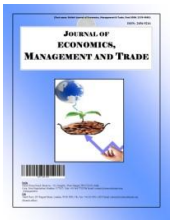

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Empirical Analyses of Tax Base Erosion and Economic Growth: Evidence in China, 1990-2018

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Authors' contributions

This work was carried out in collaboration among all authors. Author YKW designed analyzed the study. Authors LZ, WMH and FJL interpreted and prepared the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Dixon [1] defines subterranean economy(SE) as a mixture of nonmarket economic activities, including home production, prohibited production and distribution of proscribed substances and legal market activities that are concealed for reasons such as tax-evasion. Whilst the existence of SE in most countries. Up to now there are lack of consensus on the appropriate methodology for estimating its turning point. This paper seeks to shorten this gap by using Kuznets approach to analyze this results. We take China as a study case and incorporate some relevant parameters such as GDP, money supply, tax burden ratio to capture all potential dependent variable responses to relevant independent variables change, and further explore whether there exists inverse-U shaped or Kuznets curve (KC) relation between GDP and total tax revenue.

Keywords: Subterranean economy; tax burden; Kuznets curve; tax evasion.

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1. INTRODUCTION

The underground economy refers to economic activities that are deemed illegal, either because the merchandises or services traded are illegal, or because transactions fail to comply with governmental formal regulations. In the 1950s, Kaldor [2] and Cagan [3] mark the beginnings of

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preliminary research of hidden economic activity. Since then, more and more literatures have focused on the relationship between undeclared income and tax erosion. Pissarides and Weber [4] estimate that the real income of self-employed households in 1982 is 1.55 times of the declared income, and that the scale of the underground economy in Britain accountes for about 5.5% of GDP [5]. Feldman and slemrod [6] denote that the voluntary declaration ratio of salary income in the United States is 99.5% in 1987, while only 13.1% of the informal income earners, indicating that the income with declaration documents with a high tax compliance rate. Keith Blackburn et al. [7] find the result that the lower the stage of economic development, the higher the incidence of tax evasion and the greater the size of the underground economy. Habibullah et al. [8] depict the impact of financial development on the hidden economy is non-linear, with the degree of financial development, the hidden economy first rises and then falls, denoting that only under high financial development can it have a negative impact on the hidden economy [9]. However, Schneider and Enste [10] consider there has no clear relationship between financial development and underground economy [11]. Due to the lack of definite and general concurrence in the existing literature on the study of tax revenue and economic growth. Based on the traditional literature, we adopt another perspective and method to explore the correlation among tax revenue, economic growth and the influence of other variables.

2. METHODOLOGY

In this article we propose the Kuznet approach for computing whether the average tax rate has reached an inflection point. Obviously, as GDP increases, taxation should increase, however, if GDP increases, tax revenue does not increase but decreases, which means that the tax burden rate or the so-called real average tax rate is too high. If the average tax rate for a certain period is on the right side of the Kuznet inflection point, denoting that the tax burden rate is too high and there may exist tax evasion, reducing the tax rate may increase the fiscal revenue instead.

This paper mainly discusses the tax evasion and Kuznet's optimal average tax rate through relevant variables such as tax, GDP, government debt, commodity price index, public expenditure, average wages of employees and cash in circulation. In this article, all amount data are measured in RMB and came from the National Statistical Yearbook of the People's Republic of China during the past years.

3. EMPIRICAL ANALYSES

The total tax revenues as a percentage of GDP (tax burden rate) is the most widely used data when comparing the tax levels of various countries in the world. Theoretically, the main reason for the decline in the tax burden rate is that the tax base is not flexible enough. In addition, the increase in tax expenditures and the decrease in investment have also led to the loss of tax revenue. Fig. 1 shows that the tax burden of China first fell and then rose. In the past 10 years, this proportion has been maintained at more than 17%.

Under the current tax system in China, there are 26 types of taxes, which are classified in accordance with their nature and function. We analyze the relationship between total tax revenue and economic growth in the following section.

3.1 BDS Independence Test

In the beginning, the time evolution of tax revenue, GDP in terms of levels (logarithms) are presented in Fig. 2. It can be seen from the logarithm time sequence lines of tax revenue and GDP, showing that the two sequence lines have an obvious increasing trend, and the mean values in different time periods are not exactly the same, revealing that the time sequences are unstable. Furthermore, in Table 1, it is found that the p-value of lntaxrevenue and ln GDP is 0.0000 by BDS time series independence test, both of which reject the null hypothesis of i.i. [12].

3.2 Variance Ratio

Through variance ratio, if a known time series satisfies the condition, the basic property of random walk is that its change is unpredictable, that is, the residual is i.i.d. and the corresponding variance ratio statistics are as follows. The internal method shows the overlapping variation ratio test of Lo and mackinley [13] and the null hypothesis denotes the parameter is a martingale. In Table 2, we note that ln(tax revenue) and ln GDP are not a “martingale process”.

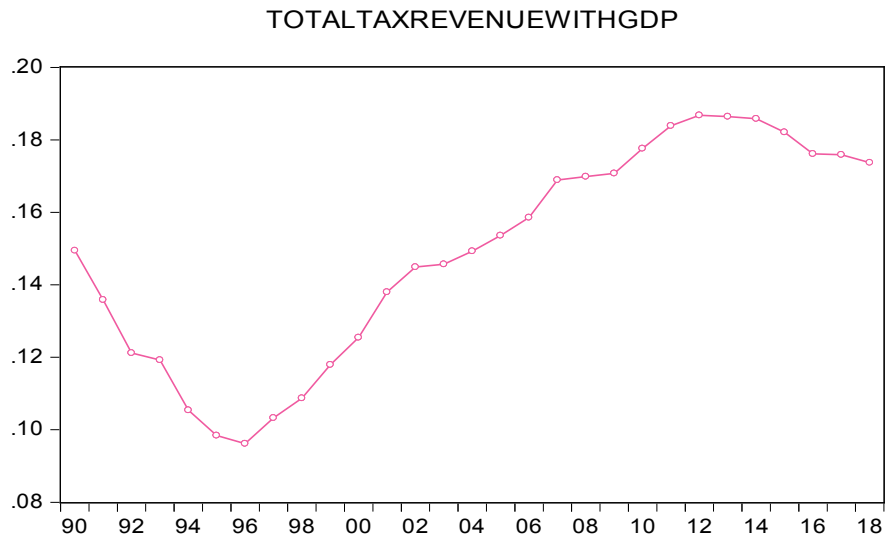


Fig. 1. Total tax revenues as a percentage of GDP, China, 1990 -2018

Table 1. BDS independence test 1990 – 2018

Variable	Dimension	BDS statistic	Std. error	z-Statistic	Prob
ln(tax revenue)	2	0.198385	0.007861	25.23693	0.0000
	3	0.332063	0.012717	26.11249	0.0000
	4	0.424469	0.015414	27.53700	0.0000
	5	0.489362	0.016361	29.90936	0.0000
	6	0.533749	0.016078	33.19680	0.0000
lnGDP	2	0.201436	0.007951	25.33575	0.0000
	3	0.335676	0.012905	26.01066	0.0000
	4	0.429009	0.015696	27.33205	0.0000
	5	0.495130	0.016717	29.61857	0.0000
	6	0.542772	0.016483	32.92888	0.0000

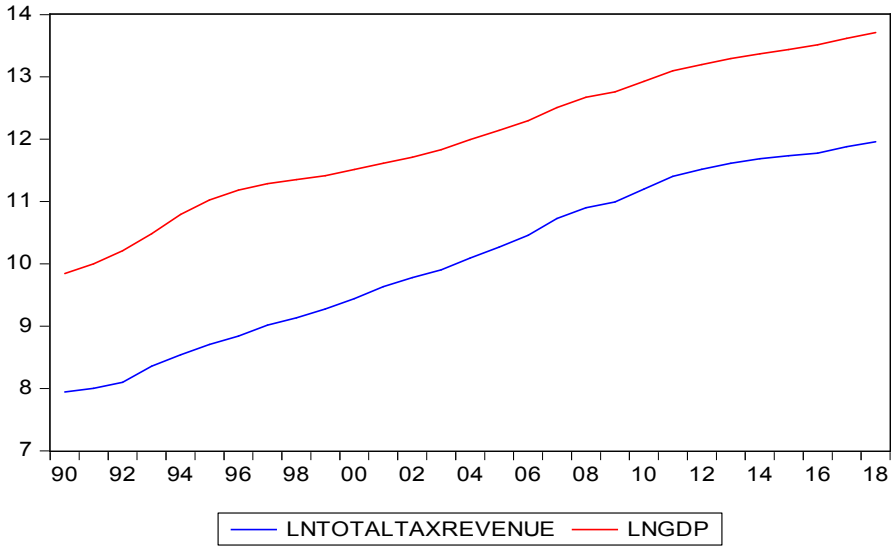


Fig. 2. Time serial analysis on tax revenue, GDP in logarithmic form for China from 1990 to 2018

3.3 Unit Root Test

Next we test the cointegration approach between the tax revenue, GDP for China over a time period ranging from 1990 to 2018, determining whether the stochastic component contains a unit root or not. The results of unit root tests are presented in Table 3, which demonstrates that the ln(tax-revenue) presents stationary at the first-order cointegration under 5% significant level, and ln GDP presents stationary at the first-order cointegration under 1% significant level respectively, depicting the logged variables are I(1).

3.4 Johansen Co-integration Analysis

As indicated in Table 3, which shows that ln(tax-revenue) and ln GDP are I(1) sequence. Hence, we adopt Johansen Cointegration to test whether there exist a long-term equilibrium correlation between ln(tax-revenue) and ln GDP. In Table 4, Trace test shows that there exists a set of cointegrating vectors at the 5% level, and Max-eigenvalue test also indicates the same result. If the non-stationary variables exist co-integration relationship, it implies variables have error correction mechanism in the long run.

3.5 Endogeneity Test

Endogeneity is related to the same period. If the variables fall behind one period, there will be no endogeneity problem. In order to avoid the explanatory variables generated by SUR-OLS became endogeneity, or the explanatory variables have the endogeneity doubt of measurement error, we seek to detect of endogeneity problem.

i. Table 5 denotes the prob (j-statistic) is 0.62664, at 5% significance level, which accepts the null hypothesis that the selected instrumental variable is an effective instrumental variable.
ii. Table 6 presents the prob (j-statistic) is 0.62664, at 5% significance level, representing the GDP (-1) meets the orthogonal condition and is an effective instrumental variable.
iii. According to Table 7, the prob (j-statistic) is 0.8534, accepting the null hypothesis that there does not exist any endogenous relation between dependent variable (tax-revenue) and independent variable (GDP) in our estimating equation.

Table 2. Variance ratio test 1990 – 2018

Variable	Period	Variance ratio	Std. error	z-Statistic	Prob
ln(tax revenue)	2	1.481035	0.190463	2.525611	0.0050
	4	2.057164	0.351952	3.003713	0.0060
	8	2.391122	0.519320	2.678735	0.0290
	16	4.005413	0.713762	4.210666	0.0060
ln(tax revenue) Joint tests	Max |z| (at period 16)	value= 4.210666		df=28	0.0070
lnGDP	2	1.874754	0.289185	3.025103	0.0020
	4	3.046082	0.478119	4.279436	0.0020
	8	1.885626	0.639961	1.383876	0.1440
	16	1.438302	0.798229	0.549093	0.6570
lnGDP Joint tests	Max |z| (at period 4)	value=4.279438		df=28	0.0070

Note: Table 2 supposes the null hypothesis: Variable ln(tax revenue) is not a martingale, variable lnGDP is not a martingale. The $variance\ ratio$: $VR_t(q) = \hat{\sigma}_t^2(q)/\hat{\sigma}_t^2(1)$, *see*

Table 3. Performance of unit root test 1990 – 2018

Variable	N-st difference	(C,T,K)	DW	ADF	5%	1%	Result
ln(tax revenue)	1	(C,n,1)	2.01	-3.77	-3.58	-4.33	I(1)**
lnGDP	1	(C,n,1)	2.07	-4.67	-3.61	-4.39	I(1)***

*Note: (C, T, K) indicates whether the test formula contains constant term, time trend and number of lagperiods. Standard errors in parentheses: *** means the first-order difference passes the stability test at 1% significance level, ** means the first-order difference passes the stability test at 5% significance level*

Table 4. Performance of Johansen cointegration test 1990-2018

Ho H1	Statistic	5% critical value	Prob**
Trace test			
None*	**29.51768**	**25.87211**	**(0.0168)**
At most 1	**7.049548**	**12.51798**	**(0.3394)**
γ=0 γ≧1			
Max-eigenvalue test			
None*	**22.47813**	**19.38704**	**(0.0173)**
At most 1	**7.049548**	**12.51798**	**(0.3394)**
γ=0 γ≧1			

Notes: γ denotes number of cointegrating equations; in the table, Trace test and Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Table 5. Two-stage least squares test 1990-2018

Dependent Variable: TOTALTAXREVENUE
Method: Two-Stage Least Squares
Sample (adjusted): 2006 2018
Instrument specification: GDP(-1) CENTRALGOVERNMENTDEBT CENTRALGOVERNMENTDEBT(-1)

Variable	Coefficient	Std. Error	t-Statistic	Prob
C	-27300.60	5537.529	-4.930104	(0.0006)
GDP	0.290145	0.022655	12.80697	(0.0000)
SQUAREGDP	9.89E-08	2.04E-08	-4.844647	(0.0007)
R-squared	0.997708	Mean dependent var		95653.00
Adjusted R-squared	0.997250	S.D. dependent var		39465.81
S.E. of regression	2069.656	Sum squared resid		42834752
F-statistic	2163.830	Durbin-Watson stat		0.920407
Prob(F-statistic)	(0.000000)	Second-Stage SSR		1.53E+08
J-statistic	0.236645	Instrument rank		4
Prob(J- statistic) (0.626640)				

Table 6. Instrument orthogonality C test 1990-2018

Instrument Orthogonality C Test
Null hypothesis: GDP(-1) are valid instruments
Specification: TOTALTAXREVENUE C GDP SQUAREGDP
Instrument specification: GDP(-1) CENTRALGOVERNMENTDEBT CENTRALGOVERNMENTDEBT(-1)
Test instruments: GDP(-1)

	Value	DF	Probability
Difference in J-stats J-statistic summary:	0.236645	1	(0.6266)
	Value		
Restricted J-statistic	0.236645		
Unrestricted J-statistic	3.89E-37		

Table 7. Endogeneity test 1990-2018

Endogeneity Test
Null hypothesis: GDP are exogenous
Equation: UNTITLED
Specification: TOTALTAXREVENUE C GDP SQUAREGDP
Instrument specification: GDP(-1) CENTRALGOVERNMENTDEBT CENTRALGOVERNMENTDEBT(-1)
Endogenous variables to treat as exogenous: GDP

	Value	df	Probability
Difference in J-stats J-statistic summary:	0.034132	1	(0.8534)
	Value		
Restricted J-statistic	0.261910		
Unrestricted J-statistic	0.227777		

4. EMPIRICAL RESULTS

4.1 KC Prediction

In order to estimate all the parameters and control the contemporaneous correlation between the heterogeneity and the residual in the equation system. we use SUR-OLS and Kuznets analysis to evaluate the correlation between tax revenue and GDP in China. In Table 8, except the parameters mentioned above, where variable squaregdp denotes $(GDP)^2$, representing a quadratic form to measure the location and curvature of Kuznets Curve, where variable money0 represents the cash supply in circulation. In Model 2 of Table 8, we incorporate merchandise price index variable on the basis of Model 1. In addition, Model 3, Model 4, Model 5 and Model 6 of Table 8, other relevant variables are added step by step for the following discussion.

The next step is to build the sur-ols model of economic growth and related variables and tax changes.

$$\Delta(tax\ revenue)_t = \beta_1 GDP_t + \beta_2 (GDP_t)^2 + \beta_3 (Merchandise\ Price\ Index)_t + \beta_4 (Public\ Expenditure)_t + \beta_5 (Central\ government\ debt)_t + \beta_6 (money0)_t + \beta_7 (wage)_t + \varepsilon_t \quad (1)$$

In Model 2 of Table 8, we add relevant variables on the basis of model 1, where other models we gradually incorporate different variables separately. Due to the lack of official data on electronic payment transactions in China in recent years, this variable does not include in the Table 8.

Case 1: In model 1 of Table 8, revealing an inverse U-shaped relationship between the tax revenue and GDP in China, and the AR(2)(second-order autocorrelation) pass the 1% significance test. Further, we denote that no considering the impact of other variables on tax revenue, China's GDP growth in 2018 has not yet exceeded the inflection point. According to model 1 of Table 8, the inflection point of the quadratic curve is 5,722,298, measured in billion yuan, showing that the total tax revenue under the GDP is maximun, while China's GDP in 2018 is 900,309 measured in billion yuan. This indicates that no considering the effects of other policies, the current GDP of China has not exceeded the inflection point of the Kuznets Curve. Model 1 indicates that with the growth of GDP, tax revenue also increases, revealing that China's GDP has not yet reached the inflection point where the elasticity of tax revenue is equal to 0. Thus, up to now, we find that China's current GDP does not exist serious tax base erosion.

Case 2: In model 2 of Table 8, incorporating merchandise price index variable into model 1, it can be seen that the regression coefficient of merchandise price index is 118.6077, which does not pass the 10% significance test, which indicates that the influence of tax increase caused by the rise of commodity price index is not significant.

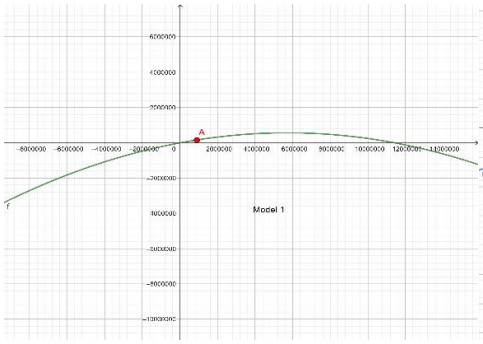
Case 3: In model 3 of Table 8, adding public expenditure variable into model 1, denoting the corresponding regression coefficient is 0.376857, passing the 1% significance test, which denotes that the increase of public expenditure, to a certain extent, may result in the increment of tax revenue. Due to public expenditure is paid through taxes or bonds, we notes that the increment of public expenditure will lead to the increment of tax revenue.

Case 4: In Model 4 of Table 8, the corresponding regression coefficient of government debt is -0.326338, passing the 1% significance test, however, we show the government debt has negative effect on raising tax revenue. According to Ricardo's equality theorem, there is no difference between fiscal expenditure whether it is financed through taxation or bonds, public debt is just a delayed tax.This model shows that government debt does bring tax reduction effect to some extent. In practice, according to the National Bureau of Statistics, China's debt in 2005 was 3,261.4 billion yuan, whereas in 2010 it was 6754.8 billion yuan, and by 2018 it had increased to 149,607.7 billion yuan.

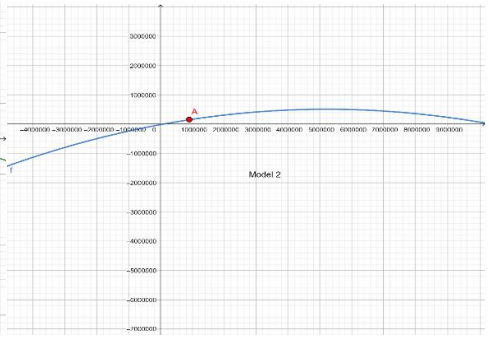
Table 8. Implementation of EK curve - SUR-OLS 1990-2018

Independent variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
GDP	0.199136*** (27.71607)	0.201259*** (27.46917)	0.120668*** (4.896770)	0.274111*** (29.41263)	0.267687*** (4.281824)	0.18021*** (7.135732)	0.311860*** (5.030862)
$(GDP)^2$	-1.74E-08* (-2.028596)	-1.93E-08* (-.235226)	-3.94E-08*** (-3.975240)	-3.80E-08*** (-3.865830)	-4.51E-08*** (-1.701530)	-5.83E-08*** (-4.964436)	-5.74E-08* (-2.645369)
Merchandise price index		118.6077 (1.221819)					-52.54095 (-0.202841)
Public expenditure			0.376857*** (3.287363)				-0.191142 (-1.319202)
Central government debt				-0.326338*** (-4.010457)			-0.308810* (-3.116031)
Moneyo					-0.543300 (-1.103759)		-0.196567 (-0.440779)
Wage						0.864437* (1.860979)	0.646016 (1.178677)
AR(1)	1.657525*** (9.509277)	1.617641*** (9.317572)	1.341313*** (6.667178)	1.321255*** (5.121856)	1.045348*** (5.351733)	1.045348*** (5.351733)	
AR(2)	-0.587963*** (-3.194091)	-0.587397*** (-3.126116)	-0.806681*** (-4.088879)				
Durbin-Watson	0.256986 (D<DL)	0.291674 (D<DL)	0.725755 (D<DL)	2.514461 (4-DU<2.514461<4-DL)	0.263732 (D<DL)	1.710499 (D<2)	2.983492 (D>4-DU)
Breusch-Godfrey LM test: Obs*R-squared	21.11751***	20.07758***	14.17193***	1.490776	22.85346***	11.71933***	10.79437***
Adjusted-R^2	0.997209	0.997554	0.997973	0.999250	0.997232	0.998014	0.999169
γ* (inflection point of KC)	5722298	5213963	1531319	3606723	2967705	1545540	2716550

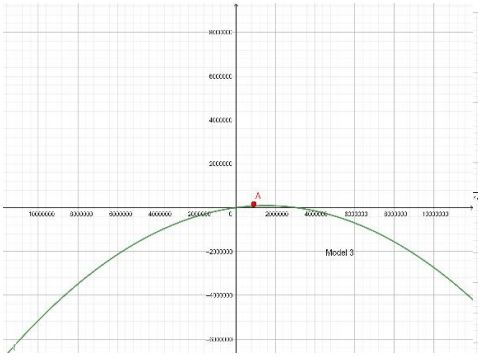
1. In brackets is the t-statistic of the estimated paramete. 2. The GDP in 2016 is 900309 ,measured in billion yuan 3. The table is based on the historical data of the National Bureau of statistics of China.4. DW can only judge the correlation of the first-order sequence and the Breusch Godfrey LM test can check the k-order serial correlation. Because LM =T R^2,it can be determined whether OBS * R-square is subject to the chi square LM Test 5. Robust standard errors in parentheses. p* < 0.10, p** < 0.05, p*** < 0.01*



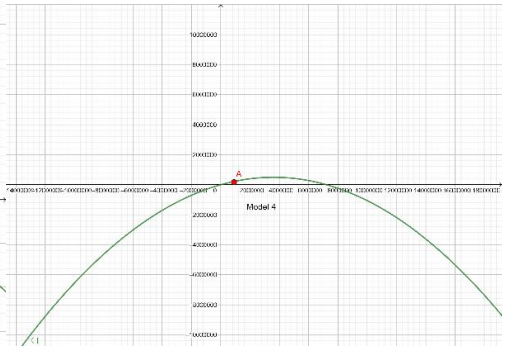
Model 1 in Table 8



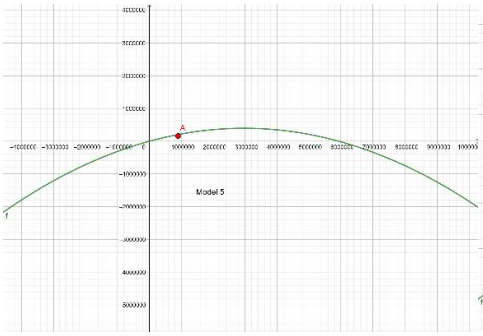
Model 2 in Table 8



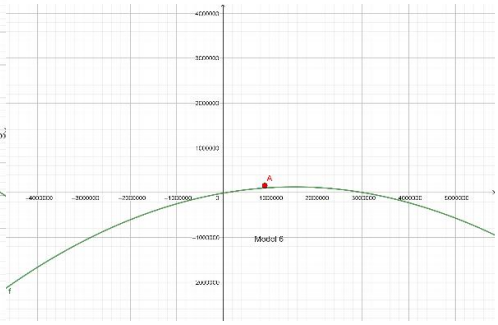
Model 3 in Table 8



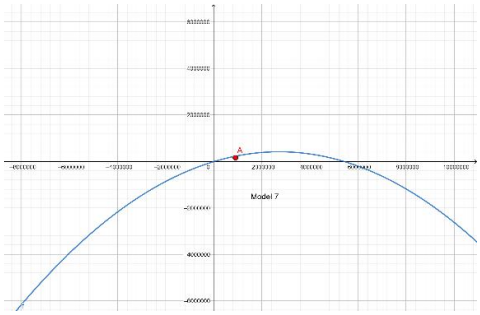
Model 4 in Table 8



Model 5 in Table 8



Model 6 in Table 8



Model 7 in Table 8

Fig. 3. Table 8 (model 1 to model 7), KC prediction on GDP and tax, x-axis is GDP, Y-axis is tax

Case 5: In model 5 of Table 8, adding cash supply in circulation variable into model 1,As is known, people engaged in the hidden economy usually conduct their activities in cash. Most hidden economy activities are, therefore, reflected in additional use of cash. This indicator is captured in M0, where the usual definition of M0 corresponds to the currency outside the banks. In model 5, we show the regression coefficient of merchandise price index is -0.5433, which does not pass the 10% significance test. However, it shows that the effect of tax revenue reduction caused by the rise of cash supply in circulation. Generally speaking, the higher the cash supply in circulation is, the larger the underground economic scale is. In line with Gutmann's [14] view, this paper finds that the increase of cash flow transactions in the market, that is, the increase of underground economic activities, results in the decrease of tax revenue, but it does not reach the significance of 10%.

Case 6: In model 6 by adding average wage of employee variable on the basis of model 1, the corresponding regression coefficient is 0.864437 which pass the 10% significance test, depicting the higher the average wage of employee, the larger the total tax revenue.

Case 7: In Model 7, we insert all relevant variables, indicating that economic growth has a positive impact on tax revenue, with a regression coefficient of 0.311860, passing the 1% significance test. Obviously, the central government debt holds a negative impact on tax revenue, with a regression coefficient of 0.308810, passing the 10% significance test. Indeed, model 7 reveals the issue of government debt does bring tax reduction effect to some extent.

In theory, if the tax base has been eroded for a long time, there would be directly reflected in the decrease of the “income elasticity of tax revenue”. As is known, the low “income elasticity of tax revenue” denotes that even if the economy is prosperous, however, the economic growth does not spontaneously increase the tax revenue. If this situation persists, it will hinder the reduction of deficit. In Model 7 of Table 8 showing that with the economic growth, tax revenue increases spontaneously. Importantly, Models 7 reveals that China's current economic growth has not yet reached the inflection point. Fig. 3 notes the relationship between China's GDP and tax change in the period 1990-2018 for models 1 to 7 in Table 8.

5. CONCLUSION AND DISCUSSION

In this paper, we take China from 1990 to 2018 as an example to explore and estimate the scale of its hidden underground economy. Up to now, there have been many articles discussing the underground economy with MIMIC (multiple indicators multiple causes) model. Hence, we use KC approach instead of MIMIC method to evaluate the underground economy and tax evasion. The policy implications we draw from these empirical results as follows. First, we find that the income tax elasticity of China is still less than 0, and has not reached the turning point of income tax elasticity which is equal to zero. Second, in China, we show that the tax burden ratio first fell and then rose. Clearly, over the past 10 years, this proportion has remained at around 17%. Third, this paper shows that the increment of public expenditure would lead to the increment of tax revenue.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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