Spatial Structure Behind The Ripple Effect: The Case Of Hong Kong

Kwok-Chiu Lam, Shanghai University of Finance and Economics, Shanghai, China

ABSTRACT

This paper aims to study the spatial structure of Hong Kong residential market using census data with the urban model, and examine more critically the ripple effect found by Lam (2015). Empirically, those irregularities observed can be explained rather satisfactorily following the lines of reasoning by Brueckner (2011). As for the aforesaid ripples, we demonstrate that the drift pattern no longer exists after introducing a structural breakpoint in End-2008. Instead, we contend that irrespective of house sizes, all price changes tend to originate from the New Territories. And we propose two theoretical explanations for it: internal migration and spatial coefficient heterogeneity.

Keywords: Spatial Structure; Urban Model; Ripple Effect; Hong Kong

1. INTRODUCTION

The property market of Hong Kong as a Special Administrative Region of China is a hot research topic. It catches wide global press attention not only for the territory's high population density (Demographia, 2016a), but also for its severely unaffordable housing prices (Demographia, 2016b). Segregating its private residential market into segments pertaining to geographical area and class/size, Lam (2015) examines the intraclass ripple effects and contends that the origin of price change shifts in the southerly direction along the area continuum as the house size increases. Yet no convincing explanations have been put forth. In order to do so, prior understanding of the spatial pattern of Hong Kong is required. This study is to fulfil two purposes: (i) sheds new insights into the spatial structure of Hong Kong, and (ii) serves as a supplement to Lam (2015) with more elaboration of the aforesaid ripple effect. The rest of the paper is structured as follows: Section 2 introduces the theoretical groundwork of the monocentric urban model. Section 3 describes the data sources and methodology. Section 4 presents our empirical findings. Section 5 proposes some refinements to the urban model. Lastly, concluding remarks and limitations confronted in our study are laid out in section 6.

2. THEORETICAL GROUNDWORK OF THE URBAN MODEL

Maybe the spatial structure of a city cannot be better described without resorting to the monocentric urban model. The whole Hong Kong private residential market would be divided into segments for examination according to two dimensions: location and size. Our lines of thought behind this approach is not new. On the contrary, the model has been set forth decades ago. In its simplest form, the model postulates that business of all kinds can only be carried out in the central part (thus called the "central business district" or CBD) of a city. Under such circumstances, all factors of production and final products have to be transported to the CBD for its full functioning. It can readily be understood that higher transportation costs would be incurred as the location gets farther away from the CBD. Early in 1903, Richard M. Hurd has emphasized in his book *Principles of City Land Values* that urban land value depends on the distance toward the city center.[1]

As for residential location, Alonso (1964) pointed out that solely focusing on distance would remarkably raise the population density around the CBD, as residents could simply cut the sizes of their houses in an effort to minimize commuting costs in the form of reduced house price or rent. Thus, considering another dimension (that is, size)

[1] The original sentence runs as: "Since value depends on economic rent, and rent on location, and location on convenience, and convenience on nearness, we may eliminate the intermediate steps and say that value depends on nearness," cited by Alonso (1964), p.6.

becomes necessary so as to make the model more adaptive. Using utility theory in microeconomics, he proposes that households makes their dwelling decisions based on location and size of the houses, subject to income budget constraints. The underlying idea is simple: other things equal, more distant houses are cheaper; the increases in commuting costs have to be "compensated" by larger sizes in effect that the occupants achieve the same utility level.

In a modern city, the concerns of households are usually not so simple. The demand side is normally characterized by heterogeneity and subtle segmentation, which are in turn determined by the socio-demographic characteristics of the community and a myriad of salient housing features shaping the preferences of homebuyers. Demographic factors like the ages of household members and life course events including childbirth, marital and employment status definitely come into play (Rabe and Taylor, 2010). The study results on European countries from Aassve, et al. (2013) confirm that, the age norms (deadlines) perceived suitable to leaving parental home vary with ages, educational levels, gender and most markedly, across countries. In Hong Kong, at least we learn that newly married young couples tend to reject co-residence with parents and prefer buying their own houses (Li, 2015). Still, it is likely for them to make their purchases in the neighborhood of parents to maintain close family ties. Young parents, on the other hand, might be more concerned with the physical attributes of dwelling, such as house size, number of rooms and presence of balcony, as well as environmental factors like the type of neighborhood and amenities (Anderson and West, 2006; Rabe and Taylor, 2010). It is a common belief that we like living with neighbors with similar characteristics. More specifically, racial composition in the surroundings may be a particular concern for locating a home (Kiel and Zabel, 2008). In fact, the distaste for income inequality in neighborhood is found to rise with income and fall with age and education level (Leung and Tsang, 2012). Li, et al. (2016) find that the air and noise pollutions in Hong Kong exert profound negative impacts upon the property value, particularly of those on lower floors. Some perceived environmental values are not directly measurable as such, but aesthetic or spiritual in nature.[2] The view that amenities like better schools are valued by parents can be exemplified by a broad range of studies such as Fack and Grenet (2010) and Ferrari and Green (2013), noting that house prices are related negatively to travel distance to school but positively to school performance. Generally speaking, open space in the nearby neighborhood is found to have favorable influence on house prices (Anderson and West, 2006).[3] Working groups might regard accessibility to workplaces or proximity to railway stations as very critical factors with a view to avoiding the nuisance of commuting (Choy, et al., 2007).[4] That said, people in search for scenery and tranquility possibly prefer to reside in the suburbs. All these have highlighted the notion of spatial submarkets with regard to their non-reproducible characteristics. It is not our focus of this paper to disentangle the relative significance of all these features.[5] Out of the endless list of attributes, we pick up two most crucial ones – *location* and *size* – as the bases to partition the residential market for further investigation, mainly due to availability of reliable data.[6]

3. DATA AND METHODOLOGY

The land area of the Hong Kong territory is around 1,105.7 square kilometers (km^2), as at End-2015. Spatially, the territory can be broken down (pointing northwards) into three areas: Hong Kong Island (HK), Kowloon (KWN) and the New Territories (NT). They approximately account for 7.3 percent, 4.24 percent and 88.46 percent of the total land area, respectively. Each of them is further subdivided into different (District Council) districts, with 18 districts in total. To save more space, a map is not inserted here. Interested readers may refer to the one ("GeoInfo Map" www2.map.gov.hk) drawn by Lands Department for the spatial delineation of all the constituent districts. Table 1 lists out the corresponding districts under each area. With respect to size, we would follow the usual practice by the Rating

[2] As an example, some homebuyers are willing to pay premium on houses with good feng shui or located on "lucky number" floor. See Choy, et al. (2007) and Li, et al. (2016). For similar reasons, some might dislike the vicinity of funeral parlor.
[3] More accurately, the value of open space hinges upon the dwelling's location and neighborhood characteristics, dropping with the distance to the CBD and rising with the number of young children, population density, average household income, crime rates in the zone.
[4] Railways are commonly favored by many Hongkongers because of punctuality and reliability. Railways here refer to Mass Transit Railway (Local line, East Rail line, Ma On Shan Rail line and West Rail line). According to Census and Statistics Department 2011 Population Census results, 34.4% of the working population rely on railways as their main mode of transport to place of work, compared to 32.4% on bus.
[5] Overview of the most common housing attributes can be found in Boumeester (2011, Table 2.1) and Li, et al. (2016, Table 7.1).
[6] A more pertinent study conducted by Kiel and Zabel (2008) on the issue of location, has underscored its importance using the 3L approach to find out that prices are jointly determined by the area, town and street where the dwelling is located. Likewise, subtler segments could be made in Hong Kong according to the area, district and street where the flat is located. But due to unavailability of reliable data sets, we would mainly focus on the broadest level with respect to location (i.e., *area*).

and Valuation Department (RVD), in that all private residential units are categorized according to the unit's saleable area into: Class A – less than 40 m^2 (A), Class B – between 40 m^2 and 69.9 m^2 (B), Class C – between 70 m^2 and 99.9 m^2 (C), Class D – between 100 m^2 and 159.9 m^2 (D), and Class E – 160 m^2 or above (E). Hence, there are 15 segments altogether.

To investigate into the spatial pattern of Hong Kong residential market, we would mainly look at whether the regularities as specified by Brueckner (2011) can be observed. In the process, various demographic phenomena will be analyzed. All census data are deemed to be sourced from the Census and Statistics Department (CSD), unless otherwise stated. Notwithstanding our efforts to assemble as much data as we can, demographic data are relatively sparse and only compiled every (five) year(s) in Hong Kong. Better data can only be found starting from the 1980s or even 1990s. The approach we adopt here tends to be descriptive in nature. To further investigate the ripple spatial pattern unearthed by Lam (2015), we would employ the same data pool and denotations as his. To detect for structural change, we first regress territorywide real rental return (DLRRI_ALL) on real price return (DLRPI_ALL) using ordinary least squares equation and then perform "sequential l+1 breaks vs. l" and "global l breaks vs. none" multiple breakpoint testing methods over his sample period (1995M1 – 2014M12). Next, we would also deploy the same methodology, Granger-causality test with lag length p determined by Schwarz Bayesian information criterion (SIC) under a trivariate vector autoregressive model (VAR) at 10% significance level, to identify ripples in another sample period (1999M1 – 2014M12).[7]

Table 1. Component districts of each area under Hong Kong territory

Area	District	Abbreviation
Hong Kong Islands (HK)	Central and Western	CW
	Wan Chai	WC
	Eastern	EA
	Southern	SO
Kowloon (KWN)	Yau Tsim Mong	YTM
	Sham Shui Po	SSP
	Kowloon City	KC
	Wong Tai Sin	WTS
	Kwun Tong	KTO
New Territories (NT)	Kwai Tsing	KTS
	Tsuen Wan	TW
	Tuen Mun	TM
	Yuen Long	YL
	North	NO
	Tai Po	TP
	Sha Tin	ST
	Sai Kung	SK
	Islands	IS

4. EMPIRICAL RESULTS

4.1 Spatial Structure

To portray the spatial pattern behind Hong Kong using the monocentric urban model, we initially posit that the central area is KWN and its CBD is situated at YTM. This is mainly because KWN occupies more amount (in m^2) of private commercial (premises) in Hong Kong, relative to HK and NT (Panel A, Appendix 1). At the same time, YTM's slice is exceptionally largest (47 percent) within that of KWN. Under such hypothesis, we herein discuss in the following several typical regularities as suggested by Brueckner (2011). As we will note, most of the irregularities observed, if any, can be explained more compellingly with refinements to the urban model.

[7] We leave out the step of Johansen cointegration testing, which runs beyond the scope of this paper.

4.1.1 Job Concentration

One manifestation of a typical CBD in a big city is high job concentration in the center due to agglomeration and scale economies. If the urban model is valid, the "places of work" should be more concentrated in KWN. Nonetheless, in Table 2, we see that the scenario of Hong Kong has called into question the accuracy of prediction from the model. Indeed, that feature is only more notable in 1996 in terms of percentage of our working population (excluding those who have no fixed work places or work on marine or outside Hong Kong).[8] Yet as time goes by, the picture becomes more obscure and jobs opportunities appear to be more equally distributed amongst the three areas, even though KWN still supplies much more private commercial space than HK and NT.

Table 2. Working population by place of work: 1996 – 2011

	1996		2001		2006		2011	
Area	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
HK	910,777	32.05	929,574	31.31	938,047	30.88	989,763	31.14
KWN	1,043,844	36.74	1,033,855	34.82	1,055,449	34.74	1,099,452	34.59
NT	886,880	31.21	1,005,782	33.87	1,044,554	34.38	1,089,464	34.27
Overall	2,841,501	100.00	2,969,211	100.00	3,038,050	100.00	3,178,679	100.00

4.1.2 Residential Building Heights and Population Density

Presumably, as the location gets more outward from the CBD, (i) heights of residential buildings decrease and dwelling sizes increase and (ii) population density drops consequently. There are vast literatures on (ii), developing econometric models with increasing level of sophistication. Perhaps one of the earliest and most influential papers on the issue came from Colin Chark's *Urban Population Densities* in 1951, recited in McDonald (1989), specifying that there existed a negative exponential function between gross population density and the distance to the CBD.[9] While it is empirically infeasible to verify (i),[10] it is easier to work on (ii) with census data. Population densities (number of persons per km^2) of districts per area (1981 – 2011) are provided in Table 3.[11] Apparently, KWN is much denser than HK, which is also much denser than NT, over the past three decades. A closer look at the district numbers reveals the same spatial tendency, especially in the 1980s. There is no doubt that the density of YTM is the highest being the CBD. Moving out into the boundaries in all directions, for example, YTM → SSP → ST → TW → YL → NO (northwards) or YTM → CW → SO (southwards), density decreases consistently. So the spatial population density has indeed behaved as predicted by the model.

Table 3. Population density by district per area (1981 – 2011)

Abbrev.	1981	1986	1991	1996	2001	2006	2011
HK							
CW	23 448	20 854	20 479	20 755	21 137	20 102	20 057
WC	23 781	20 182	18 209	17 235	16 986	15 788	15 477
EA	27 150	27 387	30 316	31 735	33 147	31 664	31 686
SO	5 833	6 380	6 701	7 505	7 482	7 083	7 173
KWN							
YTM	91 358	74 866	58 482	38 320	40 932	40 136	44 045
SSP	63 190	56 875	48 822	38 237	37 772	39 095	40 690
KC	54 207	47 156	41 759	38 553	38 059	36 178	37 660
WTS	53 947	46 940	41 331	42 331	47 810	45 540	45 181

(Table 3 continued on next page)

[8] Of course, it is possible for a district to have big employment concentration in a particular industry. For instance, we might envision that jobs in the field of financing and insurance tend to be more concentrated in CW and WC of HK, where the headquarters are usually located. But concrete data of such kind seem unavailable officially. See also subsection 5.4.
[9] Gross density refers to population per unit of total land; net density refers to that of residential land specifically (p. 364). Hong Kong data compiled by CSD belong to the former category.
[10] Reference to Brueckner (2011; Chapter 3) can be sought for theoretical explanation on irregular building height pattern in a city. The fact is that, the contracting household size in Hong Kong has spurred the demand for smaller-sized units (Lam, 2016). More new dwellings are likely to be built in the new towns in suburbs, giving the illusion that house sizes *decrease* as distance from CBD rises.
[11] In 1981, KTS and TW were combined and treated as one of the 8 districts of NT.

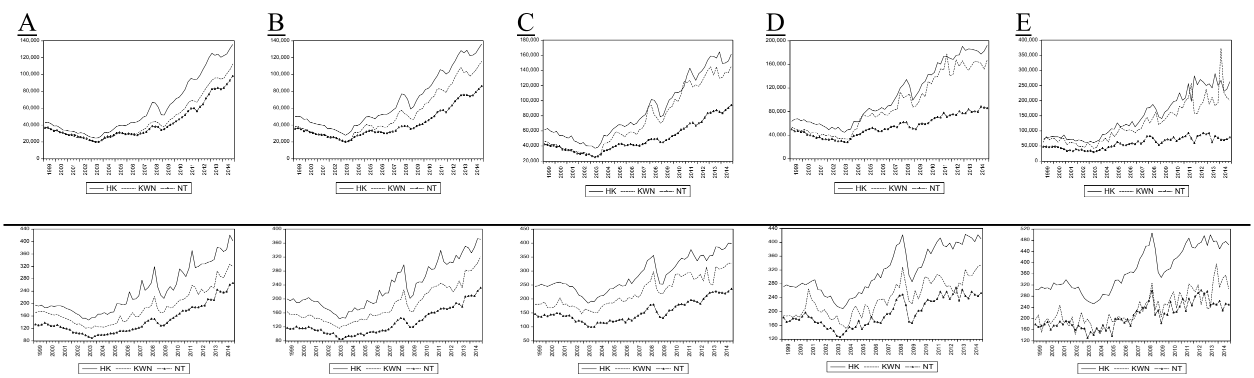
(Table 3 continued)

Abbrev.	1981	1986	1991	1996	2001	2006	2011
KTO	55 260	60 826	52 562	53 081	49 861	52 123	55 204
NT							
KTS	7 970	21 464	21 158	21 793	21 578	22 421	21 901
TW		4 159	4 581	4 502	4 566	4 679	4 918
TM	1 529	3 611	4 711	5 663	5 919	6 057	5 882
YL	1 397	1 545	1 664	2 465	3 242	3 858	4 178
NO	844	1 074	1 211	1 689	2 184	2 055	2 228
TP	551	1 033	1 496	2 103	2 287	2 156	2 181
ST	1 797	5 402	7 378	8 468	9 157	8 842	9 173
SK	339	365	1 026	1 542	2 535	3 135	3 368
IS	283	290	293	364	498	783	807
OVERALL	4 879	5 225	5 385	5 796	6 237	6 352	6 544

4.1.3 House Price and Rent

Another regularity implied from the simple urban model is that average purchase price or rental (in HKD) per m^2 would fall moving away from the central zone, serving as compensation for the nuisance of commuting.[12] To see whether such relationship really exists in Hong Kong, we collect *quarterly* data (1999Q1 – 2014Q4) from RVD — (i) average house prices and (ii) average monthly rents — for each class per m^2 per area.[13] The former (upper row) and the latter (lower row) have been plotted in Figure 1 for the ease of interarea comparison under different classes. It exhibits rather surprisingly (in particular, during the past 15 years) that the average price and rent of HK are always higher than that of KWN, which are in turn higher than that of NT. In other words, our diagrammatic analyses results have somehow belied the corollary of the urban model. Simply stated, as we move afar in the northerly direction into the suburbs (KWN → NT), house price and rentals indeed drop. Whereas, price and rentals *rise* unexpectedly moving southwards (KWN → HK).

Figure 1. Average price and monthly rent per m^2 of all segments



4.2 Ripple Effects

Due to suspicion that structural break in the residential market might occur over the sample period (1995M1 – 2014M12)[14], we run the aforementioned two ingenious breakpoint tests using EViews 8.1. Under both methods, default settings (maximum breaks = 5; trimming percentage = 15; significance level = 0.05) are kept and

[12] Brueckner (2011; p.29) has used the term "compensating differential" to explain the concept that lower price per square foot is necessary in order to elicit people's relocation into a disadvantageous/distant place.
[13] In accordance with the interpretation of RVD, average prices are based on an analysis of transactions scrutinized by the Department for stamp duty purposes. Average rents are based on an analysis of rental information (exclusive of rates and management charges) recorded for fresh lettings effective in the month being analyzed.
[14] In Figure 1 (Lam, 2015; p.24), we suspect that there is a structural break around End-2008 after which RPI sizeably outpaces RRI.

heterogeneous error distributions are allowed across breaks. As shown in Appendix 2 and 3, the outcomes signify rather unanimously that within the period, there is *one* determined break and the break date is estimated to be 2008M12.[15] Hence, the output has reinforced our belief of a structural break in End-2008. Coincidentally, this was exactly the time when US Fed first launched its quantitative easing stimulatory monetary policy during the global financial crisis, in effect boosting asset prices with falling interest rates (Williams, 2011; Joyce, et al., 2012). We therefore disaggregate the original sample period into two subsets: 1999M1 – 2008M11, and 2008M12 – 2014M12 wherein the Granger-causality tests are carried out accordingly. Associated diagnostic statistics have been tabulated in Appendix 4 and 5, respectively.

Unfortunately, the prior ripple effect documented by Lam (2015) has vanished during 1999M1 – 2008M11. Only one ripple is recognized in C, which is, KWN → HK → NT. Spanning 2008M12 – 2014M12, more discernible patterns are manifested: A (NT → KWN → HK); B (NT → HK and KWN); C (NT → KWN) and D (NT → HK). Our findings hereby indicate that irrespective of the class, all price changes actually originate from NT, with no shift at all. Possible reasons behind are deferred until Section 6. Hitherto all study results concerned can be summarized in Table 4 below.

Table 4. Exhibition summary of intraclass ripple effects

	A	B	C	D	Source
Whole sample period (1999M1–2014M12)	NT→KWN↔HK	NT↔KWN→HK	HK→NT→KWN	KWN & NT→HK	Lam (2015)
1999M1–2008M11	ND	ND	KWN→HK→NT	KWN & NT→HK	Appendix 4
2008M12–2014M12	NT→KWN→HK	NT→HK & KWN	NT→KWN	NT→HK	Appendix 5

ND: no discernible pattern

5. REFINEMENTS TO URBAN MODEL

The notion of irregularities above causes no surprise, because the monocentric urban model in the present setting is clearly an over-simplification of Hong Kong. One reason we suggest for HK consistently high price and rent is that competition for land use in HK is more intense than in KWN and NT. We attempt to look for some other elucidations with the modifications laid down by Brueckner (2011), which have to take into account of unequal spatial income and time cost, internal migration, and scattered employment locations.

5.1 Competitive Land Use

Although the land area of HK is 70 percent larger than that of KWN, after excluding country parks in HK, the difference between the two becomes very modest.[16] Relative to KWN, land in HK is more desperately in demand, not only for residential but also for office commercial purposes. Probably some light has been shed with our finding that (as at March 2016) out of the 50 constituent stocks of the Hang Seng Index, the principal business offices (within Hong Kong territory) of more than 40 are located in HK (almost exclusively in CW and WC along the coastal front of the Victoria Harbor). The truth is that, referring back to Panel B, Appendix 1, HK is the main source of private offices (of all grades) in the territory, accounting for more than half of the total supply.[17] Therefore, it is more likely for larger proportion of land in HK to be reserved for (high-grade) office construction. The rationale is clear: land use is often determined by the highest bidder. This explains more plausibly why dwellings in HK often command the highest price and rents spatially.

5.2 Spatial Income and Time Cost

At the outset, one of the crucial implicit postulations underlying the simple urban model is that all households earn identical income. This occurs only very rarely. CSD has disseminated household median monthly income on *district*

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[15] The output results follow the EViews convention in defining break dates to be the first date of the subsequent regime after the break. Equivalently, 2008M11 is the last date of the preceding regime at which the break occurs. Refer to EViews (2014; p. 174 – 186) for interpretation of output results.

[16] There are six country parks located in HK (but none in KWN), occupying around 30.3 km^2. Thus, after the exclusion of them, HK's land area amounts to 50.4 km^2 only, quite close to 46.9 km^2 of KWN. Source: *Annual Report 2001-2002*, Agriculture, Fisheries & Conservation Department.

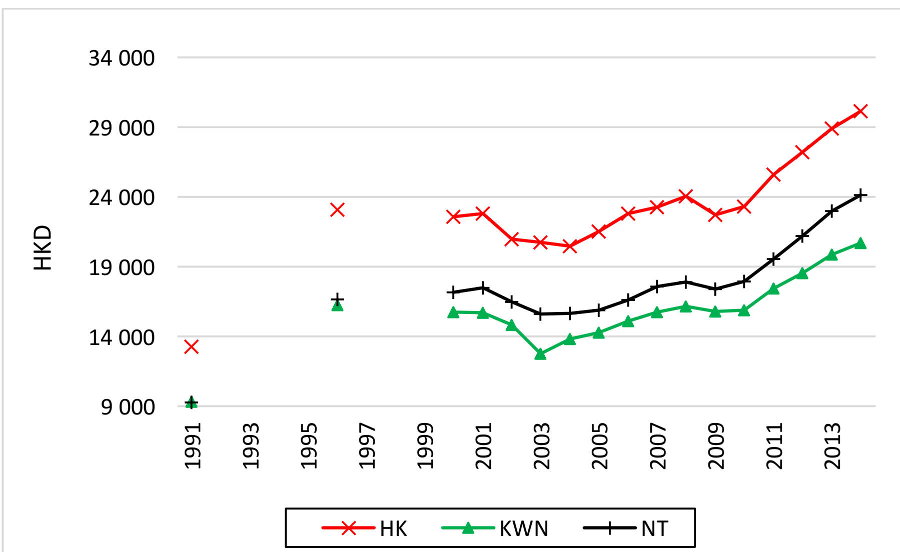
[17] Among the three grades, grade A belongs to the category of best quality.

basis at five-year interval before 2000 and annually hereafter. The incomes vary widely across districts over the course of time. In estimation of income per *area,* we compute the weighted average of the constituent district income, with weights equal to the number of households in the district divided by that in the area. The resultant spatial incomes over 1991 – 2014 are graphed in Figure 2. As shown, income in HK ranked the highest top while that in KWN and NT were almost identical (KWN = $9,323; NT = $9,281) in 1991. Nevertheless, starting from 1996, KWN has lagged behind of NT and their gap started to widen further since 2000.

The presence of unequal spatial income is more aligned with the real-world situation. Brueckner (2011) argues that higher income groups prefer more spacious and newer houses and do not mind commuting longer distance, so they are likely to move into the suburbs. The poor, by contrast, are inclined to stay in smaller-sized dwellings (despite higher per-square-foot price and rent) near the CBD wherein convenient public transit is often available. This ends up with the needy living near the center and the rich distant from it. To large extent, this is in line with the scenario in Hong Kong, where we have just demonstrated that household income in KWN has been overtaken by NT starting from mid-1990s. The result is that the wealthy move to either HK or NT, while the poor remain in KWN (especially in SSP).[18]

Another closely related concept derived from spatial income is the time cost borne by the affluent and the deprived. If we believe that the time of the rich is worth much more than that of the poor because of higher income earned by the former, the preceding implication from the urban model could be reversed, resulting in the former living near the center and the latter in the suburbs. This might partly explain why some of the well-offs live in HK (especially in CW and WC), just next to their office workplaces (but still not too far from YTM in KWN). This is possibly because their time is so precious! Therefore, once the fact that time costs differ among income groups is considered, the residing locations of them become indeterminate.

Figure 2. Household median monthly income by area (1991 – 2014)



5.3 Internal Migration

Population in absolute numbers and percentage of total population per area are illustrated under Figure 3. It substantiated strongly the tendency of internal migration from HK and KWN into NT. The population of KWN dropped rather considerably during the 1980s after which it becomes stabilized at around 2 million. Meanwhile, HK remains the least populous area of Hong Kong over the past 35 years. By contrast, we can see that the population in NT has nearly tripled over the same period and the migration trend will continue for the reasons that new town

[18] SSP is just adjacent to YTM and remains the most deprived district in Hong Kong over the past 15 years.

developments are normally feasible only in NT and that the process has been facilitated by continual modernization of the transit railway systems (Li, et al., 2016).

In Table 5, we have listed out all the district population growth rates (in descending order) over every decade between 1981 – 2011. In the 1980s, all NT districts have recorded positive growth. And the increases observed in ST, TM, SK and TP were explosive, largely thanks to the developments of new towns. Since the number of residents in HK has risen only mildly during the period, we can infer that there had been large internal migration from KWN (as demonstrated by its drastic drop as a whole) to the four districts in NT. In the following decade (1991 – 2001), the growth rates of seven out of the nine districts in NT have again ranked the very top, resulting in further 1-million surge in overall NT population. The growths in YL, IS and NO have been more impressive than in 1980s. In the meantime, modest growth and minimal decline have been recorded in HK and KWN, respectively. Hence, the prior trend of migration from KWN into NT just continued, but the pace has slowed down. Over the most recent decade (2001 – 2011), population in NT has expanded further by 0.35 million (mainly in IS, SK and YL). However, here exists a reverse direction, in that population in KWN has rebounded slightly (0.08 million), whereas those of HK has shrunk by a smaller amount (0.06 million). To sum up, over the past three decades, migration into NT is very evident. Equally noticeable is the tendency to reside outward into the edge of NT (for example, from ST and TM to YL, IS and NO) where land supply is more abundant. Even though the pace seems to have slowed down recently, NT is still believed to be the primary destination for in-migration as expanding railway network will make it more accessible and commuting costs lowered.

Figure 3. Population by area (1981 – 2011)

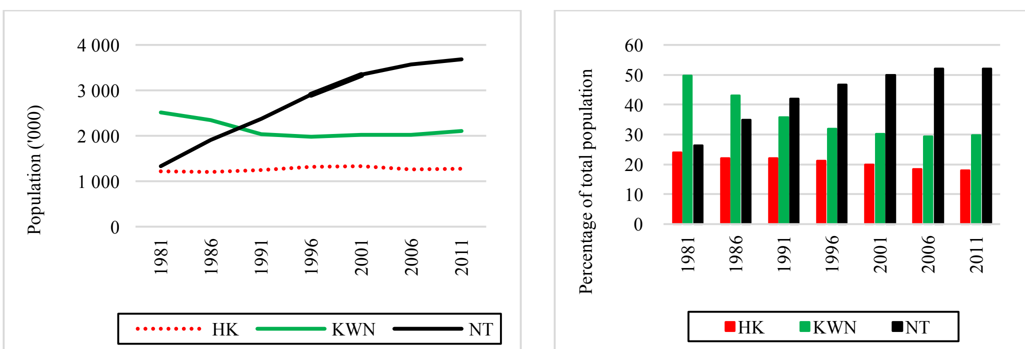


Table 5. Percentage growth in population by district (1981 – 2011)

1981 - 1991		1991 - 2001		2001 - 2011	
%	**District (Area)**	**%**	**District (Area)**	**%**	**District (Area)**
+327.9	ST(NT)	+151.3	SK(NT)	+63.1	IS(NT)
+215.5	TM(NT)	+95.5	YL(NT)	+33.2	SK(NT)
+206.6	SK(NT)	+82.6	IS(NT)	+28.8	YL(NT)
+171.8	TP(NT)	+80.3	NO(NT)	+10.6	TW(NT)
+43.6	NO(NT)	+53.8	TP(NT)	+10.6	KTO(KWN)
+21.3	YL(NT)	+28.4	TM(NT)	+9.2	YTM(KWN)
+18.1	EA(HK)	+24.1	ST(NT)	+7.7	SSP(KWN)
+16.1	SO(HK)	+15.0	WTS(KWN)	+7.1	KTS(NT)
+14.5	KTS+TW(NT)	+12.9	SO(HK)	+1.8	NO(NT)
+3.2	IS(NT)	+10.0	EA(HK)	+0.3	ST(NT)
		+8.2	KTS(NT)		
		+3.4	CW(HK)		
		+1.5	TW(NT)		

(Table 5 continued on next page)

(Table 5 continued)

1981 - 1991		1991 - 2001		2001 - 2011	
%	District (Area)	%	District (Area)	%	District (Area)
-7.5	KTO(KWN)	-0.0	YTM(KWN)	-0.3	TM(NT)
-10.8	CW(HK)	-2.8	KTO(KWN)	-1.0	KC(KWN)
-18.3	KC(KWN)	-5.4	KC(KWN)	-4.0	CW(HK)
-18.7	SSP(KWN)	-7.1	SSP(KWN)	-4.0	SO(HK)
-23.3	WTS(KWN)	-7.3	WC(HK)	-4.5	TP(NT)
-23.6	WC(HK)			-4.6	EA(HK)
-33.6	YTM(KWN)			-5.5	WTS(KWN)
				-8.7	WC(HK)

5.4 Scattered Employment Opportunities

Heretofore we have hypothesized that there is only one CBD – YTM in KWN – in Hong Kong. However, as we have shown earlier, that the actual places of work are rather evenly dispersed among HK, KWN and NT. This mystery might be better unraveled by viewing Hong Kong as a "polycentric" city, wherein there is a secondary business district (SBD) in both HK and NT. Serving as employment subcenters, SBD furnishes extra job opportunities, possibly more associated with specific type of industries. After refining the model, an appealingly new direction is unfolded to understanding the spatial structure of the territory. Via comparing the relative size of stock in Appendix 1 of each kind among areas and districts, the major type of workplaces in different areas can be identified more specifically: commercial and retail premises [KWN] (Panel A), business offices [HK] (Panel B), and factories and industrial buildings [NT] (Panel C). At district level, YTM is the CBD in KWN as previously held, and, CW and KTS turn out to be the SBD of HK and NT respectively. Horizontal summation of all stock enables spatial comparison with the following results: 11,529,700 m^2 (HK), 14,484,400 m^2 (KWN) and 12,984,600 m^2 (NT), or, in terms of percentage of total stock size in Hong Kong: 29.56 percent, 37.14 percent and 33.29 percent accordingly. Appreciably, the percentages resemble quite closely that of worksites of the working population in 2011 (Table 1).[19]

6. CONCLUSION

In this study, we heavily make use of census data (down to district level) to identify potential regular spatial patterns as recognized by Brueckner (2011) using the monocentric urban model in the context of Hong Kong. We find that such a simple model is incapable of elucidating fully the complicated setting of the modern city, and refinements are thus made to make it more adaptive. Moreover, we take one step forward after Lam (2015), by reckoning a structural break in 2008M11; after taking that into consideration, the shifting pattern of the ripple effect previously reported has simply collapsed. More strikingly, our results corroborate that NT leads the price changes of all classes since the structural change, without any drift.

Two articles from Meen (1999; 2001, Chapter 4) have distinguished several contributory factors to the formation of such spatial price patterns, two of which are especially relevant and deserve more discussion here: migration and spatial coefficient heterogeneity. The prolonged migration inflow into NT over the past three decades probably have attracted some of the rich, as reflected by its highest income growth between 2000 – 2014 [33.49 percent (HK), 31.57 percent (KWN), and 40.46 percent (NT)]. Its prices might be anticipated to be bidden up by largest extent. Yet we observe just the opposite.[20] This surely shows the insufficiency of the explanation; as our recognition of ripples is only confined to 2008M12 – 2014M12. The second factor has underscored the importance of differing price responsiveness due to underlying structural differences in segments. For example, Li (2014, Chapter 5) finds stronger relationships between GDP and prices of larger-sized units. Lam (2016) not only acknowledges similar finding but also establishes

[19] It can be argued that more accurate estimation of relative "workplaces" should be done by subtracting the corresponding vacant amount from stock. For simplicity, they are neglected in Appendix 1.

[20] We compute the spatial price returns over different periods using the real estate indices constructed by Versitech Limited, University of Hong Kong, with the following results. 1999M1 – 2014M14: 194.91% (HK), 165.81% (KWN), and 130.25% (NT); 1999M1 – 2008M11: 18.21% (HK), 2.02% (KWN), -15.03% (NT); 2008M12 – 2014M12: 151.49% (HK), 161.25% (KWN), 170.69% (NT). Computations starting from 2000M1 yield no practical difference in meaning.

that NT price is most sensitive to interest rate variations, relative to other areas. This fits in the episode that interest rates drop from End-2008 onwards, thus pushing up NT prices by greatest scale (170.69 percent).

Our evidence thus far is by no means conclusive. Neither do we think the above two explanations could explain perfectly the ripple effects. Rather, our paper attempts to, via discussion of the spatial pattern of Hong Kong, underline the socio-economic elements while analyzing our residential market, amid the main constraint of spatial demographic data shortage.

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AUTHOR BIOGRAPHY

Kwok-Chiu Lam is a Teaching Fellow at School of Accounting and Finance, Hong Kong Polytechnic University, Hong Kong and also a PhD candidate at School of Finance, Shanghai University of Finance and Economics, Shanghai, China. Academic & professional qualifications: BBA (HKUST), MSc (CUHK), CFA, CFP^{CM}, FRM. Research interest: investments, real estate finance and financial planning. Email: kwokchiulam@netvigator.com

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APPENDICES

Appendix 1. Stock (in m^2) of private commercial, offices, and flatted factories at End-2014

	Panel A: Private commercial	Panel B: Private offices				Panel C: Private flatted factories
Abbrev.	**Total**	**Grade A**	**Grade B**	**Grade C**	**Total**	**Total**
HK						
CW	1 125 300	1 904 800	771 400	577 500	3 253 700	66 900
WC	1 083 000	908 400	571 000	306 000	1 785 400	0
EA	765 200	740 000	201 900	79 800	1 021 700	1 254 800
SO	254 200	147 000	48 900	10 500	206 400	713 100
	3 227 700	**3 700 200**	**1 593 200**	**973 800**	**6 267 200**	**2 034 800**
KWN						
YTM	2 084 500	1 141 500	617 500	411 200	2 170 200	306 500
SSP	702 900	178 700	55 900	39 200	273 800	1 038 100
KC	712 000	107 300	49 200	20 400	176 900	850 500
WTS	320 000	0	45 700	1 200	46 900	763 300
KTO	629 200	1 152 500	72 900	12 500	1 237 900	3 171 700
	4 448 600	**2 580 000**	**841 200**	**484 500**	**3 905 700**	**6 130 100**
NT						
KTS	347 200	149 100	11 500	2 000	162 600	3 296 400
TW	499 000	114 600	10 300	800	125 700	2 321 400
TM	414 300	32 700	0	8 500	41 200	1 476 300
YL	468 400	9 200	9 800	19 000	38 000	203 400
NO	229 800	26 900	3 300	500	30 700	286 600
TP	232 000	0	5 200	1 200	6 400	151 900
ST	462 600	309 100	16 000	0	325 100	1 110 000
SK	290 300	9 000	0	0	9 000	9 000
IS	297 300	130 200	18 900	0	149 100	900
	3 240 900	**780 800**	**75 000**	**32 000**	**887 800**	**8 855 900**
OVERALL	**10 917 200**	**7 061 000**	**2 509 400**	**1 490 300**	**11 060 700**	**17 020 800**

Source: Hong Kong Property Review 2015, RVD

Appendix 2. "Sequential L+1 breaks vs. L" multiple breakpoint testing approach

Bai-Perron tests of L+1 vs. L sequentially determined breaks			
Sequential F-statistic determined breaks:			1
		Scaled	**Critical**
Break Test	F-statistic	F-statistic	Value**
0 vs. 1 *	10.96875	21.93750	11.47
1 vs. 2	4.384227	8.768455	12.95
Break dates:			
	Sequential	Repartition	
1	2008M12	2008M12	

* Significant at the 0.05 level.
** Bai-Perron critical values.

Appendix 3. "Global L breaks vs none" multiple breakpoint testing approach

Bai-Perron tests of 1 to M globally determined breaks					
Sequential F-statistic determined breaks:				5	
Significant F-statistic largest breaks:				5	
UDmax determined breaks:				1	
WDmax determined breaks:				1	
		Scaled	**Weighted**	**Critical**	
Breaks	F-statistic	F-statistic	F-statistic	Value	
1 *	10.96875	21.93750	21.93750	11.47	
2 *	7.760468	15.52094	18.25899	9.75	
3 *	5.860540	11.72108	16.08144	8.36	
4 *	6.111012	12.22202	19.49744	7.19	
5 *	5.163969	10.32794	20.24982	5.85	
UDMax statistic*		21.93750	UDMax critical value**		11.70
WDMax statistic*		21.93750	WDMax critical value**		12.81
Estimated break dates:					
1: 2008M12					
2: 1998M04, 2008M12					
3: 1998M04, 2001M11, 2008M12					
4: 1998M04, 2001M11, 2005M04, 2008M12					
5: 1998M04, 2001M11, 2005M04, 2008M12, 2011M12					

* Significant at the 0.05 level.
** Bai-Perron critical values.

Appendix 4. Pairwise Granger-causality test statistics on intraclass ripple effects (1999M1 – 2008M11)

Trivariate VAR Lag *p*	Null Hypothesis	F-Statistic	Probability	Causality*
1	DLKWN_A_RP does not Granger Cause DLHK_A_RP	2.38599	0.1252	HK → KWN
	DLHK_A_RP does not Granger Cause DLKWN_A_RP	12.3515	0.0006	
1	DLNT_A_RP does not Granger Cause DLHK_A_RP	9.26647	0.0029	NT → HK
	DLHK_A_RP does not Granger Cause DLNT_A_RP	2.54637	0.1133	
1	DLNT_A_RP does not Granger Cause DLKWN_A_RP	22.2822	7×10^{-6}	KWN ↔ NT
	DLKWN_A_RP does not Granger Cause DLNT_A_RP	3.45681	0.0656	
1	DLKWN_B_RP does not Granger Cause DLHK_B_RP	20.7774	1×10^{-5}	KWN → HK
	DLHK_B_RP does not Granger Cause DLKWN_B_RP	0.28789	0.5926	
1	DLNT_B_RP does not Granger Cause DLHK_B_RP	4.80264	0.0304	NT ↔ HK
	DHK_B_RP does not Granger Cause DLNT_B_RP	6.17896	0.0144	
1	DLNT_B_RP does not Granger Cause DLKWN_B_RP	2.91412	0.0905	NT ↔ KWN
	DKWN_B_RP does not Granger Cause DLNT_B_RP	9.04923	0.0032	
1	DLKWN_C_RP does not Granger Cause DLHK_C_RP	3.75011	0.0553	KWN → HK
	DHK_C_RP does not Granger Cause DLKWN_C_RP	1.82382	0.1795	
1	DLNT_C_RP does not Granger Cause DLHK_C_RP	0.78844	0.3764	HK → NT
	DHK_C_RP does not Granger Cause DLNT_C_RP	8.51668	0.0042	
1	DLNT_C_RP does not Granger Cause DLKWN_C_RP	0.90568	0.3433	KWN → NT
	DKWN_C_RP does not Granger Cause DLNT_C_RP	3.64107	0.0589	
1	DLKWN_D_RP does not Granger Cause DLHK_D_RP	5.59832	0.0197	KWN → HK
	DLHK_D_RP does not Granger Cause DLKWN_D_RP	1.15275	0.2852	
1	DLNT_D_RP does not Granger Cause DLHK_D_RP	3.69822	0.0570	NT → HK
	DLHK_D_RP does not Granger Cause DLNT_D_RP	1.99024	0.1610	
1	DLNT_D_RP does not Granger Cause DLKWN_D_RP	0.45332	0.5021	n/a
	DLKWN_D_RP does not Granger Cause DLNT_D_RP	0.11067	0.7400	

* Causality direction determined by 10% significance level.

Appendix 5. Pairwise Granger-causality test statistics on intraclass ripple effects (2008M12 – 2014M12)

Trivariate VAR Lag *p*	Null Hypothesis	F-Statistic	Probability	Causality*
1	DLKWN_A_RP does not Granger Cause DLHK_A_RP	10.1903	0.0021	KWN → HK
	DLHK_A_RP does not Granger Cause DLKWN_A_RP	0.15113	0.6986	
1	DLNT_A_RP does not Granger Cause DLHK_A_RP	8.65729	0.0044	NT → HK
	DLHK_A_RP does not Granger Cause DLNT_A_RP	0.94996	0.3331	
1	DLNT_A_RP does not Granger Cause DLKWN_A_RP	6.77046	0.0113	NT → KWN
	DLKWN_A_RP does not Granger Cause DLNT_A_RP	0.74672	0.3905	
1	DLKWN_B_RP does not Granger Cause DLHK_B_RP	2.00460	0.1613	n/a
	DLHK_B_RP does not Granger Cause DLKWN_B_RP	0.23077	0.6324	
1	DLNT_B_RP does not Granger Cause DLHK_B_RP	9.20854	0.0034	NT → HK
	DHK_B_RP does not Granger Cause DLNT_B_RP	1.43981	0.2342	
1	DLNT_B_RP does not Granger Cause DLKWN_B_RP	7.64320	0.0073	NT → KWN
	DKWN_B_RP does not Granger Cause DLNT_B_RP	1.43431	0.2351	
1	DLKWN_C_RP does not Granger Cause DLHK_C_RP	0.08451	0.7721	n/a
	DHK_C_RP does not Granger Cause DLKWN_C_RP	2.57134	0.1133	
1	DLNT_C_RP does not Granger Cause DLHK_C_RP	0.88706	0.3495	n/a
	DHK_C_RP does not Granger Cause DLNT_C_RP	0.48158	0.4900	
1	DLNT_C_RP does not Granger Cause DLKWN_C_RP	3.59609	0.0620	NT → KWN
	DKWN_C_RP does not Granger Cause DLNT_C_RP	1.97104	0.1648	
1	DLKWN_D_RP does not Granger Cause DLHK_D_RP	0.33644	0.5638	n/a
	DLHK_D_RP does not Granger Cause DLKWN_D_RP	0.93435	0.3371	
1	DLNT_D_RP does not Granger Cause DLHK_D_RP	3.19022	0.0784	NT → HK
	DLHK_D_RP does not Granger Cause DLNT_D_RP	1.94249	0.1678	
1	DLNT_D_RP does not Granger Cause DLKWN_D_RP	0.98711	0.3239	n/a
	DLKWN_D_RP does not Granger Cause DLNT_D_RP	0.12885	0.7207	

* Causality direction determined by 10% significance level.