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ENTREPRENEURSHIP, ECONOMIC GROWTH, AND EMPLOYMENT: A CASE STUDY OF TAIWAN*

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Abstract

In this study, we investigate the relationships among entrepreneurship, economic growth, and employment in Taiwan, by applying the vector autoregression (VAR) model. After estimating the VAR model, using Taiwan's quarterly macro data from 1987 to 2012, our estimated results confirm that entrepreneurship can be helpful to economic growth and employment, with 6 periods of lag, respectively. The boom of real GDP can bring the expansion of employment rate immediately and lag-1 period, but not the reverse. In addition, we also find the mutual interaction between the entrepreneurship and employment rate. Therefore, the government should build an environment that stimulates entrepreneurship.

Keywords: entrepreneurship, new company formation, economic growth, employment rate, vector autoregression (VAR)
JEL Classification Codes: L26, E24

I. *Introduction*

The importance of entrepreneurship in an economy was emphasized in Schumpeter's original publication of *The Theory of Economic Development* in 1911. He pointed out that economic processes are organic and that mechanisms of change come from within the economic system. Entrepreneurship is one of the key mechanisms of economic change. According to Schumpeter, changes in the economic system are driven by innovation. The innovator makes things happen, and the entrepreneur introduces these innovations into the economy. Thus, entrepreneurs are vital players for economic change who transform new knowledge into daily business activities and economic processes (Acs and Armington, 2006). The economic value of new knowledge is often realized by transforming the new knowledge into new products and

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processes. Such transformation might occur in an existing company or through investment in a new venture started by an entrepreneur (Audretsch and Keilbach, 2008). In the case of investment, the economic system changes according to the Schumpeterian insights on innovation. Therefore, economic performance is not only determined by new knowledge creation, but also by the ability and the willingness of innovative entrepreneurs to develop new products and processes based on new knowledge.

Human capital is an important force in human entrepreneurship. The importance of human capital for endogenous economic growth has been emphasized since the 1980s. In neoclassical theories of economic growth, per capita income grows as long as the marginal product of capital exceeds zero and savings is positive. However, the marginal product of capital actually decreases as a result of continuous capital accumulation, in the long term. Therefore, the development of technology is essential to offset the negative effect of capital accumulation on per capita income in the neoclassical model of economic growth. Assuming that the state of technology increases in an economy, it will increase the marginal product of capital (and labor), which will lead to a higher per capita income.

Technological development itself remained unexplored in the neoclassical theory of economic growth until the mid-1980s, when Romer (1986) explicitly pointed out the influences of technological research and development (R&D) on economic growth, and Lucas (1988) modeled human capital as the determinant factor in technical change. In addition, Romer (1990) modeled the endogenously determined technical change by conceptualizing technological knowledge as a nonrival and partially excludable product. The former conclusions imply that R&D may generate technological spillovers (Acs and Armington, 2006, Ch.2; Grossman and Helpman, 1991). The latter conclusions are primarily the personalized, tacit knowledge of individuals and groups, including particular experiences and insights developed and owned by researchers and business people. Acs and Armington (2006) argued that these models have not specified why and how new knowledge is spread, stating that "endogenous growth theory offers no insight into what role entrepreneurial activity and agglomeration effects play in the spillover of tacit knowledge" and that "the essence of the Schumpeterian entrepreneur is missed." In their view, the endogenous model fails to incorporate a crucial element in the growth process: the transmission of knowledge through entrepreneurship or through a company's entry into and existence in the market.

Acs and Armington (2006) developed and empirically investigated entrepreneurial endogenous growth theories from geographic perspectives, using regional data from the USA. Their results suggested that the human capital and economic growth rate in a region could positively influence the formation rates of service firms. However, they did not directly investigate the influences of regional entrepreneurial behavior on economic growth. Audretsch and Keilbach (2008) estimated the relationship between regional economic growth and entrepreneurship using regional data in Germany. Their results supported existence of mutual relationship between these two variables. Both these studies considered the externalities or spillover effects of human capital at a regional level. Thus, the relationship between entrepreneurial behavior and economic growth is analyzed on a regional basis. However, such analysis might contain the "fallacy of composition," which indicates that it might be inferred that something is true of the whole, from the fact that it is true of some part of the whole (or even every part). In addition, the previously mentioned models also ignored the lag effects between entrepreneurial behavior and economic growth. Their relationships are supposed to

exist not only at a regional level, but throughout the economy. If these arguments are true, the policies for stimulating human capital, entrepreneurship, and economic growth in a country should be considered together.

In this paper, we apply the vector autoregression (VAR) model to investigate the relationships among entrepreneurship, economic growth, and employment, using Taiwan's quarterly macro data from 1987 to 2012. Our estimated results confirm that entrepreneurship can be helpful to economic growth and employment, with one and two periods of lag respectively, and that improvement of the employment rate can negatively affect the growth rate of entrepreneurship with three periods of lag. In addition, economic growth can increase the employment rate within two periods of lag, but not the reverse. Accordingly, the government should consider policy measurement, which can directly stimulate entrepreneurship. We review the literature which focuses on the relationships among entrepreneurship, economic growth, and employment in Section II. In Section III we introduce our proposed VAR model Section IV provides the data sources and the empirical results of our VAR model. Section V presents our conclusions and suggestions for policy and further research.

II. *The Literature Review*

In this section, we review literature about the relationships among entrepreneurship, economic growth, and employment. We organize these three variables by pairs.

1. Entrepreneurship versus Economic Growth

Several studies have investigated the relationship between entrepreneurship and sustainable development. Talmaciu (2012) used regional data from Romania to discuss the relationship between degree of entrepreneurship and sustainable economic development. In more developed regions, particularly the north east region of Romania, Talmaciu found collaborative networks and innovative behavior that stimulated entrepreneurship and promoted sustainable economic development. Stefanescu and On (2012) analyzed the correlations between entrepreneurial activities and sustainable development in European countries before and during the international economic crisis of 2008. Their results showed how the indicators of entrepreneurship and sustainable development were combined. Kardos (2012) investigated the connections between sustainable entrepreneurship and sustainable development in European Union countries. His results indicate that sustainable entrepreneurship is part of the support system for sustainable development. Hall et al. (2010) discussed the emerging research around sustainable development and entrepreneurship by surveying the previous literature. In their views, entrepreneurship has been recognized as a major conduit for sustainable products and processes, and new ventures are the panacea for social and environmental concerns.

In addition, previous research has focused on the relationship between entrepreneurship and economic growth from a regional perspective. Audretsch et al. (2008) confirmed that regional innovation efforts have a positive impact on regional knowledge-based entrepreneurial activity, which also positively affects regional economic performance. By endogenizing technological change, entrepreneurs act as a "knowledge filter" that commercializes innovations. In the words of Audretsch et al. (2006) "entrepreneurship makes an important contribution to

economic growth by providing a conduit for the spillover of knowledge that might otherwise have remained uncommercialized". Audretsch and Keilbach (2008) suggested that knowledge investments are inherently unbalanced, so that the competitiveness and growth ensuing from knowledge are not equally spread across units of observation. Based on a data set linking entrepreneurial activity to growth within the context of German regions, they confirmed that entrepreneurship serves a conduit of knowledge spillovers. Mueller (2006) tested the hypotheses that entrepreneurship and university–industry relations are vehicles and transmission channels for knowledge flow and therefore encourage economic growth. Li et al. (2012) examined the impact of entrepreneurship on economic growth using a panel data set of 29 provinces in China over 20 years. Their results suggest that entrepreneurship has a considerably positive effect on economic growth. Zsuzsanna and Herman (2012) analyzed the relationship between entrepreneurship, innovative entrepreneurship, and economic development in the EU. They concluded that discontinuity in economic development can be explained by disparities in innovative entrepreneurship.

Yu (1998) discussed the role of entrepreneurship in the manufacturing sector and the economic development of Hong Kong from a nationwide perspective. He argued that the dynamics of Hong Kong's economy are attributed largely to adaptive entrepreneurs, who maintain a high degree of flexibility in their production and respond rapidly to change. Using entrepreneurial strategies adapted from foreign companies, and selling improved commodities overseas, has enabled Hong Kong to catch up with advanced economies. Dejardin (2001) surveyed the endogenous link between entrepreneurship and economic growth. He suggested that, although higher levels of entrepreneurship could result in faster economic growth, economic growth could in turn affect the individual arbitrage between various professional occupations (including entrepreneurship) and expected payoffs. They therefore maintain a mutual relationship. Nyström (2008) reviews the empirical evidence for the effect of entrepreneurship on employment, productivity, and economic growth. He concluded that, in the long term (approximately 10 years) a positive relationship appeared to exist between entrepreneurship and growth, with no evidence of a short -term relationship. Dutz et al. (2000) explored selected relationships between the promotion of competition and economic development that arise as a result of entrepreneurial companies.

2. Entrepreneurship versus Employment

Most studies have discussed the relationship between entrepreneurship and employment from a regional perspective. Fritsch et al. (2005) investigated the impact of new business formation on regional employment, wherein the main effects occurred after a considerable time lag. A large part of this effect was not ascribed to job creation by the newcomers, but rather is caused indirectly. They also assert that the evolution of indirect supply-side effects during new business formation takes some time. New businesses create more employment, but in the longer term. Fölster (2000) investigated the relationship between self-employment and overall employment. An empirical analysis, based on panel data of Swedish counties from 1976 to 1995, suggested that self-employment may have a considerably positive effect on overall employment. Acs and Armington (2004) empirically examined the relationship between knowledge externalities and future economic growth in a regional economy, by modifying the endogenous growth model, with a particular emphasis on entrepreneurial activity and its role in

promoting knowledge spillovers, leading to economic growth. They found that higher rates of entrepreneurial activity were strongly associated with faster growth of local economies and employment. Baptista et al. (2005) questioned whether a positive relationship exists between increases in new firm start-up rates and subsequent employment growth at the regional level. They found that the indirect supply-side effects of new firm births, whether because of greater competition, efficiency, or innovation, are considerably stronger than the direct effects associated with employment creation by the new entrants. However, such supply-side effects occur only after a time lag of 8 years, leading to a pattern of lagged effects. Investigating the relevance of time lags in the effect of new firm births on employment for the regions of Great Britain, van Stel and Storey (2004) found that rates of growth of regional employment are positively shaped by entry occurring in earlier years. Fritsch and Mueller (2004) modeled the lag structure of the effects of new firm entry on regional employment, and found that the net employment effects of new firm formation are small in the year of entry and became negative over the first 6 years. Positive effects only occur after that, peaking around the eighth year and dissipating after the tenth year. Li et al. (2011) examined spatially varying relationships between new company formation and employment growth across US counties, and found that the employment effects of new company formation not only differ between metro and non-metro areas but also differ within metro counties and within non-metro counties.

Nitu-Antonie and Feder (2012) and Baptista and Thurik (2007) examined this issue from a national perspective. Nitu-Antonie and Feder (2012) found that in Romania, Hungary, Croatia, and Latvia, entrepreneurial behavior, stimulated by the general conditions of the national and entrepreneurial framework, did not generate positive effects on the labor market simultaneously, but rather after a time lag of at least three years. Baptista and Thurik (2007) examined the relationship between entrepreneurship and unemployment in Portugal from 1972 to 2002. They concluded that Portugal has been a relative outlier in regard to the effects of entrepreneurship on unemployment, when compared with the average of the Organization for Economic Cooperation and Development (OECD). However, Carod Arauzo et al. (2008) investigated this issue from the perspective of manufacturing industries. They explored the effects of new business formation on employment growth in Spanish manufacturing industries, considering the time lags of new company formation and identifying how long the effect of new company entries on employment lasted. Their results showed that the effects of new business formation are positive in the short term, negative in the medium term and positive in the long term.

3. Economic Growth versus Employment

Saviotti and Pyka (2004) analyzed a model of economic development by considering the creation of new sectors for employment. In each sector, the number of firms first rose up to a maximum and then gradually fell. Sectoral employment followed a similar path. They also concluded that the average employment can continue to rise if new sectors are created at opportune times. Pini (1995) analyzed the relationship between economic growth and technological change in open economies, and studied the effects on industrial employment for nine OECD countries from 1960 to 1990. He confirmed the negative effects of the innovation process on industrial employment because of the accumulation of physical capital. Berdek and Jones (1990) investigated the causal interrelationship between economic growth, technological change, and science and engineering employment. They found that the influence of economic

growth and technological change is highly diverse among industries and occupations and, thus, the relationship between technological change and an increased demand for scientists and engineers is far more complex than is generally realized.

Odhiambo (2009) showed that employment in South Africa caused (Granger-causes) economic growth, but that economic growth did not cause employment. Lee et al. (2012) examined the relationships among women's employment, fertility, and economic growth, by applying a panel structural-vector autoregression model and estimating the variance decomposition. They found that changes in women's employment and fertility rates affect the determination of growth rates.

4. Summary

According to the literature reviewed in Subsection II.1, most studies conclude that entrepreneurship stimulates economic growth. However, none of the studies investigated the inverse relationship. Additionally, most studies investigate this relationship from the regional or local perspective, although several are from the national perspective. Few studies have considered the time-lagged effects of entrepreneurship on economic growth.

None of the studies reviewed in Section II focused on the reverse relationship between entrepreneurship and employment. Some studies reviewed in Section II.3 asserted that the growth of an economy can increase employment, nationally. However, some studies questioned the existence of such a relationship in sectorial analysis. As yet, the time-lag effect has not been thoroughly investigated.

The dynamic relationships among entrepreneurship, economic growth, and employment have not been studied. For example, where economic growth might change an entrepreneur's prediction of future profit and success, increasing the likelihood of new company formation, the increase of employment might decrease the likelihood of entrepreneurship, because of the positive labor market.

In this study, we apply the VAR model to investigate the relationships among these three variables, while at the same time considering the time-lag effects of each variable.

III. *Methodology*

The purpose of this study is to investigate the dynamic relationships among entrepreneurship, economic growth, and employment using macro data. We therefore applied the VAR model proposed by Sim (1980), which assumes that all variables in a macroeconomic model are endogenous, without any presumed limitation on their relationships. Three kinds of VAR models are used: reduced-form VAR, recursive VAR, and structural VAR. The first contains the lagged values of each analyzed endogenous variable as the explanatory variables in the regression model, and the second and third include not only the lagged endogenous variables but also the current (contemporary) period of other endogenous variables. The difference between the second and third VAR model is in the form of constraints on the parameters between contemporary values of other endogenous variables. Usually, recursive VAR is used for short-term constraints, and structural VAR is used when long-term constraints of parameters are imposed in the analytical processes. The model selected for analysis depends on the theories

of macroeconomics applied to the analyzed variables. Furthermore, the recursive VAR is a special form of structural VAR and is also called "half-structural VAR". In this study, we apply the recursive VAR as our empirical model.

1. Recursive VAR (half-SVAR)

To introduce the recursive VAR (half-SVAR), we have to consider the reduced-form VAR (p) model first (where p is denoted as the lagged periods of dependent variables included in the explanatory variables). The dependent variables are entrepreneurship (denoted as x_{1t}), economic growth rate (x_{2t}), and employment rate (x_{3t}). The most important difference between the VAR(P) and an autocorrelation (AR) model is that VAR (p) considers the cross-variable dynamics between the variables in the model. The complete model of reduced-form VAR (p) may be written as Equation (1):

$$X_t = \Phi_1 X_{t-1} + \cdots + \Phi_p X_{t-p} + e_t \tag{1}$$

where $X_t = [x_{1t}, x_{2t}, x_{3t}]'$, $X_{t-i} = [x_{1t-i}, x_{2t-i}, x_{3t-i}]'$, $i = 1, 2, \ldots p$, $e_t = [e_{1t}, e_{2t}, e_{3t}]'$, and

$$\Phi_i = \begin{bmatrix} \Phi_i^{11} & \Phi_i^{12} & \Phi_i^{13} \\ \Phi_i^{21} & \Phi_i^{22} & \Phi_i^{23} \\ \Phi_i^{31} & \Phi_i^{32} & \Phi_i^{33} \end{bmatrix}, i = 1, 2, \ldots p \tag{2}$$

We denote Φ_i^{jk} as the effect of variable k on variable j in the lagged i period. If Φ_i^{23} and Φ_i^{23} are both significant, the variables x_2 and x_3 are the mutual influences in lag period i. Therefore, the error terms of each regression (denote as e_t) are correlated, as shown in Equation (3).

$$\Sigma_\varepsilon = E(e_t e_t') = E\left(\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} \begin{bmatrix} e_{1t} & e_{2t} & e_{3t} \end{bmatrix} \right) = \begin{bmatrix} Var(e_{1t}^2) & Cov(e_{1t}, e_{2t}) & Cov(e_{1t}, e_{3t}) \\ Cov(e_{2t}, e_{1t}) & Var(e_{2t}^2) & Cov(e_{2t}, e_{3t}) \\ Cov(e_{3t}, e_{1t}) & Cov(e_{3t}, e_{2t}) & Var(e_{3t}^2) \end{bmatrix} \tag{3}$$

In Equation (3), the parameters in reduced-form VAR are considered difficult to estimate because of the correlations between various equations, i.e. $\text{Cov}(e_{it}, e_{jt}) \neq 0$. However, Enders (2010) points out that the system of reduced-form VAR is a seemingly unrelated regressions (SUR) model with identical regressors and therefore each equation in the system can be individually estimated by the ordinary least square (OLS). In addition, OLS estimates are consistent and asymptotically efficient. Even though the errors are correlated across equations, SUR do not add to the efficiency of the estimation procedure, because all regressions have identical right-hand-side variables.

We can observe that the reduced-form VAR(p) in Equation (1) considers the lagged periods of dependent variables only. To investigate the concurrent effects between endogenous variables, the equation must be modified as follows:

$$X_t = D_0 X_t + D_1 X_{t-1} + D_2 X_{t-2} + \cdots + D_p X_{t-p} + B u_t \tag{4}$$

Equation (4) is the structural VAR model and $u_t \approx WN(0, 1)$ represents the vector of structural shocks. Therefore, Equation (4) is modified as

$$X_t=(I-D_0)^{-1}D_1X_{t-1}+\cdots+(I-D_0)^{-1}D_pX_{t-p}+(I-D_0)^{-1}Bu_t \quad (5)$$

Let $\Phi_j\equiv(I-D_0)^{-1}D_j$, $e_t\equiv(I-D_0)^{-1}Bu_t$ and $\Sigma_\varepsilon=(I-D_0)^{-1}BB'(I-D_0)^{-1\prime}$, then we can rewrite Equation (5) as

$$X_t=\Phi_1X_{t-1}+\cdots+\Phi_pX_{t-p}+e_t \quad (6)$$

Equation (6) is similar to Equation (1), but their estimation processes are different. Equation (6) could not be directly estimated by OLS because of the endogeneity problem between the simultaneous equations. The elements in matrixes $\{D_0, D_1, ..., D_p, B\}$ are unidentified. If we assume B is a diagonal matric and D_0 is a lower triangular matrix, which are defined as

$$B=\begin{bmatrix}B_{11}&0&0\\0&B_{22}&0\\0&0&B_{33}\end{bmatrix} \text{ and } D_0=\begin{bmatrix}0&0&0\\D_0^{21}&0&0\\D_0^{31}&D_0^{32}&0\end{bmatrix},$$

then a structural VAR with such identifications, called "short-run recursive conditions", is called the recursive VAR. Such recursive conditions imply that x_1 is the most exogeneity-oriented variable, and can influence all other variables. In contrast, x_3 is assumed to have no influence on other variables. In this study, we set entrepreneurship as x_1 because it can directly influence economic growth and employment, according to the reviewed literature. We set x_3 as the employment variable for the same reason. By applying the Choleski decomposition, we can directly estimate the matrix $(I-\widehat{D}_0)$ and $\widehat{B}$ and determine that $\widehat{D}_j=(I-\widehat{D}_0)^{-1}\widehat{\Phi}_j$ and $\widehat{u}_t=\widehat{B}^{-1}(I-\widehat{D}_0)\widehat{e}_t$, where $\widehat{\Phi}_j$ is the matrix estimated from reduced-form VAR(p).

Another problem is the lag length that must be included in the reduced-form VAR(p) and recursive VAR model. In this paper, we will apply the Akaike information criterion (AIC), the Schwarz information criterion (SC), and the Hannan-Quinn information criterion (HQ) as the basic conditions to determine the lag length. However, the estimated parameters of lagged variables with the length we adopted from these tests were not significant. Therefore, we applied the lag exclusion test in advance to reduce the lag length included in the reduced-form VAR(p) model.

2. Granger Causality Test

Granger causality was proposed by Granger (1969) and is used as the prediction for causality. If variable x can offer enough information to predict variable y, we say that variable x "Granger-causes" variable y. As for applying the results of the Granger causality test, we could not conclude that x directly causes y if the test result is significant. This is because the test concept of Granger causality is based on statistical theory. We can only conclude that x Granger-causes y. We applied this test before the parameter estimation of reduced-form VAR (p).

3. "Impulse Response Function" and "Variance Decomposition"

In the analysis of a recursive VAR model, we applied the concepts of impulse response function and variance decomposition to predict the mutual influences among variables. Impulse

response function indicates how the changes of each endogenous variable will be influenced by a specific impulse resulting from one of the endogenous variables.

Variance decomposition decomposes the predicted variances of each endogenous variable into various channels, in percentages, showing what percentage of fluctuations of an endogenous variable can be explained by itself and others. If the recursive VAR model is correct, it explains most of the predicted variances of each endogenous variable.

IV. *Empirical Results*

1. The Data

To investigate the relationships among entrepreneurship, economic growth, and employment, we used the quarterly data, specifically the number of new company formation, the growth rate of the real general domestic product (real GDP), and the employment rate of Taiwan from the first quarter of 1987 to the fourth quarter of 2012. Data were collected from the macro database of the national statistics website, maintained by the Directorate General of Budget, Accounting and Statistics of Executive Yuan in Taiwan.[1]

As the proxy variable of entrepreneurship, Acs and Armington (2006) used the new company formation rate of regions in the US, and Audretsch and Keilbach (2008) used the index of entrepreneurship capital in regions of Germany. In other words, numerous alternatives for the proxy of entrepreneurship exist. As for the variable of economic growth, the growth rate of real GDP is often used in the macroeconomic analysis. In our data set, the real GDP was calculated according to the prices in 2006. Finally, we used the employment rate for the proxy of employment, according to the literature list in Table 1 in Nitu-Antonie and Feder (2012). This table indicates that most previous studies applied the employment rate as the proxy of employment. Therefore we used the quarterly employment rate in this study. Table 1 lists the descriptive statistics of the original and logarithm values of numbers of new company formation and real GDP and the original value of employment rate (ER). It indicates the following: the quarterly average number of new company formation is over 10 thousand; the average real GDP is about NT$ 2.35 million; and the average employment rate is 96.79% (the unemployment rate is 3.21%).

2. The Estimated Results of Reduced-form VAR(p)

In this study, we will use the logarithm values of numbers of new company formation and real GDP and the original value of employment rate (ER) to estimate the VAR (P) model.[2]

[1] Please refer to the data published in the "Macro Database" on the website of Directorate General of Budget, Accounting and Statistics of Taiwan's Executive Yuan: http: //ebas1.ebas.gov.tw/pxweb/Dialog/statfile9L.asp (in Chinese).

[2] We did not apply the unit root test to investigate the stationary property for individual variable series but simply and directly estimate the VAR (p) model in levels and rely on standard t and F distribution for testing hypotheses. According to Hamilton(1994, pp.651-653), this strategy has the following features. (1) The parameters that describe the system's dynamics are estimated consistently. (2) Even if the true model is a VAR(p) in differences, certain functions of the parameters and hypothesis tests based on a VAR (p) in levels have the same asymptotic distribution as would

TABLE 1. DESCRIPTIVE STATISTICS OF VARIABLES

Variables	Mean	Maximum	Minimum	Std. Dev.	Obs.
Number of New Company Formation	10207.37	19499	6006	2389.23	104
ln(Number of New Company Formation)	9.206	9.878	8.701	0.22	104
Real GDP(million NT$ at prices in 2006)	2346535	3812389	1025375	810724.5	104
ln(Real GDP)	14.604	15.154	13.841	0.367	104
Employment Rate (%)	96.79	98.76	93.96	1.42	104

Source: Directorate General of Budget, Accounting and Statistics, Executive Yuan, Taiwan.

TABLE 2. GRANGER CAUSALITY TEST OF VARIABLES

Null Hypothesis:	Obs.	F-Statistic	P-value
ln(real GDP) does not Granger Cause ln(NEW)**	100	2.60134	0.0411
ln(NEW)does not Granger Cause ln(real GDP)		0.47414	0.7546
ER does not Granger Cause ln(NEW)**	100	3.96658	0.0052
ln(NEW) does not Granger Cause ER**		7.16217	5.E-05
ER does not Granger Cause ln(real GDP)	100	1.23104	0.3033
ln(real GDP) does not Granger Cause ER**		4.14522	0.0039

Note: ln(NEW): ln(Number of New Company Formation); ER: Employment Rate.

TABLE 3. LAG-LENGTH SELECTION CRITERIA

Lag	Log L	LR	FPE	AIC	SC	HQ
0	-113.932	NA	0.002416	2.487911	2.56908	2.520697
1	293.3172	779.8386	5.05E-07	-5.98547	**5.660797***	-5.85433
2	307.9345	27.05755	4.48E-07	-6.10499	-5.53681	-5.87549
3	328.1042	36.04782	3.54E-07	-6.34264	-5.53095	-6.01478
4	338.0736	17.18143	3.48E-07	-6.36327	-5.30807	-5.93705
5	364.443	43.76185	2.41E-07	-6.73283	-5.43413	**.208248***
6	376.0263	18.48400	2.30E-07	-6.78779	-5.24558	-6.16485
7	388.9482	**9.79525***	**.14e-07***	-6.87124	-5.08552	-6.14994
8	398.3903	13.86183	2.14E-07	**6.880644***	-4.85142	-6.06099
9	404.5831	8.696302	2.32E-07	-6.82092	-4.54819	-5.9029
10	409.6315	6.766987	2.57E-07	-6.73684	-4.2206	-5.72046

Note: * indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Before we implemented the parameter estimation of VAR (p) model, we first applied the pairwise Granger causality test to observe the statistic relationships among the three variables. The testing results are shown in Table 2. We found that: the increase of new company formation and employment rate Granger-cause each other; real GDP Granger-causes new company formation and employment rate only, but not the reverse; Therefore, we expected dynamic interaction between entrepreneurship and employment in the estimated results in VAR

estimates based on differenced data. (3) A Bayesian motivation can be given for the usual t or F distributions for test statistics even when the classical asymptotic theory for these statistics is nonstandard. Therefore, we follow Hamilton (1994)'s recommendation here.

TABLE 4. ESTIMATED RESULTS OF VAR(7) MODEL

Variables	ln(NEW)	ln(real GDP)	ER
ln(NEW)(-1)	0.395096 [3.49506]**	0.00621 [0.47873]	0.002067 [0.16483]
ln(NEW)(-2)	0.148512 [1.29173]	-0.003164[-0.23985]	4.01E-02 [0.29937]
ln(NEW)(-3)	0.014134 [0.12123]	-0.00074 [-0.05532]	0.042637 [0.31367]
ln(NEW)(-4)	0.229002 [2.09695]**	0.003462 [0.27624]	-0.127828[-1.00395]
ln(NEW)(-5)	0.096047 [0.87079]	-0.008743[-0.69076]	0.017132 [0.13323]
ln(NEW)(-6)	-0.105283[-0.97518]	0.021971 [1.77350]*	0.507907 [4.03505]**
ln(NEW)(-7)	0.069315 [0.63430]	0.002067 [0.16483]	-0.361705[-2.83896]**
ln(real GDP)(-1)	0.643921 [0.54569]	0.90998 [6.72056]**	4.886539 [3.55186]**
ln(real GDP)(-2)	-1.149511[-0.78144]	-0.105684[-0.62610]	-3.367866[-1.96370]**
ln(real GDP)(-3)	-1.922369[-1.33251]	-0.07696 [-0.46490]	-2.638239[-1.56851]
ln(real GDP)(-4)	2.597039 [1.75691]*	0.043244 [0.25495]	0.67906 [0.39402]
ln(real GDP)(-5)	0.111034 [0.07762]	-0.073175[-0.44583]	-0.757676[-0.45433]
ln(real GDP)(-6)	-1.75388 [-1.24296]	0.071532 [0.44179]	-0.521728[-0.31713]
ln(real GDP)(-7)	1.304111 [1.17687]	0.20082 [1.57935]	1.546345 [1.19691]
ER(-1)	0.006145 [0.05663]	0.003404 [0.27338]	1.119601 [8.84857]**
ER(-2)	0.178344 [1.19266]	0.012522 [0.72977]	-0.080027[-0.45903]
ER(-3)	-0.235685[-1.81458]	-0.019044[-1.27779]	-0.232715[-1.53677]
ER(-4)	-0.065317[-0.52564]	0.008704 [0.61041]	0.58058 [4.00743]**
ER(-5)	-0.054953[-0.41962]	-0.006792[-0.45201]	-0.647699[-4.24203]
ER(-6)	0.299773 [2.13945]**	-0.013114[-0.81566]	0.157716 [0.96544]
ER(-7)	-0.153176[-1.71590]	0.011121 [1.08571]	0.01987 [0.19091]
C	0.018842 [0.36485]	1.186669 [1.60474]	0.054609 [0.93229]
R-squared	0.656977	0.997999	0.988711
Adjusted R-squared	0.560931	0.997439	0.985551
F-statistic	6.840215	1781.506	312.8032
Log likelihood for individual OLS	61.11967	271.1269	46.23086
Log likelihood for Joint model		399.3174	

Note: ln(NEW): ln(Number of New Company Formation); ER: Employment Rate. Numbers in [.] are the t-statistics. * and ** represent the estimated parameter is significant at 10% and 5% significant level respectively.

(p).

To estimate the reduced-form VAR(p), we applied the lag-length selection criteria to find the optimal length of lag periods included in the VAR model. We ran the default model of VAR(2) and then implemented the lag length selection criteria. The estimated criteria are listed in Table 3. From the results in Table 3, we included 7 lag periods into the reduced-form VAR model. That is, we ran a VAR(7) model. The estimated results are list in Table 4.

According to the estimated results in Table 4, we found that lag-6 period increase of new company formation can positively increase the employment rate significantly and real GDP slightly. These results are consistent with those of previous studies, which conclude that entrepreneurship can improve employment and economic performance, with lagged effects. In addition, several previous studies mentioned that the positive influence of entrepreneurship on employment improvement might occur after 6 to 8 years. However, our estimated results show that such influence might happen in Lag Periods 6, after the increase of new company formation. Such rapid influences of entrepreneurship on employment improvement in Taiwan might be because of the relative powerlessness of unions, or the more active labor market in Taiwan, compared with the European countries analyzed in previous studies.

TABLE 5. GRANGER CAUSALITY TEST (BLOCK EXOGENEITY WALD TEST) FOR VAR(7) MODEL

Dependent variable	ln(NEW)		ln(real GDP)			ER			d.f.
Excluded	X^2	P(X^2)	Excluded	X^2	P(X^2)	Excluded	X^2	P(X^2)	
ln(real GDP)	9.623	0.2110	ln(NEW)	5.418	0.6091	**ln(NEW)**	**26.503**	**0.0004**	7
ER	**20.244**	**0.0051**	ER	5.736	0.5709	**ln(real GDP)**	22.447	0.0021	7
All	34.056	0.0020	All	11.391	0.6551	All	51.537	0.0000	14

Note: ln(NEW): ln(Number of New Company Formation); ER: Employment Rate. d.f.: degree of freedom.

TABLE 6. ESTIMATED RESULTS OF RECURSIVE VAR MODEL

Estimated Restriction	Coefficient	Std. Error	z-Statistic	Prob.
D_0^{21}	0.019715*	0.011478	1.717738	0.0858
D_0^{31}	0.006973	0.098397	0.070867	0.9435
D_0^{32}	5.821603**	0.857512	6.788945	0.0000
B_{11}	0.146544**	0.010512	14.14214	0.0000
B_{22}	0.016566**	0.001189	14.14214	0.0000
B_{33}	0.139904**	0.010045	14.14214	0.0000
Log likelihood		361.8915		

Note: * and ** represent the estimated parameter is significant at 10% and 5% significant level respectively.

TABLE 7. ESTIMATED RESULTS OF RECURSIVE VAR MODEL IN MATRIC FORM

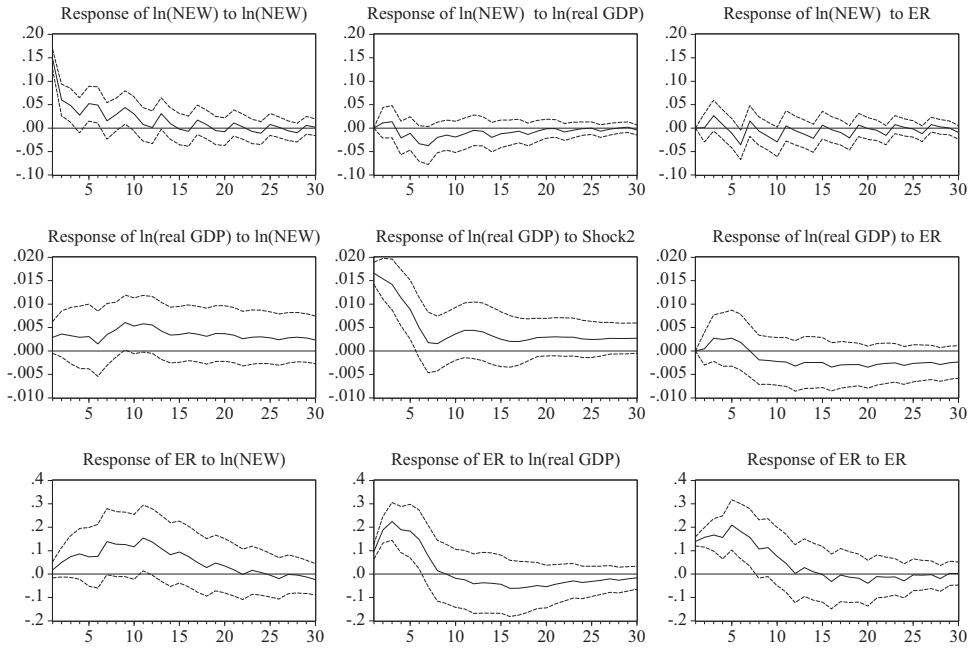
Estimated $(I-\widehat{D}_0)$ matrix:			Estimated $\widehat{D}_0$ matrix:		
1	0	0	1	0	0
-0.019715*	1	0	0.019715*	1	0
-0.006973	-5.821603**	1	0.006973	5.821603**	0

Estimated B matrix:		
0.146544**	0	0
0	0.016566**	0
0	0	0.139904**

Note: * and ** represent the estimated parameter is significant at 10% and 5% significant level respectively.

The increase of real GDP with lagg-4 period slightly influences the new company formation. As integrating the estimated results mentioned in above paragraph, it seems implies that the dynamic interaction occurs between real GDP and entrepreneurship. But the existence of this mutual interaction is not so significant because the significance level of their estimated parameters is at 10%. Therefore, further investigation of this dynamic interaction is necessary. In addition, the growth rate of real GDP positively increased the employment rate in the lag-1 period but decreased the employment rate in the lag-2 period, which means economic growth might improve the aggregate employment situation in the short run (after one quarter) but worsen it after a longer period (2 quarters later). This might explain why the previous study did not have a precise conclusion on the influence of economic growth on employment. Previous studies use yearly data to analyze the relationship between economic growth and the employment rate. Such data cannot capture the detail variation in a year. Their analysis only

FIG. 1. IMPULSE RESPONSE FUNCTIONS OF ENDOGENOUS VARIABLES



Note: ln(NEW): ln(Number of New Company Formation); ER: Employment Rate.

captured the synergic effects of four quarters. In this study, we capture the individual effect of every quarter between these two variables and provide a more precise picture of their interaction in a year.

Finally, the increase of employment rate induces more new company formation after lag-6 periods, but has no significant influence on economic growth. Therefore, according to our estimated results, a dynamic interaction also occurs between entrepreneurship and employment rate. As mentioned above, a similar phenomenon happed between real GDP and entrepreneurship. To confirm these two dynamic interactions in advance, we implement the Granger causality test (block exogeneity Wald test) and the test results are shown in Table 5. From the testing results in Table 5, we confirm that the dynamic interaction exists between entrepreneurship and employment rate but not between real GDP and entrepreneurship. In addition, these testing results also consistent with the results of pre-estimation Granger causality test in Table 2.

The dynamic interaction between entrepreneurship and employment rate has not been noted in previous studies. Such interaction is reasonable, because more new company formation will increase the demand for employees and expand the employment rate accordingly. As more employees join the labor market, more interaction between labors and more individual knowledge exchange happen, in terms of knowledge spillover, which will then trigger more new ideas, business, innovations, and products. As a result, more new companies are created.

TABLE 8. VARIANCE DECOMPOSITION OF ENDOGENOUS VARIABLES(%)

	Variance Decomposition of ln(NEW)			Variance Decomposition of ln(real GDP)			Variance Decomposition of ER		
Period	ln(NEW)	ln(real GDP)	ER	ln(NEW)	ln(real GDP)	ER	ln(NEW)	ln(real GDP)	ER
1	100	0	0	2.952083	97.04792	0	1.090451	31.85915	67.0504
2	99.49372	0.503341	0.002935	3.996032	95.96142	0.042546	3.0709	48.94465	47.98445
3	96.40447	1.106771	2.488758	4.254082	94.72987	1.016046	4.796791	54.29781	40.9054
4	94.86362	2.547173	2.589204	4.522787	93.95111	1.526108	6.487289	53.96431	39.5484
5	94.57715	2.709481	2.713372	5.036917	92.83512	2.127967	6.48019	50.54272	42.97709
6	88.91116	5.316273	5.772565	5.111953	92.4952	2.392846	6.940788	48.24743	44.81178
7	85.28119	8.63079	6.088024	6.226166	91.41673	2.357101	10.52343	44.16577	45.31079
8	84.66343	9.331747	6.004824	7.996304	89.36707	2.636622	13.40049	41.55667	45.04284
9	84.28439	9.330849	6.384761	10.95915	86.13849	2.902365	15.85623	39.13636	45.00741
10	82.26207	9.682915	8.055016	12.97242	83.80742	3.220157	17.87333	37.71971	44.40695
11	81.97839	9.960017	8.061592	15.10388	81.37059	3.525532	21.38606	35.98805	42.62589
12	81.88491	9.999192	8.115896	16.78755	79.03935	4.173095	23.95245	34.97797	41.06958
13	81.88081	9.853084	8.266107	17.64101	77.85018	4.508813	25.44661	34.35987	40.19352
14	80.41642	10.46924	9.114347	18.12717	77.00225	4.870578	26.24666	34.12462	39.62872
15	80.11193	10.73204	9.156027	18.70068	76.06548	5.233833	27.25402	33.83022	38.91576
16	79.94879	10.90071	9.150499	19.35088	74.69558	5.953542	27.71049	33.8752	38.41432
17	79.85715	10.88922	9.253629	19.89819	73.63151	6.470301	27.8288	34.13824	38.03296
18	78.8568	11.12996	10.01324	20.2439	72.80477	6.951328	27.77235	34.41609	37.81156
19	78.73428	11.19165	10.07407	20.75305	71.86405	7.382901	27.9076	34.53255	37.55986
20	78.75527	11.18203	10.0627	21.18593	70.8083	8.005777	27.8478	34.68722	37.46498
21	78.76668	11.1519	10.08142	21.5272	70.08028	8.392523	27.79246	34.86489	37.34265
22	78.28423	11.21976	10.49601	21.65845	69.62438	8.717173	27.72618	34.99163	37.28219
23	78.1922	11.23007	10.57773	21.88156	69.12711	8.99133	27.71068	35.0581	37.23122
24	78.23743	11.206	10.55657	22.09738	68.46255	9.440077	27.62013	35.14281	37.23706
25	78.25676	11.19248	10.55075	22.29357	67.95572	9.750716	27.57949	35.24186	37.17865
26	77.95868	11.24004	10.80128	22.39313	67.57173	10.03514	27.58867	35.29467	37.11666
27	77.88543	11.23102	10.88356	22.57265	67.16097	10.26638	27.56931	35.33916	37.09152
28	77.91752	11.20834	10.87414	22.75647	66.62227	10.62127	27.52566	35.38734	37.08701
29	77.92803	11.20612	10.86585	22.92051	66.22085	10.85864	27.52295	35.4237	37.05334
30	77.75932	11.21625	11.02443	22.9897	65.94456	11.06574	27.57329	35.42003	37.00667

3. The Estimated Results of the Recursive VAR Model

(1) Model estimation

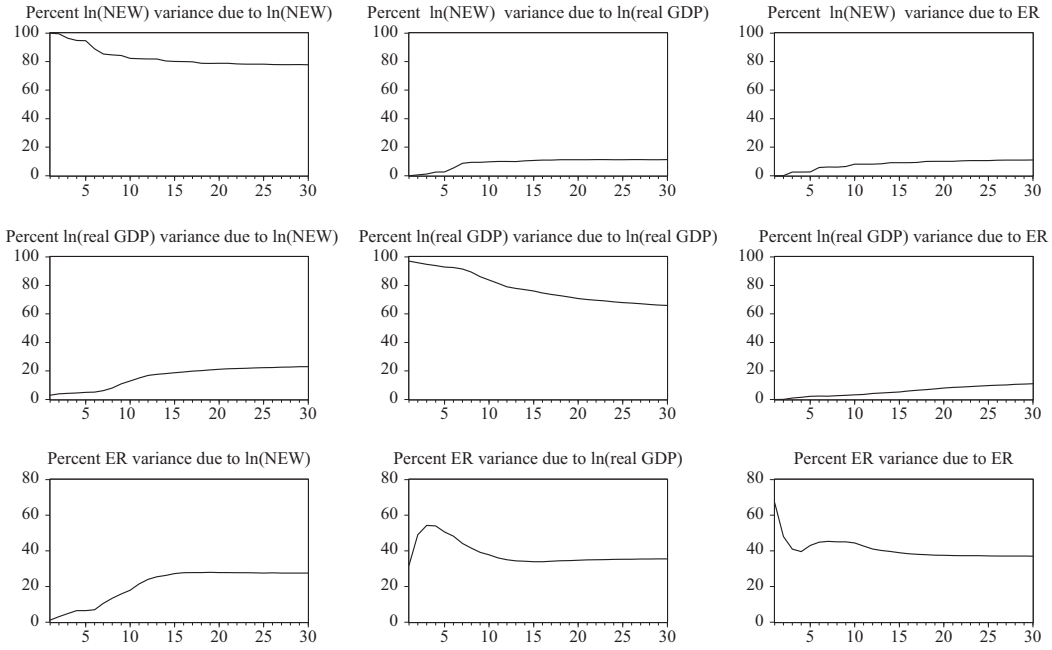
The analysis of VAR (7) in Subsection IV.2 did not include the values in the current period of other variables in the model. Therefore we could not observe the contemporary interactions between variables. To capture these contemporary effects, we assumed the restrictions of matrix D_0 as shown on page 12. That is to say, the current relationships between variables are as follows:

$$e_{1t}=B_{11}u_{1t},\ e_{2t}=-D_{21}e_{1t}+B_{22}u_{2t},\ e_{3t}=-D_{31}e_{1t}-D_{32}e_{2t}+B_{33}u_{3t}.$$

Then we estimated the $(I-\widehat{D}_0)$ and $\widehat{B}$ directly. Table 6 shows the estimated results of $(I-\widehat{D}_0)$ and $\widehat{B}$, and we rearranged them as the matrix form in Table 7.

The estimated results in Tables 6 and 7 show the concurrent effects among the new

FIG. 2. VARIANCE DECOMPOSITION FOR ENDOGENOUS VARIABLES



Note: ln(NEW): ln(Number of New Company Formation); ER: Employment Rate.

company formation, real GDP, and employment rate, because the matrix $\widehat{D}_0$ is identified. Additionally, the increased of new company formation slightly influenced the real GDP but not the employment rate concurrently. It requires 6 periods to hire employees and then increase the employment rate for new companies. Instead, the current real GDP can significantly increase the contemporary employment rate. Therefore, the increase of current new company formation can expand the economy slightly and the current real GDP can increase the employment rate significantly and immediately. Combine the estimated result in table 4, we conclude that an economic boom immediately improves the employment rate and can last for the next period.

(2) Impulse response function and variance decomposition

To understand the response of each endogenous variable to the impulse of others, we prepared graphs of impulse response functions with a confidence interval, in Figure 1. We found that the main responses of new company formation were come from itself, and the response to the real GDP and employment rate was less than 0.05. In addition, most responses of the real GDP are distributed by their own impulses. The response to the new company formation and employment rate was very small (less than $\pm$ 0.005). Finally, other than the impulses generated by itself, the response of the employment rate to the real GDP is positively higher than to new company formation in period 1-5 but lasts shorter(less than 10 periods). But its response to new company formation is higher than real GDP after period 8 and lasts longer.

Finally, we also applied the variance decomposition for endogenous variables after our estimation of recursive VAR. From the estimated results in Table 8 and Figure 2, we found that, except the employment rate, new company formation and real GDP contributed to themselves more. Almost 80% of growth rate of new company formation and 70% of real GDP generated by themselves in the long run. On the contrary, ER contributed to itself for 37% only but 35% is contributed by real GDP and 28% come from new company formation, which means that the relationship between ER and real GDP is stronger than the one between ER and new company formation. Such results are consistent with the estimated results in Table 4 and Table 7 which indicated that the real GDP influenced the ER in current and lag-1 period.

V. *Conclusions and Suggestions*

In this study, we propose a recursive VAR model to investigate the relationships among entrepreneurship, economic growth, and employment. By using the quarterly aggregate data of numbers of new company formation, real GDP growth rate, and employment rate in Taiwan from 1987 to 2012, our estimated results avoided the "fallacy of composition" which exists in the analyses using regional data.

Our empirical results show that entrepreneurship can not only stimulate economic growth, but also the employment rate, with lagged effects. Additionally, economic performance can significantly positively influence the employment rate, both immediately and over one lag period. However, economic growth negatively influences employment rate after two periods of lag. We also found that only the entrepreneurship and employment rates had mutual interaction effects, but not entrepreneurship and economic performance or economic performance and employment. However, the relationship between ER and real GDP is stronger than the one between ER and new company formation.

Based on our analysis, we propose that the implementation of a policy to promote more new company formation would be valuable in stimulating economic development and expanding the aggregate employment rate. Additionally, the dynamic reaction between entrepreneurship and employment also implies that the government should encourage workers to participate in the labor market, which might result in the spillover of personal knowledge, expand the nationwide knowledge pool, and lead to the creation of new ideas, innovation, products, and companies.

As for future study, our VAR model could be expanded, including data from more countries, and the differences in the estimated results compared. Our model may also be expanded to the panel (structural) VAR.

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