Forecasting Housing Investment in Developing Countries

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ABSTRACT In this paper we estimate alternative models of the growth rate of real housing investment for Japan, Korea, Taiwan, and the U.S. Pure time series models generally provide superior fit to these growth rate data both within and out of the sample period. These time series models are then used to forecast investment growth rates in other countries. The results indicate that such time series models can be used to provide reasonable accurate forecasts for other countries.

Residential investment accounts for a large proportion of all investment activity and is, therefore, an extremely important aspect of economic forecasting. Since inaccurate forecasts of housing investment induce inefficiencies, particularly in developing economies, it is important for decision makers to develop accurate models of housing investment activity. This is especially true for private decision makers who generally lack access to sophisticated macroeconomic models.

Most analyses of housing investment behavior model housing investment as a function of GNP, interest rates, inflation, and demographic variables.[1] A major shortcoming of these traditional models for forecasting is the need to forecast the independent variables in order to obtain forecasts of housing investment. Thus, housing investment forecasts derived from such traditional models are only as reliable as the combination of the underlying forecasting equation and the forecasts of the independent variables (which may come from large scale macroeconomic models). Several studies have noted this problem in the context of the United States, and have modeled US housing investment as a time series process.[2] This paper extends this analysis to examine housing investment forecasts for the developing economies of Taiwan and Korea. The models for these developing countries are compared with similar models for the developed economies of the US and Japan.

We also explore whether the housing investment model for one country can be reliably used to forecast housing investment in other countries. This is an important question for developing countries, as data limitations often make it difficult to accurately estimate housing investment models. Specifically, we investigate the accuracy of forecasts of housing investment obtained using one nation's model for

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predicting housing investment activity in another country. In this context, we utilize the models for the US and Japan to forecast housing investment in Korea and Taiwan, and the investment models for Taiwan and Korea to forecast housing investment in Korea, Taiwan, Thailand and the Philippines.

In the next section we develop simple models of housing investment in the US, Japan, Korea, and Taiwan using both traditional structural specifications and time series models, while in the section after that we apply these models across countries in order to evaluate the "transportability" of housing investment models. The paper concludes with a brief summary.

Models Of The Housing Investment Growth Rate

Annual housing investment for Taiwan, Korea, Japan, and the US from 1953-1983 (in 1983 constant prices in each country's currency) are displayed in Figures 1-4 respectively. Substantial growth in housing investment levels occurred in all three Asian countries until the 1970's, while the US exhibits a pattern of cyclicality around a stable mean. Japan's investment pattern since 1971 exhibits a cyclical pattern around a stable mean; however, before that time there was a strong positive trend. Korea and Taiwan show similar cyclical patterns since 1978, although these cyclical patterns are much less pronounced than is the case for either the US or Japan (after 1971).

Figures 5-8 display the annual percentage change in real housing investment for each of these four countries over the same time period. Each country appears to exhibit substantial cyclicality about a stable mean growth rate. Not surprisingly, the Asian countries display higher average growth rates than the US, with the exception of Japan since 1971. This notable decline in Japan's housing investment growth rate reflects the fact that the number of households per dwelling unit had reached approximately unity by 1971.[3]

Since one of our interests is to explore the "transportability" of housing investment models across countries, we concentrate only on modeling the annual growth rate of real housing investment for these countries. We examine growth rates because any attempt to model housing investment levels across countries must account for different mean investment levels (for example, due to population levels) across countries. Further, an analysis of "transportability" in terms of investment levels is largely intractable due to the need to forecast exchange rates across countries.[4]

We estimate three types of simple models of investment growth rates for each of these countries. The first model is a traditional specification and expresses the investment growth rate as a function of demographic and economic variables such as GNP, population growth, and interest rates. As noted earlier, these simple traditional models are useful in understanding the social and economic forces which "cause" investment change; however, as a forecasting device they are severely hampered by the need to forecast the independent variables. This is particularly troublesome for developing countries where macroeconomic forecasting models are relatively inaccurate. To eliminate the problem inherent in forecasting the independent variables employed in the traditional model, we also estimate two simple time series models: 1) a time trend model; and, 2) an ARIMA model. The trend

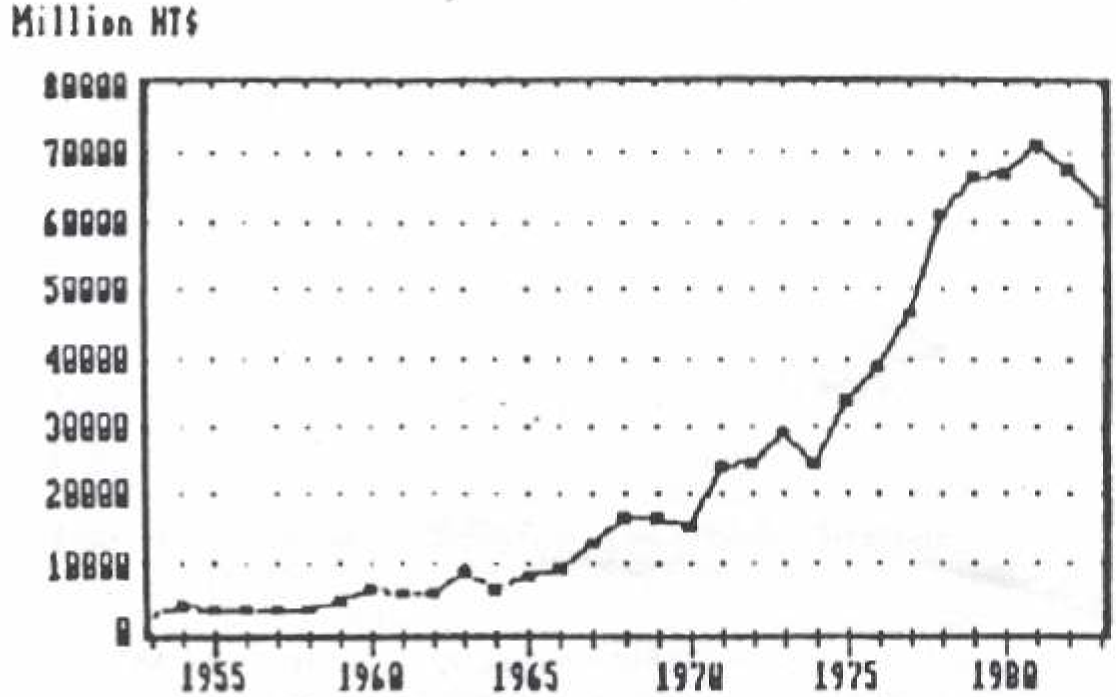

FIGURE 1. The Level of Real Housing Investment in Taiwan

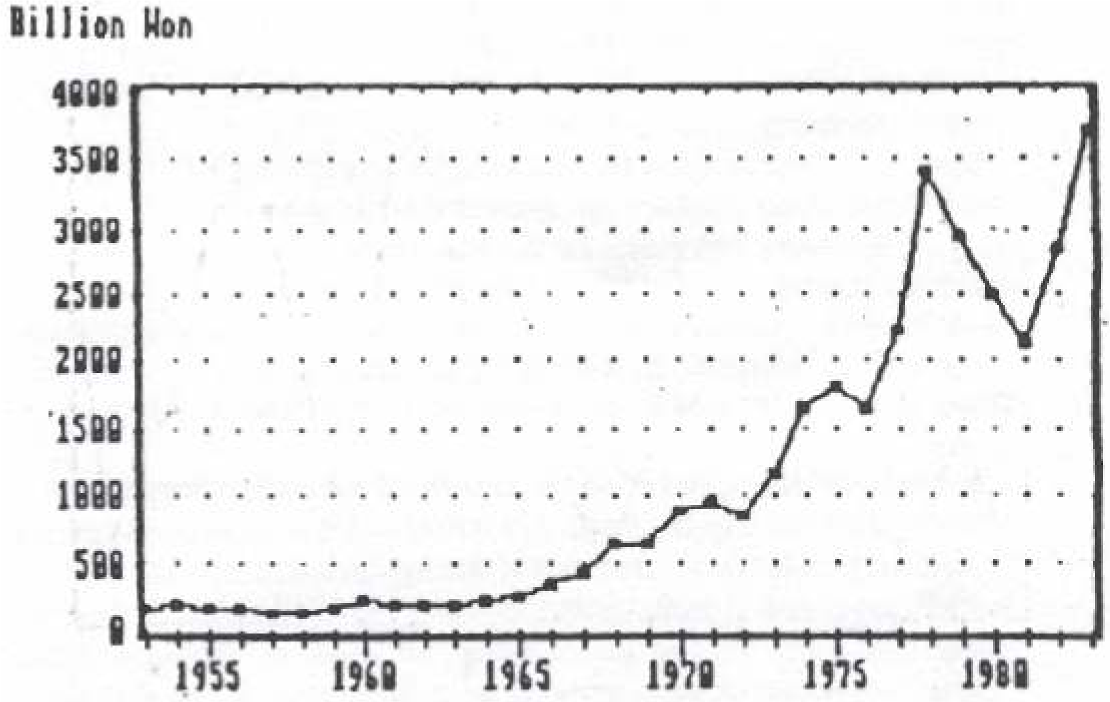

FIGURE 2. The Level of Real Housing Investment in Korea

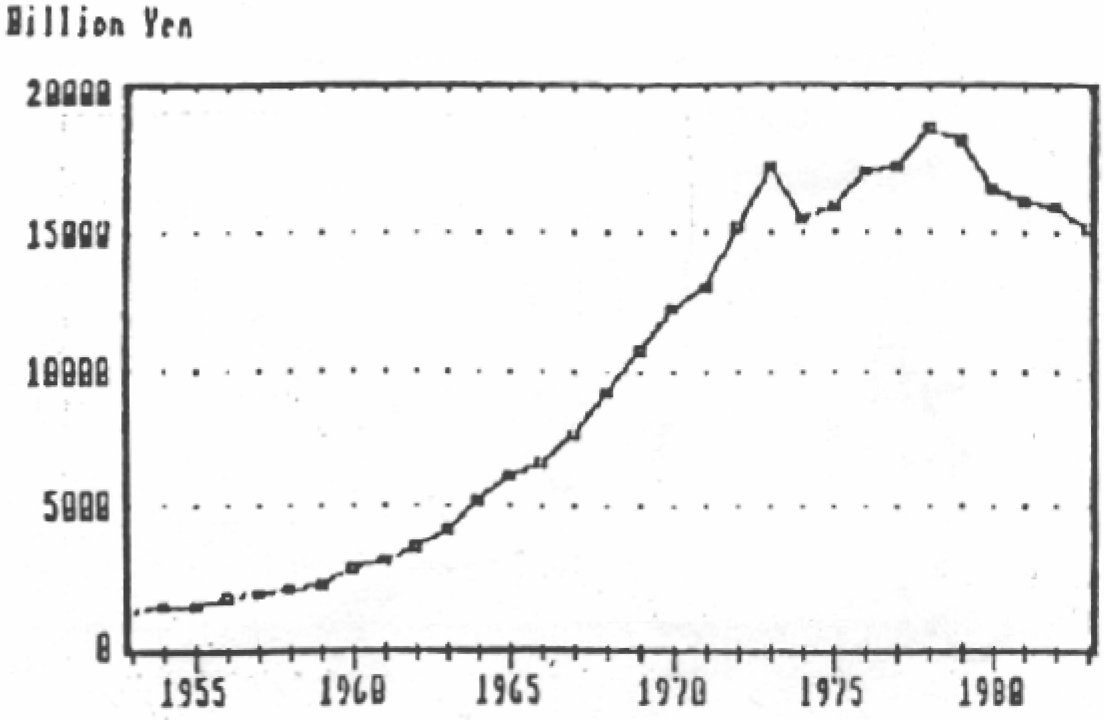

FIGURE 3. The Level of Real Housing Investment in Japan

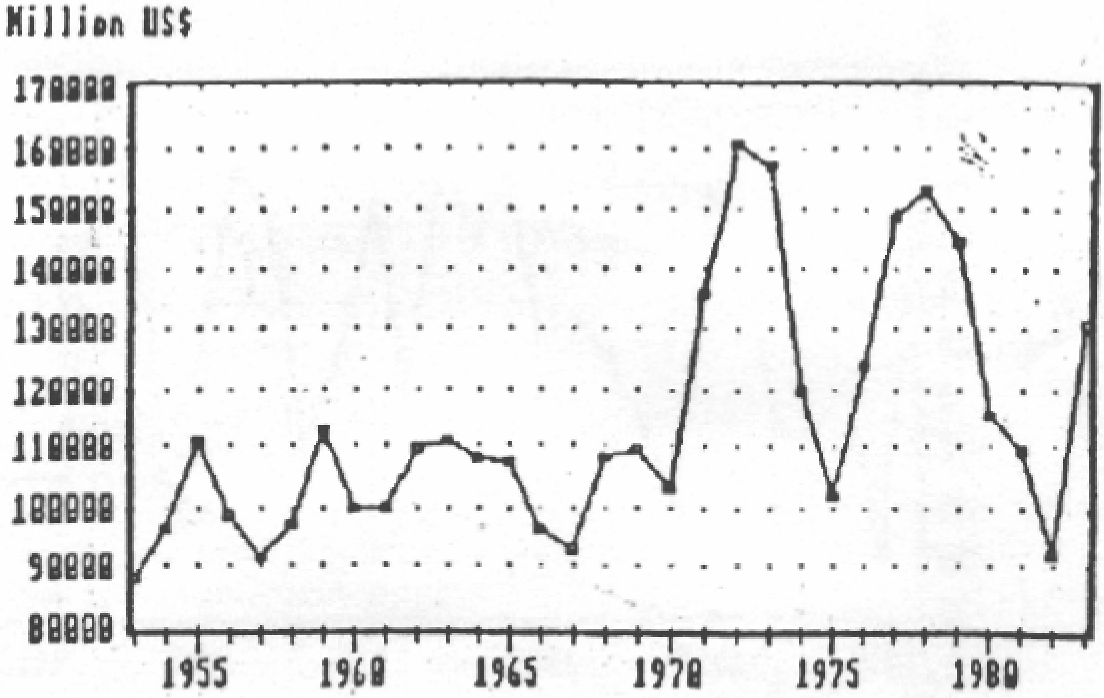

FIGURE 4. The Level of Real Housing Investment in the USA

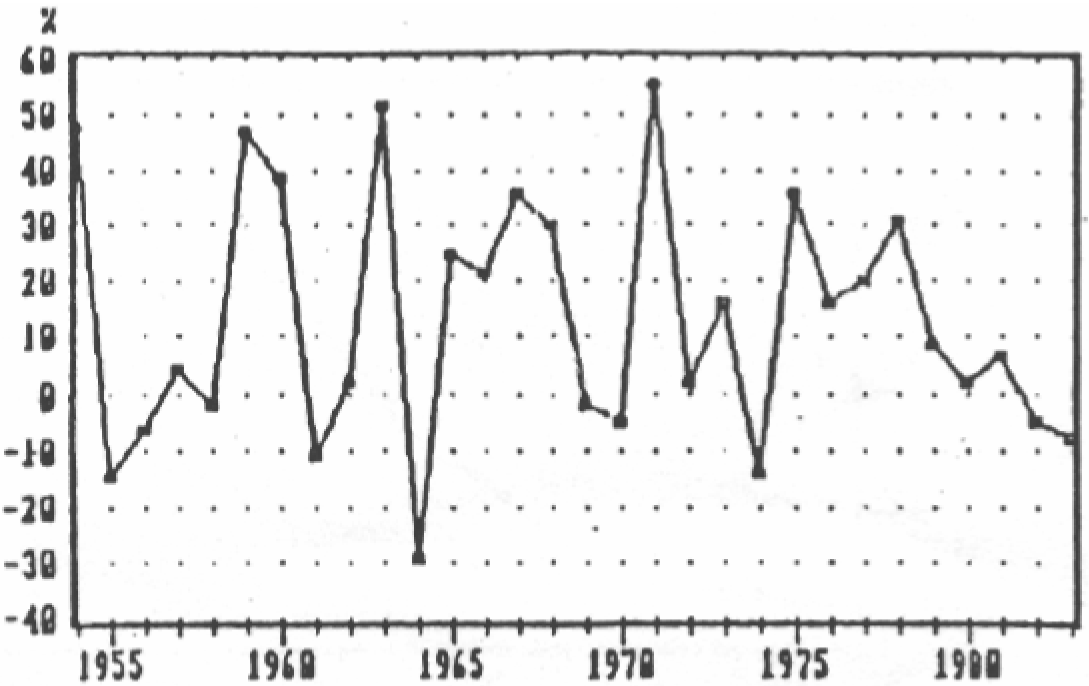

FIGURE 5. The Growth Rate of the Level of Real Housing Investment in Taiwan

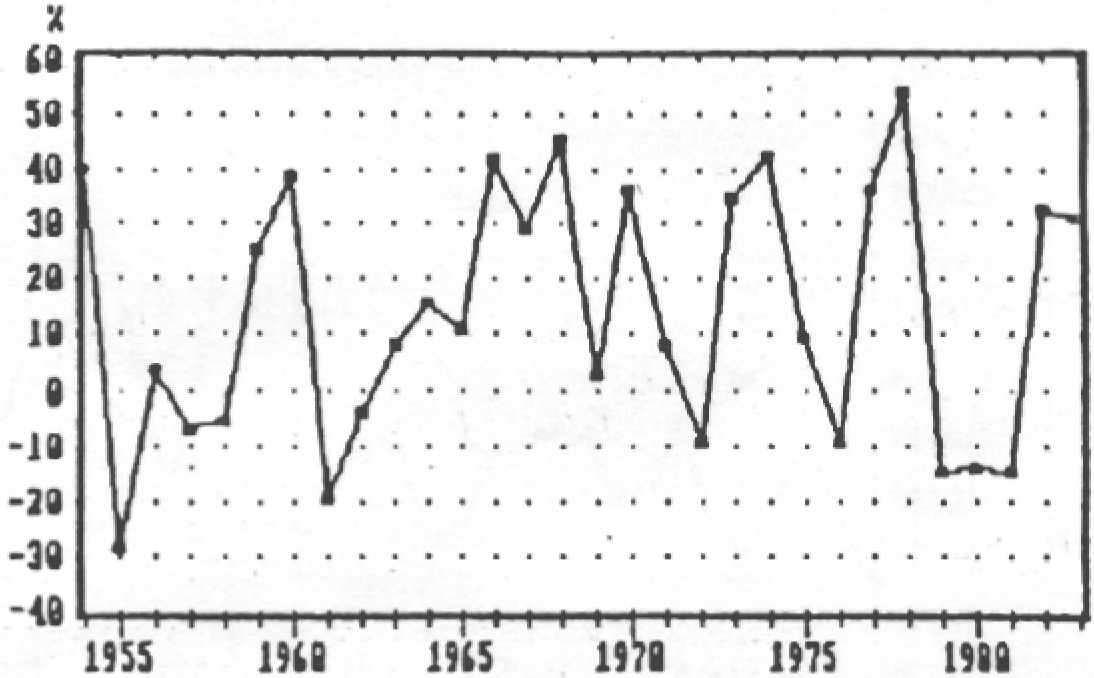

FIGURE 6. The Growth Rate of the Level of Real Housing Investment in Korea

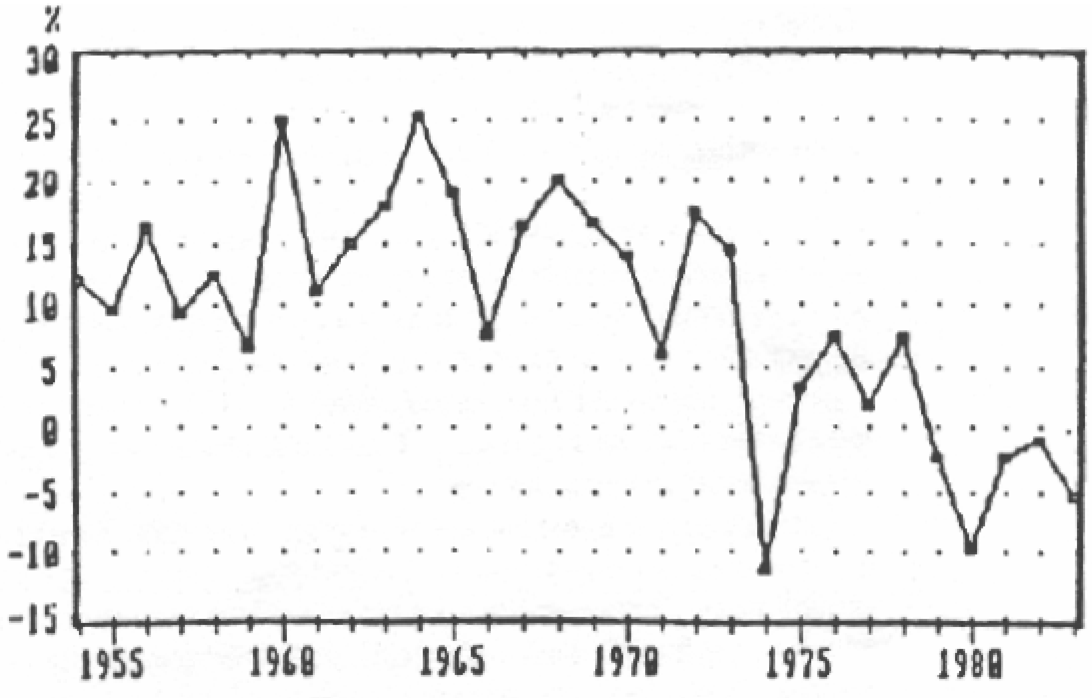

FIGURE 7. The Growth Rate of the Level of Real Housing Investment in Japan

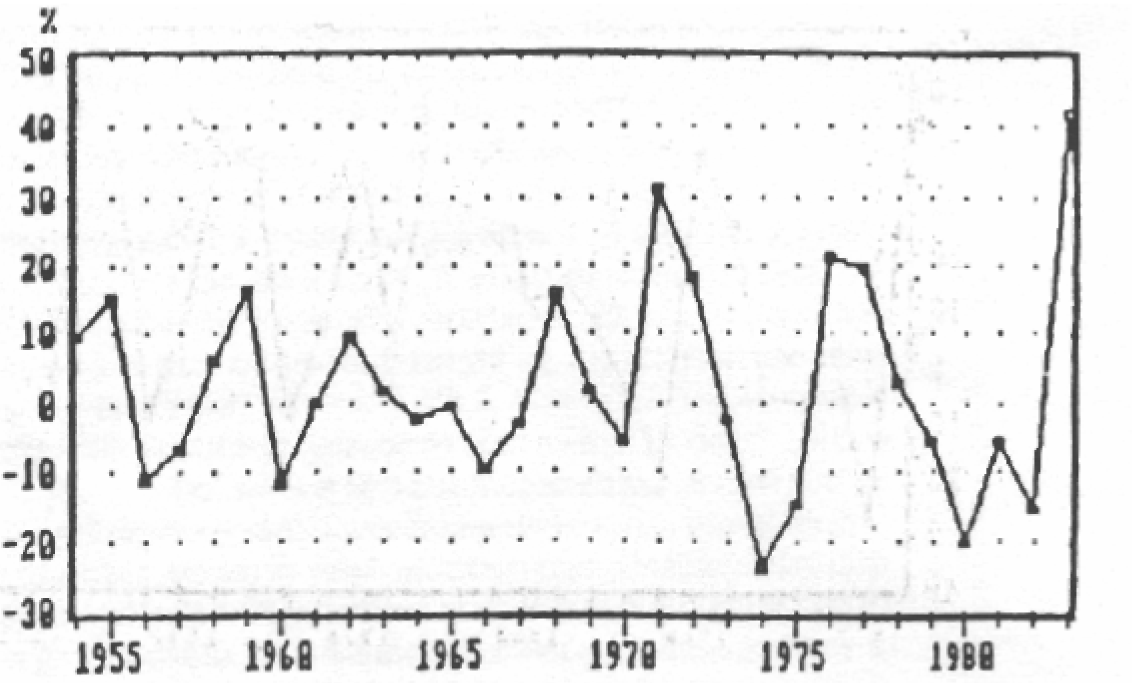

FIGURE 8. The Growth Rate of the Level of Real Housing Investment in the USA

model expresses the growth rate simply as a function of time. The simplicity of the trend model, in terms of both estimation and forecasting, is its greatest virtue. Since low-order trend models are poorly suited to forecasting cyclical series with stable means, we utilize a fourth-order time polynomial specification of the time trend.[5]

The ARIMA model specifies a stationary data series as a function of past values of the dependent variable (Auto Regressive terms) and past forecast errors (Moving Average terms). Thus, AR(t) is the value of the dependent variable t periods earlier while MA(t) is the forecast error from t periods earlier. In this paper we report the results for the ARIMA specification for each country which minimized the standard error of the regression. Time trend terms may be needed to transform a trended series to a stationary series.[6]

It should be noted that the use of time series models, instead of more traditional models, does not imply that we believe that "time" causes housing investment growth rates. Rather, these time series models assume that the complex set of economic, political, financial, social, and demographic factors which generate housing investment are statistically summarized by these simple time series models. Thus, the time series elements in these models are best viewed as highly simplified proxy variables for these more complex structural relationships.

Tables 1-4 display the three models of the real housing investment growth rate for Taiwan, Korea, Japan, and the US respectively.[7] The ARIMA specification reported reflects the specification which minimized the standared error of the regression for each country. In all four countries, the trend models fit the data significantly less precisely than either the traditional or ARIMA models. For example, the R^2 values for Taiwan are .07 for the trend model, .22 for the traditional model, and .29 for the ARIMA model. It is interesting to note that the ARIMA model provides a superior fit relative to the traditional model for Taiwan and Korea, and an equally good fit for Japan. Only for the U.S. does the traditional model provide a more precise data fit than the ARIMA model. It is also noteworthy that the models for Japan display much higher R^2 than for the other 3 countries. In both the US and Japan, rises in the interest rate bring about substantial declines in housing investment. Interestingly, the impact of the interest rate in these two countries is almost identical (-2.75 versus -2.82). However, Taiwan and Korea fail to reveal any notable impact of interest rates on housing investment rates. None of these interest rate impacts are significant at the 90 percent level.

In all four countries increased inflation brings about declines in investment rates, with quite similar impacts across the Asian countries, and much more pronounced in the US. Only in the US is the impact of inflation significantly different from zero at standard confidence levels. Surprisingly, no statistically significant impacts of population growth on real housing investment growth are discernable in any country. In general, the impact of real per capita income is positive in the relevant range, though the estimated coefficients are quite imprecise. Turning to the ARIMA specification results, time trends were necessary to create a stationary series for the Asian countries but not for the U.S. All three Asian countries displayed a significantly negative trend in the growth rate (though from a much higher

TABLE 1. TAIWAN REGRESSION RESULTS FOR HOUSING INVESTMENT GROWTH RATE

	Economic	Trend	ARIMA
Constant	-22.98 (-0.18)	17.22 (0.66)	-3.99 (-0.36)
Trend		-2.07 (-0.18)	2.97 (1.95)
Trend Squared		0.24 (0.16)	-0.094 (-2.06)
Trend Cubed		-0.0064 (-0.09)	
Trend to the Fourth		-4.02D-6 (-0.004)	
AR(1)			-0.49 (-2.60)
AR(2)			0.043 (0.134)
MA(2)			-0.54 (-1.36)
GROSS DOMESTIC PRODUCT PER CAPITA	0.069 (0.786)		
GROSS DOMESTIC PRODUCT PER CAPITA SQUARED	-2.38D-5 (-1.03)		
PERCENT CHANGE IN POPULATION	-5.73 (-0.19)		
INTEREST RATE	1.07 (0.25)		
INFLATION RATE	-0.87 (-1.25)		
R^2	0.22	0.07	0.29
# of OBS.	23	30	28
Mean of Dep. Var.	12.45	13.39	13.16

*t-values are given in parentheses.

TABLE 2. KOREA REGRESSION RESULTS FOR HOUSING INVESTMENT GROWTH RATE

	Economic	Trend	ARIMA
Constant	103.89 (1.06)	28.23 (1.07)	-11.43 (-0.82)
Trend		-14.36 (-1.26)	3.8 (1.94)
Trend Squared		2.23 (1.53)	-0.11 (-1.87)
Trend Cubed		-0.11 (-1.61)	
Trend to the Fourth		0.0010 (1.61)	
AR(2)		-0.16 (-0.53)	
MA(2)		-0.37 (-1.02)	
GROSS DOMESTIC PRODUCT PER CAPITA	-0.044 (-0.40)		
GROSS DOMESTIC PRODUCT PER CAPITA SQUARED	9.64D-6 (0.21)		
PERCENT CHANGE IN POPULATION	-19.2 (-1.12)		
INTEREST RATE	0.036 (0.027)		
INFLATION RATE	-1.00 (-1.56)		
R^2	0.16	0.14	0.27
# of OBS.	24	30	28
Mean of Dep. Var.	16.31	13.97	14.55

TABLE 3. JAPAN REGRESSION RESULTS FOR HOUSING INVESTMENT GROWTH RATE

	Economic	Trend	ARIMA
Constant	26.28 (0.99)	14.26 (1.40)	0.93 (0.24)
Early Dummy		-2.66 (-0.40)	7.9 (2.72)
Trend		-0.69 (-0.22)	1.25 (3.82)
Trend Squared		0.31 (0.74)	-0.05 (-4.40)
Trend Cubed		-0.023 (-1.07)	
Trend to the Fourth		0.0004 (1.18)	
AR(1)			-0.32 (-1.78)
AR(2)			-0.53 (-2.91)
GROSS DOMESTIC PRODUCT PER CAPITA	0.0067 (1.65)		
GROSS DOMESTIC PRODUCT PER CAPITA SQUARED	-8.30D-7 (-2.51)		
PERCENT CHANGE IN POPULATION	1.25 (0.25)		
INTEREST RATE	-2.75 (-1.02)		
INFLATION RATE	-0.55 (-1.20)		
R^2	0.71	0.63	0.71
# of OBS.	30	30	28
Mean of Dep. Var.	9.31	9.31	9.19

*Early Dummy: 1954-71 = 1, and 1972-83 = 0.

TABLE 4. U.S. REGRESSION RESULTS FOR HOUSING INVESTMENT GROWTH RATE

	Economic	Trend	ARIMA
Constant	-19.26	21.72	-1.56
	(-0.08)	(1.23)	(-0.19)
Trend		-10.26	0.404
		(-1.35)	(0.33)
Trend Squared		1.41	-
0.0097			
		(1.45)	(-0.26)
Trend Cubed		-0.07	
		(-1.50)	
Trend to the Fourth		0.0011	
		(1.53)	
AR(1)			0.18
			(0.78)
AR(2)			-0.50
			(-2.22)
GROSS DOMESTIC PRODUCT PER CAPITA	-0.007		
	(-0.18)		
GROSS DOMESTIC PRODUCT PER CAPITA	1.23D-6		
SQUARED	(0.61)		
PERCENT CHANGE IN POPULATION	14.04		
	(0.51)		
INTEREST RATE	-2.82		
	(-1.47)		
INFLATION RATE	-4.87		
	(-4.66)		
R^2	0.52	0.09	0.19
# of OBS.	30	30	28
Mean of Dep. Var.	2.38	2.38	1.68

average rate than in the US) since the early 1970's, most notably in the case of Japan.

In order to evaluate the forecasting accuracy of these alternative models, each model is used to forecast beyond the range of the data and the forecasts are compared to the actual growth rates. Two forecasting techniques were utilized for each country and each type of model. In the first technique, the real growth rate model was estimated using data for 1954-1983, and the resulting model was used to forecast the growth rates for 1984, 1985, and 1986. This technique provides one-year, two-year, and three-year out-of-sample growth rate forecasts for each country and model, which are then compared to actual growth rates. This technique provides a snapshot forecast for a three-year horizon, based upon a common set of estimated parameters. These are referred to here as the snapshot forecasts.

Alternatively, we form one-year-horizon growth rate forecasts based upon a model estimated on all data from 1954 up to the year immediately prior to the forecast period. Thus, the 1984 forecasts are obtained from models estimated on data from 1954-1983, while the 1985 forecasts are derived from models estimated on data from 1954-1984, and the 1986 forecasts are yielded by models estimated on data from 1954-1985. This technique rolls in all data which would have been available when making a one-year forecast. We refer to these forecasts as the roll-in forecasts.

Taken together, these alternative techniques for evaluating forecast errors allow us to evaluate both the short-run and longer-run forecasting accuracy of the models. Of course, since the out-of-sample analysis concentrates solely on the 1984-1986 period, the power of this analysis is weaker than if the forecasting accuracy of longer sample periods were investigated. However, since we desire to utilize as much data as possible when estimating the investment growth rate models, we chose to limit the out-of-sample period to three years.

Table 5 displays the percentage forecast errors for each of the four countries, for each of the three types of models, for both forecasting techniques. In the case of the traditional specifications, we assumed that the independent variables are forecast with perfect foresight. That is, we used actual values of the independent variables as if they were the forecast values held at the time the growth rates forecasts were being formed. Since this eliminates growth rate forecast errors arising from incorrectly forecast values of the independent variables in the prediction equation, the true forecast errors of the traditional models are substantially understated by the forecast errors reported in Table 5.

Not surprisingly, the snapshot forecast errors are generally larger than the roll-in forecast errors.[8] The only notable exception is for the Korean economic model for 1986, where the large forecast error yielded by the roll-in model is avoided by the snapshot technique's three-year forecast. In all four countries the mean absolute forecast errors are substantially smaller for the ARIMA models than for the traditional models, even though the structural models assume perfect foresight in terms of the independent variables. This strongly suggests that although traditional models provide important insights into the sources of growth, they are generally inferior models for forecasting future growth rates even over relatively short horizons. Surprisingly, the simple trend model provides notably superior forecasts for 1984-1986 for Japan when compared to either the traditional or ARIMA models.

TABLE 5. COMPARATIVE FORECAST ERRORS

	ECONOMIC		TREND		ARIMA	
	SNAPSHOT	ROLL-IN	SNAPSHOT	ROLL-IN	SNAPSHOT	ROLL-IN
TAIWAN						
1984	19.1	19.1	19.4	19.4	4.3	4.3
1985	15.4	0.4	17.7	0.4	2.9	-0.5
1986	31.6	7.9	23.3	-1.3	5.5	2.8
|MEAN|	22.0	9.2	20.1	7.0	4.2	2.5
KOREA						
1984	-30.5	-30.5	-42.5	-42.5	7.5	7.5
1985	-26.6	7.3	-52.5	-19.8	11.7	9.0
1986	-2.6	25.1	-39.4	9.1	23.5	22.3
|MEAN|	19.2	21.0	44.8	23.8	14.2	12.9
JAPAN						
1984	7.2	1.2	-2.0	-2.0	8.9	8.9
1985	15.0	11.9	0.9	0.8	12.0	11.3
1986	20.0	11.0	1.8	3.4	18.8	18.6
|MEAN|	14.1	10.0	1.6	2.1	13.2	12.9
U.S.						
1984	-21.9	-21.9	-9.1	-9.1	-2.8	-2.8
1985	-52.6	-35.0	-34.7	-26.5	17.6	18.9
1986	-60.7	-12.5	-36.8	-7.7	19.8	10.3
|MEAN|	14.1	23.1	26.9	14.4	13.4	10.7

Table 6 reports the average absolute percentage forecast errors for each model and technique across the four countries. Taken as a whole, these results indicate that either type of time series model provides more accurate forecasts than the traditional models, even when one assumes perfect foresight with respect to the independent variables. Again the roll-in forecast errors are generally smaller than the snapshot errors. Based upon the ARIMA models, which have the smallest mean absolute error across the countries, the average one-year horizon forecast error is plus or minus 9.8 percent of the actual growth rate. The average absolute forecast errors over the one-year horizons are notably smaller than for longer time horizons, particularly for the ARIMA model specifications.

TABLE 6. ABSOLUTE FORECAST ERROR SUMMARY ACROSS COUNTRIES

	ECONOMIC		TREND		ARIMA	
	SNAPSHOT	ROLL-IN	SNAPSHOT	ROLL-IN	SNAPSHOT	ROLL-IN
1984	19.7	19.7	18.2	18.2	5.8	5.8
1985	27.4	13.6	26.5	11.9	11.0	9.9
1986	28.7	14.1	25.3	5.4	16.9	13.5
MEAN	25.3	15.8	23.3	11.8	11.3	9.8

"Transportability" of Models Across Countries

Many developing countries lack sufficient data to allow estimation of investment models. However, accurate forecasts of housing investment are still important to such economies. In fact, it is arguable that because of the extreme shortage of resources and importance of housing investment, these countries are least able to afford the resource costs associated with inaccurate growth rate forecasts.

One source for obtaining housing investment growth rate forecasts for such countries is to utilize another country's investment model. This raises the question of whether forecasting equations are transportable across economies. To explore this issue, we analyze the growth rate forecast errors which result when we apply the ARIMA models reported in the last section across countries.[9] Because of their highly developed status, we do not report the results of applying other countries models to the US and Japan.[10] Instead, we utilize the models for the US, Japan, Korea, and Taiwan to forecast one year roll-in housing investment growth rates for four developing Asian countries: Taiwan (1984-1986), Korea (1984-1986), Thailand (1981-1984) and the Philippines (1981-1983).

Table 7 displays the growth rate forecasts errors associated with applying one country's model to predict housing investment growth rates for another country. Since Japan's growth pattern reflects a more developed economy after 1971, two forecasting models were utilized for Japan, one reflecting pre-1972 data and the other post-1971 data.

TABLE 7. PERCENTAGE FORECAST ERRORS FROM TRANSPORTING ARIMA MODELS ACROSS COUNTRIES

	COUNTRY MODEL USED				
	U.S.	PRE-1972 JAPAN	POST-1971 JAPAN	TAIWAN	KOREA
TAIWAN					
1984	5.1	3.8	11.7	4.3	1.6
1985	-7.9	1.2	2.9	-0.5	-4.7
1986	-4.8	3.5	3.6	2.8	4.0
|MEAN|	5.9	2.8	6.1	2.5	3.4
KOREA					
1984	4.6	17.5	32.5	20.9	7.5
1985	15.1	4.5	19.0	10.2	9.0
1986	17.3	18.7	7.8	25.7	22.3
|MEAN|	12.3	13.6	19.8	18.9	12.9
THAILAND					
1981	20.7	17.6	25.0	9.4	8.6
1982	-2.6	0.6	8.5	-2.1	-7.4
1983	19.1	19.1	24.6	17.7	17.8
1984	13.9	13.3	16.1	15.6	13.9
|MEAN|	14.1	12.6	18.6	11.2	11.9
PHILIPPINES					
1981	11.8	10.2	23.2	3.6	2.1
1982	15.0	0.7	21.1	8.5	4.9
1983	4.1	3.8	3.7	5.9	3.1
|MEAN|	10.3	8.2	16.0	6.0	3.4

In general, the results from the transportability exercise are encouraging. For example, the mean absolute Taiwan forecast error based upon Taiwan model is 2.5 percent, 2.8 percent using the early Japanese model, and 3.4 percent using the model for a similarly developed economy (Korea). In fact, the mean absolute forecast errors for Taiwan are quite reasonable (approximately 6 percent) even when the models of the developed countries are employed. Similarly, the Korean mean absolute forecast error, although larger than Taiwan's, is essentially the same whether the Korean model (12.9 percent), the U.S. model (12.3 percent), or the early Japan model (13.6 percent) is utilized. The average absolute Korean growth rate forecast errors are about 50 percent larger based upon the late Japan model (19.8 percent) and the Taiwan model (18.9 percent).

In the case of Thailand, mean absolute forecast errors range from 11.2 percent (Taiwan model) to 18.6 percent (Korea model). For the Philippines the transportability is even more impressive, ranging from a mean absolute forecast error of 3.4 percent (Korea model) to 16 percent (late Japan model). When one recalls (Table 6) that the average absolute out-of-sample forecast error for our four model countries was 9.8 percent, it is clear that these simple housing investment growth models display a substantial degree of transportability across countries. While further research is needed in this area, it appears that decision makers in developing countries can utilize models estimated for countries with richer data bases to obtain investment growth rate forecasts. Further, growth rate estimates derived from other countries' models (including more developed countries) can be used by both private and public decision makers as a check against forecasts based upon the country's own data. This could prove particularly valuable for private decision makers dependent on housing investment who fear political manipulations of official growth rate forecasts in their country.

Conclusions

Alternative real housing investment growth models for Japan, Korea, Taiwan and the US are compared in this paper. We find that simple time series models, particularly ARIMA models, provide significantly more accurate growth rate forecasts than traditional models. On average, the mean absolute growth rate forecast error is approximately 10 percent. We also find that the growth rate time series model for one country can generally be used to forecast another country's growth rate with tolerable accuracy. In general, the forecasts associated using another country's time series model are not much different than those yielded by its own model. It remains for further research to determine if this result applies to other countries and to other key economic concepts.

NOTES

1. See, for example, Annez and Wheaton (1984) and Burns and Grebler (1976).
2. See, for example, Falk (1983), Grebler and Burns (1982), and Pankratz (1983).
3. See Chang (1986) for a more complete discussion of this phenomena.
4. Chang (1986b) provides a detailed analysis of the annual real housing investment levels for these four countries.
5. Higher order polynomials were explored without yielding improved forecasts.
6. See Box and Jenkins (1976) and Nelson (1973) for more complete descriptions of ARIMA models.
7. The number of observations varies across specifications due to missing structural data and the need to delete initial observations in the ARIMA specifications.
8. These forecast errors are definitionally the same for 1984 as both techniques use the 1954-1983 period to forecast for 1984.

9. Since we found that the ARIMA models generally provided superior forecasts, we limit our discussion to the ARIMA models. However, similar calculations were done for the economic and trend models and are available upon request. These alternative models generally displayed less transportability than the ARIMA models.

10. It is interesting to note that the US provided a substantially better fit for 1984-1986 Japan data, than did the Japan model for 1984-1986 US data.

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