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Analysis of structural changes in the relationship between regional housing markets in Taiwan

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Abstract

This paper examines both the long-run and short-run relationships among the four regional housing markets in Taiwan, under the structural change framework. The empirical results demonstrate that the regional housing markets have a cointegration relationship and the long-run relation has two structural changes. One turning point occurs in the 2000Q1 and is related to the economic recession; the other one is in the 2003Q2 and is related to the boom in the Taiwan housing market. The generalized impulse responses show that the shock of any single regional housing market will affect the other three markets. This paper demonstrates the existence of a ripple effect in Taiwan's regional housing markets.

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I. Introduction

The national housing index has attracted considerable attentions from researchers due to its notable impacts on consumption, investment, fiscal and monetary policies, etc. However, an understanding of the national housing market cannot provide much useful information when attempting to comprehend the behavior of regional housing markets since regional housing markets have very different characteristics. Thus, in addition to studies on the national housing index, some literature has explored the relationships among regional housing markets by conducting cointegration analysis or impulse response analysis. This paper continues in the vein by investigating the long-run and short-run relationships among regional housing markets and testing whether these relationships change over time.

The ripple effect in the housing market has undergone extensive examination recently. Two empirical approaches have been taken to investigate this effect. The first approach uses the unit root test to examine the stationarity of the ratio of regional housing prices to national housing prices.[1] If the ratio of the two prices is stationary, then the ripple effect does exist between national and regional housing markets. The other approach adopts the cointegration test to explore the ripple effect among regional housing markets.[2] If regional housing markets have a cointegration relationship, then a long-run relation among these markets will be observed. In order to be able to examine the linkage among regional housing markets, this paper emphasizes the second approach.

Some studies have explored the housing development in Taiwan. Chen et al. (2011) investigated four regional housing prices in Taiwan: Taipei city, New Taipei city, Taichung city and Kaohsiung city. They used the traditional cointegration test and the vector autoregressive model to investigate their linkages; nevertheless, the capability of their specifications to identify the relationships among the four regional housing markets is questionable because they ignored two structural changes observed by Chien (2010).[3] In order to complement the insufficiency of the empirical approach utilized by Chen et al. (2011), this paper adopts the cointegration test with two structural change points proposed by Abdulnasser (2008) to investigate whether and when the cointegration relationship among these four regions changes. After identifying the structural shift points, this study uses the generalized impulse response function of Pesaran and Shin (1998) to investigate the short-run linkage among these regions.

[1] See, for example, Cook (2005), Clark and Coggin (2009), Chien (2010), and Lee and Chien (2011).
[2] See, for example, MacDonald and Taylor (1993), Ashworth and Parker (1997), Meen (1999), Leishman and Watkins (2003), Jones and Leishman (2006), and Chen et al. (2011).
[3] Chien (2010) demonstrates that the housing return for Taipei, Taichung and Kaohsiung cities has two different structural changing points over the 1991Q1-2006Q4 period.

This rest of this paper is organized as follows. Section II briefly introduces the cointegration test and the vector autoregressive model with structural changes. Section III reports the empirical results, and Section IV provides the conclusions.

II. The empirical model

This section begins by introducing the cointegration test of Abdulnasser (2008). The main advantage of this test over the traditional cointegration test is that it allows the cointegration relationship to undergo two structural changes and it determines these two change points endogenously. The specification of Abdulnasser (2008) is as follows:

$$x_{1t} = a_0 + a_1 I_{1t} + a_2 I_{2t} + \mathbf{b_0}' \mathbf{x}_{(-1)t} + \mathbf{b_1}' I_{1t} \mathbf{x}_{(-1)t} + \mathbf{b_2}' I_{2t} \mathbf{x}_{(-1)t} + e_t \quad (1)$$

where $\mathbf{x}_{(-1)t} = [x_{2t} \; x_{3t} \; x_{4t}]'$ and $\mathbf{b}_i = [b_{i1} \; b_{i2} \; b_{i3}]'$ for i = 0, 1 and 2. The structural changes are controlled by two dummy variables, I_{1t} and I_{2t}. The structural changes in intercept and slope terms are allowed simultaneously. Let T be the sample size. Let k_1 be located between 0.15 and 0.7 and k_2 be located between $0.15+k_1$ and 0.85. Dummy variable I_{1t} is 1 if t is larger than the integer part of Tk_1, and its value is 0 if t is not larger than the integer part of Tk_1. Similary, I_{2t} is 1 if t is larger than the integer part of Tk_2, and its value is 0 if t is less than or equal to the integer part of Tk_2. Obviously, the integral part of (Tk_1+1) is the first structural change point and the integral part of (Tk_2+1) is the second one.

The testing procedure is based on the principle that if x_{1t}, x_{2t}, x_{3t} and x_{4t} are I(1) variable and have a cointegration relation, then the error term is a I(0) variable. In order to test whether the error term is I(0) and to find the possible structural changing points, Abdulnasser (2008) follows the method of Gregory and Hansen (1996) for extending the Phillips test statistics. The method is presented as follows:

$$Z_\alpha^* = \inf_{(k_1,k_2)} Z_\alpha(k_1,k_2) \quad (2)$$

$$Z_t^* = \inf_{(k_1,k_2)} Z_t(k_1,k_2) \quad (3)$$

Here, the true limiting distributions for the statistics are unknown and depend on the number of variables. Abdulnasser (2008) tabulates the asymptotic critical values for the number of variables from 2 to 5.

The above method examines the long-run relation of regional housing markets. This paper

further investigates their short-run relationships by incorporating the structural changes identified by the above cointegration test. The short-run dynamics of regional housing returns are specified as follows:

$$\Delta \mathbf{x}_t = \boldsymbol{\alpha}_0 + \boldsymbol{\alpha}_1 I_{1t} + \boldsymbol{\alpha}_2 I_{2t} + \boldsymbol{\beta}_0 EC_{t-1} + \boldsymbol{\beta}_1 I_{1t-1} EC_{t-1} + \boldsymbol{\beta}_2 I_{2t-1} EC_{t-1} + \sum_{i=0}^{k} \mathrm{H}_{0i} \Delta \mathbf{x}_{t-i} + \sum_{i=0}^{k} \mathrm{H}_{1i} (I_{1t-i} \Delta \mathbf{x}_{t-i}) + \sum_{i=0}^{k} \mathrm{H}_{2i} (I_{2t-i} \Delta \mathbf{x}_{t-i}) + \boldsymbol{\varepsilon}_t \quad (4)$$

where Δ refers to the first difference, $\mathbf{x}_t = [x_{1t} \ \mathbf{x}_{(-1)t}]'$, EC_t represents the error correction term calculated from equation 1, I_{1t} and I_{2t} are dummy variables defined in Equation (1), and $\boldsymbol{\varepsilon}_t$ follows a multivariate normal distribution. Compared to the specification of Chen et al. (2011), which ignores the possibility of structural changes in Taiwan's regional housing markets, Equation (4) permits the short-run dynamics to have different behaviors when structural changes occur.

The orthogonalized impulse response function has been adopted to investigate the short-run behaviors among variables over a long period of time; however the inconsistent results arising from the different order of variables are the most debated issue. The virtue of the generalized impulse response function of Pesaran and Shin (1998) is that the impulse response functions are the same irrespective of which order of variables is assumed. The next section will discuss the generalized impulse response functions with and without structural changes.

III. Empirical results

This paper investigates four housing markets in Taiwan: Taipei, New Taipei, Taichung, and Kaohsiung cities. The cities of Taipei and New Taipei are located in northern Taiwan; Taichung city is located in the middle of Taiwan; Kaohsiung city is in the south of Taiwan. These are the most developed cities in Taiwan and their housing prices are high relative to other cities or counties in Taiwan.[4] The housing prices are taken from the Sinyi Real Estate Company and the sample length covers the period from the 1998Q1 to 2011Q3. Figure 1 plots the natural logarithms of housing prices.

Prior to investigating the cointegration relationships among the four regional housing prices, this paper will implement the unit root tests for the natural logarithms of housing prices. Panel A of Table 1 shows the existence of a unit root for each housing price as indicated by the augmented Dickey and Fuller test and the Phillips and Perron test. Panel B of Table 1 shows

[4] See Chien (2010), Chen et al. (2011) and Lee and Chien (2011) for their elaborate introduction to the developments and characteristics of the four cities.

that the first-differenced logarithm of the housing index is stationary for each market. The Johansen (1988) cointegration tests displayed in Table 2 show that there is only one cointegration vector. This is consistent with the finding of Chen et al. (2011).

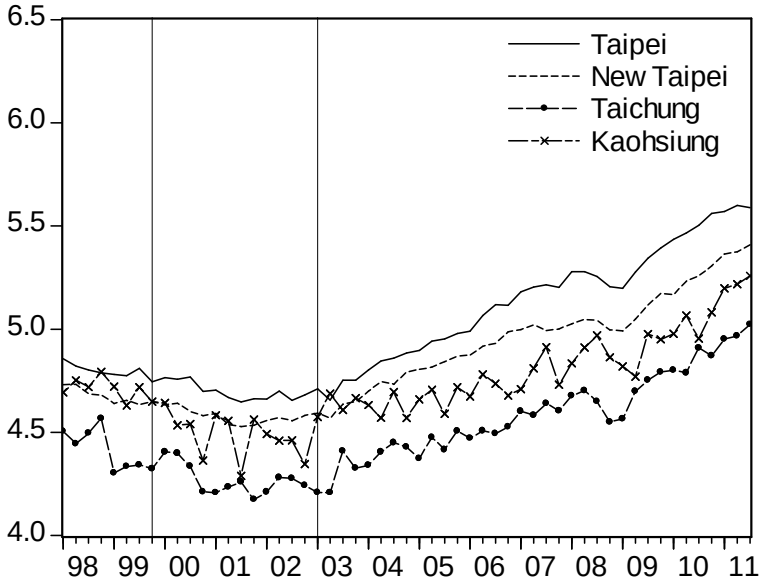

Figure 1 The natural logarithms of housing prices
Note: The vertical lines indicate the structural change points

This paper further utilizes the Abdulnasser (2008) test to detect whether and when the long-run relationships among regional housing markets encounter structural changes. Table 3 reports the test statistics and structural change points. The statistic of Z_t^* is statistically significant at the 1% level, giving evidence of two structural changes. Although the statistic of Z_α^* is insignificant, both the Z_t^* and Z_α^* tests detect the same structural turning points: 2000Q1 and 2003Q2.[5] The first turning point is close to the 2000Q4 breakpoint that appeared in Taipei city, and is observed by Chien (2010). Similarly, the second breakpoint is close to the 2003Q1 breakpoint that occurred in Taichung city, and is also observed by Chien (2010). The first structural change is related to Taiwan's economic recession starting in 2000Q3. The second structural change point is consistent with the point of recovery in the Taiwan housing market identified by the Taiwan Real Estate Research Center.

The estimation results for the cointegration relationship with and without structural

[5] The one structural change model of Gregory and Hansen (1996) has also been implemented. However, the parameter estimates for dummy variables are statistically insignificant, showing that the specification of one regime shift is unsuitable.

changes are displayed in Table 4. Without considering the structural changes, it appears that the New Taipei and Kaohsiung cities affect the Taichung city positively, supporting the results of Chen et al. (2011). Surprisingly, however, the results that take into account the two structural changes are very different from those that do not. More specifically, these results indicate that Kaohsiung city does not affect Taichung city. However, Taichung city has had a long-run linkage with Taipei city after the 1999Q4. The magnitude of positive linkage is higher during the period 2003Q2-2011Q3 than during the period 2000Q1-2003Q1. In contrast to the positive relation held between Taichung and Taipei cities, the Taichung and New Taipei cities are negatively linkage during the period 2003Q2-2011Q3. These results provide evidence for the existence of a ripple effect among some regional housing markets in Taiwan. To sum up, the long-run relationship will be incorrect without considering the structural change effect.

Table 1 Unit root tests

	Taichung	Taipei	New Taipei	Kaohsiung
Panel A: Level				
ADF	-2.410	-2.264	-1.875	-2.852
PP	-2.021	-2.264	-1.875	-2.487
Panel B: Difference				
ADF	-9.391***	-8.038***	-7.455***	-6.402***
PP	-24.239***	-8.034***	-7.454***	-22.098***

Note: ADF is the augmented Dickey and Fuller test. PP is the Phillips and Perron test.

Table 2 Traditional cointegration tests

	Trace statistic	Maximum eigenvalue statistic
None	50.694**	33.271***
At most 1	17.423	11.506
At most 2	5.917	4.151
At most 3	1.766	1.766

Note: *** and ** refer to significance at 1% and 5% levels, respectively.

Table 3 Cointegration tests with two change points

	Z_t^*	Z_α^*
Statistic	-7.9171***	-59.105
Structural break 1	2000Q1	2000Q1
Structural break 2	2003Q2	2003Q2

Note: *** refers to significance at 1% level.

Table 4 Parameter estimates

Parameter	No Break	Two Breaks
a_0	0.262	-6.084
	(1.089)	(-2.138)
a_1		3.687
		(1.082)
a_2		2.587
		(1.362)
b_{01}	0.158	-0.197
	(0.666)	(-0.239)
b_{02}		1.561
		(2.247)
b_{03}		0.881
		(2.296)
b_{11}	0.480	1.322
	(1.692)	(1.113)
b_{12}		-1.139
		(-0.955)
b_{13}		-1.004
		(-2.416)
b_{21}	0.237	-0.858
	(2.831)	(-0.962)
b_{22}		0.024
		(0.023)
b_{23}		0.292
		(1.508)

Note: Values in parentheses are t-values.

This paper continues to discuss the short-run relationships among the four regional housing markets.[6] The generalized impulse response functions with and without structural changes are plotted in Figures 2-5. It can be seen from Figures 2-4 that the structural change specification has similar response functions to the no structural change specification, with the exception of the shock from Kaohsiung city. In general, the impacts of shocks die out in about 2-3 periods. In most cases, the size of the shock from Kaohsiung city is underestimated under the specification of no structural change model. Figure 5 shows that the responses of Kaohsiung city to shocks from Taichung, Taipei and New Taipei cities are smaller in the

[6] For saving space, the estimates for Equation (4) are not reported here. They are available upon request.

structural change specification than in the no structural shift framework. Overall, this paper confirms the existence of short-run spillover effects among Taiwan's regional housing markets.

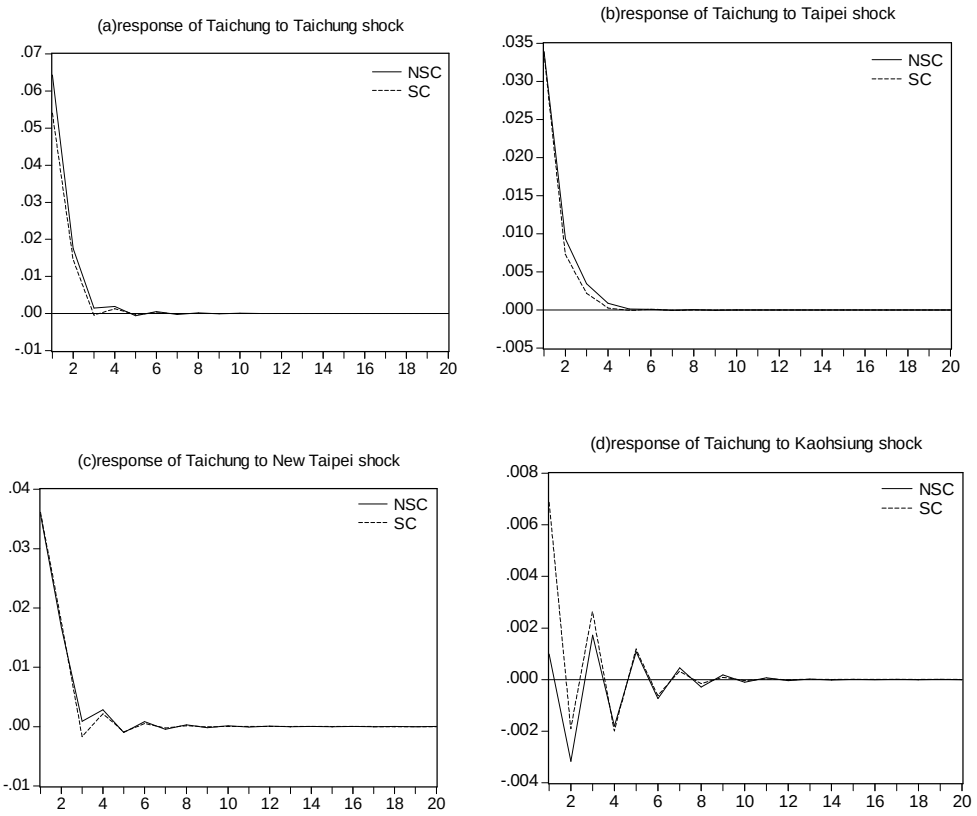

Figure 2 The generalized impulse responses of Taichung housing return

Note: "NSC" refers to the VAR(4) model without structural changes. "SC" refers to the VAR(4) model with structural changes.

IV. Conclusions

Numerous studies have investigated the relationships among regional housing markets in developed countries. However, the literature on Taiwan data is limited. The purpose of this paper was to investigate the cointegration relationships among regional housing markets by using a method that takes into account structural changes, and to investigate the short-run spillover effects of regional housing markets.

This paper demonstrates that if the possible regime shifts in the housing market data are not considered, the estimated long-run relationship will be incorrect. In fact, the long-run relationship among the four regional markets undergoes a change twice, with changing points occurring at 2000Q1 and 2003Q2. The first change takes place in the first two quarters before the recession in 2000Q3. The second one is coincident with the period of rapid development in the Taiwan aggregate housing market. Furthermore, this paper also finds significant short-run

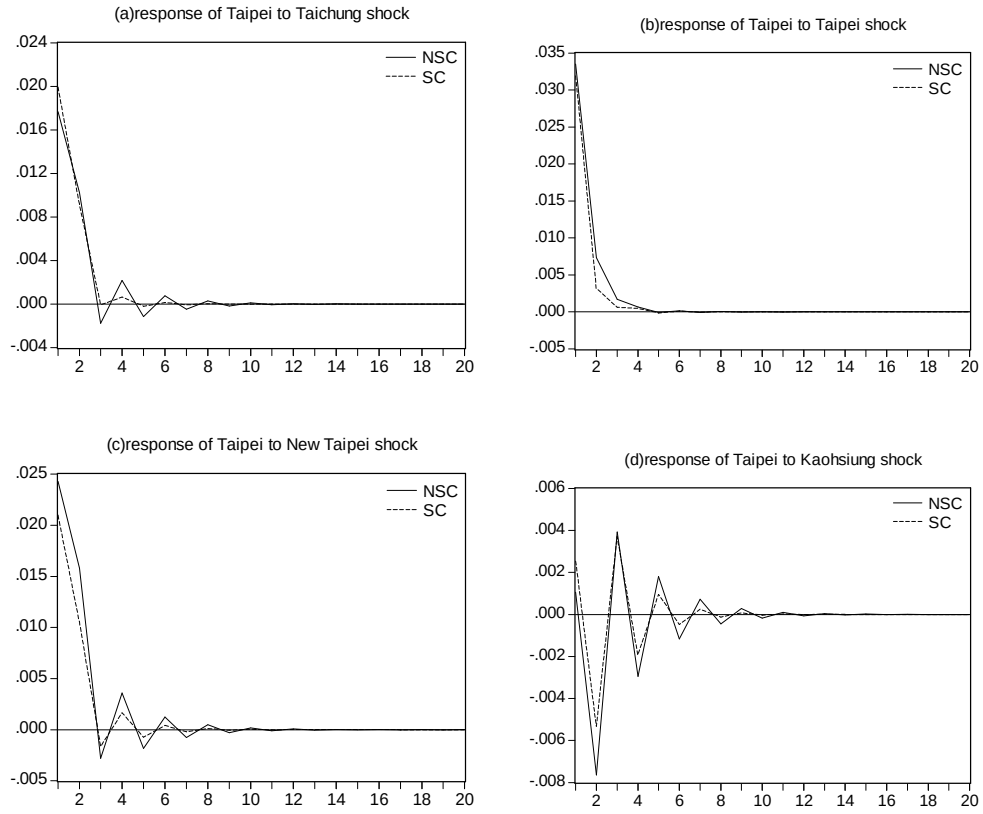

Figure 3 The generalized impulse responses of Taipei housing return

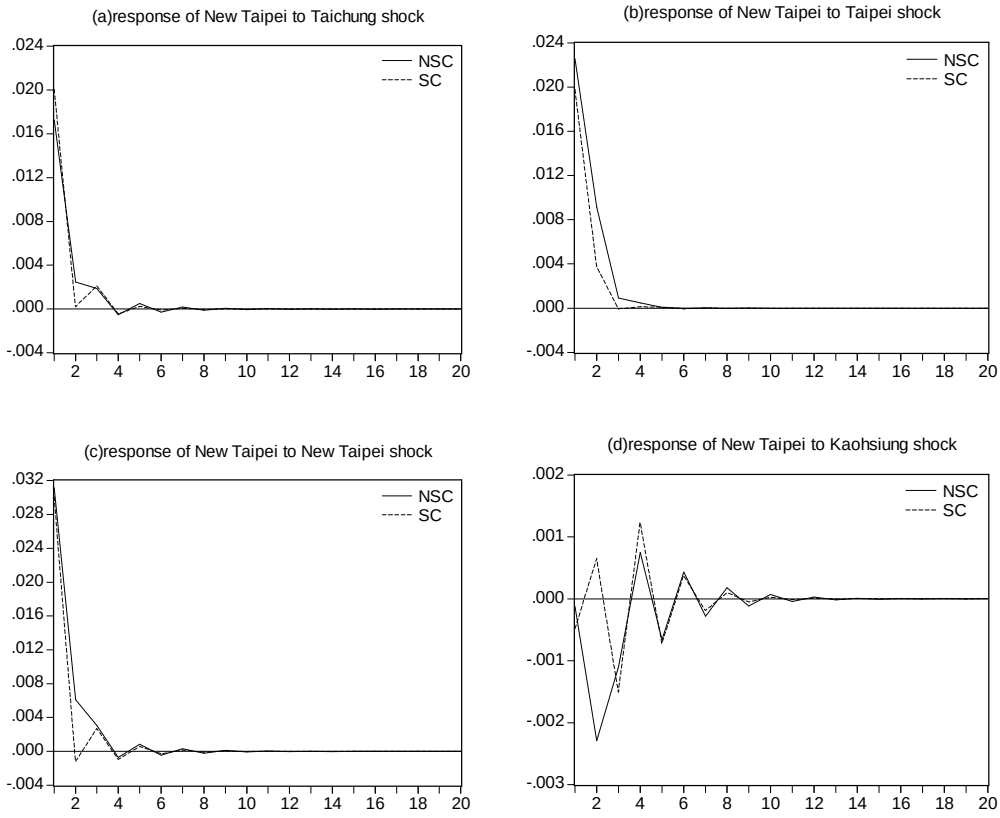

Figure 4 The generalized impulse responses of New Taipei housing return

effects among regional housing markets. These empirical results show the presence of ripple effects.

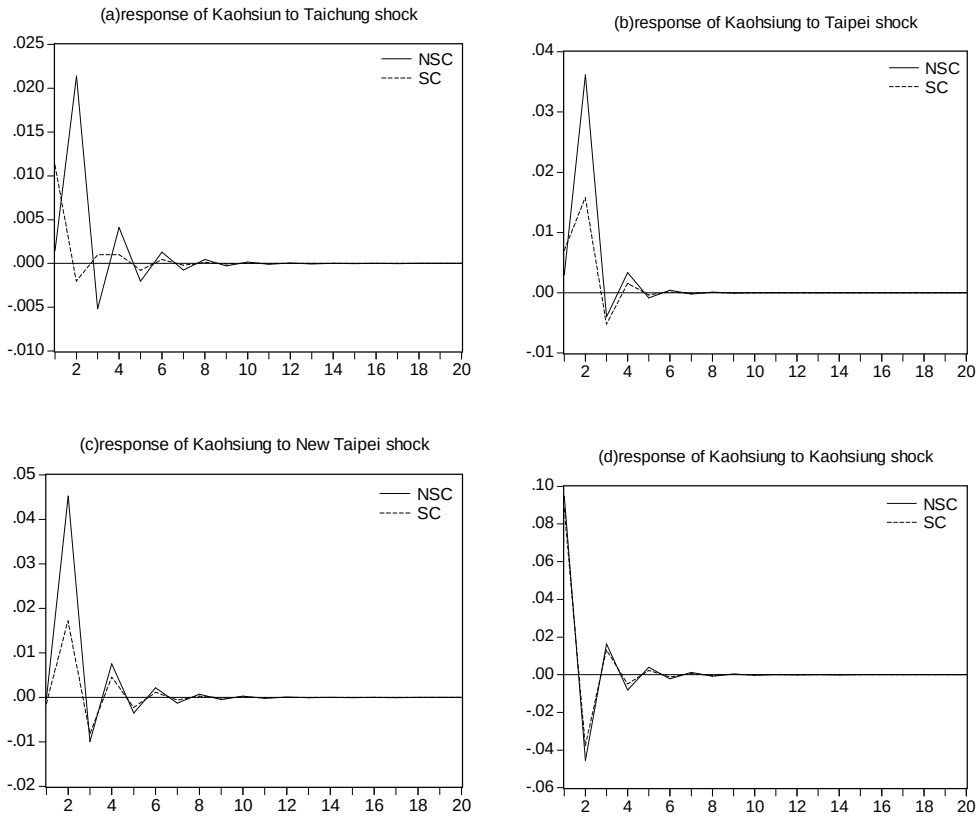

Figure 5 The generalized impulse responses of Kaohsiung housing return

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