Contribution of the Strategic Economic Plan to Singapore’s Long-term Growth: A Synthetic Control Approach

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ABSTRACT

We assess the impact of the Strategic Economic Plan on Singapore’s long-term GDP per capita. To our knowledge, we are the first to evaluate the effect of the 1991 plan on Singapore’s successful growth trajectory using methodologies aimed at causal identification. In other words, this article applies the Synthetic Control method and World Bank data from 1970 to 2018. We estimate an average increase of 6,641.71 US$ in Singapore’s GDP per capita. Results remain robust to placebo and leave-one-out tests and the Synthetic Difference-in-Differences method.

KEYWORDS

Strategic Economic Plan; Singapore; GDP per capita; Synthetic Control; Synthetic Difference-in-Differences

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1. Introduction

Singapore stands as one of the globe’s most prosperous and competitive nations\(^1\). The city-state’s public service is praised for its work ethic and competence in facilitating economic development (UNDP, 2015). The country became self-governing in 1959 and independent in 1965. Lee Kuan Yew served as Singapore’s first Prime Minister between 1959 and 1990. Although his government suffered from limitations on civil and political freedoms, Singapore experienced rapid industrialization, developing into a high-income economy (Hachten, 1989; Bruton et al., 2002).

Singapore’s success, like other Asian Tigers, combines state-oriented policies with a robust private sector. A vast literature offers various explanations and factors contributing to the East Asian Miracle (Soon and Tan, 1993; World Bank, 1993; Rodrik, 1994, 1997; UNDP, 2015; Stiglitz, 1996; Leipziger, 1997; Stiglitz and Yusuf, 2001; Quibria, 2002). In 1991, Goh Chok Tong became Prime Minister, marking the first peaceful transition of power in Singapore’s history and a new phase in Singaporean policy and industrial development, which became innovation-intensive (UNDP, 2015; Lee, 2004). The new government established the Strategic Economic Plan\(^2\) (SEP): a branch of a broader concept plan focused on Singapore’s human resource development, called The Next Lap\(^3\). Both documents preserved the successful policies of the previous government, providing social and political stability (Soon and Tan, 1993).

The SEP was a blueprint for Singaporean development in the long-term. It was drafted by the Economic Planning Committee, other subcommittees, and business representatives (Soon and Tan, 1993). It aimed to diversify Singapore’s economy, attract knowledge-intensive industries, and increase competitiveness by investing in technology, scientific advancements, education, and infrastructure (Soon and Tan, 1993; Wong et al., 2007; Wang, 2018). The plan had eight key areas: renovate local enterprises, build business clusters, reinforce international competitiveness, enhance human resources, improve national teamwork, boost international orientation, create an innovation culture, and reduce economic vulnerability. Each strategy widens into different programs implemented between 1991 and 1993. For instance, the National Productivity Board reviewed hindering government rules to sponsor innovation.

The literature has not yet established the causal impact of SEP on Singapore’s long-term GDP per capita. Some articles attempt to estimate Singapore’s growth and economic plans with alternative techniques, such as Seng (2007) and Yeoh and How (2005). However, over the last two decades, more appropriate methods of causal inference have been developed or refined, with intense application in studies focused on assessing the impact of various public policies and interventions. In particular, the Synthetic Control Method (SCM) represent advances in comparative case studies relative to traditional econometric methods based on regressions. One of the advancements, as highlighted by Abadie et al. (2015), is to allow access to the contribution of each comparison unit towards the construction of a counterfactual, thereby enabling both qualitative and quantitative comparisons. In other words, new quantitative methods have been developed to complement and strengthen qualitative analyses, which are widely used in comparative case studies.

This article pioneers by uncovering the influence of SEP on Singapore’s long-term economic growth using state-of-the-art methodologies for causal inference. We are the first to quantify the plan’s contribution and demonstrate its significance to Singapore’s successful income trajectory through estimators that identify the program's causal


\(^{2}\text{The Strategic Economic Plan: Towards a Developed Nation. Published in October 1991.}\)

\(^{3}\text{https://factsanddetails.com/southeast-asia/singapore/sub5_7c/entry-3782.html}\)

\(^{4}\text{Published in February 1991, by the Long-Term National Development Committee with the help of private and public institutions, the book contains broad strategic proposals on housing, defense, education, cultural affairs, welfare, migration, population, and the economy. See https://eresources.nlb.gov.sg/newspapers/Digitised/Article/straitstimes19910223.2.6.9}\)
effect. We employ the SCM for case studies (Abadie et al., 2010, 2015; Abadie & Gardeazabal, 2003) and data from the World Bank Open dataset from 1970 to 2018. Results show that the SEP significantly increased Singapore’s GDP per capita, with an average effect of 6,641.71 US$. Results remain robust to placebo and leave-one-out tests and the Synthetic Difference-in-Differences approach (Arkhangelsky et al., 2021), corroborating the plan’s effectiveness in promoting long-term economic growth.

In this manner, the present article seeks to contribute to the recent literature on economic growth that recognizes causal inference methods as a powerful tool for analysis, enabling the provision of evidence regarding the efficacy, or lack thereof, of public interventions. This is also especially important for the evaluation of economic recovery programs, such as those recently implemented in response to the COVID-19 pandemic. At the same time, by enabling a more detailed qualitative analysis than previously employed methods, while also providing robust quantitative outcomes, the framework of this study offers a new perspective from which evaluation of public policies implemented in the past can be conducted.

This article is structured as follows. In addition to this introduction, section two outlines the methodology and data employed to implement the causal identification strategy for the adopted policy. Section three presents the findings obtained. In section four, we scrutinize the results, assessing their robustness. Finally, in section five, we provide concluding remarks.

2. Methodology and Data

We follow the Synthetic Control Method (SCM) proposed by Abadie and Gardeazabal (2003) and Abadie et al. (2010). The SCM estimates causal effects when one observational unit ("actual" or "treated" Singapore) is exposed to an intervention (SEP disclosure). SCM generates the best comparable unit ("predicted" or "synthetic" Singapore), which is comprised of an optimally weighted combination of data from non-treated units. This donor pool of countries provides a parallel for “actual” Singapore, better than any other single country could, and closely matches Singapore’s data before the intervention (Abadie et al., 2015). SCM estimates Singaporean GDP per capita without the SEP and compares it to the "actual" Singapore income trajectory so that the gap between them is attributable to the 1991 economic plan.

In formal terms, suppose that we observe $J + 1$ countries and only the first country, Singapore, is exposed to the intervention of interest so that we have $J$ remaining countries as potential controls (the "donor pool"). Let $Y_{jt}$ be the annual GDP per capita for country $j$ at time $t$, for units $j = 1, \ldots, J + 1$, and periods $t = 1, \ldots, T$. Consider $T_0$ the number of pre-intervention periods, with $1 \leq T_0 < T$, and let $Y_{1t}$ be the GDP per capita of the treated unit, i.e., Singapore.

We assume the intervention in Singapore did not affect the outcome before implementation. Let $\alpha_{1t}$ be the effect of the policy implementation in Singapore, for $t \in \{T_0 + 1, \ldots, T\}$. We aim to estimate:

$$\alpha_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}$$  \hspace{1cm} (1)

Let $J$ be the number of countries unaffected by the intervention. Considering a $(J \times 1)$ vector of weights $W^* = (w_2^*, \ldots, w_{J+1}^*)'$ such that $w_j^* \geq 0$ for $j = 2, \ldots, J + 1$ and $\sum_{j=2}^{J+1} w_j^* = 1$. The SCM provides weights $w_j^*, j = 1, \ldots, J + 1$ for an unbiased estimator of $\alpha_{1t}$. Abadie et al. (2010) showed that the SCM estimator is unbiased even if data for only a single pre-treatment period are available. Since each set of weights produces a different synthetic Singapore, the goal is to choose a set that makes the synthetic unit most similar to the real, observed Singapore.

Let $X_1$ be a $(K \times 1)$ vector of pre-intervention observed characteristics for Singapore and $X_0$ a $(K \times \ldots$
Let $V$ be a diagonal matrix with nonnegative elements, each accounting for the relative importance of these characteristics.

The vector of optimal weights, $W^*$, is then chosen to minimize $(X_1 - X_0 W')V(X_1 - X_0 W)$ subject to $w_2 \geq 0, \ldots, w_{J+1} \geq 0$ and $w_2 + \cdots + w_{J+1} = 1$. Given that $W^*$ is influenced by $V$, it can be contended that selecting $V$ might be subjective, mirroring our prior understanding of the significance of each specific predictor of growth. We follow Abadie et al. (2003) and employ a broader approach in selecting $V$, aiming to ensure that synthetic Singapore accurately mirrors Singapore’s actual GDP per capita trajectory before the intervention. The authors present all the steps to obtain the optimal weighting matrix and a complete description and derivations of the SCM. The idea behind this approach is that a combination of units often provides a better comparison for the unit exposed to the intervention than a single unit alone.

We employ data from the World Bank Open Dataset. The intervention occurred in 1991, and the sample spans from 1970 to 2018. We cogitate as potential donors all countries with no missing data for the covariates (107 countries). Hong Kong (92.50%), Luxembourg (3.20%), Japan (2.50%), and Ireland (1.70%) best reproduced Singapore prior to the intervention in the SCM algorithm. The outcome variable is the annual GDP per capita (constant 2015 US$). As covariates, we employ population between 0 and 14 years old; labor force (population 15 and 64 years); GDP per capita levels for 1974, 1976, 1982, 1989, and 1990; and average GDP per capita for 1978-1979. These specific years represent the oil crisis, the energy crisis, the Mexico crisis, the end of the Iran-Iraq war, and the year preceding the SEP.

Table 1 presents a comparison of the descriptive statistics for actual and predicted Singapore. The observed similarity suggests that predicted Singapore serves as an adequate control group.

**Table 1.** Predictor Balance.

<table>
<thead>
<tr>
<th>Items</th>
<th>Actual (Treated)</th>
<th>Predicted (Synthetic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP p/c (1974)</td>
<td>9,726.38</td>
<td>9,717.15</td>
</tr>
<tr>
<td>GDP p/c (1976)</td>
<td>10,564.96</td>
<td>10,683.59</td>
</tr>
<tr>
<td>Aver. GDP p/c (1978-79)</td>
<td>12,340.06</td>
<td>12,625.96</td>
</tr>
<tr>
<td>GDP p/c (1982)</td>
<td>15,095.39</td>
<td>14,734.97</td>
</tr>
<tr>
<td>GDP p/c (1989)</td>
<td>22,016.04</td>
<td>22,160.60</td>
</tr>
<tr>
<td>GDP p/c (1990)</td>
<td>23,255.98</td>
<td>22,970.74</td>
</tr>
<tr>
<td>Pop (0 - 14)</td>
<td>28.23</td>
<td>26.52</td>
</tr>
<tr>
<td>Pop (15 - 64)</td>
<td>67.09</td>
<td>66.48</td>
</tr>
</tbody>
</table>

Notes: GDP per capita values are constant to 2015 US$. Population values are in % of the total population.

3. Results

The analysis of the SCM results is highly graphical. Figure 1 features two long-term GDP per capita series considering the SCM approach, illustrating the growth trajectories of actual and predicted Singapore. The vertical line marks the introduction of the SEP.
Figure 2 displays the gap between the real data and synthetic trajectory. We can see that both trajectories balance well before 1991 (with the gap close to zero) but diverge in the post-treatment period.

![Figure 2](image)

**Figure 2.** The gap between trajectories of GDP per capita (constant to 2015 US$).

Figure 2 shows that a distinct expansion in actual Singapore GDP per capita vis-a-vis predicted Singapore results in an increasing gap after 1991.

In the placebo test, we suppose that each country in the donor pool undergoes the same treatment as Singapore in 1991 (Abadie et al., 2010) and then estimate the gaps in GDP per capita of actual and predicted trajectories, expecting them to be close to zero.

![Figure 3](image)

**Figure 3.** Placebo Test - GDP per capita gap (constant to 2015 US$).

Figure 3 reveals that most countries (indicated by lighter lines) consistently exhibit gaps between actual and predicted GDPs per capita that are negative or close to zero, as opposed to Singapore (represented by the darker line), supporting the hypothesis that the positive estimated effect is unlikely to be due to chance.

![Figure 4](image)

**Figure 4.** P-values.
Figure 4 shows that the SEP effect is statistically significant (under 0.10) from 1993 onwards (oscillating around 0.05). This result is consistent with the SEP programs’ actions from 1991-1993.

The analysis indicates that the SEP significantly increased Singapore’s GDP per capita. The estimated effect shows that the economic plan shifted Singapore’s long-term income trajectory upwards, resulting in an average effect of 6,641.71 US$ in GDP per capita.

4. **Robustness Analysis**

4.1. *Leave-one-out test*

Within the donor pool, only four countries received positive weights (Hong Kong, Luxembourg, Japan, and Ireland). Given that Japan and Hong Kong underwent interventions in the 1990s, we conducted a robustness analysis known as leave-one-out (LOO).

In LOO analysis, we iteratively re-estimate the SCM by omitting a single unit at a time. Although this sensitivity check sacrifices the quality of the fit, it allows us to assess whether any of the control units drove the results from section 3.

![Figure 5. LOO Test - GDP per capita trajectories (constant to 2015 US$).](image)

Figure 5 confirms that the synthetic trajectory remains consistent even when we remove one of the countries from the donor pool group.

![Figure 6. LOO - GDP per capita gap (constant to 2015 US$).](image)
Figure 6 shows that the difference between Singapore’s actual data and its possible counterfactuals, as derived through the LOO method, follows the same pattern observed in the results section. Thus, the analysis using the LOO test corroborates the results found previously.

4.2. Synthetic Difference-in-Differences

The Synthetic Differences-in-Differences (SDD) estimator (Arkhangelsky et al., 2021) associates the Difference-in-Differences methodology with SCM by relaxing the parallel trends assumption and by assigning weights to the untreated units, while also considering additive unit and time-specific fixed effects. The SDD constructs a control group that shares the same pre-intervention trend as the treated unit and estimates the treatment effect from the double differences between these groups. The objective of SDD is to consistently estimate the causal effect of receiving the treatment (average treatment effect on the treated - ATT). The ATT estimate proceeds as follows:

$$
\beta_{sdd}^i = \arg\min \sum_{i=1}^{N} \sum_{t=1}^{T} (Y_{it} - \mu - \alpha_i - \tau_t - D_{it} \beta)^2 \tilde{w}_{it}^s \tilde{y}_{it}^s
$$

Estimated using two-way fixed effects (TWFE) with optimal weights ($\tilde{w}_{it}^s, \tilde{y}_{it}^s$), SDD emphasizes matching treated and control units based on pre-treatment trends through individual fixed effects, and not necessarily in pre-treatment trends and levels, allowing for a constant difference between treatment and control units.

To identify the impact of SEP on economic development, $D_{it}$ takes a value of one when the treated country has the policy and zero otherwise. The outcome variable $Y_{it}$ represents GDP per capita. Lastly, $\alpha_i$ controls for country-fixed effects, and $\tau_t$ captures temporal fixed effects.

SDD does not require the inclusion of covariates. Contrarily, when using covariates, the model changes, and the estimator is calculated on the residuals of the dependent variable. Thus, the use of covariates can be understood as a preprocessing task, which removes the impact of covariate changes on the outcome variable, $Y_{it}$, before calculating the synthetic control. To check the strength of the estimates, we performed both SDD strategies, with and without covariates.

Figure 7 shows the trajectories of the actual Singapore and the synthetic control group without considering the covariates in the analysis.

![Figure 7. SDD estimation without covariates - GDP per capita trajectories (constant to 2015 US$).](image)

Figure 8 displays the growth trajectory of actual Singapore’s GDP per capita compared to that of its synthetic control group, considering the covariates in the analysis.
Figure 8. SDD estimation with covariates - GDP per capita trajectories (constant to 2015 US$).

The treatment effects estimated for the SEP are positive and statistically significant. However, the second estimation presents a smaller gap: 6,288.98 US$ (with a standard error of 3,007.78) for the SDD without covariates and 5,282.22 US$ (with a standard error of 3,115.52) for the SDD with covariates. Hence, we can conclude that the SEP increased Singapore's income trajectory.

5. Conclusion

The empirical findings of this study suggest that the 1991 Strategic Economic Plan (SEP) had a significant and positive impact on Singapore's long-term economic growth, particularly on its GDP per capita. Employing the Synthetic Control Method (SCM), the study assessed the causal effect of the SEP on Singapore’s economic trajectory, using data from 1970 to 2018. The study demonstrated, through rigorous analysis and robustness checks, that the SEP led to an average increase of 6,641.71 US$ in GDP per capita.

These findings bear important implications for policymakers and researchers interested in understanding the drivers of economic growth and development strategies. Firstly, the study highlights the effectiveness of strategic planning and targeted policies in fostering economic prosperity. By emphasizing areas such as economy diversification, innovation promotion, and human capital enhancement, the SEP successfully propelled Singapore’s economic growth trajectory. Furthermore, this study leverages state-of-the-art causal inference methodologies in the analysis of economic growth. It aims to augment the existing body of literature concerning the evaluation of public policy impacts within the macroeconomic context, given the capability of this framework for assessing the efficacy of strategic economic plans and recovery initiatives.

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Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.
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