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Economic Effects of Macao's Integration with Mainland China: A Causal Inference Study

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Abstract Macao was a Portuguese colony until 1999, when its sovereignty was transferred to China, initiating its integration process. This article attempts to estimate the consequences of this socio-economic process in terms of per capita gross domestic product (GDP). We build a panel data set spanning 1970 to 2012, with 25 countries, setting 2000 as the initial treatment year for the integration process. The analysis is carried out through two alternative methodologies: the synthetic control method and the panel data approach. The integration treatment had a significant, positive effect on Macao's per capita GDP. As additional outcome variables, we also analyze the effects of integration on the per capita net inflow of foreign direct investment, the unemployment rate, and the per capita exports and imports of goods and services.

Keywords: comparative case studies, synthetic control method, panel data approach, causal inference, integration, Macao

JEL Classifications: C14, C15, C20, C34

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I. Introduction

Macao (often referred to in statistical databases as Macao SAR, China) currently holds the status of Special Administrative Region (SAR) under the central government of the People's Republic of China (PRC). Historically, Macao became a Portuguese colony when the first Portuguese traders settled in 1557 and rented the territorial dominion from the Ming officials, becoming a transshipment center for East-West trade. It was not until 1849 that Portugal increased its influence at the expense of local Portuguese inhabitants, becoming a fully developed

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colony in its own right. Nevertheless, from a strict point of view, Portugal never had sovereignty over Macao, and it was never ceded to the Portuguese (Yee, 2001).

In April 1987, the PRC and Portugal signed the “Joint Declaration by the Government of the Portuguese Republic and the Government of the People’s Republic of China on the Question of Macau,” which stipulated that the territory’s sovereignty would be ceded to the PRC in December 1999. This declaration initiated a “smooth transition” toward Macao’s future status as a SAR (as opposed to Hong Kong’s rough transition), enabling a high degree of autonomy and (as in the case of Hong Kong) becoming another instance of “One Country, Two Systems” (Edmonds & Yee, 1999; Wang, 2018; Cai et al., 2020). This autonomy excluded foreign and defense affairs, which remained under the exclusive control of the national government in Beijing.

Macao’s economy experienced a remarkable transformation as a consequence of this process. The average annual GDP growth between 1999 and 2012 was about 12.73%, allowing Macao to post a per capita GDP at current USD 74,061 in 2016, the seventh highest in the world according to The World Bank.[1] Additionally, the unemployment rate fell from 6.3% in 1999 to 1.97% in 2012.[2] Along the same lines, the annual average net inflow of foreign direct investment (FDI) per capita between 1982 and 1999 was USD 8.7, increasing to USD 7,032.5 between 2000 and 2012 (measured at chained purchasing power parity [PPP] in 2017 USD).[3] The process also affected the inflow of foreign visitors: the yearly average of foreign visitors from 1995 to 1999 was 7.5 million, which increased to 19.5 million from 2000 to 2012.[4] The gaming industry is a primary reason for such substantial economic development, which Section 2 presents in further detail. At the start of the integration process into the PRC, Macao’s economy rested on four sectors: manufacturing, construction and real estate, financial services, and gaming; however, by 2013, the gaming industry represented more than 60% of the GDP. The year 2013 marked the beginning of a turning point, as annual casino gaming revenues dropped sharply: -2.56%, -34.33%, and -3.31% in 2014, 2015, and 2016, respectively (see Center for Gaming Research at University of Nevada, Las Vegas[5]). Several factors explain this extraordinary change: first, an anti-corruption campaign that started in late 2012, which dissuaded mainland high rollers from conspicuous consumption; second, from mid-2014, a tighter transit visa policy was introduced, and China UnionPay devices were removed from casinos to fight money laundering; third, competition in the gaming sector increased in neighboring countries, such as Indonesia, Malaysia, Thailand, and Singapore; and finally, a smoking ban

1) https://data.worldbank.org/indicator/NY.GDP.PCAP.CD
2) See The World Bank (https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS). The effect on unemployment will be specifically discussed in Section 6.
3) See Penn World Table 10.0 (https://www.rug.nl/ggdc/productivity/pwt/) and The World Bank (https://data.worldbank.org/indicator/BX.KLT.DINV.WD.GD.ZS).
4) See The World Bank (https://data.worldbank.org/indicator/ST.INT.ARVL).
5) https://gaming.library.unlv.edu/abstract/macau.html

on main casino floors was implemented in October 2014 (Liu et al., 2015; Sheng & Gu, 2018; Fu et al., 2020).

Several papers have assessed Macao's economic progress since its handover to mainland China. Sheng and Gu (2018) examine Macao's gambling industry from 1999 to 2016, measuring the sector's influence on economic growth. Li and Sheng (2018) analyze the impact of the anti-graft campaign on tourism in Macao after 2014 and demonstrate that the anti-corruption policies caused a decline in Macao's gaming revenue. Choi et al. (2019) investigate the efficiency of the gambling industry and the ideal degree of industrial development to establish grounds for economic diversification in Macao. To and Lam (2022) study the relationships between Macao's economic growth, energy use, and greenhouse gases emission before and after reunification with mainland China. They also examine the rapid increase in Macao's per capita GDP compared to the previous period when the handover process had not occurred.

This study aims to assess the economic impact of Macao's integration process by providing a quantitative assessment along the lines of causal inference literature, which is becoming more prevalent in current research. To the best of our knowledge, this article represents the first study to examine the impact of the whole integration process on Macao's economy. Furthermore, we employ two different methodologies to evaluate the process above to reinforce our analysis. More precisely, we estimate the consequence in terms of i) per capita GDP, ii) per capita net inflow of foreign direct investment, iii) the unemployment rate, and iv) per capita exports and imports of goods and services of the intervention outlined above- that is, the integration process into mainland China. The closest precedents to our work are Hsiao et al. (2012) and Gardeazabal and Vega-Bayo (2017), both of which analyze, to some extent, the parallel case of Hong Kong.

Hsiao et al. (2012) study the consequences of the per capita GDP growth rate of two major interventions or treatments from 1993:Q1 to 2008:Q1. The first is the *political integration* (change of sovereignty) into mainland China in July 1997. The second (the *economic integration*) is related to the signing of the Closer Economic Partnership Arrangement (CEPA) with mainland China and the Individual Travel Scheme and Removal of Preferential Tariff signed in June 2003 (but whose implementation would start in January 2004). Both cases use the panel data approach (PDA) to estimate the counterfactual or potential outcome variable without intervention. To be more precise, in the case of political integration, the pre-treatment period spans from 1993:Q1 to 1997:Q2, setting the post-treatment period from 1997:Q3 to 2003:Q4- that is, until the beginning of the economic integration treatment. Hsiao et al. (2012) find that political integration had a statistically non-significant impact on Hong Kong's economic growth because Hong Kong saw the third-largest effect out of eight controls considered. This negative result allows them to extend the pre-treatment period for economic integration from the beginning of the sample period (1993:Q1) to 2003:Q4. Regarding economic integration, they find that Hong Kong's real GDP growth rate increased by more than 4% compared to the hypothetical growth rate from 2004:Q1 to 2008:Q1 in the absence of the CEPA agreement with mainland China.

Gardeazabal and Vega-Bayo (2017) revisit the same issue (and the same data set) using an alternative methodology to estimate the counterfactual, namely the synthetic control method (SCM). They show that the results depend on the method used to obtain the unobserved per capita GDP growth rate in the absence of treatment. Thus, the authors find that the effect of political integration is statistically significant at the 10% level under SCM; Hong Kong has the largest gap out of the other 13 countries in their sample. The immediate consequence is that if the SCM is implemented instead of the PDA, the pre-treatment period used to compute the effect of economic integration must be reduced (in particular to 2000:Q2-2003:Q4). The effect of economic integration seems to be smaller when estimated using SCM than when using PDA, and the statistical significance results are inconclusive. An additional finding is that the results obtained under PDA are less robust to changes in the set of controls than the SCM.

Macao's integration with PRC differs from the case of Hong Kong in one critical aspect: the timing. As described in the previous paragraphs, two landmark events can be distinguished in Hong Kong: the political and economic integration, separated by six years and two quarters. Macao's integration, by contrast, was a much faster process. As discussed in Section 2, Macao's cession to the PRC and the signing of the CEPA are separated by a gap of two-and-a-half years. Additionally and significantly, Macao's gaming industry was deregulated during this time, giving rise to a massive increase in economic activity, as manifested by the gaming tax revenues. This leads us to refer to a unique integration process.

This paper builds a panel data set spanning 1970 to 2012. The data set includes Macao and 24 control countries, namely, Indonesia, Japan, Malaysia, Thailand, United States, Taiwan, Philippines, Germany, United Kingdom, France, Australia, Austria, Brazil, Canada, Denmark, Finland, Italy, Mexico, Netherlands, New Zealand, Spain, Sweden, Switzerland, and Norway. According to the above discussion, we set 2000 as the initial treatment year for the integration, and we first set the per capita GDP as the outcome variable of focus. We next reinforce our analysis by considering the effects on the net inflows of foreign investment, unemployment, and exports and imports as additional outcome variables. Another variable worth considering is travel and tourism, a potential driver of economic activity. Unfortunately, the series available for the total travel and tourism contribution to GDP starts in 1996 (see The World Bank[6]), which prevents us from estimating the counterfactual. The analysis follows a similar computational strategy as in Gardeazabal and Vega-Bayo's (2017) study, which estimates the effects of the intervention using two alternative methodologies: SCM and PDA.

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6) https://tcdata360.worldbank.org/indicators/tot.direct.gdp?country=BRA&indicator=24650&viz=line_chart&years=1995,2028#table-link

Our main results are as follows:

1. The integration process of Macao into the PRC had a statistically significant, positive treatment effect on both the level of per capita GDP and its long-run growth rate from 2000 to 2012. The qualitative aspect of the result is relatively robust to the method followed in computing the counterfactual (whether SCM or PDA). The estimates of average gaps in the level of per capita GDP and its growth rate vary according to the method chosen to compute the counterfactual. Following the best pre-treatment fit criterion (which in our particular exercise is always the PDA-AICc), we find an approximate yearly average per capita GDP gap of USD 42,321 for the period. Similarly, we find a statistically significant difference of 11.4% between the observed per capita GDP growth rate and the counterfactual series.
2. We also analyzed some additional outcome variables and found a statistically significant, positive treatment effect on foreign investment. According to our PDA-AICc results, the integration of Macao into China caused an approximate yearly average increment of USD 6,358 in the per capita net inflow of foreign investment during the post-treatment period.
3. With regard to unemployment, we found a seemingly negative annual average effect (-1.392%) or fall in the unemployment rate; however, the assessment largely varies with the method implemented to compute the counterfactual. The apparent effect is not statistically significant even after focusing on the PDA-AICc approach.
4. To back up our results, we also considered two additional outcome variables: exports and imports of goods and services. With regard to the former, we found a statistically positive yearly effect on the per capita level of approximately USD 42,115. As for the latter (at first sight), the positive effect on per capita imports depends on the method implemented to compute the counterfactual, so its statistical significance is discarded.
5. Overall, we learned that the methodological approach implemented in causal inference studies of this type matters, and researchers are strongly recommended to conduct deep, rigorous sensitivity analyses to test the internal validity of their results.

The rest of the paper is organized as follows. Section 2 describes the main steps in the integration process, Section 3 describes the twofold empirical strategy implemented to estimate the counterfactual, and Section 4 describes the data. The integration results are discussed in Section 5; Section 6 discusses the effects on foreign direct investment, unemployment, exports, and imports; and Section 7 concludes the paper.

II. Macao's Integration Process

As stated in Section 1, Macao's integration process formally started on December 20, 1999, when its territory was ceded to mainland China, thus honoring the Joint Declaration[7] signed by the two parties involved 12 years previously, on April 13, 1987, explicitly following the principle of "one country, two systems." This joint agreement established, among other provisions, Macao's legal currency (the pataca) and its perfect convertibility and the exclusive right of the autonomous government to set its own tax system. Additionally, the executive power is vested in the government of the Macao SAR, formed by the local population, with the person in the highest position of responsibility appointed by the Central People's government based on the results of elections or consultations held in Macao. These events marked the beginning of the SAR of Macao in the PRC.

Macao first legalized gambling in 1847, where for decades, it operated as a monopoly concession. Immediately following the cession of sovereignty (the very next day), the Chief Executive announced his plan to deregulate Macao's gaming industry, and the Macao Gaming Committee was formed in July 2000; its main function is "to conduct studies on the development, legal issues, administrative regulations and policies related to gaming." In the words of the Gaming Inspection and Coordination Bureau[8], it aimed to reinforce the policy direction set by the Macao SAR: "tourism, gaming, conventions and exhibitions as the 'head,' and the service industry as the 'body,' driving the overall development of other industries." Consequently, a bidding process was opened in late 2001, and two concessions were granted by mid-2002. Successive sub-concessions followed, which by the end of 2012 allowed the existence of 35 casinos (Gaming Inspection and Coordination Bureau, Macao SAR; Hsieh & Wang, 2014). This ended the monopoly regime that had existed up to that point (as discussed in Section 6), making it possible to attract a substantial amount of foreign direct investment and foreign visitors (Simpson, 2018). Despite some decline in the following years, in 2016, casino gaming participation was still about 47% of that economy (Sheng & Gu, 2018). In the words of Lo (2009), Macao became "a casino-driven capitalist economy." Some further figures to emphasize the sector's magnitude are as follows: i) In 2013, the gross gaming revenue in Macao was 6.4 times higher than Las Vegas. ii) Despite the decline mentioned above, the gross gaming revenue was still 4.0 times higher in 2016 (https://www.casinonewsdaily.com/). iii) The resulting average annual growth rate of casino gaming revenues in Macao was 28.86% between 2002 and 2013. iv) The revenue from gambling tax in real terms increased by 20.38% in 2000, 13.71% in 2001, 26.75% in 2002, 38.39% in 2003, 42.62% in 2004, and 30.44% in 2005.[9] This last series of figures reinforces the concept of an integration process or a smooth transition,

7) https://bo.io.gov.mo/bo/i/88/23/out01.asp?printer=11

8) https://www.dicj.gov.mo/web/en/information/index.html

unlike the case of Hong Kong.

The CEPA represents another landmark event within this process, which the two sides signed in October 2003, becoming effective in January 2004. The CEPA, a sort of free trade agreement arrangement with the purpose of "promoting stable economic development as well as the improvement of living standard for the two sides," focused on three main ideas: i) reduction or progressive elimination of tariff and non-tariff barriers in all trade in goods between the two parties; ii) progressive liberalization of trade in services by reducing or eliminating all discriminatory measures between the two parties; and iii) promotion of trade and investment facilitation (see Government Printing Bureau[10] and CEPA[11]).

Two immediate consequences of the CEPA followed. The first was that the liberalization allowed mainland Chinese citizens (those residents in Beijing, Shanghai, and some cities in Guangdong) to visit Macao individually; they did not need to be part of an organized trip. This is the Individual Visit Scheme, which Article 14 of the CEPA explicitly covers (Liu et al., 2015). Another remarkable consequence was an arrangement for zero tariffs for trade in goods, developed in Annex 1 of the CEPA. As a result, Macao would continue to be exempt from customs duty on all goods imported from Mainland China, and the Mainland would progressively be exempt from customs duties on goods imported from Macao.

III. Empirical Strategy

This paper's results were obtained by carrying out two alternative empirical strategies, the SCM and the PDA, largely used in the literature to assess the impact of an intervention on one unit by estimating the corresponding counterfactual or potential outcome of the treated agent in the absence of treatment.[12] SCM was introduced in a seminal paper by Abadie and Gardeazabal (2003) and further developed by Abadie et al. (2010, 2015), among others.[13] PDA was introduced in Hsiao et al. (2012) and later compared to SCM's performance in Gardeazabal and Vega-Bayo (2017), Wan et al. (2018), and Hsiao and Zhou (2019).

Several articles have compared the two methodologies. Gardeazabal and Vega-Bayo (2017) studied Hong Kong's integration into mainland China using actual data and simulations and

9) See Macao's Year Book of Statistics (https://www.dsec.gov.mo/en-US/Home/Publication/YearbookOfStatistics) for several years. To obtain the figures in real terms, we used the consumer price index (base 2010) available at The World Bank (https://data.worldbank.org/indicator/FP.CPI.TOTL).

10) https://www.io.gov.mo/pt/home/

11) https://bo.io.gov.mo/bo/ii/2003/52/aviso28.asp?printer=1

12) This heavily draws on Section 2 in Gardeazabal and Vega-Bayo (2017) and Section 2 in Wan et al. (2018).

13) As per a quote that has become a classic, "The (SCM) ... is arguably the most important innovation in the policy evaluation literature in the last 15 years" (Athey & Imbens, 2017, p. 9).

reached the following conclusions. Given the SCM's need for a good match, the authors retain the experiments with a pre-intervention mean absolute error of less than 20% of the outcome variable's pre-intervention mean. The authors concluded that when a good pre-treatment fit is found, the SCM yields a smaller post-treatment mean square error, mean absolute percentage error, and mean error with a smaller interquartile range. In terms of shifting the donor pool with different control units, estimates under SCM appear to be more robust than PDA. SCM may be more useful when there are more time periods and covariates; however, SCM is infeasible when the pre-treatment fit is poor, whereas PDA may still be applied. Wan et al. (2018) compare the assumptions of both methodologies and believe that a fair comparison should be based on an equal number of experimental results. They observe that in most simulations, PDA appears to outperform SCM. They also point out that PDA improves as the pre-treatment period lengthens, although this is not always the case for SCM. Long (2019) explores how Department of Justice investigations influence policy behaviors regarding civil rights violations and police misconduct, finding that PDA matches with reduced control units better than SCM during the pre-treatment periods. Guo and Zhang (2019) evaluate the impact of city-renaming reform on economic growth in Xiangyang by comparing the empirical performances of SCM, PDA, and the least absolute shrinkage and selection operator (LASSO). They demonstrate that PDA dominates when measuring model quality, such as pre-treatment accuracy. Finally, Korolev (2021) evaluates the SCM, PDA, and LASSO to assess the effects of the 1917 Revolution on Russian economic development, indicating that SCM is less likely to suffer from overfitting because it sets restrictions on model coefficients. The author highlights that SCM may be chosen over alternative methodologies to prevent overfitting in circumstances with many potential controls and a few pre-treatment observations.

The starting point is the same in both cases. Assume that there exist $J+1$ units (countries, regions,…) where, without loss of generality, unit 1 (and only unit 1) is exposed to some sort of intervention or treatment at some time $t = T_0$. We denote the outcome variable of interest for unit j and at time t, upon which we want to measure the effect of intervention by $Y_{j,t}$. Specifically, $Y_{j,t}^1$ and $Y_{j,t}^0$ stand for the potential outcome of unit j and at time t *with* and *without* treatment, respectively. Assume that we can observe $Y_{1,t}^0$ for $t = 1, 2, \ldots, T_0$ (i.e., all pre-intervention values of Y for the treated unit), $Y_{1,t}^1$ for $t = T_0 + 1, T_0 + 2, \ldots, T$ (i.e., all post-intervention values of Y for the treated unit), and $Y_{j,t}^0$ for $t = 1, 2, \ldots, T_0, T_0 + 1, \ldots, T$ and for $j = 2, 3, \ldots, J+1$ (i.e., both pre- and post-intervention values of Y for the J control units). The question is determining how to predict $Y_{1,t}^0$ for $t = T_0 + 1, T_0 + 2, \ldots, T$ (i.e., the unobserved outcome Y for the treated unit in the absence of intervention). We assume there are no covariates other than lagged values of the outcome variable that cause or are correlated with it. A potential bias exists that using all lagged values of the outcome variable as the only predictors might generate under SCM, even though the goodness of fit might be significantly improved. Still, we wanted to use the same information with the SCM and PDA methodologies. Therefore, the difference in the results might be explained exclusively by the different methods used to estimate the counterfactual, as in the works of Gardeazabal and Vega-Bayo (2017) and Wan et al. (2018). See the discussion in Kaul et al. (2021).

The SCM assumes that there exist weights $w = \{w_j\}_{j=2}^{J+1}$ such that

$$\hat{Y}_{1,t}^0 = \sum_{j=2}^{J+1} w_j Y_{j,t}^0 . \tag{1}$$

Denoting the pre-treatment vector of the outcome variable of the treated unit and the j-th control unit by Y_1^0 and Y_j^0, respectively, the weight vector, w, is obtained as the solution to the program

$$\min_{\{w_j\}_{j=2}^{J+1}} \left(Y_1^0 - \sum_{j=2}^{J+1} w_j Y_{j,t}^0 \right)' V \left(Y_1^0 - \sum_{j=2}^{J+1} w_j Y_{j,t}^0 \right), \tag{2}$$

subject to $w_j \geq 0$ and $\Sigma_{j=2}^{J+1} w_j = 1$. V (the predictor’s weight matrix) is a diagonal positive-definite matrix representing the relative importance of (in this case) each lagged value in the prediction of Y_1^0.14)

The PDA, like the SCM, assumes that the intervention in unit 1 does not affect the pre-intervention values of Y_1 or the pre- and post-intervention values of Y_j for any of the control units. The PDA additionally i) allows for a constant term, α, to control for differences in individual fixed-effects between the treated unit and the control units. Additionally, PDA ii) imposes no restrictions on the slope regression coefficients, β, in the following regression model

$$Y_{1,t} = \alpha + \beta_2 Y_{2,t} + \beta_3 Y_{3,t} + \ldots + \beta_{J+1} Y_{J+1,t} + u_{1,t}, \tag{3}$$

for $t = 1, 2, \ldots, T_0$ and where $u_{1,t}$ stands for the i.i.d. random idiosyncratic component of unit 1 and $E(u_{1,t}) = 0$. Once the ordinary least squares (OLS) coefficients $\left(\hat{\alpha}, \hat{\beta}_2, \ldots, \hat{\beta}_{J+1}\right)$ in Eq. (3) are estimated, the prediction of $Y_{1,t}^0$ provided by the PDA is simply given by

14) We have used version 4.0.5 of R throughout all the paper and the MSCMT package, Version 1.3.4, to compute the weight vector, *w* (Becker & Klößner, 2017; Becker & Klößner, 2018). For alternative methods to compute V, see Echevarría and García-Enríquez (2020), Hasancebi (2022). The program in Eq. 2 is usually referred to as the “inner” optimization part in the SCM literature. In our case, the optimal V is endogenously obtained as the solution to the “outer” minimization part within a nested minimization procedure (Becker & Klößner, 2018).

$$\hat{Y}^{0}_{1,t} = \hat{\alpha} + \hat{\beta}_2 Y_{2,t} + \hat{\beta}_3 Y_{3,t} + \ldots + \hat{\beta}_{J+1} Y_{J+1,t}, \quad (4)$$

for $t = T_0 + 1, T_0 + 2, \ldots, T$.

Note the key difference between the estimated counterfactuals under the two procedures. In Eq. (1), the control weights are restricted (no intercept, non-negativity of weights, and controls weights add up to 1). In Eq. (4), instead, the regression coefficients are unconstrained. If such constraints are not binding, the SCM is more efficient. If this were the case (i.e., the constraints on the regression coefficients were ineffective and a perfect fit was obtained), the SCM and OLS regressions would necessarily lead to the same control coefficients. This is so because the predictor weights of matrix V in the outer optimization problem, referred to in No. 7, would become meaningless; only the control weights, w, would be relevant (see Eq. [2]). If, on the contrary, the constraints are binding, SCM will give rise to a biased counterfactual prediction. Note also that, first, not restricting the coefficients in Eq. (4) leads to extrapolation bias; the estimated coefficients may (and surely will) fall out of the $[0,1]$ interval, which allows for extrapolation out of the support of the data. Second, mechanical use of SCM can lead to an interpolation bias if the control set contains units with characteristics different from the treated unit. Thus, limiting the donor pool to similar units or penalizing the choice of controls dissimilar to the treated is highly recommended (Abadie, 2021). To minimize the interpolation issue, it would be desirable to build the set of control units only with countries belonging to the same "club" or countries as similar as possible. Assuming no external effects of Macao's integration on the rest of the country, Chinese provinces would be the optimal choice. Once again, data limitation prevents us from ideal solutions: provincial GDP data has been available starting 2001 (see National Bureau of Statistics of China[15]). Unfortunately, there seems to be no clear-cut conclusion regarding which approach is preferable.

One additional problem posed by the PDA concerns the appropriate choice of the controls or untreated units to estimate the counterfactual, where the researcher must consider the limitations raised along three dimensions. First, the number of pre-treatment observations may not be large: 30 in our case. Second, the number of potential controls and regression coefficients to estimate J might be very large depending on the case under study (up to 24 in our exercise). Finally, sparsity or parsimony (i.e., a reduced number of non-zero coefficients) is a desirable property already embedded by construction in the synthetic control method (Abadie, 2021).

The method implemented here is the same as in Hsiao et al. (2012), Gardeazabal and Vega-Bayo (2017), and Wan et al. (2018). Assuming a set of J potential control units, in a first stage, all possible combinations of $m = 1,2,3,\ldots,M \leq J$ slope regressors (i.e., in addition to the constant term) are considered up to a maximum number of controls, which is given

15) https://data.stats.gov.cn/english/easyquery.htm?cn=E0103

by $M \equiv min\{J, T_0 - g - 1\}$. T_0 denotes the number of pre-treatment observations, and the desired minimum of degrees of freedom is denoted by g. Then, for each set of such m−tuples, the model specification attaining the highest R^2 is selected. Finally, in a second stage, the resulting models are ranked according the minimum corrected Akaike information criterion ($AICc$), although other alternatives, such as the Akaike information criterion and the Bayesian information criterion, could also be considered (Konishi & Kitagawa, 2008).[16)]

An increasingly popular alternative method of model selection with the property of sparsity mentioned above is the LASSO regression originally introduced by Tibshirani (1996). By adding a penalty term in the minimization of the sum of squared residuals to the standard *OLS* case, $\lambda \Sigma_{j=1}^{J} |\beta_j|$, where $\lambda \geq 0$ represents a tuning parameter and $|\beta_j|$ stands for the absolute value of the slope regression coefficient of the j−th control unit in Eq. (3) and non-zero coefficients (regardless of their signs) are penalized. The method requires first standardizing the predictors in such a way that each (i.e., for $i = 2, 3, \ldots, J+1$) is centered ($T_0^{-1} \Sigma_{t=1}^{T_0} \ Y_{i,t} = 0$) and has unit variance ($T_0^{-1} \Sigma_{t=1}^{T_0} \ Y_{i,t}^2 = 1$). Otherwise, the LASSO coefficients would depend on the units in which the predictors are measured. If, additionally, the outcome variable is centered ($T_0^{-1} \Sigma_{t=1}^{T_0} \ Y_{1,t} = 0$), the constant term α in Eq. (3) can be suppressed. Thus, for the optimal solution on centered data ($\hat{\beta} \equiv \hat{\beta}_2, \hat{\beta}_3, \ldots \hat{\beta}_{J+1}$), the optimal solution for uncentered data could be easily retrieved. Note that $\hat{\beta}$ would be the same, and the constant term $\hat{\alpha}$ would be given by $\overline{Y}_1 - \Sigma_{i=2}^{J+1} \ \overline{Y}_i \hat{\beta}_i$, where $\{\overline{Y}_j\}_{j=1}^{J+1}$ denotes the *original* means.[17)]

The result is that increasing values of λ lead to fewer control units in the regression. In the particular case that $\lambda = 0$, one obtains the OLS estimator. If instead λ were large enough, all slope coefficients would equal zero; therefore, only the constant term, α, would be left. The final choice depends on the particular value at which the tuning parameter is set, usually accomplished by following a cross-validation procedure (Li & Bell, 2017). With regard to the distribution of the LASSO estimator, this is known only if the number of controls is relatively smaller than the sample size (Knight & Fu, 2000), and even then, only asymptotically. Moreover, although many studies have explored its asymptotic distributional properties, as Jagannath and Upadhye (2018) indicate, the asymptotic results can provide an incorrect picture of the LASSO estimator's actual finite sample behavior. Therefore, inference based on this estimator is still an open question. LASSO estimators are particularly recommended when the number of control

16) Note that the number of model specifications to be executed may be considerable: $\Sigma_{j=1}^{M} \dfrac{J!}{j!(J-j)!}$. For instance, if $J=24$, $T_0=30$, assuming that $g=3$, and keeping the maximum number of controls reasonably low, $M=10 \langle \min\{24, 26\}$, the procedure implies that a total of 4,540,385 regressions must be run. Computations were made with the R pampe package, Version 1.1.2 (Vega-Bayo, 2015).

17) See Hastie et al. (2016) for details.

units is large enough. Given that this does not seem to be the case in our exercise, we claim that the selection of controls can be conveniently implemented by following the above-described information criterion.

IV. Data

We build a balanced panel data with 43 yearly observations (between 1970 and 2012) and 25 countries: Macao and 24 control units. The beginning of the sample period is given by the first year for which we have available data for per capita GDP, our primary outcome variable in this paper, in Penn World Table 10.0[18]. The common measure unit of this variable is chained PPPs 2017 USD, which allows comparisons across units and over time. The year 2012 provides the end of the sample period because 2013 marks the start of a turning point in Macao's economy due to some significant reforms. Extending the post-treatment period beyond 2012 would contaminate any estimate of Macao's counterfactual in the absence of integration.[19]

To choose the country members of the control set, we followed the criterion of geographical proximity, economic proximity, or both. Thus, we focus on countries that exhibit, on average, minimum trade relationships with Macao from 1991 to 1999 (exports, imports, or both). These countries represent Macao's trade partners, preferably located in the Pacific basin, similar to Hsiao et al. (2012).[20] Data on export and import partner shares were obtained from the World Integrated Trade Solution database available at The World Bank.[21] Some countries were removed from the initial choice of controls for different reasons. Vietnam had its own treatment because of the war between 1955 and 1975. As the former occupying state, Portugal was also exposed to the same treatment as Macao. Singapore and South Korea, two of the four Asian tigers, experienced abnormally high GDP growth rates during the sample period. Concerning the other two omissions, Hong Kong was a relatively small economy that went through its own treatment. The time evolution of Taiwan's per capita GDP series during the pre-treatment period is similar to Macao's, following a stable trend during the post-treatment period (see panel [*b*] in Figure 1); however, the country was still included. The final donor pool consists of Indonesia, Japan, Malaysia, Thailand, United States, Taiwan, Philippines, Germany, United

18) https://www.rug.nl/ggdc/productivity/pwt/

19) An increased number of observations might be desirable, but quarterly data for Macao's GDP are only available starting in 2001 (see Macao Statistics and Census Service (https://www.dsec.gov.mo/en-US/Statistic?id=901)).

20) Given the reduced number of pre-intervention observations when studying the political integration of Hong Kong in the PRC, they choose countries that are either in the region or economically closely associated with Hong Kong (Hsiao et al., 2012); however, in our case, the issue is interpolation bias rather than observations.

21) https://wits.worldbank.org/CountryProfile/en/Country/MAC/StartYear/1991/EndYear/2016/TradeFlow/Import/Partner/BY-COUNTRY/Indicator/MPRT-PRTNR-SHR

Kingdom, France, Australia, Austria, Brazil, Canada, Denmark, Finland, Italy, Mexico, Netherlands, New Zealand, Spain, Sweden, Switzerland, and Norway. Given that the size of the countries in the control set is large enough compared to the treated country, we believe that none of them are affected by the interventions in Macao; therefore, the estimated counterfactual is free of any potential bias externalities or spillover effects.

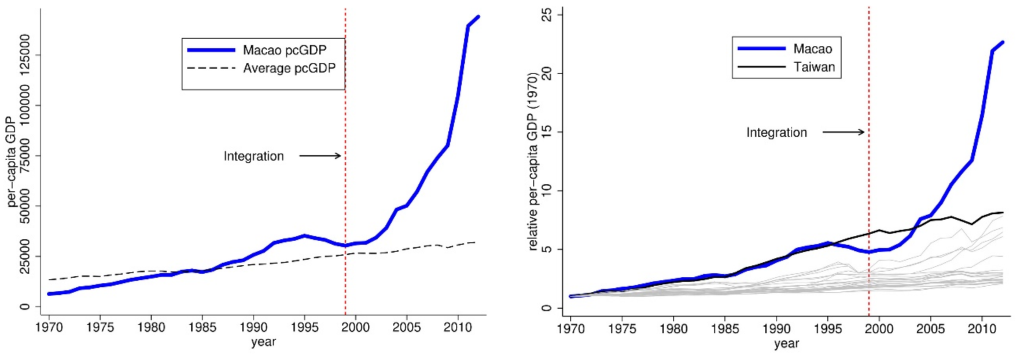
To reduce the interpolation bias resulting from putting together very different countries in the donor pool, we reduced the number of potential controls to a reasonable number at the expense of a poorer fit when estimating the counterfactual; otherwise, it might result in a case of overfitting. Enlarging the set of controls is always a straightforward method for obtaining a good match between the observed and the counterfactual during the pre-treatment period (Abadie, 2021). An additional consequence of having a relatively small set of controls is that the chances of running statistical significance tests and placebo robustness checks, which are standard in the causal inference literature, are diminished or potentially eliminated (Billmeier & Nannicini, 2013).

V. Results

According to the timing of events, the pre-treatment period for integration spans from 1970 to 1999, while the post-treatment period covers 2000 to 2012. Figure 1, panel (*a*) presents the time paths for the outcome variable for the observed values and the population-weighted average for Macao and all countries in the sample, both the pre- and post-intervention periods. The difference between the two is patent, a clear indication that there is room for improvement in searching for a counterfactual. Note that Macao's per capita GDP and the average of all the countries in the data set during the pre-treatment period follow similar trends. However, in the post-treatment period, both trends diverge; while the rest of the countries continue on a steady growth path, Macao experiences substantially higher growth rates. For completeness, panel (*b*) in Figure 1 shows the per capita GDP normalized to 1970 levels. As discussed in Section 4, Macao and Taiwan follow similar patterns during the pre-treatment period; however, Taiwan does not change during the post-treatment period, whereas Macao displays a clear increase in trend.

Figure 1. Per capita GDP for Macao and control countries

(*a*) (*b*)



Key: Panel (*a*): The blue line represents Macao's observed path of per capita GDP. The black dashed line depicts the population-weighted average per capita GDP of the control countries in the sample. Panel (*b*): Per capita GDP normalized to 1970 levels. The blue line corresponds to Macao's observed path, the gray lines represent the corresponding series for the control countries other than Taiwan, and the black line represents Taiwan.

Tables 1 and 2 provide the results. The first column in Table 1 represents Macao's actual per capita GDP, whereas the second column represents the (population-weighted) average for the 24 countries in the donor pool. The third, fourth, and fifth columns display the estimated values under the three methods discussed above: SCM in column three and PDA in columns four and five. PDA-AICc (PDA-LASSO) is implemented using AICc (LASSO) as the model selection criterion in column four (five). Both methodologies' predictions were closer to Macao's observed per capita GDP than the simple average of the donor pool countries; however, the fit is better under the PDA, particularly PDA-AICc. The root of the mean square prediction error (RMSE) is substantially lower than that obtained under the SCM and PDA-LASSO (405.084 compared to 2,007.300 and 841.747, respectively).[22] This is the expected result; by construction, the PDA admits extrapolation and a non-zero constant term, while the SCM does not. Moreover, and this is the general case in all the computations (i.e., all the outcome variables considered in this paper), the fit obtained under the PDA-AICc is slightly better than under the PDA-LASSO and with a lower number of non-zero coefficients (except for the foreign direct investment case in which only the constant term turns out to be non-zero). The worst fit corresponds to the trivial counterfactual obtained as the mean among the 24 control units (RMSE = 5,287.969) (see the third row from the bottom in Table 1).

As an alternative to the RMSE introduced in footnote 12 (and which is the standard measure of pre-treatment fit reported in all software packages computing the SCM), we compute the goodness-of-fit measure suggested by Ferman et al. (2020):

22) By definition, $\mathrm{RMSE} \equiv \left[\Sigma_{t=1}^{T_0}\left(Y_{1,t}-\hat{Y}_{1,t}^{0}\right)^2/T_0\right]^{1/2}$.

$$\widetilde{R}^2 \equiv 1 - \frac{\sum_{t=1}^{T_0} \left(Y_{1,t} - \widehat{Y}_{1,t}^0\right)^2}{\sum_{t=1}^{T_0} \left(Y_{1,t} - \overline{Y}_1\right)^2}, \tag{5}$$

where $\overline{Y}_1 \equiv T_0^{-1} \times \Sigma_{t=1}^{T_0} Y_{1,t}$. Note that, compared to the RMSE, *i*) $\widetilde{R}^2$ does not depend on the unit of measurement of the outcome variable. *ii*) $\widetilde{R}^2 \leq 1$, and possibly negative if, as might be the case, the fit obtained with the SCM is poor enough.[23] *iii*) $\widetilde{R}^2 = 1$ would denote a perfect fit. *iv*) $\widetilde{R}^2 = 0$ if, for instance, the fit obtained under the PDA were such that the estimated coefficients of all *slope* regressors happened to be identically equal to zero (i.e., $\widehat{Y}_{1,t}^0 = \hat{\alpha} = \overline{Y}_1$ for all t).[24] *v*) $\widetilde{R}^2$ would allow one to set a minimum threshold level for the counterfactual computation to be acceptable. For instance, Ferman et al. (2020) consider two lower bounds in their numerical exercise, 0.80 and 0.95.

The $\widetilde{R}^2$ obtained under PDA-AICc is the highest (0.998 vs. 0.992 and 0.953 under PDA-LASSO and SCM, respectively) (see the second row from the bottom in Table 1). The table also shows the observed and the estimated annual average growth rate of per capita GDP for the pre-treatment period. PDA-AICc provides the closest estimated value to the observed one, 5.947% vs. 5.967% (see the last row in Table 1).

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23) This is the case when estimating the effect of intervention upon exports and imports by applying SCM, as discussed in Section 6.

24) This is precisely the case when estimating the effect of intervention upon foreign domestic investment via PDA-LASSO, as discussed in Section 6.

Table 1. *Per Capita GDP Pre-treatment Values*

Year	Actual	Sample Mean	SCM	PDA-AICc	PDA-LASSO
1970	6,361.435	14,018.900	8,517.113	6,835.791	6,829.343
1971	6,798.270	14,499.050	9,110.073	6,568.518	7,354.069
1972	7,375.458	15,142.250	9,941.479	7,754.016	8,382.555
1973	9,172.819	15,944.160	10,810.471	8,866.897	9,262.238
1974	9,636.785	16,202.840	10,858.118	9,430.161	9,778.670
1975	10,514.421	16,087.190	11,000.354	9,641.516	10,213.390
1976	11,082.733	16,764.680	11,956.051	11,778.672	11,095.786
1977	12,199.522	17,161.850	12,696.756	12,566.868	12,124.612
1978	13,375.349	17,811.450	13,849.628	13,127.837	13,119.991
1979	14,178.809	18,530.350	14,777.174	14,421.575	13,857.085
1980	14,934.289	19,050.370	15,577.507	14,862.754	15,264.305
1981	15,809.837	19,067.180	15,812.486	15,733.996	16,414.205
1982	15,814.070	18,835.380	15,729.487	16,170.814	15,940.571
1983	17,433.713	19,051.620	15,959.522	17,282.128	16,765.910
1984	17,986.902	19,502.430	16,496.573	17,625.962	17,762.220
1985	17,246.930	19,580.230	16,681.898	16,932.304	17,735.223
1986	18,351.347	20,327.160	18,433.900	18,537.076	18,366.513
1987	20,857.386	21,137.320	20,338.497	20,520.760	19,664.421
1988	22,260.359	21,890.290	21,925.685	22,502.991	21,062.133
1989	23,101.346	22,630.650	23,524.268	23,328.670	23,450.777
1990	25,753.531	23,417.250	25,322.526	26,008.516	26,579.385
1991	27,740.359	23,501.380	26,777.029	28,258.109	28,539.853
1992	31,699.718	23,900.250	28,102.428	30,852.974	30,324.766
1993	32,924.308	24,213.880	29,144.130	32,713.030	31,466.516
1994	33,717.316	25,102.120	30,084.245	34,252.831	32,792.392
1995	35,288.605	26,259.530	31,489.878	34,866.867	33,865.492
1996	34,133.416	27,260.690	33,201.314	34,176.263	34,984.164
1997	33,226.595	28,323.610	34,131.127	33,727.461	35,458.787
1998	31,305.890	28,778.360	34,613.898	30,711.852	30,806.037
1999	30,374.731	29,981.500	35,269.474	30,599.039	31,394.838
RMSE		5,287.969	2,007.300	405.084	841.747
$\tilde{R}^2$		0.675	0.953	0.998	0.992
Ave. growth	5.967	2.428	5.125	5.947	5.801

Key: Estimation integration results by SCM, PDA-AICc, PDA-LASSO, Macao's actual per capita GDP, and the (population-weighted) average of the 24 countries in the donor pool. RMSE: see footnote No. 12. $\tilde{R}^2$: see Eq. (5). Annual growth: average growth rate for the pre-treatment period (in percent terms).

Table 2 shows the SCM weights and the PDA coefficients. The synthetic Macao is the result of a weighted average of only two countries, Japan and Taiwan, with weights equal to 0.410 and 0.590, respectively; however, under the PDA-AICc, nine countries display (unconstrained) non-zero coefficients. Four countries have a positive sign (Indonesia, Germany, Italy, and New Zealand), and five have a negative one (Australia, Brazil, Netherlands, Switzerland, and Sweden), which is a clear sign of extrapolation. The results under the PDA-LASSO differ. Seven countries obtain positive coefficient estimates (Indonesia, Japan, USA, Taiwan, Canada, Italy, and Mexico), and three are negative (the UK, Brazil, and the Netherlands). The two methods provide the same sign effect regarding the effect of integration, although they are quantitatively disparate. When defining the post-treatment average gap (AG) as

$$AG_j \equiv \frac{\sum_{t=T_0+1}^{T}\left(Y_{j,t}-\hat{Y}_{j,t}^{0}\right)}{T-T_0}, \tag{6}$$

where $Y_{j,t}$ and $\hat{Y}_{j,t}^{0}$ denote the observed outcome and counterfactual for country j, respectively, for $j=1,2,\ldots,J+1$, the SCM estimates a positive intervention effect (on average, per capita GDP would be USD 30,333.553 higher for each of the 14 post-intervention years). The PDA estimates also imply positive effects, USD 42,321.878 under the PDA-AICc and USD 28,634.32 under the PDA-LASSO (see the last row in Table 2).[25] The conclusion we see from these results is well-ordered; all the methods considered (SCM, PDA-AICc, and PDA-LASSO) predict a positive effect of the intervention on per capita GDP, although they provide quantitatively different figures. If the goodness-of-fit were the right criterion to choose our best estimate of the effect (either one of the two discussed above), PDA-AICc would provide the answer: an approximate yearly average of USD 42,321 between 2000 and 2012.

25) For completeness, Table 2 also shows $\lambda_{\min}$, the value obtained by λ (the tuning parameter of the PDA-LASSO estimator), which minimizes the average squared error over all the pre-treatment periods. See Section 4.2 in Li and Bell (2017).

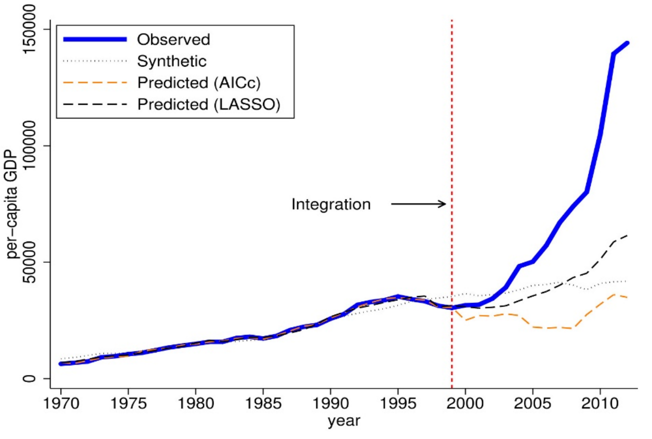
Table 2. *Per Capita GDP—Weights and Coefficients*

Country	SCM weights	PDA-AICc	PDA-LASSO
(Intercept)	-	7,430.252 (**)	-2,990.999
Indonesia	-	4.149 (***)	5.125
Japan	0.410	-	0.372
Malaysia	-	-	-
Thailand	-	-	-
United States	-	-	0.104
Taiwan	0.590	-	0.254
Philippines	-	-	-
Germany	-	1.561 (***)	-
United Kingdom	-	-	-0.402
France	-	-	-
Australia	-	-0.431 (*)	-
Austria	-	-	-
Brazil	-	-1.056 (***)	-0.710
Canada	-	-	0.160
Denmark	-	-	-
Finland	-	-	-
Italy	-	0.958 (***)	0.032
Mexico	-	-	0.031
Netherlands	-	-1.324 (***)	-0.029
New Zealand	-	1.516 (***)	-
Spain	-	-	-
Sweden	-	-0.683 (***)	-
Switzerland	-	-0.529 (***)	-
Norway	-	-	-
AG	USD 30,333.553	USD 42,321.878	USD 28,634.32

Key: Only non-zero values are shown. SCM weights are the solution to the program in Eq. (2), and PDA-AICc and PDA-LASSO coefficients are the OLS estimates of the model in Eq. (3). AG refers to the average post-treatment gap (see Eq. [6]). Significance levels of PDA-AICc coefficient estimates are (***) 0.1%, (**) 1%, and (*) 5%. $\lambda_{\min}$ = 41.34 for the LASSO regression.

The graphical counterpart of Tables 1 and 2 is shown in Figure 2. As mentioned above, it is patent that matching the pre-treatment period with the SCM is worse than those with the PDA, while PDA-AICc is slightly better than PDA-LASSO.

Figure 2. Per capita GDP—observed and counterfactuals

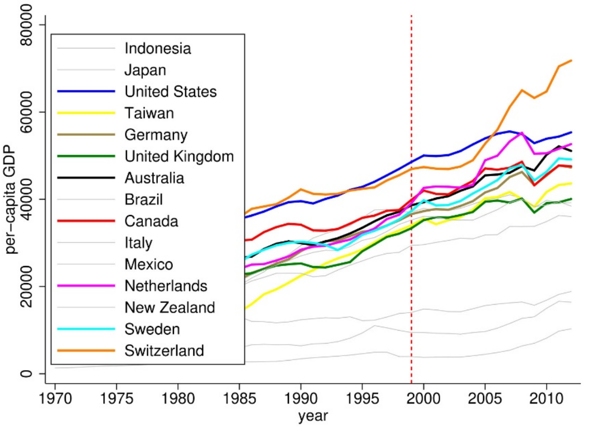


Key: Macao's observed per capita GDP is the solid blue line. The black dotted line represents the SCM counterfactual; the orange dashed line depicts the PDA-AICc counterfactual, and the PDA-LASSO counterfactual is represented by the black dashed line.

The difference in the results obtained under the two implementations of the PDA, or the fact that the model selection criterion plays a role, requires some deeper consideration. First, both methods provide different controls with non-zero coefficients (even though whenever a control country appears with a non-zero coefficient under both criteria, the sign is the same). It is important to determine why such a disparity and, in particular, why the counterfactual estimate generated by the LASSO regression is substantially higher and smoother than the one generated by the AICc regression. Second, this would lead us to study, in detail, the differential role that some control countries might be playing. Figure 3 displays the series of per capita GDP for the 15 countries that appear under at least one of the two model selection criteria considered, highlighting some specific countries.

For instance, Switzerland, the US, and Australia display some of the highest levels of pcGDP during the post-treatment period within this subset. It turns out that the LASSO coefficient is positive for the US (and zero for Switzerland and Australia) and that the AICc coefficient is negative for Switzerland and Australia (and zero for the USA). Taiwan's case is similar; we find high levels of pcGDP with a positive coefficient in the LASSO regression and a zero coefficient in the AICc counterfactual. Additionally, the Netherlands control displays a high level of per capita GDP and a (lower) negative coefficient in the AICc regression than in the LASSO regression. These results partly explain why the LASSO counterfactual is higher than the AICc counterfactual. Note that the difference between both counterfactuals would have been even more significant without the UK's negative coefficient in the LASSO regression. Finally, the time evolution of per capita GDP for the Netherlands, Sweden, and Australia and their AICc coefficients might also explain why the AICc counterfactual evolves less smoothly than the LASSO coefficient.

Figure 3. PDA-AICc vs. PDA-LASSO controls

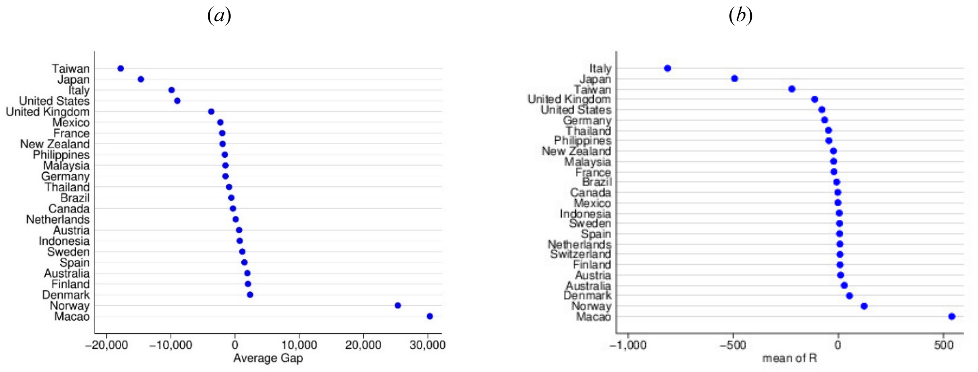


Key: Series of per capita GDP for the 15 countries that appear under at least one of the two selection criteria implemented. Specific countries are shown in color.

We next perform an in-space placebo test, the standard procedure in the related literature, to check the statistical significance of our previous estimates. We move Macao to the donor pool and then sequentially estimate the effect of the intervention in every other country in the pool. We run this exercise both for the SCM and PDA-AICc, leaving aside PDA-LASSO to avoid overloading the paper. The exercise allows us to obtain a distribution of effects for the countries that did not experience the same treatment so that our results would be validated if the probability of finding other significant treatment effects in non-treated countries were low enough. It is worth noting that this exercise did not exclude Macao from the successive donor pools, as in Abadie et al. (2010); however, the opposite might be a valid alternative.

We start with the SCM. Two types of tests are usually implemented in the literature. The first focuses on the distribution of the previously defined post-treatment AG. Before that, we remove those placebo cases for which the fit in the pre-treatment period is poor (relative to Macao's); otherwise, confidence in the post-treatment analysis and placebo test results might be reduced (Abadie et al., 2010; Acemoglu et al., 2016). Thus, we are willing to exclude those control countries for which the RMSE is at least as high as $\sqrt{2}$ times that of Macao. Only one control, Switzerland, is lost with the SCM, but none with the PDA-AICc. Figure 4, panel (*a*) displays the results. Formally, the probability of finding an AG_j higher than or equal to Macao's equals $p = 1/24 = 0.04$. Thus, the null hypothesis of no positive effect of the treatment on Macao's per capita GDP would be rejected at a 5% significance level.

Figure 4. SCM and in-space placebo test



Key: Panel (*a*) represents the distribution of the average post-treatment gap, AG_j, among the 23 countries in the sample whose RMSE is less than $\sqrt{2}$ times that of Macao (Eq. [6]): Switzerland is excluded from the sample. Panel (*b*) represents the distribution of ratio R_j across all 24 countries in the sample and Macao (Eq. [7]).

Complementary to this test, we can consider the entire distribution of the *signed* ratios of post- to pre-treatment mean squared prediction error, R_j, defined as

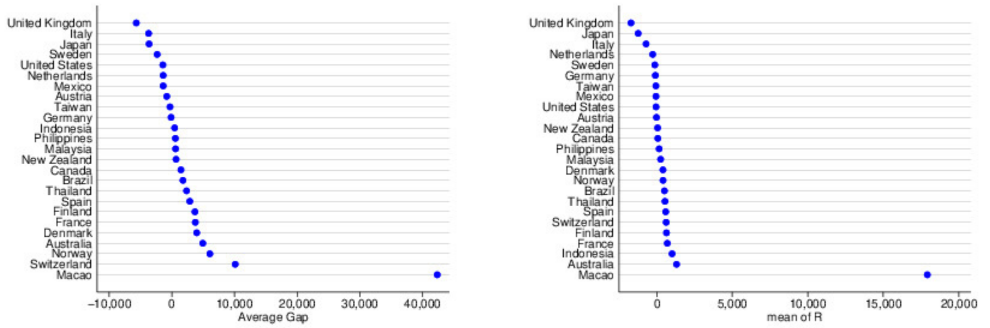
$$R_j \equiv \frac{\sum_{t=T_0+1}^{T}\left(Y_{j,t}-\hat{Y}_{j,t}^{0}\right)^2/(T-T_0)}{\sum_{t=1}^{T_0}\left(Y_{j,t}-\hat{Y}_{j,t}^{0}\right)^2/T_0}\times\frac{AG_j}{|AG_j|}. \tag{7}$$

Note that no control country was excluded this time, as a strong enough post-treatment effect can more than offset a poor fit during the pre-treatment period. Second, and most importantly, the sign of R_j depends on the sign of AG_j, allowing for a one-sided test, which may result in a substantial gain of power (Abadie, 2021). Figure 4, panel (*b*) presents the results. On this occasion, Macao ranks first as well, so the probability of finding an effect larger than or equal to Macao's equals $p = 1/25 = 0.04$.

We next carry out the same exercise, implementing the PDA-AICc method, and Figure 5 provides the results. Regarding the distribution of AG_j, all placebo runs obtain a good fit, so that none is disposed by applying the above mentioned $\sqrt{2}$ rule. Macao exhibits the highest value; in other words, the probability of finding an effect larger than or equal to Macao's equals $p = 1/25 = 0.04$ (see panel [*a*]). The same result is obtained after computing the empirical distribution of R_j (see panel [*b*]). The consequence after this placebo test run is clear; regardless of the method implemented to compute the counterfactual of per capita GDP in the absence of integration, the null hypothesis of no effect of the intervention on Macao's per capita GDP is rejected.

Figure 5. PDA-AICc and in-space placebo test

(*a*) (*b*)



Key: Panel (*a*) represents the distribution of the average post-treatment gap, AG_j, among the 24 countries in the sample whose RMSE is less than $\sqrt{2}$ times that of Macao (Eq. [6]). Panel (*b*) represents the distribution of ratio R_j across all 24 countries in the sample and Macao (Eq. [7]).

For completeness, Table 3 details the predicted effects of Macao's integration: *i*) on the per capita GDP (in terms of both levels and growth rates); *ii*) with the SCM and the PDA methods implemented to compute the counterfactual (in the PDA case, with the two model selection criteria described above, AICc and LASSO); and *iii*) for each year in the post-treatment period.

Thus, the *accumulated* difference in the per capita GDP growth rates between the actual or observed Macao and its counterfactual ranges between 360.9% (PDA-AICc) and 278.9% (PDA-LASSO). The figure for the SCM is closer to the former, 356.1%. In terms of average *annual* growth rates for each of the 10 years, such numbers would mean 11.4%, 7.2%, and 12.4%, respectively. Conversely, the effect is an increment in per capita GDP, where (necessarily) results differ depending on the procedure followed to obtain the counterfactual. Without the integration process, the *accumulated* per capita real GDP in 2000-2012 would have been between USD 550,184.4 lower (42,321.9 USD per year on average) in the PDA-AICc case and USD 372,246.1 lower (28,634.3 USD per year on average) in the PDA-LASSO case.

Table 3. *Effect on Per Capita GDP Levels and Growth Rates*

Year	SCM		PDA-AICc		PDA-LASSO	
	Δg^S	$\Delta pcGDP^S$	Δg^P_{AICc}	$\Delta pcGDP^P_{AICc}$	Δg^P_{LASSO}	$\Delta pcGDP^P_{LASSO}$
2000	0.2	-5,005.3	21.8	6,455.2	5.5	669.1
2001	3.2	-3,848.2	-7.4	4,643.6	2.4	1,442.0
2002	6.7	-1,745.7	9.1	7,507.0	7.1	3,717.0
2003	12.2	2,426.1	10.2	11,316.7	11.8	7,881.8
2004	19.4	10,139.0	26.0	21,217.1	16.2	14,795.8
2005	-0.9	10,170.4	22.0	28,046.5	-2.1	14,670.7
2006	12.9	16,761.9	15.9	35,457.8	8.6	19,781.4
2007	14.7	25,594.0	15.8	44,998.4	9.8	26,873.4
2008	13.4	33,850.4	12.6	52,476.1	2.1	30,564.5
2009	13.1	41,932.1	-19.5	52,618.7	4.0	34,864.5
2010	23.5	63,760.0	14.5	72,719.2	17.5	53,486.4
2011	31.6	97,933.8	20.4	103,456.4	18.5	80,771.7
2012	2.7	102,367.4	6.5	109,271.1	-1.2	82,727.2
Accumulated	356.1	394,336.2	360.9	550,184.4	278.9	372,246.1
AG		30,333.6		42,321.9		28,634.3
$\hat{\gamma}_1$	12.4		11.4		7.2	
t-statistic	16.0		14.8		22.8	

Key: Δg^S: difference in growth rates between actual and synthetic Macao; $\Delta pcGDP^S$: the gap in per capita GDP according to SCM; Δg^P_{AICc}: difference in growth rates between actual Macao and predicted Macao according to PDA-AICc; $\Delta pcGDP^P_{AICc}$: the gap in per capita *GDP* according to PDA-AICc; Δg^P_{LASSO}: difference in growth rates between actual Macao and predicted Macao according to PDA-LASSO; $\Delta pcGDP^P_{LASSO}$: the gap in per capita GDP according to PDA-LASSO. *Accumulated*: accumulated $\Delta pcGDP$ for all the post-treatment period. AG : yearly average of $\Delta pcGDP$. $\hat{\gamma}_1$: annual average difference of per capita GDP growth rates (see Eq. [10]), and *t*-statistic (computed with robust standard errors). All growth rates are in percent terms. As in the rest of the paper, per capita GDP is measured in PPP 2017 USD.

One debatable issue is the extent of the long-run effects of integration and its statistical significance, similar to Hsiao et al. (2012). Thus, defining $\hat{\Delta} Y_{1,t} \equiv Y_{1,t} - \hat{Y}^0_{1,t}$, for $t = T_0 + 1$, $T_0 + 2, \ldots, T$, we could fit the following $AR(p)$ model for the estimated treatment effects,

$$\hat{\Delta} Y_{1,t} = a + \sum_{i=1}^{p} b_i \hat{\Delta} Y_{1,t-i} + \eta_{1,t}, \tag{8}$$

where $\eta_{1,t}$ denotes an independent and identically distributed (i.i.d.) random term with $E(\eta_{1,t}) = 0$, and where the maximum order of such autoregressive process would depend on the number of observations in the post-treatment period, $T - T_0$. Note that, by the definition of the long run, $\hat{\Delta} Y_{1,t} = \hat{\Delta} Y_{1,t-1} = \ldots = \hat{\Delta} Y_{1,t-p} \equiv \hat{\Delta} Y^{LR}_1$. This would allow us to easily compute the long-run effect of the intervention by simply applying the delta method to estimate $\hat{\Delta} Y_1^{LR} \equiv \hat{a}/\left(1-\Sigma_{i=1}^{p} \hat{b}_i\right)$.[26] For instance, in the case of the *PDA-AICc* (where the pre-treatment fit attained is the highest), and assuming an $AR(2)$, we obtain

$$\underset{}{\hat{\Delta} Y_{1,t}} = \underset{(2413.4062)}{4997.6422} + \underset{(0.4564)}{0.9122}\ \hat{\Delta} Y_{1,t-1} + \underset{(0.5372)}{0.2601}\ \hat{\Delta} Y_{1,t-2} + \hat{\eta}_{1,t}. \tag{9}$$

The high estimated robust standard errors shown in parentheses imply that neither of the coefficients is statistically significant. The corresponding long-run effect would be -28994.547, with a t-statistic equal to -0.9465. Unsurprisingly, this is not statistically significant.

The intuition is simple: the gap between the observed series of per capita GDP and any counterfactuals considered is far from constant but increasing (see Figure 2). Therefore, it would make sense to look for the long-run effect not at the level but in the per capita GDP growth rate. Thus, assuming constant yearly growth rates in the post-treatment period for the observed and the counterfactual series (respectively g and $\hat{g}^0$), so that $Y_{1,t}^1 = Y_{1,0}^1\left(1+g^1\right)^t$ and $\hat{Y}_{1,t}^0 = Y_{1,0}^0\left(1+\hat{g}^0\right)^t$ for $t = T_0+1, T_0+2, \ldots, T$, we estimate the following model

$$\hat{\Delta} y_{1,t} = \gamma_0 + \gamma_1 t + \varkappa_{1,t}, \tag{10}$$

where $\hat{\Delta} y_{1,t} \equiv ln\, Y_{1,t}^1 - \ln \hat{Y}_{1,t}^0$, $\gamma_0 \equiv ln\, Y_{1,0}^1 - \ln Y_{1,0}^0$, and $\gamma_1 \equiv ln\left(1+g^1\right) - \ln\left(1+\hat{g}^0\right) \approx g^1 - \hat{g}^0$, and where $\varkappa_{1,t}$ is an i.i.d. random term with $E\left(\varkappa_{1,t}\right) = 0$. The last two rows of Table 3 present the results. The statistically significant estimates of γ_1 range between 12.4% under the SCM, 7.2% under the PDA-LASSO method, and 11.4% under the PDA-AICc method.

Some conclusions can be derived from this section's discussion. First, the integration process of Macao into the PRC did have a statistically significant, positive treatment effect on both the level of per capita GDP and its long-run growth rate for the 2000-2012 period. These findings are in line with the findings of Yin et al. (2018) and Hsieh and Wang (2014), who examine the economic impacts of the CEPA and the liberalization of the gaming industry, respectively. They both find a significant increase in the GDP growth rate and the per capita GDP following Macao's handover process. Second, the qualitative aspect of the result is robust to the method followed in computing the counterfactual (whether SCM or PDA); however, the estimates of the AG (in the level of per capita GDP) and the growth gaps depend on the method chosen to

26) Computations for the delta method were carried out with the R car package, Version 3.0-10 (see CRAN (https://cran.r-project.org/web/packages/car/index.html)).

compute the counterfactual. Adopting the PDA-AICc as the method implemented to assess the counterfactual (because its pre-treatment fit outperforms that of the SCM and PDA-LASSO), we find an approximate yearly average per capita GDP gap of USD 42,322 for the period. Following the same criterion, we find that the annual growth rate of the per capita GDP was 11.4% higher than that theoretically observed in the absence of treatment.

VI. Other Outcome Variables

We next consider the driving forces behind the observed effect on per capita GDP. As mentioned, foreign direct investment skyrocketed in the years following the start of the integration. The average annual per capita foreign direct investment for 2000-2012 was 80.594% higher than 1982-1999. Similarly, unemployment fell from 6.3% in 1999 to 1.97% in 2012, and per capita exports and imports of goods and services increased by 462.7% and 177.6%, respectively. Thus, to support the Section 5 results, we consider the effects of Macao's integration process on the three aforementioned economic indicators as additional variable outcomes: 1) net inflows of foreign investment; 2) the unemployment rate; and 3) exports and imports of goods and services. A variable that, in principle, might be worth considering is travel and tourism, another potential engine of economic activity. Unfortunately, the series available for travel and tourism total contribution to GDP starts in 1996 (see The World Bank[27]), which rules out the possibility of having a reasonable pre-treatment period and, therefore, a reliable estimate of the counterfactual.

A. Per capita foreign direct investment

Regarding per capita net inflows of foreign investment, Taiwan drops out of the sample because of insufficient data, reducing the number of untreated countries to 23.[28] Table 4 presents the main results. Regarding the fit, the $\tilde{R}^2$ for the SCM and the PDA-LASSO procedures are extremely poor (-0.162 and 0.000, respectively). In other words, the SCM fit is worse than the one the simple pre-treatment average provides, and the PDA-LASSO exactly equals the latter. Conversely, following the PDA-AICc method, the fit seems acceptable as $\tilde{R}^2$ = 0.978. This result leads us to a predicted annual AG for per capita net inflow of foreign direct

27) https://tcdata360.worldbank.org/indicators/tot.direct.gdp?country=BRA&indicator=24650&viz=line_chart&years=1995,2028#table-link

28) Data for the variable were obtained from Penn World Table 10.0 (https://www.rug.nl/ggdc/productivity/pwt/) and The World Bank (https://data.worldbank.org/indicator/BX.KLT.DINV.WD.GD.ZS); the latter does not provide information for Taiwan.

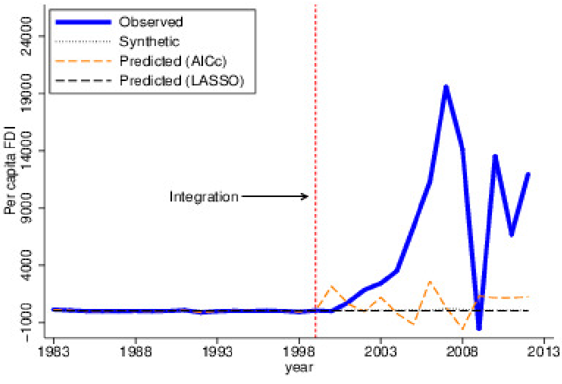
investment for the post-treatment period of USD 6,358. The results are shown graphically in Figure 6.

Table 4. *Per Capita FDI—Weights and Coefficients*

Country	SCM weights	PDA-AICc	PDA-LASSO
(Intercept)	-	110.349 (***)	8.715
Indonesia	0.174	-	-
Japan	0.700	-4.417 (***)	-
Malaysia	-	-	-
Thailand	-	0.217 (***)	-
United States	-	-	-
Philippines	-	-	-
Germany	-	-	-
United Kingdom	-	0.420 (***)	-
France	-	-0.235 (***)	-
Australia	-	-	-
Austria	-	-	-
Brazil	-	-0.422 (***)	-
Canada	-	-	-
Denmark	-	-	-
Finland	-	-	-
Italy	0.126	-	-
Mexico	-	1.523 (***)	-
Netherlands	-	-	-
New Zealand	-	-	-
Spain	-	-0.236 (***)	-
Sweden	-	-	-
Switzerland	-	-	-
Norway	-	0.206 (***)	-
RMSE	59.545	8.153	55.231
$\tilde{R}^2$	-0.162	0.978	0.000
AG	USD 6,945.000	USD 6,358.200	USD 7,023.800

Key: Only non-zero values are shown. SCM weights are the solution to the program in Eq. (2), and PDA-AICc and PDA-LASSO coefficients are the OLS estimates of the model in Eq. (3). RMSE: see footnote 12. $\tilde{R}^2$: see Eq. (5). AG refers to average post-treatment gap (see Eq. [6]). Significance levels of PDA-AICc coefficient estimates: (***) 0.1%, (**) 1%, and (*) 5%. $\lambda_{\min}$ = 24.95 for the LASSO regression.

Figure 6. Per capita FDI—observed and counterfactuals

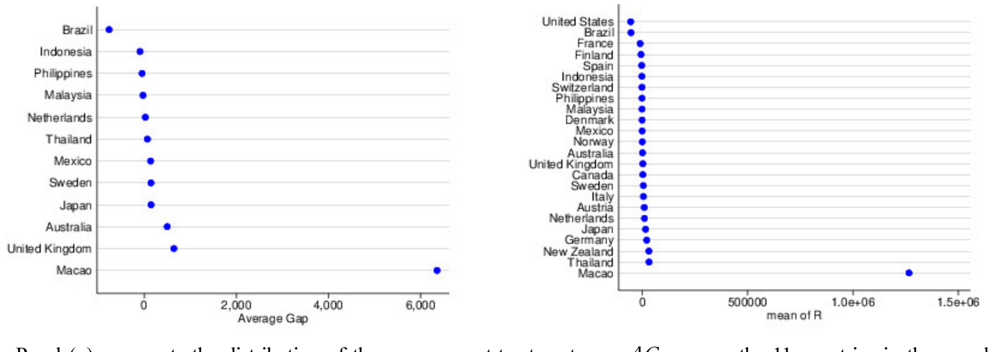


Key: The solid blue line depicts Macao's observed per capita FDI. The black dotted line represents the SCM counterfactual; the orange dashed line refers to the PDA-AICc counterfactual; the PDA-LASSO counterfactual is shown by the black dashed line.

Regarding the in-space placebo robustness check, the procedure followed is the same as per capita GDP; however, given the previous discussion, we focus on the PDA-AICc results (see Figure 7). Based on the average post-treatment distribution gap, AG, the probability of finding an effect larger than or equal to Macao's equals $p = 1/12 = 0.08$ (this time, 12 countries drop out because of a poor fit during the pre-treatment period). When looking at the distribution of the ratio R, the probability of finding an effect larger than or equal to Macao's is $p = 1/24 = 0.04$.

Figure 7. Per capita FDI—PDA (AICc) and in-space placebo test

(*a*) (*b*)



Key: Panel (*a*) represents the distribution of the average post-treatment gap, AG_j, among the 11 countries in the sample whose RMSE is less than $\sqrt{2}$ times that of Macao (Eq. [6]). The sample reduces by 50%: the United States, Spain, Switzerland, France, Finland, Denmark, Norway, Canada, Austria, Germany, New Zealand, and Italy were removed. Panel (*b*) represents the distribution of ratio R_j across all 24 countries in the sample and Macao (Eq. [7]).

B. Unemployment rate

Table 5 presents the numerical results for effect on the unemployment rate. The sample data refer to the same 25 countries considered for the effect on per capita GDP; however, the sample period is reduced. The pre-treatment period is 21 years shorter, as it starts in 1991, which seriously compromises the reliability of the counterfactual and, therefore, the effect's assessment.29) Consistent with previous calculations, the best fit is obtained with the PDA-AICc ($\tilde{R}^2 = 0.968$), implying a yearly average difference between the unemployment rate observed and the counterfactual of -1.392%, which is between those obtained with the other methods.

The graphical representation of the observed, synthetic, and predicted series is illustrative; the three counterfactuals' patterns are dissimilar, and even the predicted sign of the effect during the first years of the post-treatment periods (until 2003) differs (see Figure 8).

Finally, regarding the statistical significance of the apparent reduction in the unemployment rate (and focusing on the PDA-AICc results), we conducted the same in-space placebo analysis as the previous outcome variables considered. Regarding the distribution of the AG_j, we find that the probability of a reduction in the unemployment rate at least as large as that in Macao equals $p = 7/25 = 0.28$; regarding the distribution of the ratio R_j, the probability of attaining a value less than or equal to that in Macao equals $p = 15/24 = 0.625$.30)

Table 5. *Unemployment Rate—Weights and Coefficients*

Country	SCM weights	PDA-AICc	PDA-LASSO
(Intercept)	-	0.834	2.3019
Australia	-	-	-0.466
Austria	-	-	-
Brazil	0.004	-	-
Canada	-	-	-
Switzerland	-	-0.791 (**)	-
Germany	-	-	-
Denmark	-	-	-
Spain	-	-	-0.069
Finland	-	-	-
France	-	-	-
United Kingdom	-	-	-
Indonesia	0.748	-	-
Italy	-	-	-

29) Unemployment rate data were obtained from The World Bank (https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS) for all the countries in the sample, except for Taiwan. Taiwan's data were obtained from the National Statistics (Republic of China) Taiwan (https://eng.stat.gov.tw/ct.asp?xItem=42761&ctNode=1609&mp=5).

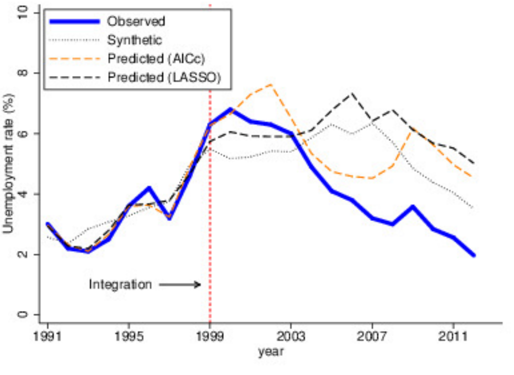
30) The figure is suppressed for the sake of brevity.

Table 5. *Continued*

Country	SCM weights	PDA-AICc	PDA-LASSO
Japan	-	1.687 (***)	0.169
Mexico	-	-	-
Malaysia	-	-	-
Netherlands	-	-	-
Norway	-	-	-
New Zealand	-	-	-
Philippines	-	-	1.74
Sweden	-	-	-
Thailand	0.248	-	0.074
United States	-	-	-
Taiwan	-	-	-
RMSE	0.548	0.224	0.342
$\tilde{R}^2$	0.814	0.968	0.927
AG (%)	-0.984	-1.392	-1.855

Key: Only non-zero values are shown. SCM weights are the solution to the program in Eq. (2), and PDA-AICc and PDA-LASSO coefficients are the OLS estimates of the model in Eq. (3). RMSE: see footnote 12. $\tilde{R}^2$: see Eq. (5). AG refers to average post-treatment gap (see Eq. [6]). Significance levels of PDA-AICc coefficient estimates: (***) 0.1%, (**) 1%, and (*) 5%. $\lambda_{\min}$ = 0.1265 for the LASSO regression.

Figure 8. Unemployment rate—observed and counterfactuals



Key: As in all previous cases, the solid blue line depicts Macao's observed outcome variable (the unemployment rate in this case). The black dotted line refers to the SCM counterfactual; the orange dashed line shows the PDA-AICc counterfactual; the PDA-LASSO counterfactual is represented by the black dashed line.

C. Per capita exports and imports

Finally, we next address the assessment of the effect of integration on exports and imports of goods and services. We first tried the same set of countries in the donor pool as in the case of GDP and the original database, Penn World Table 10.0[31]). The database contains data on the shares of imports and exports of *merchandise* alone, but not on services or merchandise *and* services, obtaining a poor pre-treatment fit under the three methods under consideration. This limitation led us to the WDI DataBank[32], which contains data on exports and imports of goods and services (as shares of GDP); however, it does not show data for Taiwan, thereby reducing the donor pool to 23 countries as in the case of foreign direct investment; the sample period begins in 1982.[33] The findings are summarized as follows.

Regarding our next outcome variable, per capita exports of goods and services, the results are shown in Table 6. The fit provided by the SCM is poor ($\tilde{R}^2 = -4.723$). The restriction imposed by the method, so that the treated unit must be within the convex hull of the control units, prevents a good fit in cases where the treated unit displays higher values of the outcome variable than the controls. More precisely, synthetic Macao comprises one single control, Switzerland. Once again, the best fit is reached by using the PDA-AICc method, with $\tilde{R}^2$ = 0.960, with a lower number of non-zero coefficients than with the PDA-LASSO procedure ($\tilde{R}^2$ = 0.937). These two methods provide different estimates for the average difference between the observed and the predicted series, AG: USD 42,115.421 and USD 37,025.770, respectively. See panel (*a*) in Figure 9 for a graphical counterpart of Table 6.[34]

31) https://www.rug.nl/ggdc/productivity/pwt/

32) https://data.worldbank.org/

33) More precisely, we used the following sources to compute the series of per capita exports and imports of goods and services: export share of GDP (The World Bank (https://data.worldbank.org/indicator/NE.IMP.GNFS.ZS)), the import share of GDP (The World Bank (https://data.worldbank.org/indicator/SP.POP.TOTL)), GDP (Penn World Table 10.0 (https://www.rug.nl/ggdc/productivity/pwt/)) and population (The World Bank (https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS)). The sample period begins in 1982, the first year we have data on export and import GDP shares. To lengthen the pre-treatment period as much as possible, the source of data on GDP is Penn World Table 10.0 (https://www.rug.nl/ggdc/productivity/pwt/), not The World Bank (https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD), because the corresponding series in the latter starts eight years later. Recall from Section 4 that GDP is measured at chained PPPs 2017USD.

34) The graphs are omitted, but it could be shown that (were the result obtained with the PDA-AICc method reliable) the probabilities of finding a larger or equal effect on exports than that of Macao would be $p = 1/24 = 0.04$ and $p = 9/24 = 0.25$ according to the distributions of AG_j and R_j, respectively.

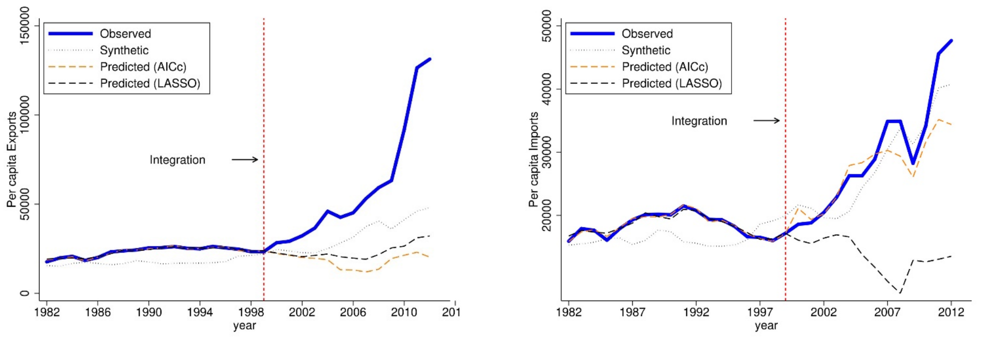
Table 6. *Per Capita Exports of Goods and Services—Weights and Coefficients*

Country	SCM weights	PDA-AICc	PDA-LASSO
(Intercept)	-	9957.920 (***)	17815.876
Australia	-	-	-
Austria	-	-	-
Brazil	-	-	3.816
Canada	-	-	-
Switzerland	1.000	-	-
Germany	-	-	-
Denmark	-	-	-
Spain	-	-	-
Finland	-	-1.241 (***)	-0.836
France	-	-	-0.688
United Kingdom	-	-	-
Indonesia	-	-	0.854
Italy	-	-	-
Japan	-	-	-2.077
Mexico	-	1.941 (**)	0.238
Malaysia	-	-	-
Netherlands	-	-1.076 (***)	-
Norway	-	-	-
New Zealand	-	2.623 (***)	-
Philippines	-	-	-
Sweden	-	-	-
Thailand	-	-	-
United States	-	4.934 (***)	5.023
RMSE	6,348.056	529.276	668.205
$\tilde{R}^2$	-4.723	0.960	0.937
AG	USD 27,504.031	USD 42,115.421	USD 37,025.770

Key: Only non-zero values are shown. SCM weights are the solution to the program in Eq. (2), and PDA-AICc and PDA-LASSO coefficients are the OLS estimates of the model in Eq. (3). RMSE: see footnote 12. $\tilde{R}^2$: see Eq. (5). AG refers to average post-treatment gap (see Eq. [6]). Significance levels of PDA-AICc coefficient estimates: (***) 0.1%, (**) 1%, and (*) 5%. $\lambda_{\min}$ = 46.2 for the LASSO regression.

Figure 9. Per capita exports and imports—observed and counterfactuals

(*a*) (*b*)



Key: Panel (*a*): The solid blue line represents Macao's observed per capita exports of goods and services. The black dotted line shows the SCM counterfactual; the orange dashed line represents the PDA-AICc counterfactual; the PDA-LASSO counterfactual is represented by the black dashed line. Panel (*b*): As panel (*a*), but referred to per capita imports of goods and services.

Table 7 provides the results for this paper's last outcome variable, per capita imports. As is the case with exports, the goodness of fit that results after applying the SCM is extremely low ($\widetilde{R}^2 = -2.428$); thus, any single attempt to draw any kind of assessment regarding the effect of the treatment would be pointless. The PDA-AICc and the PDA-LASSO methods both provide better fits for the pre-treatment period ($\widetilde{R}^2$ = 0.970 and $\widetilde{R}^2$ = 0.924, respectively). Contrary to the export case, the predicted effects (as measured by AG in Eq. [6]) are quite different (USD 2,389.713 and USD 16,237.920, respectively), so once again it does not seem meaningful to draw any conclusions, even as an approximation, concerning the extent of the effect on imports (see panel [*b*] in Figure 9).

Some conclusions can be drawn from this section's results. First, there is a statistically significant positive effect on the net inflow of per capita foreign direct investment with an approximate AG between 2000 and 2012 of USD 6,358, the PDA-AICc being the most reliable method to compute the counterfactual. Second, there seems to be an apparent average reduction in the unemployment rate of about 1.392% over the same period; however, figures vary significantly, depending on the method followed in computing the counterfactual. The effect is not statistically significant even when focusing on the method for which the best pre-treatment fit is attained (PDA-AICc). Third, following the AG distribution test, a statistically significant positive effect on the per capita exports of goods and services is obtained, resulting in an approximate average gap in the post-treatment period of USD 42,115; however, relying on the *R* distribution, the effect is not statistically significant. As with foreign direct investment, the PDA-AICc, rather than the SCM, seems to be the best method to assess the effect of the intervention. Fourth, no clear-cut effect on the per capita imports of goods and services is found. Despite both PDA-AICc and PDA-LASSO attaining reasonably good pre-treatment fits, the positive predicted effects are so distant that even attempting to search for the statistical significance is not recommended.

Table 7. *Per Capita Imports of Goods and Services—Weights and Coefficients*

Country	SCM weights	PDA-AICc	PDA-LASSO
(Intercept)	-	19,916.000 (***)	27,563.924
Australia	-	-1.361 (*)	-
Austria	-	1.337 (***)	-
Brazil	-	-	-1.449
Canada	-	-2.542 (***)	-
Switzerland	1.000	-	-
Germany	-	-	1.091
Denmark	-	-	-0.183
Spain	-	-	-
Finland	-	-	-0.164
France	-	-	-
United Kingdom	-	-	-
Indonesia	-	-	-
Italy	-	-	-0.809
Japan	-	-3.627 (***)	-0.712
Mexico	-	-	0.878
Malaysia	-	0.377 (***)	-
Netherlands	-	-	-
Norway	-	-	-0.998
New Zealand	-	-	-0.106
Philippines	-	-	-
Sweden	-	-	-
Thailand	-	-	0.425
United States	-	5.574 (***)	0.567
RMSE	3,189.498	296.783	475.295
$\tilde{R}^2$	-2.428	0.970	0.924
AG	1,761.588	2,389.713	16,237.920

Key: The same as in Table 2. Only non-zero values are shown. SCM weights are the solution to the program in Eq. (2), and PDA-AICc and PDA-LASSO coefficients are the OLS estimates of the model in Eq. (3). AG refers to the average post-treatment gap (see Eq. [6]). Significance levels of PDA-AICc coefficient estimates: (***) 0.1%, (**) 1%, and (*) 5%. $\lambda_{\min}$ = 40.85 for the LASSO regression.

VII. Conclusions

This paper assessed the economic effects of the integration process of Macao into China that started on December 20, 1999. Macao was previously a Portuguese colony, becoming a SAR and the second instance of “one country, two systems” after Hong Kong. The liberalization of gaming in 2002 and the signature of the CEPA in 2003 represent two additional milestones in this process of “smooth transition.”

Macao’s economy experienced a significant transformation because of this political-economic process. The average annual GDP growth rate between 1999 and 2016 was about 10.32%, thereby allowing Macao to post the seventh-highest worldwide per capita GDP in 2016. Regarding the net inflow of foreign direct investment per capita, the annual average between 1982 and 1999 was USD 8.7, and it was USD 7,032.5 between 2000 and 2012 (measured at chained PPPs in 2017 USD). The process also affected the inflow of foreign visitors. While the annual average of foreign visitors for 1995-1999 was 7.5 million, it reached 19.5 million for 2000-2012. The gaming industry is an essential reason for the above economic development, which by 2013 represented more than 60% of Macao’s GDP.

This article provided a quantitative assessment along the lines of the causal inference literature. We built a panel data set consisting of Macao and 24 control countries for a sample period from 1970 to 2012, in which 2000 represents the first post-treatment year. Two alternative methodologies were implemented to compute the counterfactual (or Macao’s economic theoretical performance in the absence of intervention)- the SCM and PDA- the latter displaying the best pre-treatment fit when the corrected Akaike information criterion is set as the model selection procedure.

With this data set and these analytical tools, we assessed the effect on per capita GDP, our main outcome variable of interest, and additional outcome variables. A summary of the conclusions follows.

First, the integration process of Macao had a statistically significant, positive treatment effect on both the level of per capita GDP and its long-run growth rate for the 2000-2012 period. The qualitative aspect of the result proves robust to the method followed in computing the counterfactual (whether SCM or PDA); however, the numerical estimates of the average gap in the per capita GDP and the growth rate gap vary with the method chosen to compute the counterfactual. In other words, the method (SCM vs. PDA) and model selection criteria (AICc vs. LASSO) matter. Following the best pre-treatment fit criterion (our particular exercise always led to the PDA-AICc), we found an approximate yearly average per capita GDP gap of USD 42,321 for the referred period. Similarly, we find a statistically significant difference of 11.4% between the observed per capita GDP growth rate and the counterfactual series.

Second, we found a statistically significant, positive treatment effect on foreign investment. According to our PDA-AICc results, Macao’s integration with China generated an approximate annual average increment of USD 6,358 in the per capita net inflow of foreign investment during the post-treatment period.

Third, as an additional outcome variable of interest, we analyzed the effect of integration on the unemployment rate. We found a seemingly negative average effect (-1.392%) or fall in unemployment, but the assessment largely varies with the method implemented to compute the counterfactual. The effect is not statistically significant even after focusing on the PDA-AICc approach.

Fourth, to underpin our results, we also considered two additional outcome variables: exports and imports of goods and services. Regarding exports, we cannot conclude that the effect is statistically significant, as alternative test procedures provide different results. Concerning imports, the (at first sight) positive effect on per capita imports depends on the method implemented to compute the counterfactual; therefore, its statistical significance is questionable.

Fifth, numerous studies generally examine the upsides and downsides of integration and disintegration processes on national economies, and the findings are consistent (Born et al., 2019; Campos et al., 2015; Papaioannou, 2021). As demonstrated by the case study of Macao, integration processes contribute significantly to a country's economic development. Therefore, it seems advantageous to promote such integration processes to achieve economic development and prosperity.

Overall, we learned the importance of the methodological approach implemented in causal inference studies and that researchers should conduct rigorous sensitivity analyses to test the internal validity of their results. In the words of Wan et al. (2018, p. 123), "We are still only in the process of groping toward the truth, not discovering the truth."

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