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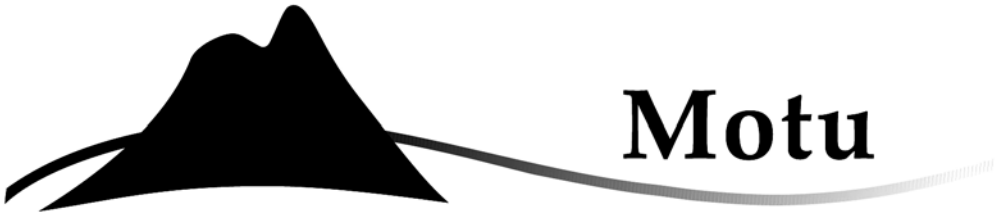

Labour productivity in Auckland firms

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Abstract

This paper examines labour productivity in Auckland, New Zealand's largest city, using microdata from Statistics New Zealand's Prototype Longitudinal Business Database. It documents a sizeable productivity premium in Auckland, around half of which is due to industry composition. There is a cross sectional correlation between productivity and employment density, reflecting differences in both physical productivity and prices. This correlation is evident both within Auckland, and comparing Auckland with other areas. The relationship between *changes* in density and *changes* in productivity is less strong. The relationship between productivity and overall or own-industry employment density varies across industries, suggesting that the nature and extent of agglomeration benefits varies. Overall, localisation effects appear stronger than urbanisation, with productivity being more strongly related to own-industry density than to overall density.

JEL classification
L25 - Firm Performance: Size, Diversification, and Scope;
R12 - Size and Spatial Distributions of Regional Economic Activity;
R3 - Production Analysis and Firm Location

Keywords
Labour productivity; Urban premium; Agglomeration

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1 Introduction

Auckland is New Zealand's largest and most densely populated city. Auckland region accounts for 33% of national employment, 40% of value added in the economy, and occupies only 2% of New Zealand's land area. Labour productivity and wages in Auckland region are also higher than in other areas of the country. Wages are around 7% higher,[1] average personal income is around 15% higher[2] and average labour productivity is around 45% higher.

At the aggregate level, labour productivity measures combine two different concepts: technical efficiency, a measure of how many goods or services a person can produce, and allocative efficiency, a measure of the value of the goods and services that are produced. Auckland's average labour productivity may be higher for various reasons. First, Auckland firms may produce a larger amount of goods and services per worker, either because they use more non-labour inputs (e.g. capital or urban infrastructure) or because they are more efficient at transforming inputs into outputs. A second potential reason for Auckland's labour productivity advantage is that firms may be able to obtain a higher price for the outputs that they produce. Third, Auckland may have a disproportionately high share of its employment involved in industries or activities for which labour productivity would be high in any location (composition effect). The current paper does not fully distinguish between these sources of labour productivity differentials. It does, however, analyse the contribution of differing industry composition, and presents industry-specific analyses that suggest a diversity of causes of Auckland's productivity premium.

The main objective of this paper is to document the extent and nature of Auckland's productivity premium, using a unique firm-level dataset, Statistics New Zealand's prototype Longitudinal Business Database (LBD). In particular, we examine labour productivity differences between the seven territorial authorities within greater Auckland and between the 370 census area units,

[1] Statistics New Zealand (2007a) reports a 4.6% hourly earnings premium for Auckland relative to the national average (including Auckland). Auckland accounts for around 33% of employment, which implies a 7% premium relative to areas outside Auckland.

[2] Author's calculations using 2006 Census data, assigning income bands to midpoints.

gauging the extent to which productivity differences can be accounted for by differences in industry composition. We examine the relationship between labour productivity and employment density as one broad indicator of possible agglomeration effects, and examine productivity premia for industries with differing spatial distributions to provide evidence on the presence of both localisation and urbanisation advantages.[3] Finally, we present maps of productivity across Auckland, as a first step towards investigating spatial (agglomeration, networks, and infrastructure) explanations of Auckland's performance.

2 Auckland's Economic Performance

It is unsurprising that Auckland's productivity and economic performance is higher than elsewhere in New Zealand. There is a clear positive relationship between urban density and good economic performance the world over – a relationship that is captured in the phrase 'agglomeration effects'. The causes of these effects are, however, still the subject of much research and debate. Recent reviews of the theoretical foundations of agglomeration effects (Duranton and Puga (2004)) and empirical evidence (Rosenthal and Strange (2004)) draw attention to the wide range of potential mechanisms through which agglomeration effects can operate, and the many different dimensions of economic performance that are subject to agglomeration economies.

As New Zealand's largest and densest city, Auckland should be expected to perform well. In addition, recent public discussions have emphasised the role that Auckland is expected to play in raising New Zealand's overall economic performance. There is a widely accepted perception that Auckland is not reaping the benefits that it should from agglomeration, and that it is consequently not delivering the economy-wide dividends that are expected of it, as illustrated in the following text from the Ministry of Economic Development's Strategy and Priorities for economic development:

[3] Localisation advantages describe advantages that accrue to a firm from locating in areas where there is a high density of same-industry employment. Urbanisation advantages refer to the advantages of locating in large dense and diverse areas,.

> "International evidence highlights the importance of having at least one outward facing, global city to lead a nation's economic development. A globally competitive city attracts world-class firms and highly skilled workers, which have significant flow-on effects throughout the economy. The concentration of activity will allow both employers and employees to benefit from specialised labour markets, allow for greater tacit knowledge flows between and within firms and research organisations, and provide the right platform for growing off a critical mass of innovation. Auckland doesn't yet play this role to the extent that major cities do in other economies."
>
> Ministry of Economic Development (2008)

The evidence for Auckland's underperformance as a city is mixed. On many indicators, Auckland is performing well relative to other regions of New Zealand, and even relative to other cities internationally. Lewis and Stillman (2005) compare Auckland's labour market performance with that of other regions and conclude that ". . . Auckland appears to be a relatively good performer and this is consistent with agglomeration economies being at work in New Zealand's largest urban concentration." For international comparisons, Ministry of Economic Development (2007) presents a range of indicators, showing Auckland's relatively good performance in areas such as quality of living, employment rate, population growth, and broadband penetration. Two prominent exceptions are Auckland's relatively poor productivity (GDP per capita) level, and low proportion of population with tertiary qualifications.

A challenge for any comparison of Auckland with international cities is the choice of comparators. Ideally, comparison should be made with cities that are of similar size and density, and that fill a similar position in the national or larger regional urban settlement system. Auckland's size and employment density are similar to a mid-sized US city[4], although comparable cities are part of a denser network of similar sized and larger cities.

New Zealand has a relatively high degree of urbanisation, with 86 percent of the population living in urban areas, compared with 74 percent (in

[4] The most similar US Urbanized areas are San Antonio TX, Riverside-San Bernadino CA, Columbus OH, Jacksonville FL, Orlando FL, Providence RI-MA and Memphis TN-MS-AR, all of which have employment in the 430,000 – 580,000 range and land area in the 1,030 to 1,300 square km range, compared with Auckland Urban Area's employment and area of 556,000 and 1,074 square km. See Appendix A.

2005) in 'more developed' countries.[5] The proportion of New Zealand's urban population that is located in the Auckland urban area ("urban primacy"), at around 34 percent, is somewhat high for a developed country, although Henderson (2000) classifies New Zealand as having "satisfactory urban concentration".[6] Auckland's place within the New Zealand or Australasian city-size distribution roughly fits the rank-size rule (Zipf's Law) found in most urban systems (Soo (2005) Gabaix (1999a)), or is slightly larger than predicted by this relationship.[7]

A priori, there appears to be little evidence that Auckland is significantly under-sized, or that agglomeration effects are abnormally weak in Auckland, given the structure of the urban settlement system of which it is a part. Nevertheless, as suggested by the quotation above, national and regional economic development policies have emphasised the need to promote the concentration of economic activity in Auckland, and the operation of agglomeration economies. It is clearly envisaged that there will be productivity gains through thicker labour markets, innovation and knowledge flows that will raise not only Auckland's economic performance but also that of New Zealand as a whole.

The argument that raising concentration in Auckland could plausibly raise New Zealand's economic performance has been eloquently asserted in a range of policy and discussion documents (eg: Skilling (2006), Auckland Regional Council (2007), Metro Project (2007) Committee for Auckland (2006)), although the presentation is often more aspirational and motivational than it is

[5] "More developed regions" comprise all regions of Europe plus Northern America, Australia/New Zealand and Japan. This is the definition used in United Nations (2008).

[6] Data are from United Nations (2008) and Statistics New Zealand (2005). The NZ urban population includes all "cities, boroughs, town districts, townships and country towns with population of 1,000 or more". Definitions for other countries vary but are broadly consistent. Urban primacy is based on urban agglomerations of 750,000 or more. For an international comparison of primacy, see also Appendix Table 1 in Junius (1997), which uses data from a previous edition of United Nations (2008).

[7] The slope of the rank-size relationship is flatter for Australasian cities than it is in many other countries, suggesting that Australasian cities are unusually highly concentrated. The two largest Australasian cities (Sydney and Melbourne) are of similar size, whereas Zipf's Law would predict that one of them would be considerably larger – about twice its current size. (See Appendix A) Gabaix (1999b) discusses a range of factors that influence the slope, and notes that the slope "allows us to get information about the archaeology of the growth processes [across cities]". Including New Zealand and Australian cities in the same ranking does not necessarily imply

evidence-based, which may reflect the severe challenges of getting clear evidence on the future potential for Auckland. Much progress has been made in developing a region-wide strategy and action plan for promoting Auckland's economic development (Metro Project (2007), Auckland Regional Council (2008))[8].

Against this background of a broad acceptance of the potential for stronger agglomeration economies in Auckland, and a practical commitment to actively promoting Auckland's growth, the objective of the current paper is to contribute to the evidence base on the strength and nature of agglomeration effects in Auckland and on patterns within Auckland.

Existing studies have analysed proximate indicators of productivity in Auckland, such as land prices (Grimes and Liang (2007)) and wages (Lewis and Stillman (2005), Paling et al (2007)). Few studies have looked directly at firm productivity measures as is done in the current paper. An exception is Maré and Timmins (2006), which looked at the overall relationship between concentration and firm productivity within New Zealand using a related data source, without a particular focus on Auckland.

3 Cities and labour productivity

It is well established that average productivity is higher in cities than in non-urban areas although there is still debate on the reasons for this advantage. Rosenthal and Strange (2004) summarise empirical evidence on the nature and sources of agglomeration effects that may give rise to urban productivity premia and Duranton and Puga (2004) survey the range of theories that have been used to provide microfoundations for agglomeration effects.

Duranton and Puga (2004) identify three sets of agglomeration mechanisms - sharing, matching, and learning. Sharing includes the use of indivisible inputs such as infrastructure, the advantages of greater variety and

integration of the two economies but serves merely to indicate the relative size of Auckland and other New Zealand cities.

[8] The action plan is organised around the 5 objectives of "Take effective and efficient action to transform Auckland's economy; Develop world-class infrastructure and world-class urban centres; Transform Auckland into a world-class destination; Develop a skilled and responsive labour force; and Increase Auckland's business innovation and export strength." Metro Project (2007)

specialisation, and risk-sharing. Matching covers improved matching between firms, between inputs and outputs, including the advantages of better matching through thick labour markets, and between suppliers and customers. Finally, learning includes a range of mechanisms that enhance knowledge generation, diffusion and accumulation.

The strength and scope of each of these mechanisms will vary across industries. Rosenthal and Strange (2004) document three dimensions along which the strength of agglomeration effects can vary – industry 'closeness', geographic proximity, and time lags. The term 'localisation' is commonly used to capture agglomeration effects that result from interactions between firms in the *same* industry, whereas 'urbanisation' refers to the broader set of effects that result from urban scale and diversity.

A commonly used summary indicator of the presence and strength of agglomeration effects is the positive relationship between employment density and productivity. While many theories of agglomeration suggest that density can lead to higher productivity, it is also possible that density is a *consequence* of productivity advantages. Cross-sectionally, such a relationship may arise due to the presence of local productive inputs (eg: a harbour).

This distinction is important for the analysis of policies that seek to increase density as a means of improving productivity, since such policies depend on density being a driver of productivity change. It is difficult to distinguish the differing sources of the density-productivity relationship from cross-sectional data alone. For instance, Ellison and Glaeser (1999)'s finding that "there remain a number of highly geographically concentrated industries in which interfirm spillovers seem important" is based on the low explanatory power of measurable 'natural advantages' in accounting for the concentration of industry employment across US states. Patterns of change over time are able to provide further insights into the potential for *changes* in density to raise productivity – do new firms choose to locate disproportionately in already dense areas? Are closures more likely in less dense areas? Are changes in density in an area associated with changes in productivity? Examining the dynamics of the density-productivity

relationship for different industries can also provide guidance on the plausibility of different agglomeration explanations of productivity performance.

In the current paper, we document the cross-sectional (2006) relationship between density and productivity at two spatial scales – first between regions and Territorial Authorities, and second between area units within Auckland. We also investigate the covariation of density and productivity within areas across time by means of fixed effects and change regressions. A positive relationship over time is consistent with either agglomeration effects or the response of employment density to product demand shocks. A negative relationship may arise due to congestion effects, or due to labour supply shocks that lower average labour productivity.

In order to shed light on the relative importance of localisation and urbanisation effects, we estimate, for selected groups of industries, the elasticity of productivity with respect to overall employment density and own-industry density.

3.1 Price effects

Our measure of labour productivity is 'value added per worker', where value added is the value of a firm's output less the value of non-durable intermediate inputs used in production. Excluded from intermediate inputs are compensation of employees, consumption of fixed capital (depreciation), and net indirect taxes. For a firm to be indifferent between locating in Auckland and elsewhere, value added would have to be higher in Auckland to cover the higher cost of labour and of property capital.[9] The firm is able to achieve the necessary higher value added if agglomeration effects lead to higher output for the same level of inputs, due to any of the agglomeration mechanisms outlined above. Alternatively, value added may be higher in Auckland if firms are able to charge a higher price for their output or if they can secure intermediate inputs at lower prices. A higher value added *per worker* may also arise if Auckland firms use more capital per worker than non-Auckland firms.

[9] At the firm level, property rental is included as intermediate consumption but the return to property capital for owners of property is not, and so will lead to higher measured Value Added.

A measured labour productivity premium in Auckland is likely to reflect a combination of these factors – higher physical or technical productivity, higher output prices, and possibly lower input prices or unit costs, and higher capital to labour ratios. Average labour productivity measures will also be influenced by the composition of employment. Average labour productivity in Auckland will be higher if Auckland has a higher proportion of firms in industries or performing functions (eg: head office functions) that would be more productive wherever they are located.

It is not the purpose of this paper to distinguish fully between these sources of productivity differentials. It does, however, analyse the contribution of industry composition, and presents industry-specific analyses that suggest a diversity of causes of Auckland's productivity premium. Analysis of the impact of differing capital intensity and of local prices remain as priorities for future research.

4 Data

The primary dataset for this study is Statistics New Zealand's prototype Longitudinal Business Database (LBD). The data were accessed in the Statistics New Zealand Data Laboratory under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The core of the LBD dataset is the Longitudinal Business Frame (LBF), which provides longitudinal information on all businesses in the Statistics New Zealand Business Frame since 1999, combined with information from the tax administration system. The LBF population includes all economically significant businesses.[10]

The LBF contains information at both the enterprise level and the plant level. At any point in time, an enterprise will contain one or more plants, and each plant will belong to only one enterprise. Plants are assigned a 'permanent business number' (PBN) that identifies them longitudinally. The longitudinal links are established through the application of a number of continuity rules that

[10] A business is economically significant if it a) has annual Goods and Services Tax (GST) turnover of greater than $30,000; or b) has paid employees; or c) is part of an enterprise group; or

allow PBNs to be linked even if they change enterprises or tax identifier (Seyb (2003), Statistics New Zealand (2006)). The LBF provides monthly snapshots of an enterprise's industry, institutional sector, business type, geographic location, and employee count.[11] For PBNs, there is monthly information on industry, location, and employee count. We apply an enterprise's industry to all plants within the enterprise, which will lead to some imprecision in the estimation of and adjustment for industry productivity differentials.

The LBD is a research database that includes the LBF as well as a range of administrative and survey data that can be linked to the LBF. The primary unit of observation in the LBD is an enterprise observed in a particular year. The current study uses business demographic information from the LBF, linked with financial performance measures (from the Annual Enterprise Survey, and various tax returns, including IR10s and the GST-sourced Business Activity Indicator data), and measures of labour input (working proprietor counts from IR10 forms, and employee counts for PBNs from PAYE (pay-as-you-earn income tax) returns as included in the Linked Employer-Employee Dataset).

Labour productivity is measured as current-price value added per worker.[12] The primary source used to obtain a value added measure is the Annual Enterprise Survey (AES). The AES is a postal sample survey, supplemented with administrative data from tax sources. We use postal returns from AES to provide annual value added for the firm-specified financial year. This information is available for around 10% of enterprises, which are disproportionately larger firms, accounting for around 50% of total employment in New Zealand.

Where AES information is not available, we use a proxy for value added, based on net sales as reported in GST returns, adjusted for changes in

d) is part of a GST group; or e) has more than $40,000 income reported on tax form IR10; or f) has a positive annual GST turnover and has a geographic unit classified to agriculture or forestry.

[11] Institutional sector distinguishes Producer Enterprise; Financial Intermediaries; General Government; Private not-for-profit serving households; households; and rest of the world.

[12] Changes over time in current price value added will reflect both quantity and price changes. The use of double deflation to isolate quantity adjustment over time at the industry level is possible using the Statistics New Zealand PPI input and output indices but only for a selection of 1-digit and 2-digit industries. Measures of productivity premia for Auckland firms within the same industry will reflect both quantity and relative price differences. Spatial price indices are not available for the separate identification of quantity differences.

stocks. A measure of stock adjustment is taken from IR10 tax forms, and where this is unavailable, the change in stocks is imputed from the ratio of stock change to sales within each 3-digit ANZSIC industry.

The GST information comes from Statistics New Zealand's Business Activity Indicator data. In some cases, GST returns are provided for groups of enterprises, or at lower than monthly frequency. In the BAI data, GST return information is allocated to enterprises within groups, and if necessary across time to derive a monthly track. In the current study, we aggregate BAI-sourced value added to group level, to reduce possible measurement error in value added per worker estimates arising from the allocation of group returns to enterprises operating in different locations. Within each group, we deduct value added as measured in AES postal returns from the group's aggregate BAI value added, and allocate this residual value added to non-AES-reporting enterprises in proportion to enterprise labour input, which has the effect of masking some labour productivity differences across enterprises.[13]

A measure of monthly labour input is calculated for each PBN as the sum of rolling mean employment (RME) and a share of working proprietor input in the enterprises to which the PBN belongs. RME is the average number of employees on the PBN's monthly PAYE return in the 12 months of the enterprise's financial year, as recorded in the LEED data. PAYE information is not always provided at the PBN level, and in LEED, there is some allocation of PAYE information to PBNs as outlined in Seyb (2003). The annual number of working proprietors in each enterprise is available in the LEED data, based on tax return information. Labour input from working proprietors is allocated to the PBNs within each enterprise in proportion to the PBN's RME. Where an enterprise has only working proprietors, the working proprietor input is allocated equally across all component PBNs. There is a large number of PBNs in each year for which RME is zero. Labour productivity is undefined for these PBNs unless working proprietor information is also incorporated in labour input. Using

[13] This aggregation is currently applied to all enterprises belonging to a group. It may be possible to identify groups for which BAI has allocated group returns, and restrict aggregation to those groups only. This would reduce the extent to which productivity differences within groups are masked.

working proprietor information increases the number of plants with usable labour productivity information by 80 to 100 percent, and increases labour input by 13 to 20 percent.[14]

For each year from 1999/2000 to 2005/06 (referred to as 2000 to 2006 respectively for the remainder of the paper), we select plants that belong to an enterprise that: a) is always private-for-profit ; b) is never a household or located overseas; c) has non-missing industry information; and d) is not in the 'Government Administration and Defence' industry.[15]

We exclude plants for which location (area unit, territorial authority, or regional council) information is missing, and plants in area units outside territorial authorities (island and inlets). In order to maintain a consistent population that can support geographic tabulations and maps later in the paper while protecting confidentiality, some additional exclusions[16] are applied. Finally, we drop observations where labour input is zero, and about half of one percent of plant observations where the absolute value of value added per worker is greater than $1m.

4.1 Firm performance by location

The geographic location of economic activity is better captured by the location of PBNs than by the location of enterprises. However, value added is available only for enterprises. An estimate of firm performance by geographic location is obtained by allocating enterprise value added to PBNs in proportion to the PBNs labour input. This approach constrains value added per worker to be

[14] The increases due to working proprietor inclusion decrease monotonically over time. The contribution to the number of plants (to labour input) are 103% (20%) in 2000, and 79% (13%) in 2006. The impacts are particularly pronounced in single-PBN enterprises that do not belong to an enterprise group. In 2006, the impacts were 101% (24%) and in 2000 they were 142% (37%). There will be some double counting of working proprietors if they also draw PAYE earnings, as they will also appear in the *rme* employee count.

[15] Formally, these restrictions refer to a) business type 1-6 (individual proprietorship, partnership, limited liability company, co-operative company, joint venture and consortia, branches of companies incorporated overseas); b) Institutional Sector is never 'household' or 'located overseas' and ANZSIC industry is not Q97 (Households employing staff); c) ANZSIC division M.

[16] Specifically, we exclude Area Units in the Chatham Islands, the Middlemore Area Unit in Auckland (521902), and six Auckland Area Units that are tidal, inlets or islands

constant within enterprises, reducing measured geographic differences in productivity. Where enterprise value added is obtained from BAI group returns, the averaging is more severe, constraining labour productivity to be constant for all PBNs in non-AES-reporting enterprises.

The allocation of enterprise or group value added to PBNs is complicated by the fact that, within a financial year, a PBN may belong to more than one enterprise, and an enterprise may belong to more than one group. Appendix B summarises the treatment of such cases.

To control for the impact of averaging, mean productivity by location is derived from an employment-weighted regression of labour productivity on a set of location *share* covariates. Average value added per worker (VAPW) within a group (s) is the employment-weighted average of location-specific value added per worker. Because we know the employment share of each group that is in each location, we can statistically recover the underlying location-specific VAPW, using the following regression specification.

$$VAPW_{st} = \sum_{j=areas} \gamma_j \left[\frac{rme_{sjt}}{rme_{st}} \right] + e_{st} \qquad (1)$$

The subscript *s* here refers to a set of plants over which value added per worker has been averaged. The term in brackets captures, for each area *j*, the proportion of employment in *s* that is located in area *j*. If each group operated in only one location, this would be equivalent to including a dummy variable for each location. The resulting estimated coefficients γ_j are estimates of the underlying mean productivities in each location. The term e_{st} captures idiosyncratic productivity in the set of plants *s* beyond what can be explained by average productivities in the locations in which the plants operate. Equation (1) is estimated separately by year.

4.2 Adjustment for differences in industry composition

Some of the differences in productivity across areas may be due to the different mix of industries in different areas. To gauge the significance of such

(615900,616001,617102,617702,617903,617604). Tidal areas of Waiheke Island (AU 520804)

industry composition differences, we also calculate an alternative set of estimated locational premia based on a regression similar to that shown in equation 1, but including a set of 3-digit industry dummies.

$$VAPW_{st} = \sum_{j=areas} \tilde{\gamma}_j \left[\frac{rme_{sjt}}{rme_{st}} \right] + \sum_{k=industry} \delta_k + e_{st} \qquad (2)$$

The equation again contains a full set of share covariates. The added industry intercepts (δ_k) are estimated relative to national means and thus have zero mean, allowing the estimated $\tilde{\gamma}_j$ coefficients to capture the level of local productivity that would be observed if each location had the national industry mix. The adjustment removes the influence of cross-industry differences such as capital or energy intensity and identifies geographic productivity premia solely from within-industry variation across locations. Equation (2) is estimated separately by year.

Having obtained estimates of average labour productivity within each area, we calculate the relative performance of Auckland or of areas within Auckland by dividing the area's average labour productivity ($\tilde{\gamma}_j$) by labour productivity averaged over all areas outside the Auckland region.

This approach can be extended to adjust for other plant-level differences that may influence productivity, although in the current paper, industry composition is the only adjustment made.

5 Results

The results in this section shed light on four main questions about the labour productivity of Auckland firms:

- How much higher is the productivity of Auckland firms compared with non-Auckland firms?
- How much of the productivity premium is accounted for by the mix of industries in Auckland?
- How does labour productivity vary *within* Auckland?

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are grouped with Waiheke Island itself.

- What is the relationship between labour productivity and the density of overall and own-industry employment?

In addressing each of these questions, we focus primarily on the patterns for the most recent year for which we have data – 2006. In addition, we report on patterns of change over the 2000-2006 period.

5.1 Auckland's Relative productivity

Average labour productivity in the Auckland central business district (CBD[17]) is more than twice as high as average labour productivity outside the Auckland Region. Auckland City as a whole, which accounts for around one sixth of New Zealand's labour input, has a premium of 50 to 80 percent. The broader Auckland Region has a productivity premium of roughly 30 to 50 percent, and accounts for a third of national labour input.[18] The Auckland Urban Area[19] contains the densest areas of the Auckland Region and accounts for most of the Auckland Region's employment and output, showing a productivity premium 5 to 10 percentage points above that of the region as a whole.

For each of the four definitions of Auckland, Table 1 presents the average labour productivity, in nominal dollars, and as a proportion of average labour productivity in the rest of New Zealand (excluding Auckland region). The table shows that the relative size of the productivity premia for the different definitions of Auckland has been maintained throughout the 2000 – 2006 period of the study, despite fluctuation from year to year, and a peak in 2004. In general, productivity in the four areas moves together, suggesting that the fluctuations are due either to changes in areas outside Auckland, or to Auckland-wide movements. The year-to-year changes in the level of value added per worker should be interpreted with caution as they reflect both price and quantity movements. Movements in the relative measures, however, are unaffected by aggregate price

[17] The Auckland CBD is here defined as the area contained in the following six (2006) Area Units: 514100-Freemans Bay; 514101-Auckland Harbourside; 514102-Auckland Central West; 514103-Auckland Central East; 514200-Newton; and 514301-Grafton West. This is also the definition used in the Auckland City Council's Growth Strategy (Auckland City Council (2003)).

[18] These productivity premia are significantly larger than premia estimated from regional GDP estimates and business demography statistics. See Appendix E

[19] For a map of the Auckland Urban Area, See Appendix C.

changes, although they will incorporate location-specific price and quantity variation.

Similar patterns of relative productivity are evident at various quantiles of the productivity distribution. Median productivity is generally between 70 and 80 percent of average productivity and quantile ratios (eg: P90/P50 or P50/P10) are similar across cities, TAs and regions.[20]

Table 1: The Auckland Productivity Premium - 2000-2006

	2000	2001	2002	2003	2004	2005	2006
New Zealand (area= 268,680,km2)							
New Zealand Average VAPW	$42,516	$43,212	$45,865	$45,818	$47,389	$49,675	$52,037
Non-Auckland VAPW	$37,596	$38,731	$41,523	$39,890	$40,452	$43,009	$45,440
Ind-adjusted Non-Akld VAPW	$39,665	$40,312	$43,339	$42,486	$43,313	$45,546	$48,126
Aggregate labour input	1,554,910	1,618,970	1,642,140	1,672,480	1,717,560	1,762,650	1,782,920
Employment Density (per km2)	5.8	6.1	6.2	6.3	6.4	6.6	6.7
Observations (plants)	344,718	346,683	339,331	362,267	363,267	363,286	353,385
Auckland Region (area=4,993 km2)							
Average VAPW	$52,685	$52,438	$54,932	$58,127	$61,551	$63,193	$65,375
- relative to non-Akld	140%	135%	132%	146%	152%	147%	144%
Ind-adjusted VAPW	$48,408	$49,182	$51,139	$52,736	$55,711	$58,049	$59,944
- relative to non-Akld	122%	122%	118%	124%	129%	127%	125%
Labour Input	507,060	529,280	531,710	543,640	564,710	582,120	589,990
Share of labour input	33%	33%	32%	33%	33%	33%	33%
Employment Density (per km2)	102	106	106	109	113	117	118
Auckland Urban Area (area=1,074 km2)							
Average VAPW	$55,520	$55,016	$57,776	$61,111	$64,488	$66,057	$68,435
- relative to non-Akld	148%	142%	139%	153%	159%	154%	151%
Ind-adjusted VAPW	$50,449	$51,223	$53,161	$54,598	$57,744	$60,046	$61,943
- relative to non-Akld	134%	132%	128%	137%	143%	140%	136%
Labour Input	476,880	498,214	499,812	511,192	531,173	548,122	556,286
Share of labour input	31%	31%	30%	31%	31%	31%	31%
Employment Density (per km2)	444	464	465	476	495	510	518
Auckland City (area=620 km2)							
Average VAPW	$61,456	$58,864	$63,744	$67,854	$72,666	$74,624	$76,930
- relative to non-Akld	163%	152%	154%	170%	180%	174%	169%
Ind-adjusted VAPW	$53,861	$53,175	$56,529	$58,825	$62,733	$65,228	$66,836
- relative to non-Akld	136%	132%	130%	138%	145%	143%	139%
Labour Input	245,180	260,500	258,050	264,630	272,330	279,680	283,610
Share of labour input	16%	16%	16%	16%	16%	16%	16%
Employment Density (per km2)	395	420	416	427	439	451	457
Auckland CBD (area=5.8 km2)							
Average VAPW	$90,966	$82,603	$92,272	$94,178	$101,951	$105,002	$106,873
- relative to non-Akld	246%	217%	226%	240%	256%	248%	239%
Ind-adjusted VAPW	$67,363	$65,332	$72,308	$72,026	$78,468	$80,025	$81,638
- relative to non-Akld	172%	165%	169%	171%	183%	178%	172%
Labour Input	66,050	73,670	72,850	73,420	73,920	76,010	78,650
Share of labour input	4%	5%	4%	4%	4%	4%	4%
Employment Density (per km2)	11,408	12,724	12,582	12,680	12,767	13,128	13,584

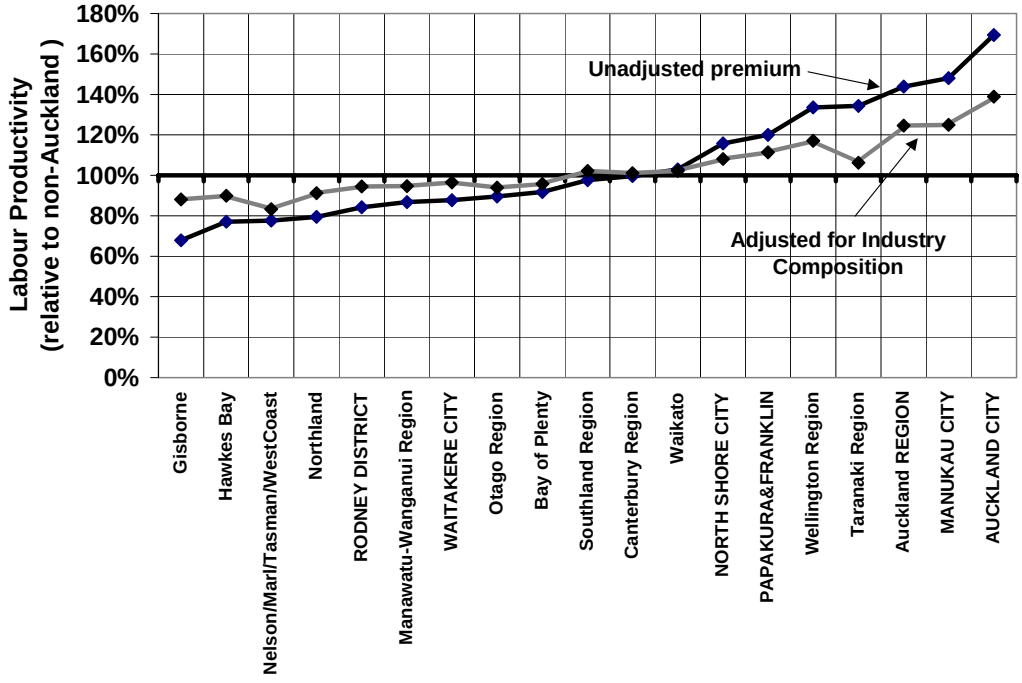
Notes: VAPW is current-price Value Added Per Worker, as defined in the text. Relative VAPW is the area's VAPW relative to the average VAPW for areas outside the Auckland region.

[20] Waitakere and North Shore are slight exceptions. The ratio of area median to non-Auckland median for these cities is slightly higher than the ratio of averages, due to slightly less skewed productivity distributions – these cities have a slightly less pronounced upper tail of very high productivity firms.

As suggested by the difference between the Auckland CBD and Auckland Region productivity premia, there is productivity variation between different areas within Auckland. Figure 1 shows, for 2006, the relative performance of the seven different Territorial Authority (TA) areas within Auckland, together with Regional Council Areas including Auckland. Two of the Auckland TAs (Papakura and Franklin) are pooled together, as are some of the RC areas.[21]

Of the areas within Auckland, Auckland and Manukau Cities have the highest relative productivity, of 169% and 139% respectively. In contrast, both Waitakere (88%) and Rodney (84%) have lower average productivity than the non-Auckland average. Auckland region overall is the region with the highest average productivity (144%), followed by Taranaki (134%) and Wellington (134%).

Figure 1: Productivity of Auckland TAs, compared with other Regional Council Areas (2006)



An alternative measure of productivity and the productivity premia is also presented in Figure 1 and Table 1, adjusting for differences in industry

[21] These groupings were chosen to allow the release of industry by area tables while still

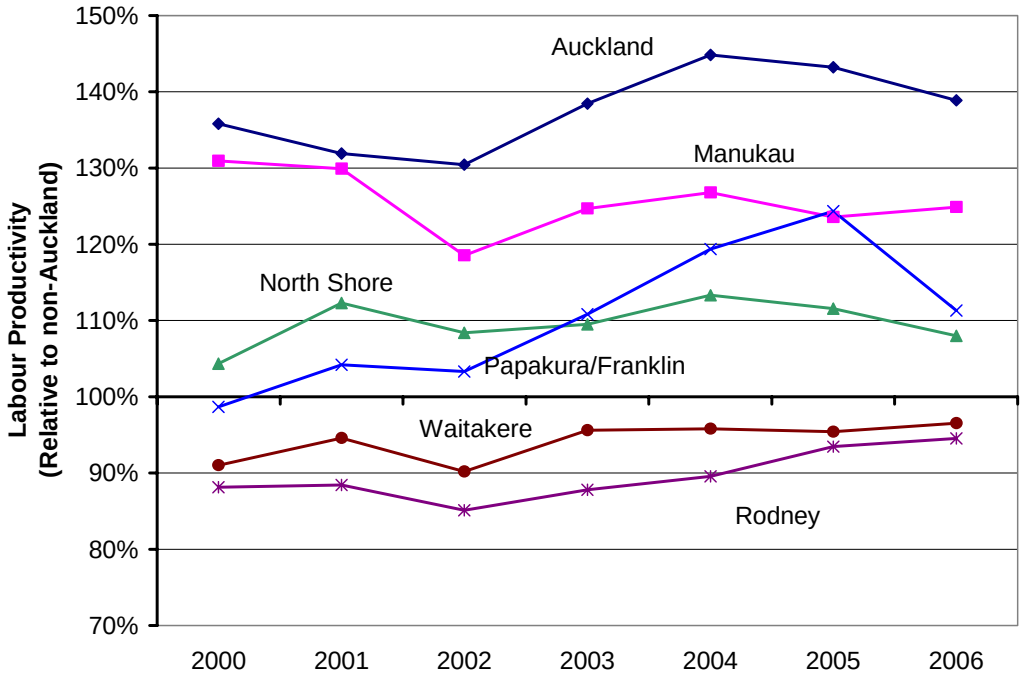
composition, as discussed in 4.2. The flatter line in Figure 1 shows the relative productivity profile for 2006, adjusted for differences in industry composition. Part of the reason that Auckland's productivity is high is that Auckland has a relatively high share of industries that have high average productivity nationally. Industry composition is a significant contributor to Taranaki's high average productivity. Taranaki's unadjusted relative productivity of 134 percent is reduced to just 106 percent once adjustment is made for the over-representation of high productivity industries – mainly in the combined Mining and Quarrying/ Electricity. Gas and Water groups.

The adjusted figures in Table 1 show that differences in industry composition account for about 45 percent of Auckland's unadjusted productivity premium, although even the adjusted premia are substantial. The 2006 Auckland CBD premium is reduced from 139 percent to 72 percent, and the premium for the Auckland Region is reduced from 44 percent to 25 percent. Auckland Region accounts for 33 percent of national labour input, but has disproportionately large shares of employment in Wholesale Trade (49%), Communication Services (48%), Finance and Insurance (46%), Education (46%), Property and Business Services (42%), and Cultural and Recreational Services (42%). Auckland shares of Agriculture (6%) and Mining/Electricity, Gas and Water (9%) are low. The productivity premium that remains after controlling for industry composition must result from the fact that there is an Auckland productivity premium *within* at least some industries. An analysis of productivity premia by 2-digit industry is presented in section 5.3.

Table 1 showed the time pattern of relative productivity for Auckland City from 2000 to 2006. In Figure 2, we show the trends for each of the Auckland TAs. The ranking remains stable with the exception of Papakura/ Franklin, which overtook North Shore in 2003. Auckland also appears to have experienced particularly strong growth in relative productivity between 2002 and 2004.

meeting the requirement to protect confidentiality.

Figure 2: Changes in (adjusted) relative productivity of Auckland TAs: 2000-2006



Note: Relative productivity has been adjusted for differences in industry composition.

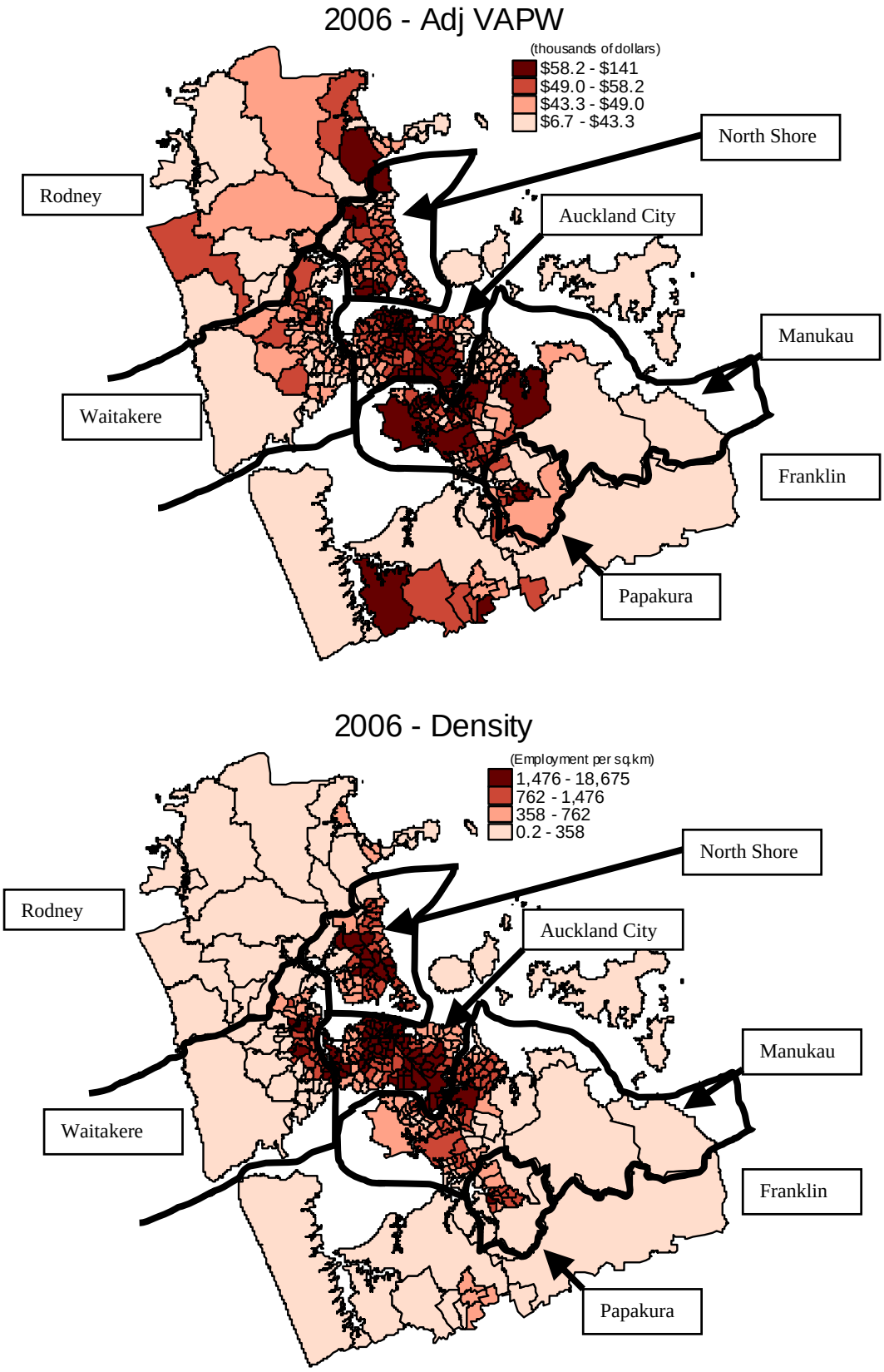
5.2 The Geography of Auckland productivity

This section provides a more detailed account of productivity variation *within* Auckland than is shown in Figure 2. Within each of the TAs shown in Figure 2 there are distinct zones of high and low productivity. The upper panel of Figure 3 is a shaded map (choropleth) of selected area units within the Auckland region, shaded to reflect relative labour productivity levels in 2006.[22]

Auckland City's high labour productivity reflects three high productivity zones – Auckland Central, extending southwest through to Mt Roskill; southern suburbs including Ellerslie, Panmure and Onehunga; and also Avondale. Manukau City's high productivity zones are broadly spread through the central and western parts of the city, including Otahuhu in the north, through Mangere, Wiri and Manurewa. Whitford (Turanga area unit) also shows up on the

[22] Labour productivity has been spatially smoothed using Euclidean distance and an Epanechnikov kernel with a bandwidth of 2km. For purely presentational reasons, the map excludes some Northern Area Units within Rodney District, including Warkworth. The broad spatial patterns are persistent over time – Appendix D compares maps for 2000 and 2006.

Figure 3: Geographic Variation in Productivity within Auckland (2006)



map as a high-productivity zone, although it has low employment density and only around 500 jobs in any year. The highest productivity areas in North Shore City are in Northcote and Birkenhead – across the Harbour Bridge from Auckland Central, around Albany, and in the low density area of Okura and Long Bay in the north of North Shore City. The remaining TAs within Auckland Region have relatively small zones of high productivity – around central Papakura in Papakura District, around Glenbrook in Franklin District, and around Silverdale in Rodney District.

5.2.1 Productivity and Density

One of the key differences between Auckland and the rest of New Zealand, and one that is frequently cited as a likely factor in Auckland's productivity premium is the density of employment. Overall in 2006, New Zealand had 6.7 jobs per square kilometre. Auckland Region had 119 jobs per square kilometre (See Table 2).

Table 2: Employment Density within Auckland - 2000-2006
Jobs per square kilometre

	year						
	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Auckland City	424	450	446	457	471	483	490
(excluding islands)	*1586*	*1686*	*1668*	*1711*	*1759*	*1806*	*1832*
Auckland City Islands	*5*	*5*	*5*	*6*	*6*	*6*	*6*
North Shore City	546	557	566	594	628	651	658
Manukau City	168	176	181	178	187	195	201
Papakura District	128	128	130	138	143	148	146
Waitakere City	119	120	120	124	128	132	132
Franklin District	18	18	18	18	19	19	19
Rodney District	11	11	11	12	12	13	13
Auckland Region	102	107	107	110	114	118	119

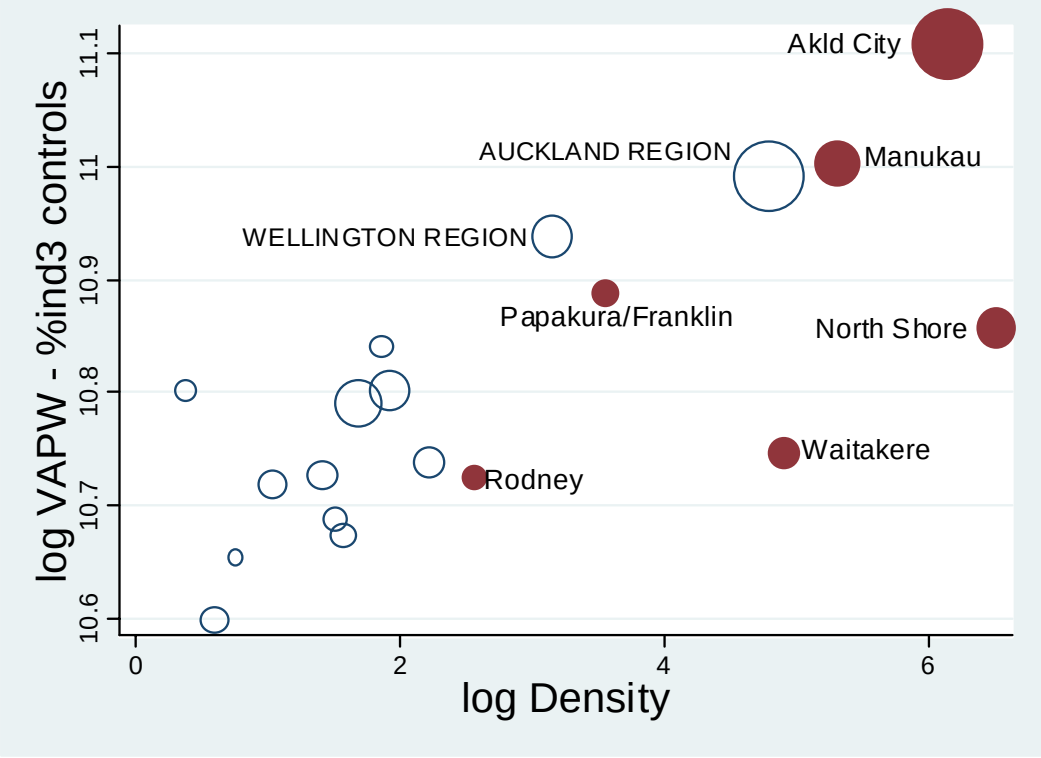
Surprisingly, the TA with the highest employment density is not Auckland City, but North Shore City. This is, however, due to the inclusion of low-employment-density offshore islands in Auckland City. Table 2 presents separate employment density measures for Auckland City including and excluding the offshore islands. If the offshore islands are excluded, Auckland City has the highest employment density, of 1832 jobs. Manukau City had the second highest labour productivity but ranked only third on employment density – partly because over half of Manukau's land area lies in two large low-density area units

(Clevedon and Kawakawa-Orere). The exclusion of offshore islands from Auckland City has virtually no impact on average labour productivity, as less than 1 percent of Auckland's employment is offshore.

Productivity and Density variation between Regions

Figure 4 shows a positive cross-sectional relationship between employment density and labour productivity for the Regional Council groupings used in Figure 1, where labour productivity is measured as the log of average labour productivity for the geographic area. The positive relationship is quantified in the first column of Table 3. The coefficient of 0.062 implies that an area with density twice as high as the average will have productivity that is 6.2% higher than average.[23] The relationship is statistically significant and similar in size to the range of estimates summarised by Graham (2005b).

Figure 4: Productivity and Density across Regions and Auckland TAs (2006)



Note: The size of symbols is proportional to average employment levels within each area. Shaded symbols are for Auckland TAs. Other symbols are for Regional Council groupings.

[23] If offshore Islands are excluded from Auckland City, the estimated slope in the first column drops to 0.055.

The fixed effects estimate in the second column of Table 3 reflects the relationship between density and labour productivity for a given area over time. The relationship is no longer significant and the coefficient estimate is negative, suggesting a weak tendency of increased density to be associated with lowered productivity. The strong cross-sectional relationship is more closely related to regional differences that were relatively stable over the seven years of our sample, and not to changes over time within areas. It may also be that random fluctuations within the seven years of our sample period mask agglomeration dynamics that operate over longer timeframes.

Table 3: Density and Labour Productivity - Regression estimates across Regional Councils and Auckland Territorial Authorities

Dependent Var: ln(VAPW)	*Least Squares*	*Area Fixed Effects*	*First Difference*	*Six-year Difference*
ln(empl density)	0.062	-0.049	-0.262	-0.299
	(0.004)**	(0.184)	(0.270)	(0.320)
Year intercepts	Yes	Yes	Yes	Yes
Observations	126	126	108	18
R-squared	0.72	0.82	0.27	0.05

Notes: All regressions are weighted by mean area employment. Each observation is for a combination of year and geographic area (Auckland TAs and non-Auckland RCs). Standard errors in parentheses. * significant at 5%; ** significant at 1%

Productivity and Density variation within Auckland

The relationship between density and labour productivity is somewhat different when we look across different areas within Auckland. Within the denser central areas of Auckland City and Manukau, there is a noticeable correspondence between area units with high relative productivity and those with high employment density. The visual similarity is evident by comparing the two panels of Figure 3. The relationship is shown graphically in Figure 5, which plots the log of area average productivity against the log of area 'effective employment density'. Effective density is a geographically smoothed measure of density. Smoothing is desirable when examining employment density for area units as it accounts for the influence of nearby dense area units. Specifically, we use the Graham (2005b) effective density measure which is calculated using the following formula:

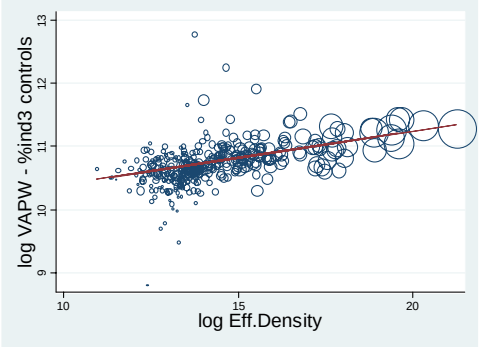
$$Eff.Dens = \frac{E_i}{\sqrt{A_i/\pi}} + \sum_{j}^{i \neq j} \frac{E_j}{d_{ij}} \qquad (3)$$

where E_i is the employment in area unit i; A_i is the land area of area unit i; and d_{ij} is the distance in km between area units i and j. Panel (a) of Figure 5 shows a clear positive relationship.

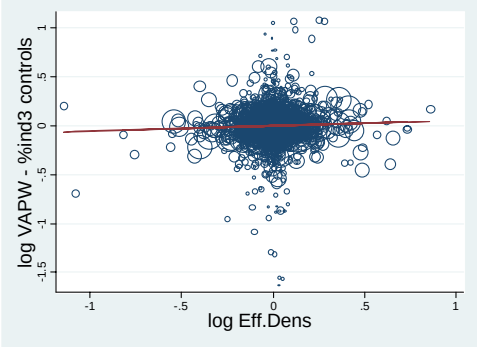
To quantify the elasticity of productivity with respect to density across area units, we estimate the relationship between the log of average labour productivity and log effective density, using the same approach as used in Table 3 for cross-regional analysis. The results are reported in Table 4. The first column reports the estimate from weighted least squares estimation (weighting area units by their mean employment level), controlling for year effects. The coefficient of 0.086 implies that an area with employment density that is twice as high as that of another area has value added per worker that is 8.6% higher.

Figure 5: Relationship between Effective Density and Labour productivity

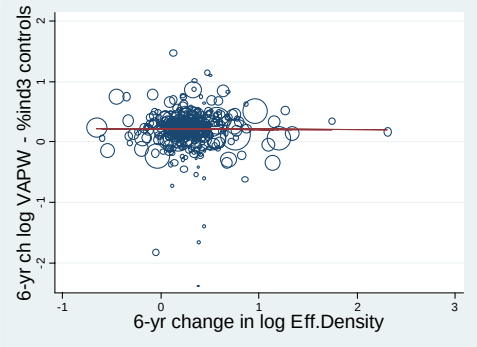
(a) Level of Density and Level of Labour Productivity



(b) Area Fixed Effects relationship (Partial Regression Plot)



(c) *Changes* in Density and *Changes* in Labour Productivity



Notes: Each circle represents an area unit within Auckland. The size of the circles is proportional to the level of employment in each area unit.

The relationship is identified both from cross sectional variation (areas with higher productivity also have higher density) and from within-area time variation (when productivity increases in an area, so does density). As noted

above, the cross sectional relationship reflects a spatial equilibrium pattern, as well as a possible functional relationship between density and productivity. A tighter test of the link between density and productivity is obtained by examining within-area time variation alone. The second column of Table 4 presents such an estimate, obtained from fixed effects estimation. For a given area unit, productivity and density increase together, with a doubling of density associated with productivity that is 5.4% higher – still a sizeable positive relationship, although the precision of the estimate is considerable smaller, as reflected in the tenfold increase in the standard error. A graphical representation of this fixed effect relationship is shown in panel (b) of Figure 5.

Table 4: Effective Density and Labour Productivity - Regression estimates within Auckland

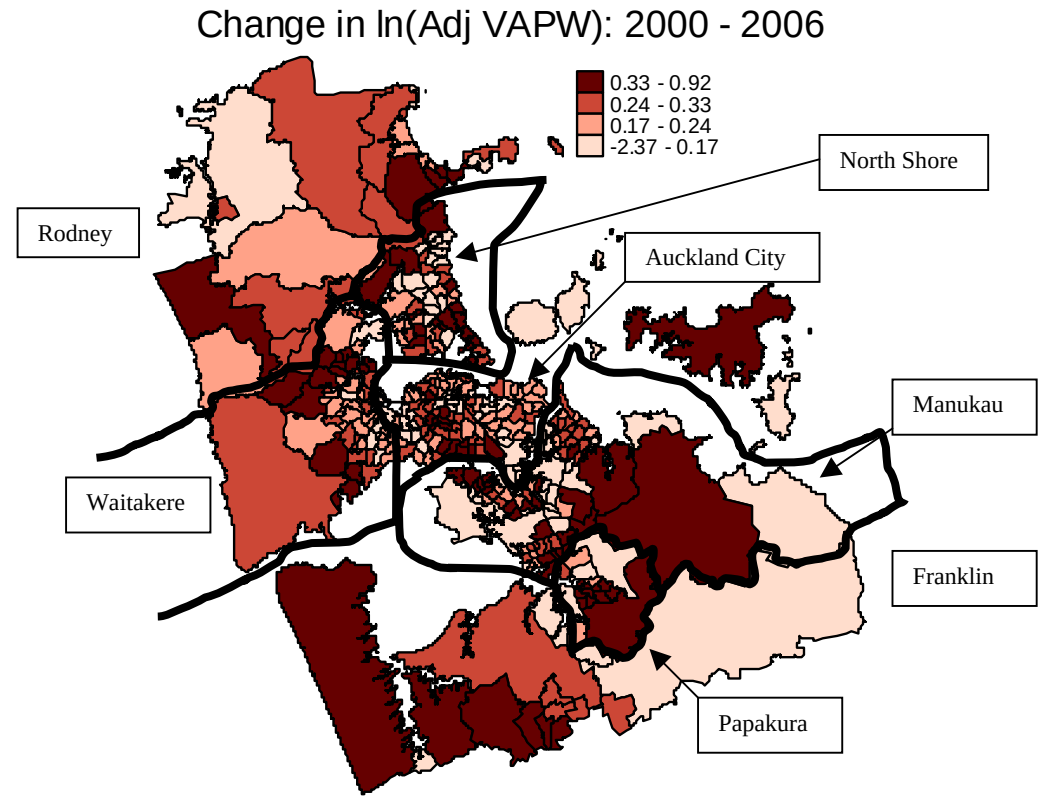
Dependent Var: ln(VAPW)	*Least Squares*	*Area Fixed Effects*	*First Difference*	*Six-year Difference*
ln(Eff. density)	0.086	0.054	0.024	-0.008
	(0.002)**	(0.019)**	(0.033)	(0.034)
Year intercepts	Yes	Yes	Yes	Yes
Observations	2579	2579	2206	368
R-squared	0.45	0.27	0.01	0.00

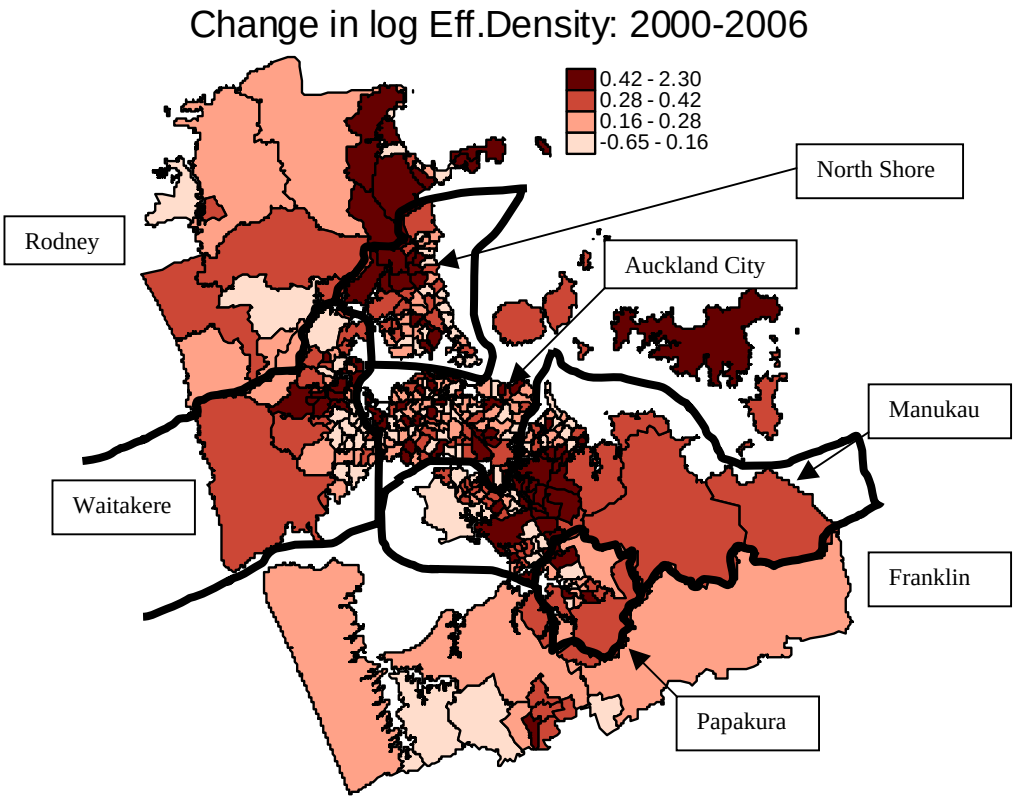
Notes: All regressions are weighted by mean area employment. Each observation is for a combination of year and Area Unit within Auckland. Standard errors in parentheses. * significant at 5%; ** significant at 1%

The third column of Table 4 reports estimates of the relationship between year-to-year changes in productivity and year-to-year changes in density. The relationship becomes statistically insignificant, with a coefficient of 0.024. Similarly, changes in density and productivity between the first and last periods of the sample period are not strongly related as shown in the final column of the table. Maps of the six-year changes are shown in Figure 6 and a corresponding graph is shown in panel (c) of Figure 5.

The implication of these patterns is that, within Auckland, firms in denser areas are, on average more productive, but that increasing density is not necessarily associated with an increase in productivity. The significant fixed effect estimate is consistent with a positive association between density and productivity, although the lack of a significant relationship in the first difference and six-year difference specifications lessens the support for this inference, and suggests the need for a fuller examination of the dynamics of this relationship.

Figure 6: Geographic Variation in Productivity Change within Auckland (2000 - 2006)





5.3 Localisation and Urbanisation

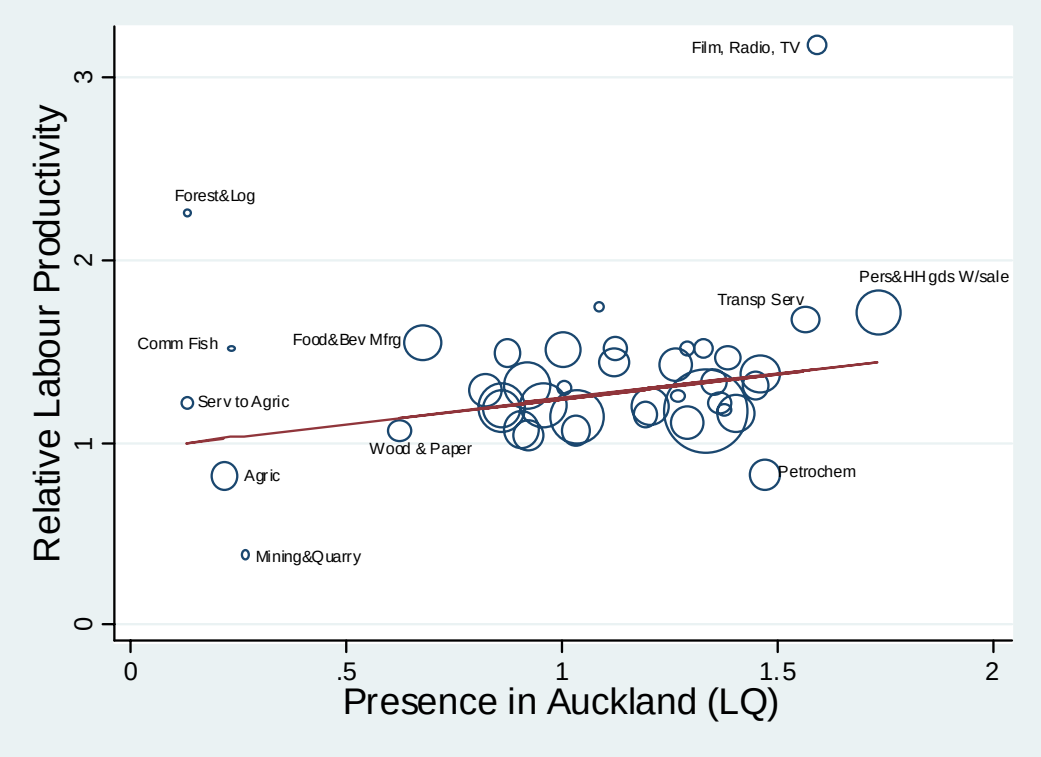
The relationship between density and labour productivity is a coarse summary measure that may mask variation in the importance of density across different industries, and in the nature of agglomeration mechanisms that operate in different industries. To shed light on the size and nature of agglomeration effects for different industries, this section provides a more detailed industry-level examination of the relationship between labour productivity and employment density, distinguishing the relative importance of own-industry employment density (localisation).

Figure 7 plots, for Auckland Region, each industry's relative productivity against an index of the industry's prevalence in Auckland.[24] Relative productivity within industries is measured as the difference between the log of average industry productivity in Auckland and that in areas outside Auckland Region. The data are for 2006 although the patterns for other years are very similar.

Relative productivity is highest for the Motion Picture Radio and TV Services industry (P91). This industry in Auckland is more than 3 times as productive as the same industry outside Auckland. Furthermore, Auckland has a disproportionate share of this industry. Other industries that are over-represented in Auckland also tend to have high relative productivity, albeit to a more modest extent. Overall, the upward sloping regression line shows the generally positive relationship between industries' prevalence in Auckland and the size of their Auckland productivity premium, consistent with positive selection of industries – the industries that benefit most from being in Auckland disproportionately locate there.

[24] The Auckland productivity premium is measured as a log-difference – mean productivity is calculated for each industry both within and outside Auckland. Each mean is logged and the Auckland/non-Auckland difference calculated. The 'prevalence' index used is the locational quotient (*LQ*), which expresses the proportion of the industry's employment that is in Auckland as a ratio to the proportion of all employment that is in Auckland. A value of 1 indicates that the industry is as prevalent in Auckland as it is nationally.

Figure 7: Relative Auckland Productivity and Presence in Auckland: within industries (2006)



Note: The size of the plotting symbols is proportional to the level of Auckland employment in each industry. The fitted regression line is based on an employment-weighted regression.

Industry prevalence in Auckland is one dimension of industry location patterns but industries also vary in their location patterns within Auckland. We summarise the degree of geographic concentration within Auckland for each industry using a Maurel-Sedillot index (*MS*) (Maurel and Sedillot (1999)). The *MS* index is an estimator of the degree of correlation in firms' location decisions and is defined as:

$$MS = \frac{\frac{\sum_i s_i^2 - \sum_i x_i^2}{1 - \sum_i x_i^2} - H}{1 - H} \qquad (4)$$

where s_i is the proportion of an industry's employment in area unit i; x_i is the proportion of total employment that is in area unit i; and H is a Herfindahl index of industrial concentration across plants.[25] A high value of the index

[25] For the derivation and interpretation of this index, see Maurel and Sedillot (1999) and Maré (2005).

indicates that industry employment is concentrated in particular area units, consistent with localisation.

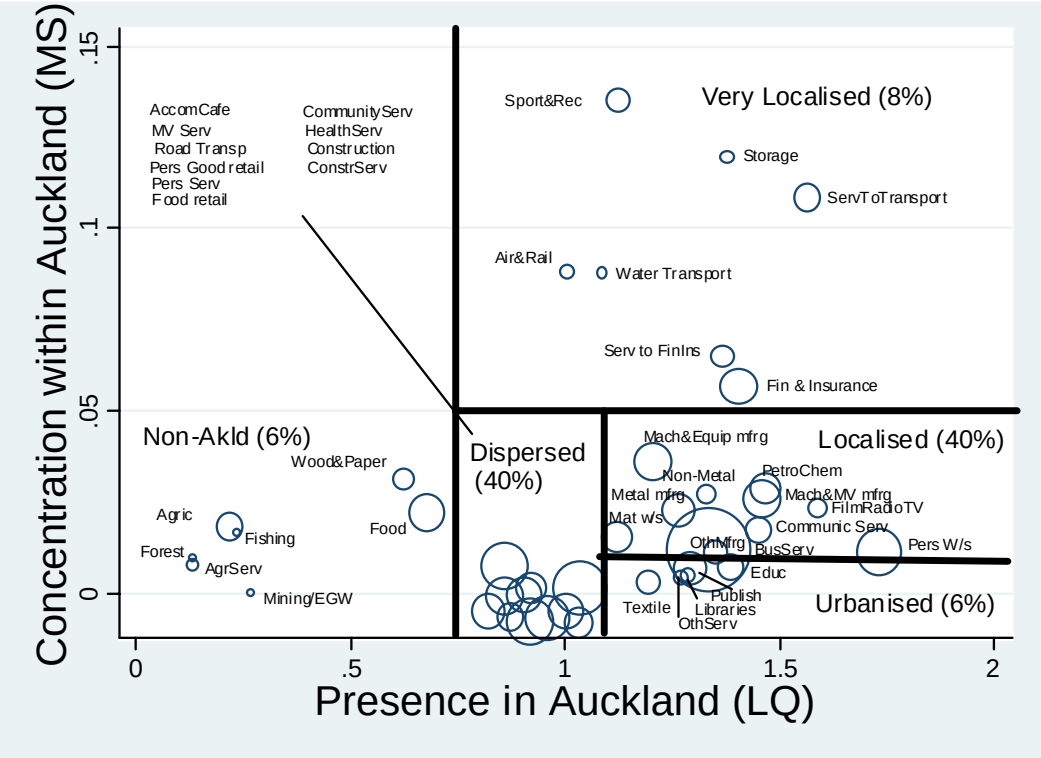
Figure 8 arranges industries according to their presence in Auckland (*LQ*) and their concentration within Auckland (*MS*). Industries have been divided into five groups, reflecting different spatial configurations.[26] About 40 percent of employment is in industries that are neither significantly over- nor under-represented in Auckland (*LQ* of around 1), and are distributed within Auckland roughly in proportion to total employment (*MS* of around 0). This group of industries is labelled 'Dispersed' and comprises mainly industries providing local goods and services. There is a 'non-Auckland' group of industries that are less prevalent in Auckland than elsewhere, which account for 6% of Auckland's employment. These are industries that are linked to the primary sector.

Industries that are disproportionately located in Auckland are divided into three groups, reflecting high, medium, and low levels of geographic concentration within Auckland. The first of these groups, labelled 'Urbanised' is dispersed throughout Auckland in proportion to overall employment, with a value of *MS* in the same range as for the 'dispersed' group. This group accounts for 6 percent of Auckland employment. The second group, labelled 'Localised' accounts for 40 percent of employment and is moderately concentrated within Auckland. The remaining 8 percent of employment is in the 'Very Localised' group, for which employment is highly concentrated within Auckland. Transport and storage industries and Finance and Insurance are represented in this group, as is the 'Sport and recreation' industry.

Table 5 contains group-level summary statistics on group employment, number of enterprises, group employment, average labour productivity, and the employment weighted averages for the *MS* and *LQ* indices. The grouping of industries based on prevalence and concentration is somewhat arbitrary, but serves to separate industries into groups that are potentially affected by different forms of agglomeration effects.

[26] A full list of industries in each group is shown in Appendix F with a range of descriptive statistics for each industry.

Figure 8: Presence in Auckland and Concentration within Auckland: by 2-digit industry (2006)



Notes: The size of plotting symbols is proportional to employment in each industry. The numbers in brackets show the percent of Auckland's employment accounted for by each group.

Table 5: Grouped industries – descriptive statistics

	# Plants	*Employment (rme)*	*Mean ln(VAPW)*	*Mean Concentration within Auckland (MS)*	*Mean Presence in Auckland (LQ)*	*Mean ln(Effective density)*	*Mean ln(Own-industry Effective density)*
Non-Akld	5,770	36,540	$75,530	0.022	0.50	10.79	7.14
Dispersed	52,180	236,500	$39,908	-0.002	0.93	11.11	7.93
Urbanised	4,700	33,640	$43,439	0.006	1.29	11.30	7.18
Localised	39,500	239,160	$74,274	0.018	1.38	11.29	8.65
V. Localised	4,860	44,200	$128,754	0.085	1.38	11.48	7.77

Notes: Appendix F contains a version of Table 5 and Table 6 for 2-digit industries. Enterprise and Employment counts have been rounded. Variables are described in the text. Appendix F contains a version of Table 5 and Table 6 for 2-digit industries.

It is plausible, for instance, that the geographic concentration of the 'very localised' industries is related to possible within-industry benefits of sharing, matching or learning. In contrast, the 'dispersed' industries are located in

proportion to overall employment, suggesting no particular advantage to being in Auckland or to being localised.

To investigate how the differing spatial configurations are related to productivity performance, we examine within-industry variation in productivity for each of the groups, comparing Auckland firms to those outside Auckland, and comparing firms in different parts of Auckland. Table 6 presents evidence on the Auckland productivity premium accruing to industries in each group. It also shows the relationship between labour productivity and overall employment density, and between labour productivity and own-industry employment density.

The first column of Table 6 reports the average relative labour productivity premium for industries in each group. These estimates are obtained from a regression as shown in equation (2), where *j* takes on only two values – Auckland Region, and all other areas. The inclusion of industry dummies absorbs the productivity differences between industries, so the reported estimates show the employment-weighted within-industry premium.

The highest premium (33.3%) is observed for the 'Very Localised' group, which contains industries that are highly concentrated within Auckland and also over-represented in Auckland. Industries in the 'Localised' group, which are also concentrated in Auckland, also have a relatively high Auckland premium (28.0%). Urbanised and Dispersed industries have somewhat lower premia of 18% to 23%. The non-Auckland industries, which are relatively highly concentrated within Auckland, have an average premium of 26.5%, although there is a lot of variation across industries, from a low of –61% to a high of 125%.

Almost all industries are more productive in Auckland than elsewhere. Only 3 industries are more productive outside Auckland – 'Agriculture', 'Mining and Quarrying', and 'Petrol Coal Chemical & Assoc Prod Mfg'. Almost 80 percent of Auckland employment is in industries with a premium greater than 15 percent, with 40 percent in the 15% to 25% range. The widespread nature of productivity premia within Auckland is consistent both with urbanisation and with Auckland-wide price effects. It is not clear from the observed patterns the extent

to which an industry's presence in Auckland raises technical efficiency, or to which the productivity advantage reflects allocative efficiency.

Table 6: Grouped industries – Auckland Premium and Density elasticities (2006)

	(1)		*(2)*		*(3)*			
	Auckland Premium (log difference)		*Effective density Elasticity*		*Effective density Elasticity*		*Own-industry Effective Density Elasticity*	
Non-Akld	1.265	**	0.287	**	0.656	**	0.825	**
	(0.03)		(0.08)		(0.10)		(0.13)	
Dispersed	1.225	**	0.236	**	0.276	**	0.570	**
	(0.01)		(0.02)		(0.02)		(0.06)	
Urbanised	1.185	**	0.160	**	0.132	**	0.194	*
	(0.03)		(0.04)		(0.04)		(0.11)	
Localised	1.280	**	0.514	**	0.337	**	0.804	**
	(0.01)		(0.02)		(0.02)		(0.05)	
V. Localised	1.333	**	0.663	**	0.106		1.115	**
	(0.03)		(0.05)		(0.07)		(0.10)	

Notes: **: 5% significance. *: 10% significance. Each row contains estimates from three separate regressions. The dependent variable in each is the log of VAPW. Appendix F contains a version of Table 5 and Table 6 for 2-digit industries.

To gauge the evidence for density-related explanations of the high relative productivity of Auckland firms, we examine whether labour productivity is higher for firms in denser parts of Auckland, compared with less dense parts of Auckland. Specifically, we run the following regression

$$\begin{aligned} \ln\left(VAPW_{gk}\right) = {} & \beta_1 \ln\left(Effective\ Density_{g}\right) \\ & + \beta_2 \ln\left(Own\text{-}industry\ Effective\ Density_{gk}\right) \\ & + \sum_{k=industry} \delta_k + e_{gk} \end{aligned} \tag{5}$$

where $VAPW_{gk}$ is the average labour productivity of workers in industry k working in area unit g. Effective density is as defined in equation (3). Own-industry effective density is calculated using the same method but using only own-industry employment. The log specification means that β_1 and β_2 can be interpreted as the elasticities of average local productivity for an industry with respect to effective density and own-industry effective density respectively. The inclusion of industry intercepts ensures that these elasticities are identified from spatial variation within industries, and do not reflect between-industry differences.

The means of the density measures are shown in Table 5. Firms in 'Very localised' industries have the highest average effective employment density. Urbanised and Localised industries have similar effective densities, implying that they are exposed to a similar degree of urbanisation. The higher *MS* measure for the Localised industries indicates that they tend to be more concentrated within Auckland and are thus exposed to a greater degree of localisation. Differences in own-industry effective densities are more difficult to interpret, as they reflect relative industry size as well as different patterns of localisation. The MS measure provides a more interpretable indication of localisation. However, variation in own-industry effective density measures across firms in the same industry provides an indication of exposure to potential localisation effects.

The second column of Table 6 shows estimates of equation (5), estimated separately for each group of industries, and with β_2 constrained to be zero. The relationship between effective density and labour productivity differs markedly across the five industry groups. The Very Localised industries have the highest effective density elasticity of 0.66, followed by the Localised industries with an elasticity of 0.51. The elasticity for the Urbanised industries is lower, at 0.16. The dispersed industries, although not geographically concentrated within Auckland, nevertheless have higher productivity in more dense areas, with an elasticity of 0.24.

The two columns labelled (3) in Table 6 contain estimates of β_1 and β_2 from equation (5), allowing for overall effective density and own-industry effective density to have different relationships with productivity. Consistent with the effects of localisation, the productivity of Localised and Very Localised industries has a particularly strong link with own-industry density. In contrast, for Dispersed and Urbanised industries, overall effective density has a stronger link with productivity, consistent with these industries benefiting from urbanisation effects. Productivity in the non-Auckland industries is positively related to both overall and own-industry density.

It is significant that the elasticity of productivity with respect to own-industry density is stronger than the overall-density elasticity. This suggests that

localisation effects are generally more pronounced than the urbanisation effects of density *per se*. The exception is the 'urbanised' group, for which the two elasticities are relatively close. Even the dispersed industries, which tend to provide local services, benefit most from localisation, despite the effects of competition that would favour dispersion.

These patterns are certainly suggestive of different types of agglomeration effects operating in different industries. They are, however, consistent with a range of explanations. Clearly, any explanation of the Auckland productivity premium must include a link with employment density, given the prevalence of positive density elasticities across a range of industries. Density-related productivity advantages could, however, include either technical and allocative efficiency benefits. As outlined earlier, technical efficiency benefits may include advantages of matching, sharing, and learning, all of which are arguably greater in dense areas. Allocative efficiency may arise if output prices are higher in dense areas, as may occur in higher land rent areas.

The existence of positive own-industry density elasticities suggests that interactions with other firms in the same industry are advantageous. It is not possible, however, to distinguish the contributions of shared inputs (such as transport infrastructure for the highly concentrated Transport and Storage industries) from the possible contributions of intra-industry knowledge transfers or matching with a common set of suppliers or customers. Finally, the patterns in Table 6 are based on cross-sectional variation. The analysis of the link between area density and average area labour productivity that was presented in Table 4 and Figure 5 demonstrated that cross-sectional patterns are not necessarily reflected in time series variation.

6 Summary and future directions

Value added per worker in Auckland region is 30 to 50 percent higher than that of regions outside Auckland. The premium is even higher in Auckland CBD (120 to 150 percent higher). While these magnitudes seem large, they are similar to the premia documented by ONS (2007) for London's GDP per capita.

London has GDP per capita that is 50 percent above the rest of the UK, and Inner London has a premium of 140 percent.[27]

Industry composition differences account for about half of Auckland's higher labour productivity. This finding is similar in magnitude to that of Rice and Venables (2004), who attribute around 40% of London's income per capita premium to job composition, as captured by occupational mix. We find that industries are positively selected into Auckland – the industries that are most concentrated in Auckland are the ones that show the highest Auckland premium.

Our analysis of productivity patterns within Auckland reveals considerable geographical variation, and a strong correlation between productivity and employment density. A significant fixed effect estimate of the relationship between density and productivity suggests that the cross-sectional pattern is not solely reflecting patterns of spatial equilibrium. However, the finding of a positive correlation of density and productivity over time within areas is not robust to alternative approaches of estimation such as first differencing or using differences across six-years. More detailed econometric analysis, taking into account spatial autocorrelation and lags may provide a fuller understanding of the links.

The cross-sectional estimates imply that having density that is twice as high is associated with productivity that is 8.6% higher. This is at the upper end of the 3% to 8% range from the studies summarised in Rosenthal and Strange (2004), and the 1% to 10% range reported by Graham (2005a) and Graham (2006a). The current paper's estimates differ from many of those reported in the literature in 2 key respects. First, the current estimates do not adjust for within-industry differences in capital intensity or labour quality, both of which are likely to be higher in dense areas. Some international studies use more sophisticated production-function approaches to control for such factors. Our estimates may therefore overstate true productivity differences. Second, our estimates cover all industries, whereas many of the studies in the literature look only at

[27] ONS (2007) reports a 40% London premia relative to the national average. We use the fact that London accounts for 12% of the UK population to express these figures relative to areas outside London (a 49% premium).

manufacturing. Graham (2006b) shows that the elasticity is lower for manufacturing than for the economy as a whole, and reports an economy-wide elasticity of 12.5% but only 5% for manufacturing.

We examine industry variation in effective employment density, both of overall employment and of industry employment. The industries that are most concentrated within Auckland, and also over-represented in Auckland, have the highest productivity premium from operating in Auckland (33%). The size of this premium is higher in areas of Auckland where employment density is high, and especially where own-industry density is high. We identify two groups of industries that show this pattern, together accounting for 48% of Auckland's employment. These groups include mainly Transport and Storage industries, Finance and Insurance, and a range of Wholesaling and Manufacturing industries.

There is a sizeable group of industries (40% of Auckland's employment) that are neither over-represented in Auckland nor particularly concentrated within Auckland. These industries mostly provide local goods and services. They do, however, appear to benefit from locating in denser areas of Auckland and from locating in areas of high own-employment density. Overall, localisation effects appear to be stronger than the effects of density *per se*. Own-industry density is more strongly related to productivity than is density, even for the most dispersed industries.

While the focus of this paper has been on documenting Auckland's productivity performance and providing an initial view into the links between density and productivity, a fuller picture of Auckland's productivity could be advanced by using more detailed firm-level information that is available from the LBD. It is possible to estimate industry-level production functions and obtain estimates of the contribution of agglomeration to multi-factor productivity (See Graham (2006b) Henderson (1986) Eberts and McMillen (1999) Rosenthal and Strange (2004) for examples of this approach.). This approach would support a decomposition of Auckland's productivity premium, gauging the relative contributions of factors such as higher capital intensity, higher labour quality, proximity to local productive inputs, local industry and market scale, head-office concentration, and residual advantages. Obtaining additional information on local

output price and quantity variation separately would allow a clearer analysis of the contributions of technical productivity and allocative productivity.

This paper helps to focus ongoing policy debates on the strength of agglomeration effects in Auckland. First, it provides estimates of the size of the Auckland productivity premium, with sub-analyses by territorial authority, by smaller area units, and by industry. Second, it confirms a cross-sectional link between productivity and density, but shows that this link is not evident over time within industries. Finally, it shows the diversity of agglomeration patterns across different groups of industries, suggesting that localisation and urbanisation effects operate differently for different industries. This delineation of patterns provides a foundation for more targeted analysis to identify which agglomeration mechanisms operate in specific sets of industries. It also emphasises that policies that aim to improve Auckland's productivity performance by increasing employment density are likely to have an uneven impact across industries.

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Appendix A: Auckland Urban Area in context

Australasian rank-size rule

Appendix Figure 1 shows the structure of the Australasian urban settlement system, and Auckland's position within it, as summarised by the rank-size rule that generally characterises systems of cities (Gabaix (1999a) Soo (2005))

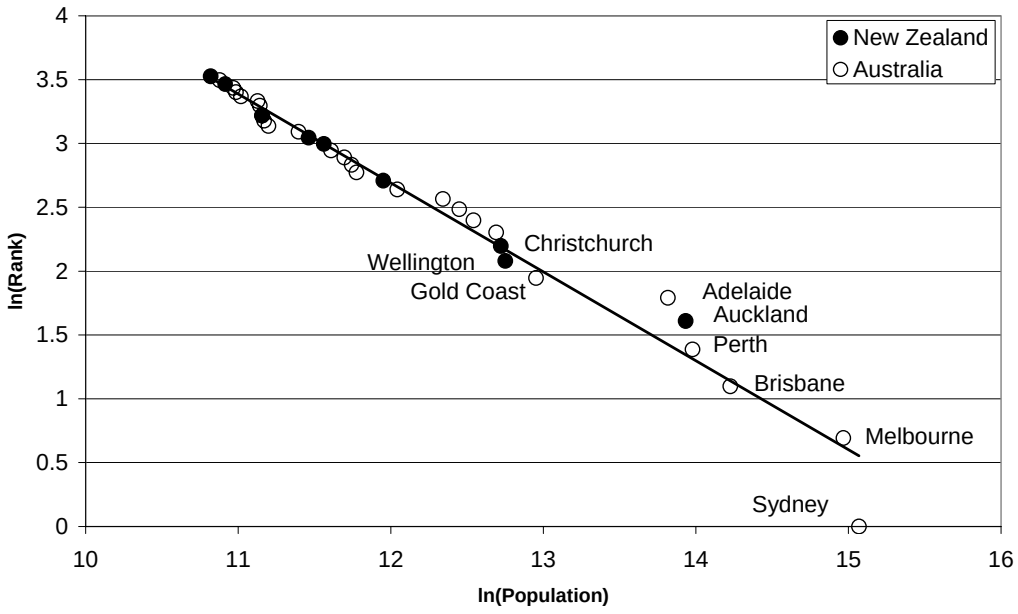
The formula for the fitted regression line is:

$\ln(\text{rank}) = -0.6964 \ln(\text{population}) + 11.047$ ($R^2 = 0.97$).

The slope of –0.6964 is flatter than in most other developed countries (Soo (2005), and Brakman et al (2008)), indicating that the Australasian urban settlement system is highly concentrated.

An unusual feature of the graph is that the two largest urban areas (Sydney and Melbourne) are similarly sized, whereas the rank-size relationship suggests that one of them should be twice as large.

Appendix Figure 1: Zipf's Law for Australasian Urban Areas

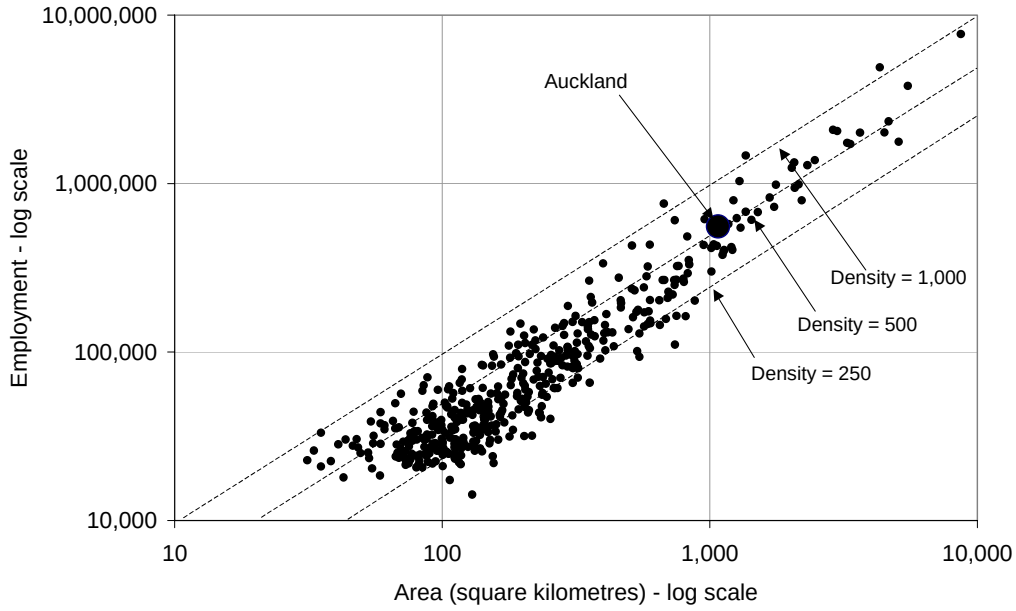


Source: World Population Rankings, available from http://www.demographia.com/db-worldua.pdf (NZ data verified against Statistics New Zealand (2005))

Comparison with US Urbanized Areas

Appendix Figure 2 shows the Auckland Urban Area's size in comparison with urbanised areas in the United States. Size is captured by geographic area and employment (both on log scales). The dotted diagonal lines are lines of constant employment density. There is a tendency for density to increase with size. Auckland ranks as a mid-sized US city, with around the expected density. Appendix Table 1 shows some US cities with similar employment, and land area.

Appendix Figure 2: Auckland Urban Area – compared with US Urbanized Areas by Area and Employment



Source: http://www.demographia.com/db-usaua-employ.htm

Appendix Table 1: Comparable US Urbanized Areas

Urban Area	Employment	Square km	dens/sqkm
San Antonio, TX Urbanized Area	581,045	1,056	550
Riverside--San Bernardino, CA Urbanized Area	572,083	1,136	503
Columbus, OH Urbanized Area	583,756	1,030	567
Jacksonville, FL Urbanized Area	426,425	1,063	401
Orlando, FL Urbanized Area	574,861	1,174	490
Providence, RI--MA Urbanized Area	547,048	1,304	419
Memphis, TN--MS--AR Urbanized Area	436,006	1,035	421
Sacramento, CA Urbanized Area	614,550	956	643
Nashville-Davidson, TN Urbanized Area	377,497	1,116	338

Source: http://www.demographia.com/db-usaua-employ.htm

Appendix B: The allocation of value added within enterprise-groups

In any month, each PBN can belong to only one enterprise and only one group. Allocating PBN labour input to different enterprises is straightforward, by aggregating across those months in which the PBN belongs to the enterprise. In addition, we wish to analyse productivity patterns by industry and location, so we group monthly PBN observations into distinct subsets for which enterprise-number, industry, and location (area unit) are constant. By construction, each plant belongs to only one enterprise during the year, and is allocated a proportion of that enterprise's value added and working proprietor input. Where enterprises belong to more than one group, it is not possible to tell how much of the enterprise's value added is associated with each group. The groups are therefore pooled for the purposes of aggregation of BAI value added, as described above.

Appendix Table 2 shows the distribution of activity across different group structures. Single plant enterprises that do not belong to an enterprise-group, in which there is no ambiguity in the link between reported value added and annual labour input, account for 76 percent of plant-year observations. Being relatively small, however, they account for only 55 percent of labour input and 37 percent of value added. Productivity is relatively low for these plants. In multi-plant enterprises not belonging to a group, labour productivity is close to the national average of $52,000, and plant size is also roughly average. These plant account for about one sixth of plants, labour, and value added.

Groups containing more than one enterprise are divided into two subsets in Appendix Table 2 – hierarchical and complex. Hierarchical groups are groups in which each enterprise in the group belongs to only one group during the year. For enterprises not having an AES postal record, productivity is constant within the group. Although these groups contain only 5 percent of plants, the plants contain, on average, 17.7 workers and account for 41 percent of value added and 23 percent of labour input. Productivity is thus high in these groups – just under $100,000 per worker. Complex groups are groups within which at least

one enterprise belongs to more than one group. Such enterprises serve to connect two or more groups. Aggregation of BAI value added takes place within sets of connected groups. Complex groups are relatively large and productive, but account for only 2 percent of plants and 6 percent of value added.

Appendix Table 2: Group Structures (2006)

	% of plant obs	% of Labour input	% of value added	Average labour input per plant	Value added per worker
Single-plant Enterprise	76%	55%	37%	2.5	$38,255
Multi-plant Enterprise	17%	18%	16%	3.6	$52,359
Hierarchical Group	5%	23%	41%	17.7	$98,662
Complex Group	2%	4%	6%	9.2	$82,901
Total	100%	100%	100%	3.5	$52,037

Appendix Table 3 shows summary statistics for three groups of firms that are less affected by the within-enterprise allocation algorithm. Single plant enterprises are not subject to any allocation of value added. They account for 55% of employment nationally, and Auckland's share of single-plant enterprises (30%) is only slightly lower than its share of total employment, reflecting the over-representation of multi-plant enterprises in Auckland. The Auckland labour productivity premium for single-plant enterprises (39%) is similar to the premium estimated for all enterprises (44%). Similarly, adjusting for industry composition, the Auckland premium for single-plant enterprises is 22% compared with 25% overall. The allocation algorithm appears to give a similar Auckland premium estimate to that based on single-plant enterprises for which there is no allocation.

Enterprises for which only AES postal returns are used (ie: no data from BAI is allocated within enterprise groups) account for 40% of Auckland employment. The AES contains a disproportionately large share of larger firms. a relatively high 39% of employment in AES-only enterprises is in Auckland. The Auckland premium is slightly lower for this group (27% raw, or 17% when adjusted for industry composition), possibly because AES also contains a relatively high share of multi-plant enterprises, so the advantage of being in Auckland may accrue in part to enterprises and plants affiliated with Auckland-

based firms. It may also be that agglomeration is of particular value to smaller firms.

The third group of firms, which is least affected by the method of value added allocation contains single-enterprise firms for which data are sourced from AES. This group accounts for only 8 percent of employment, and has employment located in Auckland to the same degree as other AES-only firms (40%). The Auckland premium for this group is similar to that for AES-only enterprises generally (28% unadjusted and 15% adjusted for industry composition).

It would appear that the method of value added allocation is not driving the overall premium estimates. The overall estimates may, however, be masking some variation in agglomeration benefits by firm size, as suggested by the lower premium for the AES sample.

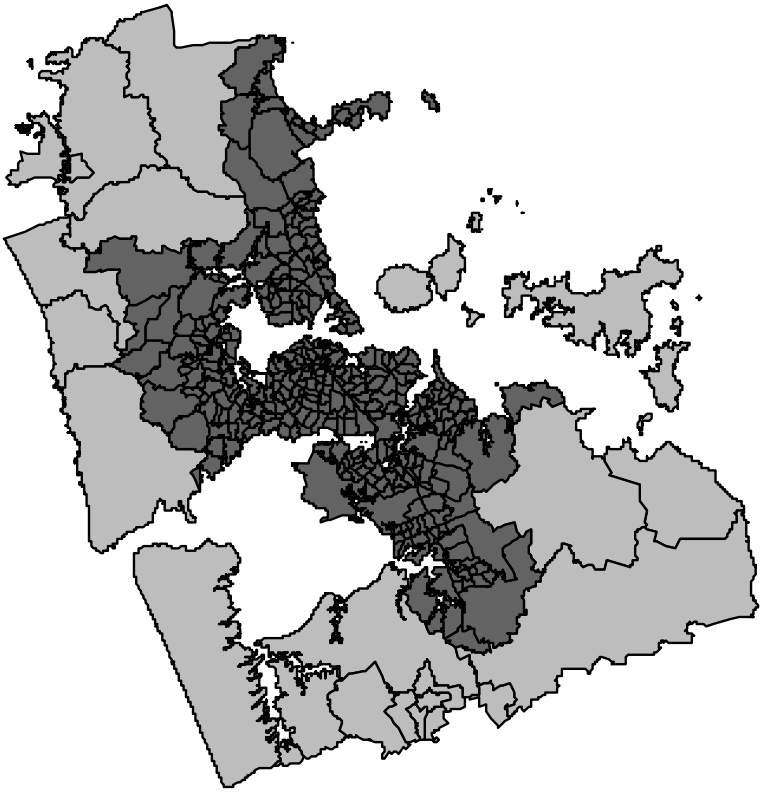
Appendix Table 3: Auckland Shares and premia (2006)

	% of Total employment	Auckland share of group employment	Raw Auckland VAPW premium	ind3% adj premium
Single-plant enterprises	55%	30%	39%	22%
AES-only enterprises	40%	39%	27%	17%
AES-only single-plant enterprises	8%	40%	28%	15%
Total	100%	33%	44%	25%

Appendix C: Map of Auckland Urban Area

The Auckland urban area is the darker-shaded area in the map.

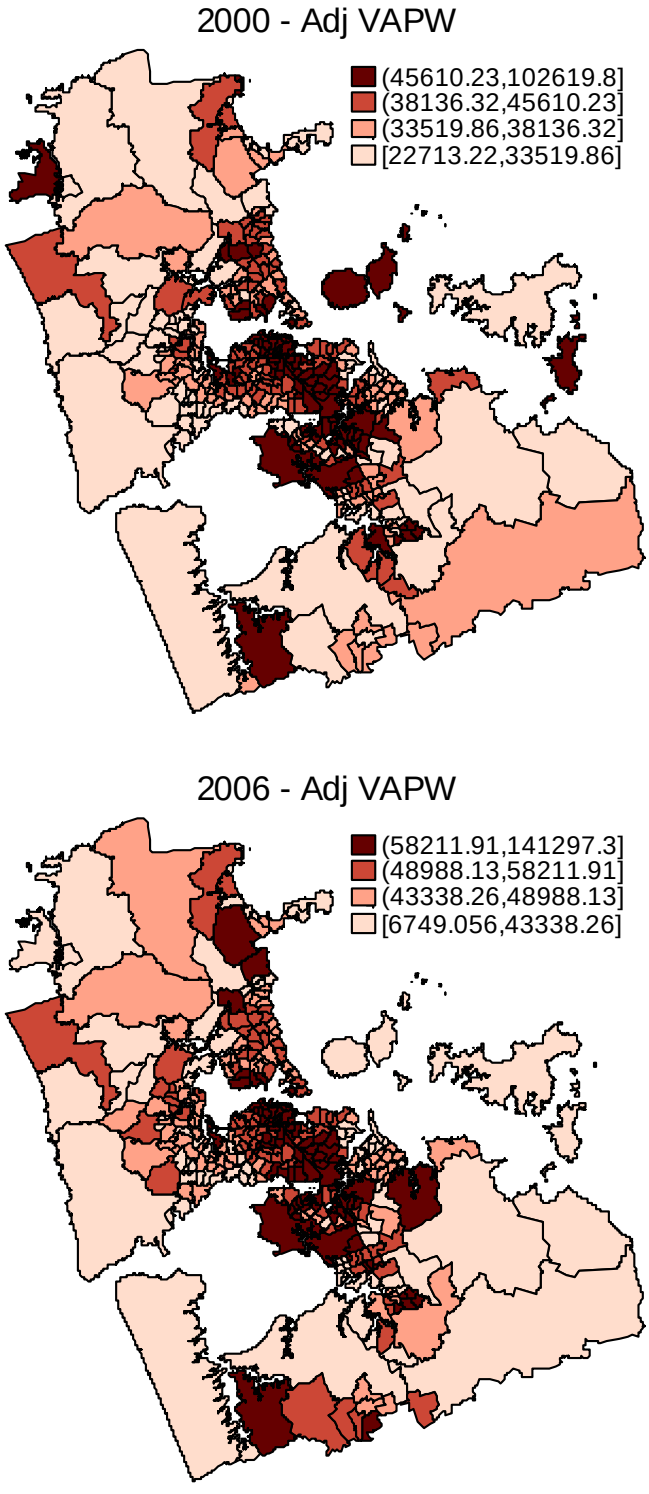
Appendix Figure 3: Map of Auckland Urban Area

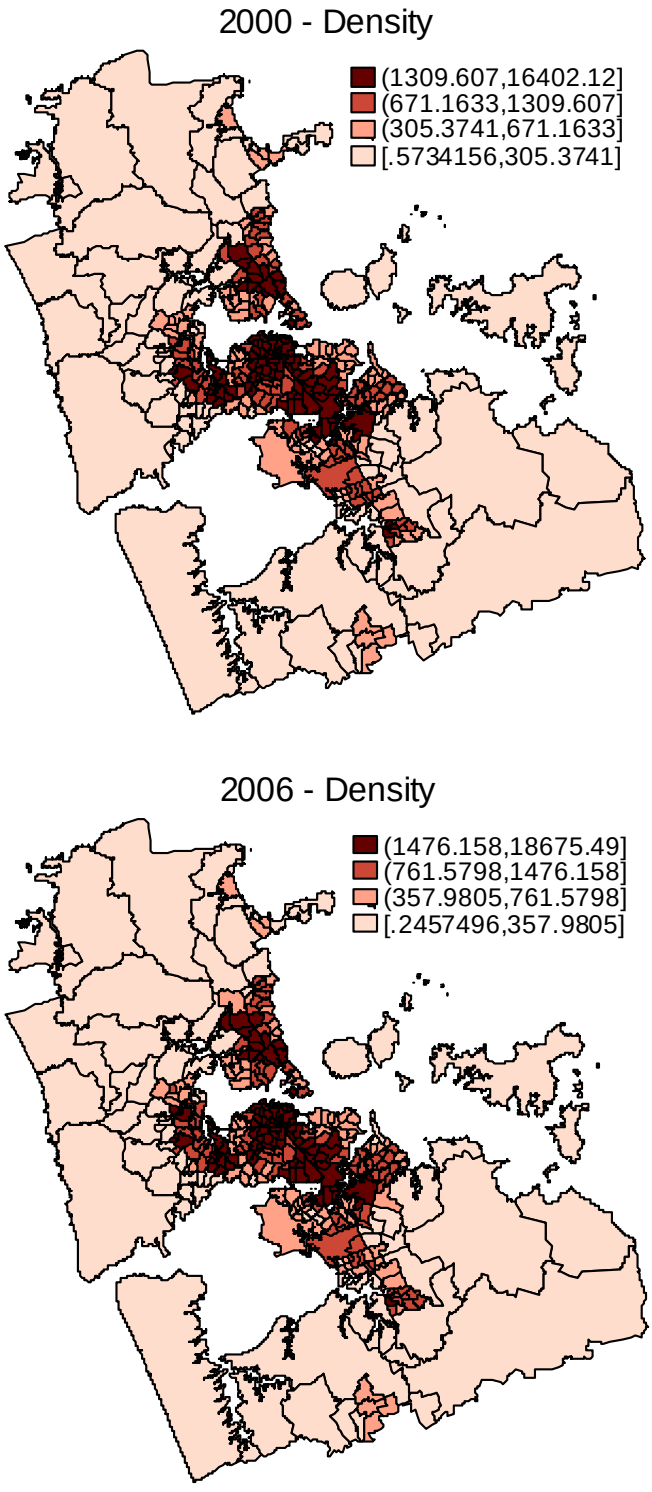


Appendix D: 2000 v 2006 maps

This appendix compares 2000 and 2006 patterns of value-added per worker and density, showing similarity across the two the periods.

Appendix Figure 4: Map of Auckland VAPW and density





Note: Data have been spatially smoothed using Euclidean distance and an Epanechnikov kernel with a bandwidth of 2km.

Appendix E: Comparison with Statistics New Zealand's Regional GDP Figures

Appendix Table 5 contains a comparison of regional GDP per worker estimates derived from Statistics New Zealand's Regional GDP Feasibility Study (Statistics New Zealand (2007c)) and Business Demography data downloaded from http://www.stats.govt.nz/products-and-services/table-builder/table-builder-business.htm. The comparison is for the 2003 year.

The LBD data used in the current paper captures Value Added of $76.6bn, which is about 60% of the $130.7bn in the more complete regional GDP measure. The LBD employment measure (rolling mean employment, including working proprietors) is larger than the employee count measure obtained from Business Demography data. A consequence of the lower value added and higher employment figures is that value added per worker, as used in this paper, is significantly lower than GDP per worker ($39,900 compared with $78,900).

Regional variation in productivity is similar across the two series, with the exceptions of Wellington and Auckland. The reasons for the Wellington difference include the omission of public sector firms in the current study. The reasons for the Auckland difference have not been fully explained. The sources and methods for the regional GDP estimates are documented in Statistics New Zealand (2007b).

Some of the methods used differ from that used in the current paper and these differences may account for some of the discrepancy. One potentially influential difference is in the way that value added is allocated across plants within multi-plant enterprises. The method is similar to the allocation outlined in Appendix B, with the difference that instead of setting value added per worker to be constant within an enterprise, the Regional GDP figures are based on setting value added per dollar of payroll to be equal. This has the effect of generating an estimated VAPW premium that is equal to the Auckland wage premium

In the current paper, the spreading of value added in proportion to employment yields a zero VAPW premium. However, the recovery of the underlying premia is achieved by regression methods, as outlined in sections 4.1

and 4.2. A similar approach could be applied in the creation of the Regional GDP estimates to generate estimates of the relative productivity rather than average wage rates.

Appendix Table 4 shows a hypothetical example of two enterprises to illustrate the impact of the different methods. Assumptions are made about the wage level (20% Auckland premium) and VAPW level (100% Auckland premium) and about the proportion of each enterprise's employment that is in Auckland. The first 3 columns of the Enterprise A case show the assumed Employment spread, and the wage bill and Value added amount implied by the assumptions.

If only total value added of $30,000 were observed, it needs to be allocated to Auckland and non-Auckland plants. The 4th and 5th columns show the split of total value added in proportion to employment, the implied value added, and the recovered premium of 0%. The 6th and 7th column show a similar calculation based on splitting value added in proportion to wage bill. The recovered premium is 20% - equal to the assumed wage premium.

The two simultaneous equations at the bottom of the table show how information is used from two enterprises (that differ in the proportion of their employment that is in Auckland) to identify the underlying VAPW premium. Our regression-based adjustment performs the same role, although with more enterprises than locations, so that the identification is not exact.

Appendix Table 4: Regional GDP v Value added per worker

Assume:	Wage	VAPW
Auckland	120	300
Non-Auckland	100	150
premium	20%	100%

						split by Emp		split by Wagebill	
Enterprise A	Emp		Wagebill		VA	VA	VAPW	VA	VAPW
Auckland	50	33%	6000	38%	$15,000	$10,000	$200	$11,250	$225
Non-Auckland	100	67%	10000	63%	$15,000	$20,000	$200	$18,750	$188
					$30,000				
Premium							0%		20%

						split by Emp		split by Wagebill	
Enterprise B	Emp		Wagebill		VA	VA	VAPW	VA	VAPW
Auckland	20	67%	2400	71%	$6,000	$5,000	$250	$5,294	$265
Non-Auckland	10	33%	1000	29%	$1,500	$2,500	$250	$2,206	$221
					$7,500				
Premium							0%		20%

A 200 = 33% * VAPW(akld) + 67% * VAPW(non)
B 250 = 67% * VAPW(akld) + 33% * VAPW(non)

=> VAPW(Akld) = 300 Premium = 100%
VAPW(Non) = 150

Appendix Table 5: Regional GDP v Value added per worker

	Regional GDP Estimates (2003)						*Current paper's estimates (2003)*					
Region	*GDP $(million)*	*GDP share of total*	*Emp employee count*	*Emp share of total*	*GDP/Emp $(000)*	*Auckland Premium*	*Value Added $(million)*	*VA share of total*	*Emp rme (000)*	*Emp share of total*	*VA/Emp $(000)*	*Auckland Premium*
Northland	3,243	*2%*	42,870	*3%*	75.65	96%	1,516	*2%*	53,650	*3%*	28.50	71%
Auckland	47,689	*36%*	534,550	*34%*	89.21	113%	31,600	*41%*	543,630	*33%*	58.13	146%
Waikato	10,598	*8%*	131,060	*8%*	80.86	103%	5,999	*8%*	157,320	*9%*	38.13	96%
Bay of Plenty	6,689	*5%*	88,540	*6%*	75.55	96%	3,896	*5%*	103,750	*6%*	37.55	94%
Gisborne	1,031	*1%*	15,430	*1%*	66.82	85%	544	*1%*	17,480	*1%*	31.14	78%
Hawke's Bay	4,318	*3%*	56,530	*4%*	76.38	97%	2,149	*3%*	63,370	*4%*	33.92	85%
Taranaki	4,414	*3%*	38,360	*2%*	115.07	146%	2,129	*3%*	45,590	*3%*	46.69	117%
Manawatu-Wanganui	5,594	*4%*	83,630	*5%*	66.89	85%	2,810	*4%*	86,580	*5%*	32.46	81%
Wellington	19,286	*15%*	202,370	*13%*	95.30	121%	10,146	*13%*	175,010	*10%*	57.97	145%
Total North Island	**102,863**	***79%***	**1,193,340**	***75%***	**86.20**	**109%**	**60,788**	*79%*	**1,246,380**	*75%*	**48.77**	122%
Tasman / Nelson	2,343	*2%*	34,040	*2%*	68.83	87%						
Marlborough	1,193	*1%*	16,540	*1%*	72.13	91%	2,391	*3%*	75,300	*5%*	31.75	80%
West Coast	779	*1%*	11,550	*1%*	67.45	86%						
Canterbury	15,074	*12%*	212,480	*13%*	70.94	90%	8,829	*12%*	223,060	*13%*	39.58	99%
Otago	5,411	*4%*	80,150	*5%*	67.51	86%	2,953	*4%*	81,620	*5%*	36.18	91%
Southland	3,023	*2%*	38,990	*2%*	77.53	98%	1,669	*2%*	46,140	*3%*	36.17	91%
Total South Island	**27,824**	***21%***	**393,750**	***25%***	**70.66**	**90%**	**15,842**	*21%*	**426,120**	*25%*	**37.18**	93%
Gross domestic product	**130,687**	***100%***	**1,587,090**	***100%***	**82.34**	**104%**	76,631	*100%*	**1,672,500**	*100%*	**45.82**	115%
Total Excluding Auckland	*82,998*	*64%*	*1,052,540*	*66%*	*78.85*	*100%*	*45,031*	*59%*	*1,128,870*	*67%*	*39.89*	*100%*

Sources: Regional GDP panel: (Statistics New Zealand (2007c)) and Business Demography data downloaded from http://www.stats.govt.nz/products-and-services/table-builder/table-builder-business.htm. The Auckland premium expresses "Auckland Premium" columns express GDP/Emp and VA/Emp as a proportion of non-Auckland levels

Appendix F: Industry Tables (grouped 2-digit)

Appendix Table 6: Two-digit industries – descriptive statistics

	# Plants	Employment (rme)	Mean VAPW	Concentration within Auckland (MS)	Presence in Auckland (LQ)	Mean ln(Effective density)	Mean ln(Own-industry Effective density)
Non-Akld							
A03: Forestry and Logging	200	600	$55,619	0.010	0.13	10.32	4.44
C21: Food Beverage and Tobacco Manufacturing	650	17,830	$108,321	0.022	0.68	11.10	7.84
C23: Wood & Paper Product Manufacturing	610	6,110	$41,402	0.031	0.62	10.97	6.64
A02: Services to Agric Hunting and Trapping	470	1,490	$31,509	0.008	0.13	10.42	5.35
A04: Commercial Fishing	140	250	$72,299	0.017	0.23	10.35	3.27
A01: Agriculture	3,620	9,750	$20,599	0.018	0.22	10.21	6.84
BD: MinQuarr / EG&W	80	510	$186,761	0.000	0.26	10.59	4.16
Dispersed							
L77: Property Services	7,730	17,630	$63,662	-0.005	1.00	11.15	7.63
O86: Health Services	4,380	15,400	$24,077	-0.005	0.82	11.17	7.64
G51: Food Retailing	4,200	29,920	$28,841	-0.007	0.92	11.07	8.10
O87: Community Services	700	9,670	$53,550	-0.006	0.87	11.01	7.04
H57: Accommodation Cafes & Restaurants	3,570	32,290	$46,879	0.008	0.86	11.32	8.55
G52: Personal & Household Good Retailing	7,310	40,670	$22,176	0.002	1.03	11.17	8.52
E42: Construction Trade Services	9,180	29,880	$62,619	-0.007	0.96	10.95	7.94
E41: General Construction	5,160	19,160	$36,846	0.000	0.86	10.96	7.53
G53: Motor Vehicle Retailing and Services	3,620	18,170	$36,379	0.000	0.90	11.08	7.63
I61: Road Transport	2,850	12,970	$27,796	0.002	0.92	10.99	7.20
Q95: Personal Services	3,480	10,740	$47,865	-0.008	1.03	11.13	7.14

	# Plants	Employment (rme)	Mean VAPW	Concentration within Auckland (MS)	Presence in Auckland (LQ)	Mean ln(Effective density)	Mean ln(Own-industry Effective density)
Urbanised							
P92: Libraries Museums and the Arts	1,230	2,110	$35,212	0.005	1.28	11.31	5.93
Q96: Other Services	260	1,900	$19,475	0.005	1.27	11.13	5.58
C24: Printing Publishing and Recorded Media	1,090	13,530	$78,891	0.007	1.29	11.35	7.74
C22: Textile Clothing Footwear Leather Mfg	950	7,760	$45,300	0.003	1.19	11.24	7.00
N84: Education	1,170	8,340	$53,449	0.008	1.38	11.31	7.13
Localised							
P91: Motion Picture Radio and TV Services	970	4,430	$121,756	0.024	1.59	11.50	7.03
J71: Communication Services	1,220	9,030	$100,396	0.017	1.45	11.53	7.71
I63: Water Transport	100	960	$80,195	0.088	1.08	11.57	5.99
F47: Personal & Household Good Wholesaling	4,120	29,530	$116,892	0.012	1.73	11.25	8.33
C26: Non-Metallic Mineral Product Manufacture	340	4,240	$83,900	0.027	1.33	11.08	6.34
F45: Basic Material Wholesaling	1,240	11,150	$84,749	0.016	1.12	11.10	7.22
F46: Machinery & Motor Vehicle Wholesaling	2,650	20,210	$84,968	0.026	1.46	11.25	7.98
C29: Other Manufacturing	1,190	7,630	$48,572	0.012	1.35	11.13	6.86
C27: Metal Product Manufacturing	1,310	14,480	$187,265	0.023	1.26	10.96	7.39
C28: Machinery and Equipment Manufacturing	2,070	19,000	$86,437	0.036	1.20	11.09	7.79
I6: Rail&Air transport	230	2,060	$68,686	0.088	1.00	11.25	5.92
L78: Business Services	23,310	104,150	$55,699	0.012	1.33	11.42	9.86
C25: Petrol Coal Chemical & Assoc Prod Mfg	750	12,290	$84,481	0.029	1.47	11.15	7.50
V. Localised							
I66: Services to Transport	1,230	9,470	$185,153	0.109	1.56	11.31	7.44
K75: Services to Finance and Insurance	1,510	6,540	$52,797	0.065	1.36	11.59	7.56
P93: Sport and Recreation	900	7,210	$85,377	0.135	1.12	11.43	7.47
I67: Storage	150	1,810	$63,516	0.120	1.37	11.11	5.83
K7: Finance & Insurance	1,070	19,170	$150,420	0.057	1.40	11.61	8.62

Appendix Table 7: Two-digit industries – Auckland Premium and Density Elasticities

	(1) Auckland Premium	(2) Effective density Elasticity	(3) Effective density Elasticity	(3) Own-industry Effective Density Elasticity
Non-Akld				
A03: Forestry and Logging	2.267 **	0.760 **	1.645 **	1.263
	(0.21)	(0.20)	(0.68)	(0.93)
C21: Food Beverage and Tobacco Manufacturing	1.550 **	0.445 **	0.690 **	0.789 **
	(0.07)	(0.18)	(0.19)	(0.25)
C23: Wood & Paper Product Manufacturing	1.523 **	0.226	0.510	0.411
	(0.31)	(0.16)	(0.39)	(0.52)
A02: Services to Agric Hunting and Trapping	1.228 **	-0.115	-0.249	-0.200
	(0.10)	(0.14)	(0.35)	(0.47)
A04: Commercial Fishing	1.072 **	0.365 **	0.638 **	1.616 **
	(0.04)	(0.12)	(0.11)	(0.20)
A01: Agriculture	0.823 **	-0.017	0.340	0.489
	(0.07)	(0.22)	(0.46)	(0.56)
BD: MinQuarr / EG&W	0.389 **	0.586 **	0.794 **	0.400
	(0.14)	(0.24)	(0.33)	(0.45)
Dispersed				
L77: Property Services	1.514 **	0.313 **	0.298 **	-2.841 **
	(0.05)	(0.08)	(0.08)	(0.60)
O86: Health Services	1.499 **	0.182 *	0.140	-0.557 **
	(0.11)	(0.10)	(0.10)	(0.17)
G51: Food Retailing	1.319 **	-0.090	0.315 **	1.623 **
	(0.03)	(0.08)	(0.12)	(0.35)
O87: Community Services	1.290 **	0.235 **	0.202 **	0.697 **
	(0.02)	(0.05)	(0.04)	(0.12)
H57: Accommodation Cafes & Restaurants	1.210 **	0.215 **	0.331 **	0.529 **
	(0.01)	(0.04)	(0.05)	(0.16)
G52: Personal & Household Good Retailing	1.199 **	0.401 **	0.205 **	0.833 **
	(0.04)	(0.06)	(0.09)	(0.28)
E42: Construction Trade Services	1.197 **	0.353 **	0.631 **	1.215 **
	(0.02)	(0.07)	(0.08)	(0.22)
E41: General Construction	1.144 **	0.173 **	0.223 **	0.606 **

	(0.02)	(0.05)	(0.06)	(0.27)
G53: Motor Vehicle Retailing and Services	1.076 **	0.199 **	0.264 **	0.424 *
	(0.02)	(0.05)	(0.06)	(0.22)
I61: Road Transport	1.070 **	0.360 **	0.437 **	0.980 **
	(0.02)	(0.06)	(0.06)	(0.24)
Q95: Personal Services	1.047 **	0.247 **	0.453 **	0.816 **
	(0.02)	(0.08)	(0.09)	(0.20)
Urbanised				
P92: Libraries Museums and the Arts	1.521 **	0.233 **	0.108	0.477 **
	(0.09)	(0.07)	(0.08)	(0.16)
Q96: Other Services	1.470 **	0.324 **	0.237 *	0.415
	(0.10)	(0.08)	(0.12)	(0.43)
C24: Printing Publishing and Recorded Media	1.259 **	-0.275	-0.405 **	0.951 **
	(0.11)	(0.20)	(0.21)	(0.40)
C22: Textile Clothing Footwear Leather Mfg	1.162 **	0.046	0.069	0.243
	(0.04)	(0.10)	(0.10)	(0.20)
N84: Education	1.112 **	0.116	0.175 **	-0.352
	(0.05)	(0.08)	(0.09)	(0.23)
Localised				
P91: Motion Picture Radio and TV Services	3.186 **	0.463 **	-0.107	1.061 **
	(0.34)	(0.15)	(0.24)	(0.35)
J71: Communication Services	1.754 **	0.303 *	0.737 **	-0.900 **
	(0.20)	(0.18)	(0.26)	(0.40)
I63: Water Transport	1.720 **	0.501 **	0.561 **	0.963 **
	(0.06)	(0.08)	(0.08)	(0.20)
F47: Personal & Household Good Wholesaling	1.518 **	0.645 **	0.688 **	0.923 **
	(0.11)	(0.15)	(0.13)	(0.18)
C26: Non-Metallic Mineral Product Manufacture	1.446 **	0.649 **	0.674 **	0.207
	(0.05)	(0.10)	(0.10)	(0.19)
F45: Basic Material Wholesaling	1.434 **	-0.280 **	-0.144 **	1.116 **
	(0.04)	(0.07)	(0.06)	(0.13)
F46: Machinery & Motor Vehicle Wholesaling	1.381 **	0.497 **	0.535 **	0.323 **
	(0.05)	(0.08)	(0.08)	(0.16)
C29: Other Manufacturing	1.337 **	0.333 **	0.360 **	0.487 **
	(0.04)	(0.08)	(0.08)	(0.15)
C27: Metal Product Manufacturing	1.317 **	1.749 **	0.127	2.708 **
	(0.06)	(0.11)	(0.20)	(0.30)
C28: Machinery and Equipment Manufacturing	1.305 **	0.482 **	0.425 **	0.849 **

	(0.11)	(0.15)	(0.14)	(0.33)
I6: Rail&Air transport	1.200 **	0.419 **	0.463 **	0.718 **
	(0.03)	(0.07)	(0.07)	(0.08)
L78: Business Services	1.175 **	0.513 **	0.018	1.292 **
	(0.01)	(0.04)	(0.08)	(0.18)
C25: Petrol Coal Chemical & Assoc Prod Mfg	0.834 **	0.628 **	0.697 **	0.359 *
	(0.04)	(0.15)	(0.16)	(0.20)
V. Localised				
I66: Services to Transport	1.678 **	-0.082	-0.199 *	1.595 **
	(0.11)	(0.12)	(0.11)	(0.21)
K75: Services to Finance and Insurance	1.524 **	1.167 **	0.160	1.637 **
	(0.09)	(0.08)	(0.11)	(0.15)
P93: Sport and Recreation	1.223 **	1.097 **	0.484 **	0.915 **
	(0.05)	(0.08)	(0.16)	(0.21)
I67: Storage	1.187 **	0.802 *	0.800 *	-0.015
	(0.15)	(0.43)	(0.43)	(0.33)
K7: Finance & Insurance	1.160 **	0.634 **	0.415	0.297
	(0.04)	(0.16)	(0.38)	(0.46)

Notes: Industries are ordered within each group in descending order of Auckland premium.

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