

**INTERNATIONAL REAL ESTATE INVESTMENTS:  
An Analysis of the Public and Private Markets in  
The United Kingdom, Spain, Belgium, and The Netherlands**

by

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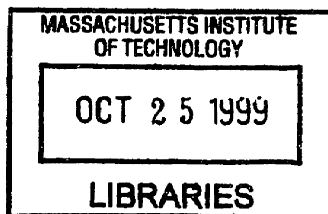
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**ABSTRACT**

In the past, international real estate investment has consisted of direct equity investment in foreign countries. Such investments have traditionally been considered to provide diversification benefits given that it was assumed that such properties were affected predominately by their respective domestic economies. Of course another benefit of international investment is the ability to seek out the best risk adjusted returns, wherever they may be.

Due to the recent globalization and securitization trends, today investors are finding that they have another investment option, international real estate public markets. This thesis addresses several of the issues related to the emergence of these markets in four countries: The United Kingdom, Spain, Belgium, and The Netherlands. For each of these countries extensive data was obtained for both the private and public markets in order to statistically examine various related relationships. Specifically, this thesis attempts to find answers to the three following questions:

1. Are GDP, rents, private, and public prices following a random walk or a trend-reverting pattern?
2. How does the local economy affect the real estate markets?
3. How do the public and private real estate markets relate with each other?

It is important to note that the purpose of this thesis was to systematically examine the data, and then to present the results. An in-depth analysis of the results was not the intent.

For Question one it was found that the majority of the public price series indicated a random walk whereas the results for rents and private prices series indicated a trend-reverting pattern. Also, an absence of any significant trends was found for the real estate data. These results would tend to indicate that for all of the countries studied the public market was much more volatile, and presumably efficient, than the private market.

Question two related directly to the issue of diversification. A significant contemporaneous relationship was found to exist between GDP and the private market. And an even stronger contemporaneous linkage between GDP and public prices was also found. It was thus concluded that shifting from direct investment to public market investment would likely reduce diversification benefits.

The results for Question three indicated a strong contemporaneous relationship between rents and private prices. The lagged relationships for the rents-public were found to be stronger than the contemporaneous in all the cases. For all the countries, except Belgium public prices were found to lead private prices.

Thesis Supervisor: William C. Wheaton

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## CHAPTER 1: INTRODUCTION

### **1.1 PUBLIC MARKET RELEVANCE**

The recent emergence of the public real estate markets in many countries has effectively changed the nature of real estate investment worldwide. Real estate investors can now either directly purchase properties, or buy public securities with claims on these underlying properties. Obviously a major consequence of a developed, efficient public market is the dramatic increase in the ease with which investors can add international real estate to their portfolios. Foreign investors will no longer have to buy properties outright, and subsequently be subjected to all of the associated cross-cultural difficulties of direct equity investment. Thus, as a direct consequence of the emergence of the public markets, investors will enjoy increased real estate liquidity in these foreign markets.

Furthermore, unlike buying stock in other industries where the intangible component is greater, buying stock in publicly traded real estate in essence is just a claim in the underlying buildings. Therefore an investor can essentially acquire comparable real estate assets through either the private or the public markets. This unique ability poses several important issues concerning the relationship between the public and private markets that are important to real estate investors as they evaluate their options. One of the most obvious issues is the exact relationship between the private and public markets. Since public and private prices are valued in large part by discounting future rent income, it stands to reason that there should be a large degree of correlation between public, private, and rent prices. However, the extent to which this is the case is unclear. Some economists even argue that it is theoretically possible for the public and private markets to be grossly out of line, possibly to the point where there is no correlation at all between them at all.

Another key concern is the time relationship between the public and private markets. Those that argue that public markets are more efficient than private markets believe that the public markets should lead the private markets. That is, that the public market should react quicker to changes in real estate

fundamentals, which affect the rent cash flows or discount rates used as determinants of private prices, than even the private prices themselves. If this is the case, then public markets are said to be “forward looking” since they are predicting asset price changes before they actually occur. Such scenario indicates the inability of private prices to fully reflect the same level information incorporated by the public prices which are priced daily. But if there is no lead, indicating that the public markets mirror current asset prices, then the public markets are said to be myopic, or “backwards looking”. In that case investors are simply extending the previous rent cash flows into the future to forecast future asset prices.

The implications of a forward looking, efficient public real estate market are profound. The existence of such a market would enforce investment discipline. Some economists and industry experts believe that this discipline may actually put an end to the vicious boom/bust cycles that have traditionally characterized the real estate industry of most countries, or at least lessen their severity. It stands to reason that as the public real estate markets grow in size, particularly in North America, Europe, and the Far East, this increased market discipline should create a more stable supply and demand balance.

The extent to which GDP affects both the public and private markets is also an interesting question to address. One would expect rents to be highly correlated with GDP since it follows that space demand increases more in good economic times than in bad. And since public prices and private prices are a function of rent prices, then all three variables should be highly correlated. However, again, the exact nature of these relationships is not clear. An increase in demand might very well cause an increase in development leading to overbuilding. In such a case rents might actually fall in good economic times. Also, firms may be inclined to “stockpile” space in economic downturns because rent prices are low, which may result in rents being bid up. And like the public-private relationship, the issue of time complicates matters even further. If public prices react more quickly to external influences like changes in GDP, then a predominately contemporaneous relationship should be found. And following the same logic, if private prices react more slowly to changes in GDP, either via rent price fluctuations or otherwise, then GDP should lead private prices.

The exact relationship that GDP has on rent, public, and private prices has direct consequences on the diversification benefits of international investment. Properties whose returns are highly correlated with their associated domestic economy, but not greatly affected by the global economy, produce the greatest diversification benefits for the international investor. To be more precise, the country specific influences can be labeled as non-systematic, idiosyncratic risks and the global economy as systematic risks. Modern portfolio theory states that by investing in several different assets the non-systemic risks could be diversified away<sup>1</sup>. The reason being that the positive influences of one economy on a portfolio would offset the negative influences of another. Removing the country specific risk from a portfolio leaves the systematic risk which can not be diversified away. The portfolio as a whole is then less volatile which translates into less risk. But if public markets are affected more by global economic fluctuations than by the local economy, then investing in public securities would tend to increase the systematic risks, and thus reduce the benefits of diversification.

In addition to analyzing the intra-market and GDP relationships, it is also important to ascertain whether or not any predictability in the economic data is present. If historical trend patterns can be identified and modeled to forecast public or private price levels, for example, then investors could conceivably profit by investing in depressed markets and selling in inflated markets. However, if the data follows a random walk then no investor using a trend-reverting forecast could ever produce abnormal positive results.

Determining whether the real estate markets follow random walks or not would also allow for a better understanding of the relationship between markets. Real estate economic theory indicates that in the long run the price of a real estate asset should be a function of its replacement cost<sup>2</sup>, and thus should revert back to a “normal” level based on cost regardless of short-run fluctuations. If private prices reflect this replacement cost, private prices should show some level of persistence. Another reason to believe

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<sup>1</sup> Harry Markowitz, “Portfolio Selection”, *Journal of Finance*, March 1952

<sup>2</sup> D. DiPasquale, W. Wheaton, “Urban Economics and Real Estate Markets” 1996



prices should show some level of persistence is the effect of rent leases on building value. A building's value depends on its rent cash flows, which change rather slowly given the existence of long-term leases. Overlapping lease terms with relatively stable rents would tend to smooth a building's value as it moves through periods of economic expansion and contraction and as a result should create a private price series with some level of persistence. The public price series, on the other hand, should tend to be uncorrelated across time as it reflects the latest available information on projected returns and thus allow for no arbitrage across time. If so, then the most recent quoted price is the best estimate for tomorrow's price and one would expect any difference between them to be pure random.

## **1.2 THESIS OBJECTIVE**

This thesis attempts to take a look at several of the previously described issues relating to the emergence of international public markets. Specifically, three questions will be addressed for four different countries and the United States. They are listed below.

- 1) Are GDP, rents, private, and public prices following a random walk or a trend-reverting pattern?
- 2) How does the local economy affect the real estate markets?
- 3) How do the public and private real estate markets relate with each other?

As was previously discussed, all of these questions relate to issues that are directly relevant to international real estate investors. If persistence can be found in the data, then investors can create econometric models to predict future returns. Measuring the extent that GDP affects both the public and private markets would help investors access the diversification benefits of their international real estate investments. By addressing the relationship between private and public markets we can determine whether or not these markets are efficient.

### 1.3 PREVIOUS RESEARCH

Given that the development of the international public real estate markets is a relatively recent event, there has been practically no research done on the subject. The main reason is that there simply has not been enough data for comprehensive statistical analysis. Global Property Research (GPR) only began collecting data around the mid-1980's. In fact, though they have 15 years of data, they only use 1990 as the base year of their GPR 250 index citing that "before this time the breadth and liquidity of the market was not sufficient to provide a well-balanced index"<sup>3</sup>.

On the other hand, international private data on average dates back much further, usually to the early 1970s. As a result there have been several papers written addressing private market issues. The most relevant for this thesis is a preliminary paper being prepared by Yale professors Bradford Case, William Goetzmann, and K. Geert Rouwenhorst. Their paper, "Global Real Estate Markets--Cycles and Fundamentals", looks at the issue of the influence of global GDP on the private real estate values in different international countries<sup>4</sup>. They attempt to separate the domestic GDP into two components, that effected by global economic events and that exclusively related to domestic economic conditions for 22 markets in 21 countries. As was discussed in the first section, this has direct implications relating to the ability of investors to diversify away country specific, non-systematic risk.

By using an equal-weighted GDP index to represent the global GDP, Case et. al. discovered that "removing the effects of global GDP from returns significantly decreased global real estate market correlations"<sup>5</sup>, even more so than when local GDP effects were removed. They concluded 1) that private property returns fluctuate with changes in the domestic GDP, 2) the relationship between domestic GDP and returns is contemporaneous, and 3) that global influences have a large effect on domestic GDP. As a

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<sup>3</sup> P. Eichholtz, N. De Graaf, W. Kastrop, H. Op't Veld, "Introducing the GPR 250 Property Share Index", Real Estate Finance, Spring 1998, p.55

<sup>4</sup> B. Case, W. Goetzmann, K. Geert Rouwenhorst, "Global Real Estate Markets, Cycles and Fundamentals", 1999.

<sup>5</sup> Op. Cit., B. Case, W. Goetzmann, K. Geert Rouwenhorst, p. 3

result, they proposed that international diversification is effective only when investing in industrial properties since it has been shown that such properties tend to be less correlated with GDP in general.

The implications of the Yale paper for this thesis are tremendous with respect to the ability of international real estate investment to diversify a given portfolio. If the paper's conclusions are correct, a high degree of contemporaneous correlation between a given country's GDP and that country's private asset prices should be found. The unknown question then is: How does GDP affect the public prices, and subsequently what is the relationship between the public market prices and the private prices? If there is also a large contemporaneous correlation between domestic GDP and public prices, then there effectively is no "escape" from the effects of the global GDP. This would mean that investors could not decrease their systematic risk by shifting from direct private investment to public real estate securities.

If it is found that there is a strong correlation between GDP and the public prices, then the relationship between the public prices and private prices becomes even more important. A large and contemporaneous link would indicate that GDP would immediately effect private prices both directly and via the public market. If the effect is lagged however, then prudent private investors could conceivably use the public markets to influence their buy/sell decision so as to catch/avoid the private market lag effect. Of course, they would still be affected by any contemporaneous GDP/private prices relationship.

In another paper published in 1995, Richard Barkham and David Geltner<sup>6</sup> examined the public and private commercial property markets in the United States and in the United Kingdom for evidence of price discovery. They defined price discovery as the process by which asset market prices are formed, or more formally, as the statistical significance of past returns in one market in the forecasting of future returns in the other market. Their goal was to see if price discovery may occur in either the private or public markets, and then be transmitted to the other.

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<sup>6</sup> R. Barkham and D. Geltner, "Price Discovery in American and British Property Markets", *Real Estate Economics*, V23, 1995, pp.21-44

Barkham and Geltner discovered that price discovery occurs first in the securities markets in both countries, and does not completely transmit to the unsecuritized property markets for about a year, perhaps even longer in the United States. These findings suggest that public markets are more efficient than private markets in the US and UK because they reflect all available information faster, and since private prices follow only after a lag. The results of this paper tend to add weight to the possibility of finding public markets leading the private markets in other countries as well.

In another article published in 1996, Chiong-Long Kuo studied the behavior of residential related data series for several cities in the United State<sup>7</sup>. He tested the common belief that the private real estate market may be less efficient than the markets of more liquid financial assets, and may not follow a random walk like stocks or bonds. In his article he proposed a two-step, two-sample method and a Bayesian method to estimate the serial correlation and test the price behavior in the residential markets of Atlanta, Dallas, Chicago and San Francisco. Kuo's results supported the rejection of the random walk hypothesis, indicating strong persistence in residential house price in three of the four analyzed cities. These findings are of enormous importance because they suggest that investors could potentially create trend-reverting models to predict future residential real estate returns. If this is the case, then the same might be true for the office markets addressed in this study.

## **1.4 GENERAL FINDINGS**

### **1.4.1 QUESTION 1: ARE GDP, RENTS, PRIVATE, AND PUBLIC PRICES FOLLOWING A RANDOM WALK OR A TREND -REVERTING PATTERN?**

- The presence of a constant time-related trend was consistently found in the GDP time series. All the other variables proved to be time independent.

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<sup>7</sup> Chiong-Long Kuo, "Serial Correlation and Seasonality in real estate market", *Journal of Real Estate Finance and Economics*, 12, 1996, pp.139-162

- When the behavior of the series were analyzed, the results for GDP, rents and private prices indicated a trend-reverting pattern in almost all of the cases. On the other hand, the results for the public prices analysis unequivocally showed that public markets in all countries were following a random walk.

These results confirm the findings presented in Kuo's paper. Only in one out of the four European cities private property markets followed a random walk. The consistent results across countries regarding the randomness of the public markets support the hypothesis of an efficient highly liquid spot market. The fact that only GDP data was trending during the period suggests some inability in the real estate market to incorporate the growth in the overall economy into real economic growth for the sector.

#### **1.4.2 QUESTION 2: HOW DOES THE LOCAL ECONOMY AFFECT THE REAL ESTATE MARKETS?**

- Both private and public prices have significant correlations with GDP in all of the analyzed countries. When relationships between random variables were tested strong evidence of co-integration, on average, was found. The link between GDP and rents was found to be weaker though significant in three out of the four European countries.
- The relationship between the local economies and the real estate market was found to be essentially contemporaneous.

The results for this question are not surprising. The general economy has a strong influence on the contemporaneous performance of the real estate markets. These results agree with the results Professor Goetzmann et. al. found in the countries they analyzed. Based on their conclusions, international investments in real estate would not provide huge diversification benefits. Furthermore, investing in the real estate markets of the analyzed European countries is essentially a bet on the local economy which fluctuates with the whole region's economy. Thus, the diversification benefits of the international real estate investor are limited.

### **1.4.3 QUESTION 3: HOW DO THE PUBLIC AND PRIVATE REAL ESTATE MARKETS RELATE WITH EACH OTHER?**

- A very strong contemporaneous correlation between rents and private prices was found.
- The correlations between rents and public prices were not as strong as those for private prices. However the co-integration test showed that the variables were moving together. Public prices were found to lead rents in all of the countries analyzed.
- The results for the public and private relationships leaned toward public market leading private market.

The results for this question, for the most part, provide few surprises. Given that rent income is a major function of private prices, there should be a strong correlation between the two variables. The fact that public prices were found to lead rent prices could also be expected due to the fact that public prices are better able to adjust to new information than is the case with rents due to extended lease contracts. Except in one out of the four European countries public markets were found to lead the private markets supporting Barkham and Geltner's findings in the US and in the UK.

## **CHAPTER 2: DATA**

### **2.1 REAL ESTATE DATA**

Finding enough quality data to do a proper study of the relationships between private, public, property markets, and GDP in foreign countries was of primary importance. As was mentioned in the previous section, the lack of available data has been a major impediment to the completion of any thorough research on international real estate markets. We used data provided by CB Richard Ellis to analyze the private real estate market in each of the selected countries and data from Global Property Research (GPR), located in the Netherlands, to analyze the public real estate market. GPR utilizes this data in the construction of its GPR 250 public market index. The GDP, CPI and exchange rate information for the foreign countries was provided by the World Tables of the International Monetary Fund. The source for the GDP data for the United States was the U.S. Department of Commerce; Bureau of Economic Analysis; and for the CPI data was the U.S. Bureau of labor Statistics.

#### **2.1.1 PRIVATE DATA: CB RICHARD ELLIS DATA**

The data from CB Richard Ellis contains information about the annual level of rents, yields, and values for prime office property in 27 cities of 21 countries around the world. The information about values is appraisal-based as opposed to transaction-based. Each of the yearly values was obtained by estimating the price that relevant buildings may sell for. There were a significant number of observations for most countries. Several of the European and Asian countries had data that went back as far as 1970, which provided almost 30 years of data for the analysis. In almost all of the cases the rents and prices were measured in local nominal currency. CB Richard Ellis calculated the required yield by real estate investors by dividing the annual rent level by the appraised value.

### **2.1.2 PUBLIC DATA: GLOBAL PROPERTY RESEARCH DATA**

The data provided by Global Property Research consisted of monthly price appreciation returns and dividend yields for an index composed of publicly traded real estate companies. The majority of the companies in the index invest primarily in office buildings. This is a key issue given that the CB Richard Ellis data is also for the office sector. Values were provided for 28 different countries. The indices for 14 of the countries began in January of 1984. Data for the other 14 countries began on various dates after January 1984<sup>8</sup>.

The GPR indices include all publicly traded property companies which have had a freely available market capitalization exceeding \$50 million for at least twelve months, and that have also demonstrated high liquidity in terms of average trading volume. Also, only property investment and investment/development companies are included in the index. Thus the data excluded pure development orientated companies<sup>9</sup>.

### **2.2 DATA LIMITATIONS**

Although we felt that these were the best data sets available for use in our research, the data inherently contains certain limitations that must be noted.

1.) In general, data on historical private real estate returns and prices is less available, and thus less accurate, than that for other investment assets. The reason being that the appreciation component for real estate is largely unknown. Stocks, for example, are traded heavily daily, thus the appreciation component of their return is readily observable. So the total return for stocks, dividend yield plus appreciation, is easily ascertained. Given that direct observation is not possible with real estate, other methods are utilized to determine the private property values. The most common being the method of “capping” the

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<sup>8</sup> Op. Cit., P. Eichholtz, N. De Graaf, W. Kastrop, H. Op't Veld.

<sup>9</sup> Ibid.



final period's, or subsequent period's, cash flow. That is, treat that cash flow as a perpetuity that is discounted at the property yield rate. As was previously noted, this was the method employed by CB Richard Ellis.

The yields for the CB Richard Ellis data were calculated dividing the level of rents by the appraised value. There are two potential problems with this methodology. The first is that rent values do not represent the income for the building. Therefore yields computed using rents values would tend to be inaccurate. The second problem is that appraised values may lag the constant-liquidity market values. The lag is due to property owners trading liquidity for reduced volatility. In other words, a typical property owner might very well choose to hold properties during down markets and sell during up markets.

This effect would tend to offset the increased volatility inherent in using transaction prices to compute property values. The smoothing effect is also prevalent in the public data values. The yearly public data was calculated by averaging monthly values to produce comparable results. As a result, the standard deviation of the public data would be greatly reduced. This is an important consideration considering that the public data should in fact be more efficient, thus more volatile, than private property prices in the short term.

2.) Some of the publicly traded companies included in the GPR indexes tend to make substantial international investments. For example, German investment funds invest heavily in Europe, as well as in the United States; however, their prices are included in the public prices for Germany only. Thus the German public prices might be heavily influenced by the state of the real estate markets in other countries as well. Obviously the more investments these companies make in foreign markets, the more that country's public prices will reflect changes in other countries. This effect would cause a decrease in the correlation between public prices and the other data series since public prices would be more heavily affected by factors outside a particular country.

3.) There were a relatively small number of observations available for much of the data. The inability to use lengthy time series data constrained the statistical tests that were performed. Specifically, it had a major impact on the t-statistics. Given the small number of degrees of freedom, the critical values were inflated making it difficult to obtain significant results in general. The logic being that as the sample size gets smaller, the magnitude by which a variable could be overestimated gets larger, so the confidence interval is necessarily increased. The public data would have been the only data series with a significant number of observations had we used monthly returns.

## **2.3 SELECTION OF COUNTRIES**

Countries were selected based on their representation in the two data sources. Some countries were immediately eliminated because they were included in one set of data but not in the other. For the remaining countries attention was focused on those that had the most amount of public data available in order to make the statistical analysis as reliable as possible. Only countries that had at least a decade of public information available and 14 years of private real estate returns were included in the study. Given that several of the Asian countries did not meet this criteria due to a lack of public data, this requirement was generally relaxed for those countries in order to include them. The United States was also included to be used as a reference to compare it with the other markets. Both the NCREIF office data and the GPR data were utilized to obtain the all of the necessary information for the study.

The final selection of countries and cities in Europe were: United Kingdom (London), France (Paris), Spain (Madrid), Germany (Frankfurt), The Netherlands (Amsterdam) and Belgium (Brussels). For Asia the countries were: Australia (Sidney), China (Hong Kong), Singapore (Singapore), Indonesia (Jakarta) and Thailand (Bangkok). This thesis analyzes the United Kingdom, the Netherlands, Belgium and Spain. The other countries were analyzed in additional theses by Alfonzo Leon and C. Randall Speck.

## **CHAPTER 3: METHODOLOGY**

### **3.1 DATA PREPARATION**

The nominal GDP, rent, and yield data provided by CB Richard Ellis was used in order to derive the private market data that was used in the study. The majority of the rent data was provided in yearly increments that were expressed in local currency denominations. Some of the rent data was given as the average rent per month for a given year. These values were multiplied by twelve in order to get the average rent per year values. The GDP and rent series were then deflated using the CPI index of each country, also provided by CB Richard Ellis, to arrive at real series values. In the few cases where the rent values were expressed in US dollars, the appropriate exchange rates were used to compute the equivalent local currency values. A real private price series was then computed by dividing the real rent series by the corresponding yield data.

A similar set of indices were created using the GPR data. Again, the nominal public values were converted into real series by dividing by the CPI index. But unlike the private data, the GPR data was provided in monthly increments. In order to be consistent with the private data the average of the twelve months was taken. All of the GPR data was in local currency denominations, so no exchange rates were needed.

After similar private and public data series were computed, they were then included in a single table for each country. The tables consisted of data series for annual real GDP, real rents, real private prices and real public prices. These tables formed the basis of the statistical analysis and are presented in Exhibits 1 through 5.

**EXHIBIT 1**  
**National, USA**

<b>Year</b>	<b>Real GDP (Base 1960)</b>	<b>Real Rents (Base 1960)</b>	<b>Real Private Prices (Base 1960)</b>	<b>Real Public Prices Ave (Base1960)</b>
1960	526.58			
1961	539.33			
1962	572.95			
1963	597.20			
1964	633.05			
1965	674.99			
1966	718.91			
1967	739.40			
1968	775.12			
1969	793.43			
1970	789.85			
1971	822.94			
1972	875.89			
1973	921.42			
1974	898.94			
1975	897.25			
1976	946.29			
1977	990.53			
1978	1040.15	49.82	46.96	
1979	1043.47	46.05	48.21	
1980	1000.65	44.40	49.52	
1981	1014.62	43.39	50.21	
1982	994.72	43.75	50.48	
1983	1044.70	44.09	50.06	
1984	1112.65	42.84	51.14	28.80
1985	1150.92	43.74	50.67	35.47
1986	1194.42	41.33	50.02	47.55
1987	1222.71	38.65	46.86	50.55
1988	1264.18	34.49	44.35	44.36
1989	1299.25	31.31	41.84	46.13
1990	1301.68	28.14	38.16	32.40
1991	1286.30	24.75	32.18	31.11
1992	1317.83	23.26	25.99	31.91
1993	1344.36	21.49	21.79	39.49
1994	1387.83	20.99	19.42	40.41
1995	1412.52	20.40	18.28	38.00
1996	1446.23	18.69	17.84	41.14
1997	1496.34	20.12	18.45	49.36
1998	1546.02	20.48	20.22	50.50

**EXHIBIT 2**  
**London, UK**

<b>Year</b>	<b>Real GDP (Base 1960)</b>	<b>Real Rents (Base 1960)</b>	<b>Real Private Prices (Base 1960)</b>	<b>Real Public Prices Ave (Base1960)</b>
1960	30.82			
1961	31.53			
1962	31.81			
1963	33.09			
1964	35.04			
1965	36.04	3.29		
1966	36.93	4.23		
1967	37.96	4.64		
1968	39.30	4.93		
1969	40.11	5.60		
1970	41.41	5.71		
1971	42.22	6.02		
1972	44.14	6.74		
1973	46.42	10.64	202.62	
1974	45.23	12.62	162.84	
1975	45.95	8.31	138.46	
1976	46.66	4.75	79.21	
1977	46.93	4.62	97.19	
1978	50.06	4.74	105.28	
1979	51.90	5.01	117.90	
1980	51.44	4.72	104.90	
1981	50.57	4.85	110.85	
1982	50.97	4.86	104.44	
1983	53.17	5.20	109.48	
1984	54.22	5.20	109.53	18.02
1985	56.06	5.29	111.45	18.13
1986	58.37	5.69	119.73	20.06
1987	61.66	8.26	173.99	27.60
1988	65.44	8.68	165.25	30.87
1989	66.44	8.44	160.67	30.85
1990	64.83	7.12	114.27	22.85
1991	63.97	5.15	77.19	20.53
1992	64.16	3.90	56.24	14.29
1993	66.55	3.43	51.95	20.82
1994	68.86	3.40	65.75	22.88
1995	70.08	3.52	70.43	19.95
1996	72.09	3.58	71.66	22.06
1997	74.10	3.80	76.08	27.11
1998	74.90	4.46	84.67	30.99

**EXHIBIT 3**  
**Amsterdam, The Netherlands**

Year	Real GDP (Base 1960)	Real Rents (Base 1960)	Real Private Prices (Base 1960)	Real Public Prices Ave (Base1960)
1960	41.80			
1961	43.63			
1962	45.94			
1963	48.18			
1964	53.58			
1965	56.57			
1966	58.20			
1967	61.73			
1968	66.01			
1969	69.58			
1970	79.98	132.00		
1971	83.81	119.74		
1972	87.89	113.92		
1973	92.82	110.74	1771.80	
1974	96.13	105.84	1568.02	
1975	96.04	109.13	1616.71	
1976	100.83	100.08	1667.92	
1977	103.35	97.74	1629.07	
1978	107.28	99.34	1727.63	
1979	109.53	96.37	1840.51	
1980	109.56	89.47	1883.56	
1981	107.54	86.86	1828.54	
1982	106.19	79.17	1321.74	
1983	106.68	72.80	1120.00	
1984	108.52	75.91	1167.92	28.28
1985	112.81	78.24	1203.69	29.36
1986	115.96	83.46	1236.41	30.18
1987	117.57	86.73	1345.90	31.11
1988	121.15	92.70	1483.23	32.62
1989	127.00	98.27	1572.24	34.81
1990	132.04	108.44	1885.89	30.27
1991	134.46	110.60	1823.26	23.90
1992	136.05	107.18	1619.54	19.50
1993	135.66	98.63	1385.48	21.62
1994	138.66	95.94	1279.18	21.30
1995	141.93	98.38	1444.52	17.54
1996	144.97	100.54	1675.66	17.98
1997	150.82	105.28	1754.61	21.97
1998	156.44	122.14	2035.61	21.25

**EXHIBIT 4**  
**Brussels, Belgium**

<b>Year</b>	<b>Real GDP (Base 1960)</b>	<b>Real Rents (Base 1960)</b>	<b>Real Private Prices (Base 1960)</b>	<b>Real Public Prices Ave (Base1960)</b>
1960	564.00			
1961	594.36			
1962	627.63			
1963	660.66			
1964	709.71			
1965	742.60			
1966	766.09			
1967	797.63			
1968	830.93			
1969	888.78			
1970	951.66	2228.71		
1971	998.51	2492.00		
1972	1059.08	2363.26		
1973	1125.18	2367.41		
1974	1171.48	2101.04		
1975	1149.24	1738.94		
1976	1198.33	1593.04		
1977	1209.71	1189.82		
1978	1243.69	1220.26		
1979	1271.12	1168.06	17637.32	
1980	1280.82	1140.85	18253.56	
1981	1239.83	1102.39	17299.02	
1982	1234.51	1013.92	15309.84	
1983	1213.78	989.56	14660.12	
1984	1229.56	967.28	13828.95	
1985	1256.10	974.34	13439.24	
1986	1304.29	1218.39	17825.89	
1987	1343.38	1389.17	21371.82	24.58
1988	1420.52	1485.56	22086.61	22.25
1989	1493.47	1634.54	27242.41	32.18
1990	1534.21	1855.03	30917.09	35.75
1991	1557.84	1941.94	30177.73	33.93
1992	1600.52	1978.90	28049.51	31.55
1993	1595.68	1885.46	25139.48	31.28
1994	1635.17	1618.04	21470.19	31.24
1995	1673.60	1620.58	21551.94	28.20
1996	1688.00	1617.52	22707.00	28.57
1997	1735.05	1562.46	22320.80	27.89
1998	1781.25	1577.86	22540.92	30.62

**EXHIBIT 5**  
**Madrid, Spain**

<b>Year</b>	<b>Real GDP (Base 1960)</b>	<b>Real Rents (Base 1960)</b>	<b>Real Private Prices (Base 1960)</b>	<b>Real Public Prices Ave (Base1960)</b>
1960	620.70			
1961	693.10			
1962	757.76			
1963	822.45			
1964	958.52			
1965	997.18			
1966	1072.69			
1967	1132.62			
1968	1209.43			
1969	1346.44			
1970	1445.40			
1971	1507.22			
1972	1634.02			
1973	1767.57	168.38	16837.59	
1974	1883.01	256.29	25628.59	
1975	1878.91	233.37	23336.60	
1976	1922.10	218.22	21821.87	
1977	1958.15	196.46	19645.85	
1978	2001.07	177.32	17732.44	
1979	2023.97	168.65	16864.61	
1980	2012.45	179.11	17911.34	
1981	1974.18	173.73	17751.01	
1982	1996.53	156.91	16373.00	
1983	2033.35	135.36	14767.05	
1984	2069.55	127.73	14597.41	
1985	2101.76	130.42	18151.40	
1986	2214.25	157.56	24455.31	
1987	2352.51	177.36	31692.20	5.65
1988	2493.20	226.61	47578.67	6.87
1989	2618.64	268.87	60022.42	7.34
1990	2731.60	292.80	70271.10	6.93
1991	2824.47	282.82	63910.20	8.74
1992	2869.30	245.76	51694.93	5.55
1993	2829.71	153.78	25715.02	5.65
1994	2872.33	110.83	18050.05	6.99
1995	2954.57	105.88	19773.77	5.03
1996	3008.94	107.87	22799.49	5.52
1997	3118.93	113.27	24713.84	7.26
1998	3222.79	122.06	26973.66	10.69



## **3.2 DATA ANALYSIS**

As was described in Chapter 1, there were three general questions to be answered for each country that was analyzed. Accordingly, the data was divided up into 3 separate sections as well. The equations and methodology used in each section in an attempt to answer the questions are described next in detail.

### **3.2.1 QUESTION #1 ANALYSIS: ARE GDP, RENTS, PRIVATE, AND PUBLIC PRICES FOLLOWING A RANDOM OR TREND-REVERTING PATTERN?**

One of the most fundamental properties of any data set is the determination of whether or not there are any recurrent patterns in the data. As was shown previously, the existence of persistency means that future values can be predicted among other things. However, if no trend-reverting behavior can be identified, then there is no way to predict future values. The differences are said to be random in such a case. In the United States it is widely believed that many key economic variables, including GDP and public prices, follow a random walk pattern<sup>10</sup>.

The identification of a random walk also means that the effects of a temporary “shock”, i.e. outlying data points will not tend to dissipate after several years, but will instead permanently alter the series<sup>11</sup>. However, in the case of a recurrent trend, the data will tend to revert back towards the equilibrium level following such a shock. Again, the implications of this analysis for real estate investors are far reaching. A trend-reverting property market suggesting the existence of persistency in the cycle could conceivably be forecasted by looking at its past performance. Under this scenario a prudent investor could identify the market’s peaks and troughs and buy or sell accordingly to make abnormal profits. Exhibits 6A and 6B show the level and percentage differences series for real GDP in the United

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<sup>10</sup> C.R. Nelson, C. I. Plosser, “Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications”, *Journal of Monetary Economics*, Vol. 10, 1982, p. 139-162

<sup>11</sup> R. Pindyck, D. Rubinfeld, “Econometric Models & Economic Forecasts”, 1991, p.460

States. The graphs illustrate an example of a drifting economic variable that appears to demonstrate a random walk pattern after the differences are taken.

To test for the hypothesis of random walks in the analyzed data the following two step statistical process was performed.

- 1) Identifying the existence of a constant time related trend using an auto-regression equation of percentage differences, i.e. a 1<sup>st</sup> order auto-regression equation (ARI).
- 2) Based on the results of Step 1, two different Dickey-Fuller tests were used to determine randomness<sup>12</sup>.

Case I: If no trend was identified a Dickey-Fuller equation that does not have a time variable was used.

Case II: If a trend was identified a Dickey-Fuller equation with a time variable was used.

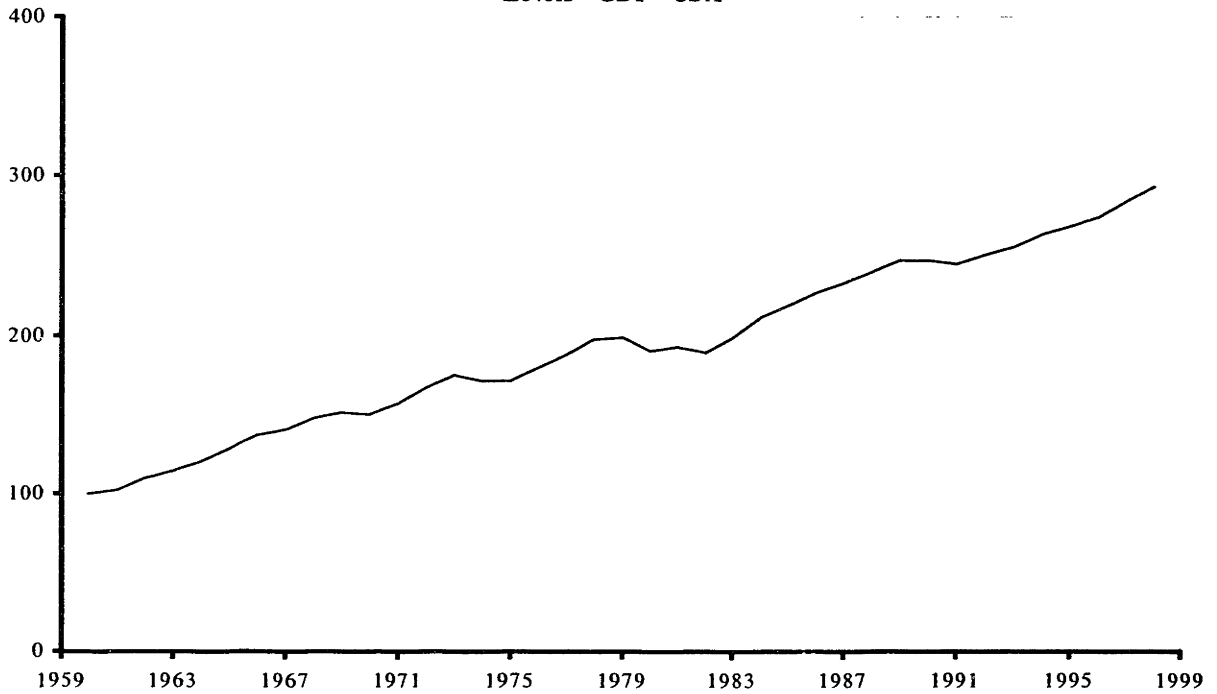
Finally, it is important to note that even though the Dickey-Fuller test is widely used, its power is somewhat limited. It only allows one to reject, or fail to reject, the hypothesis that a variable is not a random walk. And failure to reject, especially at a high significance level, is only weak evidence in favor of the random walk hypothesis<sup>13</sup>. What is more, its power is even more limited in situations where there are low degrees of freedom. In such a situation, most researchers rely more on the results, the 1<sup>st</sup> order auto-regression equation (ARI).

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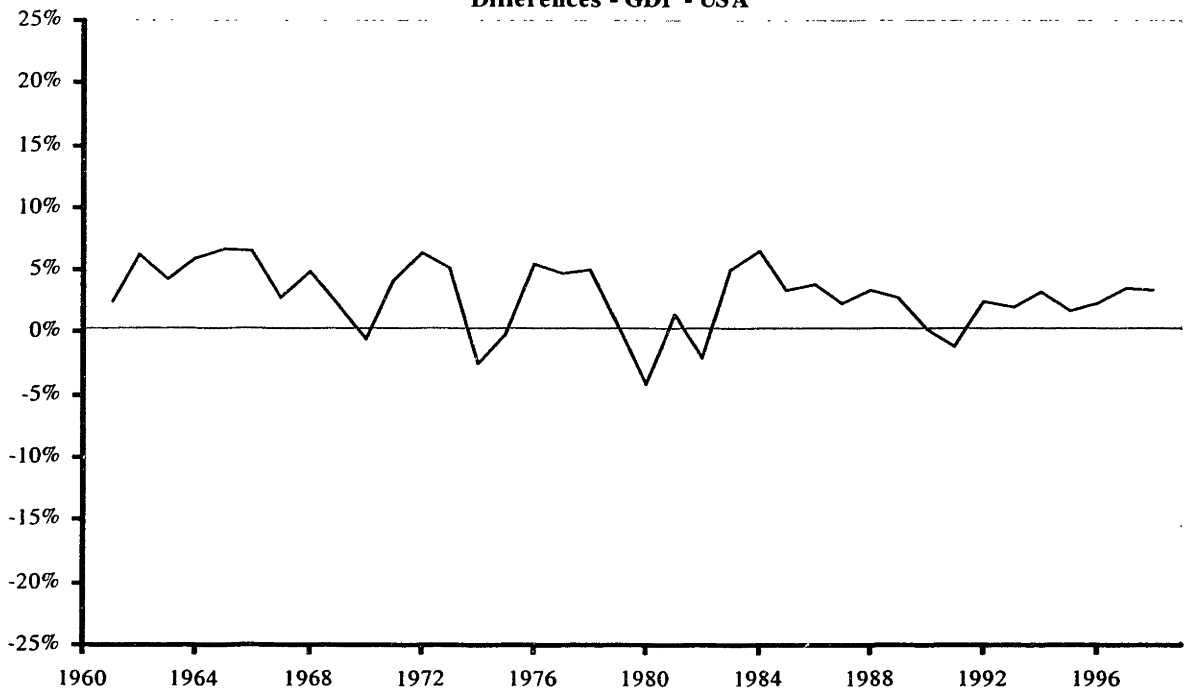
<sup>12</sup> D. A. Dickey and W. A. Fuller, "Distribution of the Estimators for Autoregressive Time-Series: with a Unit Root", *Journal of the American Statistical Association*, Vol. 74, 1979 p. 427-431; D. A. Dickey and W. A. Fuller, "Likelihood Ratio Statistics for Autoregressive Time Series with Unit Root", *Econometrica*, Vol. 49, 1981, p 1057-1072; And W. A. Fuller, "Introduction to Statistical Time Series, 1976.

<sup>13</sup> Op. Cit., Pindyck, D. Rubinfeld, p. 462

**EXHIBIT 6A**  
**Levels - GDP - USA**



**EXHIBIT 6B**  
**Differences - GDP - USA**



### Step 1: The auto-regression equation

The following auto-regression equation for the differences, given as percentages, was estimated:

$$\Delta Y_t = \alpha + \beta \Delta Y_{t-1} + \varepsilon_t \quad (\text{Eq. 1})$$

$$\text{Where } \Delta Y_t = (Y_t - Y_{t-1}) / Y_{t-1}; \text{ and } \Delta Y_{t-1} = (Y_{t-1} - Y_{t-2}) / Y_{t-2}$$

If the coefficient for  $\alpha$  in the above equation passed the student t-test, i.e. was significantly different from zero at the 5% significance level, the null hypothesis of no trend in the series was rejected. It was then concluded that the level of the variable changes because of the passage of time. The existence of an upward trend in the series, i.e. a positive and significant  $\alpha$ , indicated that the variable had been on average growing over time, so the mean of the series was time dependent. If a negative and significant  $\alpha$  was found, then it indicated that the variable had been decreasing with time. If the  $\alpha$  coefficient failed the t-test, then it was concluded that the data series was not time dependent. The  $\beta$  values for Equation 1 indicated the reliance on the previous data point. For a 1<sup>st</sup> order equation, a  $\beta$  of 0 indicates a random walk. And a  $\beta$  value different from zero indicates persistence. That is, the current change on  $Y_t$  is to a large degree a function previous changes.

Therefore Equation 1 can lead to four separate conclusions:

- 1)  $\alpha \neq 0$  and  $\beta \neq 0$ : This would indicate persistence with a trend.
- 2)  $\alpha = 0$  and  $\beta \neq 0$ : This would indicate persistence with no trend.
- 3)  $\alpha \neq 0$  and  $\beta = 0$ : This would indicate a random walk with drift.
- 4)  $\alpha = 0$  and  $\beta = 0$ : This would indicate a random walk with no drift.

### Step 2: The Dickey-Fuller unit root test

For those variables where the trend term was not significantly different from zero, i.e. failed the t-test and thus was assumed to be independent of time, the Dickey-Fuller equation without a variable for time was used. For data sets that passed the t-test, i.e. were assumed to have a constant trend and were

thus said to have a correlation with time, the Dickey-Fuller equation with a variable in the equation for time was used<sup>14</sup>.

### Case I: No Trend

In general if a series is flat, as opposed to trending, the auto-regression for levels is used given that the levels are independent of time. If there is a trend then differences must be used.

The following equation was estimated for the Dickey-Fuller test in the case of no trend:

$$Y_t = \alpha + \beta Y_{t-1} + \varepsilon_t \quad (\text{Eq. 2})$$

A random walk here is identified by a lagged coefficient close to one. In that case,  $Y_t - Y_{t-1} = \alpha + \varepsilon_t \equiv \Delta Y_t = \alpha + \varepsilon_t$ . Where  $\varepsilon_t$  is an independently distributed random variable with a zero mean. So there is no model that can provide a forecast any better than  $Y_T = Y_{T-1}$ <sup>15</sup>. When this coefficient tends to differ from one, the series was considered to show some level of persistency across time. Therefore, the relevant hypothesis to be tested with the t-test was whether or not the computed lagged coefficient was significantly different from 1. The pertinent statistical test is:

$$T_{N-K} = (\beta - 1) / s_\beta \quad (\text{Eq. 3})$$

Where  $s_{\beta t}$  is the standard error of the  $\beta$  coefficient in the auto-regression equation.

If the computed value was higher than the critical value of the t distribution at the 5 percent level of significance, then the null hypothesis that  $\beta = 1$  could not have been rejected. In such a case it was concluded that the true process that describes the behavior of the series was a random walk without a trend. Again, this conclusion meant that no predictions were possible. So, as in the case of the US stock market, the best prediction for any variable would be the previous value since the series is just as likely to go up, as it is to go down.

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<sup>14</sup> J. D. Hamilton, "Time Series Analysis", 1994p. 502

<sup>15</sup> Op. Cit., Pindyck, D. Rubinfeld, p.446-447

If the computed value was lower than the critical value at the 5% level, then the null hypothesis was rejected and it was then concluded that the series demonstrated a persistent behavior around a flat steady state or equilibrium level. In this case, the level of  $Y_{t-1}$  could be used to predict the level of  $Y_t$ .

**Case II: Constant Time Related Trend**

If a trend was identified in Step 1, then a variable was inserted into the equation to account for the effects of time. Also, differences had to be used, as opposed to levels, if a trend was found to exist in the data. The equation used is given below:

$$Y_t - Y_{t-1} = \alpha + \delta t + (1 - \rho) Y_{t-1} + \varepsilon_t \quad (\text{Eq. 4})$$

The proper statistical test to use in this case is the F-test, which tests the significance of all of the variables in the equation. In order to use the F-test an additional equation, that is assumed to describe the true process, is needed. This equation is:

$$Y_t - Y_{t-1} = \alpha + \varepsilon_t \quad (\text{Eq. 5})$$

This equation is usually referred to as the restricted equation. And consequently, the Dicky-Fuller equation is labeled as the unrestricted equation.

Next the F ratio was computed to test whether or not the restriction held. The equation used is the following.

$$F = (N - k)(ESS_R - ESS_{UR}) / q (ESS_{UR}) \quad (\text{Eq. 6})$$

$ESS_R$  is the sum of the squared residuals in the restricted equation

$ESS_{UR}$  is the sum of the squared residuals in the unrestricted equation

$N$  is the number of observations

$k$  is the number of estimated parameters in the unrestricted regression

$q$  is the number of parameter restrictions

Since this ratio is not distributed as a standard F distribution the critical values for this statistic are much larger than those found in the standard F table. Thus to test the null hypothesis that  $\delta = 0$  and  $\rho$

= 1, i.e. a random walk with trend, we had to refer to the distributions tabulated by Dickey and Fuller themselves<sup>16</sup>. If the calculated F value is less than the 5% critical value, the joint null hypothesis of a random walk with positive drift trend could not be rejected. Otherwise it was rejected and we concluded that the data series was not a random walk. In that case the series was trend-reverting around an upward or downward trend, which of course depended on the sign of the  $\alpha$  coefficient in the auto-regression equation for percentage changes. The same conclusions regarding the forecast power of the  $Y_{t-1}$  variable mentioned for Case I also apply here. In addition to the joint F-test, a T-test on Rho was used to determine if the coefficient for the lagged variable was significantly different than one. This is another test to determine randomness in the series.

### **3.2.2 QUESTION #2 ANALYSIS: HOW DOES THE LOCAL ECONOMY AFFECT THE REAL ESTATE MARKETS?**

Real estate economists have long believed that there is a strong correlation between real estate investment performance and the state of the economy. They reason that recession years should lead to a soft real estate market due to a decrease in the demand for space, while boom years should lead to a high real estate market given the increase in demand. However, over the longer term this relationship becomes less stable. The increase in rents and prices will almost certainly promote new construction as asset prices rise above replacement costs. If the amount of new development “overshoots” the new equilibrium, rents will in turn eventually fall<sup>17</sup>. This scenario is the basic premise underlying the infamous real estate boom/bust cycle. However, as was mentioned in the beginning of Chapter 1, the advent of the public markets should serve to reduce these extreme cycles.

As was also described in Chapter 1, the relationship between GDP and the private/public markets has tremendous implications as to the diversification benefits of international real estate investment. The

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<sup>16</sup> Op. Cit., D. A. Dickey and W. A. Fuller

<sup>17</sup> Op. Cit., D. DiPasquale, W. Wheaton.

conclusions of the Yale paper indicate that not only is there is a strong correlation between private property values, but that global economic effects have a major influence on a given country's domestic GDP fluctuations as well. So it is clear that correctly accessing the link between GDP and the public markets, and for the other data series, is of great importance to real estate investors. This was the intent of attempting to answer Question #2 which is detailed next.

We began the analysis by using the base data for real GDP, real rents, real private prices, and real public prices to construct four additional charts that gave the percentage changes for each variable. Then two separate statistical tests were performed for each country using the charts.

- 1) The correlation values were computed between GDP and the other data series.
- 2) The Durbin-Watson values were computed for the series.

### **Correlation Test**

The correlation values for GDP with real rents, real private prices, and real public prices were all computed. Specifically, the ratio between the covariance of the two studied variables and the product of their standard deviations was calculated to arrive at the correlation coefficient value. The equation is given below:

$$\rho = \sigma_{xy} / (\sigma_x \sigma_y) \quad (\text{Eq. 6})$$

In addition, because it is also believed that property markets may react slowly to changes in the GDP, in effect creating a lag, the same correlation values were computed between the changes in the property market variable in a given year and the GDP changes in the previous year.

In order to examine the significance of the correlation parameters the standard F-test was computed by running a regression on the two series being analyzed. The  $R^2$  value given in the regression equation is equivalent to the  $\rho$  value given above. These values were computed for both the contemporaneous and lagged cases. If the computed F value was greater than the critical F value, then



the overall equation was deemed to be significant at the 5% level. If the computed F value failed the significance test, then the correlation was deemed to be unreliable.

### **Durbin-Watson Co-Integration Test**

If two data series follow a random walk pattern, it is still possible for them to be related. This occurs if the series tend to move together in a random fashion. In this case, the variables are said to be co-integrated<sup>18</sup>. Given that some of the variables in the study were shown to be random as per the analysis of the Question 1, and that there were so few observations in that determination, a co-integration test was run for all of the series regardless of whether or not the Dickey-Fuller test indicated persistence.

The Durbin-Watson statistic was calculated from the co-integrating regression ( $X_t = \alpha + \beta Y_t + \epsilon_t$ ), and tested the hypothesis that  $DW = 0$ . The actual Durbin-Watson statistic used is given below:

$$DW = \frac{\sum(\epsilon_t - \epsilon_{t-1})^2}{\sum(\epsilon_t)^2} \quad (\text{Eq. 7})$$

Obtaining critical values of the Durbin-Watson (DW) value to test for co-integration proved to be a difficult task. The only values available were given in the paper by economists Robert Engle and C.W. Granger for 100 observations<sup>19</sup>. Those values were .386 for a 5% level of significance, and .322 for a 10% level. It was decided that higher values would be used since there were far fewer observations in this study. Those values were .4 and .35 respectively. If the computed DW value exceeded the critical value of .4, the hypothesis of no co-integration could be rejected at the 5% significance level. Thus, it was concluded that the data series were indeed co-integrated. In addition, to study the reaction of the real estate market to changes in economic production, the same co-integration tests were performed between the changes in the property market variable in a given year and the GDP changes in the previous year.

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<sup>18</sup> R. F. Engle, C. W. J. Wranger, "Co-integration and Error Correction: Representation, Estimation and Testing" *Econometrica*, Vol. 55, 1987, p.251-276.

<sup>19</sup> Op. Cit., R. F. Engle, C. W. J. Wranger, p.269

### **3.2.3 QUESTION #3 ANALYSIS: HOW DO THE PUBLIC AND PRIVATE REAL ESTATE MARKETS RELATE WITH EACH OTHER?**

Three different relationships were analyzed: rents & private values, rents & public values, and private values & public values. In general, the analysis for this question was similar to that for Question #2 in that correlations and Durbin-Watson statistics were computed for each combination of data using the previously derived percentage difference tables.

In addition to the analysis of the contemporaneous relationships, the correlations for each series lagged against one another were also examined. Using rents & private prices as an example, the rent series lagged one period was analyzed with the contemporaneous private price series. Then the private price series lagged one period was analyzed with the contemporaneous rent series. This allowed us to ascertain whether or not one series lead the other. If the correlation of one of the lagged series combinations was greater than the dual contemporaneous correlation, then it was concluded that the lagged series did in fact lead the contemporaneous series over the study period.

#### **Relationship: Rents & Private Prices**

Under the rational expectations hypothesis changes in private prices should anticipate changes in rents<sup>20</sup>. This is the case if it is assumed that the market participants are perfectly informed about predicted movements of the private market. If so, then investors should be able to correctly anticipate how the private market will respond to a shock. In the statistical analysis this would be indicated if the correlation between the lagged values for private prices and for contemporaneous rent values are higher than that for the dual contemporaneous correlation.

Under the myopic price expectation hypothesis, real estate investors use only current rents to form their price expectation for the following period<sup>21</sup>. That is, they are incapable of predicting future

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<sup>20</sup> Op. Cit., D. DiPasquale, W. Wheaton, p. 254-256.

<sup>21</sup> Ibid., p. 251-254.

rent values. In this scheme of price formation the contemporaneous correlation between private prices and rents will be greater than either of the lagged correlation combinations.

#### **Relationship: Rents & Public Prices**

The same analysis was performed for rents & public prices. In this case one would expect the public markets to be more rational given their increased liquidity and analyst scrutiny. If so, the correlation of the lagged public prices and contemporaneous rent prices should be greater than any of the other correlation values. If this is not the case, then the dual contemporaneous correlation calculation will be the greatest. This indicates no evidence of presumably greater public market efficiency.

#### **Relationship: Private Prices & Public Prices**

Once again correlation and DW statistical tests were run for the contemporaneous and lagged values of the private & public price combinations. As was mentioned in the first chapter, there has not been any extensive research conducted on this topic outside the US markets. This relationship is much more complex than the previous two that were analyzed. It stands to reason that given an efficient publicly traded market for securities, representing claims on real estate investment companies, an investor would be able to obtain a similar performance as if he/she had invested directly in the real estate assets themselves. If this was the case, then a high level of contemporaneous correlation between the public and private returns should be indicated by the statistical analysis.

However, it must be noted that the value of public real estate companies is affected by more than the value of the underlying assets. Management's contribution is also a key valuation input. If analysts feel that management can consistently add value to the company, then it is likely that the market value of the public company will in fact trade at a figure that is higher than the market value of the underlying assets. And has been demonstrated recently, the reverse situation may occur as well. That is, if analysts feel that management is not able to maintain the asset's value, then the market value of the public

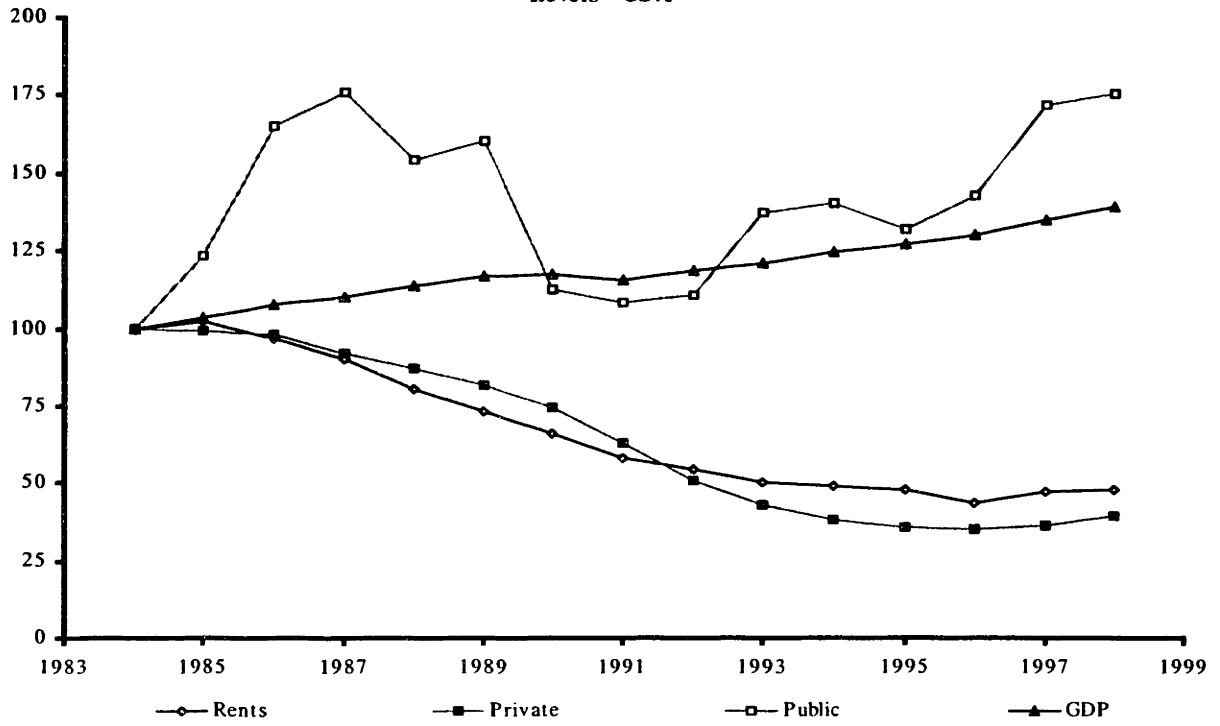
company may actually be less than that of the underlying assets. It should be clear that it is very unlikely that there would be a perfect correlation between public and private prices.

In addition to determining the direct correlation values for each country, the lagged correlation value provides crucial information as to the efficiency of the public markets. Previous studies in the US have focused on the lead/lag relationship between public and private returns. There is some evidence to indicate that the public market in the US tends to anticipate the private market movements. One would expect this to be the case given the US's relatively well developed public real estate market. Again, the idea is that if a public market is an efficient one, i.e. with high liquidity and heavy analyst and investor scrutiny, prices will adjust very quickly to all available information. Private prices on the other hand are typically very sticky, reflecting a small number of transactions and low degree of investor scrutiny.

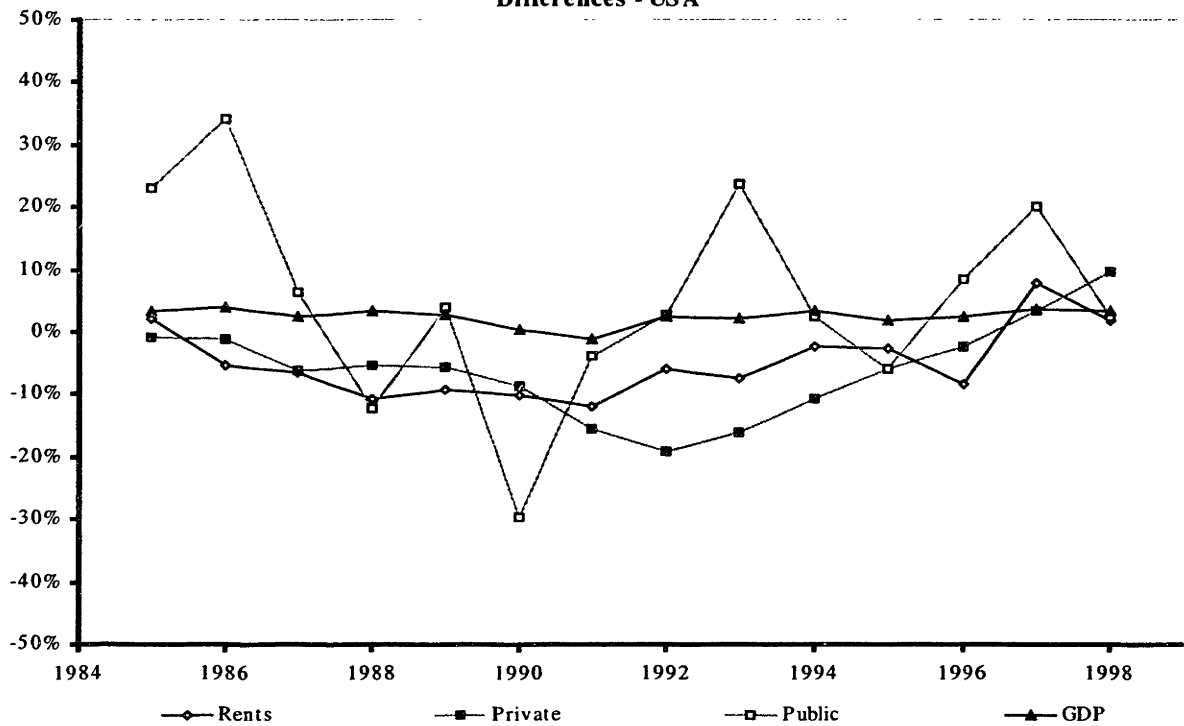
In order to address this tremendously important question in our study, the relevant correlation values were compared to see if public prices did in fact lead private prices. The specific analysis followed that which was done for the other two data combinations. If the correlation between the lagged public series and the contemporaneous private series was greater than the dual contemporaneous correlation value, then it was concluded that the public market lead the private market. If the lagged correlations were not greater than the dual contemporaneous correlation, then it was concluded that the public markets did not lead the private markets. This might indicate inefficient, underdeveloped public markets. Another possible interpretation of this result would be that the private market is also adjusting instantaneously to news, which given the stickiness of private prices, should rarely be the case.

As a final observation the limitations of the lead/lag analysis should be noted. Any non-contemporaneous relationships could not be tested in depth since only yearly data was used. Shorter lagged periods would have had to be used for a more precise determination of the lead/lag relationships. It is quite possible that monthly data would have yielded different conclusions.

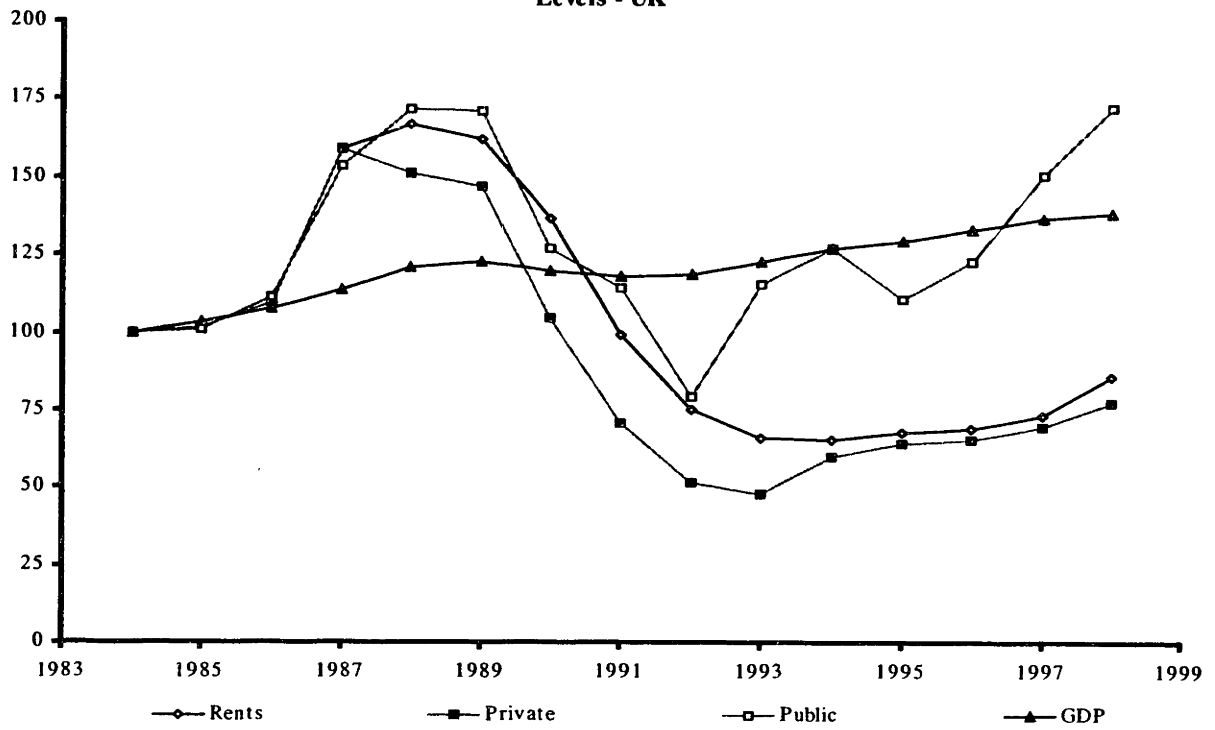
**EXHIBIT 7A**  
Levels - USA



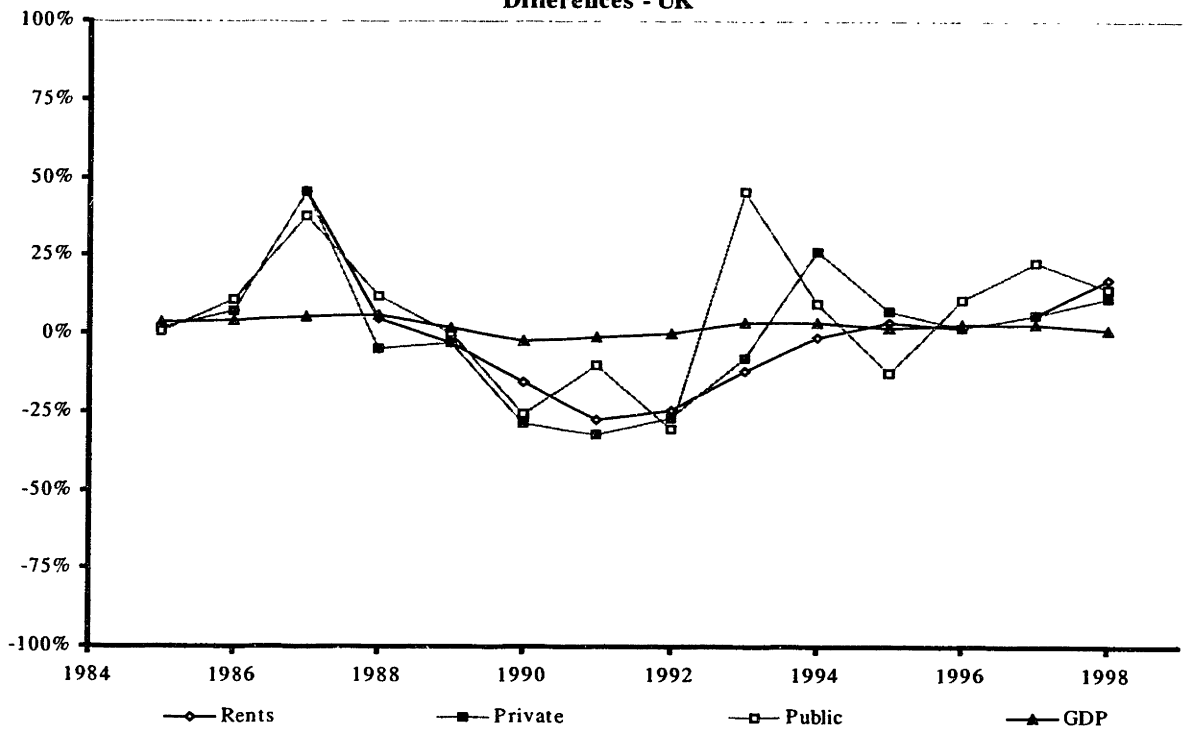
**EXHIBIT 7B**  
Differences - USA



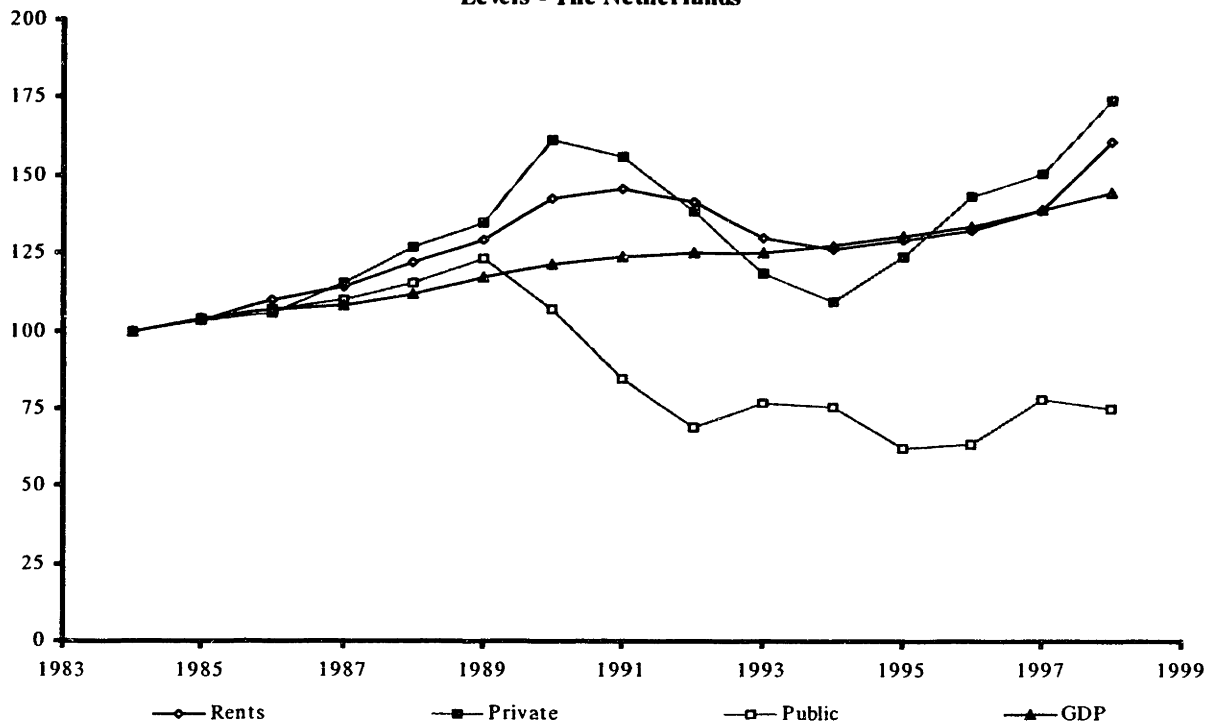
**EXHIBIT 8A**  
Levels - UK



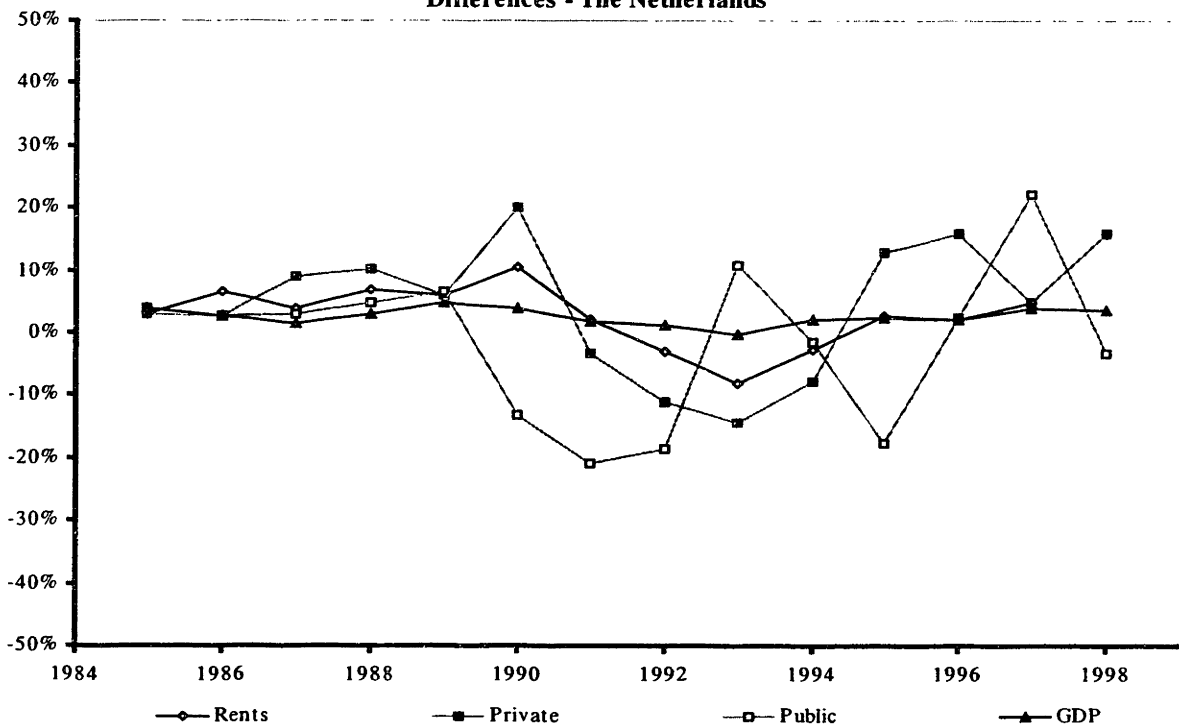
**EXHIBIT 8B**  
Differences - UK



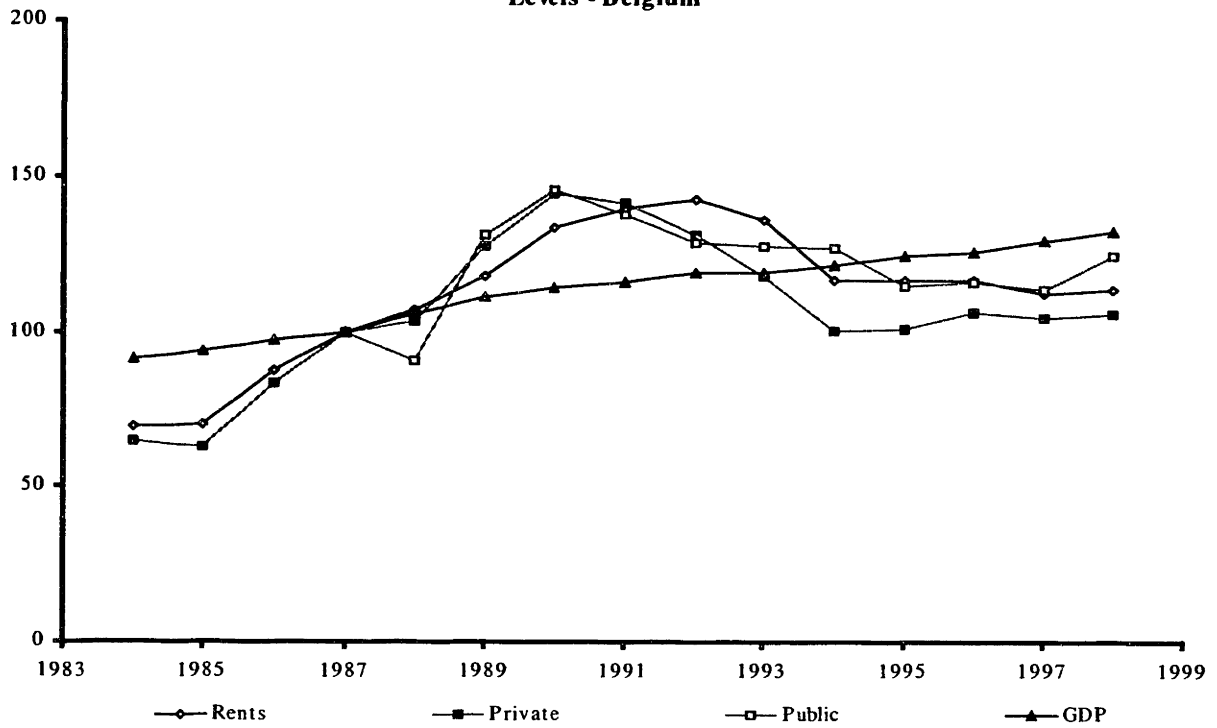
**EXHIBIT 9A**  
**Levels - The Netherlands**



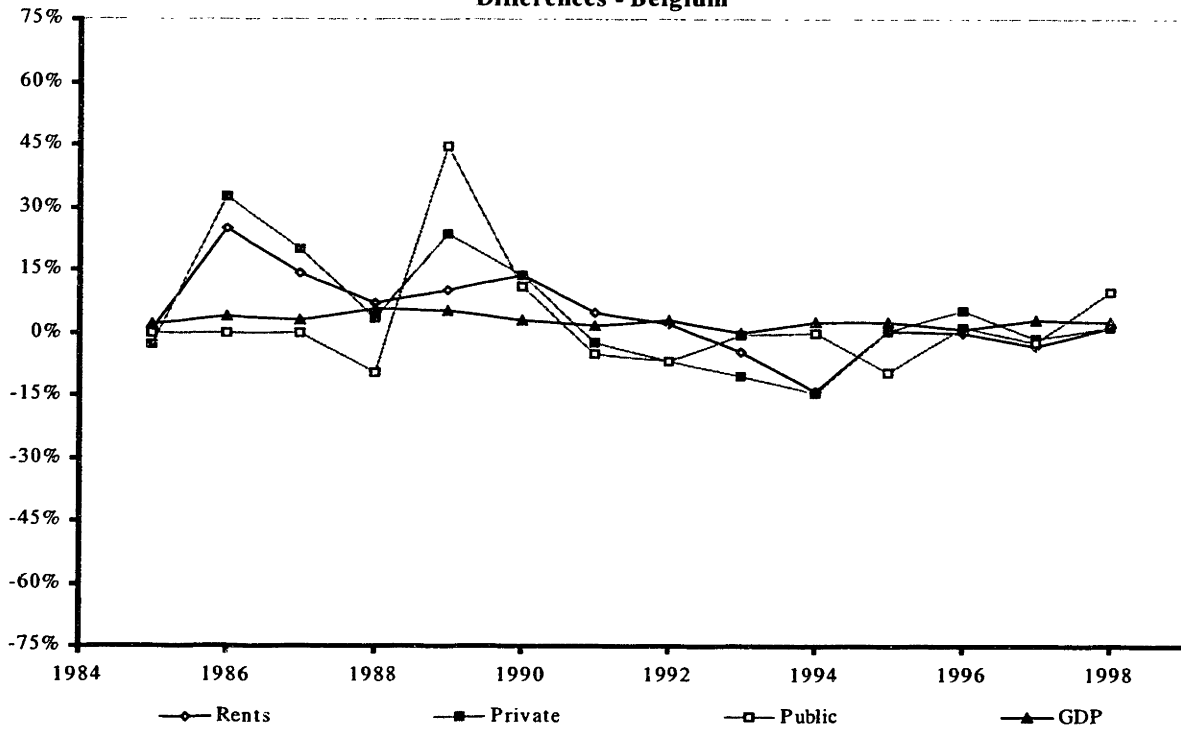
**EXHIBIT 9B**  
**Differences - The Netherlands**



**EXHIBIT 10A**  
Levels - Belgium

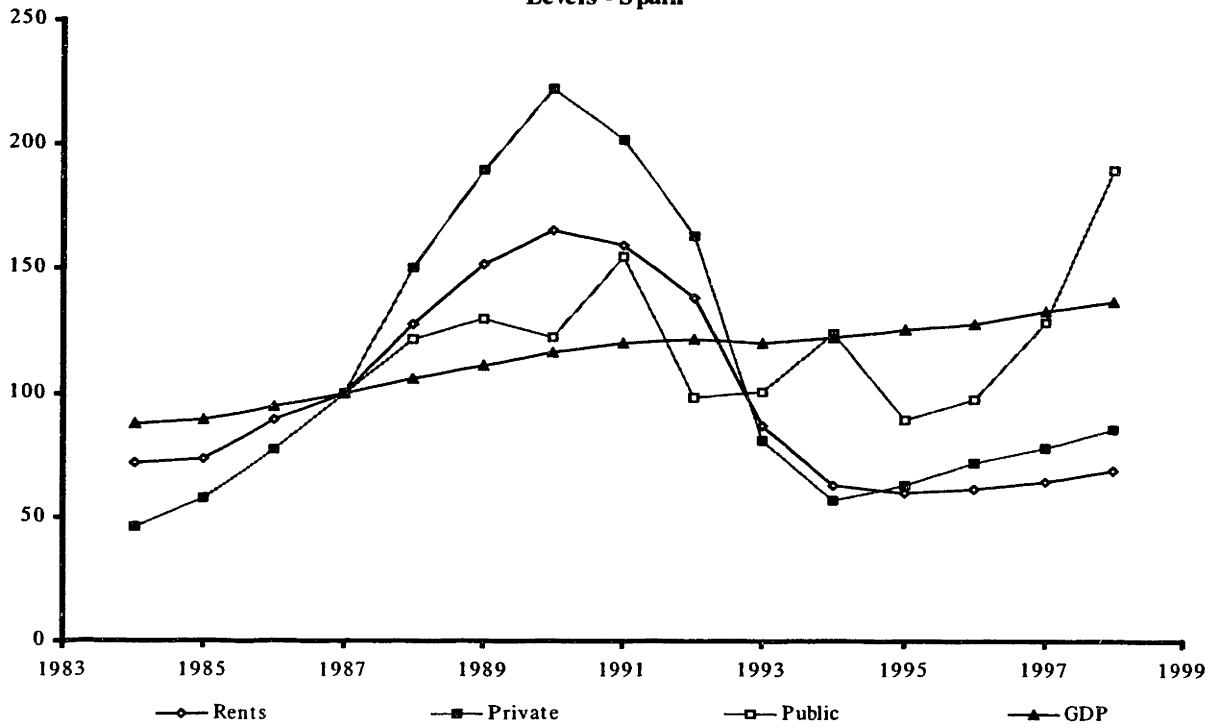


**EXHIBIT 10B**  
Differences - Belgium

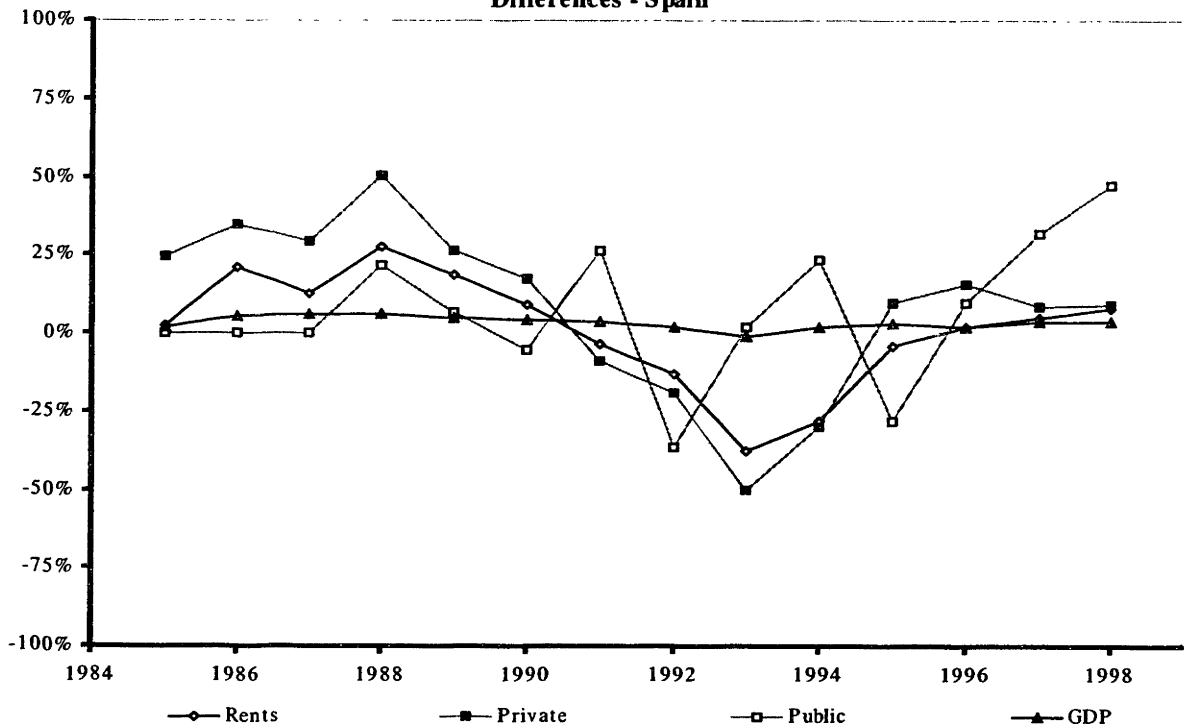




**EXHIBIT 11A**  
Levels - Spain



**EXHIBIT 11B**  
Differences - Spain



## **CHAPTER 4**

### **QUESTION 1: ARE GDP, RENTS, PRIVATE AND PUBLIC PRICES FOLLOWING A RANDOM WALK OR A TREND-REVERTING PATTERN?**

#### **4.1 CHAPTER OBJECTIVE**

The overall objectives of this chapter are twofold. The first is to identify, using the auto-regression equation, any constant trends in the time series for each country. The second is to determine whether or not this data is trend-reverting or random based on the results of the first order auto-regression equation (ARI) and the Dickey-Fuller unit root tests. The time series for each country is presented in graphical form in Exhibit 7 through 11. Both levels and differences for GDP, private prices, rents, and public prices are shown for the years 1984 to 1998. The results of the statistical analysis performed for the answer of these questions are presented in the following section.

#### **4.2 QUESTION 1 SUMMARY CHART**

Summary chart A gives the results for this question.

##### **4.2.1 GDP RESULTS**

39 yearly observations beginning in 1960 were used to examine the GDP data for all of the countries in the study. The t-statistics on the alphas were significant for all of the analyzed countries including the United States. The Dutch real economy grew at about 1.9% per year followed by the United Kingdom and Spain with approximately 1.7% per year over the study period. Belgium economy grew a little slower at the real rate of 1.3% per year. The results can be compared with the growth of the United States which had a slightly higher positive trend of about 2% per year when analyzed GDP values since the 1960.

<b>Summary Chart A</b> BEHAVIOR OF ANALYZED VARIABLES	<b>USA</b>	<b>UK</b>	<b>Netherlands</b>	<b>Belgium</b>	<b>Spain</b>
	National	London	Amsterdam	Brussels	Madrid
<b>GDP - Lagged Regression Statistics</b>	1961	1961	1961	1961	1961
	1998	1998	1998	1998	1998
<b>Autoregressive Formula: Is there a trend?</b>	<b>Trend</b>	<b>Trend</b>	<b>Trend</b>	<b>Trend</b>	<b>Trend</b>
Alpha of Differences	0 020	0 017	0 019	0 013	0 017
T-statistic	3 111	3 138	2 683	2 298	2 197
Beta of Differences	0 334	0 288	0 462	0 570	0 580
T-statistic	2 099	1 770	3 086	4 173	4 533
<i>Behavior of the Market:</i>	<b>Persistent</b>	<b>Random</b>	<b>Persistent</b>	<b>Persistent</b>	<b>Persistent</b>
<b>Dickey-Fuller Case 1 (No Trend)</b>	Random	Random	Random	Random	Random
Beta of Auto-Regression	1 003	1 007	0 994	0 992	0 994
T-test (single test for beta significant from one)	0 238	0 455	-0 495	-0 617	-0 516
<b>Dickey-Fuller Case 2 (Trend)</b>	Random	Random	Random	Random	Random
Rho of Unrestricted Regression	0 749	0 757	0 913	0 908	0 906
F-test (OLS joint test for Rho=1 & Gamma=0)	2 222	2 612	0 911	1 013	1 000
T-test (single test for Rho significant from one)	-2 051	-2 152	-1 323	-1 375	-1 382
<b>GDP - Lagged Regression Statistics (Rent time frame)</b>	1979	1966	1971	1971	1974
	1998	1998	1998	1998	1998
<b>Autoregressive Formula: Is there a trend?</b>	<b>Trend</b>	<b>Trend</b>	<b>Trend</b>	<b>Trend</b>	<b>No Trend</b>
Alpha of Differences	0 015	0 016	0 012	0 013	0 011
T-statistic	2 119	2 787	2 214	2 162	2 018
Beta of Differences	0 311	0 286	0 501	0 408	0 475
T-statistic	1 356	1 630	2 975	2 298	2 786
<i>Behavior of the Market:</i>	<b>Random</b>	<b>Random</b>	<b>Persistent</b>	<b>Persistent</b>	<b>Persistent</b>
<b>Dickey-Fuller Case 1 (No Trend)</b>	Random	Random	Random	Random	Random
Beta of Auto-Regression	1 049	1 007	1 012	1 001	1 032
T-test (single test for beta significant from one)	1 264	0 352	0 551	0 043	1 344
<b>Dickey-Fuller Case 2 (Trend)</b>	Random	Random	Random	Random	Random
Rho of Unrestricted Regression	0 644	0 754	0 914	0 901	0 920
F-test (OLS joint test for Rho=1 & Gamma=0)	5 035	2 271	0 556	0 611	1 937
T-test (single test for Rho significant from one)	-2 403	-2 014	-0 776	-1 050	-0 963
<b>Rents - Lagged Regression Statistics</b>	1979	1966	1971	1971	1974
	1998	1998	1998	1998	1998
<b>Autoregressive Formula: Is there a trend?</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>
Alpha of Differences	-0 020	0 010	0 007	-0 008	-0 019
T-statistic	-1 356	0 309	0 639	-0 471	-0 724
Beta of Differences	0 442	0 436	0 595	0 444	0 397
T-statistic	1 965	2 723	3 194	2 571	2 681
<i>Behavior of the Market:</i>	<b>Persistent</b>	<b>Persistent</b>	<b>Persistent</b>	<b>Persistent</b>	<b>Persistent</b>
<b>Dickey-Fuller Case 1 (No Trend)</b>	Random	Random	Random	Random	Random
Beta of Auto-Regression	0 965	0 757	0 834	0 899	0 840
T-test (single test for beta significant from one)	-1 016	-2 143	-1 930	-1 506	-1 321
<b>Dickey-Fuller Case 2 (Trend)</b>	Random	Random	Random	Random	Random
Rho of Unrestricted Regression	0 895	0 731	0 905	0 915	0 806
F-test (OLS joint test for Rho=1 & Gamma=0)	0 623	3 078	6 992	1 631	1 499
T-test (single test for Rho significant from one)	-0 739	-2 350	-1 206	-1 221	-1 559
<b>Private - Lagged Regression Statistics</b>	1979	1974	1974	1980	1974
	1998	1998	1998	1998	1998
<b>Autoregressive Formula: Is there a trend?</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>
Alpha of Differences	0 0006	-0 0021	0 0146	0 0095	0 0021
T-statistic	0 0528	-0 0538	0 7048	0 3411	0 0565
Beta of Differences	0 9319	0 2563	0 4498	0 4610	0 5457
T-statistic	6 9820	1 2566	2 3300	2 0787	3 5319
<i>Behavior of the Market:</i>	<b>Persistent</b>	<b>Random</b>	<b>Persistent</b>	<b>Persistent</b>	<b>Persistent</b>
<b>Dickey-Fuller Case 1 (No Trend)</b>	Random	Random	Random	Random	Random
Beta of Auto-Regression	1 0187	0 7036	0 7811	0 8866	0 8640
T-test (single test for beta significant from one)	0 4417	-2 7073	-1 4549	-1 0672	-1 3490
<b>Dickey-Fuller Case 2 (Trend)</b>	Random	Random	Random	Random	Random
Rho of Unrestricted Regression	0 8204	0 6813	0 8095	0 8570	0 8649
F-test (OLS joint test for Rho=1 & Gamma=0)	3 5244	3 5707	1 7058	0 5992	0 8706
T-test (single test for Rho significant from one)	-2 1252	-2 4091	-1 2557	-1 0298	-1 2086
<b>Public - Lagged Regression Statistics</b>	1985	1985	1985	1988	1988
	1998	1998	1998	1998	1998
<b>Autoregressive Formula: Is there a trend?</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>	<b>No Trend</b>
Alpha of Differences	0 0262	0 0617	-0 0147	0 0423	0 0827
T-statistic	0 5460	0 9230	-0 4050	0 7958	0 9211
Beta of Differences	0 2428	0 0561	0 1851	-0 0308	-0 1137
T-statistic	0 8759	0 1857	0 6287	-0 0894	-0 2833
<i>Behavior of the Market:</i>	<b>Random</b>	<b>Random</b>	<b>Random</b>	<b>Random</b>	<b>Random</b>
<b>Dickey-Fuller Case 1 (No Trend)</b>	Random	Random	Random	Random	Random
Beta of Auto-Regression	0 5649	0 6326	0 8725	0 4625	0 2221
T-test (single test for beta significant from one)	-1 9096	-1 4981	-0 8628	-2 0844	-1 6006
<b>Dickey-Fuller Case 2 (Trend)</b>	Random	Random	Random	Random	Random
Rho of Unrestricted Regression	0 5613	0 6282	0 5993	0 4809	0 2786
F-test (OLS joint test for Rho=1 & Gamma=0)	1 6795	1 1104	1 5860	2 1063	1 3381
T-test (single test for Rho significant from one)	-1 8278	-1 4591	-1 7661	-1 9073	-1 3986

The beta coefficients in the first order auto-regression equation were almost completely consistent across all countries. A strong relationship between successive GDP changes, which suggests a trend-reverting pattern was found in the Netherlands, Belgium, and Spain as well as in the United States. However for the United Kingdom the t-statistic of the beta coefficient was not statistically significant evidencing a random walk pattern.

Given that the data for all of the countries was shown to demonstrate a trend, Case II of the Dickey-Fuller test was used. The calculated F values were below the critical value of 7.00 in all the cases, indicating that the hypothesis of a random walk could not be rejected using this methodology. These low F values contradict the results of the auto-regression equation that indicates a strong trend reverting pattern in four out of the five countries. In all of the cases, the t-statistics for the rho coefficients were above the -3.5 critical values, supporting the conclusion of a random walk with trend for all countries.

We should keep in mind the limitations of the Dickey-Fuller test explained in chapter 3 of this thesis when analyzing the sometimes conflicting results of the different tests and consequently put more emphasis in the findings of the first order auto-regression equation when forming conclusions. This applies for the GDP analysis and for the analysis of all the other variables as well.

#### **4.2.2 GDP (RENT TIME FRAME) RESULTS**

Given that for all of the countries the GDP data series pre-dated the other data series by at least 10 years, a shorter GDP series was also analyzed. In this case the time period was restricted to the same interval as the rent data of each country. Again, all of the countries continued to exhibit a time-related trend, though with less significant confidence intervals, due to the increase in the critical values. In the case of Spain the calculated t-statistics was slightly below the critical value required to reject the null hypothesis of no trend at the 5% confidence level. However, the 2.02 value is high enough to reject the hypothesis of a flat series at the 10% confidence level. For all countries, including the United States the

$\alpha$  coefficients were below the ones obtained when using the complete data set. The range of real economic growth for this period is between 1.1% Spain and 1.6% for the United Kingdom.

Using this time frame the only case of a random walk behavior among the European countries was found again in the United Kingdom. However, this time the auto-regression equation evidenced a random walk pattern in the United States as well. The t-statistics of the beta coefficients for the other countries were above the critical value indicating that the lagged coefficients were significantly different from zero. Once again, the results of the Dickey-Fuller test failed to reject the null hypothesis of a random walk in all of the countries for GDP using the shorter time frame.

#### **4.2.3 RENTS RESULTS**

There were no trends found in the rents series of any country. The very small t-statistic values for the alphas seemed to indicate this rather conclusively. Interesting to note that in the case of the United States the coefficient was negative, suggesting the existence of a downward trend. However, the t-statistic was not significant to confirm the validity of this result.

The beta coefficients in the auto-regression equation were all significantly different from zero, indicating a trend-reverting pattern in the rent series. This result suggests that the level of rents this year can be used to forecast the level of the next one in all of the analyzed countries.

Since there was not trend in any of the series, case I of the Dickey Fuller test, for flat series, was used. The T-statistics on the coefficient of the lagged variable were greater than the critical value in all cases. Thus, the null hypothesis that true coefficient is 1 and the series are following a random walk process could not be rejected. The t-statistics for the United Kingdom and the Netherlands, the countries with the highest beta coefficients in the auto-regression equation, came close to the critical value of -3.00. With a few more observations the Dickey-Fuller test could very well determine that London and Amsterdam's rents had been persistent over the test period, supporting the initial conclusion of the auto-regression equation.

#### **4.2.4 PRIVATE PRICES RESULTS**

The Private price data begins in 1973 for all the European countries except for Belgium where the first observation is from 1979. In the United States the data starts in 1978. Using the auto-regression equation on differences, private prices were found to exhibit no trend at all for any of the countries. All of the alpha values were very small and t-statistics were insignificant. This indicated a weak influence of the associated GDP growth on the private price series.

Interestingly, the same behavior observed for rents was identified when analyzing property prices in all countries except the United Kingdom. The results of the auto-regression test showed persistence in the private prices of Amsterdam, Brussels and Madrid as well as in the United States. However private prices in London followed a random walk.

Again, Case I of the Dickey-Fuller test showed that in all of the cases the series were random. However, it is important to keep in mind that given the small number of degrees of freedom the critical values were inflated making it difficult to reject the random walk hypothesis.

#### **4.2.5 PUBLIC PRICES RESULTS**

Fifteen data points were available for analyzing the behavior of the public market. For Belgium as well as for Spain data begins around 1987 which gives even less than 15 observations.

Similar to private prices, public prices were found to demonstrate no trends. In the public series the alphas coefficients were much higher than for rents and private prices, however their t-statistics were still well below critical value. In the case of the Netherlands the results were interesting; the alpha coefficient was negative, suggesting the existence of a downward trend, even though the t-statistics were not significant enough to confirm this result.

Examining the beta coefficients in the first order auto-regression equation we find that they were all close to zero and the t-statistics were insignificant, suggesting that historic returns are useless to

forecast future performance. Thus, the level of public prices this year is the best forecast for the level of the next one, being the variation pure white noise or random

Case I of the Dickey-Fuller test indicated that all of the countries had random public price movements supporting the conclusion of the first order auto-regression test. This confirms the common belief that public real estate markets are predominantly efficient.

## **CHAPTER 5:**

### **QUESTION 2: HOW DOES THE LOCAL ECONOMY AFFECT THE REAL ESTATE**

#### **MARKET?**

##### **5.1 CHAPTER OBJECTIVE**

The goal of this chapter is to examine the relationships between GDP and other key real estate market variables. The analysis consisted of determining GDP's contemporaneous correlations with rents, private prices, and public prices. Then correlations using a one period lagged data series were used to determine whether or not these relationships were more strongly contemporaneous or lagged. In order to more accurately compare data series, in which one (or both) followed a random walk, the Durbin-Watson co-integration test was used to determine if random variables were moving together. This chapter will examine the results of these tests in an attempt to answer Question 2.

##### **5.2 QUESTION 2 SUMMARY CHART**

Summary chart B gives the results for this question.

###### **5.2.1 GDP-RENTS RESULTS**

The correlations between contemporaneous GDP and rent values varied considerably. As expected they were all positive but not all significant, only Spain showed a strong degree of correlation, its level of 75% was by far the largest. United Kingdom and Belgium's correlation of around 40% also proved to be significant. Finally the values for the Netherlands and the United States were the lowest. Moreover, the F statistics for both countries indicated that those correlations were not significant, thus the hypothesis of a correlation coefficient equal to zero could not be rejected.



<b>Summary Chart B</b> THE ECONOMY & THE REAL ESTATE MARKET	<b>USA</b> National	<b>UK</b> London	<b>Netherlands</b> Amsterdam	<b>Belgium</b> Brussels	<b>Spain</b> Madrid
<b>GDP - RENTS</b>					
<b>Durbin Watson</b>					
Contemporaneous Rents - GDP	0.426	0.473	0.201	0.134	0.373
GDP Leading Rents	0.507	0.476	0.205	0.136	0.376
<i>Are GDP(t) and Rents (t) Co-integrated?</i>	<b>Yes</b>	<b>Yes</b>	<b>No</b>	<b>No</b>	<b>No</b>
<b>Correlation</b>					
Correlation GDP (t) - Rents (t)	<b>23.47%</b>	<b>40.95%</b>	<b>27.02%</b>	<b>38.24%</b>	<b>74.96%</b>
F-stat	1.049	6.246	2.047	4.452	29.505
Significance F	0.319	0.018	0.164	0.045	0.000
Correlation GDP (t-1) - Rents (t)	<b>0.56%</b>	<b>53.70%</b>	<b>2.29%</b>	<b>21.51%</b>	<b>63.82%</b>
F-stat	0.001	12.560	0.014	1.261	15.805
Significance F	0.981	0.001	0.908	0.272	0.001
<i>Are GDP changes leading Rents?</i>	<b>No</b>	<b>Yes</b>	<b>No</b>	<b>No</b>	<b>No</b>
<b>GDP-PRIVATE</b>					
<b>Durbin Watson</b>					
Contemporaneous Private Prices - GDP	0.267	0.500	0.488	0.325	0.277
GDP Leading Private Prices	0.341	0.496	0.488	0.275	0.281
<i>Are GDP(t) and Private (t) Co-integrated?</i>	<b>No</b>	<b>Yes</b>	<b>Yes</b>	<b>No</b>	<b>No</b>
<b>Correlation</b>					
Correlation GDP (t) - Private Prices (t)	<b>8.49%</b>	<b>53.64%</b>	<b>53.90%</b>	<b>53.18%</b>	<b>75.55%</b>
F-stat	0.131	9.290	9.418	6.705	30.591
Significance F	0.722	0.006	0.005	0.019	0.000
Correlation GDP (t-1) - Private Prices (t)	<b>19.81%</b>	<b>37.03%</b>	<b>47.76%</b>	<b>65.04%</b>	<b>55.94%</b>
F-stat	0.735	3.655	6.796	12.461	10.476
Significance F	0.402	0.068	0.016	0.003	0.004
<i>Are GDP changes leading Private?</i>	<b>Yes</b>	<b>No</b>	<b>No</b>	<b>Yes</b>	<b>No</b>
<b>GDP-PUBLIC</b>					
<b>Durbin Watson</b>					
Contemporaneous Public Prices - GDP	0.796	0.744	0.652	0.941	1.345
GDP Leading Public Prices	0.794	0.789	0.652	0.925	1.315
<i>Are GDP(t) and Public (t) Co-integrated?</i>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>
<b>Correlation</b>					
Correlation GDP (t) - Public Prices (t)	<b>54.55%</b>	<b>72.10%</b>	<b>20.21%</b>	<b>34.88%</b>	<b>25.09%</b>
F-stat	5.085	12.991	0.511	1.247	0.605
Significance F	0.044	0.004	0.488	0.293	0.457
Correlation GDP (t-1) - Public Prices (t)	<b>28.92%</b>	<b>31.00%</b>	<b>-30.41%</b>	<b>67.21%</b>	<b>1.68%</b>
F-stat	1.095	1.276	1.223	7.415	0.003
Significance F	0.316	0.281	0.290	0.023	0.961
<i>Are GDP changes leading Public?</i>	<b>No</b>	<b>No</b>	<b>No</b>	<b>Yes</b>	<b>No</b>

The lagged correlation analysis indicated that only United Kingdom's GDP led the rent series over the study period. For this country the correlation was higher when GDP was lagged, increasing the confidence interval. For Spain the value of the correlation coefficient decreased but continued to be significant. For the rest of the countries, the state of the domestic GDP in the previous year was found to play a relatively small role in determining current rent prices.

In the United Kingdom and the United States, where GDP (for the rent time frame) follows a random walk, the contemporaneous and lagged Durbin-Watson results were significant (greater than 0.4) indicating co-integration. The Durbin-Watson result in the lagged relationship in both cases was higher than the contemporaneous one, suggesting that GDP lead rents in these countries.

### **5.2.2 GDP-PRIVATE PRICES RESULTS**

With the exception of the United States, the relationship GDP-private prices for all of the countries showed high correlation values and significant F statistics. In all of the cases they were above 50%. Spain's relationship continued to be the highest at 75.55%.

In all of the countries the lagged correlations were less than the contemporaneous values, except in Belgium where the coefficient increased from 53.18% to 65.04% for the lagged relationship. Thus, the link between GDP and private prices was assumed to be contemporaneous in nature for all the other countries. All these results contrast with the ones of the United States that showed an insignificant level of correlation both contemporaneous and lagged.

The Durbin-Watson results for the United Kingdom and the United States, the two countries with random variables, supported the conclusions of the correlation tests. The high coefficient found in the UK adds evidence in support of the hypothesis that GDP and private prices are moving together. In the US the Durbin-Watson was below the critical value supporting the previous finding of a weak relationship between these variables.

### **5.2.3 GDP-PUBLIC PRICES RESULTS**

If public prices are more volatile and liquid, and thus subject to more influence by immediate local economic considerations the correlation coefficients should be higher for this relationship than for GDP-private prices and for GDP-rents. For the countries analyzed in this thesis, only the correlation coefficients for the United States and the United Kingdom were significant and much higher than the ones obtained when using private market variables. Interestingly these are the two countries with the most developed public markets among the ones included in this study. In the Netherlands, Belgium and Spain the results of the correlation tests suggest little relationship between GDP-and public prices.

However, given that public prices are following random walks in all countries, the Durbin-Watson coefficients should also be considered. They were above the critical values in all the cases,

indicating that GDP-public prices were co-integrated for all countries. The relationship was found to be contemporaneous in all the cases except the United Kingdom. One would assume this to be the case given the ability of the public markets to quickly assimilate new economic information.

## **CHAPTER 6:**

### **QUESTION 3: HOW DO PUBLIC AND PRIVATE REAL ESTATE RELATES WITH EACH OTHER?**

#### **6.1 CHAPTER OBJECTIVE**

The objectives of this chapter are similar to those of the previous one for the various relationships being addressed. The correlations between rents & private prices, rents & public prices, and public & private prices were calculated in order to better understand these inter-market relationships. It was also determined whether these relationships were lagged or contemporaneous, as in the previous chapter. The Durbin-Watson test for co-integration was used as well. This chapter will attempt to analyze the implications of the results with the intent of answering the third and final question.

#### **6.2 QUESTION 3 SUMMARY CHART**

Summary chart C gives the results for this question.

##### **6.2.1 RENTS-PRIVATE PRICES RESULTS**

Given that rental income is such a key component of a building's value, one would expect to find a very high correlation between rent levels and private prices. This was indeed found to be the case. For the four European countries the correlation was between 75% and 95% approximately, for the United States the value of 57.55% was the lowest. All of the F values were overwhelmingly significant for these correlations.

<b>Summary Chart C</b>	<b>USA</b>	<b>UK</b>	<b>Netherlands</b>	<b>Belgium</b>	<b>Spain</b>
RELATIONSHIPS WITHIN THE REAL ESTATE SECTOR	National	London	Amsterdam	Brussels	Madrid
<b>RENTS - PRIVATE</b>					
<b>Durbin Watson</b>					
Contemporaneous Private Prices - Rents	0.305	1.124	0.561	0.558	0.114
Rents Leading Private Prices	0.507	0.703	0.715	0.593	0.342
Private Prices Leading Rents	0.187	1.576	0.609	1.003	0.236
<i>Are Rents(t) and Private (t) Co-integrated?</i>	<b>No</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>	<b>No</b>
<b>Correlation</b>					
Correlation Rents (t) - Private Prices (t)	<b>57.55%</b>	<b>77.80%</b>	<b>75.48%</b>	<b>91.47%</b>	<b>94.83%</b>
F-stat	8.913	35.273	30.462	87.033	205.362
Significance F	0.008	0.000	0.000	0.000	0.000
Correlation Rents (t-1) - Private Prices (t)	<b>68.22%</b>	<b>3.65%</b>	<b>45.53%</b>	<b>43.11%</b>	<b>39.69%</b>
F-stat	14.800	0.031	6.014	3.881	4.113
Significance F	0.001	0.862	0.022	0.065	0.055
<i>Are changes in Rents leading Private?</i>	<b>Yes</b>	<b>No</b>	<b>No</b>	<b>No</b>	<b>No</b>
Correlation Private Prices (t-1) - Rents (t)	<b>44.13%</b>	<b>50.60%</b>	<b>37.14%</b>	<b>54.26%</b>	<b>68.89%</b>
F-stat	4.110	7.571	3.519	6.678	19.868
Significance F	0.059	0.012	0.074	0.020	0.000
<i>Are changes in Private leading Rents?</i>	<b>No</b>	<b>No</b>	<b>No</b>	<b>No</b>	<b>No</b>
<b>RENTS - PUBLIC</b>					
<b>Durbin Watson</b>					
Contemporaneous Public Prices - Rents	0.750	0.671	0.392	1.950	1.262
Rents Leading Public Prices	0.752	0.737	0.443	1.462	1.268
Public Prices Leading Rents	0.862	0.950	0.412	1.543	2.298
<i>Are Rents(t) and Public (t) Co-integrated?</i>	<b>Yes</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>Yes</b>
<b>Correlation</b>					
Correlation Rents (t) - Public Prices (t)	<b>44.81%</b>	<b>60.00%</b>	<b>-0.97%</b>	<b>40.37%</b>	<b>24.01%</b>
F-stat	3.015	6.749	0.001	1.752	0.550
Significance F	0.108	0.023	0.974	0.218	0.477
Correlation Rents (t-1) - Public Prices (t)	<b>32.31%</b>	<b>18.90%</b>	<b>-14.10%</b>	<b>15.91%</b>	<b>19.38%</b>
F-stat	1.399	0.445	0.243	0.234	0.351
Significance F	0.260	0.518	0.631	0.640	0.568
<i>Are changes in Rents leading Public?</i>	<b>No</b>	<b>No</b>	<b>No</b>	<b>No</b>	<b>No</b>
Correlation Public Prices (t-1) - Rents (t)	<b>45.05%</b>	<b>47.38%</b>	<b>73.36%</b>	<b>50.97%</b>	<b>50.76%</b>
F-stat	2.800	3.184	12.815	2.807	2.776
Significance F	0.122	0.102	0.004	0.132	0.134
<i>Are changes in Public leading Rents?</i>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>Yes</b>	<b>Yes</b>
<b>PRIVATE - PUBLIC</b>					
<b>Durbin Watson</b>					
Contemporaneous Private Prices - Public Prices	0.065	0.235	0.457	0.747	0.388
Private Prices Leading Public Prices	0.075	0.370	0.511	1.553	0.369
Public Prices Leading Private Prices	0.062	0.387	0.499	0.610	0.630
<i>Are Public and Private (t) Co-integrated?</i>	<b>No</b>	<b>No</b>	<b>Yes</b>	<b>Yes</b>	<b>No</b>
<b>Correlation</b>					
Correlation Private Prices (t) - Public Prices (t)	<b>21.97%</b>	<b>63.57%</b>	<b>-2.83%</b>	<b>74.00%</b>	<b>16.50%</b>
F-stat	0.609	8.140	0.010	10.891	0.255
Significance F	0.450	0.015	0.923	0.009	0.626
Correlation Private Prices (t-1) - Public Prices (t)	<b>14.24%</b>	<b>13.39%</b>	<b>11.33%</b>	<b>10.84%</b>	<b>24.24%</b>
F-stat	0.248	0.219	0.156	0.107	0.562
Significance F	0.627	0.648	0.700	0.751	0.473
<i>Are changes in Private leading Public?</i>	<b>No</b>	<b>No</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>
Correlation Public Prices (t-1) - Private Prices (t)	<b>42.32%</b>	<b>54.47%</b>	<b>48.98%</b>	<b>24.79%</b>	<b>45.94%</b>
F-stat	2.399	4.640	3.471	0.524	2.141
Significance F	0.150	0.054	0.089	0.490	0.182
<i>Are changes in Public leading Private?</i>	<b>Yes</b>	<b>No</b>	<b>Yes</b>	<b>No</b>	<b>Yes</b>

In addition, all of the relationships for the European countries were found to be contemporaneous. The results indicate that the current level of rents played a large role in determining contemporaneous private prices over the study period. Contrasting with the United States where the correlation computed with lagged rents was found to be the approximately 10% higher than the contemporaneous, suggesting some evidence of a myopic dynamic price formation.

Since in the United Kingdom private prices were found to follow a random walk, one would expect to find also a significant Durbin-Watson statistics between the variables if they are strongly related as the correlation test suggested. The results of the co-integration test confirmed this hypothesis. The Durbin-Watson values for all of the relationships, both contemporaneous and lagged, were very significant. The co-integration test reveals evidence of private prices leading rents in the United Kingdom, given that the Durbin-Watson coefficient for that relationship was the highest one. This suggests that property prices are successfully incorporating future levels of rents.

### **6.2.2 RENTS-PUBLIC PRICES RESULTS**

The correlations between contemporaneous public prices and rents varied considerably. Overall they were significantly lower than those found between rents and private prices suggesting that variables other than the level of current rents have big influence in the prices of publicly traded real estate companies. United Kingdom's 60% value was the highest correlation, while in the Netherlands the contemporaneous relationship was found to be almost zero. Only for the United Kingdom the F value was above the critical value indicating that the results were statistically significant. The United States's correlation of 45% was also quite high. However, the calculated F was not high enough to reject the hypothesis of no correlation.

The correlation results for the public prices leading rents were higher than the contemporaneous values for all the countries analyzed except for the United Kingdom. This provides evidence that public prices lead rent prices in the Netherlands, Belgium and Spain, as well as in the United States.

The results of the Durbin-Watson test were not totally consistent with the previous conclusions. Overall rent series and public prices seemed to be co-integrated for both the contemporaneous and lagged relationships in all the analyzed foreign markets. However, the Durbin-Watson coefficients were higher for the lagged test in all cases with the exception of Belgium. Supporting the previous results that public prices tend to lead rents in the analyzed region.

### 6.2.3 PRIVATE PRICES-PUBLIC PRICES RESULTS

If the public markets are more efficient than private ones, then evidence that the public market prices lead the private market values should be found. This was the case for three of the four European countries analyzed, the United Kingdom, the Netherlands and Spain, confirming the findings for the United States. Belgium, however, did not exhibit the same results. The contemporaneous values were found to be the highest in that case. The most extreme case was the Netherlands where the contemporaneous correlation was slightly negative and jumped to 49% when public price returns were lagged. For Spain the correlation rose almost by 30%. However it should be noted that even though the correlation coefficients were higher than 45% the F values were below the critical value for a 95% confidence interval in both countries.

The Durbin-Watson results were significant for all of the relationships. They showed that there was in fact a high degree of co-integration for the public prices-rents relationship for the Netherlands, Belgium and Spain. For the Netherlands and Spain the Durbin-Watson values of the lagged relationship proved to be the highest confirming that the public market were leading private market in those countries over the study period. In the United Kingdom special attention was given to the co-integration test since both variables, private & public prices, followed random walks. Even though both Durbin-Watson coefficients were below the critical value for the 5% significance level the lagged one was found to be the highest and significant at the 10% level. Evidencing that public prices lead private prices. The results of the co-integration test for the United States were not reliable given that the Durbin-Watson values were insignificant for all the relationships.

## **CHAPTER 7: FINAL SUMMARY**

### **7.1 COUNTRY SUMMARY GRAPHS**

The results of the three questions analyzed in this thesis are presented in graphical form in Exhibits 12 through 15.

### **7.2 QUESTION 1 SUMMARY**

Interestingly the findings gave support to the common belief regarding the contrast between public and private markets. On the one hand, public prices were consistently found random in all of the countries suggesting an efficient market. On the other hand, rents were found to be persistent in all cases reflecting the stickiness of the lease contracts. Private prices and GDP series were found to follow trend-reverting pattern in all of the countries except the United Kingdom.

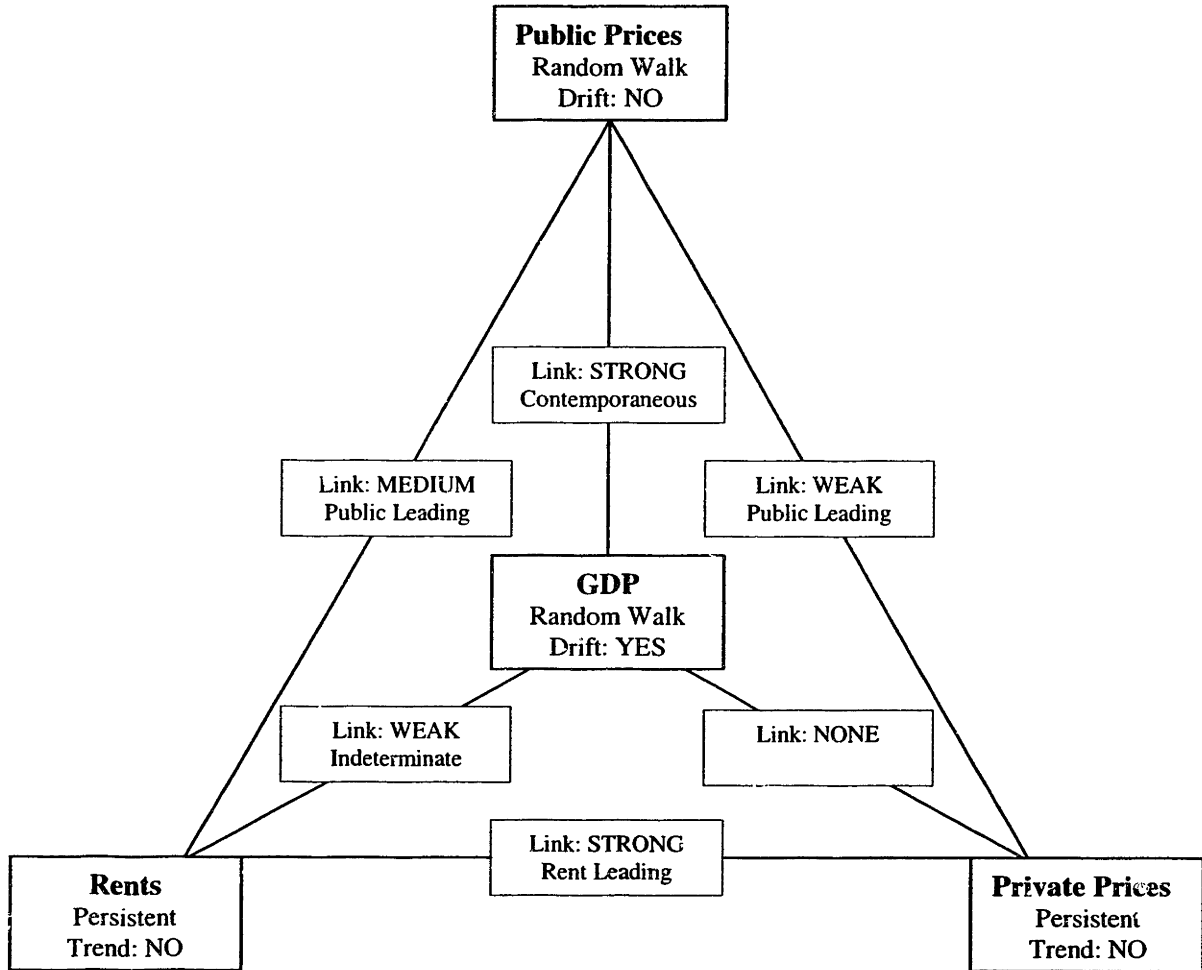
Another interesting result is the lack of trends in the real estate data. Given that there were trends found in the GDPs, the relationship between the variables and time suggest that the real estate market may sometimes get disconnected from the path of the local economy. Therefore, there could be situations where the real estate markets would not benefit from periods of steady economic expansion as the ones exhibited by these European nations.

### **7.3 QUESTION 2 SUMMARY**

Chapter 1 indicated that Professor's Goetzmann et. al. had found a strong correlation between GDP and the private real estate markets in many foreign countries. They also found that a large portion of the changes in GDP was caused by global economic influences. Therefore it was concluded that international diversification was of little help in such a scenario.

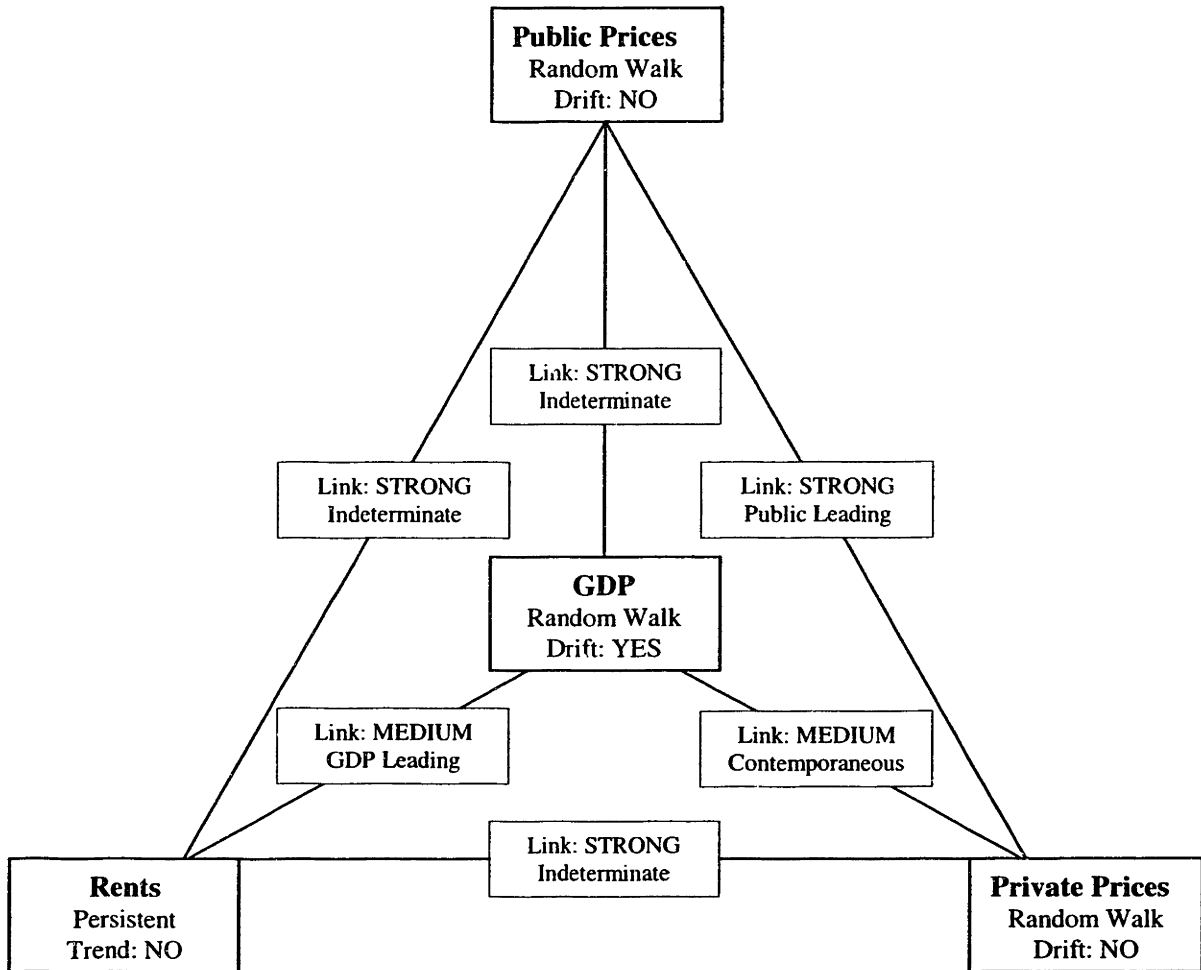


**Exhibit 12**  
**National, USA**



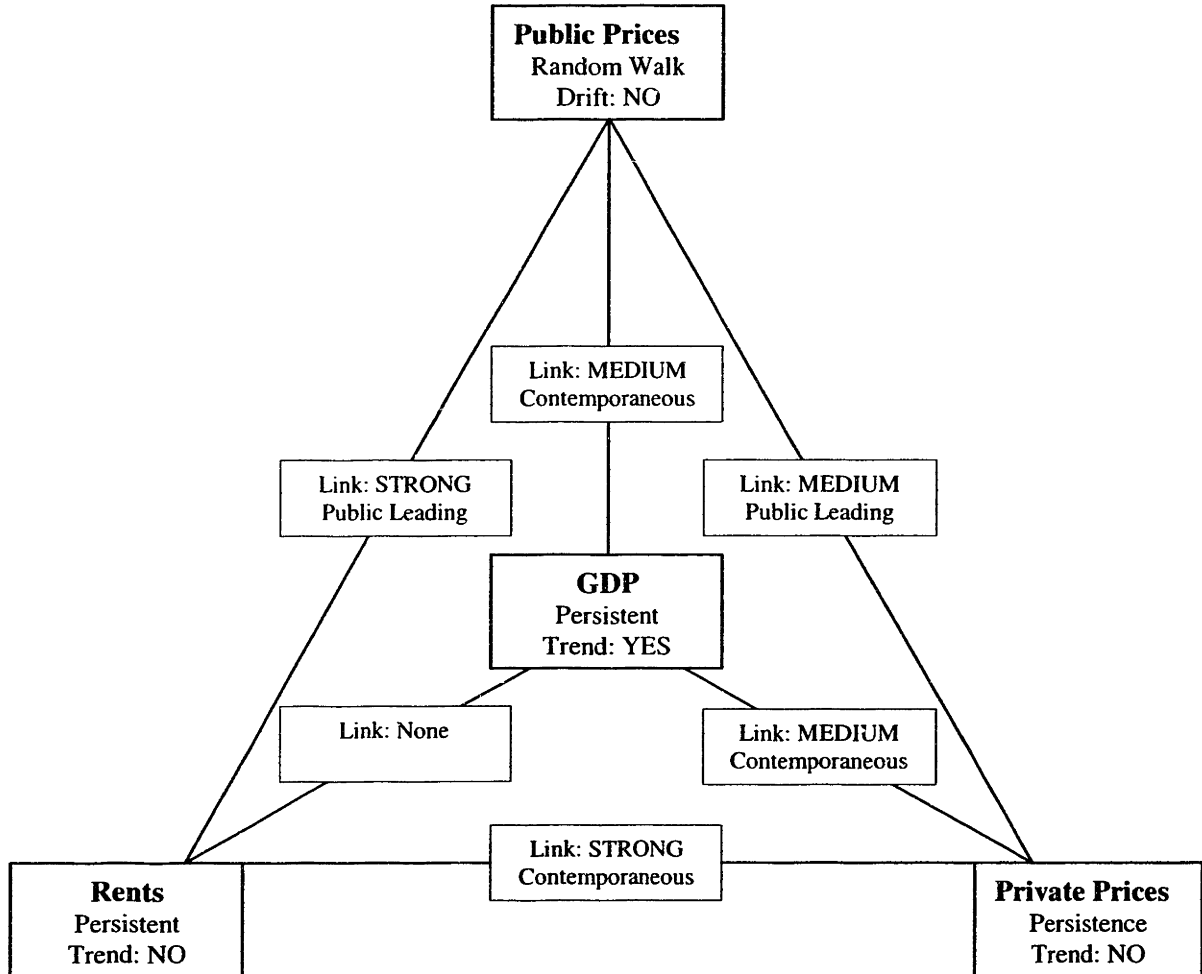
**EXHIBIT 13**

**United Kingdom, London**



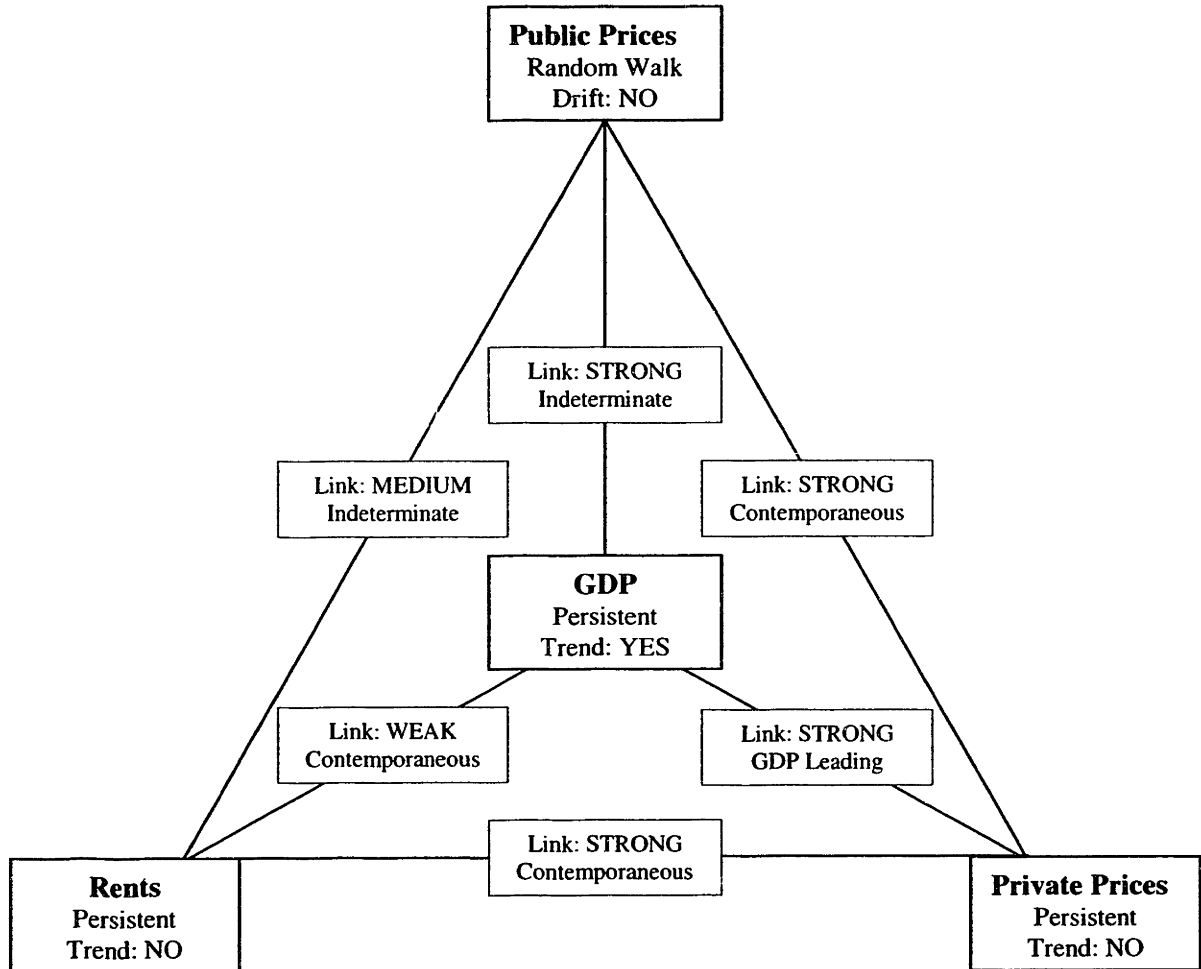
**EXHIBIT 14**

**Netherlands, Amsterdam**



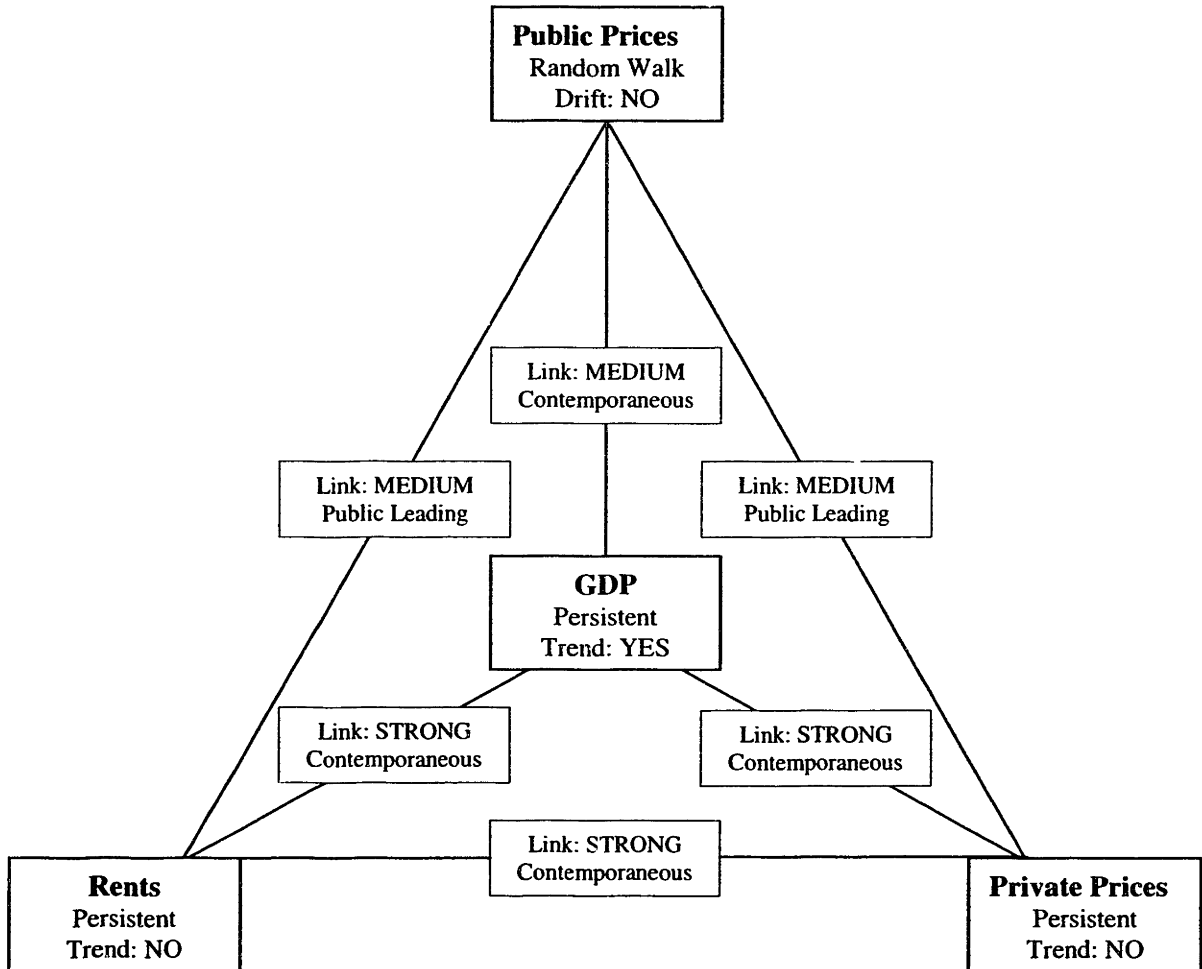
**EXHIBIT 15**

**Belgium, Brussels**



**EXHIBIT 16**

**Spain, Madrid**



The results found in this thesis also indicated a strong contemporaneous correlation between GDP and real estate prices. It was found that GDP, on average, had a higher correlation with prices than with rents. This is not surprising given that prices are able to react to new economic data whereas rents tend to remain unchanged for the duration of the contract. The co-integration coefficients also revealed a very strong relationship between GDP and public prices. The relationships between the national economies and the real estate market were found to be predominantly contemporaneous, even though evidence of GDP changes leading some real estate variables was occasionally found.

Assuming that Goetzmann et al.'s hypothesis that a large portion of the changes in GDP is due to international influences is correct, and given that GDP affects both public and private prices, the overall conclusion must be that international investment in office properties will not produce substantial diversification benefits for international real estate investors. Moreover, given the even stronger link between public prices and national GDP, switching from direct equity investments to public securities will increase non-systematic risk. However, it must be emphasized that investors will still enjoy greater investment liquidity that may very well overshadow the diversification issues since the investment options available to them are dramatically improved.

#### **7.4 QUESTION 3 SUMMARY**

There was a very strong contemporaneous link shown for the private prices-rents relationship for all of the countries. This is not surprising given that private prices are a function of rent values. The lagged relationships were all lower, except for the United Kingdom where it was found that the private prices led changes in rents and the United States where the opposite occurred.

The results for the public prices-rents relationship indicated that a definite relationship existed, but less so than for rents-private prices. However, a high degree of co-integration was observed. The results of the co-integration test are especially important given that the data analysis of Chapter 4

indicated randomness in the public data. These relatively high co-integration values indicate that the data series were moving together over the study period. Overall public prices were found to lead rents in all of the European region and in the United States as well.

The private-public results were not so conclusive. Although high enough to reject the hypothesis of no relationship in most of the countries, the link was found to be far from perfect. Suggesting that even though public and private instruments may represent claims on similar properties, variables other than the price of the underlying asset may have an influence in the variation of the value of that claim. In the lagged analysis the public markets of the Netherlands, Spain and the United Kingdom were found to lead the private markets, but this was not found to be the case in Belgium. This would tend to indicate the efficiency of the Dutch, Spanish and British public markets.

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