Housing Prices, Mortgage Payments and Savings Behavior in Taiwan: A Time Series Analysis*

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After reaching its peak at the year of 1987, the saving rate of Taiwan dropped quickly in the late 1980s. At the same time, the real average housing prices in Taiwan had increased almost three times from 1987 to 1990. Why did the savings rate in Taiwan drop so quickly after 1987? Does it relate to the dramatic increase in housing prices? Although it has been confirmed that there is a negative wealth effect of housing price appreciation on savings, the estimated wealth effect on savings could be biased if the effect of mortgage payment (also known as forced savings) on saving is neglected. Applying quarterly data from 1981 to 2000 in Taiwan, we employ a time series analysis to compare two saving models, the traditional one and the one with forced saving. As we expected, the negative wealth effect of housing price appreciation on saving is smaller in the forced saving model than in the traditional saving model. By the estimated error correction models (ECMs), ignoring the impact of housing price appreciation on forced saving, the speed of short-run adjustment in total saving would be significantly slower. For forecasting purposes, the forecast errors in ECM of the forced saving model are smaller than that in the total savings model.

Keywords: error correction model, forced savings, housing prices.

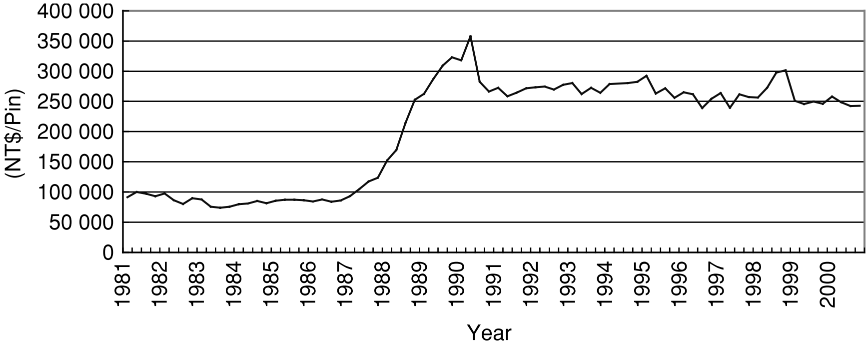
JEL classification codes: R21, E21.

I. Introduction

Taiwan, like other East Asian countries, is known for its high savings rate. After reaching its peak (38.52%) in 1987, the savings rate of Taiwan dropped quickly during the late 1980s, as shown in Figure 1, and dropped to as low as 24.03% by 2001. At the same time, the real average housing prices in Taiwan increased

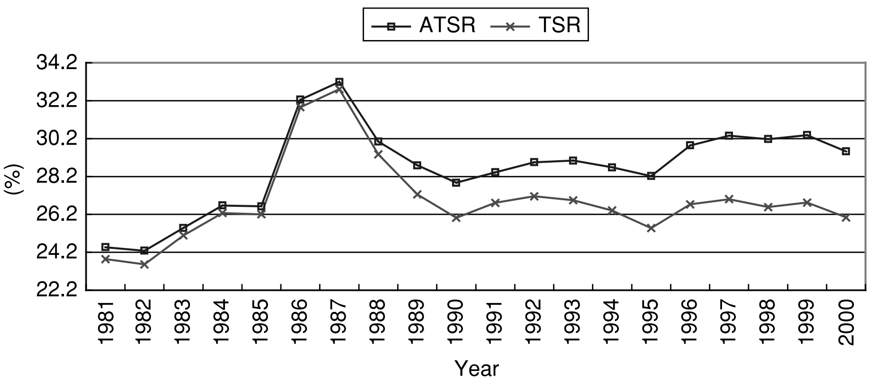
* The authors would like to thank the anonymous referee for comments and the National Science Council, Taiwan (NSC 90-2415-H-004-002) for financial support.

Figure 1 Real Housing Prices in Taiwan



Source: *Real Estate Cycle Indicators of the Fourth Season 2001* (Institute of Construction, Taiwan Ministry of Interiror Affairs, 2002)

Figure 2 Trends of Total Savings Rate Versus Adjusted Total Savings Rate



almost three times from 1987 to 1990. Since then, the housing prices have remained stable, as shown in Figure 2. Why has the savings rate of Taiwan dropped so quickly since 1988? Did it relate to the rapid increase of housing prices? How has the housing value affected Taiwanese people's savings behavior since 1988? These questions are significant for both academic research and government policy-making.

There are many studies about the general relationship between savings behavior and housing prices. For example, considering the effect of housing capital gain on homeowners' savings behavior, Bhatia (1987) and Hendershott and Peek (1989) used aggregate time-series data to estimate the positive effect of housing wealth on consumption. Leung and Chen (2002) built a theoretical model to examine how housing wealth shrinkage affects household consumption. Moreover, Ortalo-Magne and Rady (1998) analyzed how credit constraint affects housing consumption and housing prices. Finally, Skinner (1989), Skinner (1994), and

Engelhardt (1996) used micro-data to test the effect of housing windfalls on savings behavior, obtaining findings similar to Bhatia (1987) and Hendershott and Peek (1989).

For Taiwan, Lin et al. (1999) applied time series data to estimate the wealth effect of asset prices on the savings behavior of Taiwan, confirming that the wealth effect on savings is significant.[1] Hsueh and Lee (1998) and Hseuh (2001) applied cross-sectional data, also confirming that there is a windfall effect on consumption, and thus on saving.

While most literature has confirmed that there is a wealth effect on saving, Skinner (1989, 1994) derived mixed conclusions. He found that housing price appreciation has little or no impact on aggregate saving because consumers might be unable to realize their housing windfalls and might therefore not treat their housing capital gain as permanent income. Skinner (1994) even proposed that when moving costs are high, housing wealth is not significant, and his empirical results for younger people and the elderly are quite different. He suggested viewing housing wealth as a precautionary 'buffer' to explain the puzzle of why housing wealth affects saving behavior of young people, but is rarely used by the elderly to finance their consumption.

When the high housing prices increase the homeowners' consumption and decrease their savings, it has a mixed effect on those who do not own a house at all. For those who intended to buy a housing unit, they have to save more to pay a higher down-payment. Then, after buying their housing units, they have to pay a large mortgage, so their saving ability drops quickly.[2] It is clear that the mortgage payments are an important variable in determining households' saving behavior. Deaton and Paxson (1993) argued that mortgage payments should be considered a part of savings, and Tachibanaki (1994) referred to it as 'forced savings'. Applying cross-sectional data for Taiwan, Lin and Chen (1998) and Lin et al. (2001) considered mortgage payments as part of household savings. They found that the adjusted total savings rate for homeowners with a mortgage increased by almost 50%. Therefore, they suggested that the omitted forced saving is an important cause of the saving decline in Taiwan after housing price appreciation in 1987.

Applying time series data in Taiwan, this paper estimates the impact of housing appreciation on household saving behavior in Taiwan while including mortgage payment as forced savings. More specifically, we re-examine the wealth effect on savings when the forced savings are included. We also propose that the impact of housing price appreciation and other variables on savings can be miscalculated, and that this would also lead to a slower convergence rate in an economy by ignoring forced savings.

1. In their paper, Lin et al. (1999) included both housing units and stocks as people's wealth in Taiwan.

2. For some discouraged people, their consumption might increase when the housing price increased drastically as it is almost impossible for them to save enough money to buy a housing unit. See Tachibanaki (1994) and Hsueh and Lee (1998).

The structure of this study is as follows. In Section II, we first explain the theoretical relationship between housing price and savings behavior, and then build two simple saving functions, traditionally defined savings and forced savings. The data and variables for forced savings in Taiwan are explained in Section III. The time series analysis and empirical findings are presented in Section IV, and Section V concludes the study.

II. Relationship between Housing Prices and Savings Behavior in Taiwan

In traditional saving behavior, a household's saving is a function of income, interest rate, wealth, age profile, attitude towards risk and attitude towards intertemporal substitution.[3] First of all, saving is a positive function of income. On the other hand, the effect of the interest rate on saving is uncertain and it depends upon the degree of substitution effect and income effect. Usually, the interest rate has a positive effect on savings in the short run, while the long-run effect is uncertain. Furthermore, according to Lin et al. (1999), saving is a positive function of total wealth, including fixed assets and stocks. Finally, saving is a concave function of age groups, in that both younger and older people usually have lower savings rates, while middle-aged persons have higher savings rates.

In order to explain the sharply decreasing savings trend in Taiwan, in addition to income, interest rate and aging trends, we take into account of the effect of housing prices (capital gain effect or the wealth effect) on saving behavior in Taiwan. Because the home ownership rate in Taiwan is extremely high,[4] there are two effects of higher housing prices on saving behavior. First, the wealth effect on saving is significant. When the real housing prices rise, homeowners might obtain housing capital gain, which makes them feel richer and leads them to consume more. Lin et al. (1999) and Hsueh (2001) have confirmed the existence of the negative wealth effect of housing prices on savings.

On the other hand, those who intend to buy a house will face increased down-payment and mortgage payments after housing-price appreciation. In order to prepare for a higher down-payment, those who intend to buy a house have to save more as the housing prices appreciate. Therefore, their savings rate increases. However, after buying their new houses, their savings drop quickly because they have to pay very large mortgage payments. Lin and Chen (1998) found that the saving rate of homeowners with a mortgage is significantly lower than that of homeowners without mortgage payments, even though the average income of the former is higher than the latter. Applying the forced savings concept of

3. Deaton (1992) provides an excellent discussion for the determinants of household saving function.
4. According to the national census report, the home ownership rate in the year of 2000 is 82.2% in Taiwan. See *The Primary Report of the Population and Housing Census of Taiwan Area*, 2000, p. 15, Published by the Directorate General of Budget Accounting and Statistics (DGBAS), Executive Yuan, Taiwan.

Tachibanaki (1994), Lin and Chen (1998) and Lin et al. (2001) included the mortgage payments with the traditional savings and found that the total saving rates for those who with and without mortgage payments were very close.

In order to identify the capital gain effect and the forced saving effect of housing price appreciation on saving behavior in Taiwan, we construct two equations with two different saving definitions:

Total savings model TS = f (DY, HP, IR, OLD)

Forced savings model ATS = g (DY, HP, IR, OLD)

where TS represents real total saving (traditional definition of saving), ATS reperesents TS plus real forced saving (mortgage payment of housing loans), DY represents real disposable income, HP represents real housing prices, IR represents the real interest rate, and OLD represents the proportion of elderly people.[5]

According to the Permanent Income Hypothesis, the impact of disposable income on total saving is positive. Furthermore, the net influence of real private interest rate on real saving depends on the magnitude of the substitution effect and the wealth effect. By life-cycle theory, a larger number of elderly persons would increase total consumption and decrease total saving. Moreover, Tachibanaki (1994) proposed that aging trend would reduce housing-related savings of future generations. Therefore, the effect of the proportion of the elderly on total saving would be negative.

For the effect of the real housing price appreciation on saving, there is no general agreement on the housing capital gain effect in much of the related literature. Skinner (1994) pointed out that housing capital appreciation depresses non-housing savings, depending on at least three assumptions: (i) that the capital market allows homeowners to spend their housing wealth; (ii) that homeowners treat housing wealth similarly to other types of wealth; and (iii) that there is no bequest motive. However, even if the housing capital gain effect is uncertain, housing appreciation would still make the forced saving of housing loans rise. In our total savings model, the increase of real housing prices would raise housing mortgage payments so that the impact of a change in real housing price on saving is negative (housing capital gain effect may less or equal to zero, but forced saving effect is definitely negative). But in the forced savings model, we have taken into account the forced savings effect so that the housing price appreciation would increase forced savings (mortgage payment) to raise the adjusted total saving (ATS). Combining the positive forced saving effect and the uncertain capital gain effect, the net impact of the real housing price on adjusted total saving is undetermined.

In conclusion, the signs of the explanatory variables in our two models could be expected as followed:

5. In Section IV of this paper, we will provide more details about the definitions of these variables.

$$\text{Total savings model } TS = f\,(\underset{+}{DY},\ \underset{-}{HP},\ \underset{?}{IR},\ \underset{-}{OLD})$$

$$\text{Forced savings model } ATS = g\,(\underset{+}{DY},\ \underset{?}{HP},\ \underset{?}{IR},\ \underset{-}{OLD})$$

In our empirical study, we also introduce a housing dummy (before 1987 = 0, after 1987 = 1) to take care of possible structural change in the macroeconomic situation of Taiwan.

In this paper, we employ cointegration analysis to avoid the possibility of a spurious relationship of traditional regression in non-stationary time series variables, and we follow the maximum likelihood estimation procedure. After obtaining the long-run cointegration relationships, we construct the error correction terms and estimate the error correction models, which can capture the dynamic adjustment pattern of saving. Comparing the coefficients in these two models can give significant conclusions on savings behavior in Taiwan.

III. Estimation of Forced Savings in Taiwan

Table 1 shows the ratio of monthly mortgage payment to income for households with housing mortgages in Taiwan. It is clear that the payment ratio has increased sharply from 1987 to 1989 in line with the increase in real housing prices during that period. This implies that forced savings rose as housing prices appreciated. Therefore, if we add mortgage payments into the tradition definition of total savings, the adjusted total savings must be increased. Furthermore, as

Table 1 Ratio of Monthly Payment to Income for Households with Housing Mortgage

Year of purchase	*Monthly mortgage payment to income ratio (unit : %)*
1981	12.62
1982	16.13
1983	17.17
1984	16.39
1985	20.46
1986	19.23
1987	21.84
1988	23.19
1989	26.08
1990	24.79
1991	28.69
1992	26.01
1993	24.54

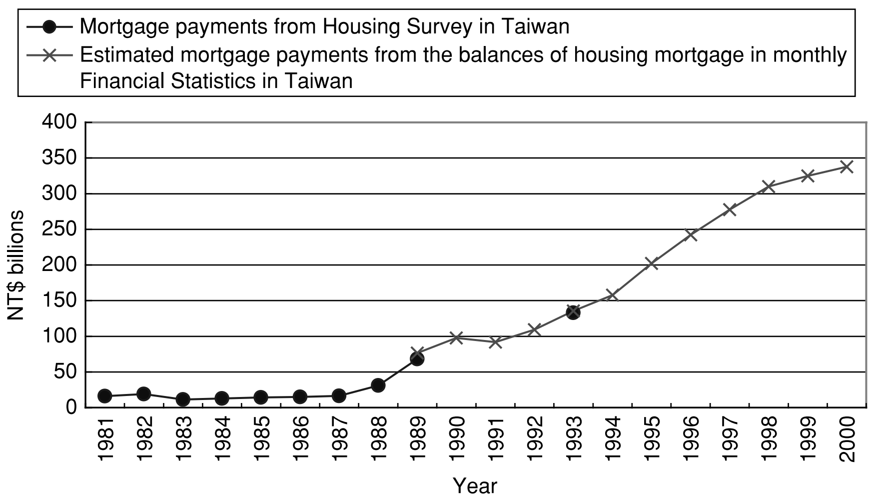
Note: The Survey was finally suspended in 1994.
Source: Directorate General of Budget Accounting and Statistics (DGBAS), Report on the Housing Survey in Taiwan Area, 1993. Published by DGBAS, Executive Yuan, Taiwan.

households bought more housing units after the rapid housing price appreciation, the impact of forced savings on total savings would be even stronger because usually mortgages take a long time to be paid off.

However, one problem in calculating the forced savings for Taiwan is that Taiwan lacks the data for total mortgage payments to banks as a whole.[6] Only the balance of total housing mortgages is reported each year, which is the unexpired total housing loan of the whole banking system. In order to estimate total monthly mortgage payments, we apply the raw data of the Housing Survey in Taiwan Area from 1981 to 1989 and 1993.[7] To obtain a complete time series data after 1993, we adopt the balance of housing-purchasing loans reported as consumer loans in the *Financial Statistic Monthly* Taiwan District, 1989 to 2000.[8] As, on the average, home mortgages are paid off in 7 years in Taiwan,[9] we divide the balance of mortgage into 7 years to approximate the amount of yearly mortgage payment. Then, we put these two time series data of estimated forced saving together to see if the data are consistent.[10] Figure 3 shows that the two data points of 1989 and 1993 are almost the same, so that we can combine these two time series to get a complete time series data for mortgage payment for further econometric analysis in this study.

Figure 3 shows that the amounts of mortgage payment grew rapidly after the housing price appreciation. As the impact of real housing prices on forced savings

Figure 3 Estimation of Yearly Mortgage Payments in Taiwan



6. For details about the data set for housing loans in Taiwan, see Chang and Lin (1994).
7. The years that the Housing Survey was conducted in Taiwan.
8. Published by the Economic Research Department, Central Bank of Taiwan, Taiwan.
9. See the analysis of Liu and Chang (1997) on the average length of home mortgage in Taiwan.
10. Remember that the data points for the years 1989 and 1993 of the two time series overlap each other, which provides a good chance to check if the estimation is good or not.

would be accumulated over time, if one analyzes savings behavior under the traditional definition of savings, the distortion of actual savings behavior would become more and more serious after the huge housing price appreciation. For this reason, we add forced saving to traditional total savings and derive the adjusted total savings rate (ATSR), as shown in Figure 2. Here, it can be seen that the traditional total savings rate (TSR) underestimates household actual savings, and the degree of underestimation increases over time.[11] This verifies the long-run accumulation effect of housing price appreciation on savings. Therefore, the amount of total saving under traditional definition declined year by year after housing price appreciation, because more and more forced savings were omitted. When we put mortgage payments back into the tradition total savings in Figure 2, the adjusted saving rate in Taiwan tends to recover gradually. In conclusion, in order to properly describe household saving behavior, we should consider the forced savings effect to correctly estimate the impact of housing price appreciation on savings in Taiwan.

IV. Empirical Study

The empirical analysis below uses aggregate quarterly time-series data from 1981 to 2000 to test the effect of housing windfalls on saving behavior in Taiwan.[12] The original data for all variables are derived from the official website of the Directorate General of Budget Accounting and Statistics (DGBAS) in Taiwan, except for forced savings and real housing prices. The estimated amount of forced saving has been explained in Section III. The variables are defined as follows:

TS: real total saving, billions of NT dollar.
TSR: real saving rate, TS/GDP, %.
ATS: adjusted real total saving (or forced saving), TS + mortgage payment (only the principle), billions of NT dollar.
ATSR: adjusted real saving rate, ATS/GDP, %.
IR: real interest rate, %. We apply the black market rate in Taipei City for this variable.[13]
DY: real disposable income, billions of NT dollar.
HP: real housing prices, NT dollars per pin.[14] We apply the pre-sale housing prices for this indicator.[15]

11. This is because the discrepancy between total savings (TS) and adjusted total savings (ATS) becomes larger over time.
12. The data used in this paper are not seasonally adjusted.
13. Before the year 1986 when Taiwan's interest was controlled by the central bank of Taiwan, the official interested rate was very stable over time, which was a poor indicator of the loan market situation. On the other hand, the black market rate was more accurate in indicating the real market situation.
14. The pin is a common measure both in Japan and Taiwan. One pin equals to 36 square feet.
15. For details about the time series of pre-sale housing prices in Taiwan from 1981 to 2000, see *Real Estate Cycle Indicators of the Fourth Season 2001*, published by Institute of Construction, Ministry of Interior Affairs, Taiwan, March 2002.

Table 2 Augmented Dickey-Fuller Unit Root Test

Level	*Test statistics*	*Lag*	*Difference*	*Test statistics*	*Lag*
TS	−2.463	8	ΔTS	−3.477*	7
ATS	−2.457	8	ΔATS	−3.538*	7
DY	−2.149	4	ΔDY	−3.182*	3
HP	−1.032	1	ΔHP	−2.972*	2
IR	−2.211	4	ΔIR	−10.946*	1
Old	0.731	1	ΔOld	−6.702*	1

Note: *Indicates that the test statistics are significant at the 5% level.

OLD: the ratio of total number of persons 65 years of age and older to total population of Taiwan, %.

All real variables above are deflated by the gross domestic product (GDP) deflator, and the base year is 1996. Moreover, the variables including TS, ATS, DY, HP, are taken as logarithms.[16]

A few time-series studies have shown that housing wealth has a positive effect on consumption (Bhatia, 1987; Hendershott and Peek, 1989). But a potential shortcoming of these time-series regressions is the possible spurious relationship between consumption and explanatory variables. Therefore, we have to examine the stationarity of the variables in our model before we apply these data.

First, we employ the augmented Dickey-Fuller (ADF) unit root test. Table 2 summarizes the results of unit root test and the ADF tests reject the null hypothesis at the 5% significance level. That is, all the variables in our model are non-stationary time series and traditional ordinary least squares (OLS) might lead to the potential of 'spurious regression'.

Before the cointegration rank test, we must choose a proper lag length for the vector autoregression models to pass the diagnostic check. From Table 3, we get the optimal lag lengths $k = 4$ in both the total savings model and the forced savings model. The P-values of L-B, LM(1) and LM(4) residual non-autocorrelation test in two models are 0.12, 0.29, 0.80 and 0.22, 0.44 and 0.84, respectively. These indicate that we can not reject the null hypothesis of non-autocorrelation, that is, residuals are white noise.

Second, we use a trace test and a λ_{max} test to determine the cointegration rank in our two models. According to Table 4, both in the total savings model and in the forced savings model, we cannot reject that there is one cointegration vector

16. We have also tried to put the inflation rate as an explanatory variable to check its impact on demand for a real saving rate. The intuition for putting this variable is to see if there is any expectation effect on demand for mortgage (and on demand for saving). It turns out that the coefficient is insignificant and implies that there is no expectation effect. This result is consistent with our observation as after 1991, Taiwan's real estate market has been in recession until now. We appreciates the referee's suggestion on this point.

Table 3 Diagnostic Checking of the Model Settings

National saving model			Forced saving model	
Non-autocorrelation test				
L-B(19)	$\chi^2(395) = 428.371$	P-value = 0.12	$\chi^2(395) = 416.895$	P-value = 0.22
LM(1)[a]	$\chi^2(25) = 28.426$	P-value = 0.29	$\chi^2(25) = 24.449$	P-value = 0.44
LM(4)[a]	$\chi^2(25) = 18.867$	P-value = 0.80	$\chi^2(25) = 18.050$	P-value = 0.84
Normality test*[b]				
	$\chi^2(10) = 58.525$	P-value = 0.00	$\chi^2(10) = 58.250$	P-value = 0.00

Notes: *The simulation results of Gonzalo (1994) showed that even if the residual is not normal, there is little impact on Johanson's estimation procedure.
[a]LM(1) and LM(4) are LM-type tests for the first and fourth order autocorrelation.
[b]The test of normality is based on a multivariate version of the univariate Shenton-Bowman test. Appendix A in Hansen and Juselius (1995) lists the precise formulae and the distributions under the null hypothesis of L-B test, LM-type test and normality test in Table 3.

Table 4 Cointegration Rank Determination

H_0:r	p-r	Eigenvalue	λ_{max}	Trace	λ_{max}97.5	Trace97.5
Total savings model						
0	5	0.4559	46.25	99.30	35.546	72.140
1	4	0.3141	28.66	53.04	29.335	50.424
2	3	0.2089	17.81	24.39	23.002	32.313
3	2	0.0657	5.17	6.57	15.810	17.299
4	1	0.0183	1.40	1.40	5.332	5.332
Forced savings model						
0	5	0.4798	49.67	99.33	35.546	72.140
1	4	0.2959	26.67	49.67	29.335	50.424
2	3	0.2135	18.25	23.00	23.002	32.313
3	2	0.0394	3.06	4.75	15.810	17.299
4	1	0.0220	1.69	1.69	5.332	5.332

Note: Critical values can be referred to in Hansen and Juselius (1995) in Appendix B.

at the 2.5% significant level based on the λ_{max} test and at the 1% significance level based on the trace test. The results imply that there exists only one cointegration relationship among all variables in both the saving models. Therefore, there is a long-run equilibrium among real total savings, real disposable income, real housing prices, real private interest rate and the proportion of the elderly. Table 5 summarizes the normalized cointegration vectors and the corresponding loadings in two models so that the cointegration relationships are:[17]

17. Wickens (1996) pointed out that if the cointegration vector is unique and the model is well-defined, then the cointegration vector of Hohanson's maximum likelihood estimation could be uniquely identified and explained economically.

Table 5 Cointegration Vectors and Loadings

Total Saving Model					*Forced Saving Model*				
TS	*DY*	*HP*	*IR*	*Old*	*ATS*	*DY*	*HP*	*IR*	*Old*
Cointegration vector									
β_1	β_2	β_3	β_4	β_5	b_1	b_2	b_3	b_4	b_5
1.000	−2.368	0.514	64.083	29.827	1.000	−1.899	0.326	50.334	15.331
Loadings									
α_1	α_2	α_3	α_4	α_5	a_1	a_2	a_3	a_4	a_5
−0.157	−0.026	−0.221	−0.020	−0.001	−0.197	−0.024	−0.231	−0.032	−0.001

Table 6 Significance Test

Null hypothesis	*Total saving model*		*Forced saving model*	
	$\chi^2(K)$	*P-value*	$\chi^2(K)$	*P-value*
H_0: DY = 0	$\chi^2(1) = 3.52$	0.06	$\chi^2(1) = 4.53$	0.03
H_0: HP = 0	$\chi^2(1) = 12.87$	0.00	$\chi^2(1) = 12.01$	0.00
H_0: IR = 0	$\chi^2(1) = 10.50$	0.00	$\chi^2(1) = 18.88$	0.00
H_0: Old = 0	$\chi^2(1) = 3.13$	0.08	$\chi^2(1) = 2.41$	0.12

In the total savings model:

$$TS = 2.368*DY - 0.514*HP - 64.083*IR - 29.827*OLD$$

In the forced savings model:

$$ATS = 1.899*DY - 0.326*HP - 50.334*IR - 15.331*OLD$$

From Tables 5 and 6, in both saving models, the signs of the coefficients are all consistent with our expectation. The impacts of a change in real disposable income (DY) on real national saving (TS) and real adjusted national saving (ATS) are significantly greater than zero (2.368 and 1.899), is consistent with the predictions of the permanent income theory. The intertemporal substitution effect of the increase of the real interest rate is stronger than the wealth effect in our two empirical models, and that is consistent with the empirical results of Liu (1982) and is different from the findings of Chen (1984) and Tseng (1987). Based on the life-cycle theory and our results, the increase of the proportion of the elderly should lower the aggregate saving ability in Taiwan. This is consistent with the conclusions of Sun and Liang (1981) and Hou and Chou (1987). Tachibanaki (1994) also pointed out that the serious aging trend might even have a strong discouraging impact on the housing-intent savings in the twenty-first century.

Although the rise in real housing prices would significantly make both real total savings and real adjusted total savings decline, the sources and the degree of the impact are quite different in the two models. In the total savings model, the influence of real housing prices on real national savings contains both capital gain effect and mortgage payment effect. However, when real housing prices appreciate, there is a potentially negative capital gain effect and a certain negative mortgage payment effect, discouraging total savings. But in the forced savings model, as we have put the mortgage payments into total saving, there is a potentially negative capital gain impact and certain positive forced saving effect when the real housing prices appreciate.

As our estimation of the forced saving model, the coefficient of HP (0.326), verifies the existence of housing capital effect, consistent with findings from Bhatia (1987), Hendershott and Peek (1989), Hsueh and Lee (1998) and Lin et al. (1999). The increase in real housing prices would bring homeowners capital gain and wealth illusion. Furthermore, from the cointegration vectors in Table 5, b_3 (0.326) in the forced savings model is smaller than β_3 (0.514) in the total savings model. That is, when we put the forced saving effects of housing price appreciation into the traditional savings, the impact of the real housing prices on total savings would decline. In other words, we would overestimate the housing capital gain effect on saving if we omit the forced saving effect when real housing prices appreciated. In order to estimate the correct impact of housing prices and of other variables on total saving, we should put mortgage payments into the traditionally defined savings as forced savings.

Then, based on the cointegration relationships in Table 5, we construct the error correction terms in our two models to construct the error correction model (ECM) to compute the speed of adjustment whenever there is a shock, throwing major variables out of equilibrium.
In the total savings model:

$$EC = TS - 2.368{*}DY - 0.514{*}HP - 64.083{*}IR - 29.827{*}OLD$$

In the forced savings model:

$$EC = ATS - 1.899{*}DY - 0.326{*}HP - 50.334{*}IR - 15.331{*}OLD$$

Put the lagged error correction terms in error correction models. In this paper, we adopt Hendry's ECM setting, including current difference terms of explanatory variables.[18]

Tables 7–10 summarize the estimation of the ECMs of the total saving model and the forced saving model. Both the adjusted R^2 (0.982) are very high in the two ECMs. That is, the ECMs of the two saving models provide good explanations of the short-run savings adjustment pattern in Taiwan. The coefficients of the lagged error correction terms in our two ECMs are significantly negative, indicating that the long-run cointegration relationships of the variables in our model would definitely influence the adjustment patterns of total saving. And the directions of adjustments are consistent with theoretical expectation.

18. See Hendry and Mizon (1978), Hendry and Ericsson (1991) and Mehra (1991).

Table 7 Error Correction Model of the Total Savings Model

Variable	*Dependent variable: ΔTS*			
	Coefficient	*Standard error*	*t-statistic*	*Probability*
C	−1.317178	0.757625	−1.738562	0.0890
EC_{t-1}	−0.123911	0.071007	−1.745060	0.0878
ΔTS_{t-1}	−0.493036	0.135499	−3.638684	0.0007
ΔTS_{t-2}	−0.583743	0.141308	−4.130986	0.0002
ΔTS_{t-3}	−0.526972	0.149738	−3.519294	0.0010
ΔTS_{t-4}	0.155889	0.144896	1.075874	0.2877
ΔDY_{t}	1.839353	0.240228	7.656691	0.0000
ΔDY_{t-1}	0.946661	0.380973	2.484851	0.0167
ΔDY_{t-2}	0.952977	0.371461	2.565481	0.0137
ΔDY_{t-3}	0.780007	0.365021	2.136883	0.0381
ΔDY_{t-4}	0.001073	0.343630	0.003124	0.9975
ΔHP_{t}	−0.116653	0.069915	−1.668493	0.1022
ΔHP_{t-1}	−0.045815	0.075740	−0.604908	0.5483
ΔHP_{t-2}	−0.181879	0.072264	−2.516875	0.0155
ΔHP_{t-3}	−0.138977	0.073979	−1.878594	0.0668
ΔHP_{t-4}	−0.042914	0.076407	−0.561658	0.5771
ΔIR_{t}	−0.701548	1.259240	−0.557120	0.5802
ΔIR_{t-1}	2.895777	3.530983	0.820105	0.4165
ΔIR_{t-2}	−0.215569	2.829315	−0.076191	0.9396
ΔIR_{t-3}	−0.333149	2.039852	−0.163320	0.8710
ΔIR_{t-4}	−0.048671	1.110368	−0.043833	0.9652
ΔOld_{t}	−9.110031	10.91777	−0.834423	0.4085
ΔOld_{t-1}	−2.480581	10.09405	−0.245747	0.8070
ΔOld_{t-2}	1.656590	9.853909	0.168115	0.8672
ΔOld_{t-3}	4.658686	9.807350	0.475020	0.6371
ΔOld_{t-4}	−3.686858	9.356847	−0.394028	0.6954
SEA1	−0.096830	0.082770	−1.169864	0.2482
SEA2	0.117204	0.048329	2.425122	0.0194
SEA3	−0.115864	0.084758	−1.366991	0.1784
Housing Dummy	−0.011610	0.012259	−0.947058	0.3487
R-squares	0.989			
Adjusted *R*-squares	0.982			
Standard error of regression	0.032			

If the actual saving at the previous period is higher than the long-run equilibrium value, then total saving would spontaneously adjust to the direction of equilibrium level this period. However, the absolute value of the coefficient of the error correction term (12.4%) in the total savings model is smaller than that in the forced savings model (24.1%). This implies that the convergence rate in the total saving model is slower than that in the forced saving model. The convergence rates of the two models can be compared clearly in Figure 4. In conclusion, if we neglect the forced saving effect of the change in housing prices, we would get a slower convergence rate due to the misleading cointegration relationship of the variables.

Table 8 Diagnostic Checking and Forecast in the Total Savings Model Error Correction Model

Fitness				
F-statistic	138.1149			
Log likelihood	171.0903			
Durbin-Watson statistic	1.985401			
Wald test				
$C(\Delta TS_{t-i}) = 0$, $(i = 1–4)$	F-statistic = 14.55		*P*-value = 0.000	
$C(\Delta DY_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 13.59		*P*-value = 0.000	
$C(\Delta HP_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 3.96		*P*-value = 0.005	
$C(\Delta IR_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 0.99		*P*-value = 0.434	
$C(\Delta Old_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 0.22		*P*-value = 0.953	
Diagnostic test				
LM test[a]	F-statistic = 0.312		*P*-value = 0.579	
ARCH test[b]	F-statistic = 0.352		*P*-value = 0.555	
Heteroskedasticity test[c]	F-statistic = 1.903		*P*-value = 0.057	
Normality test	Jarque-Bera = 0.861		*P*-value = 0.650	
Forecast errors (period: 1995–2000)				
	Static forecast		Dynamic forecast	
	Root mean squared error	0.0258	Root mean squared error	0.0300
	Mean absolute error	0.0227	Mean absolute error	0.0242
	Mean abs. percent error	300.874	Mean abs. percent error	233.3315

Notes: [a]The Lagrange multiplier (LM) test could be used to test for ARMA(r;q) errors. The null hypothesis fo the LM test is that there is no serial correlation up to lag order p, where p = max{r,q}. Note that the alternative includes both AR(p) and MA(p) error processes. The LM tests in Tables 8 and 10 are to test first order serial correlation.

[b]The autoregressive conditional heteroskedasticity (ARCH) LM test, an LM test for ARCH in the residiuals, is to test the null hypothesis that there is no ARCH up to order q in the residuals.

[c]In Tables 8 and 10, we use the White test with no cross terms to test the null hypothesis of no heteroskedasticity.

Figure 4 Convergence Rates From The Total Savings Model Versus Forced Savings Model

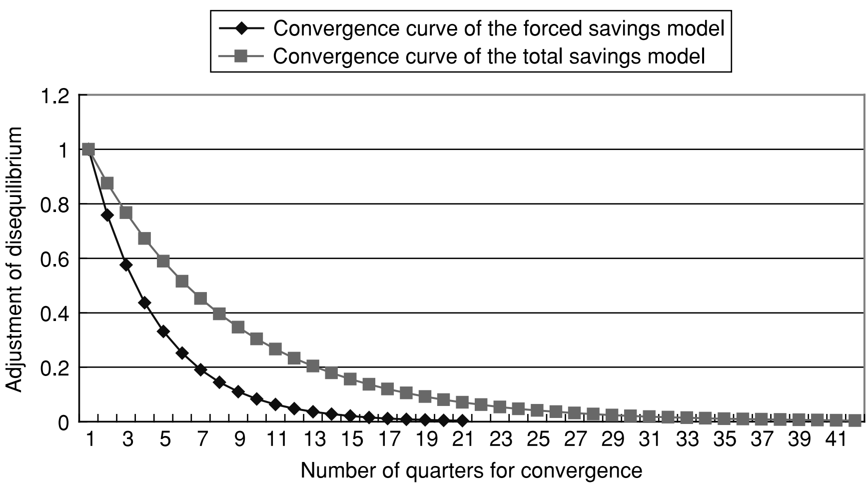


Table 9 Error Correction Model of the forced savings model

Variable	*Dependent variable: ΔATS*			
	Coefficient	*Standard error*	*t-statistic*	*Probability*
C	1.488730	0.615655	2.418124	0.0197
EC_{t-1}	−0.241246	0.097325	−2.478765	0.0170
ΔATS_{t-1}	−0.519791	0.136516	−3.807549	0.0004
ΔATS_{t-2}	−0.634260	0.139452	−4.548214	0.0000
ΔATS_{t-3}	−0.651328	0.149372	−4.360445	0.0001
ΔATS_{t-4}	0.067968	0.147504	0.460790	0.6472
ΔDY_{t}	1.819178	0.225474	8.068249	0.0000
ΔDY_{t-1}	1.171729	0.369115	3.174425	0.0027
ΔDY_{t-2}	1.151699	0.362127	3.180369	0.0027
ΔDY_{t-3}	1.063121	0.357879	2.970619	0.0048
ΔDY_{t-4}	0.131563	0.330944	0.397539	0.6928
ΔHP_{t}	−0.115981	0.062784	−1.847294	0.0713
ΔHP_{t-1}	−0.040899	0.070677	−0.578684	0.5657
ΔHP_{t-2}	−0.148403	0.066122	−2.244396	0.0298
ΔHP_{t-3}	−0.132396	0.067236	−1.969120	0.0551
ΔHP_{t-4}	−0.040190	0.068976	−0.582667	0.5630
ΔIR_{t}	−1.241898	1.206455	−1.029378	0.3088
ΔIR_{t-1}	5.805736	3.746035	1.549835	0.1282
ΔIR_{t-2}	1.680403	2.913575	0.576749	0.5670
ΔIR_{t-3}	0.652500	2.009870	0.324648	0.7470
ΔIR_{t-4}	0.491256	1.070499	0.458904	0.6485
ΔOld_{t}	−12.55432	10.04752	−1.249494	0.2179
ΔOld_{t-1}	−5.154720	9.416279	−0.547426	0.5868
ΔOld_{t-2}	−0.619370	9.170837	−0.067537	0.9465
ΔOld_{t-3}	3.300318	9.185996	0.359277	0.7211
ΔOld_{t-4}	−1.916573	8.695474	−0.220410	0.8265
SEA1	−0.045501	0.071905	−0.632788	0.5301
SEA2	0.120163	0.045373	2.648373	0.0111
SEA3	−0.068514	0.074033	−0.925456	0.3597
Housing dummy	−0.020274	0.012975	−1.562531	0.1252
R-squares	0.989			
Adjusted R-squares	0.982			
Standard error of regression	0.029			

Finally, we examine the fitness of the above two error correction models. From the information criteria (Akaike's information criterion and Schwarz criterion) in Tables 8 and 10, the forced-saving ECM performs slightly better than the total-saving ECM. To go one step further, we adopt the two ECMs to forecast the saving patterns during 1995 to 2000, respectively. In Tables 8 and 10, we find that the root mean squares error (RMSE), mean absolute error (MEA) and mean absolute percent error (MAPE) in ECM of the forced savings model is smaller than that in the total savings model. That is, the ECM of the forced saving model forecasts the saving behavior in Taiwan better than the total saving

Table 10 Diagnostic Checking and Forecast in the Forced Savings Model Error Correction Models

Fitness				
F-statistic	137.2834			
Log likelihood	177.1678			
Durbin-Watson statistic	1.954051			
Wald test				
$C(\Delta ATS_{t-i}) = 0$, $(i = 1–4)$	F-statistic = 15.65		*P*-value = 0.000	
$C(\Delta DY_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 15.08		*P*-value = 0.000	
$C(\Delta HP_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 4.40		*P*-value = 0.002	
$C(\Delta IR_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 1.69		*P*-value = 0.155	
$C(\Delta Old_{t-i}) = 0$, $(i = 0–4)$	F-statistic = 0.38		*P*-value = 0.860	
Diagnostic test				
LM test	F-statistic = 0.075		*P*-value = 0.786	
ARCH test	F-statistic = 0.193		*P*-value = 0.661	
Heteroskedasticity test	F-statistic = 1.360		*P*-value = 0.227	
Normality test	Jarque-Bera = 1.603		*P*-value = 0.449	
Forecast error (period: 1995–2000)				
	Static forecast		Dynamic forecast	
	Root mean squared error	0.0233	Root mean squares error	0.0296
	Mean absolute error	0.0204	Mean absolute error	0.0234
	Mean abs. percent error	81.119	Mean abs. percent error	132.956

model. In short, if the forced savings effect is neglected, one would get larger forecast errors when the traditional total savings is applied.

V. Conclusion

Skinner (1994) viewed housing wealth as a precautionary 'buffer'. Deaton and Paxson (1993) believed that mortgage payments are a part of savings, and Tachibanaki (1994) referred to it as 'forced savings'. In this paper, we introduce this concept and employ cointegration analysis to suggest the explanation of savings decline in Taiwan since 1987. We derive several important findings as follows.

First, from our estimation in Section III, the amount of forced savings in Taiwan accumulated rapidly after housing price appreciation in 1987, and this resulted in the underestimation of households' actual saving behavior under traditional saving definition. However, when we considered mortgage payments as a part of forced savings, the adjusted savings rate recovered recently.

Second, in our two savings models, the rise of real housing prices would discourage total savings. However, the negative impact of housing appreciation in the forced savings model is weaker than that in the total savings model. This is because of our deduction of the effect of housing price on mortgage payment in the forced saving model. In conclusion, one would overestimate the housing capital gain effect on saving if the forced saving effect by housing price appreciation is omitted. In order to estimate the correct impact of housing price and other variables on total savings, one should add mortgage payments as forced savings into the traditionally defined savings, as in our forced savings model.

Third, the coefficients of the error correction terms in our two ECMs reveal that the convergence rate in the traditionally defined savings model is slower than that in the forced savings model. Consequently, ignoring the impact of housing price appreciation on forced savings, the speed of short-run adjustment in total saving would be significantly slower, and it would take more time to reach the long-run equilibrium.

Finally, for forecasting purposes, the forecast errors in ECM of the forced savings model are smaller than that in the total savings model. This indicates that the forced savings model ECM performs better in forecasting than the total savings model.

Based on these conclusions, the decline of the total savings rate in Taiwan could be explained by the omission of forced savings. The degree of underestimation of households' saving behavior in traditional savings definition becomes larger and larger after housing price appreciation in late 1980s. If we include the housing-motive forced savings into the total savings, the adjusted saving rate recovered recently. In short, the savings decline in Taiwan is not because people are less thrifty, but the definition of savings is the key point in the discussion of saving behavior.

Along with the aging trend in Taiwan, the large number of elderly people would reduce the overall saving ability through life-cycle theory. Moreover, as Tachibanaki (1994) mentioned, the aging trend with strong bequest motive might discourage housing-related saving. In addition, the social insurance programs would reduce the uncertainty faced by households and lower the precautionary demand for savings. Therefore, we expect that the trend of total savings rate in Taiwan must decrease in the long run, following the national health-insurance program, which started in 1995.

In this paper, we were restricted to the time series of our estimation in forced savings, and had to take the estimation efficiency of our models into account, so we could not analyze many other factors that might be important in savings decisions. If a complete housing financial database could be established, it would be helpful for further studies on savings behavior in Taiwan.

References

Bhatia, K. B., 1987, Real Estate Assets and Consumer Spending. *Quarterly Journal of Economics*, **102**, pp. 437–44.

Chen, K. M., 1984, [*Official Interest Rate, Black Market Loan, and Households Saving Research Report No.45.*] CIER, Taipei (in Chinese).

Chang, C. O. and C. M. Lin, 1994, [A Survey on Real Estate Finance in Taiwan.] In: *Real Estate Price, Quality, and Finance.* (ed. Chang, C. O.) pp. 345–64. National Chengchi University, Taipei (in Chinese).

Deaton, A., 1992, *Understanding Consumption*. Oxford University Press, New York.

Deaton, A. and C. Paxson, 1993, Saving, Growth and Aging in Taiwan, In: Studies in the Economics of Aging (ed. Wise, D. A.) pp. 331–357. University of Chicago Press, Chicago.

Engelhardt, G. V., 1996, House Prices and Home Owner Saving Behavior. *Regional Science and Urban Economics*, **26**, pp. 313–36.

Gonzalo, J., 1994, Five Alternative Methods of Estimating Long-Run Equilibrium Relationships. *Journal of Econometrics*, **60**, pp. 203–33.

Hansen, H. and K. Juselius, 1995, *Cats in Rats: Cointegration Analysis of Time Series*. Estima, Evanston, Ill.

Hendershott, P. H. and J. Peek, 1989, *Aggregate U.S. Private Saving: Conceptual Measures and Empirical Tests*. *The Measurement of Saving, Investment, and Wealth*. University of Chicago Press, Chicago.

Hendry, D. F. and G. E. Mizon, 1978, Serial Correlation as a Convenient Simplification, Not a Nuisance: A Comment on a Study of the Demand for Money by the Bank of England. *Economic Journal*, **88**, pp. 549–63.

Hendry, D. F. and N. R. Ericsson, 1991, An Econometric Analysis of UK Money Demand in Monetary Trends in United States and the United Kingdom. *American Economic Review*, **March**, pp. 8–38.

Hou, C. M. and J. Chou, 1987, [Causes of Current Economic Problems and Government Reacting Policies: A Study on Excess Saving.] Technical Report, Chung-Hwa Institute for Economic Research, Taipei (in Chinese).

Hsueh, L. M. and C. B. Lee, 1998, [A Study of the Relationship of Housing Price, Tenure Choice, and Saving.] The Proceedings of the Seventh Annual Conference of the Chinese Society of Housing Study; pp. 21–40, August 1998. Chinese Society of Housing Study, Taipei (in Chinese).

Hsueh, L. M., 2001, The Relationship between Housing Price, Tenure Choice, and Saving Behavior in Taiwan. *International Real Estate Review*, **3**, pp. 11–33.

Institute of Construction, Taiwan Ministry of Interior Affairs, 2002, *Real Estate Cycle Indicators of the Fourth Season 2001*. Ministry of Interior Affairs, Taiwan.

Leung, C. K. Y. and N. K. Chen, 2002, Collateral Damage and Economic Recovery. Paper Presented at the International Conference on Money, Growth, and Distribution; 2001, Academic Sinica, Taipei, Taiwan. Institute of Economics, Academic Sinica, Taipei.

Lin, C. C. and C. L. Chen, 1998, Mortgage Payment and Forced Saving: An Analysis of the Behavior for Households Saving in Taiwan. The Proceeding of 1998 Annual Conference of Taiwan Economic Association. Taiwan Economic Association, Taipei (in Chinese).

Lin, C. C., C. L. Chen and S. J. Lin, 2001, Life Cycle, Mortgage Payment, and Forced Savings. *International Real Estate Review*, **3**, pp. 109–41.

Lin, C. C., 2002, An analysis on the Determinants of Housing Inventories in Taiwan. *Journal of Housing Studies*, **11**, pp. 23–34 (in Chinese).

Lin, J. L., C. S. Wu and S. W. Chen, 1999, [Financial Assets and Savings: the Case of Taiwan.] *Academia Economic Papers*, **27**, pp. 81–102 (in Chinese).

Liu, S. S., 1982, [*The Relationship between Interest Rate and Saving Deposits, Research Report 17*.] Chung-Hwa Institute for Economic Research, Taipei (in Chinese).

Liu, T. H. and C. O. Chang, 1997, [A Study on the Speed of Mortgage Payment: A Case of Hsin-Chu City.] The Proceedings of the Sixth Annual Conference of the Chinese Society of Housing Study; July 1997, Taipei. Chinese Society of Housing Study, Taipei (in Chinese).

Mehra, Y. P., 1991, An Error-Correction Model of U. S. M2 Demand Federal Reserve Bank of Richmond. *Economic Review*, **May/June**, pp. 3–12.

Ortalo-Magne, F. and S. Rady, 1998, Housing Market Fluctuations in a Life-Cycle Economy with Credit Constraints. Research Paper 1501. Graduate School of Business, Stanford University, Palo Alto, CA.

Skinner, J., 1989, Housing Wealth and Aggregate Saving. *Regional Science and Urban Economics*, **19**, pp. 305–24.

Skinner, J., 1994, Housing and Saving in the United States. In: *Housing Markets in the United States and Japan*. (eds Y. Noguchi Y. and J. M. Poterba) pp. 191–214. University of Chicago Press, Chicago.

Sun, C. and M. Y. Liang, 1981, Saving in Taiwan, 1953–1980. In: *Experiences and Lessons of Economic Development in Taiwan*. (eds Li K. T. and T. S. Yu). Academia Sinica, Taipei.

Tachibanaki, T., 1994, Housing and Saving in Japan. In: *Housing Markets in the United States and Japan*. (eds Noguchi, Y. and J. M. Poterbar) pp. 161–90. University of Chicago Press, Chicago.

Tseng, Y. C., 1987, Individual Taxation and Saving: An Empirical Study in Taiwan. *Quarterly Review of Bank of Taiwan*, **38**, pp. 64–84 (in Chinese).

Wickens, M. R., 1996, Interpreting Cointegrating Vectors and Common Stochastic Trends. *Journal of Econometrics*, **7**4, pp. 255–71.