Forecasting Housing Investment: A Comparative Study in Taiwan (ROC), Korea, Japan, and the USA.

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摘　要

本文以住宅投資爲研究對象，探討各種預測模型：從簡單的時間序列趨勢模型 (Trend Model) 到複雜的自我廻歸移動平均模型 (ARMA Model)，另外亦利用解釋模型進行預測分析。本文以中華民國、韓國、日本及美國等四國從1953到1983年三十一年間的住宅投資資料作分析比較各種預測模型的精確程度。在預測精確度及便利性的考慮下，建議 ARMA 模型較爲適當進行預測分析。最後本文亦測試了不同國家預測模型的轉換運用情形，發現在有限資料的情況下，類似背景不同國家模型之轉換可以嘗試。

I. Introduction

One of the important purposes of housing investment study is to forecast housing investment in the future accurately. This is especially a concern in housing policy of the government. The results of poor forecasting in housing investment will lead to inadequate housing policies and outcomes. For example, underestimates in housing investment may cause over-investment by many private developers as well as the public sector's inefficient use of resources and also financial difficulties for many developers. There is also a high degree of interdependence among the forecast of housing and non-housing sectors. For example, poor forecasting in housing investment will cause production errors in construction materials, such as brick, steel, and furniture, etc..

Forecasting of housing investment conventionally is applied econometric models which use a regression equation with economic variables like GNP per capita, interest rates, and inflation as well as demographic variables to forecast housing investment, Burns and Grebler (1976), Annez and Wheaton (1984), for example. The major drawback of the application of econometric/explanatory models is the need for data on the independent variables' future values. Although

many models and/or assumptions can be applied for the determination of future values, the chance of increasing forecasting error will occur due to the inaccuracy of the independent variables' future values.

Forecasting housing construction which using time-series methods is applied in the US only recently, Grebler and Burns (1982), Pankratz (1983), Falk (1983). A comparative study of housing investment forecasting in Taiwan, Korea, Japan, and the USA which taken together produce continuous of development stage and housing stock, and share in the cases of Japan, Taiwan, and Korea similar national backgrounds has yet to be done. Since many forecasting methods have not yet been applied in these Asian countries, it is important first to test these methods. We will focus on developing time-series models in this paper which require data of only one variable, namely, the housing investment in our study.

Because of different housing conditions as well as different economic and socio-cultural backgrounds among countries, developed countries' forecasting models are difficult to apply to developing countries. One major problem of housing investment forecasting in some developing countries is that lack a long period of housing investment data, or in newly mature housing stock condition with only limited mature data points.[1] It is difficult to establish a forecasting model in such situation. One alternative, however, is using forecasting models from other countries which have similar/closed backgrounds. This paper will test how the appropriate forecasting model works across countries. For instance, how would US forecasting model fit current Japan housing investment? How would Japan's early model fit Taiwan and Korea? Similar, how would Taiwan or Korea's models fit other developing countries, such as the Philippines or Thaliland?

This paper compares how goodness of prediction by different forecasting models among different countries. Section II presents the level of housing investment and fluctuation patterns in Taiwan, Korea, Japan, and the USA. The third and forth sections develop time-series forecasting models – trend and ARMA models for each country. Using explanatory models to forecast housing investment is showed in section V. Then, section VI compares the results of these different models among these four countries. Section VII tests how these forecasting models work across countries. Concluding comments to this paper are provided in the final section.

In the following models, we will focus on the criterion of accuracy for a moment. Two measures of accuracy of housing investment forecasting are suggested: first, using housing investment data of 1953-83 to forecast the results

of 1984, and comparing the forecasting and primary results of 1984; second, using housing investment data of 1953-80 to forecast the results of 1981-83, and calculating mean absolute percentage error (MAPE) of forecasting and actual results of 1981-83.

II. Housing Investment and Fluctuation Patterns

The level of housing investment which is represented in 1983 constant prices of each country's currency value appears in Table 1 and Figures 1 – 4. We see some exponential growth before the seventies in all three Asian countries which differentiales their growth pattens from that of the US. After 1971 Japan fluctuates at a stable investment level. Taiwan seems also at a stable level after 1977, although its future trend is not clear yet. Korea, however, becomes highly unstable regarding housing investment after 1976. Housing investment in the

Table 1. The Level of Housing Investment at 1983 Constant Prices in Taiwan, Korea, Japan, and the USA

Country	Period	Mean	S. D.	Maximum	Minimum
Taiwan	1953-69	6944	4448	16491	2544
	1970-83	45213	20345	71745	15419
	1953-83	24227	23767	71745	2544
Korea	1953-69	251	164	644	126
	1970-83	2053	941	3717	860
	1953-83	1065	1109	3717	126
Japan	1953-69	4139	2952	10711	1165
	1970-83	15950	1798	18566	12184
	1953-83	9473	6461	18566	1165
USA	1953-69	102257	7814	112964	88134
	1970-83	128333	22209	160672	92297
	1953-83	114033	20502	160672	88134

* Units: Taiwan: Million NT$, Korea: Billion Won, Japan: Billion Yen, USA: Million US$.

Fig. 1: The Level of Real Housing Investment in Taiwan

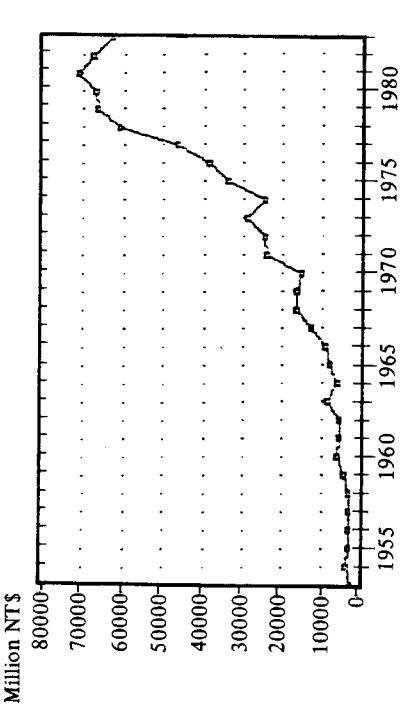


Fig. 2: The Level of Real Housing Investment in Korea

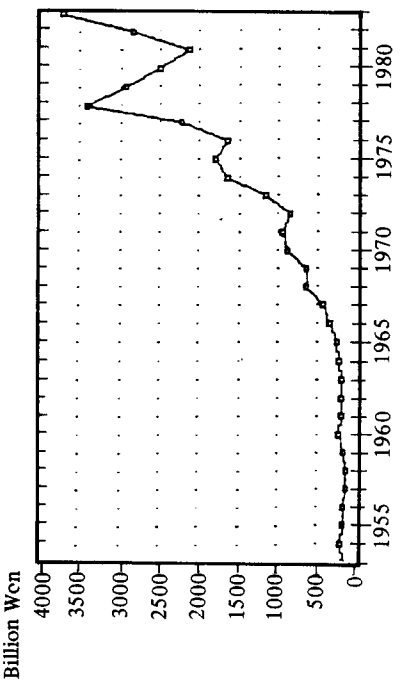
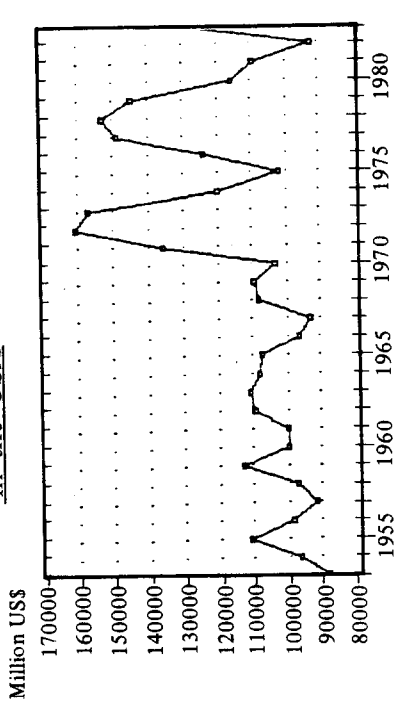


Fig. 3: The Level of Real Housing Investment in Japan

Fig. 4: The Level of Real Housing Investment in the USA



later stage is high in these Asian countries, about 4-8 times of the early stage on average, compared to only 1.3 times in the US's pattern.

Housing fluctuations in terms of the percentage of change in the level of housing investment from the previous year, Table 2 and Figure 5 – 8 show rather stationary patterns in all these countries. The growth rates of housing investment in these Asian countries are very high, 9-14% on average, compared to only 2.4% in the US. High volatility of growth rates in Taiwan and Korea share a similar pattern in the US. The later stage of Japan has a much lower growth rate (3%) than that of the early stage (15%) which reflects a different pattern than the same growth rates in the early and later stages of Taiwan and Korea.

III. Trend Model

From the previous description, we recognize that there are some trend

Table 2. The Growth Rate of the Level of Real Housing Investment in Taiwan, Korea, Japan, and the USA

Country	Period	Mean	S. D.	Maximum	Minimum
Taiwan	1954-69	14.96	25.26	51.23	−29.14
	1970-83	11.6	19.22	55.79	−13.73
	1954-83	13.39	22.33	55.79	−29.15
Korea	1954-69	12.3	22.74	45.24	−28.72
	1970-83	15.87	24.78	53.81	−14.74
	1954-83	13.97	23.37	53.81	−28.72
Japan	1954-69	15	5.62	25.21	6.48
	1970-83	2.8	8.72	17.36	−11.1
	1954-83	9.31	9.42	25.21	−11.1
USA	1954-69	1.77	9.45	16.41	−11.75
	1970-83	3.07	20.22	42.07	−23.78
	1954-83	2.38	15.16	42.07	−23.78

* Unit: %

Fig. 5: The Growth Rate of the Level of Real Housing Investment in Taiwan

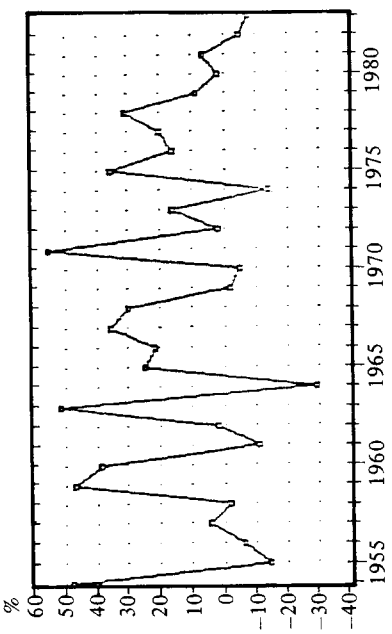


Fig. 6: The Growth Rate of the Level of Real Housing Investment in Korea

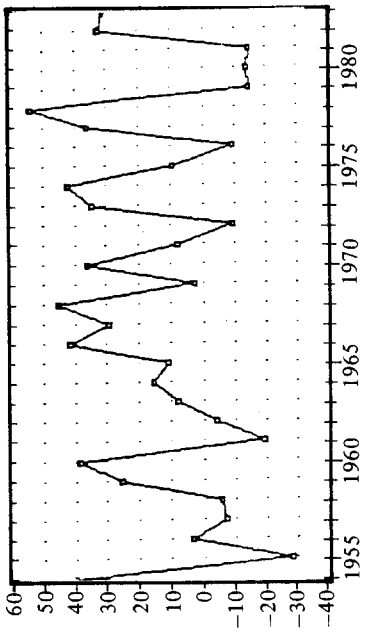
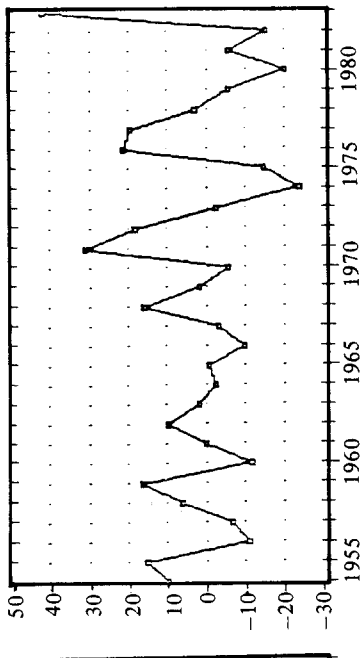


Fig. 7: The Growth Rate of the Level of Real Housing Investment in Japan

Fig. 8: The Growth Rate of the Level of Real Housing Investment in the USA



patterns of housing investment in these three Asian countries. Especially when we transform the level of housing investment into a logarithmic fuction, there is a clearly linear relationship with trend in Taiwan and Korea. Therefore, the most simple and easy way to build a forecasting model is using simple regression of housing investment on time (trend). Both the linear and the quadratic trend models have been tested. Table 3 shows the statistical results of regression which only one appropriate model (either linear or quadratic) with and without logarithm form on trend is presented in these four countries. The fitted results of the trend model and the actual housing investment in 1953-83 are also plotted in Figure 9 – 16. We can see a much higher R-squared and better fit in these Asian countries than in the US.

The future of housing investment can be predicted by the trend model which we have built in Table 3. The predicted results and errors are presented in Table 4. We can see that the predicted results through the trend model seem not very accurate. In terms of the forecasting results of individual countries, Taiwan and Korea have better accuracy of prediction than that of Japan by the trend model, because the turning point has occurred in Japan which cannot fit the previous trend line any more. We also can find that the higher R-squared of the model does not guarantee the better accuracy of prediction. We may conclude that the better "goodness of fit" of the model through the previous data does not necessarily result in the better "accuracy of prediction" for the future.

IV. ARMA Model and Its Combination

The modern time series method – Autoregressive Moving-average (ARMA) model recently has been widely used in forecasting in many areas. Although ARMA model has not been applied in the forecasting of housing investment in these three Asian countries, it will be interesting to see the forecasting results by the ARMA model. Particularly as there are different housing investment patterns among these four countries, the forecasting by ARMA model may be considered differently.

Since stationarity of a time series is the condition for the application of ARMA model, it is important to remove the nonstationarity of housing investment before proceeding with ARMA model. There are many methods to change nonstationarity into stationarity. One of the common ways is the method of differencing. According to the previous housing investment pattern study[2],

Table 3. Regression of Housing Investment on Linear or Quadratic Trend in Taiwan, Korea, Japan, and the USA

DEPENDENT VARIABLE		INDEPENDENT VARIABLES			REGRESSION RESULTS		
Housing Investment	Period	Trend	Trend 2	Constant	ADJ-R2	F-STAT	#OBS
TAIWAN (HI$)	1953-83	−1058.11	114.9	5055	0.9557	324.34	31
		(390.52)	(12.58)				
TAIWAN (HI$)	1553-80	−1664.66	141.1	7136	0.9624	346.34	28
		(349.61)	(12.51)				
TAIWAN Log (HI$)	1953-83	0.122		7.72	0.9739	119.92	31
		(0.0036)					
TAIWAN Log (HI$)	1953-80	0.1256		7.68	0.972	938.61	28
		(0.0041)					
KOREA (HI$)	1953-83	−53.76	5.42	217	0.9184	169.76	31
		(24.72)	(0.80)				
KOREA (HI$)	1953-80	−85.22	6.87	318	0.9296	179.21	28
		(22.90)	(0.82)				
KOREA Log (HI$)	1953-83	0.127		4.44	0.9325	415.53	31
		(0.0062)					
KOREA Log (HI$)	1953-80	0.1312		4.4	0.9204	313.35	28
		(0.0074)					
JAPAN (HI$)	1953-83	839.07	−5.43	−1458	0.9028	140.4	31
		(157.18)	(5.06)				
JAPAN (HI$)	1953-80	493.48	9.91	−304	0.945	232.8	28
		(137.27)	(4.91)				
JAPAN Log (HI$)	1953-83	0.21	−0.0035	5.79	0.9781	669.66	31
		(0.01)	(0.00036)				
JAPAN Log (HI$)	1953-80	0.19	−0.0028	5.85	0.9819	735.03	28
		(0.012)	(0.00042)				
USA (HI$)	1953-83	1230.59		95574	0.2736	12.3	31
		(350.87)					
USA (HI$)	1953-80	1738.3		90902	0.4466	22.79	28
		(364.13)					
USA Log (HI$)	1953-83	0.0104		11.47	0.2885	13.16	31
		(0.0029)					
USA Log (HI$)	1953-80	0.0146		11.43	0.4713	25.07	28
		(0.0029)					

(Standard errors are given in parentheses which are applied in this paper.)

* HI$: Housing Investment at 1983 Constant Price
Taiwan: Million NT$, Korea: Billion Won, Japan: Billion Yen, USA: Million US$.

** Trend 2: Trend * Trend

Fig. 9: The Fitted of Housing Investment by Quadratic Trend Model in Taiwan

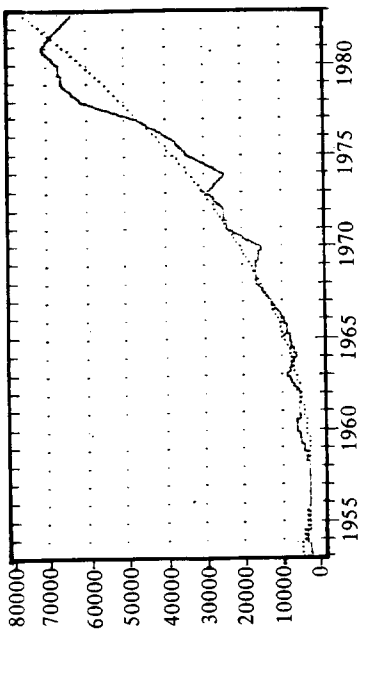


Fig. 10: The Fitted of Logarithm of Housing Investment by Linear Trend Model in Taiwan

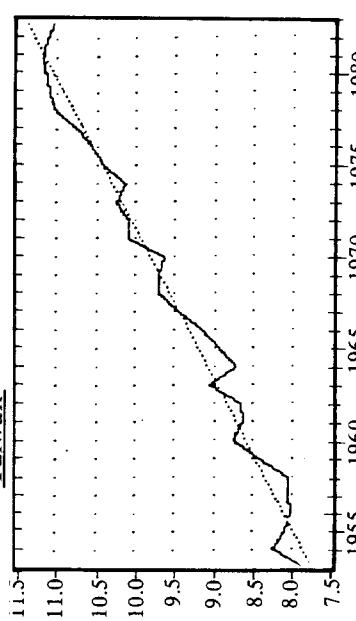


Fig. 11: The Fitted of Housing Investment by Quadratic Trend Model in Korea

Fig. 12: The Fitted of Logarithm of Housing Investment by Linear Trend Model in Korea

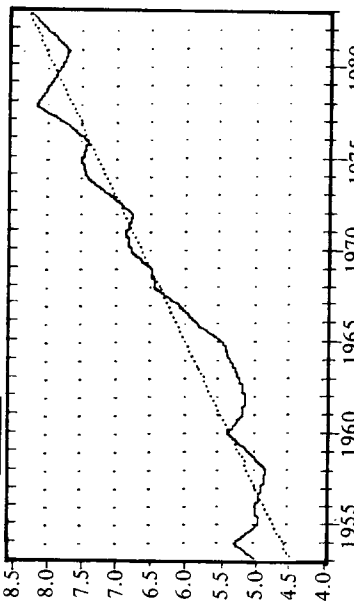


Fig. 13: The Fitted of Housing Investment by Quadratic Trend Model in Japan

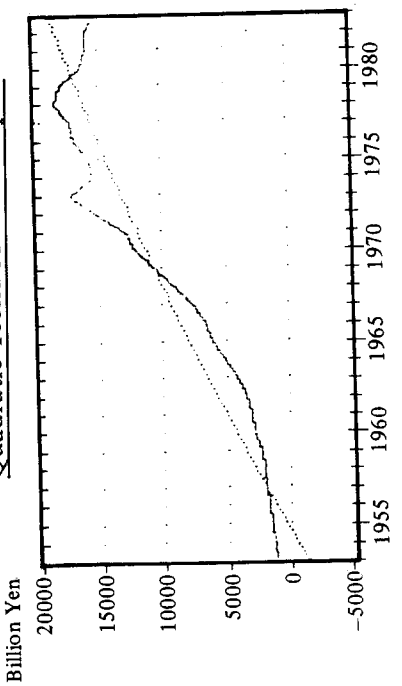


Fig. 14: The Fitted of Logarithm of Housing Investment by Quadratic Trend Model in Japan

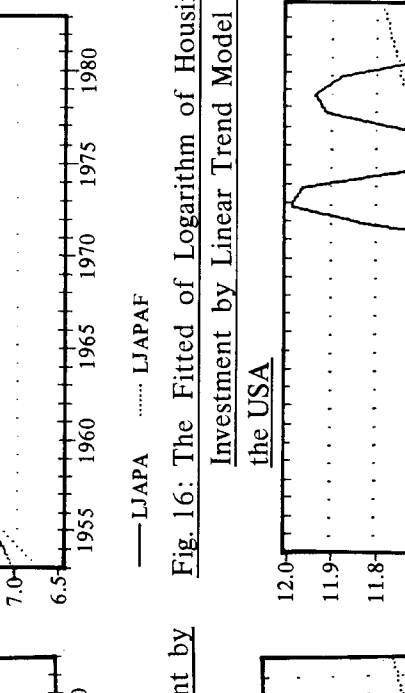


Fig. 15: The Fitted of Housing Investment by Linear Trend Model in the USA

Fig. 16: The Fitted of Logarithm of Housing Investment by Linear Trend Model in the USA

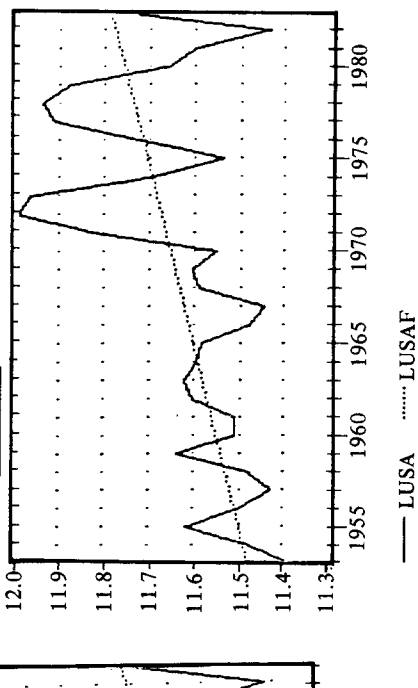


Table 4. The Results & Errors of Prediction through the Trend Model

Country	Year	Actual	Forecast 1 (HI$)	Forecast 2 Log (HI$)	Error 1 %	Error 2 %
Taiwan	1984	67570	82669	100134	−22.34	48.19
	1981	71745	71151	74258	0.83	−3.5
	1982	68072	77530	84198	−13.89	−23.69
	1983	62794	84190	95470	−34.07	−52.04
	1981-83				(16.26)	(26.41)
Korea	1984	3694	3762	4552	−8.84	−23.23
	1981	2140	3319	3382	−55.09	−58.04
	1982	2839	3625	3856	−27.69	−35.82
	1983	3717	3945	4397	−6.13	−18.29
	1981-83				(29.64)	(37.38)
Japan	1984	14700	19339	17948	−31.56	−22.1
	1981	16041	21280	21570	−32.66	−34.47
	1982	15903	22338	22257	−40.46	−39.95
	1983	15049	23416	22840	−55.6	−51.77
	1981-83				(42.91)	(42.06)
USA	1984	145567	133723	134064	8.83	8.59
	1981	109264	139575	140403	−27.74	−28.5
	1982	92297	141313	142471	−53.11	−54.36
	1983	131127	143051	144570	−9.09	-10.25
	1981-83				(29.98)	(31.04)

* Forecast 1: Forecast through housing investment trend model

Forecast 2: Forecast through logarithm of housing investment trend model adjusted by S.E. of regression ($\hat{Y} = e^{x\hat{\beta}} * e^{0.5(\text{S.E. of Regression})^2}$)

** 1981-83: Mean absolute percentage error in 1981-83.

however, the growth rate of housing investment is considered the better stationary situation than that of differencing or any other transformation of housing investment. Thereofre, we choose to forecast the growth rate of housing investment through ARMA model.

Based upon various mixed ARMA model testing and comparison, the best fitted ARMA model in each of these four countries is presented is Table 5. We can see that ARMA (1, 1) is fitted in Japan and Korea, ARMA (1, 2) is fitted in Taiwan, and MA (1), MA (2) is fitted in the US. Although the R-squared is not high in the growth rate of housing investment by the ARMA model, the fitted results of housing investment seem quite good except in the US (see Figures 17 – 20).

Using the ARMA model in Table 5, the results and errors of prediction

Table 5. ARMA Model of the Growth Rate of Housing Investment in Taiwan, Korea, Japan, and the USA

DEPENDENT VAR.	INDEPENDENT VAR					REGRESSION RESULTS	
Growth Rate (%) of Housing Investment	Period	AR (1)	MA (1)	MA (2)	Constant	R-Squared	#OBS
TAIWAN (DHI$)	1955-83	−0.2898		−0.2661	13.09	0.1043	29
		(0.1869)		(0.2084)			
TAIWAN (DHI$)	1955-80	−0.4399		−0.458	14.74	0.2269	26
		(0.1829)		(0.2059)			
KOREA (DHI$)	1955-83	−0.8003	0.978		13.6	0.1172	29
		(0.2012)	(0.2811)				
KOREA (DHI$)	1955-80	−0.7109	0.8785		13.25	0.1258	26
		(0.2418)	(0.3103)				
JAPAN (DHI$)	1955-83	1.0028	−0.7567		232.95	0.4166	29
		(0.0351)	(0.2018)				
JAPAN (DHI$)	1955-80	0.9891	0.7397		31.87	0.2741	26
		(0.1542)	(0.2660)	(0.2660)			
USA (DHI$)	1955-83		−0.1998	−0.7509	1.39	0.3112	29
			(0.2314)	(0.2497)			
USA (DHI$)	1955-80			−0.8729	2.37	0.4531	26
				(0.1962)			

Fig. 17: The Fitted of Housing Investment by the ARMA Model in Taiwan

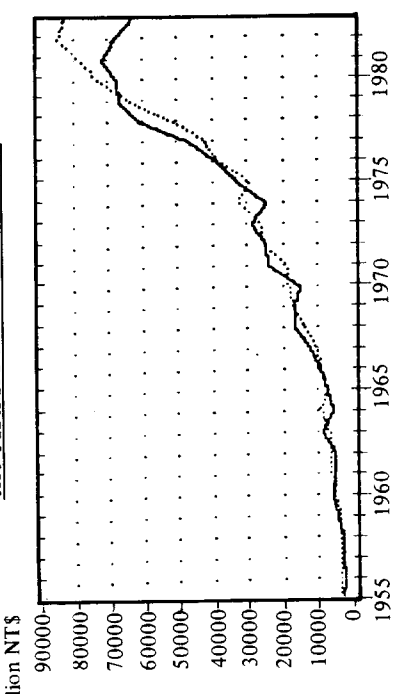


Fig. 18: The Fitted of Housing Investment by the ARMA Model in Korea

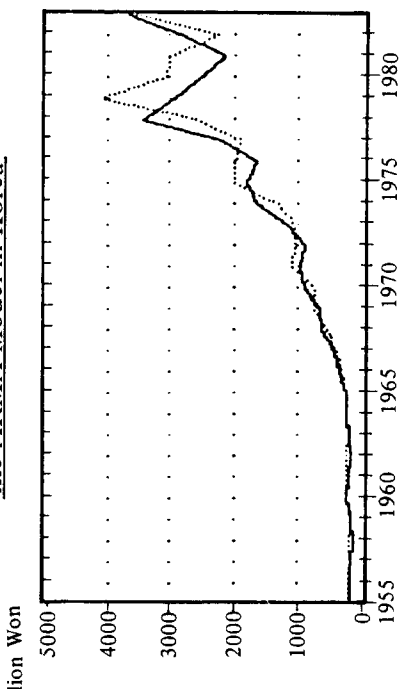
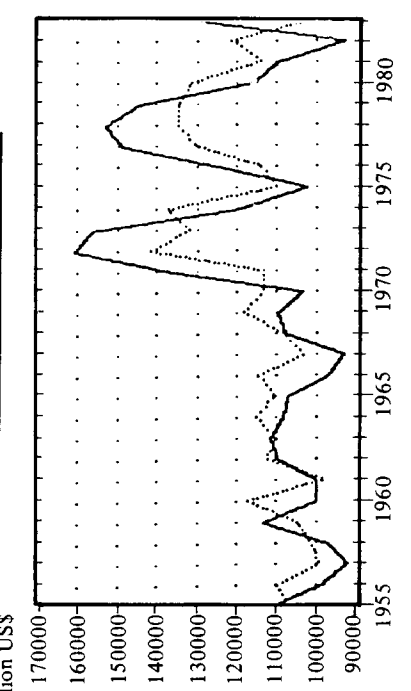


Fig. 19: The Fitted of Housing Investment by the ARMA Model in Japan

Fig. 20: The Fitted of Housing Investment by the ARMA Model in the USA



Using the ARMA model in Table 5, the results and errors of prediction for the growth of housing investment in 1984 and 1981-83 are showed in Table 6.

Table 6. The Results & Errors of Prediction Through the ARMA Model

Country	Year	Actual DHI$%	Forecast DHI$%	Error % DHI$%	Actual HI$	Forecast HI$	Error % HI$
Taiwan	1984	7.61	13.09	−72.01	67570	71014	−5.1
	1981	6.35	17.34	−172.95	71745	79156	−10.33
	1982	−5.12	17.11	434.18	68072	92698	−36.18
	1983	−7.75	13.7	276.65	62794	105395	67.84
	1981-83			(294.59)			(38.12)
Korea	1984	−0.62	13.51	2279.03	3694	4219	−14.21
	1981	−14.64	16.02	209.42	2140	2909	−35.91
	1982	32.66	11.28	65.46	2839	3237	−14.01
	1983	30.93	14.65	52.64	3717	3711	0.17
	1981-83			(109.17)			(16.70)
Japan	1984	−2.32	−6.82	−193.97	14700	14023	4.61
	1981	−2.38	−1.03	56.64	16041	16262	−1.38
	1982	−0.86	−1.37	−59.15	15903	16040	−0.86
	1983	−5.37	−1.7	68.29	15049	15767	−4.77
	1981-83			(61.36)			(2.34)
USA	1984	11.85	13.62	−14.94	146667	148982	−1.58
	1981	−5.31	−1.32	75.14	109264	113873	−4.22
	1982	−15.53	19.48	225.43	92297	136054	−47.41
	1983	42.07	2.37	94.37	131127	139277	−6.22
	1981-83			(131.65)			(19.28)

* DHI%: The percentage of growth rate in the level of housing investment

** Forecasting results are used in the prediction of 1982-83.

Then the prediction of housing investment in 1984 and 1981-83 can be calculated by the growth of housing investment. The forecasting errors of housing investment are quite small, particularly in the case of Japan.

Since the growth rate of housing investment is predicted, the results of housing investment prediction actually have combined the concept of time-lag (one-year lag) model and ARMA model. Along with this idea of the combination of models, we can consider the combination of ARMA model and trend model for housing investment prediction. This combination will improve the fitted results over solely using trend model, particularly in the cases of Taiwan and Korea due to their strong trend line of housing investment. The regression results of the logarithm of housing investment and fitted plots by the combination of trend and ARMA models in Taiwan, and Korea[3] are presented in Table 7 (equations 1 & 4) and Figure 21 – 22. We can find a little better fit in this combination model than that in the trend model, especially in the earlier period of Taiwan and Korea.

This trend and ARMA combination model, however, is not fitted well in the later period of Taiwan and Korea. It is because the pattern of trend line has been changed in the later period. This situation is especially obvious in the case of Japan. We consider it useful to add dummy variable in the trend and ARMA combination model in these three Asian countries in order that the better fit of the later period of housing investment can be achieved. According to our observations of the housing investment patterns in these Asian countries, we believe that the dummy variables are pre-1972 in Japan, pre-1977 in Korea, and pre-1978 in Taiwan separately. The regression results of the logarithm of housing investment and fitted plots by the dummy variable with the trend and ARMA model are showed in Table 7 and Figures 23 – 25. We can see very high R-squared and better fit of housing investment, in the later period especially, in the model of ARMA, trend with dummy variable than in the model without dummy variable.

The forecasting results and errors though the model of trend, dummy variable, and ARMA for 1984 and 1981-83 housing investment in these three Asian countries are showed in Table 8. We can see relatively stable and small percentage errors among these three countries. We feel more confident in the prediction of housing investment by this combination of trend, dummy variable, and ARMA model than any other model in these three Asian countries.

Table 7. Regression of Logarithm of Housing Investment on Trend, Dummy Variable, and ARMA Model in Taiwan, Korea, and Japan

DEPENDENT VARIABLE		INDEPENDENT VARIABLES						REGRESSION RESULTS		
Logarithm of Housing livestment	Period	Trend	Dummy	TrendDumy	AR (1)	MA (2)	Constant	R-Squared	S.E. of Regress.	#OBS
1. TAIWAN Log (HI$)	1954-83	0.122			0.3827		7.7	0.9766	0.1738	30
		(0.0050)			(0.1906)					
2. TAIWAN Log (HI$)	1954-83	0.016	−2.9644	0.1076	0.2778	−0.2264	10.64	0.9819	0.1621	30
		(0.044)	(1.2318)	(0.0455)	(0.2002)	(0.2073)				
3. TAIWAN Log (HI$)	1954-80	0.067	−1.6559	0.0571	0.2839	−0.2264	9.33	0.9774	0.171	27
		(0.119)	(3.1094)	(0.1202)	(0.2126)	(0.2201)				
4. KOREA Log (HI$)	1954-83	0.1386			0.7202		4.17	0.9739	0.1984	30
		(0.0157)			(0.1188)					
5. KOREA Log (HI$)	1954-83	0.048	−2.8464	0.1128	0.7957	−0.394	6.64	9,8672	0.1922	30
		(0.065)	(1.9340)	(0.0800)	(0.1373)	(0.2127)				
6. KOREA Log (HI$)	1954-80	0.0502	−2.8636	0.1135	0.8056	−0.4138	6.61	0.9762	0.1919	27
		(0.1056)	(2.8641)	(0.1186)	(0.1390)	(0.2253)				
7. JAPAN Log (HI$)	1954-83	−0.0017	−2.8373	0.1477	0.542		9.74	0.997	0.0542	30
		(0.0078)	(0.2189)	(0.0185)	(0.1586)					
8. JAPAN Log (HI$)	1954-80	0.012	−2.5231	0.1321	0.415		9.45	0.9972	0.0546	27
		(0.0099)	(0.2433)	(0.0116)	(0.1939)					

* Dummy Variable: Japan: 1953-71 = 1, and 1972-84 = 0;
Korea: 1953-75 = 1, and 1977-84 = 0;
Taiwan: 1953-77 = 1, and 1978-84 = 0.

** TrendDumy: Trend * Dummy

Fig. 21: The Fitted of Housing Investment by the Trend and ARMA Model in Taiwan

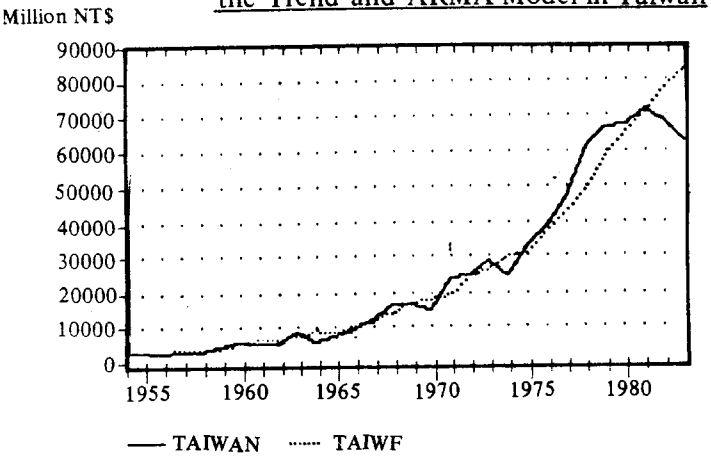


Fig. 22: The Fitted of Housing Investment by the Trend and ARMA Model in Korea

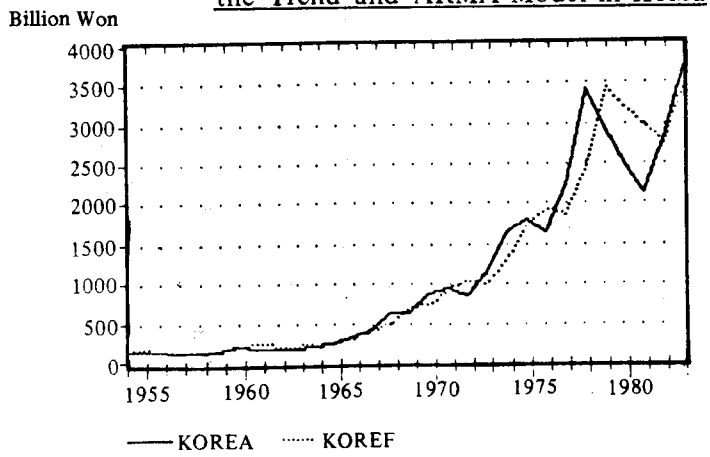


Fig. 23: The Fitted of Housing Investment by the Trend, Dummy Variable, and ARMA Model in Taiwan

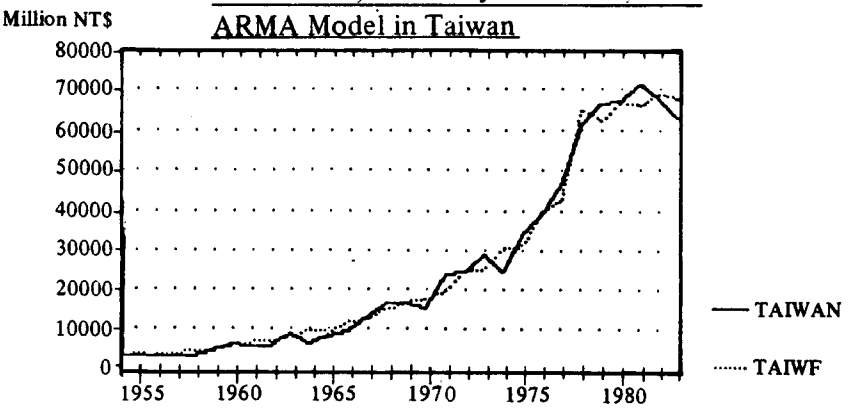


Fig. 24: The Fitted of Housing Investment by the Trend, Dummy Variable, and ARMA Model in Korea

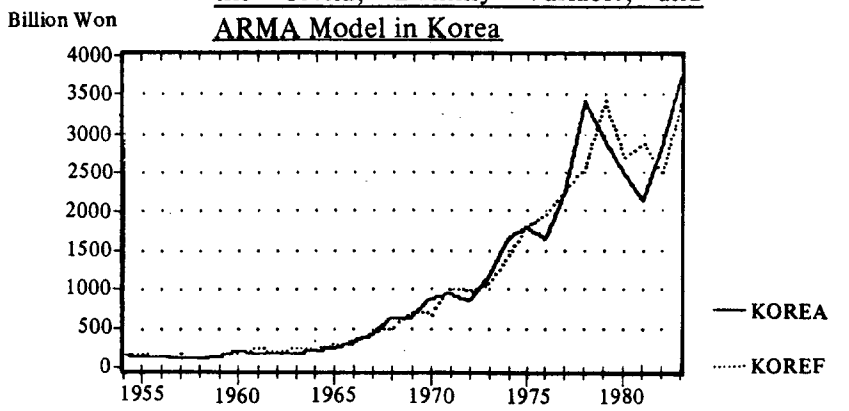


Fig. 25: The Fitted of Housing Investment by the Trend, Dummy Variable, and ARMA Model in Japan

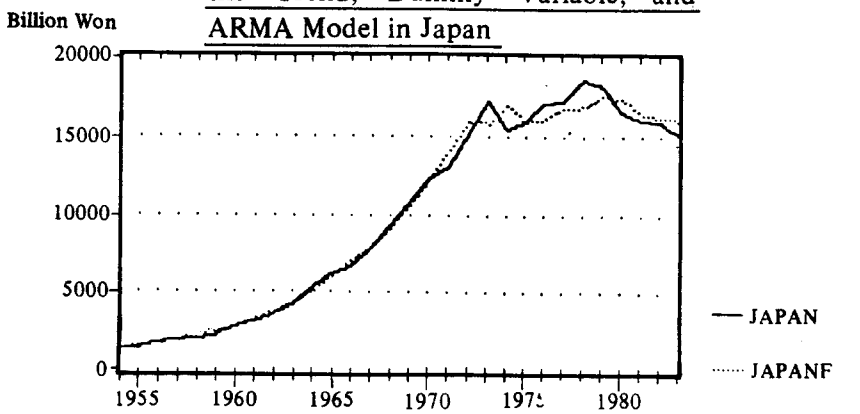


Table 8. The Results & Errors of Prediction through the Trend, Dummy Variable, and ARMA Model in Taiwan, Korea, and Japan

Country	Year	Actual	Forecast*	Error %
Taiwan	1984	67570	68943	−2.03
	1981	71745	73236	−2.08
	1982	68072	79809	−17.24
	1983	62794	85190	−35.67
	1981-83			(18.33)
Korea	1984	3694	3655	1.06
	1981	2140	2947	−37.71
	1982	2839	3219	−13.38
	1983	3717	3388	8.85
	1981-83			(19.98)
Japan	1984	14700	15544	−5.74
	1981	16041	17286	−7.76
	1982	15903	17768	−11.73
	1983	15049	18097	−20.25
	1981-83			(13.25)

*Forecast is adjusted by S.E. of Regression.

V. Explanatory Models

As we mentioned earlier, the traditional explanatory models can be applied to predict the future housing investment. We are particularly interesting in comparing the forecasting results by the explanatory models and the previous time-series models. The regression results for the prediction from Chang (1986b)[4] and the fitted plots by the explanatory models in these four countries are showed in Table 9 and Figures 26 – 29. We can see that the fitted plots are good, particularly in the later period of the US which is not fitted well by the previous time-series models yet.

Table 9. Regression of Housing Investment by the Explanatory Models in Taiwan, Korea, Japan, and the USA

DEPENDENT VARIABLE	INDEPENDENT VARIABLES							REGRESSION RESULTS		
Housing Investment	Period	GDPC	GDPC2	DPOP	INTR	DCPI	Constant	ADJ-R2	F-STAT	#OBS
TAIWAN (HI$)	1953-83	43.02		8425.9			−49837	0.9802	744.45	31
		(1.99)		(1769.41)						
TAIWAN (HI$)	1953-80	45.95		9631.99			−55986	0.9824	754.25	28
		(1.99)		(1531.02)						
KOREA (HI$)	1953-83	2.38					−976	0.9452	518.13	31
		(0.10)					−976	0.9452	518.13	31
KOREA (HI$)	1953-80	2.42					−995	0.9454	468.1	28
		(0.11)								
JAPAN (HI$)	1973-83	29.04	−0.0017	4035.72	−597		−105097	0.8993	23.32	11
		(5.78)	(0.00032)	(2174.52)	(163.37)					
JAPAN (HI$)	1973-80	42.07	−0.0025	5181.55	−421.97		−161640	0.8348	9.84	8
		(29.00)	(0.0017)	(3101.44)	(459.91)					
USA (HI$)	1953-83	37.07		60316.11	−9840.98	−1838.35	−236327	0.7036	18.3	31
		(5.28)		(16625.6)	(1742.73)	(1010.38)				
USA (HI$)	1953-80	34.97		58071.49	−6615.31	−3018.11	−226283	0.6984	16.63	28
		(6.47)		(17378.9)	(4610.88)	(1813.51)				

Fig. 26: The Fitted of Housing Investment by the Explanatory Model in Taiwan

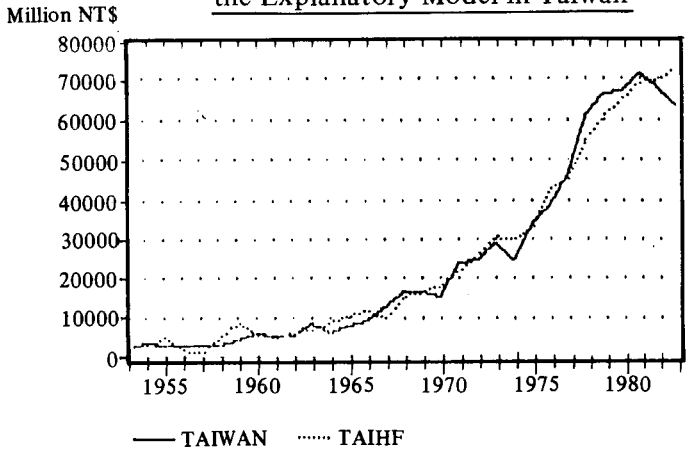


Fig. 27: The Fitted of Housing Investment by the Explanatory Model in Korea

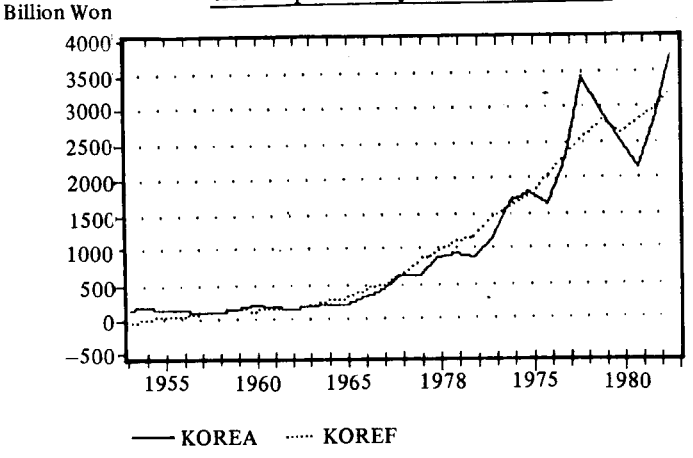


Fig. 28: The Fitted of Housing Investment by the Explanatory Model in Japan

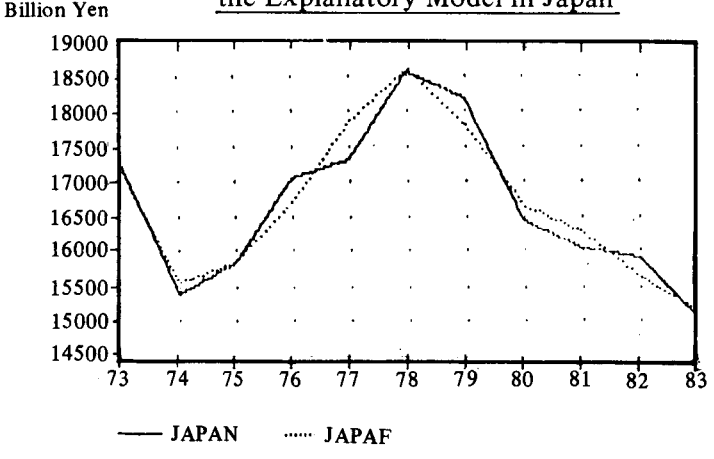
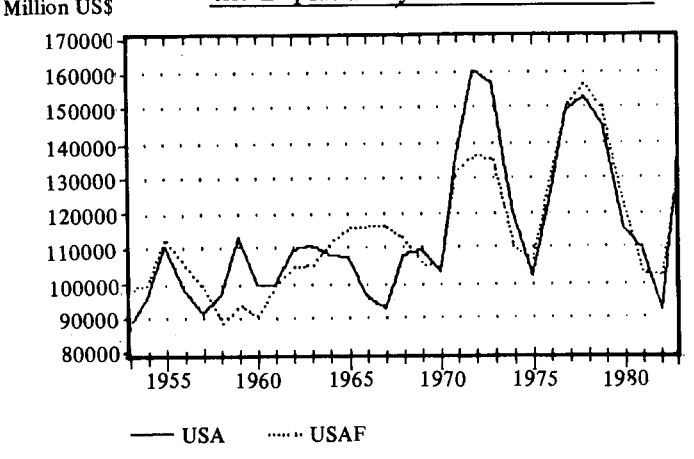


Fig. 29: The Fitted of Housing Investment by the Explanatory Model in the USA



The forecasting results and errors in these four countries by the explanatory models are presented in Table 10. The percentage errors are not much smaller than those of previous time-series models however. Particularly the actual data of those independent variables in the explanatory models in 1984 and 1981-83 are used to forecast. We considered that the higher percentage error will occur when the actual data of those independent variables are not available.

Table 10. The Results & Errors of Prediction through the Explanatory Models

Country	Year	Actual	Forecast	Error %
Taiwan	1984	67570	81716	−20.94
	1981	71745	72117	−0.52
	1982	68072	72223	−6.1
	1983	62794	76118	−21.22
	1981-83			(9.28)
Korea	1984	3694	3509	5.00
	1981	2140	2793	−32.35
	1982	2839	2939	−5.01
	1983	3717	3244	11.47
	1981-83			(16.28)
Japan	1984	14700	12752	13.25
	1981	16041	15700	2.13
	1982	15903	14573	8.36
	1983	15049	13690	9.03
	1981-83			(6.51)
USA	1984	146667	131647	10.24
	1981	109254	115599	−5.8
	1982	92297	118155	−28.02
	1983	131127	144564	−10.25
	1981-83			(14.69)

VI. Forecasting Models Comparison

Since the criterion of accuracy is usually the top priority for the comparison of forecasting models, we will discuss this criterion first. Although it is difficult to compare the accuracy of forecasting results in these models, the forecasting results and errors in 1984 and 1981-83 provide some indications/references to evaluate the accuracy of the forecasting models. All of these forecasting percentage errors by these models from the previous tables are summarized in Table 11. We can see that the best forecasting results in 1984 for these three Asian countries on average are predicted by the trend, dummy and ARMA model (No. 4). And the ARMA model (No. 3) has better prediction in the average of these four countries in 1984. In 1981-83, the best forecasting results for these Asian countries as well as the USA, on average, are predicted by the explanatory models (No. 5).

In terms of individual country's prediction in 1984 and 1981-83, the first and second best forecasting models for each country are listed in Table 12. The average percentage error of the best forecasting model for these four countries are 2.32% in 1984 and 10.65% in 1981-83 which are quite accurate for these forecasting results. The forecasting results for the short term are more accurate than that for the long term.

Except for the criterion of accuracy, it is also important to evaluate the criterion of time horizon. From Table 11 we can find that, on average, the ARMA models (No. 3 & 4) are more accurate for the short term, next year (1984) prediction, and the explanatory models (No. 5) are more accurate for the long term, three years (1981-83) prediction. There is, however, not much difference between the ARMA models and explanatory models in the short and long term prediction, according to our study in these four countries.

In practice, data collection and number of items to be forecast are the major costs for prediction. Since time-series models only require one variable, we can easily see that there is less expense in the time-series models than in the explanatory models. Particularly when the explanatory variables in the explanatory models are not available, we have to build other models to forecast those variables first. It is much more expensive to build many models at the same time for the purpose of prediction only.

The final criterion for the evaluation of goodness of prediction may be considered the ease of application. Usually we believe that the more complicated and expensive model that is used, the better the accuracy of prediction that is

Table 11. Summary of the Percentage Error of Prediction by these Forecasting Models in Taiwan, Korea, Japan, and the USA

Forecasting Model	Country	1984	1981	1982	1983	1981-83
1. Trend Model	Taiwan	−22.34	0.83	−13.89	−34.07	16.26
	Korea	−1.84	−55.09	−27.69	−6.13	29.64
	Japan	−31.56	−32.66	−40.46	−55.66	42.91
	USA	8.83	−27.74	−53.11	−9.09	29.98
	MAPE 1	18.58	29.53	27.35	31.93	29.6
	MAPE 2	16.14	29.08	33.79	26.25	29.7
2. Trend Model (Log of Housing Investment)	Taiwan	−48.19	3.5	−23.69	−52.04	26.41
	Korea	−23.23	58.04	−35.82	−18.29	37.38
	Japan	−22.1	−34.47	−39.95	−51.77	42.06
	USA	8.59	−28.5	−54.36	−10.25	31.04
	MAPE 1	31.17	32	33.15	40.7	35.28
	MPAE 2	25.53	31.13	38.46	33.09	34.22
3. ARMA Model (% Growth Rate of Housing Investment)	Taiwan	5.1	−10.33	−36.18	67.84	38.12
	Korea	−14.21	35.91	−14.01	0.17	16.7
	Japan	4.61	−1.38	0.86	4.77	2.34
	USA	−1.58	−4.22	−47.41	−6.22	19.28
	MAPE 1	7.97	15.87	17.02	24.26	19.05
	MAPE 2	6.38	12.96	24.62	19.75	19.11
4. ARMA + Trend + Dummy Model	Taiwan	−2.03	−2.08	−17.24	−35.67	18.33
	Korea	1.06	−37.71	−13.38	8.85	19.98
	Japan	−5.74	−7.76	−11.73	−20.25	13.25
	MAPE 1	2.94	15.85	14.12	21.59	17.19
5. Explanatory Models	Taiwan	−20.94	−0.52	−6.1	−21.22	9.28
	Korea	5	−32.35	−5.01	11.47	16.28
	Japan	13.25	2.13	8.36	9.03	6.51
	USA	10.24	−5.8	−28.02	−10.25	14.69
	MAPE 1	13.06	11.67	6.49	13.91	10.69
	MAPE 2	12.36	10.2	11.87	12.99	11.69

* 1981-83: Mean Absolute Percentage Error (MAPE) in 1981-83

** MAPE 1: MAPE in Taiwan, Korea, and Japan three Asian Countries.
MAPE 2: MAPE in Taiwan, Korea, Japan, and USA four countries.

Table 12. The First and Second Best Forecasting Model in 1984 and 1981-83 in Taiwan, Korea, Japan, and the USA

Country	Forecasting Models in 1984				Forecasting Models in 1981-83			
	First	Error %	Second	Error %	First	Error %	Second	Error %
Taiwan	No. 4	−2.03	No. 3	−5.1	No. 5	9.28	No. 1	16.26
Korea	No. 4	1.06	No. 1	−1.84	No. 5	16.28	No. 3	16.7
Japan	No. 3	4.61	No. 4	−5.74	No. 3	2.34	No. 5	6.51
USA	No. 3	−1.58	No. 2	8.59	No. 5	14.69	No. 3	19.28
MAPE		2.32		5.32		10.65		14.69

* No. 1: Trend Model
No. 2: Trend Model (Log of Housing Investment)
No. 3: ARMA Model (% Growth Rate of Housing Investment)
No. 4: ARMA + Trend + Dummy Model
No. 5: Explanatory Model

achieved. This common sense idea, however, is not held in our forecasting housing investment study. If two types of forecasting method – time-series models vs. explanatory models are compared by the criterion of the ease of application, we can find that the explanatory models are more difficult to apply than the time-series models, in terms of model building, model complexity, and data collection. In terms of the application of long term (1981-83 for example) prediction, the explanatory models are difficult to apply if the data of the current period are not available. In this long term prediction case, time-series models, however, are much easier to apply. In terms of the application of techinique, the ARMA model is probably more complicated and difficult than other models. It is the case, however, that personal computer and software packages have been well developed already[5] and can be easily learned and applied for ARMA model.

To summarize this forecasting models comparison, we conclude that there is not a direct link between the sophistication of a forecasting mathod and its accuracy. We also conclude that there is not a direct link between the "goodness of fit/explanation" of a model and its "goodness of prediction". Based upon our forecasting case studies, we conclude that ARMA model is rather appropriate

for housing investment prediction in terms of accuracy and feasibility.

In order to provide some references for future housing investment in each country, we would like to use our models, built from the ARMA, trend and dummy[6] to further predict housing investment for 1985, 1986, 1987, and 1988. The forecasting results are shown in Table 13.

VII. Forecasting Models Across Countries

Since the different units of housing investment value are forecasted among different countries, the forecasting model in each country cannot be transferred to other countries directly. We choose the ARMA model which forecast the growth rate of housing investment in each country to test how well of these models work in terms of model transferability. The correlation coefficients of housing investment between two countries which forecasting models are transferred are examined first in Table 14. We can see that high correlation coefficients imply similar housing investment patterns among them.

Table 13. Housing Investment Forecasting for 1985 – 88 in 1983 Constant Prices in Taiwan, Korea, Japan, and the USA

	1985	1986	1987	1988
Taiwan (Million NT$)	72329	73015	74079	75263
Korea (Billion Won)	3665	3841	4029	4224
Japan (Billion Yen)	15794	15919	15975	15993
USA (Million US$)	152160	126266	112454	121045

* These forecasting results of Taiwan, Korea, and Japan are estimated by the ARMA, trend, and dummy model (No. 4).

** The forecasting results of the USA are estimated by the ARMA and dummy model (see footnote 5).

Table 14. Correlation Matrix of the Level of Housing Investment

	USA	JAPAN (E)	TAIWAN	KOREA
JAPAN (L)	0.7 (74-83)			
TAIWAN		0.91 (53-69/67-83)		0.95 (53-83)
KOREA		0.88 (53-69/67-83)	0.95 (53-83)	
PHILIP			0.9 (70-83)	0.83 (70-83)
THAI			0.81 (70-83)	0.83 (70-83)

The forecasting ARMA models in the US, earlier Japan[7], Taiwan, and Korea from Table 5 (1955-83) are transferred to forecast 1984 and 1981-83 housing investment in Japan, Taiwan, Korea, the Philippines, and Thailand. The forecasting results and percentage of errors through transfer models are showed in Table 15 – 19. We can see that transfer models for the forecasting housing investment are not bad in terms of the accuracy in 1981-84. Especially the forecasting results that used Taiwan and Korea's models to predict housing investment in the Philippines and Thailand are quite accurate. We consider that this alternative – forecasting models across similar countries may be as a potential approach if its own country's forecasting model is either not available or not appropriate.

VIII. Conclusion

There are two types of forecasting model for housing investment prediction. The conventional one is the application of an explanatory model; and the other one is the time-series model. Generally, the explanatory model is more complicated than the time-series model in forecasting in practice. This paper has compared how goodness of prediction by different forecasting models (trend

model, ARMA model, and explanatory model) among different countries (Taiwan, Korea, Japan, and the USA). We conclude that ARMA model is rather appropriate for housing investment prediction in terms of accuracy and feasibility. This paper also tests how accuracy of the ARMA models across other countries. We demonstrate that the forecasting model across similar countries may be considered as a possible approach if no other better forecasting models exist. Since this paper seeks to study a number of countries which taken together produce continuous of development stage and housing stock, and share in the cases of Japan, Taiwan, and Korea similar national backgrounds, this paper is helpful in clarifying the forecasting of housing investment.

Table 15. The Results & Errors of Prediction in Taiwan through Taiwan, Korea, and Earlier Japan's ARMA Models

Model	Year	Actual DHI%	Forecast DHI%	Error % DHI%	Actual HI$	Forecast HI$	Error% HI$
Taiwan	1984	7.61	13.09	−72.01	67570	71014	−5.1
	1981	6.35	17.34	−173	71745	79156	−10.33
	1982	−5.12	17.11	434	68072	92698	−36.18
	1983	−7.75	13.7	277	62794	105395	67.84
	1981-83			(295)			(38.12)
Korea	1984	7.61	26.72	−251	67570	79573	−17.76
	1981	6.35	5.97	5.98	71745	71487	0.36
	1982	−5.12	19.71	485	68072	85577	−25.72
	1983	−7.75	8.71	212	62794	93031	−48.15
	1981-83			(234)			(24.74)
Japan (Earlier)	1984	7.61	25.63	−237	67570	78888	−16.75
	1981	6.35	26.85	−323	71745	85573	−19.27
	1982	−5.12	27.99	647	68072	109525	−60.9
	1983	−7.75	29.14	476	62794	141441	−125.25
	1981-83			(482)			(68.47)

*Forecasting results are used in the prediction of 1982-83.

Table 16. The Results & Errors of Prediction in Korea through Korea, Taiwan, and Earlier Japan's ARMA Models

Model	Year	Actual DHI%	Forecast DHI%	Error % DHI%	Actual HI$	Forecast HI$	Error % HI$
Korea	1984	−0.62	13.51	2279	3694	4219	−14.21
	1981	−14.64	16.02	209	2140	2909	−35.91
	1982	32.66	11.28	65.46	2839	3237	−14.01
	1983	30.93	14.65	52.64	3717	3711	0.17
	1981-83			(109)			(16.07)
Taiwan	1984	−0.62	6.55	1156	3694	3960	−7.2
	1981	−14.64	23.96	264	2140	3108	−45.23
	1982	32.66	16.32	50.03	2839	3615	−27.33
	1983	30.93	12.16	60.69	3717	4055	−9.09
	1981-83			(125)			(27.22)
Japan (Earlier)	1984	−0.62	30.4	5003	3694	4847	−31.21
	1981	−14.64	23.99	264	2140	3108	−45.23
	1982	32.66	25.13	23.06	2839	3889	−36.98
	1983	30.93	26.28	15.03	3717	4911	−32.12
	1981-83			(101)			(38.11)

Table 17. The Results & Errors of Prediction in Japan through Japan and USA's ARMA Models

Model	Year	Actual DHI%	Forecast DHI%	Error % DHI%	Actual HI$	Forecast HI$	Error % HI$
Japan	1984	−2.32	−6.82	−194	14700	14023	4.61
	1981	−2.38	−1.03	56.64	16041	16262	−1.38
	1982	−0.86	−1.37	−59.15	15903	16040	−0.86
	1983	−5.37	−1.7	68.29	15049	15767	−4.77
	1981-83			(61.36)			(2.34)
USA*	1984	−2.32	11.06	577	14700	16713	−13.69
	1981	−2.38	9.67	506	16041	18021	−12.34
	1982	−0.86	11.2	1402	15903	20039	−26.01
	1983	−5.37	1.39	126	15049	20318	−35.01
	1981-83			(678)			(24.45)

*Only 1974-83 data points in Japan are used in the USA model

Table 18. The Results & Errors of Prediction in the Philippines through Taiwan and Korea's ARMA Models

Model	Year	Actual DHI%	Forecast DHI%	Error % DHI%	Actual HI$	Forecast HI$	Error % HI$
Taiwan	1984		15.08			24693	
	1981	14.13	15.44	−9.27	17682	17885	−1.15
	1982	14.4	13.87	3.68	20228	20366	−0.68
	1983	6.08	12.86	−112	21457	22985	−7.12
	1981-83			(41.65)			(2.98)
Korea	1984		16.37			24970	
	1981	14.13	11.87	15.99	17682	17332	1.98
	1982	14.4	14.99	−4.1	20228	19930	1.47
	1983	6.08	12.49	−105	21457	22419	−4.48
	1981-83			(41.70)			(2.64)

Table 19. The Results & Errors of Prediction in Thailand through Taiwan and Korea's ARMA Models

Model	Year	Actual DHI%	Forecast DHI%	Error % DHI%	Actual HI$	Forecast HI$	Error % HI$
Taiwan	1984	15.76	12.65	19.73	43467	42299	2.69
	1981	37.86	23.29	38.48	30038	26864	10.57
	1982	2.37	14.8	−524	30749	30840	−0.3
	1983	22.12	12.6	43.04	37549	34726	7.52
	1981-83			(202)			(6.13)
Korea	1984	15.76	11.9	24.49	43467	42017	3.34
	1981	37.86	22.32	41.05	30038	26652	11.27
	1982	2.37	6.62	−179	30749	28416	7.59
	1983	22.12	19.18	13.29	37549	33866	9.81
	1981-83			(77.78)			(9.56)

Footnotes

1. According to Chang's (1986b) study that different housing stock conditions will require the use of different forecasting. For example, Taiwan's housing stock will probably be mature in the near future. Once this condition is achieved, the forecasting model which worked best for the non-mature period may no longer be appropriate. At that point a new forecasting model for the newly mature housing stock condition in Taiwan becomes relevant. But only one data point, so may reduce confidence, look to other mature country models as a second source of information. For detailed discussion the relationship between housing stock and housing investment, see Chang (1986b), pp. 65-77.
2. See Chang (1986b), Chagter 3, pp. 31-39.
3. Since a non-stationary situation occurs when the combination of ARMA and trend model was applied in Japan, this combination model is not appropriate for the case of Japan. In addition, since no clear trend line exists in the US pattern, the combination of ARMA and trend model can also not be applied in the case of the US.
4. For detailed see Chang (1986b) Chapter 4: Explanatory Model of Housing Investment, pp. 61-102.
5. The software package, *Micro TSP*, can deal especially well with the ARMA model.

6. Since US housing investment has not been built on that type of model, we estimate ARMA, dummy variable without trend model as following:

   US (HI$) = 131289 – 27485 Dummy + 0.7372 AR(1) – 0.7250 AR(2)
   (1955-83) (4475) (0.1624) (0.1831)

   * Dummy variable: 1955-70 = 1, 1971-83 = 0.

   This model then is used to predict housing investment for 1985-88 in the US.
7. The earlier Japan's ARMA model is estimated by the following:

   Japan (DHI%) = 3547 + 1.00 AR(1) – 0.96 MA(1)
   (1955-69) (0.002) (0.31)

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