Auckland's Density Part Two

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Introduction

I'm keen to understand residential development patterns in Auckland, in particular residential density.

As part of my continuing professional development, I've given myself the task of investigating whether there is any way of objectively determining what Auckland's residential density should be - now, as well as in the future.

In my previous article I looked at different ways of measuring population density and how Auckland's density has changed over time. I compared Auckland's density with other cities in Australia and Canada as one way of answering the question of whether Auckland is too densely settled, or if it should it be more intensely developed.

Firstly, I looked at different city-wide measures of density, in particular average density and population weighted density. Population weighted density gives a better indication of a city's density profile than average density; that is, how density varies across a city.

On a population weighted density measure, while Auckland is comparable to other similar sized cities, it is more densely settled. This may be because of incomes, topography and transport, as much as any planning-imposed policy of densification.

What is clear, is that as cities get bigger, then they get more intensely developed. As Auckland grows towards 2 million people, then it is likely that the city's overall population weighted density will

increase by at least 20% from current. From 30 people per hectare to 35 people per hectare, based on other cities.

I then looked at Auckland's population density profile. That is, density in relation to distance from the central area, and how that has changed over time. Distance was measured as the crow flies, while density was measured on the basis of resident population by census area unit. Looking at density in relation to distance gives an idea of the city's density profile or gradient - how density reduces from the centre.

Generally, in new world cities at least, the pattern is for density to decrease as one gets further from the centre. When compared to cities in Australia and Canada, Auckland is not too different in this regard, but perhaps has a flatter density profile than other cities. How will the general increase density that can be expected over the next twenty or so years manifest itself - spread evenly across the city, or clustered closer in?.

In this paper, I want to explore how urban economists explain a city's density profile and compare this explanation with what exists in Auckland. I'm not an economists, so have much to learn![1]

Density as a trade off.

In simple terms, density is the way that a city irons out differences in costs between the edge and the centre of a city.

Economists explain density as a trade off between transport costs and housing costs. Closer into the city centre, transport costs are lower, further out they are higher. As a result, closer in households have more money to spend on housing, while further out they have less. Landowners know that closer to the centre, households have more money to spend on housing compared to those further out, so land values are higher. Further out land price should drop to compensate for higher travel costs.

As land values rise, then housing needs to get more dense (smaller land component) to keep prices reasonable.

Households face a choice then, given a set amount they can or want to spend on housing and transport. Closer into the centre, while transport costs are lower, and in theory a household could

1 Two references I found helpful were: Urban Economics by Arthur Sullivan, Seventh Edition, McGraw Hill 2009; and Lectures on Urban Economics, Jan K. Brueckner, MIT Press.

spend more on housing, they tend to not want to spend too much more than if they brought a house further out. As land values are higher closer in, the size of section shrinks and urban density increases. Further out, transport costs are higher than if they were closer in, so households spend less on housing, but not that much less than if they were closer in. To compensate for the higher transport costs, they expect to be able to buy a larger section, and hence urban density is less.

An interesting (and very important) point from this process is that house prices should not necessarily vary much between inner and outer areas (setting aside the issue of different income levels across the community). What changes is land values and urban density. Density changes due to two factors, called consumer substitution and input substitution:

- consumer substitution is the process outlined - where households close to the centre don't necessarily spend all of the money they save on transport on more expensive housing, much of it may go on other goods and services. Rather, they accept smaller sections. Further out to compensate for higher transport costs, consumers expect more land.

- input substitution comes into play when land values start to get high, and at some point it starts to make sense 'going up'. That is building apartments, rather than stand alone houses. In effect capital is substituted for land.

In the following I look at the role of consumer substitution, first based on an average household, then assuming different income bands. Then I turn to input substitution, before considering what happens when population increases.

A hypothetical case

Let's look at an Auckland-based hypothetical example of the inter relationships between housing costs, transport costs and residential density. Some BOE (back-of-the-envelope) calculations are needed.

Take an average, two working person household on a total combined income of $85,000 per year as a starting point. $85,000 is more than the median household income for Auckland, but not a bad figure for an average working household. Assuming 35% of income is spent on housing, then that is equal to a household being able to "afford" a $530,500 house, on a 20% deposit and current (early 2014) bank mortgage interest rates. While $530,500 is below the Auckland median house price, it is not an unreasonable "middle of the road" figure to use for a house in the mid to outer parts of Auckland.

The average commute trip (car or public transport) in Auckland is 11km[2]. At 80 cents per kilometre, costs for the work trip by car are $8.80 per trip, or $17.60 per day, for the two way trip. This is just travel-related costs - petrol, car maintenance, vehicle financing etc. It doesn't cover parking costs or the value of time. Economists like to keep things simple. Public transport costs are not too different - my 5km bus ride into the city covers two zones and is about $3.60 (I can't remember the exact figure now that I use a HOP card!).

At 200 working days per year for one person in our average household and 100 days for the other (i.e. a part timer), then commuter-related transports cost are a total of $6,000 per year. This is an average of $115 per week on travel. The latest Statistics New Zealand Household Economic Survey has total, average transport costs for Auckland region households at $176 per week, so this is a reasonable guess for the commuting-related component.

Now based on this average, we can estimate the effect of distance and hence different transport costs, on density.

First up, the following table estimates what households would pay in terms of transport costs, based on distance from the central city. Obviously only some people travel into the central city, while most travel across town, so using the distance into the CBD as the sole way of estimating transport costs is a bit simplistic. But don't forget, that overall, the Isthmus area accounts for the bulk of jobs in the Region and so using the CBD as the central point for determining travel distances is not necessarily that bad. Further away from the centre, it is more likely that trips to work will be to a sub regional centre, not into the city centre, but some of these could be long cross-town trips (North Shore to Manukau, for example).

Absent any detailed data on travel patterns by area unit, I need to make some estimates. What I have done is taken 80% of the distance from the CBD as being the average commute. For example, for a household 20km from the CBD, the average commute is 16km. This means that further away from the CBD, there is a greater moderation in distances travelled, compared to closer in.

The 80% figure is based on looking at the number of people living at different distances from the CBD and calculating the average trip length if they all commuted into the CBD. This results in an average commute of 13.64 km (as a lot of people live 20 to 30km from the CBD). To get to an average of 11km, I reduced the distance travelled by 20%. This results in an average of just below 11km per trip. See the appendix for the detailed figures.

[2] http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7432

Table One below sets out the estimate of commuting costs, based on distance travelled. Also set out is the amount of money that could be spent on a house, for our $85,000 income household, taking the 15km distance as the being the "mid-point " and the associated increase or reduction in transport costs either side of this.

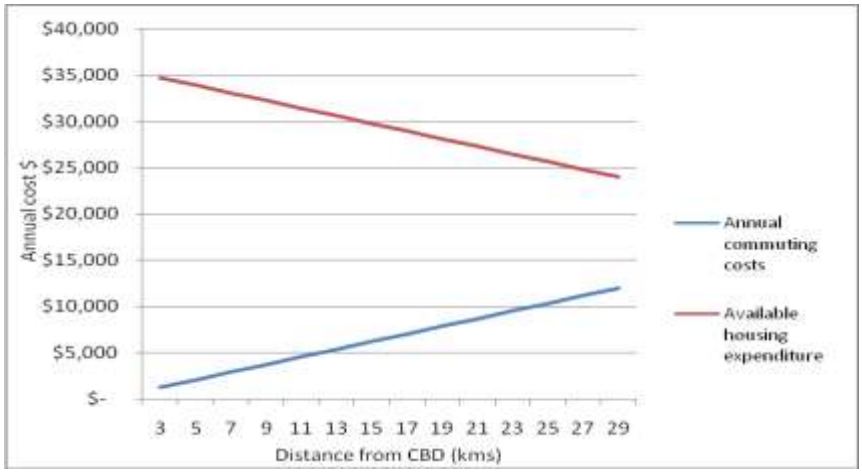
Table 1: Commuting costs and possible housing expenditure

Distance from CBD (kms)	Distance travelled (kms)	Annual commuting costs	Possible annual house expenditure
3	2.4	$1,238	$34,704
5	4	$ 2,064	$33,878
7	5.6	$ 2,890	$33,052
9	7.2	$3,715	$32,227
11	8.8	$4,541	$31,401
13	10.4	$ 5,366	$30,576
15	12	$6,192	$29,750
17	13.6	$7,018	$ 28,924
19	15.2	$7,843	$28,099
21	16.8	$8,669	$27,273
23	18.4	$9,494	$26,448
25	20	$10,320	$25,622
27	21.6	$11,146	$ 24,796
29	23.2	$11,971	$23,971

Closer in than 15km, transport costs drop and in theory there is more money to spend on housing. The reverse occurs with increasing distance from the central areas.

Graphically, this relationship looks something like Figure 1.

Figure 1: Relationship between transport and housing costs



As those with a mortgage will know, there is a big difference between what can be borrowed based on annual mortgage repayments of $34,000, rather than $24,000. However the relationship between transport and housing is not as simple as this.

Calculated Density

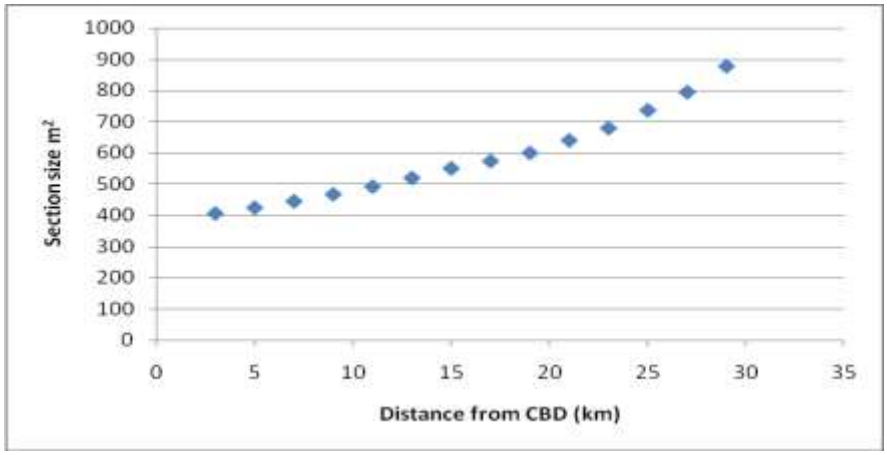
In terms of dwelling density, the above figures can be translated into an estimate of section sizes, based first on the idea of consumer substitution. As noted, landowners are not dumb and they know that closer in, people pay less for transport and therefore have more cash on hand than those further out. As a result land prices rise. Another way to look at this is to say that there is greater demand for housing close in - people will pay a premium to live close to work and amenities associated with inner suburbs. Land prices rise due to the increased demand.

Using the same $85,000 household, living at the mid-point of 15km from the CBD, and assuming a 550m^2 , $250,000 section as the starting point, each kilometre closer into the city raises average land values as transport costs fall, and for our average household to not pay too much more for a house than the midpoint, then section sizes need to come down.

The opposite process occurs as distance increases from the central area. Land values fall, and people expect larger sections to off-set the higher transport costs.

My calculation based on the above dynamics, results in an estimate of sections sizes like this (Figure 2). I have started my calculations at 3km from the CBD, so the figures that follow do not cover the central city. It is the suburbs that I am interested in.

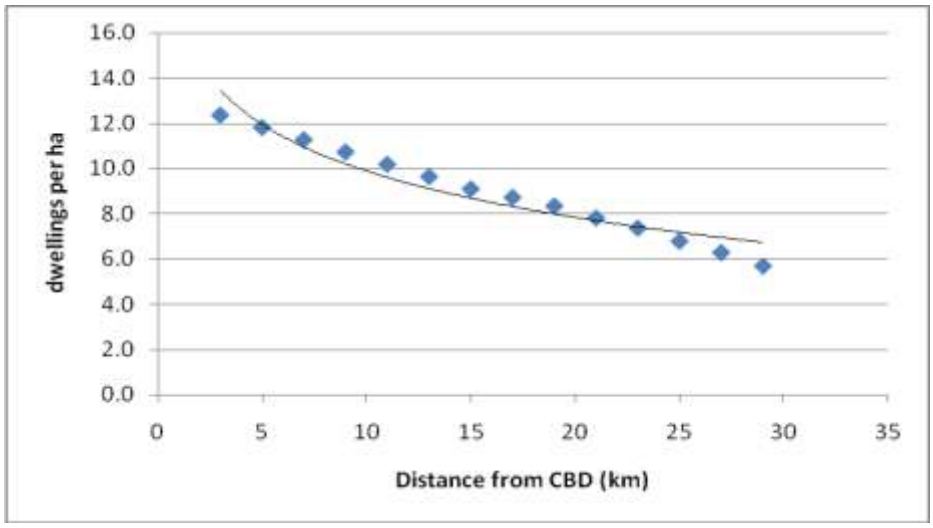
Figure 2: Estimated average section sizes by distance from the CBD.



This estimate can then be translated into a housing density calculation of dwellings per hectare. To do this, I had to make some assumptions as to how many sections (dwellings) there are per hectare of urban land. Account has to be made for land taken up by roads, open spaces, schools etc.

I have anchored the calculation of density at the mid point of 15km. My calculaiton of current 2013 dwelling density at 15km from the CBD is in the order of 9 dwellings per hectare.

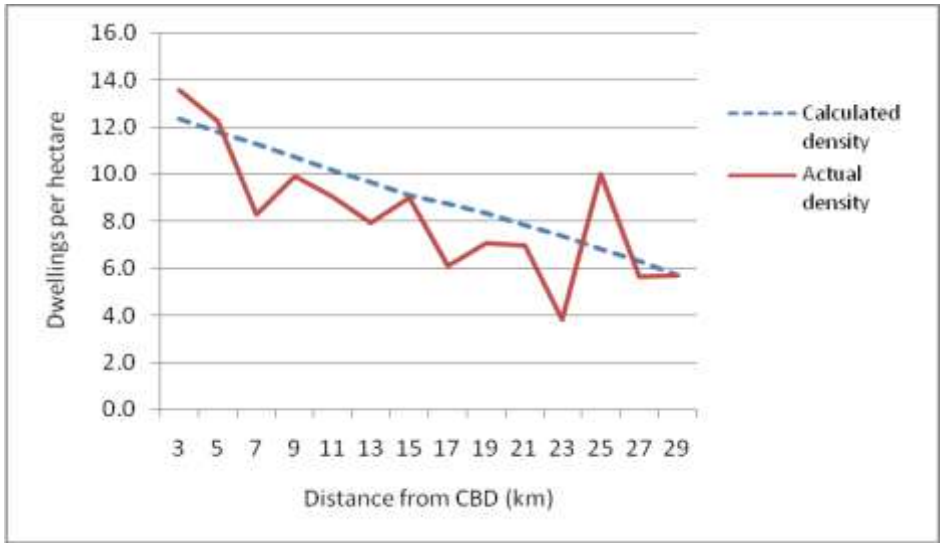
Figure 3: Estimated dwelling density by distance from the CBD



Note: The table in the appenddix sets out the inputs into the analysis of transport-related land value and density changes, for the $85,000 household, and the calculaitons to generate the above graphs.

This calculated density profile can then be compared to the actual dwelling density profile for Auckland. Figure 4 makes this comparison. The actual density is based on 2013 census results for total dwellings by census area unit. Travel distance was calculated by using Google maps and taking the mid point of the area unit and the distance that Google calculates to drive to the central city area (bottom of Queen Street).

Figure 4: Actual versus calculated housing density



Now this is not a bad fit in terms of overall fall in dwelling density from inner to outer, but there is a difference between the two lines. Partly this may be explained by how I have calculated density, as well as distance.

My calucated density has had to make a big assumption about how much land is not used for housing within any given area. I have used an average across the entire city area. The actual density is the number of houses divided by the area of the relevant Census Area Unit, and the amount of residential land in each Area Unit will vary.

As I've said, I tried to correlate the 15km mid point as best I can in terms of calucated and observed density, but it may be that either side of that, more or less land may actually be occupied by activities other than housing.

There are a number of points of divergence along the line.

Looking first towards the edge of the city, away from the central area, there is a noticable blip up in actual density at around the 25km mark. This blip may be a degree of clustering around sub regional nodes like Albany , where transport closts are relatively lower compared to in middle ring subrubs, and hence land values and as a result densities are higher.

The other explanation could be that in some way density is not being alllowed to fall sufficiently to off-set higher commuting costs. This might be an "MUL" (Metropolitan Urban Limit Line) or urban fence effect.

Closer into the CBD, and actual density is a bit higher than the calculated density, while for much of the city the actual density is less than the calculated density, but not that much given how the figures were calculated.

The analysis to date suggests that Auckland's density is not too far off what it might be, if zoning and planning did not play a major role in how the city developed, at least in terms of the current urban area, but there are question marks either end of the spectrum - close into the CBD and out on the edge.

Land Values

The next stage of my investigation is to look at the land values which the calculation of transport costs imply. Land values drive urban redevelopment and intensification. Density responds to land values.

The above calculation is based on an "average" household. Obviously the city has a range of households on different incomes and this is bound to affect land values.

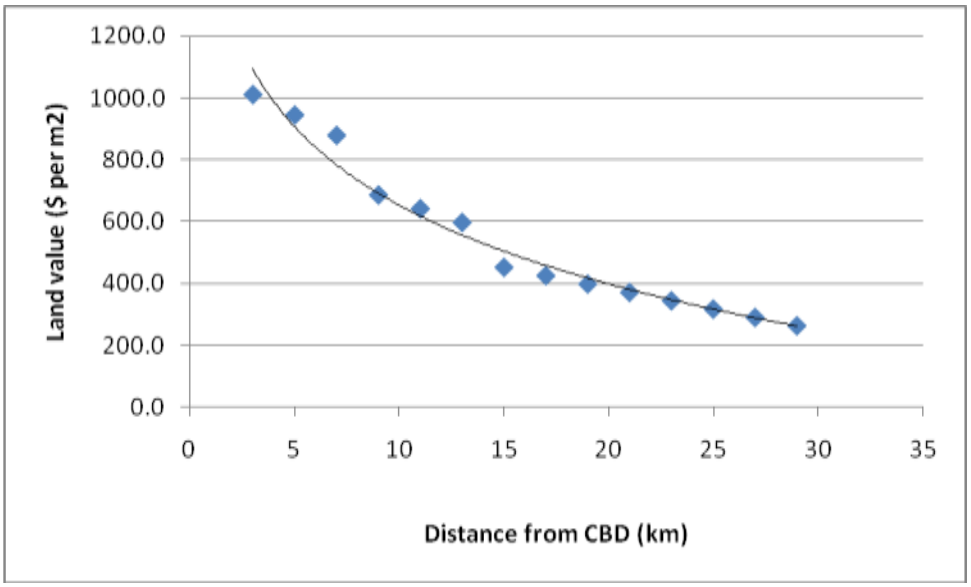
So to take things the next step, I've recalculated the density calculations for a $100,000 and $120,000 income household. Now to make these calculations, I have assumed that as household income increases, then they are likely to live closer in, and so the midpoint at which trasnport costs rise or fall moves closer in, than for the middle of the road household. I have also made some assumptions that as incomes rise, then households consume more housing (larger floor area).

I have also assumed that transport costs increase per kilometre travelled, for higher income households. This is based on the notion of value of time. People with higher incomes face higher opportunity costs and each extra minute travelling is a minute less that they could otherwise be doing their well paid work or tending to their significant investments. To keep it simple, I doubled transport costs, from 80cents a kilometre to $1.50 per kilometre.

Close into the CBD, for the first three distance bands (3,5 and 7kms), I have assumed that the higher income households will out bid others and so land values are based on their calculations. Likewise for the next three bands, where the $100,000 income band households will predominate.

The upshot of all these factors is the following graph (Figure 5).

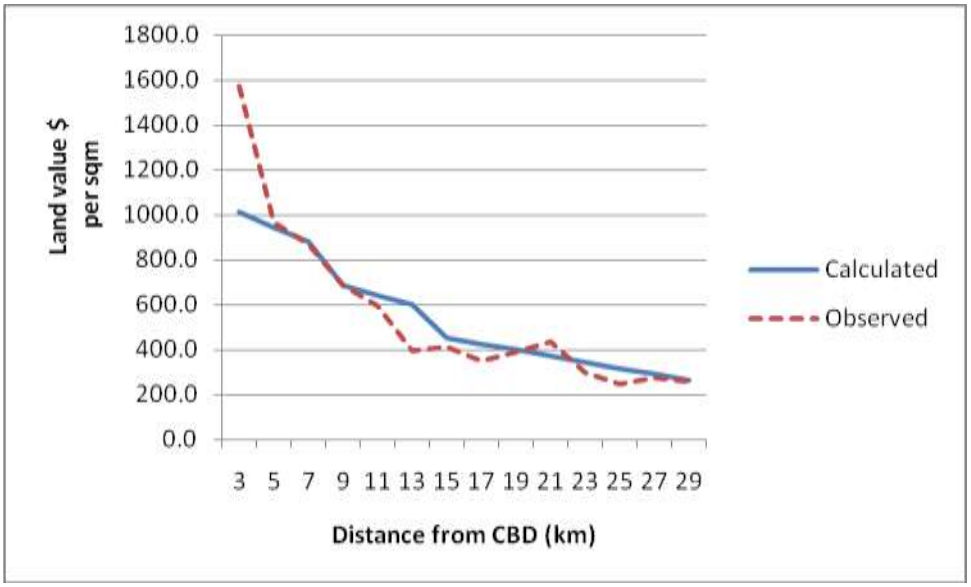
Figure 5: Estimated residential land values ($ per square metre) based on transport costs and different income bands.



If we compare Figure 5 with actual data on land values, then the following is the result (Figure 6). Again a reasonable fit. In fact it is scary how a few simple calculations can get you so close to some real numbers! Maybe this is sheer coincidence.

The data on actual land values is obtained from Qutoable Value and is based on median land values per square metre of residential land, by Census Area Unit, for 2013. I have grouped this data into distance bands and averaged it within each band.

Figure 6 Residential land values ($ per square metre), calculated and observed



The very notcable tick up in actual land values close to the CBD has a number of possible causes. Most likely it is due to a grouping of very high income households who can bid more for land than others. But it may also be a sign that housing supply close into the central area is constrained by the heritage suburbs that ring the central area. Here, housing supply cannot expand to meet demand, and so a form of "bubble" is created. Great if you are inside the bubble, but a real pain if you are outside and want to get in!

At this piont, a range of questions come to the fore:

- Given all of the above is essentially based on a few assumptions about transport costs, what happens if transport costs rise or fall? What happens to land values, and hence density?
- You are also probably asking about households on less than $85,000 per year. The median regional household income is, after all, $76,000 as of the 2013 census. What about their housing needs and whether they can afford a house? What sort of land values and density gradient is needed to accommoadte their needs?
- At what point does it make sense to start to build apartments, rather than just shrink section sizes?
- What about population growth? How will that affect density?

I will set aside the first two questions and look at them in my next round of work, as they are more of a policy type question. Below I look at when multi-storey development makes sense and population growth

Multi-story development.

An important issue for Auckland is when and where multi-storey development becomes feasible. Given the land value gradient set out in my calculations and as recorded by Quotable Value, is there anyway of determining when multi-storey development will occur, and hence densities will be much higher. This is where factor or input substitution comes into play.

Economists tackle the question of multi-level development in terms of substitution of capital for land. As land gets more and more expensive, at some point it becomes more effective to build more storeys (use more capital) and use less land per unit. However, the costs of building multi-level units is a lot more expensive per square metre of floor space than for stand alone houses, so threre are some break points to be identified.

It is possible to gain some idea of where it becomes more effective to use capital rather than land by looking at land values and building costs per square metre of floorspace.

For example, take a 150 square metre house. For a standard stand alone house, total construction costs may be around $2,500 per square metre, but for an apartment, construction costs may be closer to $5,000 per square metre (inlcuding basement lifts etc). It is only once land values get very high, does it make sense to build an apartment.

Table 2 sets out a hypothetical example, using a land value of $300 per square metre. The basic stand alone house on a 500m^2 section is the cheapest option, even assuing that the apartment is quite a bit smaller than the house. The middle optionof a terrace house on 250 squre metres is more expensive because I've assumed a higher per sqaure metre build cost. Perhaps this is an unreasonable assumption, but then consumers are probably going to want to see a higher spec build if they are going to accept a smaller living area in total.

Table 2: Hypothetical development options -land value of $300 per m^2

	Stand alone house	Terrace house	Apartment
Storeys	1	2	4
Number of units	1	2	8
Land area per unit (m^2)	500	250	63
Floor area (m^2) per unit	130	130	100
Build costs ($ per m^2)	1,800	2,500	5,000
Total building costs	$234,000	$325,000	$500,000
Fees/charges/profit	$292,500	$406,250	$625,000
Land $ per m^2	300	300	300
Land cost	$150,000	$75,000	$18,750
Total cost	$442,500	$481,250	$643,750

Playing around with the land value numbers shows that it is only once land values rise to above $1,200 per square metre, does an apartment start to make sense in terms of being cheaper than a house or terrace unit.

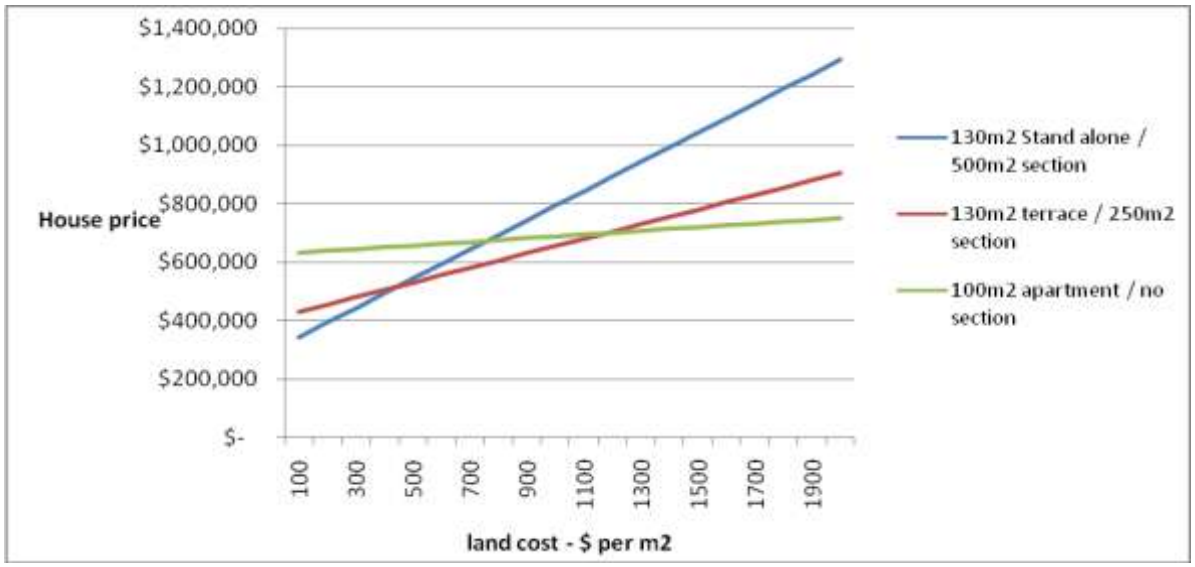
Table 3: Hypothetical development options - land value of $1200 per m^2

	Stand alone house	Terrace house	Apartment
Storeys	1	2	4
Land area per unit (m^2)	500	250	63
Floor area (m^2)	130	130	100
Build costs per m^2	$1,800	$2,500	$5,000
Total building costs	$234,000	$325,000	$500,000
Fees/charges/profit	$292,500	$406,250	$625,000
Land - $ per m^2	$1,200	$1,200	$1,200
Land cost	$600,000	$300,000	$75,000
Total cost	$892,500	$706,250	$700,000

The assumptions in Tables 2 and 3 could be debated: build costs may be different to that used; the floor areas modified; while the amount allowed for fees, charges and developer profit could also change. At this point, it is the more general concept, but Ive tried to use realistic figures that are available.

The above analysis can be used to help develop a trigger point graph like Figure 7, which shows when the different housing typologies become feasible.

Figure 7: Apartments versus stand alone house



In simple terms, the analysis suggests that at around a land value of $500 per square metre, terrace type units on lots of around 250 square metres or smaller start to make sense. At land values of $1,000 or greater, it becomes likely that there will be a sudden step up in density, as terrace/town house developments gives way to 4 or more storey apartments.

In other words, as land values rise, a 1,000 square metre site goes from accommodating 1 stand alone house to 2 stand alone infill dwellings, to 4 terrace houses to potentially 16 apartments (4 each on 4 levels). So density goes up exponentially.

Remember we are talking about general residential areas at this point. Commercial land may well be valued at higher levels, but the drivers in commercial areas as to whether apartments will be built are different to residential areas. So too with redevelopment of industrial land, and with specific activities like retirement villages that often have apartments within them.

Back to my land value analysis. My esitmate of land values and actual land values was pretty close, except for near the CBD. See Table 4. Within 3km of the CBD, residential land values are now up to $1,500 per square metre, and even at 5km from the CBD, land values are close to $1,000 per square metre.

Table 4: Estimated versus actual residential land values

Distance from the CBD (km)	Calculated values per m^2	Observed values per m^2
3	1,013	1,570
5	947	963
7	881	866
9	688	687
11	643	594
13	599	393
15	454	413
17	427	345
19	400	388
21	373	434
23	346	295
25	319	245
27	292	271
29	264	257

Within 3km of the CBD, according to the above analysis, 4 to 6 storey apartments should be sprouting up everywhere. And they are where they can find scope to do so. But you could say that the rate of development of apartments is no where as fast and as wide spread as might be the case should zoning, height and heritage controls not be restraining them.

Not every section within 3 to 5km of the CBD would be redeveloped for an apartent building in a free market situation, as there is existing development to contend with, including many small lots, unit titles and cross leases and the like, but the general principle holds true.

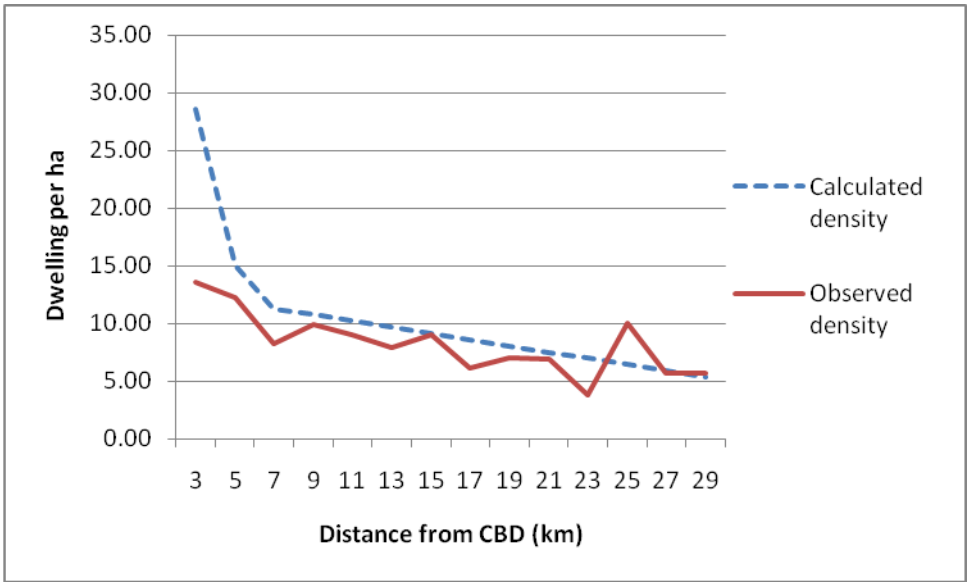
The important message from an urban economics point of view is that multi-storey development is generally only feasible in places with very high land values. A point made by developers during the preparation of the Auckland Unitary Plan.

For Auckland, the conundrum is that the areas with highest land values tend to be areas where special character prevails - the inner heritage subrubs and along coastlines. These areas have important public values associated with them - values that provide benefits to the community - but by not allowing for redevelopment, there is a cost in terms of housing supply, density and affordability.

Provoiding capacity for apartments in areas of moderate residential land value does not help address the issue of providing appropriate capacity for intensificiation, as apartment type development is not feasible in these areas, unless apartment sizes drop to very small units and construction costs get parred back to the minimum.

The outcome of considering when multi-storey apartment development becomes feasible is for the calculated density line to take a steep upward flick close to the CBD. Figure 8 sets out my stab at what the density gradient might look like, compared to what exists today.

Figure 8: Possible density profile, based on residential land values and input substitution



Open any economics text book on cities, and the blue dashed line is the standard density profile presented.

Population growth

The above analysis of Auckland's population and housing density is a static analysis. Yet cities grow, especially Auckland. How does population growth affect the density profile?

The basic steps of populaiton growth can be set out as follws:

1. The populaiton of the city increases
2. More houses are needed to accommodate these people
3. House prices rise due to the increased demand
4. Developer's respond to the higher prices by building more houses, and adjust to the higher prices by economising on the land component within the city boundaries, while also pushing out the city footprint
5. As a result of the price rise, to maintain affordability people accept the need for smaller sections within the current urban area
6. The city expands both upwards and outwards.

The above steps involve a stready rise in land values as a city grows in population, and as a result density. This is a point noted in my first paper that looked at a range of cities and their density. The data on other cities suggests that Auckland could expect at least a 20% rise in the overall populaiton weighted density figure for the city, over the next 20 years.

The question is how will the density profile change?

Understanding the likely impact of population growth on density and land prices is not easy, given that incomes also change over time, as well as other factors like construction costs and mortgage interest rates. Also we need to look over the long term, not at short term shocks like a sudden surge in immigration.

One NZ study stated that:

We find that a one percent increase in an area's population is associated with a 0.2 to 0.5 percent increase in local housing prices[3]

This means that a 10% increase in population should see house prices rise by about 5%, holding other things equal (and if I take the upper end of the range). Over the next 20 years, Auckland's urban population could grow by up to 40% under a high growth scenario. A 10 year figure of 20% population growth therefore implies house price increases of 10%

A 10% increase doesn't sound like much, but because density is so sensitive to land value increases, it does imply a steady upswing in urban density.

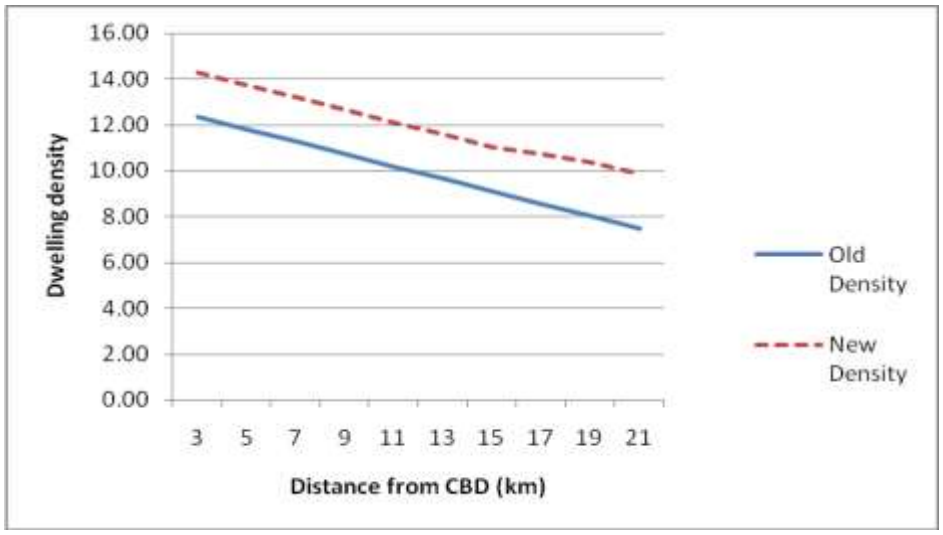
Taking my middle of the road, $85,000 household as an example, currently they can afford a $535,500 house. Assuming the house is valued at around $286,000 (130 square metres times $2,200), then the land value component will be $249,500. We know at 15km from the CBD, residential land values are in the order of $450 per square metre. This means that the $85,000 household can afford a 550 square metre section. This size pretty much fits the actual housing density measured in Auckland, at 15km from the centre.

So with a 20% population rise, the price of my middle of the road house will increase by 10% to $589,050. Given that the size (floorarea) of the house and its value doesnt change (still $286,000), then the increase in value is translated into the land price, which goes from $249,500 to $303,050. The 550 square metre section is now valued at $551 per square metre. However the household's income has not gone up. They still can only afford a total of $535,500. So to make the books balance, the size of the section that they can afford comes down from 550 square metres to 450 square metres. This is a 18% reduction in land area. Dwelling density in the area goes from 9 to 11 dwellings per hectare. This change in density accommodates the 20% increase in population.

My calculation of the change in density as a result of an increase in population growth expected for Auckland looks something like Figure 9.

[3] Housing Markets and Migration: evidence from New Zealand

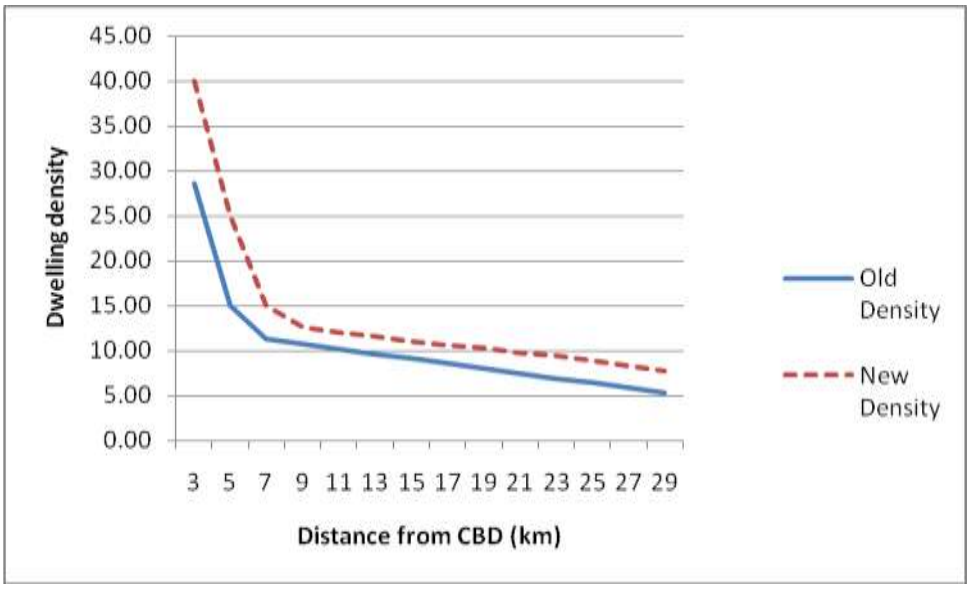
Figure 9: Change in dwelling density as a result of an 20% increase in population.



The effect of the increased price is also to push out the boundary of the city. This is not an issue I have directly looked at, but in simple terms, if 5 dwellings per ha was the cut off point as to when urban stopped and rural started, then it could be seen from Figure 9 that the city might exapnd by another 2 to 3kms out.

The general increase in density is only part of the actual outcome. As I found out in relation to land values and apartments**,** the increase in land values means that more land will be at a level where apartments are the more effective means of delivering housing. So the actual graph may look something more like the following.

Figure 10: Population growth and density profile



The important point here is that the step up in density is across the city, but with a noticable increase close to the central city. Sub regional hubs may also be a focus for some intensification, but that intensificaiton will be relative to what is around it. Density increases in incremental steps, until it hits the point when apartment development becomes the more effective option.

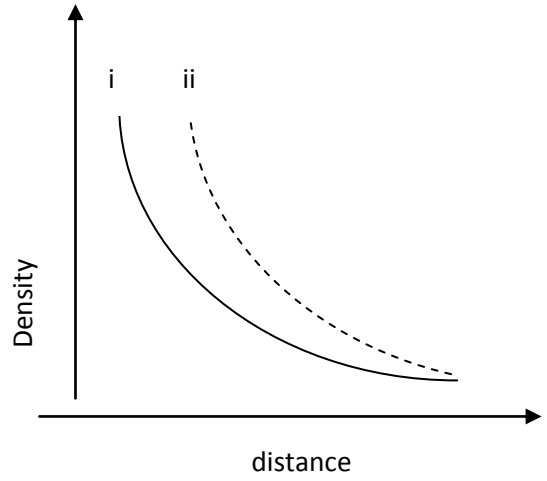
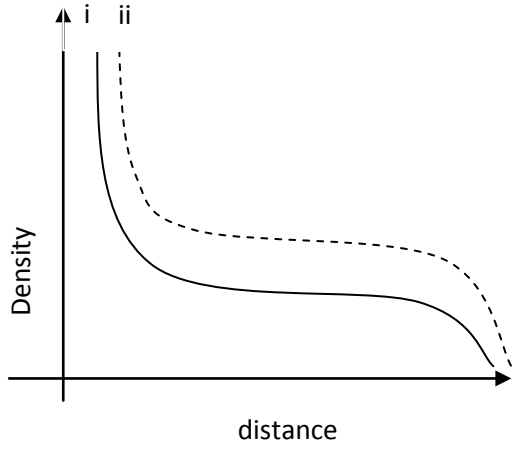
The potential costs to households and the economy in general of not allowing for the incremental increase in dwelling density that can be expected across Auckland is huge. Back to our $85,000 household, 15 kms from the CBD. If new households cant find a $535,500 house, but only a $589,050 house due to section sizes not being able to drop in response to increased prices, then annual expenditure on housing has to go up by about $3,000 dollars. This is $3,000 that is not spent on other goods and services, it is money that goes to a landowner.

Conclusion

I've taken another step forward in understanding Auckland's density. A simple model of household incomes, transport costs and housing expenditure provides some useful insights into Auckland's density profile. Perhaps Auckland's land value and density profile is not too far off what you might expect by just looking at the fundamentals.

But taking into account land values and input substitution , a more complex picture emerges. Closer into the CBD, land values support much more intensive development than is currently the case. A rise in population will see land values increase further, no matter what planning policy is in place.

After looking at the city from the point of view of urban economics, the issues that Auckland face are stark. Fundamentals mean that more density closer in to the CBD is the way to go (Option 1 below) from an efficiency point of view, but the current strategy is to try to spread out intensification and redevelopment across the city (like Option 2), partly on the basis of keeping the heritage character of inner suburbs, parlty to support public transport and town centres.

Option 1: More density closer in	Option 2 - Across the city
	

So there are still things to look into, more in the nature of policy type questions:

- What happens when transport costs rise?
- What about lower income households?
- How can the city intensify, if the inner city is a no go area for redevelopment and how is it possibly to incrementally increase density across the city?

Appendix

Average distance of work to trip calculation.

Figure 11

Distance from CBD, Kms	Total People	% Working	Number working	distance travelled (km)	total distance (km)	adjusted distance (km)	total distance (km)
5	147,045	0.65	95,579	5	477,896	4	382,317
10	377,085	0.65	245,105	10	2,451,053	8	1,960,842
15	367,470	0.65	238,856	15	3,582,833	12	2,866,266
20	180,963	0.65	117,626	20	2,352,519	16	1,882,015
25	75,093	0.65	48,810	25	1,220,261	20	976,209
30	103,542	0.65	67,302	30	2,019,069	24	1,615,255
>30	20,424	0.65	13,276	5	66,378	4	53,102
cbd	26,307	0.65	17,100	0		0	
rural	117,243	0.65	76,208	5	381,040	4	304,832
total	1,415,172		919,862		12,551,048		10,040,839
				Average	13.64		10.92

$85,000 middle of the road household density profile

In puts

Annual income	$ 85,000
Weekly gross	$ 1,635
Housing @ 35% per annum	$ 29,750
Housing per week @ 35%	$ 572
House value	$ 535,500
Ratio weekly to house value	936
Ratio yearly to house value	18
Travel costs per KM	$0.8
Work days per year	215
Number of workers per dwelling	1.5
House value per m^2	$2,200

Midpoint analysis

Distance from CBD	Commute distance	Annual commute costs	Annual house costs	Total house value	House size (m2)	house value	Land value	Land area (m2)	Land value per m^2
15	12	$ 6,192	$ 29,750	$ 535,500	130	$ 286,000	$ 249,500	550	$ 453.64

Density profile analysis

Distance from CBD	Distance travelled	Annual commute costs	Annual house costs	Total house value	Difference to equilibrium	Land value ($ per sqm)	Difference spent on house compared to mid point	Total house value	Land value	Section size 1 (m2)	Section size 2 (m2)	Selected section size (m2)	Dwellings per ha
3	2.4	$ 1,238	$ 34,704	$624,665	$ 89,165	$ 616	$29,722	$ 565,222	$279,222	453	405	405	12.34
5	4	$ 2,064	$ 33,878	$609,804	$ 74,304	$589	$ 24,768	$560,268	$274,268	466	424	424	11.80
7	5.6	$ 2,890	$ 33,052	$ 594,943	$ 59,443	$562	$19,814	$555,314	$ 269,314	479	444	444	11.26
9	7.2	$ 3,715	$ 32,227	$580,082	$ 44,582	$535	$14,861	$550,361	$264,361	494	467	467	10.72
11	8.8	$ 4,541	$31,401	$565,222	$ 29,722	$508	$ 9,907	$ 545,407	$ 259,407	511	491	491	10.17
13	10.4	$ 5,366	$ 30,576	$550,361	$ 14,861	$ 481	$4,954	$540,454	$254,454	529	519	519	9.63
15	12	$6,192	$ 29,750	$535,500	$	$ 454	$ -	$535,500	$249,500	550	550	550	9.09
17	13.6	$ 7,018	$28,924	$520,639	-$ 14,861	$ 427	-$ 4,954	$530,546	$244,546	573	585	573	8.72
19	15.2	$7,843	$ 28,099	$505,778	-$ 29,722	$ 400	-$7,430	$528,070	$242,070	606	624	606	8.25
21	16.8	$8,669	$27,273	$490,918	-$ 44,582	$ 373	-$11,146	$524,354	$238,354	640	670	640	7.82
23	18.4	$ 9,494	$26,448	$ 476,057	-$ 59,443	$ 346	-$11,889	$ 523,611	$237,611	688	722	688	7.27
25	20	$ 10,320	$ 25,622	$461,196	-$ 74,304	$319	-$ 14,861	$520,639	$234,639	737	783	737	6.79
27	21.6	$11,146	$ 24,796	$446,335	-$ 89,165	$292	-$14,861	$ 520,639	$234,639	805	856	805	6.21
29	23.2	$ 11,971	$23,971	$431,474	-$ 104,026	$264	-$ 17,338	$ 518,162	$ 232,162	878	943	878	5.70