APPLIED ECONOMICS
2021, VOL. 53, NO. 30, 3499–3514
https://doi.org/10.1080/00036846.2021.1883529

Routledge
Taylor & Francis Group

Check for updates

Assessing economic impact of sovereignty transfer over Hong Kong: a synthetic control approach

Jing Li, Sarina Sangal† and Ling Shao‡

Miami University, Oxford, United States

ABSTRACT
This article compares the trajectory of Hong Kong's purchasing power parity–adjusted GDP per capita before and after the 1997 handover with the trajectory of a weighted combination of similar economies, using weights determined endogenously by data. The synthetic Hong Kong is constructed to provide the counterfactual of what would have happened to Hong Kong economy in the absence of transfer of sovereignty. We find that Hong Kong economy is negatively affected, and the gap between actual and synthetic Hong Kong from 1997 to 2001 on average is 7% of the 1996 level if Japan receives the greatest weight. The average negative effect becomes 9% if Singapore receives the greatest weight.

KEYWORDS
Hong Kong; synthetic control; handover; sovereignty; GDP

JEL CLASSIFICATION
N95; P52; O47

I. Introduction

In 1992, 5 years before Hong Kong was officially reverted to Chinese sovereignty, the purchasing power parity (PPP)–adjusted GDP per capita in Hong Kong and Singapore were 24,540 and 25,372 international dollars,[1] respectively. The difference is less than 4% In 2001, 4 years after the handover, those numbers became 27,830 and 35,519, and the difference rose to 28%

The goal of this article is to answer the question of how much is the effect of the 1997 handover on the Hong Kong economy. The answer can quantify the degree to which the observed divergence in economic growth in Hong Kong and Singapore is attributed to that treatment, and may shed new light on understanding the anti-government protests that had unsettled Hong Kong for months until China passed the controversial Hong Kong security law in June 2020[2]

To answer that question, we need to know the potential outcome of what would have happened if the Hong Kong economy had not been exposed to the handover treatment. Then, the causal effect can be estimated as the difference between the actual Hong Kong economy and the counterfactual. Given the closeness of pre-1997 living standards in Hong Kong and Singapore, and the fact that both cities are former British colonies, and both are international financial centres and two of the world's busiest container ports, it is natural to use Singapore as the control group to mimic Hong Kong without the treatment. However, relying on Singapore only has at least two limitations: first, just one comparison is prone to be sensitive to idiosyncratic shocks such as the 1997 Asian Financial Crisis that had different impacts on the two economies. Second, the rivalry status of Singapore and Hong Kong in finance,[3] trade and other sectors implies that Singapore might 'crowd out' Hong Kong and benefit from the 1997 handover. In other words, using Singapore as the sole control group may produce just an upper bound of the treatment effect.

*CONTACT Jing Li lij14@miamioh.edu Department of Economics, Miami University, 800 E. High Street, Oxford, OH 45056. We wish to thank William Even and Charles Moul for their comments. All errors are ours

†Department of Economics, Miami University, 800 E. High Street, Oxford, OH 45056. Email: sangals2@miamioh.edu.
‡Department of Economics, Miami University, 800 E. High Street, Oxford, OH 45056. Email: shaol2@miamioh.edu.

[1]An international dollar is a hypothetical currency that has the same purchasing power as the U.S. dollar does in the United States. It is commonly used to compare living costs or standards across countries.
[2]For a summary of recent protests see the BBC report titled 'The Hong Kong protests explained in 100 and 500 words' https://www.bbc.com/news/world-asia-china-49317695 A summary of Hong Kong security law can be found at https://www.bbc.com/news/world-asia-china-52765838.
[3]Goldman Sachs projected that capital would flow from Hong Kong to Singapore because of the ongoing protests, see https://finance.yahoo.com/news/hong-kong-may-lost-us-093000630.html

To obtain the lower bound we search for an economy with a living standard similar to Hong Kong, albeit the two economies are more like complements rather than substitutes. We hope this economy did not grow as quickly as Singapore after 1997. That is why we pick Japan, where the living standard is near a steady state owing to its ageing population. We believe that an *interval* estimate of the treatment effect with upper and lower bounds is needed to underline the uncertainty inherent in results.

Singapore and Japan are similar to Hong Kong in terms of the *level* of socioeconomic development. But when it comes to growth rate, South Korea and Taiwan are more comparable to Hong Kong, so are included in the donor pool, the set of economies serving as control groups.[4]

It is evident that separate or group-wise comparisons of Hong Kong to other economies would give rise to ambiguity in conclusion – the result depends on to which economy Hong Kong is compared. That motivates us to employ the synthetic control method (SCM) proposed in Abadie and Gardeazabal (2003), which is concerned with constructing a synthetic Hong Kong as a weighted average of Japan, Singapore, South Korea, and Taiwan, with optimal weights determined in a data-driven fashion. The SCM is able to take advantage of multiple controls and deliver a unified answer. Then the treatment effect is estimated as the gap in living standards between the actual and synthetic Hong Kong. We focus on the gap between 1997 and 2001 in order to avoid the impact of confounding events such as China's joining the World Trade Organization in December 2001[5]

In addition to choosing weights systematically, SCM enables straightforward placebo studies (permutation test). For instance, we can apply SCM to the year 1994, before the handover actually occurred, or we can apply SCM to Taiwan, an untreated unit in the donor pool. We expect to see patterns in the trajectory of living standards different from what we observe after applying SCM to Hong Kong in 1997.

It is crucial to take into account the 1997 Asian Financial Crisis that started with the sudden devaluation of the Thai baht on 2 July 1997, just 1 day after the official handover ceremony. The endogeneity issue we need to address is to what degree the economic growth of Hong Kong had been altered by the 1997 handover, as opposed to the 1997 Asian Financial Crisis. Our first identification strategy compares Hong Kong to four economies with similar living standards that were all subject to the detrimental shock of the Financial Crisis. The second identification strategy is to demonstrate that the China factors caused the growth of the Hong Kong economy to slow down even before the 1997 crisis.

II. Literature review

The literature about the 1997 handover is vast. To name a few, McGiffert and Tang (2008) and Luk (2018) collect essays about the sovereignty transfer; Martin (2007) provides an overview of Hong Kong after the transition; Lui (1999) discusses social discontent and political contentions in post-1997 Hong Kong; Tsang (1999) lists the factors that have shaped the Hong Kong economy during the transition period; Sung and Wong (2000) examine how Hong Kong's integration with mainland China contributes to its growth; Chau (1997) and Kim and Mei (2001) look at how political uncertainty affects the real estate and stock market; Meyer (2008) investigates economic restructuring and structural changes in Hong Kong after 1997; Hsieh and Woo (2005) and Suen (1995) examine the effect on the labour market and income inequality. None of these studies invoke multiple comparisons of Hong Kong to other economies.

One example of studies comparing Hong Kong and Singapore is Cheung (2008); Liu (1999) documents that a bubble in the property sector had built up in Hong Kong prior to the crisis, but not in Singapore. Hong Kong, Singapore, South Korea and Taiwan are frequently referred to as 'The Four Little Dragons' as a result of their rapid industrial transformation, see Vogel (1991). For our

[4]We use Indonesia, Malaysia, Philippines, and Thailand as control groups only in Robustness Check section since their living standards were much lower than Hong Kong before and after 1997.

[5]Other prominent confounding events include the burst of the dot-com bubble in 2001, the 2002–2004 outbreak of severe acute respiratory syndrome (SARS), and the announcement of Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA) in 2003..

purpose, this similarity suggests natural candidates for control groups.

In terms of utilizing variation across economies, this study is close to Hsiao, Ching, and Wan (2012), but the two differ in three ways: first, this article uses SCM while Hsiao, Ching, and Wan (2012) use a panel data evaluation method that assumes the outcome variable is driven by unobserved common factors and economy-specific fixed effects. It is unclear how to discover the potential mechanism using the panel data methodology; second, Hsiao, Ching, and Wan (2012) consider a much bigger donor pool that includes economies not directly affected by the 1997 Financial Crisis and economies whose living standards are not necessarily comparable to Hong Kong; third, Hsiao, Ching, and Wan (2012) do not disentangle the effect of 'China factor' from the 1997 Financial Crisis, but the authors show how other prominent shocks such as CEPA affected Hong Kong economy. Given those differences, this study can be seen as a complement to Hsiao, Ching, and Wan (2012).

III. Data and difference-in-difference approach

Annual country-level panel data for the period 1989–2008 is used. Transfer of Sovereignty over Hong Kong occurred on 1 July 1997, so the sample contains a pre-intervention period of 8 years. The sample ends in 2008 as we believe 12 years are long enough to illustrate the treatment effect. A longer post-intervention period would be subject to more confounding shocks such as the 2008 Summer Olympics in Beijing.

The outcome variable is the PPP-adjusted GDP per capita (chain series, 2005 international dollars), a measurement of living standard that takes into account exchange rates and living costs. For simplicity, GDP refers to the PPP-adjusted per capita GDP thereafter. Figure 1 plots the time series of GDP for Hong Kong, Japan, Singapore, South Korea and Taiwan. Economic growth is observed in every economy, though growth rates vary. Singapore stands out with the best performance by more than doubling its living standard, whereas the improvement in Japan is moderate. After 20 years South Korea and Taiwan still lag behind Hong Kong with no indication of convergence.

Figure 1 clearly shows the drawback of separate or group-wise comparison of Hong Kong to other economies – the conclusion depends on which economy is used as the control group. Hong Kong is a loser relative to Singapore: despite the fact that their living standards were almost the same between 1989 and 1992, the gap between their GDPs seems to widen over time, especially after 1997. On the other hand, Hong Kong won the race against Japan with its living standard overtaking Japanese in 2004.

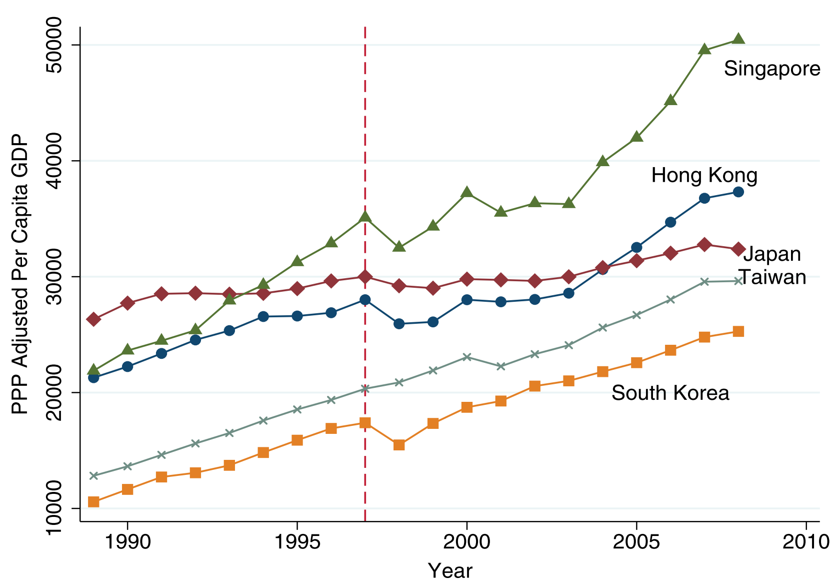

Figure 1. Time-series plot of PPP-adjusted per capita GDP. Note: A vertical line is drawn in year 1997 when the transfer of sovereignty over Hong Kong occurred.

To quantify the difference in economic growth shown in Figure 1, Panel A of Table 1 reports a set of basic difference-in-difference (DID) estimates of the effect of 1997 handover on Hong Kong economy. For each pair of economies, the regression is

$$y_{it} = \beta_0 + \beta_1 D_{HongKong} + \beta_2 D_{year\geq 1997} + \beta_3 (D_{HongKong} D_{year\geq 1997}) + u_{it} \quad (1)$$

where i is the index for economy, t is the year index, y denotes the GDP, the dummy variable $D_{HongKong}$ equals 1 for Hong Kong, the dummy variable $D_{year\geq 1997}$ equals 1 for the post-intervention period (1997–2008) and the last regressor is the product of $D_{HongKong}$ and $D_{year\geq 1997}$, the interaction term. OLS is used to estimate the DID regression.

The interpretation of each β is as follows. β_0 measures the average y value for the untreated unit (Japan, Singapore, South Korea, Taiwan) in the pre-1997 period; β_1 is the difference in the average y value between Hong Kong and untreated units prior to 1997; β_2 is the post-1997 average y value minus the pre-1997 average y value for the untreated unit. Most importantly, the DID estimate of the treatment effect is β_3, which is the change in the living standard of Hong Kong minus the change in the living standard of an untreated unit.

The Japan column in Table 1 confirms that (1) Hong Kong was poorer than Japan before 1997 ($\hat{\beta}_1 < 0$), (2) there was moderate growth in Japan over 20 years ($\hat{\beta}_2 > 0$), and (3) Hong Kong is a winner with faster growth ($\hat{\beta}_3 > 0$). Nevertheless, the third conclusion changes when we look at the Singapore column – now $\hat{\beta}_3 = -6667$ is negative, indicating that Hong Kong is a loser with slower growth. Part of the reason is that post-1997 growth in Singapore is much larger than that of Japan ($\hat{\beta}_2 = 12432$ of Singapore is much larger than $\hat{\beta}_2 = 2209$ of Japan). Intuitively you are more likely to lose when facing a stronger opponent.

There is no statistically significant difference in growth rates when comparing Hong Kong to South Korea and Taiwan. This finding is consistent with the observation that the GDP paths of Hong Kong, South Korea and Taiwan in Figure 1 are largely parallel. That comovement likewise explains the greater R^2 (the coefficient of determination) in the regressions using South Korea and Taiwan as control groups.

To mitigate the impact of different magnitudes of living standards, Panel B of Table 1 reports the DID estimate with y_{it} being replaced by its natural logarithm in regression (1). Now $\hat{\beta}_3$ measures the

Table 1. DID estimates of treatment effect.

	Hong Kong versus				
	Japan (1)	Singapore (2)	South Korea (3)	Taiwan (4)	All (5)
Panel A					
$\hat{\beta}_0$	28,350***	27,088***	13,668***	16,086***	32,830***
	(900)	(1569)	(1098)	(1123)	(4497)
$\hat{\beta}_1$	−3745***	−2483	10,937***	8520***	920
	(1273)	(2219)	(1552)	(1588)	(2589)
$\hat{\beta}_2$	2209*	12,432***	6989***	8528***	4779***
	(1162)	(2026)	(1417)	(1449)	(1652)
$\hat{\beta}_3$	3556**	−6667**	−1224	−2763	−5485*
	(1644)	(2865)	(2004)	(2050)	(3198)
Adjusted R^2	0.43	0.62	0.79	0.71	0.58
Panel B					
$\hat{\beta}_0$	10.25***	10.20***	9.51***	9.68***	10.45***
	(0.03)	(0.05)	(0.05)	(0.04)	(0.19)
$\hat{\beta}_1$	−0.14***	−0.09	0.60***	0.43***	0.19*
	(0.04)	(0.07)	(0.07)	(0.06)	(0.11)
$\hat{\beta}_2$	0.07*	0.38***	0.41***	0.43***	0.22***
	(0.04)	(0.06)	(0.06)	(0.06)	(0.07)
$\hat{\beta}_3$	0.13**	−0.17**	−0.21**	−0.22**	−0.32***
	(0.06)	(0.08)	(0.09)	(0.08)	(0.13)
Adjusted R^2	0.47	0.65	0.82	0.76	0.55

Note: Columns (1)–(4) represent a separate difference-in-difference (DID) regression given by (1). Column (5) represents the DID regression that includes all untreated units and control variables of Trade Openness, Inflation Rate, Unemployment Rate and Investment Share. Panel A uses GDP as the dependent variable; while Panel B uses the log of GDP. The SEs are in parentheses. ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.

difference in growth rates. According to this new specification, the Hong Kong economy grew slower (significant at 5% level) than Singapore, South Korea and Taiwan. Again, this can be seen in Figure 1 – the GDP lines of Singapore, South Korea and Taiwan were somewhat steeper than Hong Kong between 1997 and 2005.

Column (5) in Table 1 reports the DID regression incorporating all countries in the control group and the predictors of trade openness, inflation rate, unemploymentrate and investment share. We do not find qualitative changes in results compared to pair-wise DID regressions. To summarize, because of heterogeneity in starting point and growth rate, a direct comparison of Hong Kong to another economy is like an apple-to-orange comparison, so is problematic.

IV. Principal component approach

One may wonder whether we can get an aggregate control group by averaging the multiple control groups, in the hope that heterogeneity in untreated units can be smoothed out. Towards that end, Panel A of Figure 2 plots Hong Kong GDP and the simple average of GDPs of Japan, Singapore, South Korea and Taiwan.

We make progress by reducing four control groups into just one and removing ambiguity in the conclusion. However, the simple average control group is not ideal because it still leads to an apple-to-orange comparison. Panel A shows a noticeable and persistent gap between the two GDP trajectories before 1997, meaning that the simple average control fails to mimic Hong Kong before the treatment, so is unable to provide a satisfactory counterfactual. We do not know, based on this poor control, whether the discrepancy in GDP trajectories after 1997 is attributed to the transfer of sovereignty or a lack of fit.

That pre-1997 gap shown in Panel A mainly reflects the fact that the GDPs of South Korea and Taiwan were much lower than Hong Kong. Notwithstanding the gap, *slope* of the simple average GDP of the donor pool is akin to Hong Kong GDP, simply because the living standards of

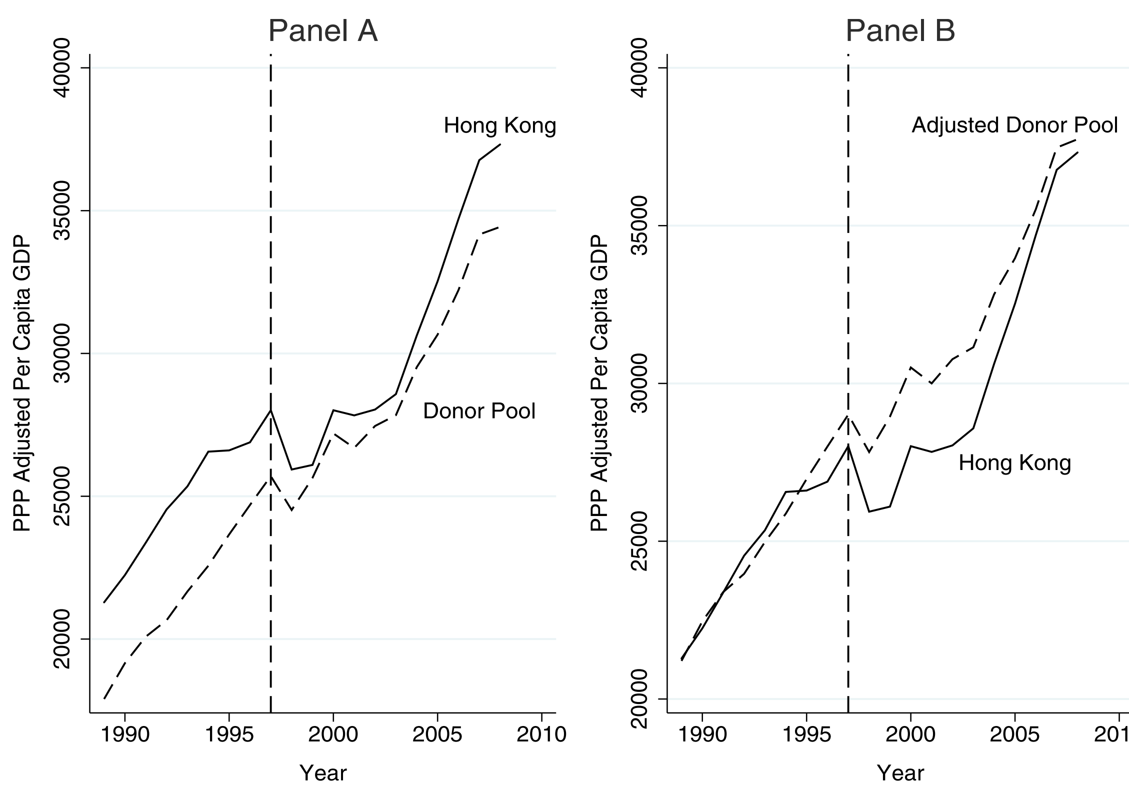

Figure 2. Panel A: Comparison of PPP-adjusted per capita GDP of Hong Kong and simple average GDPs of Japan, Singapore, South Korea and Taiwan (Donor Pool). Panel B: Comparison of PPP-adjusted per capita GDP of Hong Kong and adjusted donor pool that corrects the pre-1997 gap shown in Panel A.

Hong Kong, South Korea, and Taiwan grew roughly at the same rate before 1997 as shown by Figure 1. This suggests that we can obtain an improved or adjusted donor pool by correcting the pre-1997 gap (i.e. adding the average pre-1997 difference between the two GDPs to the simple average of GDPs of the donor pool), while still using equal weights for untreated units.

Panel B of Figure 2 contrasts Hong Kong GDP with the GDP of the adjusted donor pool. Now we see a close pre-1997 match between the two trajectories, which implies that a counterfactual is readily available. Moreover, even though both trajectories went down in 1998, the GDP of the adjusted donor pool lay above Hong Kong GDP between 1997 and 2001. This is the first indication that Hong Kong suffered *more* than the control groups during and shortly after the 1997 Asian Financial Crisis.

The equal weights for untreated units used in the simple average actually are not that *ad hoc*; in some sense, they are 'data driven' by being the weights from the principal component analysis (PCA).[6] More specifically, the first principal component loadings, or the eigenvector of the largest eigenvalue of the variance-covariance matrix of standardized GDPs of untreated economies, are 0.49 for Japan, 0.50 for Singapore, 0.50 for South Korea, and 0.50 for Taiwan. Those numbers can be translated into a weight of 0.25 for each economy. In short, PCA supports the use of equal weights to compute the simple average.

V. Synthetic control approach

Because the simple average indiscriminately assigns equal weights to the four economies, correction of the pre-1997 gap is needed to make the adjusted donor pool comparable to Hong Kong prior to the treatment. Alternatively, we can directly (i.e. without correction) obtain a comparable control by assigning unequal weights to untreated units. That is exactly the idea behind the synthetic control method (SCM) developed in Abadie and Gardeazabal (2003), which relaxes the assumption of the equal importance of untreated units. Intuitively, an economy that is more similar to Hong Kong should receive greater weight. Towards that end, SCM gives data-driven or endogenous weights to untreated units and the weights depend on the predictive power. Specifically, a synthetic Hong Kong – an optimal weighted average of untreated economies, is created by solving the following two nested optimization problems:

$$W(V) = \text{argmin}_W (A_1 - A_0 W)' V (A_1 - A_0 W), \quad (0 \leq w_j \leq 1, j = 1, \ldots, J) \tag{2}$$

$$V^{optimal} = \text{argmin}_V (B_1 - B_0 W(V))' (B_1 - B_0 W(V)) \tag{3}$$

where V is the $K \times K$ diagonal matrix of weights for predictors of the outcome variable (there are K predictors); W is the $J \times 1$ vector of weights for the untreated units (there are J untreated units); A_1 is the $K \times 1$ vector of values of predictors for the treated unit in a subset of pre-intervention periods (called training set); A_0 is the $K \times J$ matrix of values of predictors for untreated units in the training set; B_1 is the vector of outcome variables of the treated unit in a subset of pre-intervention periods (called validation set), and B_0 is the matrix of outcome variables of untreated units in the validation set.

Minimizing the quadratic form in (2) produces the optimal weights for untreated units for given V, and the optimal V is obtained by cross-validation (i.e. minimizing the mean squared out-of-sample prediction error in the training set given by $B_1 - B_0 W(V)$). The optimization is solved by the method of restricted quadratic programming because the weight is bounded between 0 and 1. Results in this article are obtained using the SYNTH module of Stata. In the end, the synthetic control estimate for the treatment effect is given by

$$C_1 - C_0 W(V^{optimal}) \tag{4}$$

where C_1 and C_0 contain values of outcome variables in the post-intervention periods for the treated and untreated units, respectively. In words, the weighted average of post-intervention outcome variables of untreated units $C_0 W(V^{optimal})$ is used

[6]PCA is a computationally low-cost method for data reduction. The weights from PCA are computationally more robust than the highly nonlinear synthetic control method.

to approximate the potential outcome of the treated unit in the absence of treatment. For more details about SCM, see Abadie, Diamond, and Hainmueller (2015).

We follow Abadie, Diamond, and Hainmueller (2015) when selecting predictors for the outcome variable. The predictors include lagged values of GDP, trade openness (exports plus imports divided by GDP), inflation rate (per cent change of consumer price index from a year ago, index 2010 = 100), schooling (percent of secondary school attained in the total population aged 25 and older, reported in 5-year increments) and investment share (of PPP-adjusted per capita GDP at constant price).

We extend Abadie, Diamond, and Hainmueller (2015) by considering unemployment rate (aged 15 and over), total factor productivity (ratio of output divided by the weighted average of labour and capital input, index USA = 1, level at current PPP) and stock market capitalization to GDP (total value of all listed shares in the stock market as a percentage of GDP). The rationale is that the unemployment rate measures slack in the labour market, total factor productivity measures the level of technology or economic efficiency, and the stock market plays a critical role in financial centres such as Hong Kong and Singapore. The data sources are in the Appendix.

Table 2 reports the pre-1997 mean values of those predictors. The similarity in living standards between Hong Kong, Singapore, and Japan is evident, which explains why either Singapore or Japan will dominate the donor pool. Table 2 also highlights the diversity among the five economies. In particular, note the low trade openness in Japan (17.8), high inflation rate[7] in Hong Kong (6.2), and low schooling in Singapore (10.6). Those extreme values can help understand the matching result of SCM.

Table 3 summarizes the process of the model specification to acquire a synthetic Hong Kong using SCM. The training set includes the years 1989–1993, and the validation set includes the years 1994–1996. The two sets do not overlap so that the error of out-of-sample forecasting for the outcome variable is utilized by cross-validation.

Model 1 in Table 3 is the baseline model in which the predictors are the average values of trade openness and inflation rate over the whole pre-intervention period. For lagged GDP, we only use average values of 1991–1993 since Hong Kong GDP was trending upward.[8] Because schooling is observed once every 5 years and has an upward trend as well, we only use the 1995 value as the predictor.

For Model 1, the estimated weights are 0.171 for Japan, 0.619 for Singapore, 0 for South Korea, and 0.21 for Taiwan. Thus, Model 1 selects Singapore as the economy with the closest proximity to Hong Kong. The weight for Japan rises and the weight for Singapore falls after the average unemployment rate is added as a predictor in Model 2. The root mean squared prediction error (RMSPE) decreases from 1753 to 1149, attesting to the importance of utilizing the unemployment rate. Remarkable changes happen after the average investment share is included in Model 3, the best

Table 2. Means of economic growth predictors before transfer of HK sovereignty.

	Hong Kong	Synthetic Hong Kong[a]	Donor Pool[b]	Japan	Singapore
PPP-adjusted GDP per capita	24,605.5	24,877.3	21,298.2	28,350.4	27,088.4
Trade openness	229.4	129.2	119.1	17.8	330.8
Inflation rate	6.2	2.1	2.6	1.5	1.8
Schooling[c]	24.3	22.2	22.9	29.2	10.6
Unemployment rate[d]	2.0	2.3	2.2	2.6	1.7
Investment share	35.0	36.1	37.0	34.0	39.9
Total factor productivity	1.02	.94	.87	1.00	1.01
Stock market capitalization to GDP[e]	172.9	84.9	82.9	82.3	130.9

Note: [a] Except for stock market capitalization, Synthetic Hong Kong is the linear combination of Japan, Singapore, South Korea and Taiwan using weights of Model 3 in Table 3. For stock market capitalization, the weights for synthetic Hong Kong are from Model 5. [b] Donor pool represents a simple average of Japan, Singapore, South Korea and Taiwan. [c] Schooling data in 1985, 1990 and 1995. [d] The unemployment rate for Singapore starts in 1992. [e] Unavailable for Taiwan.

[7]The pre-1997 high inflation in Hong Kong was due to labour shortage, land shortage, rapid economic restructuring as well as economic integration with mainland China, see Liu (1999).

[8]In other words, the average GDP of the whole training period (1989–1993) would substantially under-predict the value in the validation period.

Table 3. Model specification for constructing synthetic Hong Kong.

	Model 1	Model 2	Model 3	Model 4	Model 5
RMSPE	1753	1149	783	3485	682
Panel A: Weight for untreated unit w					
Japan	.171	.389	.45	.51	.507
Singapore	.619	.425	.315	.49	.271
South Korea	0	.186	.08	0	.218
Taiwan	.21	0	.155	0	
Panel B: Weight for predictor v					
$\overline{GDP}_{1991-1993}$	.885	.721	.813	0	.940
$\overline{TradeOpenness}_{1989-1996}$	.092	.024	.034	.045	0
$\overline{Inflation}_{1989-1996}$	.022	0	.008	.019	.002
$Schooling$, 1995	0	.122	0	0	0
$\overline{Unemployment}_{1992-1996}$		.132	.110	.111	.041
$\overline{InvestmentShare}_{1989-1996}$			.035	.009	.017
$\overline{TFP}_{1989-1996}$				.816	
$\overline{Stock}_{1989-1996}$					0

Note: Each column is one specification using SCM. A predictor with overline denotes its sample mean.

one among the first three specifications in terms of minimizing RMSPE. In Model 3, the weights are 0.45 for Japan, 0.315 for Singapore, 0.08 for South Korea, and 0.155 for Taiwan. In short, the dominating roles of Japan and Singapore switch from Model 2 to Model 3.

Adding total factor productivity into Model 4 results in a big jump in RMSPE, and weights of South Korea and Taiwan become zero.[9] Model 5 replaces total factor productivity with stock market capitalization. Since that variable is missing for Taiwan, it has to be dropped from the donor pool in Model 5, in which Japan receives the highest weight once again.

In all specifications except Model 4, the weight for lagged GDP exceeds 0.7. Thus, it is crucial to use lagged GDP as a predictor for two reasons: First, GDP is trending, and previous values aid in forecasting a trending series by accounting for persistence and momentum in data. Second, those lagged values can capture the effect of slow-evolving *unobserved* driving factors of GDP such as corporate governance and business infrastructure.

VI. Results and placebo study

Figure 3 plots the GDP paths of actual and synthetic Hong Kong constructed with the weights from Model 3.[10] We see a much closer match relative to Panel A of Figure 2 between the two series prior to 1997, a signal that SCM works well here. Another favourable evidence is in Table 2 where the average pre-1997 GDP of synthetic Hong Kong is 24,877, close to the actual average value of 24,605.[11] In contrast, the average GDP of the donor pool is 21,298, well below Hong Kong's value. Given the close match prior to 1997, we are confident that synthetic Hong Kong is able to approximate what would have happened to the Hong Kong economy after 1997 without the handover treatment.

The two GDP series in Figure 3 both went down in 1998. The falling GDP of synthetic Hong Kong is mainly attributed to the 1997 Asian Financial Crisis that negatively affected all economies to varying degrees (see Figure 1). Hong Kong was not immune to that adverse shock. In addition, there is an impact of the transfer of sovereignty (or 'China factor' in general), and that is why the GDP of actual Hong Kong went down by a bigger amount than the synthetic one. Our identification of the treatment effect hinges on that *difference* in the way the actual and synthetic Hong Kong performed during and shortly after the economic downturn.

One advantage of SCM is that it enables us to extract a medium run signal from short-run noise. The 1997 Asian Financial Crisis is short-lived. As a result, the gap between actual and synthetic Hong Kong in the medium run from 1999 to 2001 is more likely to be indicative of the effect of sovereignty transfer. We emphasize the year 2001 because China joined the World Trade Organization in December 2001, and the US economy went into recession from March 2001 to November 2001. The former may help Hong Kong get ahead of Japan years later (see Kwok (2008)), and the latter prompted the GDPs of Singapore and Taiwan to dip down in 2001 (see

[9] Later, we will show that total factor productivity is highly correlated with GDP, and that may explain why the weight for lagged GDP becomes 0 in Model 4 after total factor productivity is included.

[10] Even though Model 5 has less RMSPE than Model 3, we believe the conclusion is not convincing without Taiwan in the donor pool. That is why we prefer Model 3 over Model 5. The results do not change qualitatively if weights from Model 5 are used to construct synthetic Hong Kong.

[11] Synthetic Hong Kong fails to generate a good match with actual Hong Kong in terms of the inflation rate (because Hong Kong had unusually high inflation), trade openness (because of Japan's low value), and stock market capitalization (due to the extreme value of Hong Kong). This is expected because SCM is not designed to mimic extreme values.

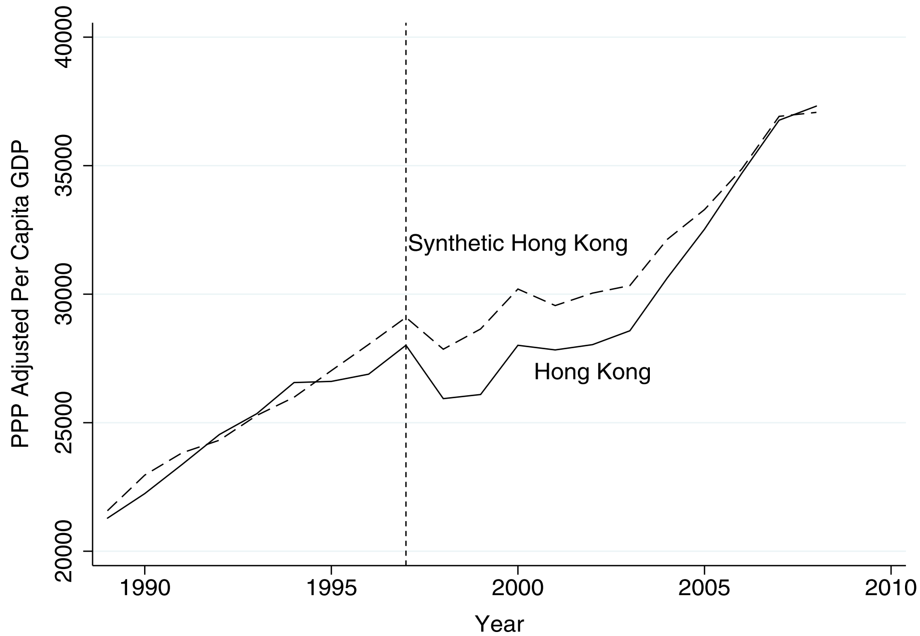

Figure 3. Comparison of PPP-adjusted per capita GDPs of Hong Kong and synthetic Hong Kong. Note: Synthetic Hong Kong is the weighted average of Japan, Singapore, South Korea and Taiwan, with weights determined by Model 3 in Table 3.

Figure 1). Those confounding events need to be downplayed in order to isolate the effect of the 1997 handover.

Overall, the 1997–2001 *average* gap between actual and synthetic Hong Kong GDP can serve as a reasonable estimate for the effect of sovereignty transfer. More explicitly, define $GDP_{SyntheticHongKong,t} = \sum_i w_i GDP_{i,t}$, $i = (Japan, Singapore, South\ Korea, Taiwan)$ and the weight w_i are given by Model 3 in Table 3. Then, the estimated treatment effect using SCM is

$$\frac{\sum_{t=1997}^{2001} (GDP_{HongKong,t} - GDP_{SyntheticHongKong,t})/5}{GDP_{HongKong,1996}} = -.0705 \tag{5}$$

To summarize, based on the weighting from Model 3, the 1997 handover is associated with 7% decrease, relative to the 1996 level, in Hong Kong's GDP in each year from 1997 to 2001. The accumulative effect is about 35% decrease in living standard, or in other words, Hong Kong had forgone about 35% economic well-being within 5 years after the 1997 handover. These effects are economically significant.

Because Model 3 assigns the highest weight to Japan, the 7% average decrease in living standard is likely to underestimate the true treatment effect. As a result, we use 7% as the lower bound estimate. In Section VII, we obtain the upper bound by giving the highest weight to Singapore.

We run two placebo tests to guard against the possibility that we observe the pattern shown in Figure 3 just by chance. The first one is 'in time placebo' that applies SCM to Hong Kong again but pretends the handover took place in 1994, 3 years before the actual date. We see in Panel A of Figure 4 that the year 1994 is not followed by an immediate and persistent *negative* gap between the actual and synthetic Hong Kong GDP as shown in Figure 3.

Panel B of Figure 4 displays the 'in place placebo' in which SCM is applied to Taiwan in the year 1997, and we actually see a transitory *positive* gap between the actual and synthetic Taiwan. The reason why Taiwan outperforms its synthetic counterpart is that Taiwan was almost unaffected by the 1997 Financial Crisis, see Figure 1. In fact, the Taiwanese government was criticized for letting its currency depreciate somehow unnecessarily so that Taiwan could maintain its competitive position during the crisis. That first-move advantage is at the cost of Hong Kong and Singapore whose currencies were pegged to other currencies, see

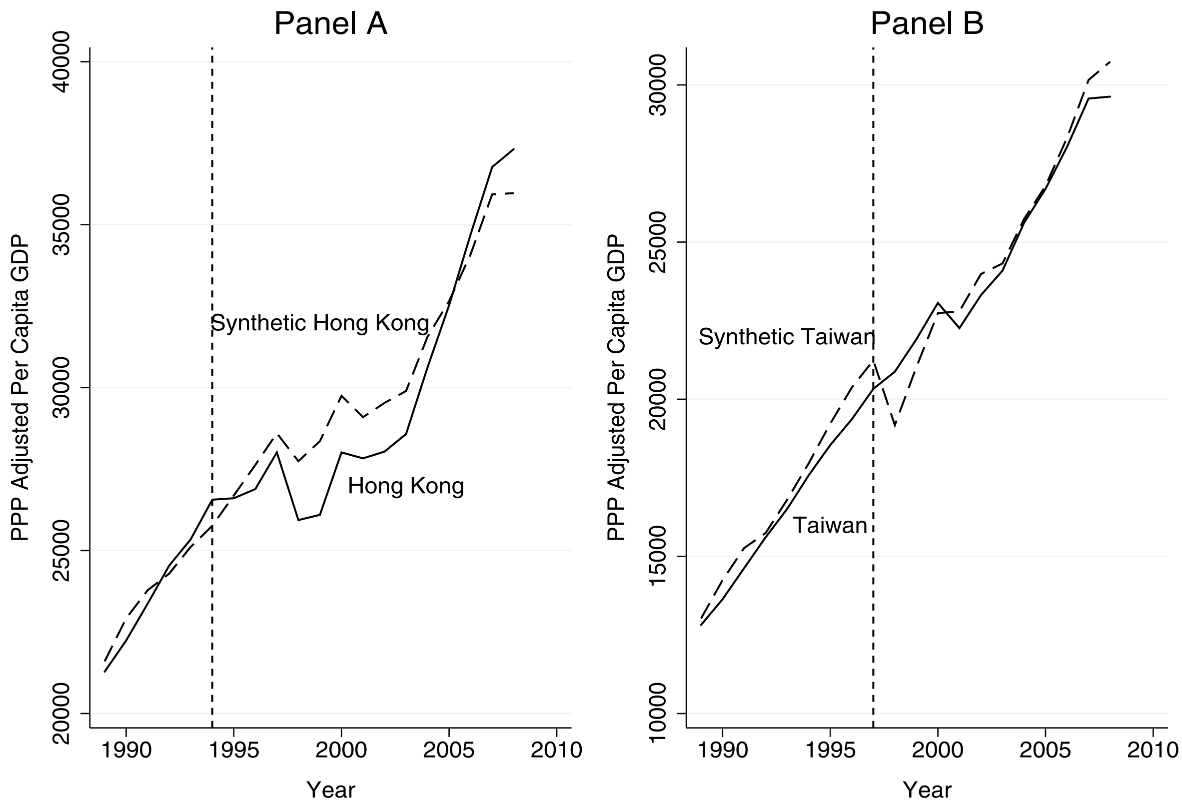

Figure 4. Placebo study Panel A: Pretending transfer of Hong Kong sovereignty occurred in 1994; Panel B: Applying the synthetic control method to Taiwan.

Walker (2000). In the long run, the actual and synthetic Taiwan GDP series in Panel B restore to close overlapping, which is missing in Figure 3. Overall Figure 4 adds credibility to Figure 3 by not duplicating its pattern.

To put the post-1997 performance of the Hong Kong economy into perspective, Figure 5 plots the gap in GDPs between an economy and its synthetic counterpart for all five units. We see the synthetic control method does a good job when applied to Hong Kong and Taiwan as their pre-1997 GDP gaps are almost zero, implying that the synthetic economies imitate real economies well. That is not the case for Japan and South Korea, whose pre-1997 gaps are persistent and substantial. Thus, for these two economies, the other economies do not serve as good control groups.

For Singapore, we see near-zero GDP gap in the training period (1989–1993), and then the gap became increasingly positive. On the other hand, we see an increasingly negative gap for Japan. Note that these two economies are at the two ends of the spectrum for GDP growth. Taken literally, the graph implies that Singapore over-performs and Japan under-performs more and more relative to their controls as time goes by. This does not imply the failure of SCM. Rather, it is because no control groups can match the best winner and the worst loser, no matter what weights are used to create the synthetic control.[12]

VII. Robustness check – Interval estimate and pretreatment effect

Table 3 highlights the uncertainty inherent in the estimation result. From Model 3 to Model 4, by just adding total factor productivity as the predictor, we see a big jump in RMSPE and a big deterioration in fit. This is not unexpected given that predictors can be correlated (collinearity), and the objective in (2) and (3) are two *nested* nonlinear functions whose behaviour might be explained by chaos theory.

Despite the volatility of RMSPE, there is a recurring pattern in Table 3 – either Singapore

[12]SCM does not allow for extrapolating and imposes bounds on weights, see the restriction of $0 \leq w_j \leq 1$ in (2).

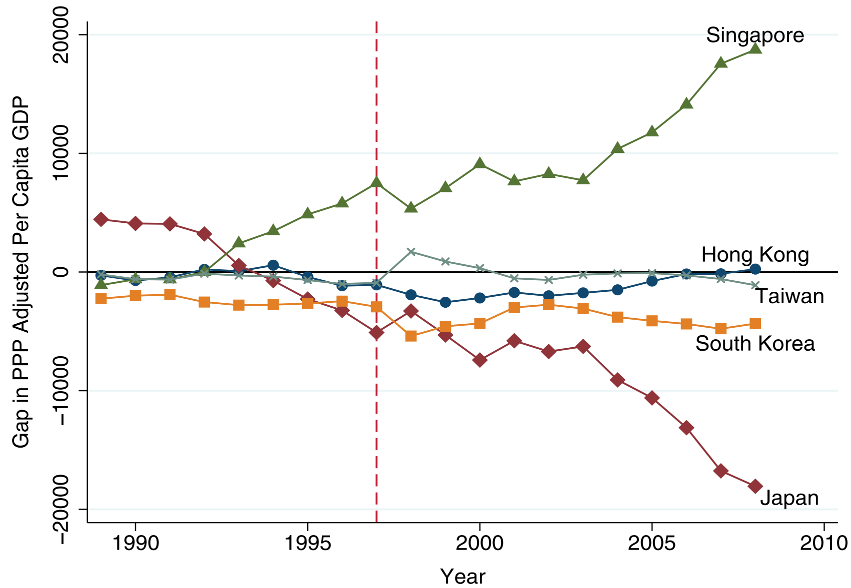

Figure 5. Distribution of gaps in PPP-adjusted per capita GDPs.

(in Models 1, 2) or Japan (in Models 3, 4, 5) dominates the donor pool by receiving the highest weight. This fact echoes Panel A of Table 1 that reports a statistically significant DID[13] estimate of the treatment effect using either Singapore or Japan as the control group.

In light of this, it makes sense to revisit Model 2, which assigns greater weight to the winner Singapore, and less weight to the loser Japan, relative to Model 3. In other words, we may think of the estimate from Model 3 as the lower bound (with the loser receiving the greatest weight) for the *negative* treatment effect, while the estimate from Model 2 is the upper bound (with the winner receiving the greatest weight).

Panel A in Figure 6 re-dos Figure 3, but using weights from Model 2. Assigning a greater weight to Singapore results in two noticeable changes. First, the GDP of actual and synthetic Hong Kong started to diverge in 1995, 2 years before the handover. This is consistent with the observation that the impact of 'China factor' had already been felt by forward-looking economic agents prior to 1997. For instance, in awareness of the forthcoming sovereignty transfer, owners of financial and human capital might start to move out of Hong Kong before 1997. For instance, Liu (1999) discusses the rising emigration of highly skilled Hong Kong residents before 1997.

Second, both the magnitude and duration of the negative GDP gap in Panel A of Figure 6 are greater than Figure 3. We see actual Hong Kong caught up with synthetic Hong Kong after 2005 in Figure 3 (because Japan has the greatest weight), whereas actual Hong Kong falls behind the synthetic Hong Kong persistently in Panel A of Figure 6 (because Singapore has the greatest weight).[14] Based on Model 2, the estimated average effect of sovereignty transfer is negative 9% of the 1996 Hong Kong GDP, and we use that number as the upper bound estimate for the treatment effect.

To further investigate the pretreatment effect (i.e. the trajectory of the Hong Kong economy

[13]The DID estimator is computationally robust since it minimizes an objective function much less nonlinear than SCM.

[14]We see narrowing gap in two GDPs after 2003, mainly because of the positive shocks of Closer Economic Partnership Arrangement (CEPA) and China's joining WTO.

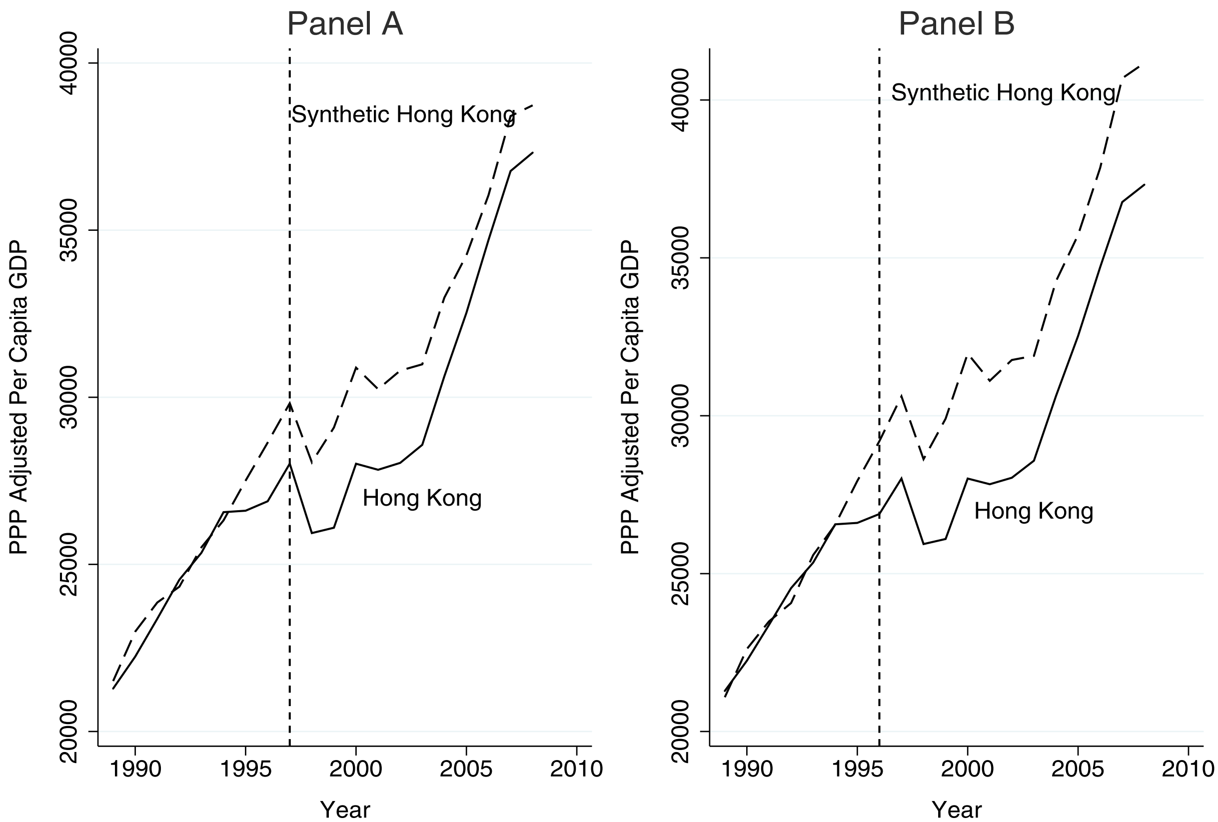

Figure 6. Panel A: Robustness check by using weights of model 2 to construct the synthetic Hong Kong; Panel B: Re-estimating Model 2 by shifting the intervention period to 1996.

was altered before 1997), Panel B in Figure 6 re-estimates Model 2 by shifting the intervention period to 1996. This is intended to reveal more of the true pretreatment effect that would otherwise be de-emphasized by SCM because synthetic Hong Kong should supposedly match actual Hong Kong as much as possible before the treatment.

The pre-1997 GDP gap in Panel B is similar to Panel A. Therefore, the pretreatment effect illustrated by both panels is unlikely to be a statistical artefact. In fact, the message from Panels A and B is coherent – the *total* effect of 1997 handover would be underestimated if we just focus on the GDP gap in the post-1997 period since ‘China Factor’ pushed Hong Kong economy below its potential level at least 1 year before the handover. Given that a negative yet smaller pretreatment effect is also visible in Figure 3, we can explain the significance of finding the pretreatment effect as follows: our second source of identification of the treatment effect is based on the GDP gap in Hong Kong *before* 1997, which is free of the confounding effect of the 1997 Asian Financial Crisis.

Next, we report the treatment effect using weights implied by the principal component analysis. That is, we compute (5) after applying equal weights to the adjusted donor pool shown in Panel B of Figure 2. The new estimate of the treatment effect is negative 7.7% of the 1996 Hong Kong GDP, which lies between the lower bound and upper bound estimates of SCM. Because principal component analysis does not involve optimizing nested nonlinear functions, this new estimate is computationally robust and is able to add support to the SCM estimate.

More robustness checks are provided in Figure 7, where each panel makes one change to Model 3 in Table 3. Panel A shows the synthetic Hong Kong using the weights of Model 5 in Table 3; Panel B replaces average GDP between 1991 and 1993 with 1993 GDP as the predictor; Panel C uses 1995–1996 as the validation set; Panel D uses the natural log of GDP as the outcome variable; Panel

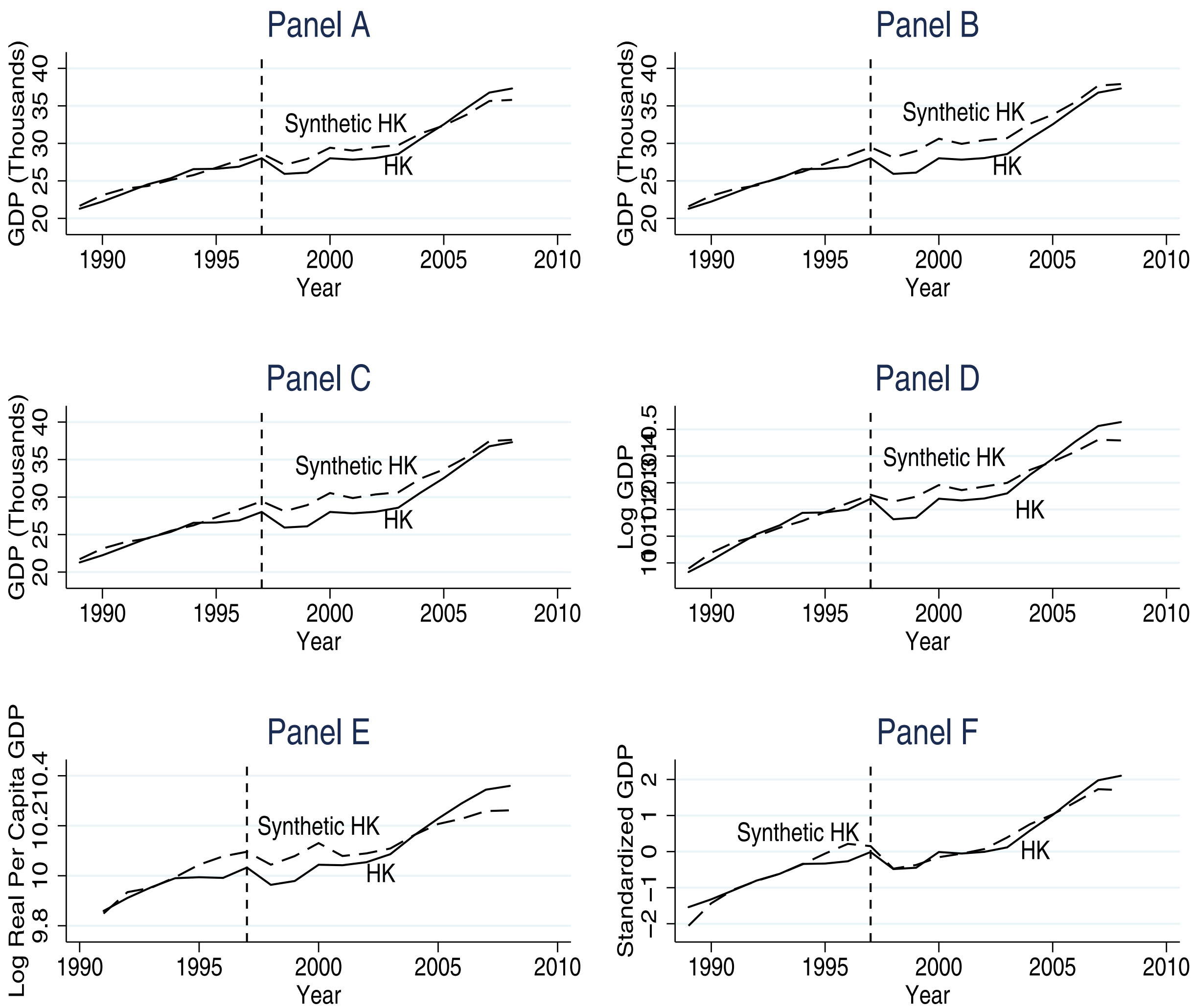

Figure 7. Robustness check. Note: Panel A shows the synthetic Hong Kong (HK) using the weights of Model 5 in Table 3; Panel B replaces average GDP between 1991 and 1993 with 1993 GDP as the predictor; Panel C uses 1995– 1996 as the validation set; Panel D uses the natural log of GDP as the outcome variable; Panel E uses the natural log of real GDP per capita (without PPP adjustment) as the outcome variable; Panel F includes Indonesia, Malaysia, Philippines and Thailand in the donor pool.

E uses the natural log of real GDP per capita (without PPP adjustment) as the outcome variable. Because that variable is unavailable in 1989 and 1990 for Taiwan, the training set becomes 1991–1993. Comparing those panels to Figure 3, we see there is always a negative gap in the outcome variable between 1996 and 2001, indicating the inferior performance of the Hong Kong economy relative to its potential during that time.

Panel F is different, where Indonesia, Malaysia, Philippines, and Thailand are added to the donor pool. Due to data unavailability for some predictors of those countries, we only use GDP in 1991, 1992, and 1993 as predictors. Given the substantial variation in living standard[15] among the nine economies, we standardize GDP in order to acquire a close pre-1997 match. The estimated weights are .286 for Japan, 0.044 for Taiwan, 0.67 for Thailand, and 0 for all other economies. We see in Panel F that actual Hong Kong still underperformed relative to the synthetic one during the Asian Financial Crisis, though the size of the GDP gap becomes negligible. This is because the winner Singapore now receives 0 weight while Thailand, which suffered hugely during the crisis and has great growth potential due to its low living

[15]The pre-1997 average GDP is 2522, 7082, 2321 and 5211 for Indonesia, Malaysia, Philippines, and Thailand, respectively. The pre-1997 average GDP of Hong Kong is 24,877.

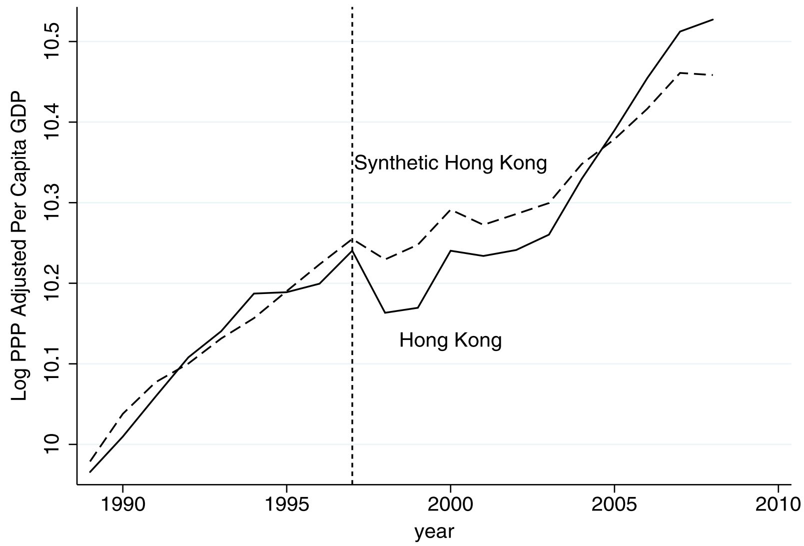

Figure 8. Comparison of log PPP-adjusted per capita GDPs of Hong Kong and synthetic Hong Kong. Note: Synthetic Hong Kong is the weighted average of Japan, Singapore, South Korea and Taiwan.

standard, dominates the donor pool. Despite the shrinking post-1997 GDP gap, a negative pre-1997 GDP gap is still evident in Panel F. Accordingly, even this unfavourable comparison is suggestive of the pretreatment effect.

Figure 8 zooms in Panel D in Figure 7 and uses the natural log of PPP-adjusted per capita GDP as the outcome variable. Compared to Figure 3, the only noticeable difference is that Hong Kong catches up with synthetic Hong Kong earlier than in Figure 3. The most important findings of the negative treatment effect and the pre-intervention effect remain unchanged.

VIII. Conclusion

This article makes four contributions to the literature: (i) To our best knowledge, this is the first study attempting to use the synthetic control method to quantify the effect of 1997 handover on Hong Kong economy; (ii) An interval estimate of the treatment effect is provided by contrasting Hong Kong with the synthetic Hong Kong, with either Japan or Singapore dominating the donor pool; (iii) The endogeneity issue we need to tackle is to what degree economic growth of Hong Kong had been altered by the 1997 handover, as opposed to the 1997 Asian Financial Crisis. Our identification strategy entails the comparison of Hong Kong to economies that *all* suffer from the economic downturn. We document evidence that 'China factor' causes Hong Kong to suffer *more* than other economies in the presence of this adverse shock. Put differently, our estimate of the treatment effect is derived from the *difference* in the performance of five economies in the 1997–2001 period; (iv) We report evidence that 'China factor' pushed Hong Kong economy below its potential level at least 1 year *before* the 1997 Financial Crisis. This finding of the pre-intervention effect underlines an additional source of identification for the treatment effect.

We report the lower and upper bounds of the treatment effect. If Japan receives the highest weight in synthetic Hong Kong, the estimated negative effect of sovereignty transfer is 7% of the 1996 Hong Kong GDP. If Singapore receives the highest weight, the estimated treatment effect rises to 9%. The principal component analysis estimates the treatment effect as 7.7% of the 1996 Hong Kong GDP, which is in line with the synthetic control estimate.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abadie, A., A. Diamond, and J. Hainmueller. 2015. “Comparative Politics and the Synthetic Control Method.” *American Journal of Political Science* 59 (2): 495–510. doi:10.1111/ajps.12116.

Abadie, A., and J. Gardeazabal. 2003. “The Economic Costs of Conflict: A Case Study of the Basque Country.” *American Economic Review* 93 (1): 112–132. doi:10.1257/000282803321455188.

Chau, K. 1997. “Political Uncertainty and the Real Estate Risk Premiums in Hong Kong.” *Journal of Real Estate Research* 13 (3): 297–315. doi:10.1080/10835547.1997.12090878.

Cheung, A. B. 2008. “The Story of Two Administrative States: State Capacity in Hong Kong and Singapore.” *The Pacific Review* 21 (2): 121–145. doi:10.1080/09512740801990188.

Hsiao, C., H. S. Ching, and S. K. Wan. 2012. “A Panel Data Approach for Program Evaluation: Measuring the Benefits of Political and Economic Integration of Hong Kong with Mainland China.” *Journal of Applied Econometrics* 27 (5): 705–740. doi:10.1002/jae.1230.

Hsieh, C. T., and K. T. Woo. 2005. “The Impact of Outsourcing to China on Hong Kong’s Labor Market.” *American Economic Review* 95 (5): 1673–1687. doi:10.1257/000282805775014272.

Kim, H. Y., and J. P. Mei. 2001. “What Makes the Stock Market Jump? An Analysis of Political Risk on Hong Kong Stock Returns.” *Journal of International Money and Finance* 20 (7): 1003–1016. doi:10.1016/S0261-5606(01)00035-3.

Kwok, K. C. 2008. “Hong Kong Economy 10 Years after Reunification.” In *Hong Kong on the Move, 10 Years as the HKSAR*, edited by C. McGiffert and J. T. Tang. CSIS 72-90. Washington, D.C. United State.

Liu, P. W. 1999. “The Asian Financial Crisis and the Hong Kong Economy.” In *Hong Kong in China, the Challenges of Transition*, edited by G. Wang and J. Wong. Singapore: Time Academic Press.

Lui, T. L. 1999. “Hong Kong Society: Anxiety in the Post-1997 Days.” *Journal of Contemporary China* 8 (20): 89–101. doi:10.1080/10670569908724337.

Luk, G. C. 2018. *From a British to a Chinese Colony? Hong Kong before and after the 1997 Handover*. Institute of East Asian Studies. Berkeley, California, United states.

Martin, M. 2007. *Hong Kong: Ten years after the handover—CRS Report for Congress*

McGiffert, C., and J. T. H. Tang. 2008. *Hong Kong on the Move: 10 Years as the HKSAR*. CSIS. Washington, D.C. United State.

Meyer, D. R. 2008. “Structural Changes in the Economy of Hong Kong since 1997.” *China Review* 8: 7–29.

Suen, W. 1995. “Sectoral Shifts Impact on Hong Kong Workers.” *Journal of International Trade & Economic Development* 4 (2): 135–152. doi:10.1080/09638199500000013.

Sung, Y. W., and K. Y. Wong. 2000. “Growth of Hong Kong before and after Its Reversion to China: The China Factor.” *Pacific Economic Review* 5 (2): 201–228. doi:10.1111/1468-0106.00100.

Tsang, S. K. 1999. “The Hong Kong Economy: Opportunities Out of the Crisis?” *Journal of Contemporary China* 8 (20): 29–45. doi:10.1080/10670569908724334.

Vogel, E. F. 1991. *The Four Little Dragons: The Spread of Industrialization in East Asia*. Harvard University Press. Cambridge, Massachusetts, United States.

Walker, S. 2000. “A Tale of Two Tigers and A Giant: Comparing the Responses of Japan, Korea, and Taiwan to the Asian Financial Crisis.” *Asian Perspective* 24: 27–58.

Appendix Data Sources

The data sources used for obtaining the empirical results are as follows:

- Purchasing Power Parity Converted GDP Per Capita (chain series, 2005 International Dollars). Source: FRED Economic Data.
- Unemployment Rates (aged 15 and over) for Japan and South Korea are from FRED Economic Data. The data for Hong Kong are from the website of Hong Kong Census and Statistics Department.

https://www.censtatd.gov.hk/hkstat/sub/sp200.jsp?tableID=006&ID=0&productType=8

The data for Singapore are from the website of Singapore Ministry of Manpower,

https://stats.mom.gov.sg/Pages/UnemploymentTimeSeries.aspx

The data for Taiwan are from the website of Taiwan National Statistics,

https://eng.stat.gov.tw/ct.asp?xItem=42761&ctNode=1609&mp=5

- Trade openness (per cent) is exports plus imports divided by GDP. Source: FRED Economic Data.
- Inflation rates (per cent change of consumer price index from year ago, index 2010 = 100) for Hong Kong, Japan, Singapore and South Korea are from FRED Economic Data. The data for Taiwan are from the website of Taiwan National Statistics.

https://eng.stat.gov.tw/ct.asp?xItem=12092&ctNode=1558&mp=5

- Schooling (per cent of secondary school attained in the total population aged 25 and older) reported in five-year increments (i.e. for this study, we download data for 1985, 1990, 1995). Source: the website of Barro-Lee Educational Attainment Dataset.

  http://www.barrolee.com/data/yrsch2.htm
- Stock Market Capitalization to GDP (total value of all listed shares in a stock market as a percentage of GDP) for Hong Kong, Japan, Singapore and South Korea are from FRED Economic Data. The data for Taiwan are unavailable.
- Investment Share (of Purchasing Power Parity Converted GDP Per Capita at constant prices). Source: FRED Economic Data.
- Total Factor Productivity (Index USA = 1, Level at Current Purchasing Power Parity). Source: FRED Economic Data.
- Real (Constant) GDP Per Capita. Source: FRED Economic Data.