model

- BSTS approach of Brodersen et al. (2015) employs a diffusion-regression state-space model to construct synthetic control
  - Generalization of difference-in-difference estimation to time series modelling
  - Effect of intervention (launch of Pudong New Area Open Economic Zone) on response variable (GDP per capita of Shanghai) calculated using Bayesian estimation and model averaging to construct counterfactual
  - Selection of control units for construction of counterfactual based on how well they explain the dependent variable of the treated unit before the intervention
  - No additional independent variables (i.e. growth predictors)
- Settings: No prior believes concerning contribution of specific provinces to counterfactual, so $b = 0$ in spike-and-slab prior, $g = 1$ and $w = 1/2$ in g-prior, prior inclusion probability $= 0.10$ for all potential predictors, $100,000$ MCMC samples

Data and Sample

- We obtain annual province-level data for the period 1981-2003 from the China Statistical Yearbooks Database (CSYD) via the China National Knowledge Infrastructure (CNKI) platform
- We manually check check the dataset for consistency and outliers
  - Value-added of primary industry overstated for Henan province in 1981 $\rightarrow$ Set value to missing
  - Population (GDP per capita) overstated (underestimated) for Jiangxi province in 2000 $\rightarrow$ Drop Jiangxi province

Results – Descriptive Statistics

Table 1: Pre-Reform Policy Characteristics

This table presents the mean values for the dependent variable (GDP per capita) and the auxiliary covariates for Shanghai and China for the period 1981 to 1990, i.e., before the establishment of the Pudong New Area Open Economic Zone. [a] in Chinese Yuan; [b] persons/km²; [c] chain index (preceding year=100); [d] in %; [e] % of GDP; [f] % of population.

	Shanghai	China
GDP per Capita[a]	4,014.23	978.47
Population density[b]	1,978.50	111.40
Consumer price index[c]	107.60	107.22
Unemployment rate[d]	1.01	2.41
Investment in capital construction[e]	13.89	10.20
Value-added of primary industry[e]	4.05	28.55
Value-added of secondary industry[e]	69.57	43.44
Value-added of tertiary industry[e]	26.39	28.19
Graduates from primary schools[f]	1.01	1.86
Graduates from secondary schools[f]	1.19	1.24

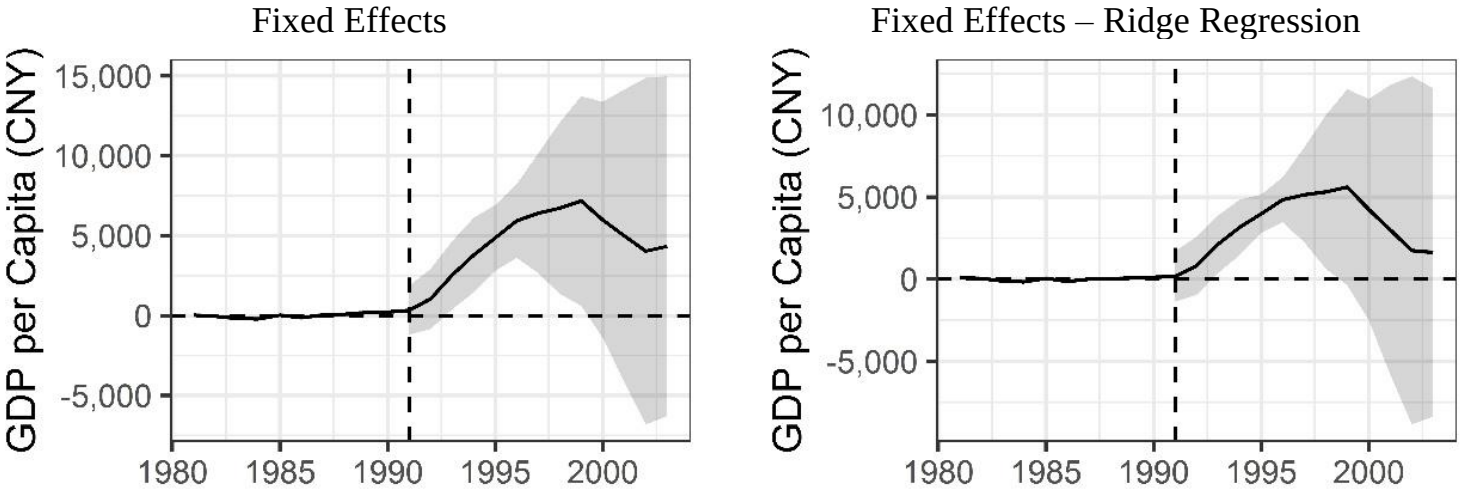
Results – Augmented Synthetic Control Method I

- Adding unit fixed effects to SCM is arguably on the simpler end of the range of possible outcome models
- Ben-Michael, Feller and Rothstein (2021) make a strong case for ridge regression as the outcome model

Figure 1: Development of Per Capita GDP for Shanghai vs. Counterfactual – Augmented Synthetic Control Method

This figure shows the development of the GDP per capita gap between Shanghai and the synthetic counterfactual using the augmented synthetic control method of Ben-Michael, Feller and Rothstein (2021). All models include auxiliary covariates (see Table 1). The shaded area shows the 95% confidence interval based on jackknife standard errors (jackknife+ standard errors) in Panel A (Panel B).

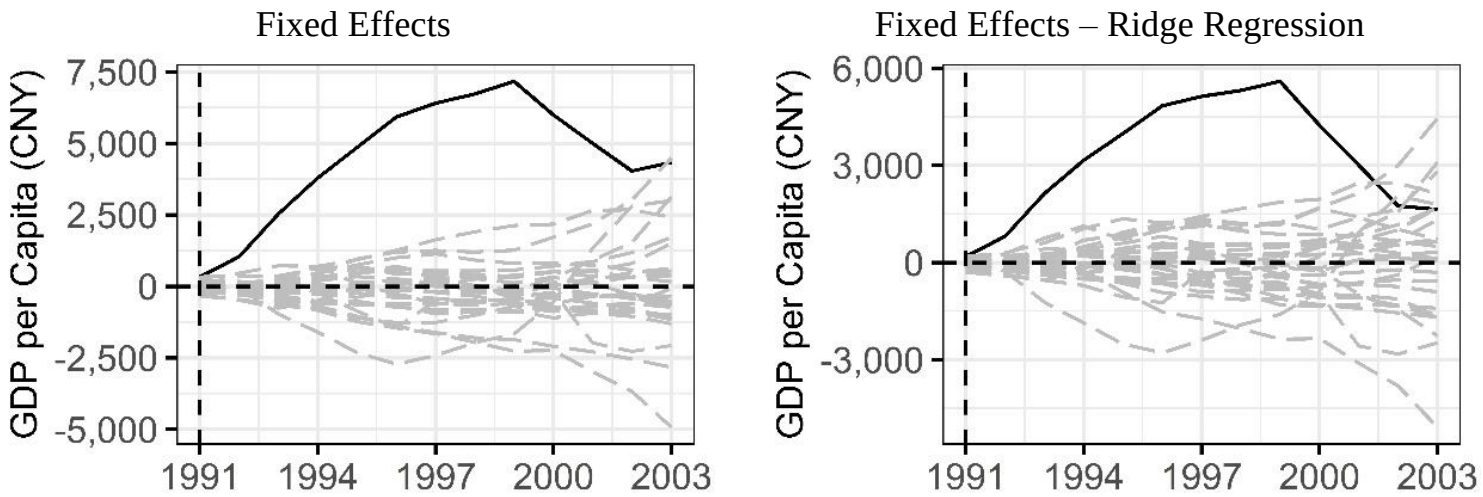
Panel A: Jackknife Standard Errors



Results – Augmented Synthetic Control Method II

- We check whether our estimates could be driven by chance → How often would we observe an effect of this magnitude if we pick a province at random?
- Probability of estimating a GDP per capita gap of the same magnitude under a random permutation of the intervention is 3.45% (1/29, as we have 29 provinces for the placebo studies)

Figure 2: Development of Per Capita GDP for Shanghai vs. Counterfactual – Augmented Synthetic Control Method: Placebo Tests
This figure shows the development of the GDP per capita gap between Shanghai and the synthetic counterfactual (solid line) as well as the respective GDP per capita gaps for 29 provinces (dashed lines) using the augmented synthetic control method of Ben-Michael, Feller and Rothstein (2021).



Results – Bayesian Structural Time Series Model I

- All potential donor provinces exceed prior inclusion probability of 0.10 and thus contribute to counterfactual (exception: Tibet)
- Launch of Pudong New Area Open Economic Zone increased GDP per capita in Shanghai by 42%
  - Effect of CNY 6,961 per year on average
  - Cumulative effect of CNY 83,538 over 1991-2003 period
- Posterior probability of causal effect of Pudong New Area Open Economic Zone on GDP per capita in Shanghai is 98.87%

Table 2: Posterior Inference of the Causal Impact of the Pudong New Area Open Economic Zone on GDP per Capita

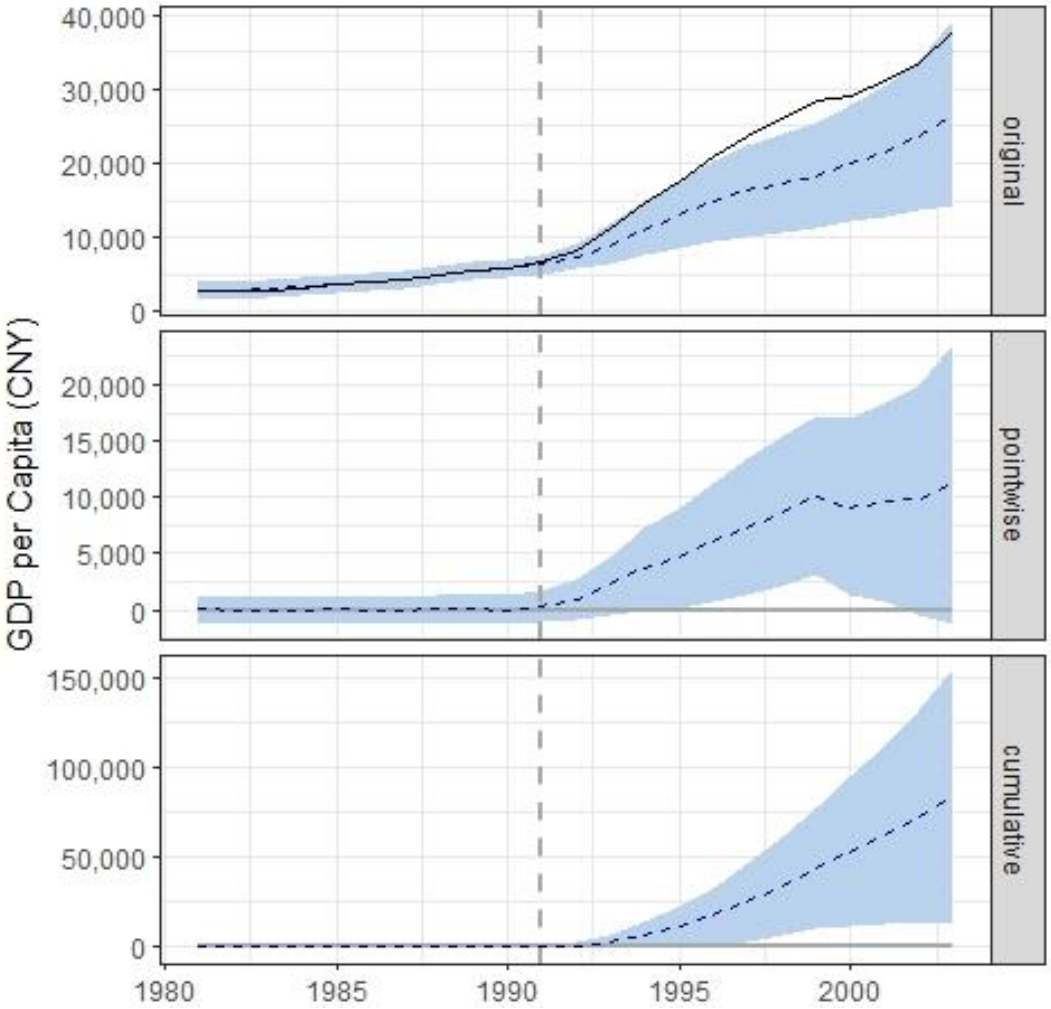
This table presents the estimates of the causal impact of the launch of the Pudong New Area Open Economic Zone in 1991 on GDP per capita in Shanghai. Standard deviation in parenthesis. Values in squared brackets show the 95% confidence interval. Posterior tail-area probability $p = 0.011$ so that results are statistically significant at the 5% level. Actual, prediction and absolute effect in CNY; relative effect in %.

	Actual (1)	Prediction (2)	Absolute Effect (3) = (1) – (2)	Relative Effect (4) = (3) / (2)
Average Effect	23,537	16,576 (2,947)	6,961 (2,947)	42 (18)
		[10,628; 22,429]	[1,108; 12,910]	[6.7; 78]
Cumulative Effect	282,449	198,911 (35,362)	83,538 (35,362)	42 (18)
		[127,531; 269,152]	[13,297; 154,918]	[6.7; 78]

Results – Bayesian Structural Time Series Model II

Figure 3: Development of Per Capita GDP for Shanghai vs. Counterfactual – Bayesian Structural Times Series Model

This figure shows the development of the GDP per capita gap between Shanghai and the synthetic counterfactual using the Bayesian structural time series model of Brodersen et al. (2015). The top Panel shows the trajectories of Shanghai (solid line) versus the synthetic counterfactual (dashed line). The middle Panel shows the estimated treatment effect, i.e. the difference between the trajectories of Shanghai and its synthetic counterfactual. Ths bottom Panel shows the cumulative treatment effect. The shaded area shows the 95% confidence interval.



Summary

- As Shanghai is one of the most important cities in terms of economic activity, we use the augmented synthetic control method of Ben-Michael, Feller and Rothstein (2021) and the Bayesian structural time series approach of Brodersen et al. (2015) to analyze the effect of the launch of the Pudong New Area Open Economic Zone
- The opening up of Pudong had a substantial impact on the development of GDP per capita in Shanghai over 1991-2003 period
- Given that the remaining Chinese provinces which form the synthetic counterfactual are influenced by economic reform policies themselves, our findings might be considered conservative