Economic Modelling 70 (2018) 147–158

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.journals.elsevier.com/economic-modelling

Assessing the gains and vulnerability of free trade: A counterfactual analysis of Macau☆

Hua Yin [a], Zaichao Du [b], Lin Zhang [c,*]

[a] School of Shanghai Development, Shanghai University of Finance and Economics, 777 Guoding Road, Shanghai 200433, China
[b] Research Institute of Economics and Management, Southwestern University of Finance and Economics, 555 Liutai Avenue, Chengdu 611130, China
[c] Canada Mortgage and Housing Corporation, 700 Montreal Road, Ontario K1A0P7, Canada

ARTICLE INFO

Jel Classifications:
C14
C82
F14
F15

Keywords:
Free trade agreement
Vulnerability
Program evaluation
Counterfactual
Macau

ABSTRACT

Free trade can generate macroeconomic gains but also vulnerability to external shocks for a highly-specialized economy. To test this hypothesis, we evaluate the effects of Mainland-Macau Closer Economic Partnership Arrangement (CEPA) on Macau's real GDP growth rate and its volatility, as well as the costs of exposure to the anti-corruption campaign from mainland China using a counterfactual analysis. Counterfactuals of Macau are constructed by exploiting the inter-dependence among different economic entities and the optimal control group is selected with a leave-n_v-out cross-validation method. Our results support the hypothesis. CEPA raised the annual real GDP growth rate of Macau by 20.76% from 2004 to 2007, meanwhile it increased the volatility of real GDP growth rate by 35%, and the anti-corruption campaign reduced the annual real GDP growth rate by 17.54% from 2013 to 2016. Our findings imply that free trade could be a double-edged sword for a small and highly-specialized economy and the gains of free trade can be enlarged by reducing its vulnerability.

1. Introduction

Historical and recent observations raise the issue on whether international trade generates gains as well as vulnerability to external shocks for a highly-specialized economy. In the 7th century BC, Guan Zhong, China's first prime minister, used international trade to increase a target country's specialization, and exploited the resulted vulnerability as a strategy to gain control over the country[1]; Russia enjoyed rapid growth with exports of oil and natural gas, but was hit hard when oil prices plumbed and sanctions were imposed by Western countries in 2015 with a decrease of 2.83 per cent in real GDP[2]; Macau, highly relying on gaming industry, experienced rapid real-GDP growth since it signed the Closer Economic Partnership Arrangement (CEPA) with China, but saw its economy hard landed with a drop of 24.3 percent in real GDP in 2015 when China launched the anti-corruption campaign that affected the VIP market on which Macau's gaming industry highly relies.

While assessing the vulnerability of free trade is as important as evaluating its gains and practitioners heatedly debate on the topic, the issue on free trade and vulnerability remains unanswered, and is largely understated in theoretical and empirical studies (Montalbano, 2011). The development of trade theories, from inter-industry comparative advantage (Ricardo, 1951) to the "New Trade Theory" (Krugman, 1979, 1980) on intra-industry trade of differentiated products to the "New Trade Theory" (Melitz, 2003; Bernard et al., 2003; Melitz and Trefler, 2012) on firm heterogeneity, tries to explain why international trade takes place and the gains of trade. Empirical studies also have focused on the gains of free trade, e.g., Baier and Bergstrand (2007), Caporale et al. (2009), Lakatos and Walmsley (2012), and Jean et al. (2014), among

☆ We would like to thank the editor and two anonymous referees for their constructive comments that have significantly improved the paper. The usual disclaimer applies.
* Corresponding author.
E-mail addresses: yin.hua@mail.shufe.edu.cn (H. Yin), duzc@swufe.edu.cn (Z. Du), zhanglin2161@icloud.com (L. Zhang).

[1] Guan Zi, written between the 6th and 7th century BC. It is on how a country lost its sovereignty because it had neglected the vulnerability of specialization-enhancing trade. The country in question produced the best swords and its people were bellicose. In order to get control over the country, Mr. Guan Zhong, doubled the market prices to purchase the country's swords. With competing purchases from other countries, the country saw the prices of swords increased by 10 fold and decided to concentrate on producing swords by even giving up farming. Meantime Mr. Guan Zhong ordered to store a large amount of food both from the target country and other countries. When the target country had abandoned farming in a large scale, he hauled all trade relations with the target country and closed all trade passages as well. The prices of swords slumped while food prices went up. The target country had no access to buy food, could not produce food within a short period of time, and had to surrender in the end.

[2] Data source: World Bank.

https://doi.org/10.1016/j.econmod.2017.10.019
Received 11 April 2017; Received in revised form 17 October 2017; Accepted 28 October 2017
Available online 2 November 2017

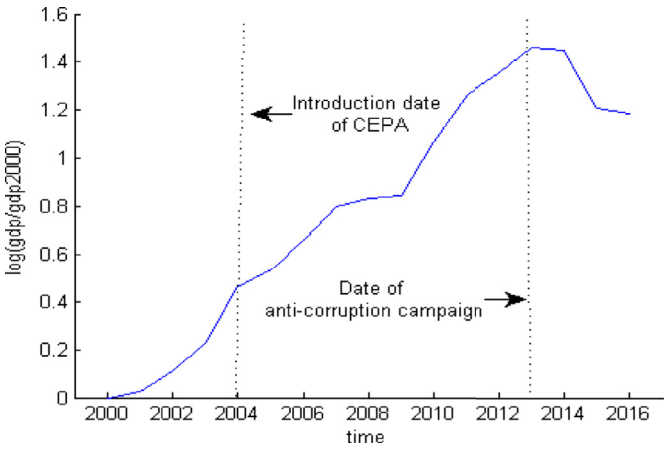

Fig. 1. The real GDP growth rate of Macau from 2000 to 2016.

many others. Despite some attempts (Montalbano et al., 2008; Guillaumont, 2010; Naudé et al., 2009), the issue on trade openness and vulnerability remains unanswered. As pointed out by Montalbano (2011), the main challenge is that assessing vulnerability requires counterfactuals because vulnerability is an ex ante condition and is not observable.

This paper aims to contribute to the debate by evaluating the effects of CEPA on Macau's real GDP growth and its volatility, as well as the costs of exposure to the external shock of the anti-corruption campaign from mainland China using a new counterfactual analysis. The basic idea behind the method is that the economic growth of different countries and regions are often driven by some common factors, and therefore information on countries/regions not subject to CEPA/shock can help to construct the counterfactuals of Macau. This is confirmed by our real data analysis below (cf. Figs. 2–6), which show that the GDP growth rate, per capita GDP growth rate and unemployment rate of Macau before the occurrence of CEPA (anti-corruption) can be fitted very well using the data of other economy entities. Then the effect of CEPA (anti-corruption) is just the difference between what actually happened to Macau's real GDP growth rate (or per capita real GDP growth rate, unemployment rate) and the counterfactual growth rate if CEPA (anti-corruption) had not taken place. This method does not involve modelling how and why the real GDP, and unemployment have evolved over time and what factors have affected their evolution, and hence, our results are not affected by such model specifications or the choice of instrumental variables compared with the aforementioned studies.

To get a more accurate counterfactual prediction, we use the leave-n_v-out cross-validation criterion as in Du and Zhang (2015, hereafter DZ) to select the optimal control group rather than the Akaike information criterion (AIC, Akaike, 1973; 1974) and corrected Akaike information criterion (AICC, Hurvich and Tsai, 1989) used in the original method by Hsiao et al. (2012, hereafter HCW). As showed in DZ, this modified method has smaller mean squared prediction error.

The main results of the paper support the hypothesis that CEPA generates macroeconomic gains to Macau, as well as vulnerability to external shocks. Specifically, we find that from 2004 to 2007 CEPA raised the annual real GDP growth rate of Macau by 20.76%, per capita real GDP growth rate by 11.1% and reduced the unemployment rate by 1.23%. Meanwhile, CEPA increased the volatility of real GDP growth rate by 35%. The anti-corruption campaign in mainland China reduced the annual real GDP growth rate of Macau by 17.54%, and raised the unemployment rate by 0.30% from 2013 to 2016. Our findings establish that free trade could be a double-edged sword for a small and highly-specialized economy if it makes the economy even more concentrated. However, with sound macro management and diversification the gains of free trade could be enlarged by reducing its vulnerability.

This paper complements the existing literature in several ways. First, we provide a new counterfactual approach to assess the gains as well as vulnerability of free trade. The counterfactuals are constructed in an intuitive way. What would have been the economic path, had free trade or shock not occurred? This method does not need to set a benchmark to discern actual situation of vulnerability from normal variability (Alwang et al., 2001).

Second, we use a panel-data approach to exploit the inter-dependence between different economies, while the existing studies use panel data in the VAR framework. Kose et al. (2003), Hnatkovska and Loayza (2004), and Calderòn et al. (2005) use panel data to measure the impacts of openness and financial shocks. Loayza and Raddatz (2007) apply semi-structural VAR to a panel of 90 countries and show that trade openness magnifies the output impact of external shocks. Structural VAR allows to solve the simultaneous-equation bias and error terms are considered as shocks, but the problem of identification has always been its weakness. The advantage of our method is that we do not need to specify how factors affect economic growth.

Last, our study improves on Zhang et al. (2015), who use a similar counterfactual analysis to study the macroeconomic effects of the U.S.-Canada FTA on Canada. Using aggregate data, they find similar results as in Trefler (2004) who models explicitly tariff changes to study both the short-run adjustment costs and long-run gains in economic growth using firm-level data. Here we assess both the gains of free trade in economic growth and the costs in terms of economic fluctuations and exposure to external shocks.

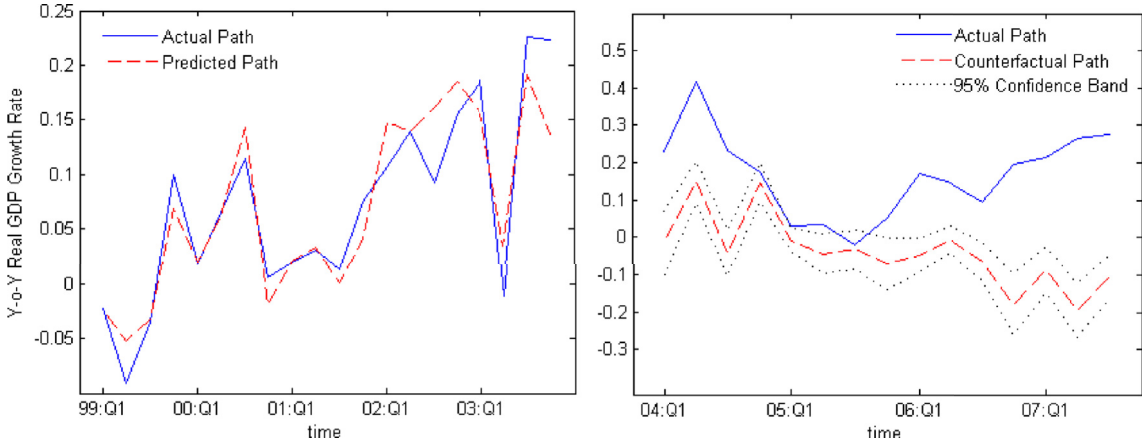

Fig. 2. Actual and predicted/counterfactual real GDP from 99:Q1 to 03:Q4 and 04:Q1 to 07:Q3.

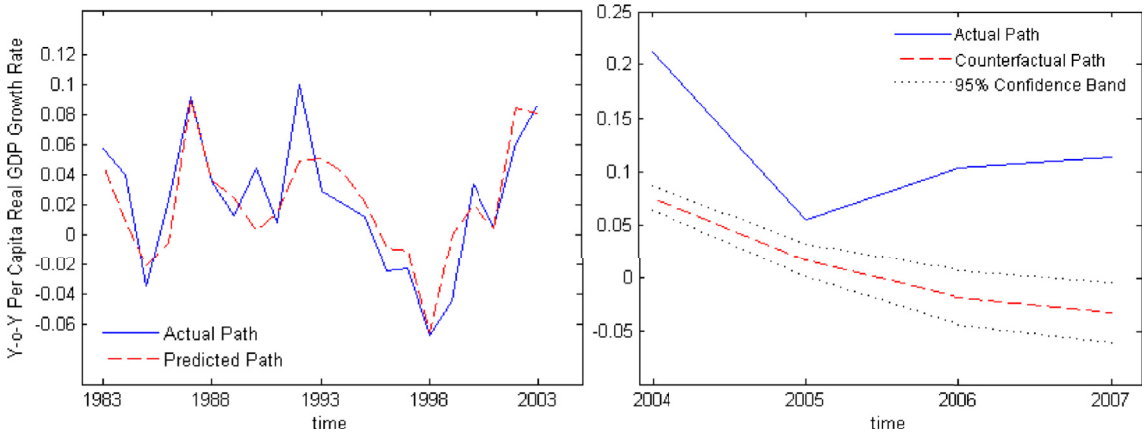

Fig. 3. Actual and predicted/counterfactual per capita real GDP from 1983 to 2003 and 2004 to 2007.

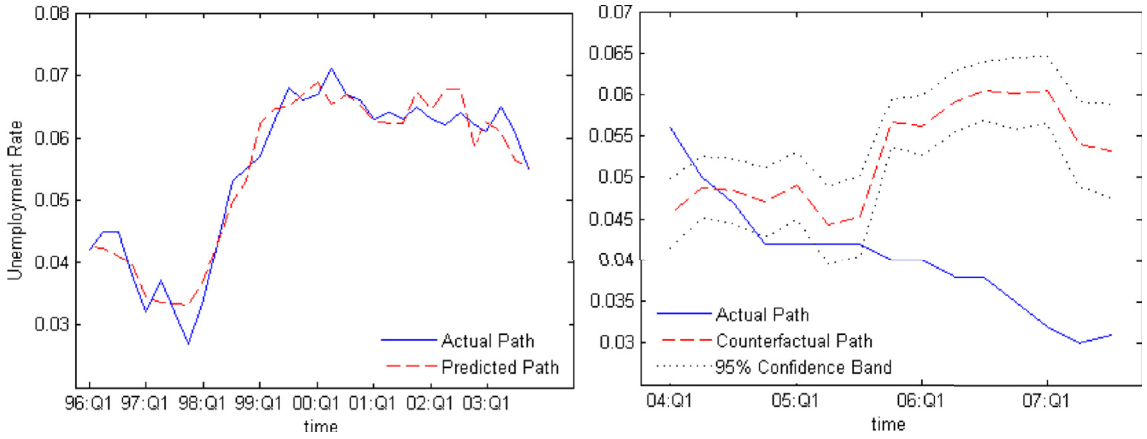

Fig. 4. Actual and predicted/counterfactual unemployment rate from 96:Q1 to 03:Q4 and 04:Q1 to 07:Q3.

The rest of the paper is organized as follows. Section 2 provides an institutional background of our research. Section 3 introduces our main empirical method. Section 4 assesses the macroeconomic gains of CEPA on Macau's economy. Section 5 evaluates the effects of CEPA on the vulnerability of Macau's economy. Section 6 includes robustness checks. Section 7 contains some concluding remarks and policy implications.

2. Institutional background

In this section, we present a brief introduction to Macau's economy, CEPA, and the anti-corruption campaign from mainland China. Early in 221 BCE, Macau was only a village of China. The Portuguese resided in Macau from the sixteenth century, and took charge of Macau till 1999. Based on the statement issued by China and Portugal on April 13, 1987, Macau returned back to China on December 20, 1999.

Macau's economy exhibits several main characteristics. First, it is a small, high-income, and mono economy. Macau has 651,000 populations and its GDP in 2016 is 44.8 billion USD.[3] With one of the highest GDP per capita in the world, Macau's economy heavily relies on gaming industry that accounts for 63% of GDP in 2013.[4] Second, Macau is the only legal casino market in China. In mainland China gambling is illegal, while in Hong Kong it is illegal to gamble except lotteries, horse racing, and football matches from Hong Kong Jockey Club. Last, on average more than 70% of Macau's annual gambling revenue is generated by VIP market over the last decade, and most of the high-end players are from mainland China (Liu et al., 2015).

To enhance economic integration between mainland China and Macau, CEPA was signed on October 18, 2003 and took effect from January 1, 2004. It is a FTA. The term CEPA was coined to emphasize that it is an arrangement between the central government and regional government under the same sovereignty, while FTA refers to an agreement between two sovereign states. In conformity with WTO rules, CEPA was regarded as a gift to Macau from mainland China. The initial goal of CEPA was to increase economic integration between mainland China and Macau, and to help Macau diversify its economy with a ratio of gaming to GDP of 38% in 2002.[5]

The Mainland and Macau CEPA consists of gradual elimination of tariffs on goods, preferential access to service sectors, and cooperation in tourism and finance. More specifically, 273 Macau products are exempt from import tariffs (though Macau does not produce some of these products at the moment of signing the CEPA) from January 1, 2004.[6] By 2006, all Macau products are eligible for zero-import tariff. Regarding to services, from 2004 entry barriers are lowered or removed in eighteen service sectors from Macau. According to the supplement CEPA VIII, the preferential access is enlarged to 43 service sectors from 2012. On tourism, Mainland residents are gradually allowed to individually visit Macau, dubbed as the Individual Visit Scheme (IVS). Prior to the IVS,

[3] Data source: World Bank.
[4] Data source: Macau Statistics and Census Service.
[5] Data source: Macau Statistics and Census Service.
[6] In the first phase, 273 Macau products exempt from import tariff account for 90% of total export values to mainland China.

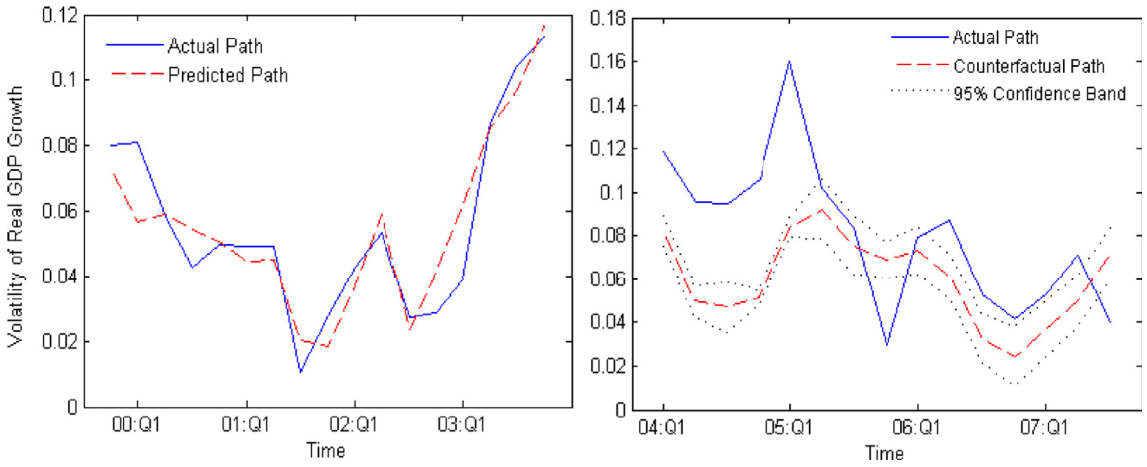

Fig. 5. Actual and predicted/counterfactual GDP growth volatility from 99:Q4 to 07:Q3.

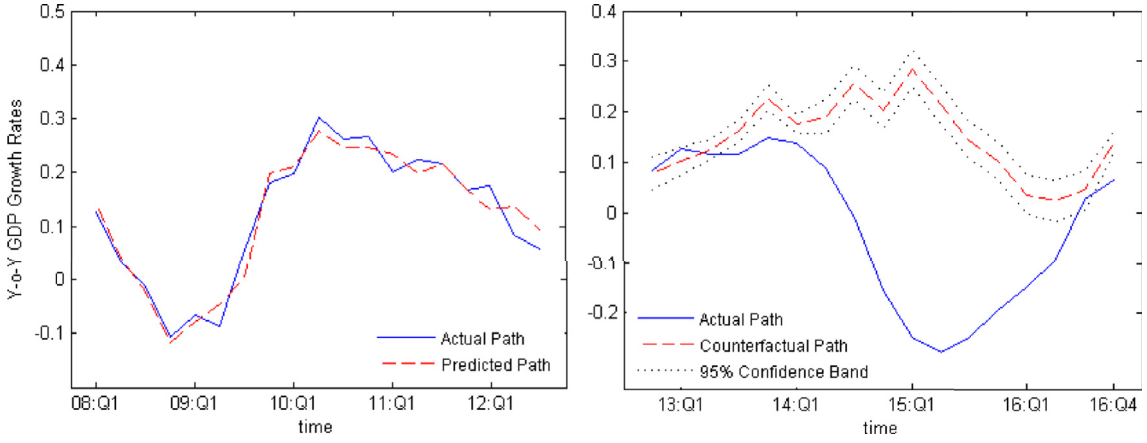

Fig. 6. Actual and predicted/counterfactual real GDP from 08:Q1 to 12:Q3 and 12:Q4 to 16:Q4.

Mainland residents could only visit Macau on business visas or in group tours. From July 28, 2003, only four cities of Guangdong province are granted the IVS, while from January 1, 2004, residents of Beijing, Shanghai and other eight cities of Guangdong province are allowed to individually visit Macau. IVS was then extended to all 21 cities of Guangdong province and to 9 other cities in Jiangsu, Zhejiang and Fujian provinces in July 2004. Until now the IVS has been extended to 49 cities in mainland China.[7]

Macau's economy has been largely changed since CEPA was implemented. Table 1 shows changes in Macau's economy between 1995 and 2012.[8] We make several observations. First, Macau's real GDP increased almost by more than three-fold from 2003 to 2012. Second, Macau's economy was already highly concentrated on gambling industry before CEPA. The share of value-added of gambling industry in GDP was as high as 42.3% in 2003, while the share of manufacturing in GDP was only 4.9%. Last, Macau became more concentrated on gambling industry to the detriment of manufacturing industry. From 2003 to 2012, the value-added increased by over sevenfold in gambling industry, while decreased by 48% in manufacturing industry[9]; employment increased almost by threefold in gambling industry, but decreased by 73% in manufacturing. The share of gambling in GDP increased from 42.3% in 2003 to 63% in 2012, while the share of manufacturing in GDP dropped from 4.9% in 2003 to 0.46% in 2012. We also note that the share of visitors from mainland China increased to 60% in 2012 from 48.3% in 2003.

The anti-corruption campaign in mainland China was launched in late 2012, following the conclusion of the 18th National Congress of the Communist Party. It is the largest campaign against corruption since 1949. As of October 2017, over 260 high-ranking officials and more than 100,000 lower-ranking officials were investigated and prosecuted for corruption, according to the Central Commission for Discipline Agency. The campaign also tightens rules and audit on public spending. It prohibits middle- and high-ranking public servants to visit Macau. The anti-corruption campaign is considered as the main factor contributing to the sharp decline in Macau's GDP in 2014–2016 (Liu et al., 2015; Economist, 2017a).

To visualize the contrast, Fig. 1 plots the changes of real GDP growth rates from 2000 to 2016. The annual real GDP growth rate of Macau from 2004 to 2012 is 14% in comparison to 9.1% from 2000 to 2003. However, after the anti-corruption shock from mainland China, the annual real GDP growth rate of Macau from 2013 to 2016 dropped to −3.45%.

[7] See more details at http://www.cepa.gov.mo/cepaweb/front/eng/itemI_2.htm.

[8] Because the anti-corruption campaign from mainland China began in late 2012, data points in 2012 are used to illustrate the contrast.

[9] Data source: Macau Statistics and Census Service.

Table 1
Macau's economy before and after the implementation of CEPA.

	Real GDP	Share of Gambling	Share of Manufacturing	Employment	Employment of Gambling	Employment of Manufacturing	Share of Tourists
1995	71.6	34.0%	6.9%	180.3	21.5	38.0	24.8%
2003	86.9	42.3%	4.9%	205.4	23.9	37.7	48.3%
Change	21.4%	8.3%	−2.0%	13.9%	11.1%	−0.8%	23.5%
2004	111.2	46.2%	4.1%	219.1	31.3	36.1	57.2%
2012	306.3	63.0%	0.46%	343.2	89.5	10.3	60.2%
Change	175.5%	16.8%	−3.6%	56.6%	186%	−71.5%	3.0%

Notes: The second column denotes Macau's real GDP at 2010 constant price. The third and fourth column denote the share of value-added of gambling and manufacturing in GDP, respectively. The fifth denotes the total employment in Macau. The sixth and seventh columns denote the employment of gambling and manufacturing, respectively. The eighth column denotes the share of visitors from mainland China in total visitors in Macau. The scale of real GDP and employment is MOP billion and thousand, respectively. The employment of gambling is not available before 2003, so here we report the employment of gambling and related services.

3. Methodology

We illustrate our methodology using real GDP, and similar method can be directly applied to per capita real GDP and unemployment rate. To assess the impact of CEPA on Macau, we use the real GDP data of economic entities other than Macau to construct the counterfactuals of Macau, i.e. the real GDP growth rate of Macau had it not been subject to CEPA. We exploit the dependence of real GDP growth among different entities, and attribute the dependence to the presence of common factors that drive the growth of relevant economic entities.[10]

Before we illustrate our method, we introduce some notations first. Let y_{it}^0 denote the GDP growth rate of economic entity i at time t without the CEPA. Without loss of generality, we let $i = 1$ correspond to Macau. As in Forni and Reichlin (1998), Gregory and Head (1999), we assume that y_{it}^0 is generated by a factor model of the form

$$y_{it}^0 = \mathbf{b}_i' \mathrm{f}_t + \alpha_i + \varepsilon_{it}, \qquad i = 1, \ldots N, \quad t = 1, \ldots . T, \tag{1}$$

where f_t denotes the $K \times 1$ (unobserved) common factors that vary over time, $\mathbf{b}_i'$ denotes the $1 \times K$ vector of constants that may vary across i, $\mathbf{b}_i = c < \infty$ for all i, α_i is the fixed unit-specific effect, and ε_{it} is the idiosyncratic error term with $E(\varepsilon_{it}) = 0$. Stacking $N \times 1$ y_{it}^0 it into a vector yields

$$\mathbf{y}_t^0 = \boldsymbol{B}\mathbf{f}_t + \boldsymbol{\alpha} + \boldsymbol{\varepsilon}_t, \tag{2}$$

where $\mathbf{y}_t^0 = (y_{1t}^0, \ldots, y_{Nt}^0)'$, $\boldsymbol{\alpha} = (\alpha_1, \ldots, \alpha_N)'$, $\boldsymbol{\varepsilon}_t = (\varepsilon_{1t}, \ldots, \varepsilon_{Nt})'$, and $\boldsymbol{B} = (\mathrm{b}_1, \ldots, \mathrm{b}_N)'$ is the $N \times K$ factor loading matrix. Here $\boldsymbol{\varepsilon}_t$ is I(0) with $E(\boldsymbol{\varepsilon}_t) = 0$ and $E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t') = V$, where V is a diagonal constant matrix, $E(\boldsymbol{\varepsilon}_t \mathbf{f}_t') = 0$ and $Rank(\boldsymbol{B}) = K$.

Let y_{it}^1 denote the GDP growth rate of economic entity i at time t under the CEPA. Often we do not simultaneously observe y_{it}^0 and y_{it}^1. The observed data, y_{it}, are in the form

$$y_{it} = d_{it} y_{it}^1 + (1 - d_{it})\, y_{it}^0, \tag{3}$$

where $d_{it} = 1$ if economic entity i is under the CEPA at time t, and $d_{it} = 0$ otherwise. There is a key assumption, $E(\varepsilon_{jt} | d_{it}) = 0$, for $j \neq i$, which means the jth economic entity's idiosyncratic components are independent of d_{it}. This assumption requires that economic entities in the control group should not be affected by the CEPA implemented in Macau. In order to keep this assumption hold, we exclude mainland China and Hong Kong from the potential control group.[11]

At time $T_1 + 1$, in this case the first quarter of 2004, the CEPA took effect in Macau. Therefore,

$$y_{it} = y_{it}^1 \quad \text{for} \quad t = T_1 + 1, \ldots . T. \tag{4}$$

As economic entities other than mainland China and Macau are not affected by the CEPA relatively speaking, we have

$$y_{it} = y_{it}^0 \quad i = 2, \ldots, N, \; t = 1, \ldots, T \tag{5}$$

The CEPA effect for Macau at time t will be

$$\Delta_{1t} = y_{1t}^1 - y_{1t}^0 \tag{6}$$

if we can predict y_{1t}^0 for $t = T_1 + 1, \ldots ., T$. If both N and T are large, we can use procedure of Bai and Ng (2002) to identify $\mathbf{f}_t$ and $\mathbf{b}_1$ in equation (1) and hence predict y_{1t}^0. However, neither N nor T is large in our data. Instead, we construct the counterfactuals using the data $(y_{2t}^0, \ldots, y_{Nt}^0)'$.

Our method is simple to implement. The main idea is to predict the GDP growth rate of Macau y_{1t}^0 using the GDP growth rates of other economic entities $\mathbf{y}_{-1t}$

$$\mathbf{y}_{-1t} = \left(y_{2t}^0, \ldots, y_{Nt}^0\right)', \tag{7}$$

instead of using explicit common factors shared by economic entities. Actually we can always express y_{1t}^0 as a linear combination of $\mathbf{y}_{-1t}$ plus some error terms. To see this, let $\mathbf{a}$ be a vector lying in the null space of $\boldsymbol{B}$, $N(\boldsymbol{B})$. We normalize the first element of $\mathbf{a}$ to be 1 and denote $\mathbf{a}' = (1, -\tilde{\mathrm{a}}')$. If $\mathbf{a} \in N(\boldsymbol{B})$, then $\mathrm{a}'\boldsymbol{B} = 0$. From (2) and (7) we then get

$$y_{1t}^0 = \overline{\alpha} + \tilde{\mathrm{a}}_{-1}' \mathbf{y}_{-1t} + \varepsilon_{1t} - \tilde{\mathrm{a}}_{-1}' \varepsilon_{-1t}, \tag{8}$$

where $\overline{\alpha} = \mathbf{a}'\alpha$, and $\varepsilon_{-1t} = (\varepsilon_{2t}, \ldots, \varepsilon_{Nt})'$.

As ε_{-1t} is correlated with $\mathbf{y}_{-1t}$, the linear projection of ε_{-1t} on $\mathbf{y}_{-1t}$ gives us equation (9)

$$y_{1t}^0 = \overline{\alpha} + \tilde{\mathbf{a}}_{-1}^{*\prime} \mathbf{y}_{-1t} + \varepsilon_{1t}^*, \tag{9}$$

where $\tilde{\mathbf{a}}_{-1}^* = \tilde{\mathbf{a}}_{-1}' (I_{N-1} - cov(\varepsilon_{-1t}, \mathbf{y}_{-1t}) var(\mathbf{y}_{-1t})^{-1})$, and $\varepsilon_{1t}^* = \mathbf{a}'\varepsilon_t + \tilde{\mathbf{a}}_{-1}' cov(\varepsilon_{-1t}, \mathbf{y}_{-1t}) var(\mathbf{y}_{-1t})^{-1} \mathbf{y}_{-1t}$ is uncorrelated with $\mathbf{y}_{-1t}$.

Equation (9) suggests the following procedure to construct the counterfactuals:

1. Regress y_{1t}^0 on $\mathbf{y}_{-1t}$ to get the estimation $\widehat{\overline{\alpha}}$ and $\widehat{\mathbf{a}}_{-1}^*$ using data before the CEPA, i.e. $t \leq T_1$.
2. Construct the counterfactual $\widehat{y}_{1t}^0 = \widehat{\overline{\alpha}} + \widehat{\mathbf{a}}_{-1}^{*\prime} \mathbf{y}_{-1t}$ for $t = T_1 + 1, \ldots T$.

A prediction for the effect of the CEPA on Macau at time t will be

$$\widehat{\Delta}_{1t} = y_{1t}^1 - \widehat{y}_{1t}^0 \quad \text{for} \quad T_1 + 1, \ldots T. \tag{10}$$

One remaining problem is the optimal choice of control group to construct the counterfactuals. DZ show that the leave-n_v-out cross-validation performs better than the AICC or AIC criterion proposed by HCW in terms of mean squared prediction error. CV (n_v) method is as follows:

Let γ be a subset of $\{2, \ldots N\}$ with d_γ elements, $1 \leq d_\gamma \leq N - 1$, which

[10] The methodology is also applicable for analyzing the effects of the anti-corruption campaign in mainland China.

[11] As a similar CEPA was simultaneously signed between mainland China and Hong Kong, we exclude Hong Kong to construct the counterfactual growth rates of Macau.

corresponds to the choice of the control units indexed by γ. Let $y_{\gamma t}$ denote the components of $\mathbf{y}_{-1t}$ that are indexed by γ. Here, $\mathbf{y}_{-1t} = (y_{2t}^0, \ldots, y_{Nt}^0)'$ denotes the other units without the implementation of CEPA. First, split the data $\{(y_{1t}, y'_{\gamma t})\}_{t=1}^{T_1}$ into two parts $\{(y_{1s}, y'_{st}),\ s \in \tau\}$ and $\{(y_{1s}, y'_{st}),\ s \in \tau^c\}$, where τ is a subset of $\{1, 2, \ldots T_1\}$ with n_v elements and τ^c is its complement with $n_c = T_1 - n_v$ elements and the economic integration occurs at time $T_1 + 1$. Then, regress y_{1s} on constant and $y_{\gamma s}$ using the data indexed by τ^c and get the OLS coefficients $\widehat{\widehat{\alpha}}_{\gamma,\tau^c}$ and $\widehat{\mathbf{a}}_{\gamma,\tau^c}$; Last, calculate the average squared prediction error using the data indexed by τ, $n_v^{-1}\sum_{s\in\tau}(y_{1s} - \widehat{\widehat{\alpha}}_{\gamma,\tau^c} - \widehat{\mathbf{a}}'_{\gamma,\tau^c})$.[2] As there are $\binom{T_1}{n_v}$ ways to divide $\{1, 2, \ldots T_1\}$ into τ and τ^c, we randomly draws M of them, $\{\tau_j, \tau_j^c\}_{j=1}^M$, and calculates the average squared prediction error as

$$\widehat{\Gamma}_\gamma = \frac{1}{n_v M}\sum_{j=1}^{M}\sum_{s\in\tau_j}\left(y_{1s} - \widehat{\widehat{\alpha}}_{\gamma,\tau_j^c} - \widehat{\mathbf{a}}_{\gamma,\tau_j^c} y_{\gamma s}\right)^2, \tag{11}$$

The optimal choice of the control units is given by the γ that minimizes $\widehat{\Gamma}_\gamma$ and thus we can get the best predictor for y_{1t}^0, for $t = T_1 + 1, \ldots, T$.

Our procedure for constructing the counterfactuals is as follows:

Step 1: From all the possible subsets of $\{2, \ldots N\}$, choose γ^* that minimizes $\widehat{\Gamma}_\gamma$ defined in (11).[12]

Step 2: Regress y_{1t} on constant and $y_{\gamma^* t}$ using data before the implementation of CEPA, i.e., $t \le T_1$ and get the coefficients estimates $\widehat{\widehat{\alpha}}_{\gamma^*}$ and $\widehat{\mathbf{a}}_{\gamma^*}$.

Step 3: Construct the counterfactuals $\widehat{y}_{1t}^0 = \widehat{\widehat{\alpha}}_{\gamma^*} + \widehat{\mathbf{a}}'_{\gamma^*}\mathbf{y}_{\gamma^* t}$ for $t = T_1 + 1, \ldots T$. A prediction for the effect of the implementation of CEPA at time t will then be the difference between the actual GDP growth rate and the counterfactual GDP growth rate, i.e. $\widehat{\Delta}_{1t} = y_{1t}^1 - \widehat{y}_{1t}^0$, for $t > T_1$.

4. Assessing the macroeconomic gains of CEPA

We assess the macroeconomic gains of CEPA from three angles. First we apply our method to evaluating the real GDP growth effects of economic integration of Macau with mainland China. In order to examine whether CEPA improved people's welfare in Macau, we also consider the per capita GDP growth effects. Last we evaluate the impact of CEPA on unemployment.

4.1. Impacts on real GDP and real GDP per capita

We use quarterly data starting from 1998:Q1 to study the effect of CEPA on real GDP growth rate. Considering Macau is located in the Asia-Pacific region, we include Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand into the data sample. Aware of the influence of industrialized countries and data availability, we also include Australia, Austria, Canada, France, Germany, Italy, the UK, and the USA. All the nominal GDP and CPI are from Global Economic Monitor database in World Bank, International Financial Statistic in IMF. We calculate the quarterly growth rates on a year-on-year basis, i.e. we measure the GDP change compared with the corresponding quarter in the previous year.

For the per capita real GDP growth rate data, we have the annual data[13] of Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Australia, Canada, France, Germany, Italy, Netherlands, Spain, Switzerland, the UK, and the USA from 1982. All the annual per capita GDP at constant price in local currency are from IMF and World Bank.

Our in-sample period ends at 2003:Q4 before the start of CEPA. Since the global financial crisis broke out in late 2007 and it is not easy to separate out the effects of CEPA after the crisis[14] without strong assumptions, we restrict our out-of-sample evaluation period to 2004:Q1-2007:Q3. As a result we can get a more clean effect of CEPA.

Equation (9) is estimated using the in-sample data. The estimated coefficients of the optimal control groups for the GDP growth rate and per capita GDP growth rate are shown in Table 2. The leave-n_v-out cross-validation criterion selects Austria, Japan, France, Italy and Taiwan as the optimal control group for GDP growth rate while Singapore, France and Netherlands for per capita GDP growth rate. The estimated CEPA effects for GDP growth rate and per capita GDP growth rate are reported in Table 3.

Table 2 shows that all the estimated coefficients of the selected countries are statistically significant at 1% level. Here the estimated coefficients simply indicate the correlation patterns of GDP growth rate and per capita GDP growth rate among different regions driven by some common factors. According to Table 3, the estimated average treatment effect for GDP growth rate is 20.76%, which is the average difference between the actual growth rate and the counterfactuals without CEPA from 2004:Q1 to 2007:Q3. In other words, CEPA raised the real GDP growth rate of Macau by 20.76% compared with the growth rate had there been no CEPA. The estimated average treatment effect for per capita GDP growth rate is 11.1% as shown in Table 3. In other words, CEPA improved the growth rate of Macau's real GDP per capita by 11.1% from 2004 to 2007.

Fig. 2 plots the actual and predicted/counterfactual GDP growth paths for the period 1999:Q1 to 2003:Q4 and 2004:Q1 to 2007:Q3. The dotted lines denote the 95 percent confidence bands of the counterfactuals. The left panel of Fig. 2 shows that the predicted growth path traces closely the actual growth path for the period 1999:Q1-2003:Q4. The right panel of Fig. 2 shows the actual and counterfactual real GDP growth paths from 2004:Q1 to 2007:Q3. We note that the actual growth path is always above the counterfactual growth path and out of the confidence bands from 2004:Q1 to 2007:Q3. By and large, the implementation of CEPA had a significantly positive impact on Macau's economy and raised the Macau's economic growth by 20.76% according to Table 3.

Fig. 3 respectively plots the actual and predicted/counterfactual per capita GDP growth paths for the period 1983–2003 and 2004–2007. The left panel of Fig. 3 shows that the predicted growth path traces closely the actual growth path for the period 1983–2003. More importantly, the right panel of Fig. 3 shows the same treatment effect as that in the right panel of Fig. 2.

4.2. Impact on unemployment

For the unemployment rate data, we have quarterly data from 1996:Q1 of Belgium, Denmark, Finland, France, Germany, Italy, Ireland, Japan, Netherlands, Norway, Spain, Singapore, Sweden, Taiwan, the UK and the USA. The unemployment data are from European Statistics, IFS and Statistics and Census Service of Macau.

The leave-n_v-out cross-validation method selects Japan, Ireland and UK as the optimal control group (see Table A in Appendix). The estimated CEPA effects on unemployment are reported in Table 4. The actual and predicted/counterfactual growth paths for the period 1996:Q1-2003:Q4 and 2004:Q1-2007:Q3 are shown in Fig. 4.

According to Table 4, the estimated average treatment effect is −1.23%. In other words, CEPA reduced the annual unemployment rate of

[12] Following Du and Zhang (2015), we choose n_c to be the integer part of $T_1^{3/4}$ and $M = 2T_1$.

[13] Because the entities of the Asia-Pacific region stopped reporting the quarterly population data from 1982, we use annual data.

[14] We estimated the mixed effects of CEPA and the crisis after 2007. We found that the crisis had a more negative effect on Macau compared with other countries, but it was still dominated by the positive effect of CEPA.

Table 2
Weights of optimal control groups for real GDP and real GDP per capita.

	Real GDP				Real GDP per capita		
	Beta	SE	t-stat		Beta	SE	t-stat
Constant	0.0619	0.0271	2.2845	Constant	0.0339	0.0123	2.7600
Austria	−5.2501	2.0021	−2.6223	Singapore	0.6584	0.1488	4.4240
Japan	−3.4402	1.2767	−2.6947	France	1.8622	0.7772	2.3960
France	−8.4014	2.3163	−3.6271	Netherlands	−3.2961	0.7284	−4.5250
Italy	11.7147	2.6109	4.4869				
Taiwan	1.9361	0.4546	4.2593				

Table 3
Treatment effects of CEPA on real GDP and real GDP per capita 2004–2007.

	Real GDP				Real GDP per capital		
	Actual	Counterfactual	Treatment		Actual	Counterfactual	Treatment
2004:Q1	0.2298	−0.0143	0.2441	2004	0.2128	0.0754	0.1374
2004:Q2	0.4177	0.1490	0.2687	2005	0.0542	0.0161	0.0382
2004:Q3	0.2311	−0.0422	0.2733	2006	0.1029	−0.0188	0.1217
2004:Q4	0.1747	0.1462	0.0285	2007	0.1139	−0.0328	0.1467
2005:Q1	0.0304	−0.0084	0.0388	Average	0.1210	0.0100	0.1110
2005:Q2	0.0324	−0.0448	0.0772				
2005:Q3	−0.0188	−0.0317	0.0130				
2005:Q4	0.0515	−0.0715	0.1230				
2006:Q1	0.1697	−0.0479	0.2176				
2006:Q2	0.1475	−0.0069	0.1544				
2006:Q3	0.0968	−0.0631	0.1599				
2006:Q4	0.1950	−0.1786	0.3736				
2007:Q1	0.2151	−0.0860	0.3012				
2007:Q2	0.2669	−0.1941	0.4609				
2007:Q3	0.2779	−0.1032	0.3811				
Average	0.1678	−0.0398	0.2076				

Macau by 1.23% compared with the one had there been no CEPA. In Fig. 4 we observe that the changes of the treatment effect on unemployment rate are consistent with those on GDP growth rate. The real GDP growth is accompanied by the increase of employment.

5. Assessing the vulnerability

As pointed out by Montalbano (2011), studying the vulnerability of free trade requires both factual and counterfactual analyses. We assess vulnerability in two ways. First, we study how CEPA affects the volatility of Macau's real GDP growth rate. CEPA could raise Macau's real GDP growth rate, at the same time its volatility. Second, we evaluate the costs of exposure to the anti-corruption shock from mainland China.

5.1. CEPA and volatility of real GDP

To evaluate how CEPA affects the fluctuations of Macau's real GDP growth, we compute standard deviations of Macau's real GDP growth rate using a rolling window of four quarters. We use the same method to construct new volatility series for all candidate countries and regions. The countries in the control group are the same as those in the analysis of the effect of CEPA on real GDP growth rate. As in the previous section, we restrict our out-of-sample evaluation period to 2004:Q1-2007:Q3.

The leave-n_v-out cross-validation method selects Canada, Germany, Japan and Taiwan as the optimal control group (see Table B in Appendix). The constructed counterfactuals are illustrated in Fig. 5, and the estimated treatment effects are reported in Table 5. Fig. 5 shows that the actual path is almost above the counterfactual path from 2004:Q1 to

Table 4
Treatment effect of CEPA on unemployment 2004:Q1-2013:Q4.

	Actual (%)	Counterfactual (%)	Treatment (%)
2004:Q1	5.60	4.57	1.03
2004:Q2	5.00	4.88	0.12
2004:Q3	4.70	4.83	−0.13
2004:Q4	4.20	4.71	−0.51
2005:Q1	4.20	4.90	−0.70
2005:Q2	4.20	4.42	−0.22
2005:Q3	4.20	4.53	−0.33
2005:Q4	4.00	5.66	−1.66
2006:Q1	4.00	5.62	−1.62
2006:Q2	3.80	5.91	−2.11
2006:Q3	3.80	6.04	−2.24
2006:Q4	3.50	6.02	−2.52
2007:Q1	3.20	6.05	−2.85
2007:Q2	3.00	5.41	−2.41
2007:Q3	3.10	5.32	−2.22
Average	4.03	5.26	−1.23

Table 5
Treatment effect of CEPA on GDP growth volatility 2004:Q1-2007:Q3.

	Actual	Counterfactual	Treatment
2004:Q1	0.1189	0.0826	0.0363
2004:Q2	0.0957	0.0500	0.0456
2004:Q3	0.0948	0.0471	0.0477
2004:Q4	0.1062	0.0515	0.0547
2005:Q1	0.1602	0.0839	0.0763
2005:Q2	0.1017	0.0924	0.0093
2005:Q3	0.0834	0.0756	0.0079
2005:Q4	0.0300	0.0693	−0.0393
2006:Q1	0.0797	0.0733	0.0065
2006:Q2	0.0875	0.0610	0.0265
2006:Q3	0.0529	0.0324	0.0206
2006:Q4	0.0418	0.0244	0.0173
2007:Q1	0.0528	0.0370	0.0158
2007:Q2	0.0712	0.0500	0.0212
2007:Q3	0.0400	0.0717	−0.0318
Average	0.0811	0.0601	0.0210

Table 6
Treatment effect of anti-corruption on real GDP and unemployment 2012:Q4-2016:Q4.

	Real GDP			Unemployment Rate		
	Actual	Counterfactual	Treatment	Actual(%)	Counterfactual(%)	Treatment(%)
2012:Q4	0.0821	0.0778	0.0043	1.90	1.73	0.17
2013:Q1	0.1270	0.1024	0.0246	1.90	1.59	0.31
2013:Q2	0.1160	0.1249	−0.0089	1.80	1.56	0.24
2013:Q3	0.1172	0.1626	−0.0454	1.90	1.49	0.41
2013:Q4	0.1474	0.2287	−0.0813	1.80	1.46	0.34
2014:Q1	0.1387	0.1755	−0.0369	1.70	1.42	0.28
2014:Q2	0.0880	0.1906	−0.1025	1.70	1.37	0.33
2014:Q3	−0.0090	0.2583	−0.2673	1.70	1.42	0.28
2014:Q4	−0.1556	0.2028	−0.3584	1.70	1.31	0.39
2015:Q1	−0.2481	0.2854	−0.5335	1.70	1.33	0.37
2015:Q2	−0.2787	0.2130	−0.4918	1.80	1.38	0.42
2015:Q3	−0.2487	0.1439	−0.3926	1.90	1.63	0.27
2015:Q4	−0.1951	0.1037	−0.2988	1.90	1.59	0.31
2016:Q1	−0.1481	0.0354	−0.1836	1.90	1.60	0.30
2016:Q2	−0.0931	0.0241	−0.1172	1.90	1.67	0.23
2016:Q3	0.0271	0.0444	−0.0173	1.90	1.71	0.19
2016:Q4	0.0632	0.1380	−0.0749	1.90	1.67	0.23
Average	−0.0276	0.1478	−17.54	1.82	1.52	0.30

2007:Q3, which indicates that the implementation of CEPA increased the fluctuations of Macau's real GDP growth.

The results in Table 5 show that CEPA increased the volatility of Macau's annual real GDP growth by 0.02 in terms of standard deviation or by 35% from 2004:Q1 to 2007:Q3. Thus, CEPA raised Macau's real GDP growth but also its fluctuations.

5.2. Anti-corruption shock

In late 2012, mainland China launched the largest anti-corruption campaign in the history of Communist rule in China. We assess the impacts of this anti-corruption shock on Macau's economy in two ways. We first evaluate how the anti-corruption shock affects Macau's real GDP growth and employment. We then evaluate how the anti-corruption campaign affects the volatility of Macau's real GDP.

Our in-sample period for this part is 2008:Q1-2012:Q3, and out-of-sample evaluation period is 2012:Q4-2016:Q4. Our sample starts from 2008 because the recent crisis might change the relationship among the countries and effects of CEPA can be viewed as stable after 2008. Equation (9) is estimated using the in-sample observations and the coefficients of the optimal control groups for the GDP growth rate and unemployment are shown in Table C and Table D in Appendix. The estimated anti-corruption effects are reported in Table 6. The actual and predicted/counterfactual real GDP growth and unemployment paths for the period 2008:Q1-2012:Q3 and 2012:Q4-2016:Q4 are shown in Figs. 6 and 7, respectively.

The right panel of Fig. 6 shows that from 2012:Q4 to 2016:Q4 the actual growth path is always below the counterfactual growth path and these two paths exhibit a huge gap, especially in 2015. The huge gap indicates that the anti-corruption campaign in mainland China resulted in a very negative impact on Macau's economy.

According to Table 6, the estimated average treatment effect for GDP growth rate is −17.54%, which is the difference between the average actual growth rate and the average counterfactual growth rate had there been no anti-corruption shock from 2012:Q4 to 2016:Q4. In other words, the anti-corruption shock reduced the real GDP growth rate of Macau by 17.54%. The estimated average treatment effect for unemployment rate is −0.30% shown in Table 6. In other words, the anti-corruption shock increased the annual unemployment rate of Macau by 0.30. In Fig. 7 we observe that the results of unemployment rate are consistent with those of GDP growth rate in Fig. 6. The decrease in real GDP is associated with the increase of unemployment.

To evaluate the effects of the anti-corruption shock on the volatility of real GDP growth, we compute standard deviations of Macau's real GDP growth rate using a rolling window of four quarters. The leave-n_v-out cross-validation method selects Singapore and Thailand as the optimal control group (see Table E in Appendix). The constructed counterfactuals are illustrated in Fig. 8, and the estimated treatment effects are reported in Table 7.

The right panel of Fig. 8 shows that after 2014:Q1 the actual path is always above the counterfactual path. According to Table 7, the treatment effect is 0.039, while the actual standard deviation is 0.063.

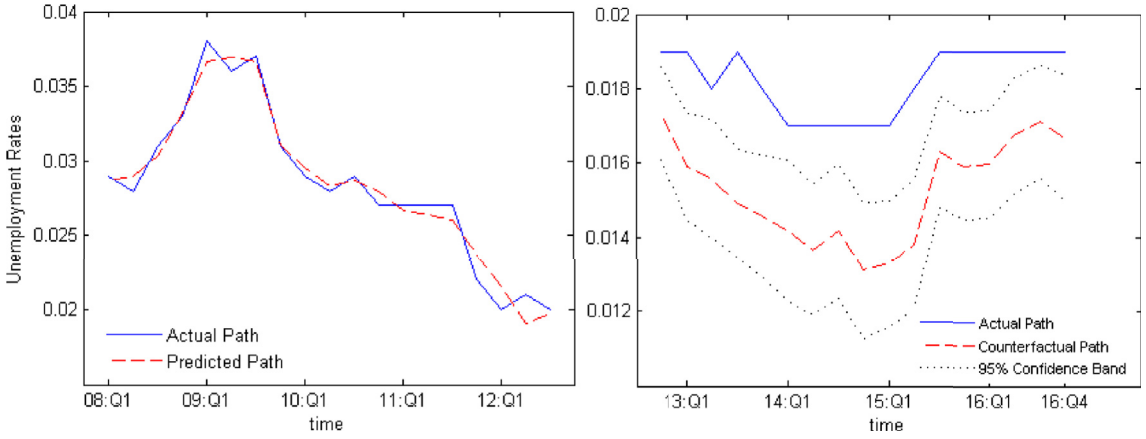

Fig. 7. Actual and predicted/counterfactual unemployment rate from 08:Q1 to 12:Q3 and 12:Q4 to 16:Q4.

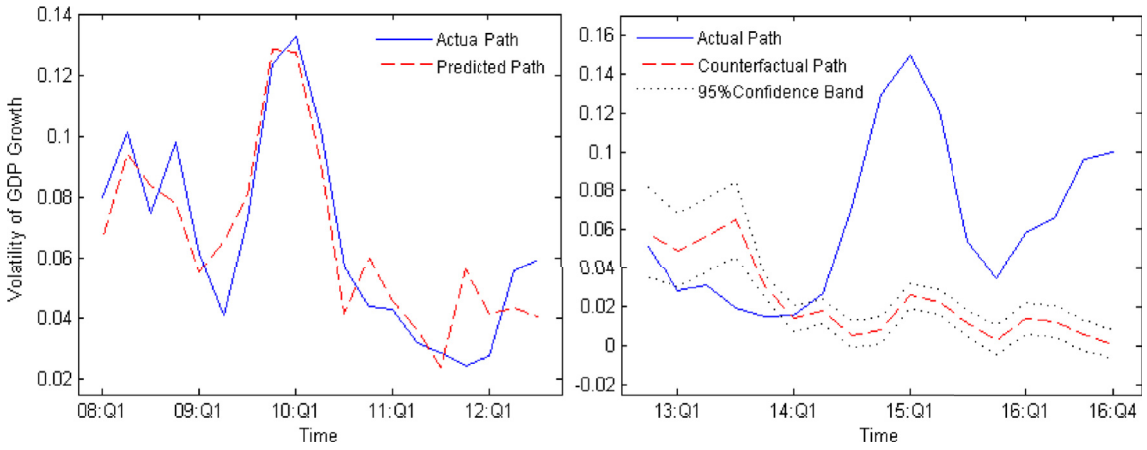

Fig. 8. Actual and predicted/counterfactual GDP growth volatility from 08:Q1 to 16:Q4.

Table 7
Treatment effect of anti-corruption on GDP growth volatility 2012:Q4-2016:Q4.

	Actual	Counterfactual	Treatment
2012:Q4	0.0515	0.0583	−0.0068
2013:Q1	0.0283	0.0491	−0.0208
2013:Q2	0.0312	0.0568	−0.0256
2013:Q3	0.0196	0.0656	−0.0460
2013:Q4	0.0145	0.0305	−0.0160
2014:Q1	0.0157	0.0140	0.0016
2014:Q2	0.0264	0.0177	0.0087
2014:Q3	0.0718	0.0053	0.0665
2014:Q4	0.1295	0.0080	0.1215
2015:Q1	0.1497	0.0256	0.1241
2015:Q2	0.1211	0.0224	0.0987
2015:Q3	0.0534	0.0119	0.0416
2015:Q4	0.0348	0.0028	0.0319
2016:Q1	0.0578	0.0142	0.0436
2016:Q2	0.0664	0.0128	0.0536
2016:Q3	0.0958	0.0056	0.0902
2016:Q4	0.0994	0.0007	0.0987
Average	0.0628	0.0236	0.0392

Therefore, the anti-corruption shock raised the volatility of Macau's annual real GDP growth by 166% from 2012:Q4 to 2016:Q4.

6. Robustness check

In this section, we first analyze the channels through which CEPA affects Macau's economy using a regression discontinuity design (RDD). We then do a leave-one-out robustness check.

6.1. Channels analyses

In this subsection we study which industries are affected by CEPA. We aim to examine the effects of CEPA on gambling and manufacturing industries. As the exports and imports of Macau are mainly due to manufacturing industry, we use export and import data as indicators for manufacturing.

To solve the possible endogeneity problem caused by omitted variables, we use a RDD argument with time as the running variable. The idea is that one may assume the confounding factors affect our outcome variables continuously over time. If we consider a small window of time around the implementation of CEPA, the unobserved factors affect gambling and manufacturing industries similarly before and after CEPA within this small time interval. Therefore, the differences before and after CEPA within this small time interval can be attributed to CEPA. Similar arguments have been used in Davis (2008).

We use quarterly data from 2000:Q1 to 2006:Q4 to do the RDD analyses. We regress outcome variables on *cepa*, a dummy variable equal to one after the implementation of CEPA, polynomials of time, and some other control variables. As the time interval around CEPA is relatively small, we can attribute the coefficients of *cepa* as the policy effects by RDD arguments. The estimated results are reported in Table 8.

Column (1) of Table 8 shows a significantly positive effect of CEPA on gambling industry at 5% level. Column (2) of Table 8 further controls the number of tourists from mainland China, where the coefficient of *cepa* is

Table 8
Effects of CEPA on gambling and manufacturing industries by RDD.

	lngam	lngam	lnexp	lnimp
	(1)	(2)	(3)	(4)
cepa	0.2212**	−0.0569	−0.1955*	−0.0209
	(0.0901)	(0.0623)	(0.1075)	(0.1197)
lntour		0.8374***		
		(0.1092)		
lncgdp	8.9383	−3.1173	−19.929***	−15.354**
	(5.6587)	(2.5511)	(5.2243)	(5.9428)
t	−0.1051	0.0426	0.4709***	0.3321***
	(0.1157)	(0.0454)	(0.1047)	(0.1135)
t^2	−0.0034**	0.0011	0.0020	0.0035**
	(0.0012)	(0.0008)	(0.0013)	(0.0016)
constant	−121.32	52.135	311.50***	242.84**
	(86.622)	(38.262)	(79.984)	(90.995)

Note: The sample data is ranging from 2000:Q1 to 2006:Q4. *lngam* denotes the log of real expenditure of non-residents on gambling in Macau. *lntour* denotes the log of the tourists from mainland China. *lncgdp* denotes the log of real GDP of mainland China. *lnexp* denotes the log of real export values of Macau to mainland China. *lnimp* denotes the log of real import values of Macau from mainland China. Robust standard errors are in parentheses.

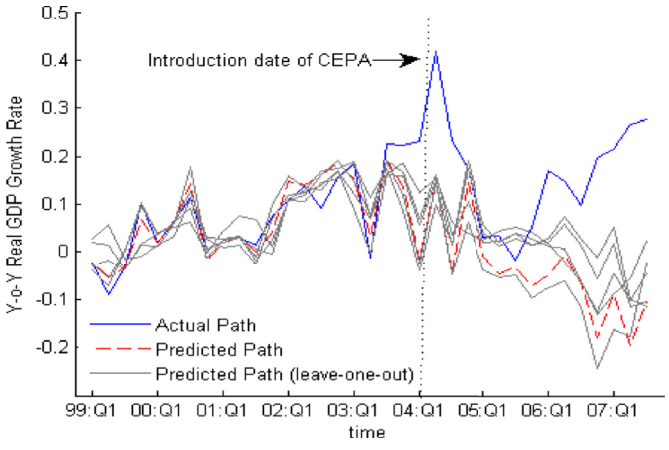

Fig. 9. Actual and predicted (leave-one-out) real GDP growth rate from 99:Q1 to 07:Q3.

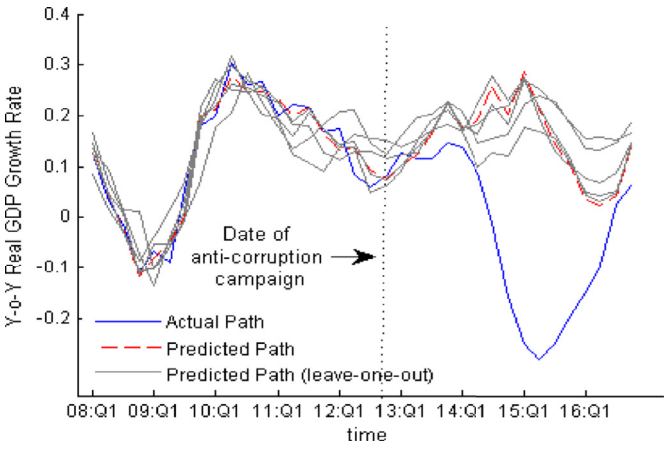

Fig. 10. Actual and predicted (leave-one-out) real GDP growth rate from 08:Q1 to 16:Q4.

not significant anymore, while the coefficient of *lntour* becomes significantly positive. Results from Columns (1)–(2) indicate that CEPA affect gambling industry through the increasing of tourists from mainland China. The results in Table 8 also show that the export of Macau significantly decreases after the implementation of CEPA, while import also decreases but insignificantly. One possible explanation could be the concentration of gambling industry holdbacks the manufacturing industry, which is consistent with the results in Table 1.

6.2. Leave-one-out robustness check

We also implement the leave-one-out robustness check to see whether the results are driven by some particular countries in the optimal control group. We find that our results are robust to the removal of one particular country. To be specific, we iteratively remove one country from the optimal control group of the final model, and construct the counterfactuals using the remaining countries in the control group. Similar leave-one-out robustness check has been used in Abadie et al. (2015). Fig. 9 displays the results for real GDP growth rate, which reproduce Fig. 2 (blue and dash red lines) while also incorporating the leave-one-out estimates (gray lines).

One can see that although we sacrifice some goodness-of-fit by excluding one country of the optimal control group, we get similar results as those in Fig. 2. After the implementation of CEPA all the predicted paths produced with leave-one-out are below the actual path. That's to say, the results of the previous analyses are robust to the exclusion of any particular country from the optimal control group.

We also do the same robustness check for the anti-corruption shock. As shown, in Fig. 10, after the occurrence of the anti-corruption campaign all the leave-one-out predicted paths are above the actual path. The results are in line with those in the right panel of Fig. 6. Thus, the results of the previous analyses are robust to a different method of exclusion.

7. Conclusions and policy implications

In this paper we employ a new counterfactual analysis method to study the gains of free trade, as well as vulnerability to external shocks. We assess the effects of CEPA on Macau's real GDP growth and volatility, as well as the costs to exposure of the anti-corruption shock from mainland China. Our method exploits interdependence between economic entities to construct counterfactuals and the control group is optimally selected using a leave-n_v-out cross-validation method that trains models to best fit data. Our study provides a new approach to assess both the gains and vulnerability of free trade. We find that CEPA raised Macau's real GDP growth but also its fluctuations and exposure to external shocks. In particular, CEPA raised the annual real GDP growth rate of Macau by 20.76% from 2004 to 2007, but it also increased the volatility of real GDP growth rate by 35%, and the anti-corruption shock reduced the annual real GDP growth rate of Macau by 17.54% from 2013 to 2016. Our findings imply that free trade can be a double-edged sword for a small and highly-specialized economy, and the gains of free trade can be obtained by reducing its vulnerability.

Our empirical findings have three economic and policy implications. First, we established from the case of Macau conditions under which free trade might magnify exposure to external shocks. If free trade makes an already-specialized economy more concentrated, the economy, often small, is more susceptible to external shocks. The resulted big ups and downs in real GDP have non-negligible welfare costs. From the macroeconomic perspective, counter-cyclical policies, whether monetary or fiscal, would help stabilize the economy.

Second, the analysis of Macau shows that the double reliance, on gambling industry and within gambling industry on VIP market, is the main reason why the anti-corruption campaign could drastically destabilize the economy. While diversification towards manufacturing to compete with mainland China and other labor-intensive countries and regions has been proven futile, inter-industry diversification between tourism and gambling industry, intra-industry diversification by developing mass market within gaming industry, and attract tourists from different countries could help Macau build up a more resilient industry structure (Liu et al., 2015; Chou, 2013). In addition, as government revenue relies on gambling industry, public funds would help hedge against hard times.

Last, the case of Macau also shows heavily relying on players/tourists from mainland China magnifies vulnerability, and to some extent might reduce Macau's political and economic bargaining power towards the central government (Economist, 2017b).

Acknowledgments

We would like to thank the editor and two anonymous referees for their constructive comments that help improve the quality of the paper. The usual disclaimer applies.

Appendix

Table A
Weights of optimal control groups for unemployment rate for the period 1996:Q1-2003:Q4

	Beta	SE	t-stat
Constant	−5.9971	1.6166	−3.7097
Japan	2.3581	0.2516	9.3736
Ireland	−0.9861	0.1009	−9.7728
UK	0.8799	0.2067	4.2571

Table B
Weights of optimal control groups for GDP growth volatility for the period 99:Q1-03:Q4.

	Beta	SE	t-stat
Constant	0.1321	0.0126	10.5032
Japan	−2.6366	0.7894	−3.3400
Canada	−2.2549	0.5263	−4.2848
Germany	−5.8249	1.0362	−5.6212
Taiwan	0.7729	0.3134	2.4664

Table C
Weights of optimal control groups for real GDP for the period 2008:Q1-2012:Q3.

	Beta	SE	t-stat
Constant	0.1234	0.0301	4.1006
Canada	2.2677	0.3512	6.4574
Japan	−0.9786	0.7606	−1.2866
Philippines	−1.8696	0.6416	−2.9139
Singapore	1.2065	0.1525	7.9103
USA	3.1929	0.7530	4.2403

Table D
Weights of optimal control groups for unemployment rate for the period 2008:Q1-2012:Q3.

	Beta	SE	t-stat
Constant	0.0272	0.0027	10.0475
Italy	−0.2511	0.0224	−11.2144
Singapore	0.4347	0.0836	5.2004
Taiwan	0.2473	0.0481	5.1400

Table E
Weights of optimal control groups for GDP growth volatility for the period 2008:Q1-2012:Q3.

	Beta	SE	t-stat
Constant	−0.0128	0.0118	−1.0800
Singapore	1.0705	0.1431	7.4835
Thailand	0.8178	0.2513	3.2536

References

Abadie, A., Diamomd, A., Hainmueller, J., 2015. Comparative politics and the synthetic control method. Am. J. Polit. Sci. 59 (2), 495–510.

Akaike, H., 1973. Information theory and an extension of the maximum likelihood principle. In: Petrov, B.N., Csaki, F. (Eds.), Proceedings of the 2nd International Symposium on Information Theory. Akadémiai Kiadó, Budapest, pp. 267–281.

Akaike, H., 1974. A new look at the statistical model identification. IEEE. Trans. Auto. C 19, 716–723.

Alwang, J., Siegel, P.B., Jorgensen, S.L., 2001. Vulnerability: A View from Different Disciplines. The World Bank, Washington DC. Social Protection Discussion Paper Series No.0015.

Bai, J.S., Ng, S., 2002. Determining the number of factors in approximate factor models. Econometrica 70 (1), 191–221.

Baier, S.L., Bergstrand, J.H., 2007. Do free trade agreement actually increase members' international trade? J. Int. Econ. 71 (1), 72–95.

Bernard, A.B., Eaton, J., Jensen, B., Kortum, S., 2003. Plants and productivity in international trade. Am. Econ. Rev. 93 (4), 1268–1290.

Calderón, C.A., Loayza, N., Schmidt-Hebbel, K., 2005. Does Openness Imply Greater Exposure? World Bank Policy Research Working Paper No. 3733.

Caporale, G., Rault, C., Sova, R., Sova, A., 2009. On the bilateral trade effects of free trade agreements between the EU-15 and the CEEC-4 countries. Rev. World Econ. 145 (2), 189–206.

Chou, M.C., 2013. Does tourism development promote economic growth in transition countries? A panel data analysis. Econ. Model 33, 226–232.

Davis, L.W., 2008. The effect of driving restrictions on air quality in Mexico city. J. Polit. Econ. 116 (1), 38–81.

Du, Z.C., Zhang, L., 2015. Home-purchase restriction, property tax and housing price in China: a counterfactual analysis. J. Econ. 188 (2), 558–568.

Economist, 2017a. The High Roller Return.

Economist, 2017b. Why Macau Is Less Demanding of Democracy than Hong Kong.

Forni, M., Reichlin, L., 1998. Let's get real: a factor-analytic approach to disaggregated business cycle dynamics. Rev. Econ. Stud. 65, 453–473.

Gregory, A., Head, A., 1999. Common and country-specific fluctuations in productivity, investment, and the current account. J. Monet. Econ. 44, 423–452.

Guillaumont, P., 2010. Assessing the economic vulnerability of small island developing states and the least developed countries. J. Dev. Stud. 46 (5), 828–854.

Hnatkovska, V., Loayza, N., 2004. Volatility and growth. In: Aizenman, J., Pinto, B. (Eds.), Managing Volatility and Economic Crises: a Practitioner's Guide. Cambridge University Press, New York.

Hsiao, C., Steve, C.H., Wan, K.S., 2012. A panel data approach for program evaluation: measuring the benefits of political and economic integration of Hong Kong with mainland China. J. Appl. Econ. 27 (5), 705–740.

Hurvich, C.M., Tsai, C.L., 1989. Regression and time series model selection in small samples. Biometrika 76 (2), 297–307.

Jean, S., Mulder, N., Ramos, M.P., 2014. A general equilibrium, ex-post evaluation of the EU-Chile free trade agreement. Econ. Model 41, 33–45.

Kose, M.A., Prasad, E.S., Terrones, M.E., 2003. Financial Integration and Macroeconomic Volatility. IMF Staff Papers, 50.

Krugman, P.R., 1979. Increase returns, monopolistic competition, and international trade. J. Int. Econ. 9 (4), 469–479.

Krugman, P.R., 1980. Scale economies, product differentiation, and the pattern of trade. Am. Econ. Rev. 70 (5), 950–959.

Lakatos, C., Walmsley, T., 2012. Investment creation and diversion effects of the ASEAN-China free trade agreement. Econ. Model 29 (3), 766–779.

Liu, M.T., Chang, T.G., Loi, E., Chan, A., 2015. Macau gambling industry current challenges and opportunities next decades. Asia Pac. J. Mark. Log. 27 (3), 499–512.

Loayza, N., Raddatz, V.C., 2007. The structural determinants of external vulnerability. World Bank. Econ. Rev. 21 (3), 359–387.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71 (6), 1695–1725.

Melitz, M.J., Trefler, D., 2012. Gains from trade when firms matter. J. Econ. Perspect. 26 (2), 91–118.

Montalbano, P., 2011. Trade openness and developing countries' vulnerability: concepts, misconceptions, and directions for research. World Dev. 39 (9), 1489–1502.

Montalbano, P., Federici, A., Pietrobelli, C., Triulzi, U., 2008. Socio-economic vulnerability and trade liberalization: a cross-country evidence in central and eastern Europe during the transition. In: Squire, L., Fanelli, J.M. (Eds.), Dimensions of Reform: Reach, Range, Reason. Edward Elgar Publishing, Northampton, MA.

Naudé, W., Santos-Paulino, A., McGillivray, M., 2009. Measuring vulnerability: an overview and introduction. Oxf. Dev. Stud. 37 (3), 183–191.
Ricardo, D., 1951. On foreign trade. In: Sraffa, P., Dobb, M.H. (Eds.), The Works and Correspondence of David Ricardo, vol. 1. Cambridge University Press, Cambridge, UK.
Trefler, D., 2004. The long and short of the Canada-U.S. free trade agreement. Am. Econ. Rev. 94 (4), 870–895.
Zhang, L., Du, Z., Hsiao, C., Yin, H., 2015. The macroeconomic effects of the Canada-U.S. free trade agreement on Canada: a counterfactual analysis. World Econ. 38, 878–892.