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Analysis of the V.A.R. as a tool to investigate the impact of higher education on economic growth in Macau in the period 2000–2019

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ABSTRACT

This article employs the panel data model to investigate the influence of both higher education scale and quality on economic growth in Macau from 2000–2019 and constructs a V.A.R. model to examine the impact of the higher education scale on economic growth. The model is constructed based on the Cobb–Douglas production function with an alteration derived from existing relevant studies to include enrolled university students as one of the variables. It is found that all-time series are stationary; through the pairwise Granger Causality test, it is observed that the number of students enrolled in the Granger cause of G.D.P. Study results show a high level of a statistically significant relationship in the positive direction between higher education and economic growth, while a 1% increase in enrolled students will lead to a 0.5547% increase in G.D.P. Moreover, in general, higher education exerts a significant positive effect on economic growth in Macau, while the effect of fixed capital formation appears insignificant. In addition, the labour force plays a remarkably positive role in the economic growth of Macau.

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1. Introduction

The production function is a way of calculating the output compared to its input. Charles Cobb and Paul Douglas developed the first mathematical expression, namely the Cobb–Douglas production function, which explains the economic relationship between inputs and outputs (Cobb & Douglas, 1928). The Cobb–Douglas production function reflects the relationships between its inputs – namely physical capital and labour – and the amount of output produced. It is a means for calculating the impact of changes in the inputs, the relevant efficiencies, and the yields of production activity. This practical model is widely used in policy analysis and economic forecasts of the Congressional Budget Office (C.B.O.) and others (Miller, 2008).

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In this paper, education is included in the production function. Education is universally acknowledged as a significant element contributing to long-term economic growth as it improves the skills and knowledge of the workforce, which could boost economic efficiency. Therefore, the overall productivity would increase. Both individuals and society are the beneficiaries of education. Macau is an affluent city. Its G.D.P. per capita reached US$79,977 in 2019 (Government of Macao Special Administrative Region, Statistics and Census Service, 2019), the second-highest in the world after Qatar. Macau's tremendous wealth is predominantly collected from the thriving gaming industry. By 2018, the industrial importance of gaming and junket activities accounted for 50.5% (DSEC, 2018). However, as economic theories suggest that a country or a city should not depend solely on one industry, Macau's government has been working on lowering the share of the gaming industry in recent years. In 2002, Macau's government announced the policy of 'moderate economic diversification in the hope of balancing Macau's economic structure (Sheng, 2020).

Macau's economy is a mini economy, according to the definition of Professor Wan Chong Ieong, a professor from the University of Macau, due to three features, namely its local population that is under 0.6 million, a relatively independent economic system, and international board recognition (Li & Liu, 2012). Not only is it tiny, but it is also immensely dependent on the gaming industry. Out of 281.8 thousand total employed residents in 2019, 71.9 thousand of their occupations are related to casinos-running, which accounts for roughly 25.51% (DSEC, 2020). On top of that, revenue from the gaming industry accounts for roughly 60–80% of the public revenue in Macau from 2000 to 2018. Due to the epidemic's impact, Macau's G.D.P. in 2021 amounted to US$29.9 billion, and the per-capita G.D.P. was US$43,774, compared with US$81,969 in 2019 before the epidemic. G.D.P. contracted by 8.9% year-on-year in real terms in the first quarter of 2022 due to the weakening total demand (DSEC, 2021, 2022).

The development of higher education in Macau has developed only for several decades. The Portuguese government established St. Paul's College, a higher education college, in the sixteenth century. However, in 1762, Jesuit priests and the Portuguese government had an argument, and the college was closed. This resulted in the standstill of Macau's higher education until the University of East Asia was established in 1981, which was the predecessor of the University of Macau (Hao, 2016). In the 2019/2020 academic year, there are 10 tertiary educational institutions in Macau, which is consist of 36,107 registered students and 2598 teachers (DSEC, 2020). The university ranking by Times Higher Education (T.H.E.) ranked only two Macau universities, namely the University of Macau and Macau University of Science and Technology. Their overall scores are 44.5–46.8 and 46.9–50.0 and ranked 301–350 and 251–300, respectively. However, their international outlook is third and ninth highest globally (THE, 2020).

The government of Macau has been backing the 10 universities in Macau since 2000. Throughout the 2010s, sizable efforts have been seen in advancing Macau's higher education system, namely the expansion of the University of Macau and numerous student subsidies. In the April of 2020, the chief executive of Macau SAR Mr. Ho Iat Seng, announced that the marketisation of Macau's higher education is

necessary, and the government has been examining the model of the U.K., which has a renowned education system, to extract useful experience (GCS, 2020). Once marketisation is completed, universities in Macau can achieve financial independence and are less affected by governmental budget changes. In 2021, the United Nations Educational, Scientific, and Cultural Organization noted that 'inequalities within countries have risen at different rates' and that there is a need to 'see education as our path to a sustainable common future and to realize its full transformative potential' (UNESCO,2022).

The research question of this study Is to what extent higher education is related to G.D.P. growth in Macau. Many studies have pinpointed that there is a correlation between education and economic growth (Hanushek & Woessmann, 2020; Zhu et al., 2018; Sun, 2021; Cheng, 2020; Zhong et al., 2019). Hence the objective of this study is to discover whether this statement is valid and the degree it is valid in Macau.

Existing studies have demonstrated progress in showing the relationship between higher education development and economic growth nationally (Zhong et al., 2019; Zhu et al., 2018; Köksel & Yilmaz, 2021; Sun, 2021; Cheng, 2020). However, in the specific context of Macau, there is very little empirical research that examines the impact of higher education marketisation on economic growth from the perspective of economic models. In addition, the majority of them are characterised as descriptive-oriented research. Overall, it is evident that this research field is inconclusive and remains more to be explored and developed. This study will extend from the continuing efforts of past research and contribute to the broader goal of devising an accountable learning model using figures. This study is of particular importance, especially in the light of the current economic hardship that this study is in due to the global pandemic. It sheds light on whether it can be used as an immediate short-term panacea by policymakers.

This article adds to existing writing in the accompanying two viewpoints: for a specific something, we use the V.A.R. model to study the relationship between the development of higher education in Macau and the economy of Macau. Predicted the stimulating effect of the growth of higher education in Macau on the Macau economy. For another, we develop a fixed-effect panel data model with variable intercepts and coefficients, considering the role of technological innovation in the regression equation, to study the impact of higher education scale on economic growth and the causal relationship between them in small and micro-society Macau.

2. Literature review

In 1928, to analyse the relationship between the various production factors and the maximum output, University of Chicago professors Charles Cobb and Paul Douglas proposed the Cobb–Douglas production function in the analysis of extensive sample data in manufacturing (Saini, 1974). The accounting method of the economic growth rate can be further calculated through the deformation of the Cobb–Douglas function.

In the 1950s, Thodore W. Schultz (1961) put forward the theory of human capital, arguing that investment in human capital is the source of social and economic

growth, and investment in education is one of the essential factors that human capital plays in economic growth. Therefore, Schultz (1961) defines human capital as the quantity and quality of workers engaged in work, where quality includes workers' level of knowledge and proficiency. At the same time, Schultz (1961) and Becker (1975) believe that the quality of human capital is the product of investment, and the accumulation of human capital is the source of economic growth, formal education at all levels, vocational and technical education, medical and health care, etc. are all important contents of human capital investment. Globally in the era of increasingly fierce competition and continuous improvement of the information technology level, human capital's impact on economic growth is particularly significant, especially at all levels – formal education investment in human capital (Schultz, 1961).

This has laid a theoretical foundation for scholars at home and abroad to study the role of education in promoting the economy. In addition, Schultz proposed the economic growth residual analysis method based on the Cobb–Douglas function, calculated the contribution rate of education to economic growth in the U.S. from 1929 to 1957, and found that the contribution rate of education to the economy was as high as 33% (Richardson, 1973).

In the 1960s, Edward Fulton Denison, based on human capital theory, combined with endogenous economic theory, used mainstream analysis methods to conclude that the contribution rate of education to economic growth in the U.S. from 1922 to 1957 was 20%. In the 1980s, the four-factor economic growth theory proposed by Paul M. Romer took human capital as an essential factor in the economic system. Robert E. Lucas, Jr. (1988), based on the Paul Romer model, emphasised the role of human capital accumulated by workers in school education rather than actual production in economic growth, pointing out that human capital can produce scale effect only in school education.

A few investigations affirm the positive job of training on economic development. For the model, in light of the information from 1960 to 2010 in Pakistan, Jalil and Idrees (2013) utilise the nonlinear two-stage least square instrumental variable (N.L.T.S.L.S.-I.V.) strategy to assess the blunder adjustment model, and the outcomes demonstrate that there is a beneficial outcome of various degrees of training on economic development in Pakistan. Solarin and Yen (2016) have completed a detailed exploration given board information from 169 nations from 1996 to 2013: they track down that, regardless of whether inspecting created or non-industrial nations, the result of logical exploration applies a positive impact on economic development. Furthermore, Hassan and Cooray (2015) inspect the orientation disaggregated impact of training on financial development because of the information from 18 Asian nations from 1970–2009. They find that paying little heed to orientation, their essential, auxiliary, and advanced education has constructive outcomes on economic development, and no matter what the period of study, the tutoring of males counts higher than that of females. In this way, males offer more to economic development than females, and it is critical to work on tutoring females in order to advance the fast monetary development of Asian nations. Saviotti et al. (2016) contend that schooling might prompt a trade-off between pay imbalance and its development rate, even though it makes a positive difference in friendly versatility by expanding the populace

portion of the upper social class, given a quantitative model and experimental examination. A growing number of studies have been undertaken in order to determine the relationship between higher education development and economic growth. For instance, The U.S., the U.K. and Australia have relatively higher degrees of marketisation of higher education over the past thirty or forty years and have both similarities and differences in terms of their formation and development of higher education markets (Jiang, 2016). Tian and Li (2012) conducted empirical research on the influence of China's east coast education development on the region's economic growth. With the adoption of the Cobb–Douglas production function, their research concludes that 'education has driven the economy by enhancing the level of human capital' (Köksel & Yilmaz, 2021; Sun,2021; Cheng,2020; Zhu et al.,2018; Zhang & Liu, 2022;) .

The concept of higher education marketisation has been proposed in the past decades. In the 1950s, Friedman (2002) advocated allocating public education resources by market-oriented means to play the role of the market mechanism in education development. Chubb and Moe (1990) proposed shifting school systems from democratic politics to the marketplace, which expands the revenue of educational institutions by introducing the education industry into the market.

In the context of China, the theory of 'marketisation of higher education' considers higher education as an industry under the economic system. Therefore, the higher education industry should adapt to the economy to realise the 'equivalent exchange' with the market (Xiang & Xue, 2006). In addition, similar views are put forward. Xiong (2012) considered the marketisation of higher education aims to adhere to economic and social development as the fundamental guide, promote the sustainable improvement of the industry, and strengthen the combination of production, learning, and research by constructing the input and output mechanism of the industry in order to integrate higher education and production activities.

Sun (2010) studied the connotation of the marketisation of higher education. He concluded that: (1) The marketisation of higher education focuses on input–output efficiency. However, commonality, the attribute of higher education, is not neglected, which is different from marketisation; (2) The marketisation of higher education is market–demand-oriented; and (3) The marketisation of higher education aims to develop various forms of higher education running – the purpose of education marketisation: (1) Personal and social development; (2) Assist the economic build-up in China or any nation; and (3) Equalise the education system. (Nickolai et al., 2012)

Successful experiences of other countries developing higher education marketisation could be observed. Nickolai et al. (2012) pointed out that the reason for the wave of marketisation of higher education in western developed countries from the 1950s to the mid-1970s is that policymakers realised the pivotal role of higher education in enhancing comprehensive national strength, especially after the outstanding performance of the higher education industry of the former Soviet Union. By the end of the 1920s, the former Soviet Union had started building colleges and university systems by setting up many diverse majors and establishing a unified engineering technology education system. In a series of reforms, the size of the higher education industry increased by up to four times in just 13 years. This significantly increased the enrolment rate of higher education and rapidly improved labour productivity.

Serving as a primary industry, the higher education industry has become an essential part of the former Soviet Union's entire national industrial structure. Other developed countries had also performed similar practices. In the 1950s, aiming to converse advances in science and technology into fundamental productive forces, Stanford university opened up the Stanford Industrial Park, making one's teaching and scientific research and the industrial park complement and promote each other. After decades of construction, Silicon Valley has gradually been built into a world-class technological and knowledge-intensive industrial development zone, which solves the problem of insufficient funds for educational research and promotes the transformation from an industrial economy to a knowledge economy (Zhang & Li, 2006). With a rich history of private schooling in Britain, the government started to fund many private universities and carried out unified planning for all universities through the former University Grant Committee in the 1960s and 1970s. Since 1986, the Swedish government has nationalised higher education and almost all private universities. The Australian Federal Government switched to a federal grant to coordinate the higher education and vocational and technical training systems. The patterns of how the U.K.'s higher education market has formed are similar to Australia's, namely reducing public expenditure, encouraging institutional revenue-generation, establishing a tuition system, introducing competition mechanism, expanding the international market, and so on (Jang, 2016). However, the marketisation of higher education in Australia has led to the excessive emphasis on the economic value and market efficiency of education, which has triggered various views of the public on the quality education of educational equity, as well as the crisis of higher education (Pan,2021).

To sum up, under the assumption that the land remains unchanged, economic growth mainly depends on the increase of capital and labour force, and the increase of labour force mainly depends on the progress of the labour force and labour skill level. School education is the critical link in improving labour skill levels, reflecting the importance of education to economic growth (Zhu et al., 2018; Goczek et al., 2021; Apostu et al., 2022).

3. Methods and data specification

3.1. Methods

In this article, the V.A.R. is used to research the relationship between total production, fixed capital formation, the employed population, and the number of students enrolled in higher education in Macau. The V.A.R. model is a dynamic simultaneous equation model proposed by the American econometrician Sims in 1980. The model does not set relevant constraints on the variable index parameters. The variable on the right side of the equation includes the lag term of all endogenous variables. Thus, the univariate autoregressive model is extended to a vector model consisting of multiple time series variables. The V.A.R. model overcomes the difficulty of traditional simultaneous equations in estimating exogenous and endogenous variables. It can also be used to analyse and predict interconnected multivariate time series systems to explain the impact of various economic shocks on economic variables.

SPSS 26.0 was used for descriptive statistics and correlation analysis. Then, using the Augmented Dickey-Fuller (A.D.F.)-test, Eviews10.0 was used to check the

stationarity of the time series. And then check co-integration using Johansen co-integration test. If you find any co-integration equation, use the V.E.C. model. However, V.A.R. is fine, too, for simplicity. Estimation parameters do not differ drastically – finally, the Granger causality analysis. At the same time, the Granger causality test was carried out, and the corresponding conclusions were finally obtained (Zhong et al.,2019).

3.2. Data specification

The time series of the variables were taken from the official website of Statistics and Census Service of Macau S.A.R. and they were the annual data. The standard form of Cobb–Douglas production function is:

$$Y = AL^{\alpha}K^{\beta}\varepsilon\# \tag{1}$$

However, as more statistical effort was made to balance both sides of the equation, the problem of significant 'residuals' was well identified (Hanif & Arshed, 2016). As such, adding variables to the function, such as education, is academically plausible to potentially lessen the residuals. However, Zhang (2008) pinpointed that the number of students enrolled in higher education and G.D.P. are cointegrated, to avoid estimation error, the number of enrolled students is also considered as an independent variable in the regression. The Cobb–Douglas production function used is expressed by the following formula:

$$Y_t = f(L_t,\ K_t,\ E_t)\ \# \tag{2}$$

where:
Y = total production (G.D.P., billion M.O.P.)
L = labour input (employed population, thousand person)
K = capital input (fixed capital formation, billion M.O.P.)
E = education (the number of enrolled higher education students, person)
t = analysed period (2000–2019)

Since the logarithmic transformation does not change the cointegration relationship of the original variables, eliminate the effects of heteroscedasticity and dimension to a certain extent, this paper performs natural logarithmic transformation on each variable, which is ln(GDP), ln(L), ln(K), ln(E) represents the G.D.P., the employed population, fixed capital formation and the number of students enrolled in higher education. All data are from the official websites of the Macao Statistics and Census Service and the Education and Youth Development Bureau.

4. Results and discussion

4.1. Descriptive analysis

Due to the impact of the COVID-19 epidemic, the data after 2019 fluctuates wildly. Therefore, we use data from 2000 to 2019, a total of 20 samples. In 2019, the total workforce of Macau was 394.6 thousand, with 387.8 thousand employed population

Table 1. Descriptive statistics.

	N	Avg.	Min.	Max.	S.D.
Y (MOP million)	20	237442.95	53938.00	444666.00	150784.58
K (MOP million)	20	44693.90	5093.00	91004.00	28579.24
L (thousand people)	20	306.37	195.30	396.50	73.43
E (people)	20	23452.05	9000.00	36107.00	8642.46

Source: author's own production.

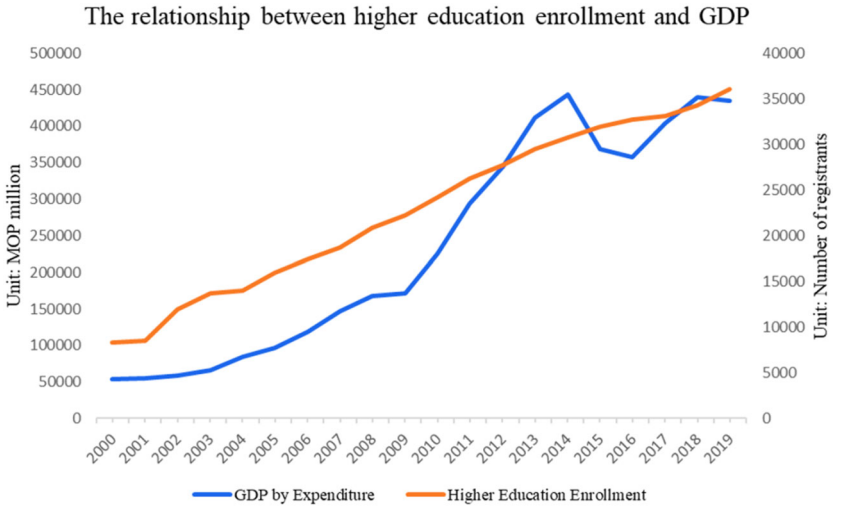

Figure 1. The relationship between higher education enrolment and G.D.P.
Source: author's own production.

(DSEC, 2020). Macau's non-resident workers are a notable feature, with 196.5 thousand workers total, accounting for approximately half of the employed population (Labour Affairs Bureau, 2020). In 2019, there were 184.5 thousand employees with higher educational attainment, which made up 38.30% of the entire workforce (DSEC, 2020).

The descriptive statistics results were given in Table 1, showing that Macau's G.D.P. was the lowest in 2000, at 53,938 M.O.P. million, and the highest in 2018, at 444,666 M.O.P. million. The fixed capital formation (K) had a minimum of 53,938 M.O.P. million in 2001 and a maximum of 91,004 M.O.P. million in 2015. The labour force (L) was the lowest at 195.3 thousand in 2000, and the highest in 2015 was 396.5 thousand. Registered students in higher education (E) was the lowest in 2000 at 9,000 and the highest in 2019 at 36,107.

Figure 1 shows that from 2000 to 2019, Macau's G.D.P. and the number of higher education student enrolments showed an upward trend. However, G.D.P. fell abruptly in 2014 before rising again in 2017. The number of higher education student enrolments has maintained a steady upward trend, and a specific correlation exists between G.D.P. and the number of higher education student enrolments.

4.2. Pearson correlation analysis

When Table 4 is evaluated, according to the results of the correlation analysis, It was determined that there was a high level of a statistically significant relationship in the

Table 2. Pearson correlation analysis between G.D.P. and higher education enrollment.

		Gross domestic product	Higher education enrollment
Gross Domestic Product	r	1	.968*
	p		.000
	N	20	20
Higher Education Enrollment	r	.968*	1
	p	.000	
	N	20	20

$p < .05$*; $p < .01$**.
Source: author's own production.

Table 3. Unit root test result.

		Critical value			
Variables	ADF-Fisher	1%	5%	10%	Result
ln(GDP)	1.67	−2.70	−1.96	−1.61	Non-stationary
d(ln(GDP))	−1.76	−2.70	−1.96	−1.61	10% stationary
dd(ln(GDP))	−4.51	−2.72	−1.96	−1.61	Stationary
ln(K)	0.61	−2.70	−1.96	−1.61	Non-stationary
d(ln(K))	−1.82	−2.70	−1.96	−1.61	10% stationary
dd(ln(K))	−3.83	−2.72	−1.96	−1.61	Stationary

Source: author's own production.

Table 4. Unrestricted cointegration rank test (trace).

Hypothesised No. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.**
None*	0.95	84.01	47.86**	0.00
At most 1*	0.56	31.78	29.80**	0.03
At most 2*	0.48	16.85	15.49**	0.03
At most 3*	0.25	5.15	3.841**	0.02

$p < .05$*; $p < .01$**.
Source: author's own production.

positive direction. These outcomes can be deciphered that as higher education student enrolment increments, the Macau G.D.P. will likewise increment, r=.968, $p < 0.05$.4.3 Unit root test and Cointegration test

To avoid biased conclusions arising from spurious regression problems, the test for stationary property has to be carried out on the time series variables before conducting any regression analysis (Shrestha & Bhatta, 2018). As such, unit root test is necessary before conducting cointegration analysis. After converting all variables into natural logarithm, which transforms the Cobb–Douglas production function into a linear function, the A.D.F. test is conducted to ln(GDP), ln(K), ln(L) and ln(E). (Table 2)

From Table 3 shows that the A.D.F. value of all variables exceed their critical values, so the null hypothesis of not having a unit root in the variables cannot be rejected. However, when the first difference is applied, all variables except ln(E), which is already stationary, are only stationary at 10% critical value. The result of the 2nd difference shows that all variables are stationary.

A cointegration test is imperative before building a regression model (Zhong et al., 2019). It determines whether a group of non-stationary linear combinations are equilibrium by showing result that indicates whether the variables are related in the long run. Although all variables are not stationary in their original series, they are stationary at 2nd difference level, which meet the prerequisites of cointegration test.

Table 5. Unrestricted cointegration rank test (maximum eigenvalue).

Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen statistic	0.05 critical value	Prob.**
None*	0.95	52.24	27.58**	0.00
At most 1	0.56	14.93	21.13	0.29
At most 2	0.478	11.70	14.26	0.12
At most 3*	0.25	5.15	3.84**	0.02

$p < .05^{*}$; $p < .01^{**}$.
Source: author's own production.

Table 6. Granger causality test.

Null hypothesis	Number of lags	F-statistic	Prob.	Result
ln(K) does not Granger Cause ln(GDP)	1	0.13	0.72	Accept
ln(GDP) does not Granger Cause ln(K)	1	0.14	0.72	Accept
ln(L) does not Granger Cause ln(GDP)	1	0.03	0.86	Accept
ln(GDP) does not Granger Cause ln(L)	1	4.67*	0.05	Reject
ln(E) does not Granger Cause ln(GDP)	1	7.28**	0.02	Reject
ln(GDP) does not Granger Cause ln(E)	1	0.57	0.46	Accept

$p < .05^{*}$; $p < .01^{**}$.
Source: author's own production.

By comparing the figures in 'None' row of Trace statistic in Table 4 and the figures of Max-Eigen statistic in Table 5 with their corresponding 0.05 critical values, it is clear that both figures are larger than their critical values. This implies that four variables have cointegration relationships. In order words, they are statistically related in the long run.

After the cointegration test, the potential problem of spurious regression is averted. Using the least squares method, a regression equation is produced regarding ln(GDP), ln(K), ln(L), ln(E). The following equation is the result:

$$\ln(\mathrm{GDP}) = 0.6349 - 0.1171\ \ln(\mathrm{K}) + 1.0656\ \ln(\mathrm{L}) + 0.5547\ \ln(\mathrm{E})\# \qquad (3)$$

R^2=0.9743, DW = 0.9351 (R^2 = residual squared, DW = Durbin-Watson stat). Both R^2 and DW value are adjacent to 1, indicating that model is very optimal. It is apparent that the output elasticity of fixed capital, employed population and enrolled students are −0.1171, 1.0656, 0.5547 respectively. Therefore, 1% increase in fixed capital will bring −0.1171% increase in G.D.P. and 1% increase in employed population will generate 1.0656% increase in G.D.P., while 1% increase in enrolled student will lead to 0.5547% increase in G.D.P.

Apart from that, the sum of the three figures of output elasticity is greater than 1, suggesting returns to scale are increasing. In other words, it is beneficial to expand production scale in current manner.

4.4. Granger causality test

To determine whether there is a causality relationship between the time series, Granger causality test is conducted between ln(GDP), ln(K), ln(L) and ln(E).

As shown in Table 6, the corresponding null hypothesis is accepted when the value in the probability (prob.) column is more significant than 0.05. Hence, fixed capital formation and G.D.P. are not interrelated. ln (L) and ln(GDP) are one-way Granger causality, and the increase in G.D.P. can boost the employed population. In addition,

there is a one-way Granger causality between ln(GDP) and ln(E), which suggests that increasing enrolled students can promote economic growth.

5. Conclusion

Based on the comprehensive indices of education and the panel data model, this study discusses the influence of the higher education scale on economic growth in Macau from 2000 to 2019. A few sound ends are drawn as follows:

First, Macau's G.D.P. and the number of registered higher-education students have grown steadily over the past 20 years, and a high level of a statistically significant relationship is related in a positive direction. These outcomes can be deciphered that as higher education student enrolment increments, the Macau G.D.P. will likewise increment, which reflects that Macau's higher education development still has great potential in the following year.

Second, according to the analysis result, a 1% increase in students enrolled in tertiary education institutions can generate a 0.5547% increase in G.D.P., and it (student enrolled) is the Granger cause of G.D.P. Therefore, quantitative development of higher education is worthwhile for Macau as it can bring G.D.P. growth.

Finally, in general, the higher education development scale exerts a significant positive effect on economic growth in Macau. In addition, labour has a significant positive effect on economic growth in Macau.

5.1. Managerial implications

In the short term, attracting mainland students studying in Macau can stimulate consumption, employment, and the average income of residents (Min & Falvey, 2018). Take the University of Macau as an example; the tuition fee per annum is roughly HKD75,000 for mainland students, and the cost of living is around HKD50,000 per annum. Therefore, one mainland student can contribute HKD11,0000 to Macau per year. Assuming that 50,000 mainland students are to study in Macau, it can generate approximately HKD6.3 billion of revenue. Huang (2003) stated that the consumption multiplier is around 3.3. Computing that with the previous data, the G.D.P. of Macau can be raised by HKD21 billion, which equals 5% of the G.D.P. in 2019 (HKD422 billion). The target of 50,000 students may seem enormous. Nevertheless, it takes four years to complete a bachelor's degree, so it should suffice to attract 12,500 students a year.

In the long term, further development in higher education will provide high-quality personnel to change the economic structure of Macau. Currently, the gaming industry and tourism dominate Macau's economy, which the government seeks to change. In 2002, three Macau-born or bred scholars, Prof Chung Laung Liu, Prof Yum-Tong Siu, and Prof Alfred Wong, said that 'although Macau is a small place, it never affects researching high-technology projects.' Hence, once the personnel requirement is met, other industries like technology or finance will have the conditions to expand.

Due to the insufficient number of local students, policymakers are recommended to reinforce the government's initiative in facilitating internationalisation to attract students around the globe. Jiao (2015) proposed several strategies for the

internationalisation of higher education. In order to improve the international level of higher education, enhance English as the primary teaching language to establish a platform for dialogue with world-renowned colleges and universities. Meanwhile, in the light of Macau's colonial history, Portuguese could be developed as one of its special projects aiming to build Macau as the Portuguese-speaking training centre of East Asia, which could strengthen exchanges and cooperation with institutions of Portuguese-speaking countries.

The excellent academic level is the main pulling force of international students. Thus, reinforcing the research strength of universities should be the core of the whole initiative (Jabbar et al., 2018). This could be accomplished by increasing the investment in the scientific research funds, such as setting up special funds and providing scientific research subsidies, Formulating corresponding scientific research assessment systems such as teacher assessment and promotion system and scientific research awards to encourage teachers to carry out scientific research activities. In addition, colleges and universities can also set up full-time scientific research posts and employ researchers to engage in scientific research to avoid the conflict between teaching and scientific research to a certain extent. Moreover, improving the overall quality of teachers in higher education is also stressed (Niu, 2015). As a result, it is necessary to set up a particular management organisation for overall teaching planning to fulfil the responsibilities of planning, supervision, and management and to avoid fragmentation and localisation of educational institutions. By doing so, these incentives are anticipated to enhance the competitiveness in different aspects of Macau higher education and positively trigger the interest of potential students.

This research mainly demonstrates the relationship between the development scale of Macao's higher education and Macao's economy and has obtained a positive answer. This study selects higher education enrollment as the primary variable to explore the relationship with the local economy, ignoring the quality of education, and the quality of education is an essential consideration for economic development.

In the future, there is still much important work to be finished: whether this model is valid in the current market or not in post-pandemic. Does the quality of education have a more significant impact on economic development, or does the quantity have a more significant impact on economic development? Whether the development of compulsory education has an impact on the local economy. Moreover, the influence discrepancies between private and public universities, the regional difference of the influence, the influence of different economic developing cycles, and the influence of higher education inequality on economic growth quality can be discussed.

Disclosure statement

The authors declare that they have no competing interest.

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Data availability statement

The data used to support the findings of this study are included within the article.

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