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Lead-Lag Relationship between the Price-to-Rent Ratio and the Macroeconomy: An Empirical Study of the Residential Market of Hong Kong

Daniel Lo [1,*], Yung Yau [2,*], Michael McCord [1] and Martin Haran [1]

[1] Faculty of Computing, Engineering and the Built Environment, Ulster University, Newtownabbey BT37 0QB, UK
[2] Department of Sociology and Social Policy, School of Graduate Studies, Lingnan University, Tuen Mun, Hong Kong
* Correspondence: d.lo@ulster.ac.uk (D.L.); yungyau@ln.edu.hk (Y.Y.)

Abstract: The price-to-rent (PtR) ratio is one of the most commonly used indicators to assess housing market conditions by policy makers and real estate practitioners. It is often employed as an economic barometer to detect whether a housing bubble exists and determine whether the property market has become unaffordable relative to historical trends. Despite a plethora of research studies on the PtR ratio in the housing literature, relatively little is known about its long-term dynamics with macroeconomic and financial determinants. By utilising time series data on the Hong Kong residential property market, this study examines the cointegration and causal relationships between a wide spectrum of macroeconomic indicators and the PtR ratios of housing segments of different tiers which comprise different socioeconomic groups of homebuyers and investors. The results point towards market compartmentalisation, in the sense that the PtR ratios of the housing submarkets respond to changes in macroeconomic fundamentals in a differential manner. For instance, the PtR ratios of housing segments with a greater proportion of owner-occupiers are statistically less y correlated with investment-related macroeconomic attributes, such as foreign direct investment and equity market performance. On the other hand, the pricing of large-sized housing units in prime locations, generally favoured by investors from mainland China, are found to be Granger-caused by the exchange rate of the Chinese Yuan to the Hong Kong dollar.

Keywords: price-to-rent; affordability; asset pricing bubble; macroeconomics; Granger causality; Hong Kong

Citation: Lo, D.; Yau, Y.; McCord, M.; Haran, M. Lead-Lag Relationship between the Price-to-Rent Ratio and the Macroeconomy: An Empirical Study of the Residential Market of Hong Kong. *Buildings* **2022**, *12*, 1345. https://doi.org/10.3390/buildings12091345

Academic Editor: Davide Settembre-Blundo

Received: 29 July 2022
Accepted: 26 August 2022
Published: 31 August 2022

1. Introduction

The housing market of Hong Kong and its macroeconomy are highly interconnected [1–3], not least by virtue of the city's well-developed capitalist market with flows of capital, labour, goods and services from one sector to another essentially unrestricted. Due to its economic openness and financial efficiency, the housing market of Hong Kong is also significantly influenced by the inflow and outflow of international funds, which are in turn affected by the volatility of the currency market. Further, the United States interest rates have for decades been a key determinant of the performance of the Hong Kong property market through a monetary mechanism known as the Linked exchange rates system [1,4]; whilst the Hong Kong stock market has also played a key role in dictating the trend of its housing development through cross-sector diffusion of wealth, with the two sectors generally trending in synchronisation with one another over time. Given the numerous intertwined macroeconomic forces that are at play within the market, the domestic property price movements have been subject to much volatility, as well as speculative activities, over the past few decades, often resulting in problems and issues that are of great social concern and importance, such as housing bubbles, supply shortages, undesirable living conditions and issues with housing affordability.

Accordingly, the price-to-rent (PtR) ratio is an indicator often utilised to monitor property market conditions, which provides useful market information about speculative investment behaviour, formation of asset pricing bubbles, future price expectations and rental market performance. On one hand, it can be examined cross-sectionally to compare different property markets so as to assess which one is relatively overvalued and whether temporal and spatial path dependencies exist within a system of housing markets [5]. On the other hand, it can also be employed as a benchmark to assess whether a given housing market deviates from its historical trends in terms of pricing, against which the economic relationship between renting and buying can be objectively established. Indeed, previous studies on the residential real estate of Hong Kong using the PtR ratio indicator have identified the existence of market bubbles around the Asian Financial Crisis in 1997 and the Global Financial Crisis in 2008 [4,6]. The extent to which the property market is overvalued is often scrutinised relative to its underlying market fundamentals. Notably, Leung [7] observed that the pricing of residential real estate in Hong Kong is mainly dependent on the amount of land supply, real per-capita income and real interest rate over a long-time horizon. In a more recent study, Chong and Li [8] illuminated, in the historical context of Hong Kong, that its exorbitant property prices have been largely attributable to the oligopolistic nature of the market and the inelasticity of land supply for residential development.

Despite a corpus of studies investigating the temporal and cross-sectional dynamics between the market fundamentals and the pricing of residential property in Hong Kong, none of them has examined how the PtR ratio and its macroeconomic determinants are cointegrated and causally related. A better conceptualisation of the ratio with respect to the macroeconomic environment is of crucial importance for property valuation, investment and formulation of public housing policy. As elucidated by Lo et al. [9], the applications of the PtR ratio are versatile. The ratio can serve as an effective early measure for evaluating the impacts of changes in macroprudential policies. It can also indicate how these impacts may manifest across different segments of property tiers within a wider real estate market. From a market regulator's viewpoint, the PtR ratio can be viewed as a signal for mitigating future irrational price cyclicity, informing housing, macroprudential and lending policy designs. Against this backdrop, this study attempts to shed light on the macroeconomic factors affecting the PtR ratio of the private residential property market of Hong Kong, using the techniques of Johansen Cointegration and Granger Causality. More specifically, we undertook an analysis across housing segments of different quality tiers and locations by considering a wide spectrum of macroeconomic attributes that are identified in previous studies as important determinants of property prices and rents, including inflation, money supply, exchange rates, foreign direct investment, employment, performance of the stock market and housing supply. The results clearly point to market compartmentalisation with, for example, the PtR ratios of housing segments having a greater proportion of owner-occupiers exhibiting less causal correlation with investment-related macroeconomic attributes, such as foreign direct investment and equity market performance. On the other hand, the pricing of large-sized housing units in prime locations, generally favoured by investors from mainland China, are found to be Granger-caused by the exchange rate of the Chinese Yuan to the Hong Kong dollar.

The remainder of the paper is structured as follows: Section 2 discusses the relevant studies in the literature, with attention paid to the macroeconomic factors that influence the PtR ratio in different international property markets. Section 3 presents the research methodology employed in the study, covering a detailed discussion on the Cointegration and Granger Causality models. Section 4 depicts the sample data of the study and a descriptive analysis on the Hong Kong housing market. The empirical results are presented in Section 5 and discussed in Section 6. The last section provides some concluding remarks and discusses the inferences and implications arising from the study.

2. Literature Review

The PtR ratio of real estate can provide useful market insights, including information about speculative pricing behaviours of market participants, formation of asset pricing bubbles, and expectations of future market trends, as well as degree of housing affordability [10]. Therefore, it is frequently employed as an economic indicator for gauging whether the property market is in a condition of equilibrium that reflects the clearing of the sales and rental markets [11], or under-/over-valuation of the real estate assets [12]. Generally, departures from the long-term historical trends of PtR ratio signal that the market could be in a state of disequilibrium, implying possible deviations from the underlying economic fundamentals, and a mean reversion could be expected to occur to adjust prices back to a "normal" level relative to rents [13].

Indeed, such an adjustment process interlinking the temporal movements of prices and rents is embodied in the DiPasquale and Wheaton's model (or the DW Model) [14], which is frequently used by academics to explain the interaction of price, rent and other market fundamentals of real estate. The DW Model establishes that price is determined by rent in the sense that the former is equal to the summation of all present net cashflows and discounted future rental incomes. Subsequently, the rent of housing space is jointly determined by the total stock of housing space and the demand for rental housing. The price of housing asset is calculated based on the house rent through a process known as capitalisation. Indeed, in real estate investment, the rate of capitalisation is very often known as rental yield, which is essentially the required rate of return (or discount rate) that investors require for acquiring the housing asset. According to the model, the way in which yield is formed in the long run is determined jointly by four underlying economic factors, namely the long-term interest rate, the expected rental income growth by market participants, and the total risk involved in the process of rental income generation, as well as property taxation policy.

A plethora of studies has attempted to investigate the underpinning economic dynamics of real estate price and rent by employing different statistical methods and data. Most noticeably, by undertaking a present value analysis based upon the methodological framework of Campbell and Shiller [12], Kishor and Morley [15] explored the macroeconomic attributes that affected the changes in PtR ratios of 18 metropolitan statistical areas (MSAs) in the United States. In their study, the PtR ratios were first decomposed into two components, each of which was taken as a time series that was exogenously defined. The first component was an unobserved part which was affected by the expected real estate return, as well as real rental growth rate. The second component was a residual series which explained non-stationary deviations of PtR ratio from its conventional present value ratio (PVR) over time. The authors revealed that the PVR components were circa 30% larger in magnitude than the size suggested by the present value model for large MSAs, such as New York and Los Angeles, during a period of property market expansion. The results further highlighted that MSAs with a larger deviation from their respective PVRs are statistically more sensitive to change in interest rates, which indeed suggests a larger responsiveness to monetary policy. In addition, the study confirmed an important empirical phenomenon, whereby PtR ratios tend to exhibit persistence over time. In other words, MSAs with higher PtR ratios and PVRs keep exhibiting the same pricing characteristics during different periods of economic cycle, with a large fraction of the variation in the PVR component explained by change in the expected market returns.

In a similar study, Kim and Lim [16] examined the variations in the PtR ratios of the Irish residential property market for the period of 1976 to 2012, using the framework of the Campbell-Shiller present value equation. They revealed that a large part of the variations in the ratio could be accounted for by the expected housing premium, whereas expected rental growth and real interest rates were less significant attributes influencing the ratio. A subsequent study on the Irish market by Cronin and McQuinn [17] found that macroprudential policy on residential housing tenure could have an impact on PtR ratio with curtailments of loan-to-value ratios generally resulting in greater demand for housing space, hence a lower PtR ratio, holding price levels constant.

Campbell et al. [18] dissected the PtR ratios of 23 metropolitan cities in the United States over a 32-year period by undertaking a variance decomposition analysis based on the dynamic Gordon Growth Model. They observed that the PtR ratios could be decomposed into several components that could be explained by real interest rates, and housing premia over real rates, as well as expected present discounted values of rental growth, the covariances of which could dampen fluctuations in the PtR ratios. Furthermore, a significant part of the volatility of the PtR ratio was found to be related to the housing premia at both the national and local levels. Sommer et al. [19], also examining the United States' residential property market, but applying a dynamic equilibrium stochastic life cycle model of housing tenure choice, uncovered that over 50% of the rise in the PtR ratio was attributed to interest rates, and less restrictive lending requirements for homebuyers, as well as real income levels. They further confirmed that these three factors indeed caused faster growth in property prices, more subdued rental levels, increasing rates of homeownership and higher degrees of household indebtedness.

In the context of the United Kingdom, Bracke [20], using micro-level spatial data on the London housing market, revealed that neighbourhoods with higher levels of affluence tended to display higher PtR ratios. Such a finding was reinforced by a later investigation by Clark and Lomax [21] who employed matched sales and rental price data from houses across England to study how the ratio was influenced by location and property type in various residential submarkets. Their results demonstrated the desirability of a property and the neighbourhood in which it is located are positively associated with the PtR ratio. Pertinently, these empirical insights are in line with the stylised facts of other geo-demographic studies examining the linkages between real estate pricing and urban adversity. In [22–25] the research showed that neighbourhoods in challenged areas of urban adversity, such as those in close proximity to undesirable retail properties (e.g., bookmakers and tobacconists) and/or environmentally hazardous facilities, tend to exhibit less resilience in pricing and, thus, typically display lower PtR ratios. Several studies have examined residential PtR ratios in the Nordic European context. For instance, Borgersen [11] empirically confirmed the linkage between the PtR and the loan to value ratio with the return on leverage, partially determined by the interrelationship between real estate price growth and borrowing cost. In a more recent study, Bago et al. [26], using the GSADF test, empirically observed spatial diffusion of housing bubbles price-to-rent bubbles between Denmark, Finland, Norway and Sweden, with the degree of contagion strengthened by their geographical proximity. With regard to the Chinese housing market, Wu and Jiang [27], in a comparative study, evaluated the price-to-rent ratios and the price-to-income ratios of a number of regional housing markets. Their findings suggested that higher house prices tended to result in a higher degree of distortion between the relationship, driving up rental prices, which posed structural challenges in terms of supporting the mainstream property market.

More recently, McCord et al. [28] and Lo et al. [29] examined the cointegration dynamics and Granger lead-lag associations between the PtR ratios of different property types within the housing market of Belfast, in the United Kingdom. The research provided some evidence that property prices Granger-causes rents in the short run, inferring that sales price information can be used as a leading indicator to predict the movement of rent. In addition, the PtR ratios of the detached submarket seems to Granger-cause those of other property types, including the semi-detached and terrace segments, in both the short and long terms, indicating a possible ripple effect of pricing signals from the top tier to the lower strata within the housing market hierarchy. Their subsequent study [9] further explored the cointegration and Granger causal relationships between the PtR ratios and an array of financial and economic attributes, with some novel empirical findings revealed. For instance, the exchange rates of EUR/GBP and USD/GBP seem to drive the PtR ratios of various housing submarkets within Belfast, highlighting the importance of capital inflow to the Northern Ireland housing economy. In addition, money supply (M3), the performance of the Financial Times Stock Exchange (FTSE), mortgage interest rates and the productivity of the construction sector are all causally correlated with the PtR ratios of the aggregate housing market and submarkets in the long run, confirming the inextricably strong interconnectedness between the pricing of real estate and the macroeconomic and financial fundamentals of the wider market.

3. Methodology

We utilised Johansen Cointegration and Granger causality methods to detect the presence, if any, of cointegration and lead-lag associations between the PtR ratios and a broad spectrum of macroeconomic attributes that we conjectured may be a cause, or consequence, of the property market of Hong Kong. The sample period was 2010 Q1 to 2019 Q4, which was characterised by a relatively stable market environment and a gradual recovery process post-GFC. It was chosen by design to minimise statistical noise caused by potential exogenous influences, such as the global credit crunch in the immediate aftermath of the GFC, that would otherwise be difficult to account for in our models.

3.1. The PtR Time Series

We compiled several PtR time series using property price and rent data from the Rating and Valuation Department (RVD) of the Hong Kong Special Administrative Region Government. The RVD provides quarterly data on average prices and rents measured on a per m^2 basis for five property classes of private residential premises in the city. They are defined by unit size as follows in Table 1:

Table 1. Classification of private residential units of Rating and Valuation Department, Hong Kong.

Class A: Below 39.9 m^2
Class B: 40–69.9 m^2
Class C:70–99.9 m^2
Class D:100–159.9 m^2
Class E: Over 160 m^2

In addition, the five classes of property are further subdivided by district. In other words, time series on three districts, namely Hong Kong Island (HK), Kowloon (KL) and New Territories (NT), are available by property class with each district property time series, capturing a different cross-section of homebuyers and property investors with varying capital constraints, risk aversion levels and other socioeconomic characteristics. Generally speaking, properties on the Hong Kong Island are the most sought after, and, hence, the most unaffordable, due primarily to its locational advantage of being the most accessible to the CBD and other important facilities and amenities in the city. On the other hand, properties in NT are, on average, the most affordable with the greatest supply of small to medium sized apartments targeting first-time homebuyers and young families. Geo-economically, KL is somewhat in between HK and NT. Pertinently, KL is perhaps the most wealth-unequal amongst the three. It is a district where tens of thousands of "cage-homes", "cubicle flats" and partitioned housing units can be found, whilst luxury properties near the Victoria Harbour front fetch record-breaking sales prices.

To simplify our analysis, we mainly considered three district-class time series, namely HK (Class E), KL (Class C) and NT (Class A), which, in our view, should cover the broadest spectrum of homebuyers and property investors in terms of their socioeconomic characteristics. They represented the average, as well as the more extreme, segments of the property market of Hong Kong. For instance, properties within HK (Class E) are considered to be the most expensive and sought-after in terms of price, unit size and location with values derived mainly from capital appreciation instead of rental yield. They are mostly targeted by people in the upper economic echelon of the society and institutional funds, particularly those from mainland China. KL (Class C) comprises properties that suit typical middle-class households in Hong Kong, whereas NT (Class A) is considered as a submarket for first-time buyers and young professionals.

3.2. Macroeconomic Attributes

In our study, we explored the short- and long-term relationships between the PtR ratios of the abovementioned housing submarkets, and a basket of macroeconomic attributes, including the following: (i) inflation, (ii) stock market performance, (iii) exchange rate of RMB/HKD, (iv) USD index (i.e., DXY), (v) money supply, (vi) foreign direct investment, (vii) occupancy rate, (viii) supply of private housing, (ix) employment rate, (x) GDP and (xi) GDP of the construction sector. The selection of these macroeconomic variables was primarily based on the findings of relevant research studies in the literature, as well as the availability of the corresponding data to undertake the analysis.

3.3. Inflation

As Tsai and Peng [30] contended, the potential impact of inflation on property price and the PtR ratio is likely to be statistically ambiguous, depending largely upon the underpinning economic characteristics and the composition of buyers and investors of the market/submarket concerned. On one hand, if the general price level is in synchronisation with the property market, then naturally a rising inflation should entail a higher average property price at the aggregate level, and, hence, a higher PtR ratio. This is in view of the stylised fact that market rents are prone to lag behind transaction prices, given the contractual rigidity in making rental adjustments. On the other hand, a higher inflation rate could imply erosion of the purchasing power of the homebuyer, depressing the overall demand for housing and, consequently, lowering the PtR. In our analysis, we used the year-on-year rate of change in Consumer Price Index (CPI), published by the Census and Statistics Department of Hong Kong, to measure inflation.

3.4. Stock Market Performance

Research studies that have observed a strong and persistent association between residential real estate market and the performance of stock market have been voluminous, for example, the studies [31–34], with the majority pointing towards possible sectoral spillovers of price, return and/or volatility from one market to another. To test the effect of the stock market on the real estate market, the Hang Seng Index (HSI) was used to proxy the general performance of the financial market. More specifically, we measured the year-on-year growth of the index for the investigation period, in line with Lo et al. [9].

3.5. Market Liquidity Attributes

The private residential housing market of Hong Kong is highly dynamic with free inflow and outflow of international funds buoying its liquidity. This is largely attributed to the city's low-tax and low-regulation business environment and the long-standing reputation of its well-functioning legal and judicial system that is rooted in British common law. Therefore, we posit that the exchange rates between the Hong Kong dollar (HKD) and other major currencies should have an impact on the pricing of the housing market. In this study, we considered RMB/HKD and the inverse of the American dollar index (DXY) as independent variables that influenced the PtR ratio.

The ratio of RMB/HKD represents the relative strength of the purchasing powers between the two currencies. It is a proxy that measures how attractive, in terms of pricing, the housing assets in Hong Kong are, from the perspective of investors in China, who have, in recent years, played a key role in developing and investing in the Hong Kong property market [35]. Since the HKD is pegged against the USD through a mechanism known as the linked exchange rate system at a conversion rate of approximately USD 1 = HKD 7.8, the strength of the USD should, therefore, signal how affordable or expensive HKD-denominated assets are, as perceived by global investors. On the other hand, DXY is an index of the USD relative to a basket of international currencies, including GBP, Euro, CAD and JPY. Therefore, if the inverse of DXY increases, HKD-denominated assets, including real estate in Hong Kong, should become more appealing within the international investment market and property prices in the city should, therefore, be expected to increase, holding other things constant.

Aside from the abovementioned exchange rate variables, we also considered the amount of foreign direct investment (FDI) and the growth of M3 money supply as two other macroeconomic variables that affect the liquidity conditions of the property market of Hong Kong.

3.6. Supply-Side Factors: Occupancy Rate and Private Completion Level

It is enshrined in the DW Model that the amount of existing and new housing stock should have a direct impact upon the pricing of real estate, with the magnitude of effect determined by the degree of housing supply elasticity. In light of this, we incorporated two variables into our cointegration and Granger Models, namely occupancy rate and amount of private housing completion. Both variables are property-class specific and were entered into the models by an inverse operator, since both are expected to be inversely related to real estate pricing, i.e., the higher the value of the variables, the lower the property price.

3.7. Employment Rate and GDP Growth

A large volume of studies in the literature has established that there is a strong correlation between the housing market and economic growth. [36–38] Hence, we included a quarterly variable, year-on-year GDP growth (GDP), in our analysis to measure the change in the output level. To the extent that the property market is growing in tandem with the wider economy over time, we should expect that the PtR ratios would be cointegrated with GDP and might even display Granger causation. Apart from investigating the general productivity of Hong Kong, we further examined the output of its construction sector (GDP (Construction)) and its relationships with the PtR ratios of the property market. Indeed, the DW Model implies that the output of the construction is strongly associated with the pricing of real estate, with the strength of association determined by the elasticity of the housing supply.

Lastly, considering empirical evidence in the literature [39,40] which revealed a significant relationship between the employment market and the housing market, we further took into consideration the employment rate of Hong Kong within our analysis. The effect of employment on the PtR ratio is intuitively unclear, and requires empirical scrutiny. On one hand, a more active labour force should naturally lead to higher house prices, increasing the PtR ratio. On the other hand, it could also fuel rental prices to an even greater extent, not least when the supply elasticity of new private housing has been relatively low, as in the case of Hong Kong in recent years.

3.8. Statistical Models

Prior to examining possible cointegration and causality relationships between two variables, it is essential to detect, in the first place, if unit roots exist in their time series, for the statistical robustness of the subsequent analyses. As Granger and Newbold [41] contend, if stationarity of the time series is not adequately accounted for, it could result in spurious results which could, in turn, undermine the inference power of the tests. Hence, we subjected our investigation to the Augmented Dickey Fuller (ADF) unit root test to examine whether unit roots existed within the sample time series. For the purpose of conducting the ADF test, the following equation was used:

$$\Delta Y_t = \alpha + \beta T + \varnothing Y_{t-1} + \sum_{i=1}^{k} \partial \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

where Y_t is the level of the subject time series; α is a constant term and T is a time trend; k denotes the total number of time periods for achieving white noise, which is governed by the Schwarz Information Criterion (SIC); and ε_t is an error term with a mean of zero and constant variances. If $\varnothing \neq 1$ and is statistically significant, the null hypothesis that a unit root is present should be rejected.

3.9. Cointegration Tests

In this study, we checked whether long-run cointegration existed between the sample time series, using the Johansen Cointegration tests [42,43]. Generally speaking, the components of a vector V_t~CI (i, j) are said to be cointegrated of order i, j if V_t is I (1) and we can find a non-zero vector α such that $\alpha' V_t$~I$(i - j)$ where $i \geq j > 0$. α is a cointegrating vector of the time series. We can confirm that there is a cointegration relationship if, and only if, a long-term equilibrium relationship exists between these time series. Procedurally, we can detect the existence of a cointegration relationship between two I (1) variables, say X_t and Y_t, by running a regression of Y_t on X_t [44]. Afterwards, unit root tests are undertaken to examine whether unit roots in the residual of the regression equation are present. Accordingly, we construct the following equation:

$$Y_t = \alpha + \beta X_t + u_t \tag{2}$$

Equation (2) is a cointegrating regression. X_t and Y_t are cointegrated if the residual term, u_t is a stationary time series, which can be validated by conducting the ADF test on u_t. However, Dickey et al. [44] argue that Engle and Granger's [45] method could indeed be sensitive to the regressands chosen. In other words, estimates could be inconsistent and regressand-sensitive. In light of this, Johansen [42,43] proposed using the following equation for the cointegration test:

$$\Delta Y_t = \eta Y_{t-1} + \sum_{i=1}^{k} \Gamma_i \Delta Y_{t-i} + BX_t + \varepsilon_t \tag{3}$$

where $\eta = \sum_{i=1}^{k} A_i - I$ and $\Gamma_i = -\sum_{j=1+1}^{k} A_i$. Y_t represents a k-vector of I (1) which is non-stationary and X_t is a d-vector of deterministic variables. The value η denotes the rank of the coefficient matrix, which tells the number of cointegrating vectors. To determine whether the restrictions suggested by the reduced rank of η can be invalidated, we should examine the cointegration relationship by estimating η in an unrestricted form [42]. Trace test statistics can subsequently be determined by conducting the likelihood ratio (LR) test for the null hypothesis that there are at most r cointegrating vectors between the time series, against the alternative of $r - 1$ or fewer cointegrating vectors. The variables of the analysis should be integrated of order one [45]. The value ε_t is a vector of white noises with a mean equal to zero and constant variance.

3.10. Granger Causality Test in Error Correction Models (ECMs)

When the traditional Granger approach is adopted to test for causality, the long-term relationship of two time series may be mis-specified if they are cointegrated [45]. Hence, we subjected our tests to the framework of Error Correction Model and the tests were done based on the following equation:

$$\Delta Y_t = \lambda + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{j=1}^{q} \beta_j \Delta X_{t-j} + \phi z_{t-1} + \varepsilon_t \tag{4}$$

where λ is the constant term of the equation. z_{t-1} is the error correction (EC) term and ϕ is its coefficient. An ECM-based Granger causality test is statistically appealing for being more informationally implicative. It can detect both long- and short-run equilibria and/or dynamics of a given pair of time series that are cointegrated in the long term. The values p and q are the number of time lags that are sufficiently large to obtain an error term ε_t that indicates the white noises. In Equation (4), $\beta_j's$, which represents the impact of lagged independent variables ΔX_{t-j}, signals the short-term influence of Y on change in X. In other words, β_j gauges Y's short-term elasticity with respect to X. On the other hand, z_{t-1} indicates the long-term temporal dynamic between the two variables. Statistically, z_{t-1} takes the form of:

$$z_{t-1} = Y_{t-1} - w_0 - w_1 X_{t-1} + w_2 t \quad (5)$$

where w_1 is the coefficient on X_{t-1}, which measures the degree of Y's long-run elasticity with respect to X [46], t is a time trend over the study period and w_2 is its coefficient. Besides, ϕ signals the speed with which the variables adjust their short-term disequilibria towards a more long-term equilibrium, or the degree of adjustment to the short-run disequilibrium achieved relative to the long-run equilibrium during the subsequent time period(s). Statistically, the coefficient of adjustment is indicated by ϕ.

Mathematically, the sign of the EC term should be positive if changes in the regressand variable are greater than its average value. In other words, ΔY_t tends to move downwards to converge to the path of equilibrium in the long run. Conversely, the EC term should display a positive sign if ΔY_t is below its average value, and ϕ should, therefore, be negative, driving the dependent variable upward over time [47]. To sum up, the EC term is designed in such a way that Y is "pushed" back towards its long-run equilibrium position.

As discussed above, the researcher should employ the ECM to conduct the Granger causality test if the variables in question are cointegrated in the long run. Under the framework of ECM, short-run and long-run causality should be examined separately. To achieve this, the researcher can test for the coefficient restriction on the first differenced terms using the Wald test, because the short-term dynamics between the variables are indicated by the coefficients β_j's [48]. In a case where β_j is non-zero and statistically significant, the null hypothesis of non-causality in the short run should be rejected. On the other hand, examination of the coefficient restriction on the EC term can help the researcher determine the long-term causality between the variables. If the difference between ϕ and zero is not statistically significant, the null hypothesis of the non-Granger causality should not be rejected. On the other hand, a long-term Granger causal relationship exists if, and only if, ϕ is negative and statistically significant [49,50].

4. Data and Descriptive Analysis

Over the sample period of 2010 to 2019, the residential housing market of Hong Kong witnessed strong and persistent growth in terms of both price and rent, observing a rising streak for 10 years. Numerous studies have revealed that residential real estate has indeed been the most unaffordable around the globe for years. For instance, Bertaud [51], by constructing a housing affordability ratio using a median multiple, which is defined as the median home price divided by the median annual gross pre-tax household income, reported that Hong Kong ranked first amongst the 309 sample international property markets with the affordability ratio of circa 20. The figure implies that a typical family in Hong Kong would need to take 20 years to buy an average property, even assuming that they save all of their household income for housing over the entirety of the period. In fact, in the context of Hong Kong, the issue of housing unaffordability is intimately linked to insufficient housing supply and rising construction costs, which have frequently been cited as the root causes for the sky-high costs of housing [8].

Figure 1 depicts the average prices per meter square of the three sample housing submarkets over the investigation period. The three submarkets followed broadly similar trends over time, albeit HK (E) exhibited a relatively higher magnitude of volatility. In 2010, the average price/m^2 for the three submarkets were circa HKD 200,000, HKD 100,000 and HKD 48,000, respectively, implying that property values in the submarkets of Kowloon and New Territories were approximately 50% and 24% of that of Hong Kong Island. By the end of 2019, the three markets seemed to have converged in terms of pricing with prices in Kowloon and New Territories equating to circa 78% and 66% of the average price of HK (Class E).

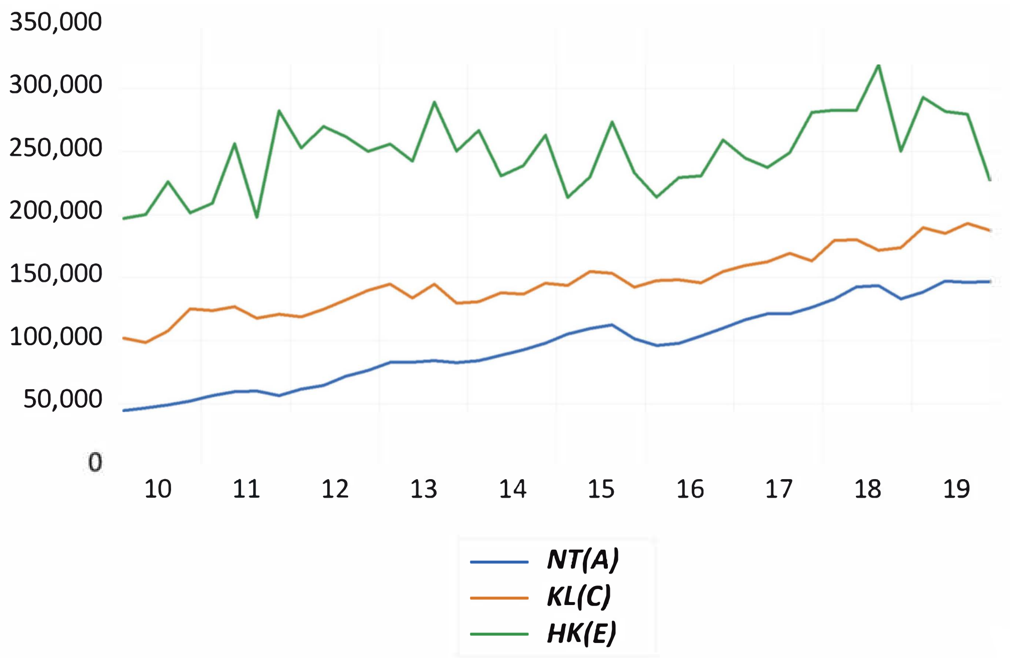

Figure 1. Average price per m^2 of the three sample submarkets.

Figure 2 presents the historical average rental price per m^2 for the three submarkets, which were generally moving in tandem with one another with varying magnitudes of volatility over the sample period. Similar to the findings in Figure 1, properties within NT (Class A) observed the fastest growth in rental price, from circa HKD150/m^2 in 2010 to HKD300/m^2 in 2019, which was equivalent to a one hundred percent increase. The rental market of Hong Kong, on the other hand, appeared to be more sluggish over the same time period. Its average rental price was circa HKD 370/m^2 in 2010 and circa HKD 450/m^2 in 2019, representing a mere 22% increase over a ten-year period, which was equivalent to an annual growth of circa 0.86%.

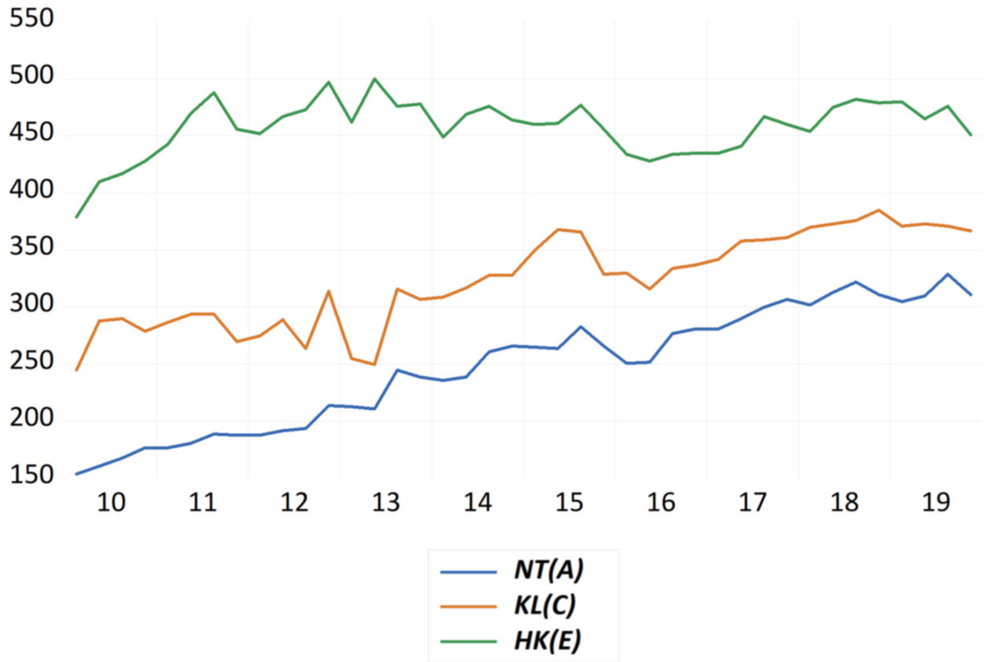

Figure 2. Average rent per m^2 of the three sample submarkets.

We further compared the temporal movements of the PtR ratios of the three districts of Hong Kong (Figure 3). Consistent with findings in other empirical studies in the housing literature [20,21], the prime region of Hong Kong, namely Hong Kong Island, displayed the highest PtR ratios throughout most of the sample period, only with the Kowloon submarket briefly overtaking it during 2012. In terms of magnitude of PtR ratio, HK (Class E), KL (Class C) and NT (Class A) showed a 10-year average value of circa 45.3, 36.7 and 34.1, respectively. It iss particularly noteworthy that the PtR ratios of all the three submarkets exhibited an upward sloping trend over time, implying that the growth of the sales market was more pronounced relative to the rental market, especially in the case of NT (Class A), which showed the steepest slope of PtR against time.

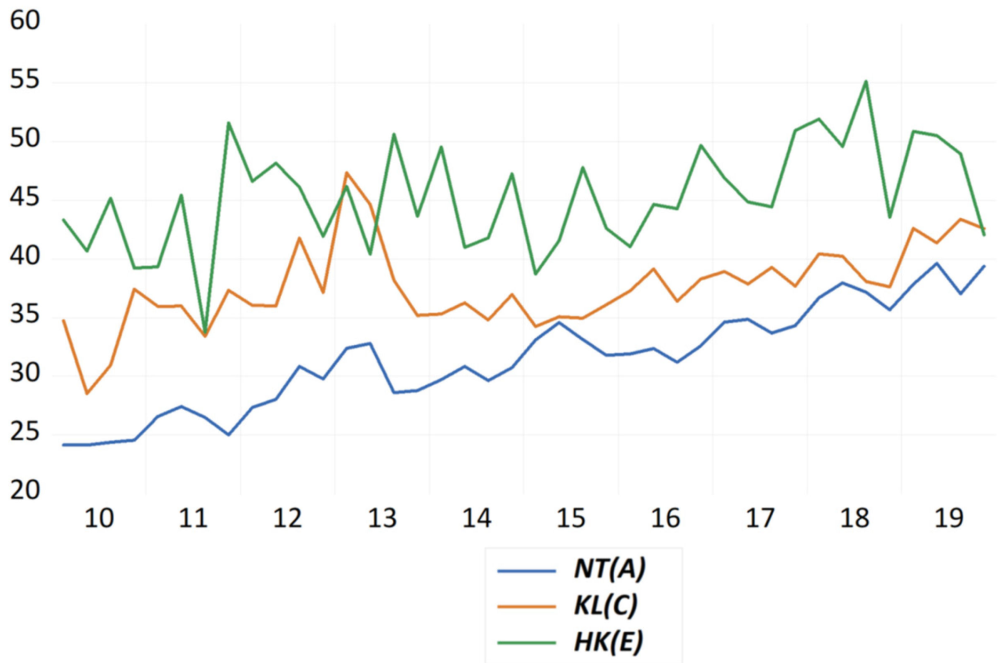

Figure 3. PtR ratios of the three sample submarkets.

If a time series exhibits a temporal trend, whether it is deterministic or stochastic, the researcher should give consideration to incorporating a time trend and an intercept term into the model [52]. Based on our initial graphical analysis, the time series under investigation all displayed a time trend, as well as non-zero means, so we assumed model specifications with a time trend and a constant term to account for their temporal characteristics, accordingly. The main results of the ADF tests are presented in Table 2. Most of the time series were either stationary at level or at the first difference at the 5% significance level, except for the three variables on the occupancy rates, which were stationary at the second difference. Following the methods developed by Granger and Newbold [42], we applied time series differencing methods, based on the stationarity of the variables.

The results of the cointegration tests on the PtR ratio and macroeconomic time series were determined jointly by the trace statistics and eigenvalues using the 5% statistical significance threshold, which are reported in Table 3. It is worth noting that most pairs of the time series examined were cointegrated in the long run. For instance, inflation, RMB/HKD, FDI, occupancy rate and the GDP of the construction sector were cointegrated with all the three PtR time series, suggesting that they were moving largely in tandem with one another over the investigation period. However, the more domestic users-dominated submarket, namely KL (Class C), exhibited less temporal association with the general macroeconomic environment than the other submarkets did in terms of cointegration. Its PtR ratio time series was not cointegrated with HSI, M3 and the inverse of DXY. Furthermore, the DXY variable displayed no cointegration with any of the three PtR ratio time series based on the eigenvalues.

Table 2. Results of ADF Tests.

Variable	Variable	Stationarity *
Price-to-rent ratio of Hong Kong (Class E)	PtR HK(Class E)	At level
Price-to-rent ratio of Kowloon (Class C)	PtR KL(Class C)	At level
Price-to-rent ratio of New Territories (Class A)	PtR NT(Class A)	At level
Year-on-year growth rate of the Hang Seng Index	HSI	At level
Exchange rate of RMB/HKD	RMB/HKD	At first difference
Money supply (M3)	M3	At first difference
Inverse of occupancy rate (Class A)	Occ_A	At second difference
Inverse of occupancy rate (Class C)	Occ_C	At second difference
Inverse of occupancy rate (Class E)	Occ_E	At second difference
Inverse of private completion (Class A)	PC(A)	At first difference
Inverse of private completion (Class C)	PC(C)	At first difference
Inverse of private completion of (Class E)	PC(E)	At first difference
Employment rate	Employment	At level
Growth rate of GDP	GDP	At first difference
Growth rate of GDP (construction sector)	GDP(con)	At level
Inverse of the United States Dollar Index	1/DXY	At first difference
Growth rate of foreign direct investment	FDI	At level

* Determined by the 5% statistical level. Full results are available upon request.

The results of the cointegration tests formed the methodological basis for the subsequent causality analysis. Procedurally, if a given pair of time series are long-term cointegrated at the conventional significance level, the corresponding Granger causality equations should be examined within an ECM analytical framework. Otherwise, an ordinary Vector Autoregressive Regression approach is applied to investigate their short-term lead -lag dynamics. Table 4 portrays the results of the Granger causality tests with the Chi-square statistics and *p*-values presented in parentheses for each pair of time series based upon the 5% statistical significance level. The findings suggested that the PtR ratios of the different housing segments of Hong Kong were, indeed causally correlated with the macroeconomic variables in a disparate manner, particularly in view of the time lags and directionality of their lead-lag relationships.

Table 3. Results of cointegration tests.

	New Territories (Class A)		Kowloon (Class C)		Hong Kong (Class E)	
	None Trace Statistics (Prob) Eigenvalue (Prob)	At most 1 Trace Statistics (Prob) Eigenvalue (Prob)	None Trace Statistics (Prob) Eigenvalue (Prob)	At most 1 Trace Statistics (Prob) Eigenvalue (Prob)	None Trace Statistics (Prob) Eigenvalue (Prob)	At most 1 Trace Statistics (Prob) Eigenvalue (Prob)
Inflation	29.92008 (0.00) *** 0.404416 (0.03) **	11.26440 (0.00) *** 0.268677 (0.00) ***	21.00857 (0.02) ** 0.381169 (0.04) **	5.435599 (0.02) ** 0.140143 (0.00) ***	28.60053 (0.00) *** 0.376509 (0.05) **	0.275329 (0.00) *** 0.275329 (0.00) ***
HSI	26.39682 (0.00) *** 0.351446 (0.05) **	9.942457 (0.00) *** 0.230215 (0.00) ***	23.41383 (0.00) *** 0.309652 (0.15)	9.703139 (0.00) *** 0.230679 (0.00) ***	22.57622 (0.01) ** 0.896948 (0.01) **	9.187921 (0.00) *** 0.214777 (0.00) ***
RMB/HKD	34.39084 (0.00) *** 0.434982 (0.01) **	13.26761 (0.00) *** 0.301335 (0.00) ***	31.21049 (0.00) *** 0.445536 (0.00) ***	9.389629 (0.00) *** 0.224133 (0.00) ***	37.05416 (0.00) *** 0.509602 (0.00) ***	10.69029 (0.00) *** 0.250933 (0.00) ***
FDI	29.64460 (0.00) *** 0.375772 (0.04) **	11.73751 (0.00) *** 0.265732 (0.00) ***	26.73523 (0.00) *** 0.365495 (0.05) **	9.448667 (0.00) *** 0.220146 (0.00) ***	31.77390 (0.00) *** 0.414612 (0.02) **	11.42565 (0.00) *** 0.259682 (0.00) ***
M3	31.92160 (0.00) *** 0.432912 (0.01) **	10.93371 (0.00) *** 0.255845 (0.00) ***	24.99483 (0.00) *** 0.334452 (0.09) *	9.930490 (0.00) *** 0.235392 (0.00) ***	31.58928 (0.00) *** 0.422021 (0.00) ***	11.30524 (0.00) *** 0.263280 (0.00) ***
Inverse Occupancy Rate	34.94922 (0.00) *** 0.440479 (0.00) ***	14.04496 (0.00) *** 0.323036 (0.00) ***	24.67913 (0.00) *** 0.398858 (0.03) **	6.357828 (0.01) ** 0.161890 (0.01)	33.24350 (0.00) *** 0.450552 (0.00) ***	11.68525 (0.00) *** 0.277177 (0.00) ***
Inverse Private Completion	40.09702 (0.00) *** 0.558562 (0.00) ***	9.841444 (0.00) *** 0.233549 (0.00) ***	26.74840 (0.00) *** 0.360628 (0.05) **	10.19944 (0.00) *** 0.240929 (0.00) ***	30.82707 (0.00) *** 0.373196 (0.00) ***	13.54356 (0.00) *** 0.306526 (0.00) ***
Employment	34.69204 (0.00) *** 0.394479 (0.00) ***	15.62876 (0.00) *** 0.337201 (0.00) ***	23.05382 (0.01) ** 0.377806 (0.04) **	9.074025 (0.00) *** 0.212420 (0.00) ***	30.39310 (0.00) *** 0.422962 (0.00) ***	9.498909 (0.00) *** 0.221177 (0.00) ***
GDP growth	32.57362 (0.00) *** 0.440968 (0.00) ***	11.05630 (0.00) *** 0.258306 (0.00) ***	23.41383 (0.00) *** 0.309652 (0.05) **	9.703139 (0.00) *** 0.230679 (0.00) ***	26.61156 (0.00) *** 0.340921 (0.09) *	11.18582 (0.00) *** 0.260898 (0.00) ***
Construction GDP	33.79705 (0.00) *** 10.44770 (0.00) ***	0.459065 (0.00) *** 0.240382 (0.00) ***	31.90949 (0.00) *** 0.488048 (0.00) ***	6.467565 (0.01) ** 0.156503 (0.01) **	24.52292 (0.00) *** 0.326121 (0.00) ***	9.524150 (0.00) *** 0.221694 (0.00) ***
1/DXY	30.91107 (0.00) *** 0.362000 (0.05) *	14.28267 (0.00) *** 0.320242 (0.00) ***	14.00970 (0.18) 0.263742 (0.26)	2.375036 (0.12) 0.060588 (0.12)	26.90460 (0.00) *** 0.330471 (0.10) *	12.06093 (0.00) *** 0.278174 (0.00) ***

Note: *** denotes 1% statistical sig.; ** 5% sig.; * 10% sig. Full results are available upon request.

Table 4. Results of Granger Causality tests.

M′ Econ Attribute (X)	Price-to-Rent Ratio (Y)								
	New Territories (Class A)			Kowloon (Class C)			Hong Kong Class E		
	Short-Term Chi-sq (Prob)	Long-Term t-Statistic (Prob)	R^2; Adj R^2 AIC; SCC DW; F Lag Based on SIC	Short-Term Chi-sq (Prob)	Long -Term t-Statistic (Prob)	R^2& Adj R^2 AIC& SCC DW, F Lag Based on SIC	Short-Term Chi-sq (Prob)	Long-Term t-Statistic (Prob)	R^2& Adj R^2 AIC& SCC DW, F Lag Based on SIC
Inflation									
X→Y	12.84898 (0.0003) ***	−3.370279 (0.0020) ***	0.349016; 0.265018 3.678193; 3.898126 1.971222; 4.155053 Lag = 1	45.54901 (0.0000) ***	−1.036956 (0.3342)	0.906059; 0.637658 4.133872; 5.133025 2.012681; 3.375758 Lag = 9	2.068207 (0.3555)	−0.951909 (0.3493)	0.537577; 0.438486 6.155810; 6.466880 1.965977; 5.425101 Lag = 2
Y→X	5.571361 (0.0617) *	−3.974995 (0.0004) ***	0.421095; 0.346398 1.022895; 1.242828 2.223722; 8.654930 Lag = 2	32.70926 (0.0000) ***	−5.856786 (0.0000) ***	0.740591; 0.657581 0.072435; 0.476472 1.884914; 8.921628 Lag = 3	75.37410 (0.0000) ***	−3.736594 (0.0039) ***	0.943164; 0.840861 −0.726205; 0.169610 2.292317; 9.219242 Lag = 8
HSI growth									
X→Y	0.834930 (0.3609)	−3.716986 (0.0007) ***	0.318116; 0.235463 3.656677; 3.872149 3.733340; 1.985340 Lag = 1	0.069737 (0.9657)		0.339070; 0.258958 5.037590; 5.253062 2.101390; 4.232416 Lag = 2	1.805311 (0.1791)	−3.284278 (0.0024) ***	0.569340; 0.517139 5.904837; 6.120309 2.014147; 10.90666 Lag = 1
Y→X	11.86429 (0.1051)	3.955446 (0.0014) ***	0.753044; 0.470808 −1.569356; −0.782976 2.113016; 1.852770 Lag = 7	1.836159 (0.3993)		0.345841; 0.266549 −1.319012; −1.103540 1.906339; 4.361613 Lag = 2	11.50742 (0.1180)	−2.782564 (0.0139) ***	0.668066; 0.314003 −1.331324; −0.552652 1.962174; 1.886858 Lag = 7
RMB/HKD									
X→Y	0.266543 (0.8752)	−1.186006 (0.2452)	0.236569; 0.078618 3.948641; 4.256548 2.011461; 1.497736 Lag = 2	2.549868 (0.2794)	0.748549 (0.4602)	0.233806; 0.075283 5.156217; 5.464123 1.993393; 1.474905 Lag = 2	8.272876 (0.0160) **	−2.600621 (0.0145) **	0.633017; 0.557089 5.885365; 6.193271 1.926745; 8.337106 Lag = 2
Y→X	8.921204 (0.1781)	1.166080 (0.2597)	0.651902; 0.365234 −3.971920; −3.284856 2.197814; 2.274063 Lag = 6	3.074091 (0.8781)	1.490946 (0.1582)	0.623963; 0.194207 −3.709382; −2.923001 1.926977; 1.451899 Lag = 7	4.461146 (0.7254)	−1.666552 (0.1163)	0.649233; 0.298465 −3.843462; −3.103339 1.914355; 1.850892 Lag = 7

Table 4. *Cont.*

M′ Econ Attribute (X)	**Price-to-Rent Ratio (Y)**								
	New Territories (Class A)			**Kowloon (Class C)**			**Hong Kong Class E**		
	Short-Term Chi-sq (Prob)	**Long-Term *t*-Statistic (Prob)**	R^2; **Adj** R^2 **AIC; SCC** **DW; F** **Lag Based on SIC**	**Short-Term Chi-sq (Prob)**	**Long -Term *t*-Statistic (Prob)**	R^2**& Adj** R^2 **AIC& SCC** **DW, F** **Lag Based on SIC**	**Short-Term Chi-sq (Prob)**	**Long-Term *t*-Statistic (Prob)**	R^2**& Adj** R^2 **AIC& SCC** **DW, F** **Lag Based on SIC**
Net FDI									
X→Y	3.159706 (0.2060)	−2.691584 (0.0115) **	0.352517; 0.223020 3.746480; 4.051248 2.059329; 2.722205 Lag = 2	0.754033 (0.6859)	−0.367704 (0.1021)	0.543172; 0.451806 26.49414; 26.79891 2.171669; 5.945036 Lag = 2	3.421343 (0.1807)	−1.670832 (0.016) **	0.533399; 0.4400796.112603; 6.417371 2.008949; 5.715801 Lag = 2
Y→X	5.751609 (0.0564)*	−2.624781 (0.0135) **	0.537761; 0.445313 26.50592; 26.81068 1.913874; 5.816905 Lag = 2	5.419120 (0.0666)*	−2.246536 (0.0322) **	0.543172; 0.451806 26.49414; 26.79891 2.071669; 5.945036 Lag = 2	9.891422 (0.0071) ***	−3.841640 (0.0006) ***	0.605753; 0.526903 26.34681; 26.65158 2.251507; 7.682401 (lag = 2)
Money Supply									
X→Y	13.15932 (0.0014) ***	−0.340353 (0.0169) ***	0.440015; 0.324156 3.638728; 3.946635 2.191177; 3.797852 Lag = 2	14.37071 (0.0008) ***	−0.061500 (0.5243)	0.489777; 0.384214 4.749630; 5.057536 2.279777; 4.639650 Lag = 2	2.602502 (0.2722)	−2.089794 (0.0455) **	0.545852; 0.451890 6.098472; 6.406379 1.937562; 5.809294 Lag = 2
Y→X	3.301475 (0.1919)	−7466.560 (0.0596)*	0.355298; 0.221911 24.14389; 24.45180 2.286163; 0.034995 Lag = 2	1.400325 (0.4965)	−4560.855 (0.0037) ***	0.443735; 0.328645 23.99635; 24.30426 2.033691; 3.855564 Lag = 2	3.235573 (0.1983)	−2.444011 (0.0208) **	0.378629; 0.250070 24.10703; 24.41494 1.94902; 2.945166 Lag = 2
Inverse Occ Rate									
X→Y	4.384377 (0.1117)	−0.147954 (0.4623)	0.295784; 0.150084 4.175811; 3.975372 2.088885; 2.030088 Lag = 2	0.558838 (0.7562)	0.056518 (0.3383)	0.212583; 0.049669 5.183539; 5.491446 2.155230; 1.304882 Lag = 2	3.913943 (0.1413)	−0.100610 (0.1885)	0.566745; 0.477106 6.051375; 6.359281 2.024501; 6.322524 Lag = 2
Y→X	8.931552 (0.0115) **	−0.000672 (0.0001) ***	0.420744; 0.300898 −10.54786; −10.23995 1.874422; 3.510705 Lag−2	2.157296 (0.3401)	−0.000179 (0.0021) ***	0.259247; 0.002714 −8.808102; −8.500195 2.218582; 3.041535 Lag = 2	4.086783 (0.3944)	−0.000245 (0.0112) ***	0.584037; 0.403184 −6.530739; −6.036916 1.861728; 3.229338 Lag = 4

Table 4. *Cont.*

M′ Econ Attribute (X)	Price-to-Rent Ratio (Y)								
	New Territories (Class A)			Kowloon (Class C)			Hong Kong Class E		
	Short-Term Chi-sq (Prob)	Long-Term *t*-Statistic (Prob)	R^2; Adj R^2 AIC; SCC DW; F Lag Based on SIC	Short-Term Chi-sq (Prob)	Long -Term *t*-Statistic (Prob)	R^2& Adj R^2 AIC& SCC DW, F Lag Based on SIC	Short-Term Chi-sq (Prob)	Long-Term *t*-Statistic (Prob)	R^2& Adj R^2 AIC& SCC DW, F Lag Based on SIC
Inverse Private Completion									
X→Y	66.02619 (0.0000) ***	−5.634173 (0.0206) ***	0.971762; 0.847515 1.926263; 3.020574 2.591764; 7.821231 Lag = 10	41.17458 (0.0000) ***	−3.723983 (0.0051) ***	0.932513; 0.635572 3.945995; 5.040306 2.041293; 3.140399 Lag = 10	3.353094 (0.1870)	−0.191184 (0.2866)	0.530882; 0.433823 6.130903; 6.438809 2.084938; 5.469683 Lag = 2
Y→X	11.78448 (0.0190) **	−0.000136 (0.0204) **	0.645383; 0.491201 −11.48317; −10.98935 1.983447; 4.185865 Lag = 4	14.63815 (0.0233) **	-7.34×10^{-5} (0.0193) **	0.749604; 0.543396 −11.62527; −10.93820 2.039518; 3.635185 Lag = 6	17.20730 (0.0086) ***	0.000472 (0.0143) **	0.761316; 0.564753 −8.381464; −7.694400 2.123426; 3.873138 Lag = 6
Employment									
X→Y	134.3365 (0.0000) ***	−13.09323 (0.0003) ***	0.987658; 0.942403 1.031413; 2.115820 2.092343; 21.82449 Lag = 10	37.34154 (0.0000) ***	−1.401784 (0.0085) ***	0.861521; 0.553791 4.554702; 5.535540 2.096908; 2.799595 Lag = 9	5.203745 (0.3915)	−1.537821 (0.0335) **	0.676367; 0.514550 6.106750; 6.645466 1.874513; 4.179835 Lag = 5
Y→X	10.04993 (0.1226)	0.048155 (0.0196) **	0.746018; 0.548477 −3.511656; −2.831425 1.778268;3.776520 Lag = 6	7.275527 (0.4008)	0.001852 (0.6995)	0.629193; 0.233666 −3.597704; −2.819032 1.895697; 1.590772 Lag = 7	24.31285 (0.0002) ***	0.017169 (0.0041) ***	0.792599; 0.688899 −3.576332; −3.037616 2.259116; 7.643163 Lag = 5
GDP growth									
X→Y	47.63135 (0.0000) ***	−0.917254 (0.0256) **	0.896733; 0.727750 2.876674; 3.764099 2.284482; 5.306659 Lag = 8	5.293330 (0.1515)	−0.131415 (0.0785) *	0.321035; 0.112123 5.180890; 5.580836 2.085980; 1.536698 Lag = 3	14.81995 (0.0051)) ***	−0.196771 (0.0378) **	0.713874; 0.589471 5.924749; 6.418572 2.152625; 5.738408 Lag = 4
Y→X	4.960620 (0.0837)*	−0.625505 (0.0005) ***	0.534472; 0.438155 3.785732; 4.093639 1.826669; 5.549133 Lag = 2	0.843097 (0.8391)	−0.123489 (0.0037) ***	0.465522; 0.301067 3.949200; 4.349147 1.853068; 2.830697 Lag = 3	1.550917 (0.8176)	0.069586 (1.994482) *	0.489406; 0.267408 4.045356; 4.539179 1.997538; 2.204556 Lag = 4

Table 4. *Cont.*

M′ Econ Attribute (X)	Price-to-Rent Ratio (Y)								
	New Territories (Class A)			Kowloon (Class C)			Hong Kong Class E		
	Short-Term Chi-sq (Prob)	Long-Term t-Statistic (Prob)	R^2; Adj R^2 AIC; SCC DW; F Lag Based on SIC	Short-Term Chi-sq (Prob)	Long -Term t-Statistic (Prob)	R^2& Adj R^2 AIC& SCC DW, F Lag Based on SIC	Short-Term Chi-sq (Prob)	Long-Term t-Statistic (Prob)	R^2& Adj R^2 AIC& SCC DW, F Lag Based on SIC
Construction GDP growth									
X→Y	7.175316 (0.0277) **	−0.467433 (0.0360) **	0.338771; 0.206525 3.767486; 4.072254 2.065251; 2.561679 Lag = 2	10.28619 (0.0058) ***	−0.717158 (0.0017) ***	0.397718; 0.277262 4.991019; 5.295787 1.922749; 3.301760 Lag = 2	6.394726 (0.0409) **	−0.569612 (0.0468) **	0.578181; 0.493817 6.011705; 6.316474 1.821232; 6.853426 Lag = 2
Y→X	4.338048 (0.1143)	−0.028138 (0.0117) **	0.540998; 0.449198 −2.253981; −1.949213 1.926378; 5.893209 Lag = 2	4.489548 (0.1060)	−0.015985 (0.0068) ***	0.551540; 0.461848 −2.277215; −1.972447 1.813891; 6.149267 Lag = 2	3.413717 (0.1814)	−0.011705 (0.0093) ***	0.580551; 0.496662 −2.344093; −2.039325 2.108040; 6.920410 Lag = 2
1/DXY									
X→Y	0.037853 (0.8457)		0.398601; 0.323427 3.564536; 3.782228 1.901349; 5.302326 Lag = 1	0.688677 (0.7087)		0.278157; 0.187926 5.024579; 5.242271 1.832261; 3.082735 Lag = 2	3.698752 (0.1573)		0.546266; 0.452390 6.097560; 6.405466 1.954836; 5.819008 Lag = 2
Y→X	0.057825 (0.9715)		0.492472; 0.387466 −12.50037; −12.19246 1.969582; 4.689948 Lag = 2	1.774415 (0.4118)		0.056433; 0.041513 −12.69683;−12.47913 2.068160; 0.478462 Lag = 2	6.629089 (0.0364) **		0.494825; 0.390306 −12.50502; −12.19711 1.742864; 4.734302 Lag = 2

Notes: *** denotes 1% statistical significance; ** 5% statistical significance; * 10% statistical significance. Full results are available upon request.

First of all, inflation Granger-caused the PtR ratio of NT (Class A) but not those of the other two submarkets in the long run, whereas all the three PtR ratios were drivers of the city's long-term inflation with varying lengths of time-lag, from two quarters to eight quarters. Second, the HSI did not display any short-term causality with any of the PtRs in either direction. Nonetheless, in the long run, it was Granger-caused by HK (Class E) and Granger-caused NT (Class A).

Third, the findings on the four liquidity variables, namely RMB/HKD, 1/DXY, FDI and M3, indicated both the idiosyncratic nature of a given submarket as well as similarities between the submarkets, in terms of pricing. RMB/HKD seemed to be the driver of the most luxurious segment of the market, i.e., HK (Class E) but not of the others from a long-term pricing perspective. Net FDI and M3 Granger-caused HK (Class E) and NT (Class A) but not KL (Class C), which was a submarket dominated mainly by end-users. On the other hand, the PtR ratios of all the three submarkets seemed to be a catalyst for more investments from overseas and more money supply, as suggested by the Granger causal links running from PtR ratio to the two macroeconomic variables with a time lag of two quarters. It is further noteworthy that the United States Dollar index displayed no significant long-term causal relationship with the three PtR ratio time series.

In terms of the supply-side attributes, it is interesting to observe that only uni-directional causal relationships existed between the PtR ratio and the occupancy rate. In particular, the findings suggested that the higher the PtR ratio, the lower the occupancy rate in the long run. This could be an alarming indication of housing unaffordability problems that have persisted within the city of Hong Kong over a long period of time. On the other hand, we could observe bi-directional Granger causations between the PtR ratios and the private housing completion variables across the submarkets of NT (Class A) and KL (Class C) over both the short- and long-term time horizons, but, surprisingly, not for HK (Class E).

Consistent with the findings in the existing housing literature, it was evident in our causality analysis that the real estate market of Hong Kong is very much tied to its general economic performance. Long-term bi-directional causal relationships were observed between the PtR ratios of the three submarkets and the time series on GDP and GDP (Construction) (except for the causation from HK (Class E) to PtR), whilst short-term causation was less statistically apparent. In relation to the labour market, there seemed to be an observable trend that Employment Granger-caused the PtR ratios for the three submarkets, but not the other way around in the long run, indicating that the labour market has historically tended to be a leading indicator for the residential real estate market in terms of price discovery.

5. Discussion of Results

The empirical results stemming from the cointegration and causality tests offer some interesting and noteworthy insights into the causal dynamics between the price determination process of the residential real estate in Hong Kong and the underlying fundamentals of various macroeconomic segments of the city, including its construction industry, financial sector, labour market and the foreign exchange market. First and foremost, as suggested by the results of the Granger Causality tests, inflation seemed to be a driver of the PtR ratios of the two most affordable housing segments in our sample, namely NT (Class A) and KL (Class C), but not HK (Class E). Relative to rent, house price seemed to increase at a faster pace over time with respect to the general price level of goods and services for the housing segments that comprised mostly middle- and working-class population. On the other hand, a reverse causation was noticeable for all the three submarkets, confirming that there was a feedback loop that reinforced general inflation by the property market. Such an empirical finding was indeed in agreement with the reality of Hong Kong, where expenditures on housing generally take up a significant percentage of an average household's disposable income.

Secondly, we observed wealth spill over from the stock market to the real estate market in the long run, particularly within NT (Class A) and HK (Class E), a finding which is also well-acknowledged in the literature [12,31]. Specifically, HSI was found to Granger-cause NT (Class A) and HK (Class E), but not KL (Class C). We argue that this could be attributable to the fact that Class A properties in the New Territories offer the lowest investment threshold in terms of capital requirements, whilst Class E properties on Hong Kong Island have been historically appealing from the viewpoint of long-term capital appreciation, making them the two most attractive investment options for property investors. It is of further empirical significance that a reverse Granger causation, running from HK (Class E) to HSI, was evident in the long run, highlighting the role that large institutional funds and cash-rich individual investors played in the city's wealth creation.

Thirdly, exploration of the causal interaction between the four liquidity-related macroeconomic attributes and the PtR ratios revealed that the Hong Kong residential market is highly compartmentalised by submarket in terms of pricing behaviour. For instance, the exchange rate of RMB/HKD only exerted causal influence on the submarket of HK (Class E), seemingly suggesting that investors from mainland China are more inclined to invest in the most expensive segment of the Hong Kong real estate market. On the other hand, net FDI and money supply displayed highly similar characteristics in terms of their causal relationships with the PtR ratio. In a Granger sense, the two macroeconomic factors were long-term determinants of the PtR ratios of the submarkets of NT (Class A) and HK (Class E) with lag length of two quarters, based on the Schwarz Information Criterion. The abovementioned arguments of capital requirements for investors and capital appreciation seemed to be relevant and applicable in explaining the existence of the causal relationships found in NT (Class A) and HK (Class E), which were persistently driven by the inflows of foreign capital and further cemented by an enlarged monetary base in a low-interest market environment during the investigation period. Indeed, the two liquidity variables were also lagging indicators with an optimal lag length of two quarters for all the three housing submarkets, as evidenced in the results of the long-term Granger causality tests. Surprisingly, DXY did not seem to be causally associated with the three PtR ratios in the long run. We argue that this could be due to the composition of DXY, with 57.6% of its weighting given to the Euro, 13.6% to the Japanese Yen, 9.1% to the Canadian dollar and 4.2% to the Swedish Krona, whilst the main international investors in the Hong Kong real estate market are mainly individuals and firms from the United States who do not benefit from a potential weakening of the Dollar Index, given the linked exchange rate system that pegs HKD against USD at a fixed rate.

Another important revelation of the cointegration and causality analysis was that a unidirectional causal link emanating from the PtR ratio to the inverse of occupancy rate was detected across the three housing submarkets, but not vice versa. In other words, when property prices increased at a more rapid pace relative to the movement of rent, a propensity for a reduction in occupancy rates became more likely. This, perhaps, could be of great economic and social concern for policy makers, as it might signal strong statistical evidence of housing unaffordability across all housing market segments during periods of property price appreciation. On the other hand, it was statistically discernible that the PtR ratio and the inverse of private housing completion were causally linked in a bi-directional fashion within the two owner-occupier-dominated submarkets, suggesting that the two variables were both lagging and leading indicators for one another. On closer examination, private completion led the PtR ratio by ten quarters, which indeed reflected the time intensive and informationally inefficient nature of real estate development in Hong Kong [50].

The cointegration analysis further uncovered that GDP and GDP (Construction) were highly cointegrated with the PtR ratio time series at the submarket level, confirming a consistent linkage between the residential property sector and the general productivity of other sectors within the economy. In addition, the results on the lead-lag relationships between the time series pointed towards the interdependence of the housing market and the general economy. More specifically, bi-directional Granger causations were observed across all submarkets, albeit slightly less statistically significantly for the submarkets of HK (Class E) and KL (Class C). The finding reinforces the popularly accepted notion that the economy of Hong Kong is greatly reliant upon the development of the housing market, which, in turn, hinges on the overall prosperity and productivity of the city.

Lastly, the employment time series was strongly cointegrated with the PtR ratios over time. Results emanating from the ECM further indicated that a unidirectional Granger causal relationship ran from the labour market to the PtR ratios, and could be found across all the three submarkets at the 5% confidence level, suggesting a possible wealth transfer effect from the labour market to the housing market. Upon further scrutiny, the time lags between the two markets ranged from five quarters in HK (Class E), to nine and ten quarters in KL (Class C) and NT (Class A), respectively.

6. Conclusions

This study attempts to enrich the understanding of the linkages between the PtR ratio and a spectrum of macroeconomic attributes using property and macroeconomic data of Hong Kong. The underpinning dynamics of property prices and rents are found to be useful prognosticators for understanding the property market and submarkets in general, and whether their pricing structures are temporally associated with the demand and supply-side macroeconomic fundamentals. This helps assess whether an asset pricing bubble may be forming, which has significant practical implications for addressing societal issues, such as housing market affordability and provision of public housing. Accordingly, we examined the temporal interactions between the PtR ratio and a number of macroeconomic determinants within the Hong Kong market and further explored and dissected these economic relationships by housing segment of different quality tiers using cointegration and causality techniques.

Broadly consistent with recent empirical research studies [9,26], the findings arising from this investigation provide important theoretical and market insights into the distinct short-run and long-run dynamics between macroeconomic factors and the pricing structures across the various property market segments. Importantly, the results highlighted market compartmentalisation issues, and, more precisely and appositely, were in agreement with the well-stablished submarket hypotheses in the literature with each sample housing submarket governed by both common and unique macroeconomic forces at play within the wider housing market and the economic environment. For example, our analysis demonstrates that the submarkets that are more accessible in terms of capital constraints are more causally correlated with market liquidity related determinants, such as net inflow of foreign direct investment, whereas market segments with a significant portion of housing demand, originating from mainland China, are observed to be more sensitive to the fluctuation of RMB/HKD.

From the standpoint of public finance, it would be in the interest of policy makers and other stakeholders to be more aware and conscious of how housing submarkets of different tiers and quality within the real estate sector should be understood vis-à-vis different fundamental aspects of the wider economy. That should facilitate the undertaking of mass property valuation and formulation of real estate related taxation policies for the purposes of funding public infrastructure, urban development projects and other social programmes and schemes. The PtR ratio can indeed also be employed as a measure for establishing the effects of macroprudential policy changes to mitigate overheating of the housing market and correcting for irrationality arising from speculative pricing behaviours. In terms of property appraisal practice, traditional valuation methods, such as replacement cost and investment approaches could perhaps utilise the PtR ratio and take into consideration its dynamics with other macroeconomic indicators to inform the undertaking of valuations, as they are not designed to identify or account for speculative market practices within the housing market environment. The findings of the study could also provide an empirical basis for enhanced conceptualization of the housing market of Hong Kong, in terms of informational efficiency and arbitrage strategies for property traders, by comparing the PtR ratios of different property submarkets temporally and cross-sectionally.

Whilst the study establishes significant causal relationships between the PtR ratio and its macroeconomic determinants, and presents empirical results that throw new light on issues such as housing affordability and price discovery of real estate, future research efforts could be directed at investigating micro-level dynamics within a given housing market with respect to macroeconomic shocks, using geo-coded and more granular economic data. Despite the research revealing that submarket-level characteristics play a significant role in shaping the overall pricing landscape of the market, the sample submarkets are defined solely on the basis of unit house price and an administratively imposed district boundary, which does not explicitly account for other important neighbourhood-specific attributes, such as accessibility and socioeconomic profiles of residents, that should also affect the pricing structure of the market in a more spatially distinct manner through, for example, spatial clustering and segregation. Further, the findings of the study should also be interpreted in conjunction with the methodology by which RVD compiles the transaction and rental price data. The RVD data are based on average prices and rents within one quarter, with the intra-quarter averaging effect prone to "smooth" the time series, resulting in mis-estimation of the serial correlations. In addition, the transaction and rental prices may not reflect the true underlying market values, especially in the context of Hong Kong, where rent concessions are common during periods of market recession. Lastly, in view of the research sample, the results of the study should be caveated and interpreted with caution since the investigation period was relatively short and characterised by a largely stable macroeconomic environment. Our results, therefore, may not be applicable to other economic and historical contexts, where the performance of the subject housing market is more volatile and influenced by more unpredictable exogenous factors, such as the global economic shocks during the Global Financial Crisis in 2007.

Author Contributions: Conceptualization, D.L.; methodology, D.L.; software, D.L.; validation, D.L., Y.Y., M.M. and M.H.; formal analysis, D.L.; investigation, D.L., Y.Y., M.M. and M.H.; resources, D.L.; data curation, D.L.; writing—original draft preparation, D.L.; writing—review and editing, Y.Y., M.M. and M.H.; visualization, D.L.; supervision, D.L.; project administration, D.L.; funding acquisition, Y.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: No applicable.

Data Availability Statement: The data and information utilized in this research are publicly available on the websites the Rating and Valuation Department and Census and Statistics Department of the Hong Kong Government.

Conflicts of Interest: The authors declare no conflict of interest.

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