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Labor force participation and juvenile delinquency in Taiwan: a time series analysis

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Abstract This study examines the null hypothesis of Granger no-causality between labor force participation (LFP) and juvenile delinquency in Taiwan. In order to explore this issue more thoroughly, this study adopts the approach proposed by Toda and Yamamoto (1995, *Journal of Econometrics, 66*(1–2), 225–250). It uses official time-series data provided by the Government of Taiwan. After estimating both a four- and five-variable VAR system, one that substitutes both male and female LFP rates for the aggregate LFP rate, the primary findings of this study reveal the following: The higher the past juvenile crime rate, the lower the future aggregate and female LFP rate will be. In addition, the higher the past male LFP rate, the higher the future juvenile crime rate will be. These findings are quite robust in terms of different lag-length structures.

Keywords Juvenile delinquency · Labor force participation · Taiwan · Youth crime

Introduction

A spate of events concerning juvenile crime has received a great deal of attention from the public and the media in Taiwan, the media reports cases almost every day. Here are gruesome examples. Two teenagers allegedly kidnapped and murdered a 15-year-old boy then dumped his body in a barrel of cement in December of 2000.[1] A female elementary school teacher was murdered in 1992 by two teenagers who

[1] These two teenagers were indicted by Shihlin district (Taipei) prosecutors, who demanded in December 2000, that they be given the death sentence (Jou, 2000).

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were not arrested until 10 years later.[2] In 2004, five teenagers who attacked a police detective were later questioned for cutting off the policeman's fingers. It is a matter of fact that more and more teenagers are now involved in taking drugs,[3] being members of joy-riding gangs, becoming ''enjokosai'' girls (a euphemism for ''prostitute''), and taking part in sexual abuse. Worse, there is a growing list of examples where high school students are regarded as small-time gangsters who are known to participate in the funerals of major organized crime figures in Taiwan.[4]

Juvenile delinquency is not just a problem in Taiwan, but it is a major issue in most countries. The juvenile crime rate is defined as the ratio of criminal adolescents to all adolescents between the ages of 12 and 18. Although Taiwan's juvenile crime rate has declined since the middle of 1996,[5] as shown in Fig. 1, it is still slightly greater than the overall offender rate. Most juvenile crime in Taiwan is associated with theft or violence and it has received a great deal of attention from the public, the media, and social scientists.[6] Just like adult crime, juvenile crime causes turmoil in society and even discourages foreign direct investment. It could also postpone or arrest adolescent learning from a very early stage.[7] Hence, juvenile crime might damage a country's human capital accumulation more than adult crime, and it may also adversely affect a country's economic development. Viewed in this way, the importance of understanding juvenile crime seems obvious. While many scholars have shed light on this issue, most studies focus only on the labor market conditions that teenagers in need of gainful employment must face.

The relationship between parents' labor force participation (LFP) and juvenile delinquency has always been an important assumption. On the one hand, parental work habits reflect the level of family supervision, while delinquency is associated with the quality of juveniles. In this regard, people make decisions according to leisure needs and the quantity and quality of their children. Under the conditions that their total available time is distributed in two parts, the amount of time spent

2 Taiwan's National Police Administration's Criminal Investigation Bureau announced on August 8, 2002 that a 23-year-old man and a 19-year-old man had been arrested for allegedly murdering a former teacher at Taipei's Hsinhu Elementary School 8 years ago. However, since one was 15 and the other 11 when they allegedly committed the crime, the first youth now 23, could only face up to 2 years of probation, while the other, 19, was exempt from the death penalty or even a life sentence (Chuang, 2002).

3 For example, ecstasy pills (originally named MDMA, a class-two drug known as ''head-shake pills'' or ''happy pills'' in Taiwan) have spread from Europe to the rest of the world over the last few years. Many teenagers and young adults have experimented with the drug (Yeh, 2002).

4 All of these descriptions are reported by Ko (2000).

5 Monthly and annual data on the criminal adolescent population are provided from the 1992–2003 issues of the *Monthly Statistics of the National Police Administration Ministry* and of the *Taiwan Demography Quarterly, Republic of China*. It is assumed that the monthly adolescent population is the same as the yearly one in a specific year.

6 According to the 1992–2003 issues of the *Monthly Statistics of the National Police Administration Ministry*, theft and violence account for over 50% of juvenile crimes in Taiwan.

7 Mocan, Billups, and Overland (2005) adopted a dynamic model to show that current criminal activity simultaneously increases the criminal human capital of participants and depreciates their legal human capital, thus making future criminal activity more likely. Furthermore, an individual may tend to remain in the criminal sector after a recession ends which conflicts with the predictions of Becker-Ehrlich-type crime models constructed in Becker (1968), Ehrlich (1973), and Block and Heineke (1975).

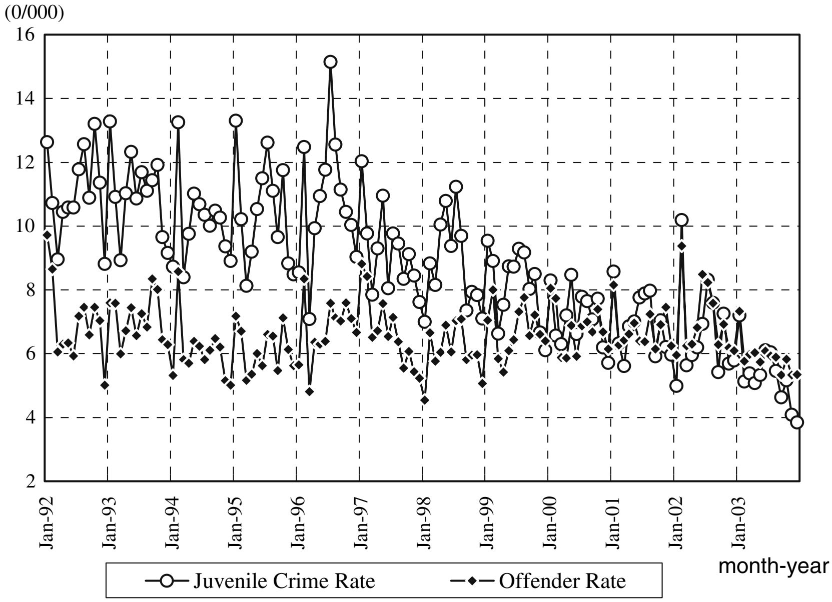

Fig. 1 The Juvenile Crime Rate and the Offender Rate in Taiwan (January 1992-December 2003). Sources: Monthly Statistics of the National Police Administration Ministry (n.d.) and Taiwan Demography Quarterly (1992–2003)

working and the amount of time spent child-rearing,[8] Razin (1980) assumes that the quality of children relies on the total amount of time that parents spend caring for their children, as each family maximizes its utility functions subject to the time constraint. This analysis is basically in the spirit of Becker (1965) and Gronau (1977).[9] The argument seems obvious. The greater the time a family spends at work, the less time they spend on child-minding, and this, therefore, will diminish the quality of their teens. Further, the less supervision, the higher the probability is that these teenagers will engage in criminal behavior.[10]

Family supervision, therefore, plays a deciding role in juvenile crime. This implies that LFP of the adult and the proportional time lost on child-minding will play an important role in a teenager's propensity to crime. Since many families in Taiwan have similar choices with regard to work and supervision, this study proposes that there is a causal linkage between aggregate LFP rate and Taiwan's

[8] In fact, the components of T could include working time, child-minding time, and leisure time other than sleeping time. However, for simplicity, this study assumes that T consists only of the first two components without changing the analytical results. The author thanks anonymous reviewers of *JFEI* for pointing this out.

[9] Since Razin (1980) discussed primarily the issue of a mother's birth spacing, in actual fact, the quality of children is defined as the total amount of time that a mother spends caring for her children.

[10] This hypothesis is also supported by Cookston (1999) in that the role of parent supervision can have a positive impact on deterring the rate of adolescent problem behavior acquisition.

juvenile crime rate.[11] Although there is literature discussing the relationship between youth crime and family supervision vis-à-vis LFP, few studies have examined this causal relation empirically. Hence, this study aims at conducting the first research to examine a Granger causality relationship between aggregate LFP rate (including both male and female) and the juvenile crime rate. To accomplish this task, this study uses Taiwan's official time-series data from January 1992 to December 2003 and an approach proposed by Toda and Yamamoto (1995).

The remainder of this paper is organized as follows. Section ''Literature review'' reviews related literature, followed, in Sect. ''Methodology,'' by an illustration of the empirical model used to perform the Granger no-causality test as proposed by Toda and Yamamoto (1995). Section ''Empirical results of the granger no-causality test'' presents the empirical evidence, and the robustness of the empirical results are considered. Finally, Sect. ''Concluding remarks'' outlines and discusses the conclusions.

Literature review

Many scholars to date have engaged in research regarding the relationship between female LFP and crime, but not in regard to juvenile crime. Kwon (1996) asserted that the influence of women moving into the labor market with no concomitant decrease in male LFP has increased the opportunity for juvenile crime and so has potentially increased the supply of under-age criminals. Mocan and Rees (2005) tested the economic model of crime for juveniles and separately explored the determinants of selling drugs and committing assault, robbery, burglary and theft for males and females using micro data.[12] It was found that violent crime arrests, local unemployment, local poverty, family poverty, local characteristics, and family supervision play important roles in juvenile crime. Witt and Witte (2000) estimated a vector error correction model (VECM) that provided strong evidence that the time series for crime and female LFP share a common trend. It further suggested that factors associated with an increase in female LFP are also related to the juvenile crime rate.

Regarding the relationship between juvenile delinquency and LFP, only statements without empirical evidence have been made in the corresponding literature. Kwon (1996) indicated that married women and highly educated women in South Korea contribute to its relatively low crime rate and that murders attributed to teens are low compared with their counterparts in the United States.[13] Witt and Witte (2000) explained that children, particularly teenagers, are often subject to much less supervision, which is one of the effects of increased female LFP on juvenile crime.

[11] This study uses a micro-level family theoretical model, not a macro-level one, and later adopts a macro time-series empirical model. By doing this, there may seem to be a lack of connection between them, but this is quite common in many studies, such as Becker (1998) who used a micro-level family theoretical model to explain the decline in the fertility rates in Taiwan and the United States. The author thanks anonymous reviewers of *JFEI* for pointing this out.

[12] They used a nationally representative sample of 16,478 high school children surveyed in 1995.

[13] Even though they are discriminated against and the female LFP rate in South Korea is relatively low as pointed out by Monk-Turner and Turner (1994), mothers stabilize the family unit, raise children properly, and further lower the youth crime rate.

Moreover, they asserted that the short-run effect of increased LFP on crime may be significantly higher than its long-term effect.[14]

Witt and Witte (2000) asked whether "increases in female LFP have more influence on some types of crime than on others?" Their study indicated the rise in gang-related activity and violent crime is associated with increased LFP of women and that it may influence violent crime by youth in particular. For example, one factor could be the lack of adult supervision in residential neighborhoods during working hours. However, they left this issue for future research which few scholars have shed light on particularly concerning the relationship between LFP and juvenile crime. On the other hand, according to Vander Ven, Cullen, Carrozza, and Wright (2001), the answer to this question is a qualified *no*.[15]

It may also be a mistake to ignore the important role of a father in juvenile delinquency. Some studies support the important role of a father in adolescent problem behavior. Thomas, Farrell, and Barnes (1996) found that for white adolescent males, a non-resident father's involvement buffers the negative effects of single-mother parenting such as delinquency, heavy drinking, or illicit drug use.[16] Flouri and Buchanan (2002) also showed that for boys, early father involvement protects them from later delinquency, lending further support to the idea that fathers play an important developmental role in the lives of their sons.[17] But this has been known for a long time in Eastern societies as evidenced by the Chinese quote, "To feed without teaching is the fault of the father." It also implies that fathers play a more important role in adolescent problem behavior than mothers, particularly in Chinese societies.

The relationship between LFP and juvenile delinquency might not be unidirectional, however. When children are prone to misbehaving, both parents are expected to change their labor supply decisions in order to provide more caring for their children. Nonetheless, according to statements from Kwon (1996) and Witt and Witte (2000), the mother seemed to be the primary person to supervise the children due to her secondary worker status in the family. It is thus more likely that juvenile crime is more sensitive to female LFP than to male LFP.

While several statements regarding the relationship between LFP and teenage criminal behavior have been made in the literature, few empirical studies shed light on this issue. In addition, based on the literature, both maternal and paternal LFP may have an influence on youth crime, but in varying degrees. Therefore, this study investigates the possible causal relationship between the juvenile crime rate to both maternal and paternal LFP rates and examines their variable influence upon it.

[14] The reason is that some institutions other than the family, such as schools, child-care providers and employers, require time to find ways of substituting for the supervision and nurturing provided by mothers who stay at home.

[15] They used data from the National Longitudinal Survey of Youth (NLSY) to empirically examine whether the occupational status of mothers has criminogenic effects on their children. They found that the characteristics of maternal work have relatively little or no influence on delinquency, but do have a slight (and complex) indirect effect through the delinquency pathway *supervision* after tracing the effects of work hours and occupational conditions through risk factors to delinquency.

[16] This study is based on a representative household sample of over 600 adolescents and their parents and a multivariate analysis of covariance to obtain this conclusion.

[17] This study uses data from three sweeps of the NCDS. NCDS is a continuing longitudinal study of some 17,000 children born between March 3 and 9, 1958 in England, Scotland, and Wales.

Methodology

Based on the conclusions suggested by previous studies, LFP rate and juvenile crime rate seem to affect one another. Hence, they must be treated separately as endogenous variables within the empirical model. The Granger no-causality test estimated by a vector autoregressive (VAR) system is an appropriate methodology to investigate the bi-directional relationship between these two variables and whether they should each influence the other.[18] Should a bi-variate VAR framework be used without considering other important variables, however, a spurious causality may result. Therefore, this study has adopted a four-variable VAR model that includes the aggregate LFP rate, the juvenile crime rate, real industrial output, and the unemployment rate. The last two variables were chosen given the probable sensitivity of the juvenile crime rate to economic cycles and the labor market.[19]

To undertake our investigation, the four-variable VAR system is described as follows:

$$\begin{bmatrix} \mathrm{JCR}_t \\ \mathrm{LFPR}_t \\ \mathrm{IO}_t \\ UR_t \end{bmatrix} = A_0 + B_1 \begin{bmatrix} \mathrm{JCR}_{t-1} \\ \mathrm{LFPR}_{t-1} \\ \mathrm{IO}_{t-1} \\ \mathrm{UR}_{t-1} \end{bmatrix} + \cdots + B_{k+d_{\max}} \begin{bmatrix} \mathrm{JCR}_{t-k-d_{\max}} \\ \mathrm{LFPR}_{t-k-d_{\max}} \\ \mathrm{IO}_{t-k-d_{\max}} \\ \mathrm{UR}_{t-k-d_{\max}} \end{bmatrix} + C \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix} + \begin{bmatrix} \varepsilon_{\mathrm{JCR}_t} \\ \varepsilon_{\mathrm{LFPR}_{rt}} \\ \varepsilon_{\mathrm{IO}_t} \\ \varepsilon_{\mathrm{UR}_t} \end{bmatrix} \tag{1}$$

where JCR, LFPR, IO, and UR in Eq. (1) represent the juvenile crime rate, the aggregate LFP rate, the real industrial output index, and the unemployment rate, respectively. Term A_0 is an identity matrix and the *B's* are four-by-four matrices of coefficients. Since the variables are not seasonally adjusted, three seasonal dummy variables, S_1, S_2, S_3, are also included to account for seasonal variations.[20] Term C is thus a four-by-three matrix of coefficients. In order to examine the different types of causality between the aggregate male LFP rate and the youth crime rate, and the different types of causality between the aggregate female LFP rate and the youth crime rate, we substitute both aggregate male and female LFP rates for the aggregate LFP rate thus transforming our empirical model into a five-variable VAR system. The juvenile crime rate and three kinds of LFP rates are shown in Fig. 2.

The traditional F-test in a regression system is used to determine whether some parameters of the model are jointly zero. But as pointed out by Toda and Phillips

[18] Some relevant studies in the literature are careful about the endogenous problem. They take the initial inequality level as an explanatory variable of economic growth, such as Persson and Tabellini (1994) and Forbes (2000). In addition, Huang (2003) used the same technique to deal with family issue of divorce.

[19] This paper uses national aggregate time-series data rather than data for smaller sub-national units due to measurement errors. As pointed out by Witt and Witte (2000), in the process of aggregation, many individual oddities have resulted due to the abnormal and failure reports generated by individual police departments. These are averaged out and the outliers are greatly reduced. In addition, due to data limitation, this study cannot find other complete time-series variables for the whole research period and some variables might only be available in the individual-level cross-sectional or panel data, but not in the time-series data, such as family background.

[20] If 0–1 seasonal dummy variables are included in the VAR, then this will affect both the mean and the trend of the y series. Johansen (1995) suggested using centered (orthogonalized) seasonal dummy variables, which only shift the mean without contributing to the trend.

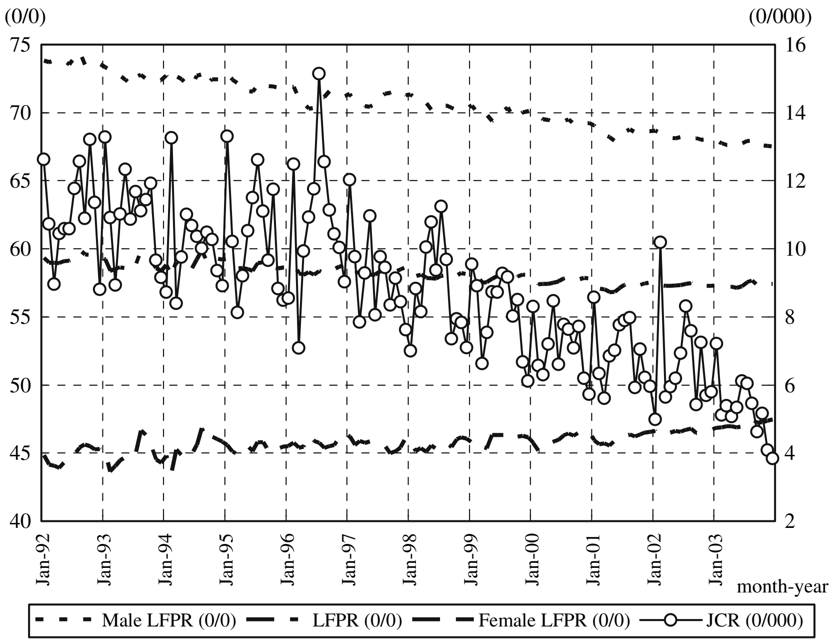

Fig. 2 Taiwan's Juvenile Crime Rates (JCR) and Aggregate Labor Force Participation Rate (LFPR) from January 1992 to December 2003. *Source*. Same as for Figure 1

(1993) and Gujarati (1995), such a test is not valid as the variables are integrated in a stable VAR system and the test statistic does not have a standard distribution. Though several econometricians, like Johansen and Juselius (1990), Mosconi and Giannini (1992), and Toda and Phillips (1993), have tried to improve the power of the Granger no-causality test by developing alternative procedures, Rambaldi and Doran (1996) indicate in their work that these alternatives lose power of simplicity and ease and as Shan and Sun (1998a) concluded "these tests are cumbersome."

Therefore, the current study applies an easy-to-operate and more accurate methodology as proposed by Toda and Yamamoto (1995) and then further expanded by Rambaldi and Doran (1996), and Zapata and Rambaldi (1997). The adoption of this testing procedure for Granger no-causality in a multiple time series is already prevalent in empirical literature (Asai & Shiba, 1995; Hatemi-J & Irandoust, 2000; Shan, Morris & Sun, 1999; Shan & Sun, 1998a, b; Shan & Wilson, 2001; Yamada, 1998).[21] The reason why such a testing methodology has been widely

[21] Asai and Shiba (1995) and Shan and Sun (1998a) used this methodology to investigate the interrelationship between the Japanese stock market and the macro-economy and between domestic savings and foreign investment in Australia, respectively. Shan and Sun (1998b), Yamada (1998), and Hatemi-J and Irandoust (2000) applied this methodology to test the export-led growth hypothesis in different countries. Shan and Sun (1998b) focused on the Little Dragon countries of Asia, including Taiwan, Hong Kong, and South Korea. Yamada (1998) tested this hypothesis in OECD countries. Countries investigated in Hatemi-J and Irandoust (2000) include Greece, Ireland, Mexico, Portugal, and Turkey. Shan et al. (1999) and Shan and Wilson (2001) examined the causality between immigration and unemployment in Australia and New Zealand and between trade and tourism in China by means of this procedure, respectively.

adopted is that it can overcome many of the shortcomings of the alternative procedures mentioned above. Moreover, the method has the elegance of simplicity!

For example, Zapata and Rambaldi (1997) argued that its advantage is that there is no need for the cointegration properties of the system as long as the order of integration is not greater than the true lag length of the model.[22]

The methodology constructed by Toda and Yamamoto (1995) employs a modified Wald (MWALD) test for restrictions on the parameters of VAR(k), where k is the optimal lag length in the system. This MWALD test has been proven to have an asymptotic χ^2 distribution when VAR ($k + d_{\max}$) is estimated, where $d_{\max}$ is the maximal order of integration suspected to occur in the system. Rambaldi and Doran (1996) have mathematically proven that the MWALD statistic can be computed easily by using a seemingly unrelated regression (SUR) form.[23]

Empirical results of the granger no-causality test

The official Taiwan dataset used in our empirical model is comprised of monthly data in real terms (at 2001 prices) over the period from January 1992 to December 2003.[24] Using monthly data gives the model enough degrees of freedom for accurate estimation. The steps taken to conduct the Granger no-causality test are as follows. Before testing for causality between the aggregate LFP rate and the juvenile crime rate, it is necessary to test for the order of integration for each variable. After the maximal order of integration is determined, the four-variable VAR system built into a SUR form, as shown in Eq. (1), is estimated. Finally, the MWALD statistic is calculated to test the Granger no-causality relationship between the aggregate LFP rate and the juvenile crime rate in Taiwan.

Unit root test

In modern time-series econometrics, the first question of interest is whether or not the time series under consideration is stationary. Therefore, before conducting the Granger no-causality test between the various time series, it is necessary to test their order of integration. An Augmented Dickey–Fuller (ADF) test, as constructed by Dickey and Fuller (1979, 1981), is employed to test each time series variable in both

[22] Zapata and Rambaldi (1997) conducted a Monte Carlo experiment and concluded that the MWALD test has a comparable performance in terms of size and power to the likelihood ratio (LR) and the WALD tests if the correct number of lags for estimating $k + d_{\max}$ is identified and if no important variables are omitted, provided that a sample of 50 or more observations is available.

[23] Rambaldi and Doran (1996) showed how readily available routines in RATS, SAS, and SHAZAM can be used to obtain the MWALD test for the Granger no-causality introduced by Toda and Yamamoto (1995). It is possible that the MWALD statistic can be also computed by using other methods, such as FGLS. However, these methods have to be proven before being used. Due to space limitation, for a more detailed mathematical proof, please refer to Rambaldi and Doran (1996).

[24] The LFP rate and the unemployment rate are obtained from the 1992–2003 issues of the *Yearbook of Manpower Survey Statistics, Taiwan Area, R.O.C.* published by the Directorate-General of Budget, Accounting and Statistics, and real industrial output is obtained from the *Industrial Production Statistics Monthly* (n.d.) published by the Ministry of Economic Affairs, Republic of China. Since all of Taiwan's official data are provided in real terms only at 2001 prices, all real terms in this study are in 2001 prices.

Table 1 Basic statistics and unit root tests

Variables	Basic Statistics	
	Mean	Standard Deviation
Juvenile Delinquency Rate (JDR, $^0/_{000}$)	8.795	2.288
Aggregate LFP Rate ($LFPR_a$, %)	58.180	0.723
Aggregate Male LFP Rate ($LFPR_m$, %)	70.621	1.879
Aggregate Female LFP Rate ($LFPR_f$, %)	45.779	0.790
Industrial Output Index (IO, 1996 = 100)	97.120	11.521
Unemployment Rate (UR, %)	2.913	1.313
Variables	ADF unit root tests	
	Constant and trend	Constant but no trend
I. Level		
Juvenile Delinquency Rate (JDR, $^0/_{000}$)	–1.915(24)	1.085(24)
Aggregate LFP Rate ($LFPR_a$, %)	–2.849(13)	–1.095(13)
Aggregate Male LFP Rate ($LFPR_m$, %)	–1.766(22)	0.282(22)
Aggregate Female LFP Rate ($LFPR_f$, %)	–1.753(12)	0.368(12)
Industrial Output Index (IO, 1996 = 100)	–2.273(14)	0.317(13)
Unemployment Rate (UR, %)	–2.034(17)	–0.312(17)
II. First difference		
Juvenile Delinquency Rate (JDR, $^0/_{000}$)	–3.656**(23)	–3.383**(23)
Aggregate LFP Rate ($LFPR_a$, %)	–5.004**(11)	–4.894**(11)
Aggregate Male LFP Rate ($LFPR_m$, %)	–5.363**(21)	–5.378**(21)
Aggregate Female LFP Rate ($LFPR_f$, %)	–5.014**(11)	–5.013**(11)
Industrial Output Index (IO, 1996 = 100)	–3.612**(12)	–3.506**(12)
Unemployment Rate (UR, %)	–3.609**(16)	–3.693**(16)
Critical Value at 5%	–3.448	–2.886

Note. Symbols * and ** denote rejections of the hypothesis of a unit root at the 10% and 5% significance levels, respectively. The critical values are taken from Hamilton (1994). The numbers in parentheses for the ADF tests represent the number of lags included in the regression to ensure white noise

its level and differenced forms.[25] If the null hypothesis of non-stationarity cannot be rejected after conducting an ADF test, then the time series is transformed into a first differentiated form and the same testing procedure is re-applied. The number of lags included is determined using Akaike Information Criteria (AIC).

Table 1 shows the basic statistics of all variables and ADF statistics for each variable and for the first difference. According to the ADF statistics, the null hypothesis of a unit root cannot be rejected for all the series, but it can be rejected for all series in the first difference around a non-zero mean and a non-zero mean with a linear trend. Therefore, it is concluded that all series are stationary after the first difference—that is, they are integrated of order 1, $I(1)$.

[25] The ADF tests for the presence of a non-zero mean and a non-zero mean with a linear trend are carried out by estimating the following two equations: $\Delta y_t = \mu + \gamma y_{t-1} + \sum_{i=1}^{k-1} \delta_i \Delta y_{t-i} + \varepsilon_t$ and $\Delta y_t = \mu + \rho t + \gamma y_{t-1} + \sum_{i=1}^{k-1} \delta_i \Delta y_{t-i} + \varepsilon_t$, where ε_t is assumed to be Gaussian white noise and the lag length is chosen to ensure an approximate white noise that is determined by AIC. These two augmented specifications are then used to test the null hypothesis that H_0: $\gamma = 1$ against the alternative hypothesis that H_A: $\gamma < 0$. If the test statistic is smaller than the critical value, then the null hypothesis cannot be accepted, which means that the variable does not have a unit root.

Granger no-causality test

After carrying out the ADF test, the Granger no-causality test is applied. Table 2 presents the Granger no-causality test results derived from the Toda and Yamamoto (1995) procedure.[26] It is found that a one-way causality from the juvenile crime rate to the aggregate LFP rate (JCR to $LFPR_a$) is significant at the 10% level. Since the sum of lagged coefficients of *JCR* is negative, this suggests that the higher the past juvenile crime rate, the lower the future aggregate LFP rate will be.

As the aggregate LFP rate is replaced by both aggregate male and female LFP rates in the VAR model, there is evidence to support a one-way causality from the aggregate male LFP rate to the juvenile crime rate ($LFPR_m$ to JCR) that is significant at the 5% levels. The positive sum of lagged coefficients of $LFPR_m$ implies that a higher aggregate male LFP rate is tied to a higher juvenile crime rate. Significantly, this study finds that aggregate female LFP rate is not a significant influence on the juvenile crime rate. This is consistent with the findings of Vander Ven et al. (2001).

Another one-way causality can be found in the VAR system with aggregate female LFP rate. It was found that the null hypothesis, the Granger no-causality test from juvenile crime rate to aggregate female LFP rate, can be rejected at the 10% level. According to the sum of the lagged coefficients, this finding implies that the higher the past juvenile crime rate, the lower the future aggregate female LFP rate will be.[27] This finding also suggests that a high juvenile crime rate is an important incentive for a low aggregate female LFP rate. This is *not true* for aggregate male LFP rate. This conclusion is consistent with implications drawn from Kwon (1996), and Witt and Witte (2000).

Robustness

Although the AIC approach has been applied to help with the choice of the optimal lag length in Table 2, a study by Pindyck and Rubinfeld (1991) suggested that "it is best to run the test for a few different lag structures and make sure that the results are not sensitive to the choice of *k*." In order to ensure that the empirical results are not sensitive to the choice of lag length, the model has been estimated using both $k + 1$ and $k–1$ lag structures. Table 2 also presents the estimated *P*-values for different lag structures.

Table 2 shows the results of testing six null hypotheses. For the three hypotheses with primary findings in this study, JDR does not cause $LFPR_a$, $LFPR_m$ does not cause JDR, and JDR does not cause $LFPR_f$, and these results are quite robust by adding an additional lag in the model. It is thus concluded that the results reported in this study are robust and sturdy.[28]

[26] The Granger no-causality test results of variables other than LFPR and JDR are available upon request.

[27] This paper uses AIC to choose the "optimal" lag length of months for the VAR models to be equal to 3. It implies that the effect from the juvenile crime rate to aggregate LFP is about 3 or 4 months. The explanation might be because employees by custom turn in their resignations to employers at least one month before they quit their jobs in Taiwan. Therefore, if a teenager is involved in bad behavior, then the mother exits the labor market after one or even more months. Hence, the optimal lag length of the number of months being 3 based upon AIC should be reasonable. The author thanks an anonymous reviewer of JFEI for pointing this out.

[28] Shan and Sun (1998a, 1998b) used the same method to cope with this issue. They asserted that this robust test is similar to Leamer's Extreme Bound Analysis and this avoids a fragile statistical inference.

Table 2 Granger no-causality test

H_0:	Aggregate labor force participation rate and juvenile delinquency rate		Male labor force participation rate and juvenile delinquency rate		Female labor force participation rate and juvenile delinquency rate	
	$LFPR_a$ does not cause JDR	JDR does not cause $LFPR_a$	$LFPR_m$ does not cause JDR	JDR does not cause $LFPR_m$	$LFPR_f$ does not cause JDR	JDR does not cause $LFPR_f$
Optimal Lag Length (VAR order)	3(4)	3(4)	3(4)	3(4)	3(4)	3(4)
P-values	0.87	0.10*	0.03**	0.77	0.21	0.10*
Sum of Lagged Coefficients	0.39	-0.02	0.11	4.96×10^{-3}	0.38	-1.48×10^{-2}
Adj. R^2	0.85	0.94	0.82	0.99	0.82	0.87
D-W statistic	2.10	2.08	2.16	2.02	2.12	2.07
SC:χ^2(q = 6)	2.16 (0.90)	5.63 (0.47)	3.07 (0.80)	5.88 (0.44)	2.51 (0.87)	12.27 (0.06)
SC:χ^2(q = 12)	11.25 (0.50)	29.59 (0.03)	14.33 (0.28)	14.15 (0.19)	12.50 (0.41)	39.72 (0)
Lag structure (VAR order)						
k–1 (k–1 + d_{max})	0.23	0.31	0.37	0.95	0.03	0.15
k (k + d_{max})	0.87	0.10*	0.03**	0.77	0.21	0.10*
k + 1 (k + 1 + d_{max})	0.78	0.03**	0.02**	0.24	0.27	0.08**

Note. LFPR, $LFPR_m$, $LFPR_f$, and JDR denote the labor force participation rate, the male labor force participation rate, the female labor force participation rate, and the juvenile delinquency rate, respectively. The symbols **, and * denote rejections of the hypothesis of Granger no-causality at the 5%, and 10% significance levels, respectively. The results for other equations are not reported here for simplicity. VAR order = $k + d_{max}$ where k is the optimal lag length used in the system and d_{max} is the maximum order of integration in the system. Here, it is I(1) according to the ADF unit root test 5. The null hypothesis of SC is that there is no serial correlation in the residuals up to q order, and the numbers in the parentheses are *P*-value.

Concluding remarks

This study aims to examine the null hypothesis of Granger no-causality between LFP and juvenile delinquency in Taiwan. Official data provided by the Taiwan Government and methodology proposed by Toda and Yamamoto (1995) are adopted to conduct the Granger no-causality test by estimating a four-variable and a five-variable VAR system under which the aggregate LFP rate is replaced by both male and female LFP rates. The primary findings of this study are as follows. The higher the past juvenile crime rate, the lower the future aggregate LFP rate and aggregate female LFP rates will be. Conversely, the higher the past aggregate male LFP rate, the higher the future juvenile crime rate will be. These findings are quite robust in terms of the different lag-length structures.

Since individual-level data are not available in Taiwan, this study adopts macro-level data and the Granger causality test to investigate the Granger relationship between the juvenile crime rate and the aggregate LFP rate. The contribution of this study is to provide the first empirical evidence to the important issue of the relationship between the juvenile crime rate and the aggregate LFP rate, which has not been empirically explored by scholars before. However, it is worth noting that the concept of Granger causality is used to investigate whether a set of variables has any prediction power for another set of variables, but nothing more. Nevertheless, this study poses several interesting questions based upon the primary findings:

Is the decision for women to enter or leave the labor force more easily effected by a change in a juvenile delinquency than the same decision on the part of men? Does male LFP have a positive influence on juvenile delinquency? Such follow-up research requires individual-level data to be conducted in an empirical manner in Taiwan or other countries considering this type of question.

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