DEPARTMENT OF THE
PRIME MINISTER AND **CABINET**
TE TARI O TE PIRIMIA ME TE KOMITI MATUA

21 July 2023

[redacted]

Ref: OIA-2022/23-1042

Dear [redacted]

Official Information Act request relating to consulting reports on the affordability of Canterbury housing after the earthquakes

Thank you for your Official Information Act 1982 (the Act) request received on 22 June 2023. You requested:

> *I would like to make an OIA request. Can I please have any consulting reports provided to the Department of Prime Minister and Cabinet directly or indirectly (eg via another minister's office or department) in this last parliamentary term about what made Canterbury housing more affordable for several years after the earthquakes. Exclude reports commissioned by the Greater Christchurch Spatial Strategy.*

The Department of the Prime Minister and Cabinet has undertaken a search and identified one document which is in scope for your request.

I am releasing to you the document listed below, subject to a small amount of information being withheld as noted. The relevant ground under which information has been withheld is:

1. section 9(2)(a), to protect the privacy of individuals.

Date	Document Description	Decision
15 November 2021	Housing lessons from the Canterbury rebuild	Release in part

In making my decision, I have considered the public interest considerations in section 9(1) of the Act. No public interest has been identified that would be sufficient to override the reasons for withholding that information. You have the right to ask the Ombudsman to investigate and review my decision under section 28(3) of the Act.

This response will be published on the Department of the Prime Minister and Cabinet's website during our regular publication cycle. Typically, information is released monthly, or as otherwise determined. Your personal information including name and contact details will be removed for publication.

Yours sincerely

[redacted]

Anneliese Parkin
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Housing lessons from the Canterbury rebuild

Report to DPMC
15 November 2021

SENSE PARTNERS
DATA LOGIC ACTION

Key points

After the earthquakes, eventually homes were relatively affordable

- Our quantitative analysis of trends shows that unlike other parts of New Zealand, house prices did not rise relative to incomes despite rapid population growth. This is striking since Canterbury lost over 28,000 homes due to the quakes.
- We conducted qualitative interviews to uncover four key factors that proved key to achieving more affordable housing than elsewhere in New Zealand.
- We then model the impacts of this suite of factors as a one-off shock to consenting activity in Christchurch and find declines in rents and house prices.
- The context of rebuilding after the disaster matters, but four factors meant supply kept pace with demand and hold lessons for cities seeking affordable housing

Factor 1: Significant capacity was available in the form of flat, open land

- Flat and open landscape meant significant land for residential purposes. There was zoned land available for development when the earthquakes hit. This was used quickly. More land had to be zoned and serviced (connected to infrastructure). This provided choice and competition in the market that kept price affordable.
- Taking a wider perspective on infrastructure increased availability of land that was developed. Motorway connections between Christchurch City, Selwyn District and Waimakariri District significantly improved travel times, reducing economic distance.
- Opening up Selwyn and Waimakariri created a significant outlet for demand. People travel for work between Christchurch and these districts – so demand for housing was met across a broad area rather than from within local council boundaries only.
- Christchurch City Council area lost over 23,000 homes in the earthquakes – for many years new supply was replacing lost stock, rather than adding new additions in net. In contrast, new supply in Selwyn and Waimakariri Districts was largely net new supply.

Factor 2: Where coordination occurred, housing supply was rapid

- The recovery from the earthquakes showed the importance of coordination between stakeholders. A long period of effort to coordinate efforts across the region – after many years of adversarial approaches – paid dividends.
- Coordination between developers and councils, and between councils – where it happened – also sped up housing supply. Key relationships helped drive supply.
- A long process of co-ordination across Christchurch City Council, Selwyn District Council, Waimakariri and other parties had led to an Urban Development Strategy (a broad spatial plan for future growth) that was the critical blueprint for the recovery.
- The Urban Development Strategy was held up in the Environment Court when the earthquakes hit. It was actioned using special earthquake related legislative powers.

- These powers limited the appeals and objections process, and mostly relaxed constraints on where building could occur – increasing choice and competition – rather than relaxing constraints on what could be built.

Factor 3: Existing funding and financing arrangements, helped by large insurance payouts, secured much-needed capital

- Standard funding and financing arrangements were used for the infrastructure, needed for subdivisions and house building. Councils used development contributions, debt and rates in different mixes, across the three local councils.
- Large insurance payouts created a secure source of demand. This injection of new money (over $11b) created significant confidence to finance housing developments.

Factor 4: Delivery by existing businesses could scale up

- Labour was hard to come by and costs rose to a 10% premium over the New Zealand average to attract workers. Many developers initially found workers from other parts of New Zealand, until a large pool of overseas workers flowed in.
- Subdivision and housing developers scaled up with the demand. There were also new entrants and existing business grew larger, but usually with little product innovation.

Quantitative analysis shows the suite of factors improved affordability

- We test quantitative impacts by treating these factors as a one-off housing supply shock, within a model that captures key housing dynamics over the past 30 years. Figure 1 and Figure 2 show this shock lowered rents and prices over several years.

Figure 1: Rents fall after the supply shock

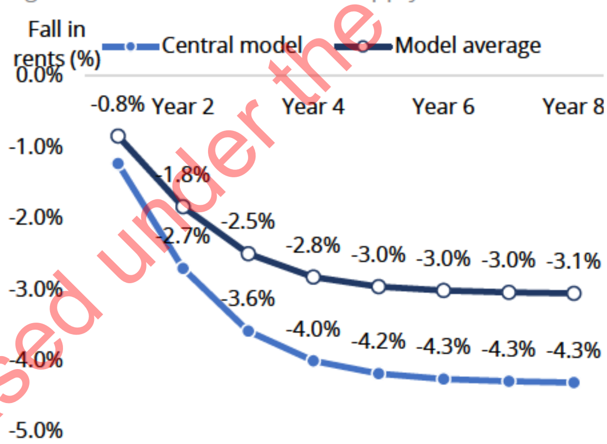
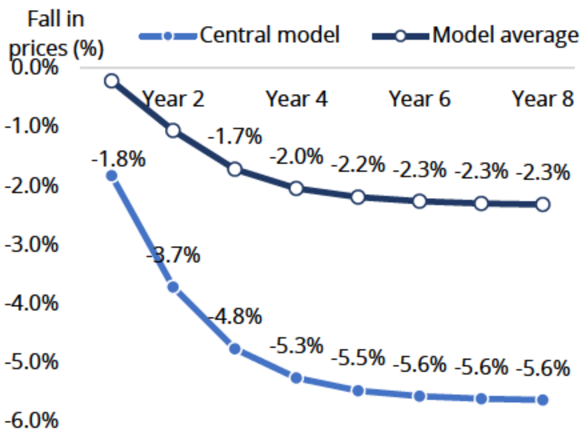


Figure 2: House prices fall in some models



- We use 12 different model specifications to test the robustness of our findings: rents always decline, prices almost always decline but only some findings are significant
- We find some modest evidence of spillovers across council boundaries from housing supply to rents and prices in the Christchurch region.
- We find little evidence of spillovers of changes in housing supply in other tier 1 cities to rents and house prices in Christchurch.

Our findings suggest key lessons for other parts of New Zealand

- A coordinated and integrated strategic spatial plan across the functional labour market area (that is the area people are connected across through commerce, education and leisure), rather than local authority boundaries, is needed.
- The plan should make sufficient land available to enable choice and competition across options to meet demand for many decades of expected growth. Agreed plans can then be fast-tracked if demand should arise sooner.
- The plan should be derived via a robust process with input from experts, politicians and the public. This inclusive approach ensures the maximum level of buy-in from all stakeholders (but expect discontent from some disaffected parties).
- Once a workable plan is found, the appeals/objection process needs to be limited and timebound. Disaffected parties can hold up otherwise 'good' plans.
- Funding and financing need to be aligned to plans, but existing tools and mechanisms were sufficient in the case of Canterbury.
- Allow market mechanisms to work to attract workers, subdividers and developers.
- Our quantitative modelling does not allow us to isolate the impacts of individual policies. But for councils that can implement the full suite of factors to enable flexible housing supply can expect improvement in housing affordability.

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Context

The Department of the Prime Minister and Cabinet (DPMC) commissioned Sense Partners to research lessons from the changes in the Christchurch housing market following the earthquakes of 2010 and 2011.

There was widespread damage in the 2010-2011 earthquakes, but housing supply responded quickly and at scale. Consequently, house prices remained relatively affordable. DPMC wanted to know whether it was possible to identify which policies and other changes contributed to the observed outcomes, and whether these were applicable elsewhere in New Zealand.

To understand the factors that allowed a flexible housing supply and test the impacts on housing affordability we take a mixed qualitative-quantitative approach.

Our approach begins with an overview of the relevant trends and housing market outcomes.,

Then we synthesize qualitative information from interviews with a range of stakeholders involved in the evolution of the housing market before, during and after the rebuild, to identify the package of factors that facilitated a flexible expansion in housing supply.

To estimate the impacts of these factors we then turn to a quantitative model to estimate impacts on housing affordability in Christchurch. We believe the combination of qualitative and quantitative impacts can help other cities understand the impacts of a suite of factors necessary to deliver flexible housing supply.

We are grateful to the interviewees, who generously shared their time, knowledge and insights with us. We have used quotes with permission throughout the report, but we have not attributed quotes to individuals.

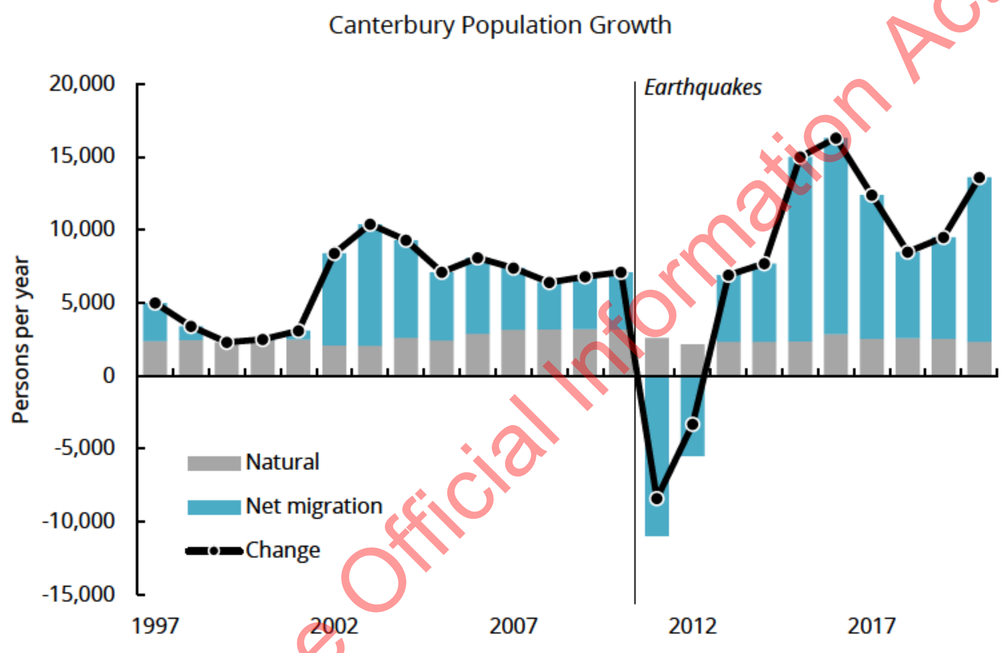
Table of figures

1. Overview of key trends

Housing ultimately more affordable than elsewhere despite an initial spike in prices

Canterbury was severely affected by large scale earthquakes in 2010 and 2011, and aftershocks for several years. This caused widespread property damage and loss of life. After an initial exodus of people from the region, the population grew rapidly, (see Figure 3), at least in part to deliver the rebuild.

Figure 3: The earthquakes initially led to short-term outflows of people from Canterbury

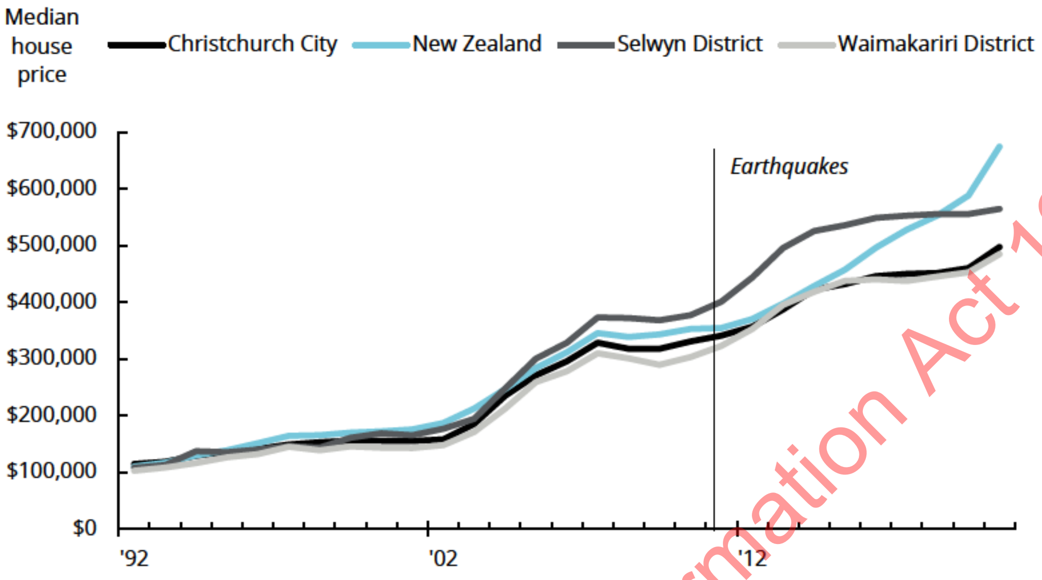


Source: Statistics New Zealand

Housing supply appeared to keep pace. Although prices in the region increased in the immediate aftermath of the earthquakes (see Figure 4), homes were eventually more affordable in the Christchurch region compared to other fast-growing tier 1 cities in New Zealand (see Figure 5).

This is striking since Canterbury lost over 28,000 homes due to the quakes. Land damage was also extensive, reducing the footprint of where homes could be rebuilt. While population pressures abated a little – Canterbury did not grow at the same rate of population as elsewhere in New Zealand (see Figure 6). It is remarkable that housing was relatively more affordable in the Christchurch region than other cities in New Zealand, and relatively more affordable after the earthquake than in the pre-earthquake period.

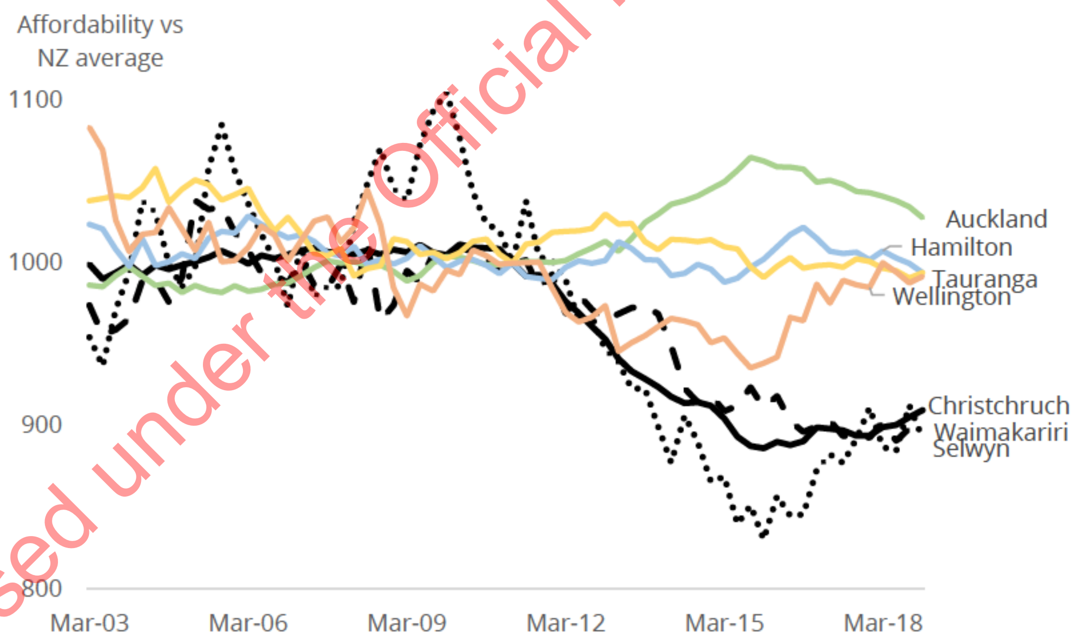
Figure 4: House prices in the region rose initially in the aftermath of the earthquakes...



Source: REINZ, Sense Partners

Figure 5: ...but ultimately homes in the region were more affordable than other cities

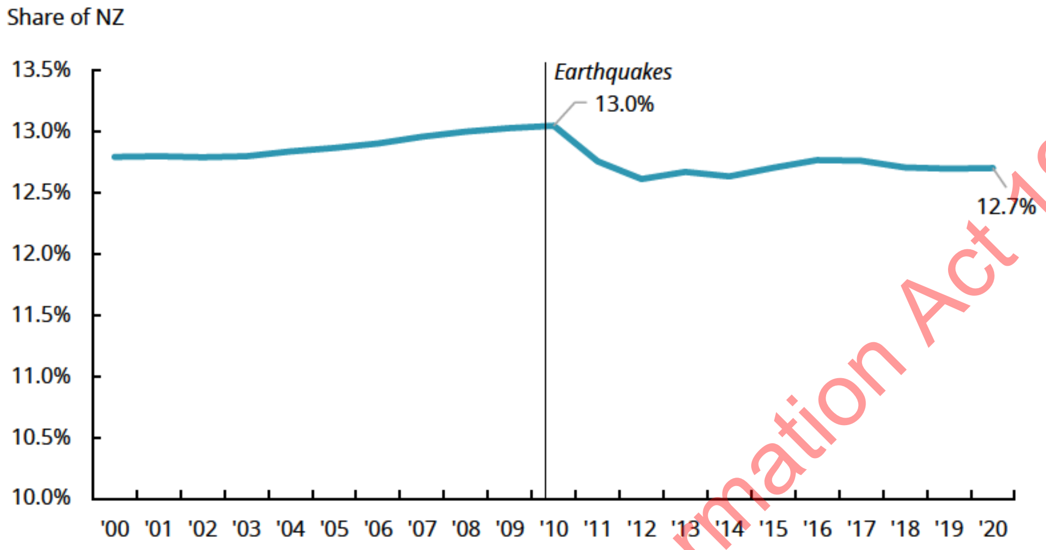
Housing affordability relative to national average, March-2011 =1000



Source: HUD Housing Affordability Measure, Sense Partners

Figure 6: Canterbury has not recovered its pre-quake share of New Zealand's population

Canterbury Population Share of New Zealand

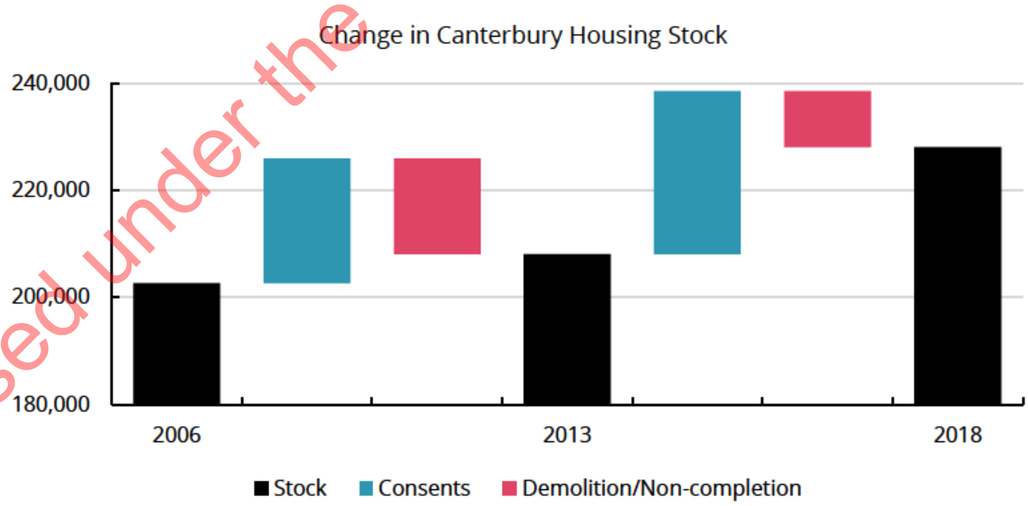


Source: Statistics New Zealand

Earthquake damage led to a shortage of housing

As of September 2020, there were 28,891 properties with damages exceeding $100,000 per dwelling.[2] Our analysis of the change in housing stock shows a similar tally. Between the 2006 and 2018 Censuses the number of dwellings rose by 25,400, about 28,400 short of the 53,800 consents issued over the same period (see Figure 7).

Figure 7: The earthquakes led to the loss of some 28,400 homes in the region



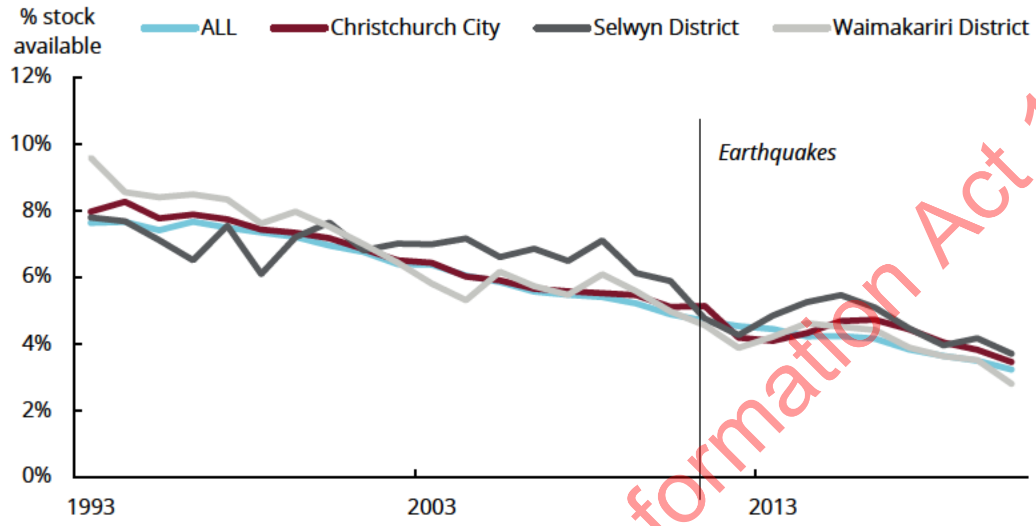
Source: Statistics NZ, Sense Partners

[2] ICNZ, Canterbury Earthquake Progress Report: Q32020, accessed 7 May 2021: https://www.icnz.org.nz/fileadmin/Assets/PDFs/Canterbury_Earthquake_Progress_Stats_Q3_2020.pdf

This led to a shortage of housing. The rental stock slumped (see Figure 8). Along with an increase in house prices, rents surged immediately after the earthquakes (see Figure 9).

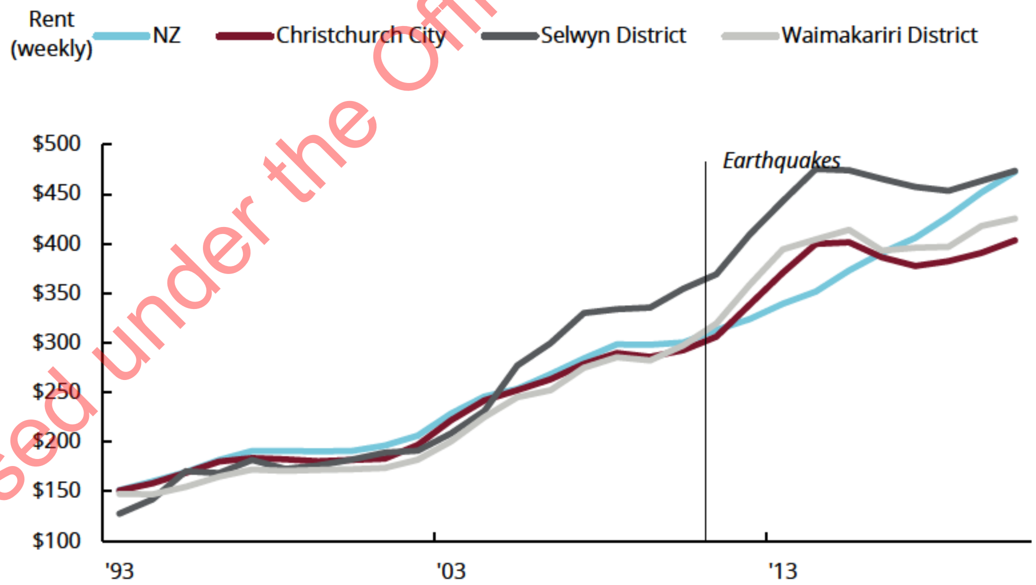
Figure 8: The available stock of rentals declined after the earthquakes

Rental Vacancy Rate



Source: MBIE, Sense Partners

Figure 9: The cost of renting in the region surged higher after the earthquakes



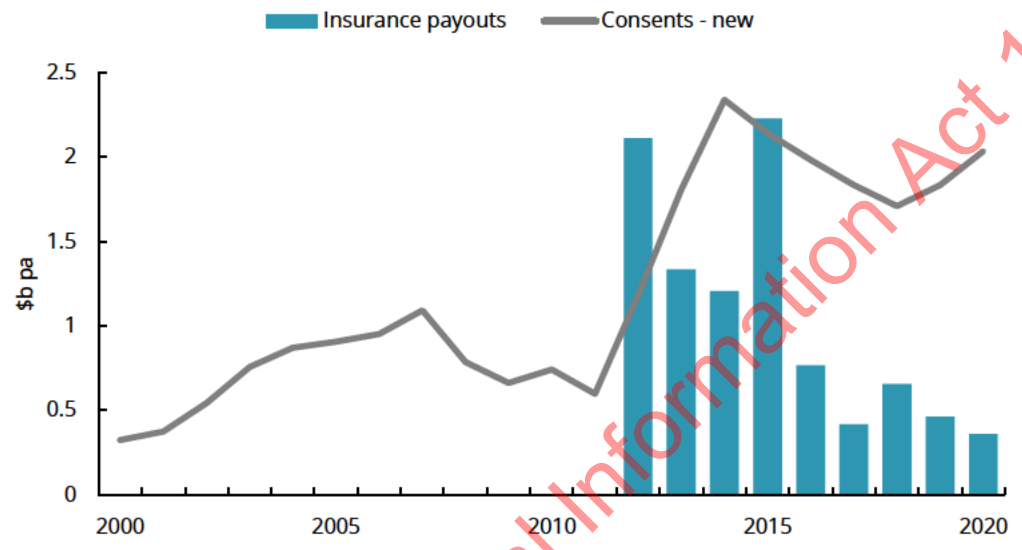
Source: MBIE, Sense Partners

But by 2020, pressures in rents had eased. Housing was more affordable than prior to the earthquakes.

House building was enabled by a variety of factors and by 2015, shortages had eased, aided at least in part by $11.33b of insurance pay-outs, three-quarters of which was paid out by the end of 2015 (see Figure 10).

Figure 10: Insurance pay-outs aided the initial house building surge from 2012 to 2015

Canterbury: Dwelling Consents & Residential Insurance Pay-outs

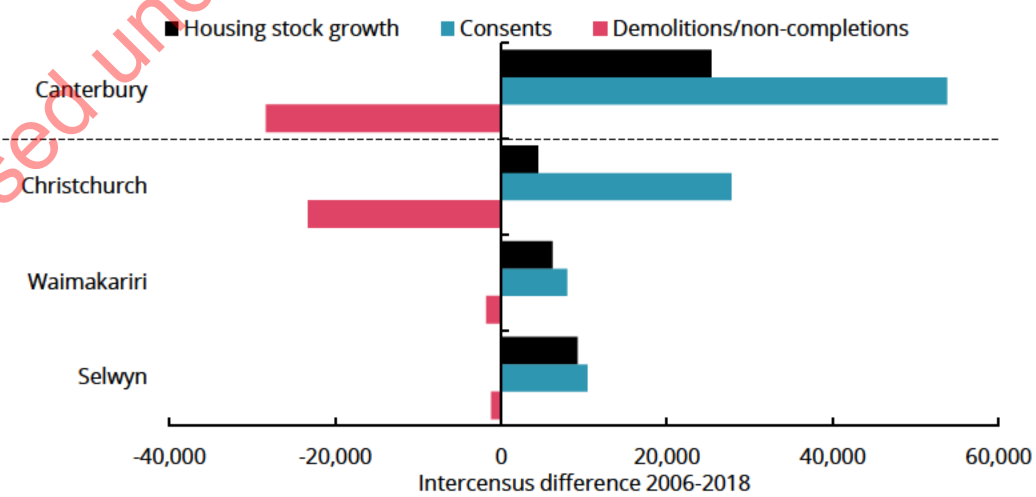


Source: Statistics New Zealand, RBNZ, EQC, ICNZ, Sense Partners

Demand was displaced from the Red Zone and many people moved to neighbouring districts and further afield (which were less affected by liquefaction for example). Net new housing stock increases in Waimakariri and Selwyn outstripping Christchurch. Christchurch mainly rebuilt damaged and lost homes, while Waimakariri and Selwyn District accommodated new homes (see Figure 11,12 and 13).

Figure 11: Waimakariri and Selwyn increased their housing stock significantly

Housing Supply/Loss in Canterbury, 2006-2018



Source: Statistics NZ, Sense Partners

Figure 12: New consents largely replaced lost homes in the periphery of Christchurch

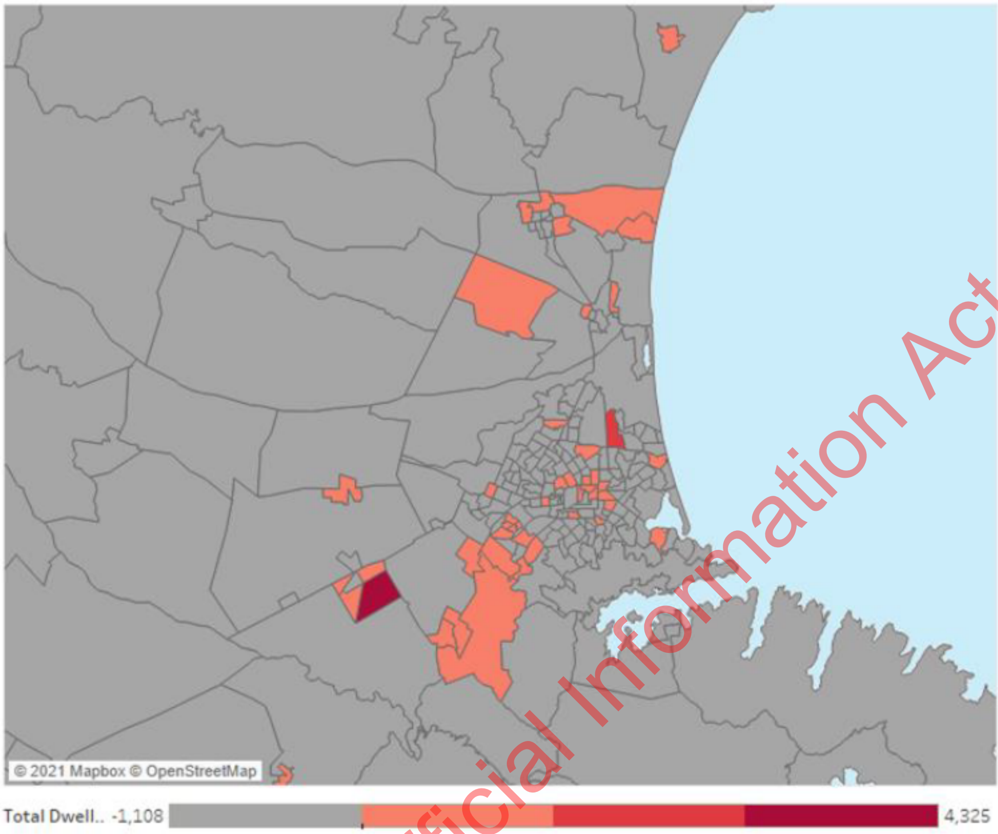
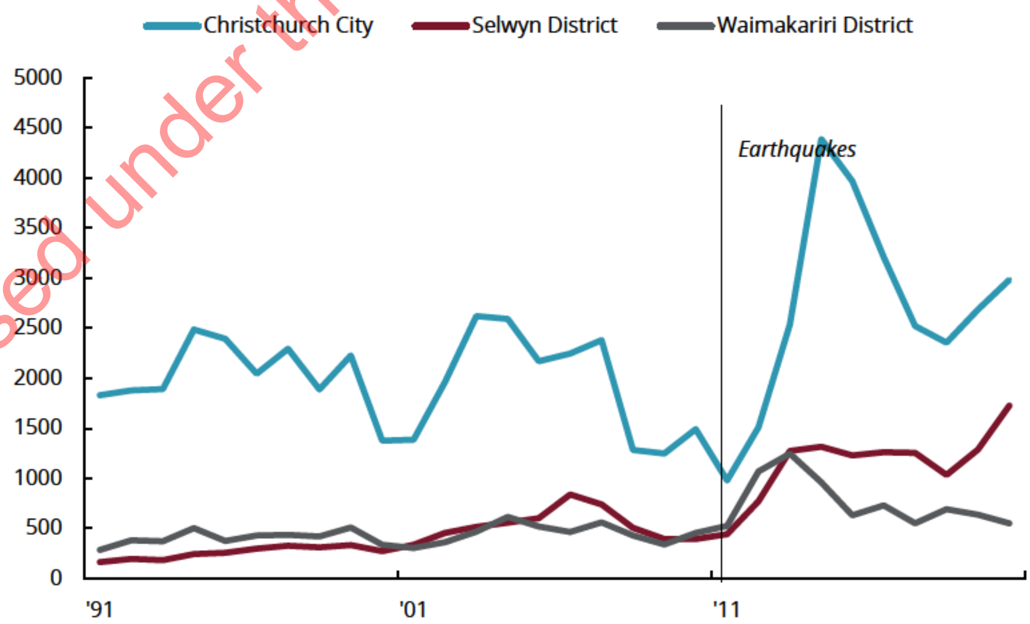


Figure 13: Most of the new builds were in Christchurch city

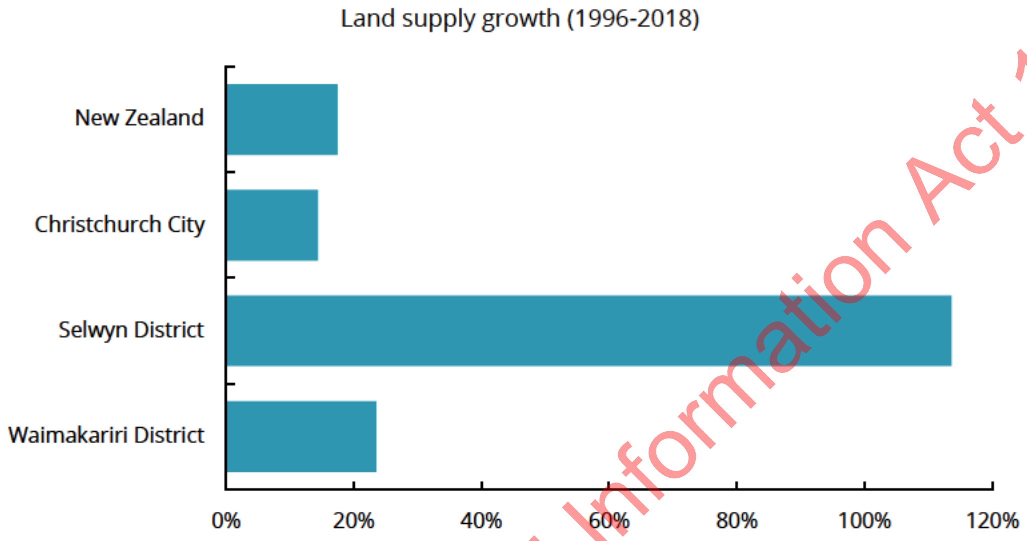
Building Consents for New builds



Source: Statistics NZ, Sense Partners

The loss of properties was not evenly spread across the region. Christchurch City bore the brunt of the damage with over 80% of the lost homes in the region in Christchurch. But the housing supply was not met in the same way. Selwyn District opened up a substantial amount of new land to accommodate new properties (see Figure 14).

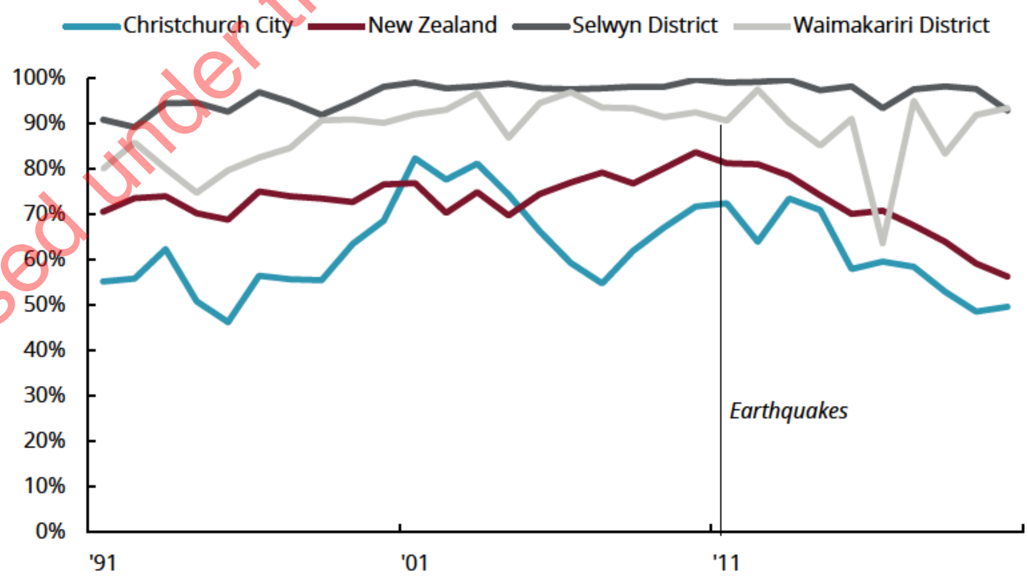
Figure 14: Land supply for housing more than doubled in Selwyn District



Source: Sense Partners

Initial house building was focused on standalone homes. Greenfields were predominantly standalone houses. Eventually housing density returned after the initial flurry of activity (see Figure 15). Most density was accommodated in in Christchurch City.

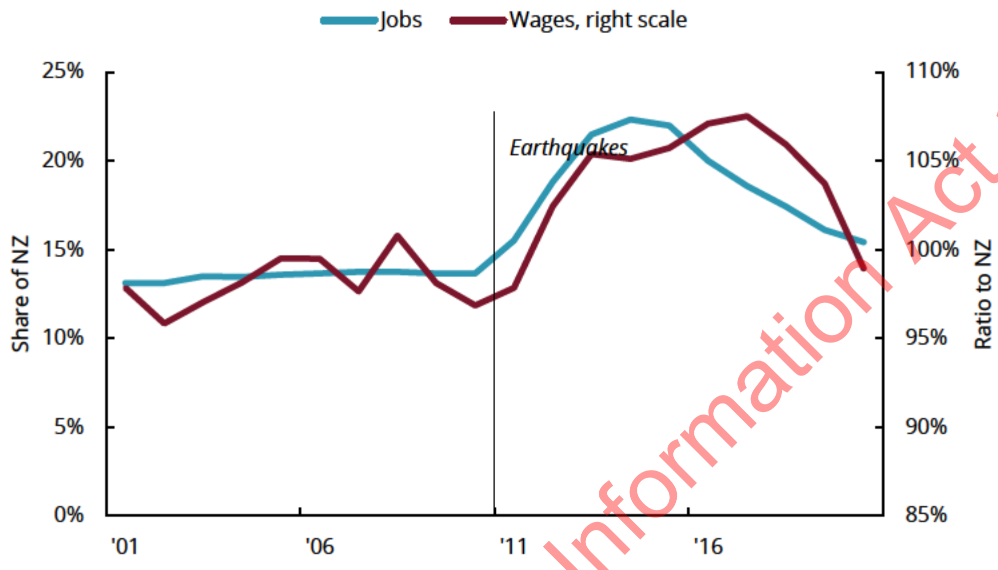
Figure 15: Buyers and insurers initially preferred standalone houses
Standalone houses, share of total consents



Source: Statistics New Zealand, Sense Partners

The surge in building activity needed to meet demand led to labour shortages. Wages rose to attract and retain staff (see Figure 16), as well to compensate workers for high housing costs. Some builders even housed workers in newly built homes temporarily.

Figure 16: Construction wages rose sharply to attract the necessary labour

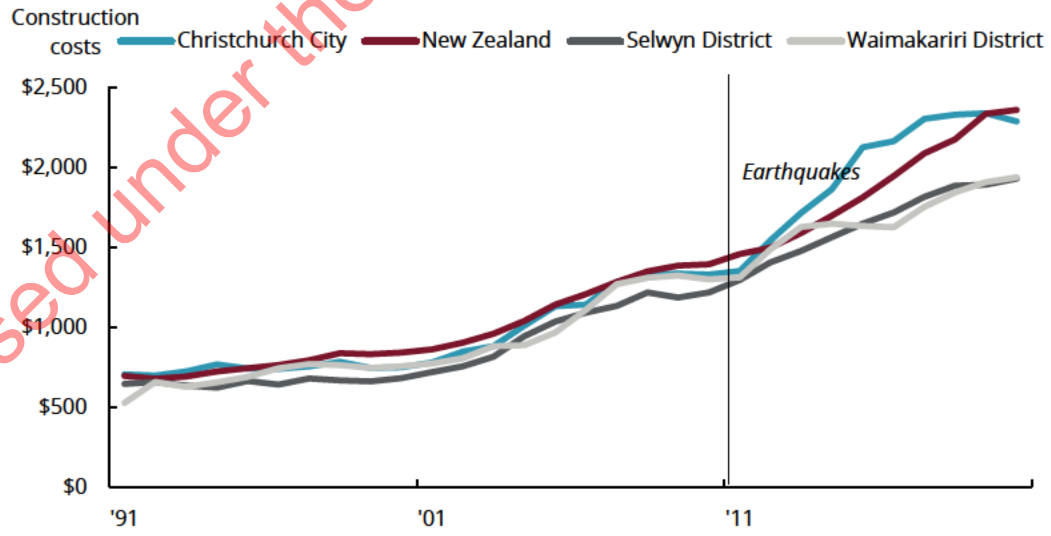


Source: Statistics NZ, Sense Partners

Unsurprisingly construction costs increased quickly (see Figure 17), pressured by increases in labour costs and the cost of materials.

Figure 17: Construction costs increased rapidly after the earthquakes

Average cost of construction per square metre

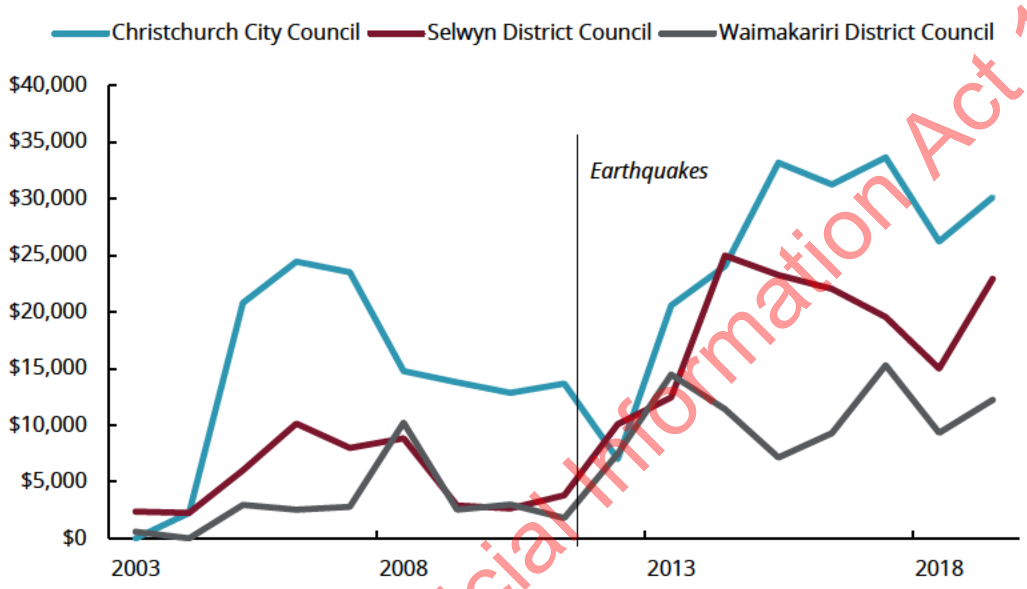


Source: Statistics New Zealand, Sense Partners

To finance the infrastructure required to meet the increase in demand, councils raised development contributions to meet the costs of local infrastructure. Additional city-shaping infrastructure, that could not be pinned to specific developments, were financed from debt (see Figure 19).

Figure 18: Councils increased the average development contributions across the region

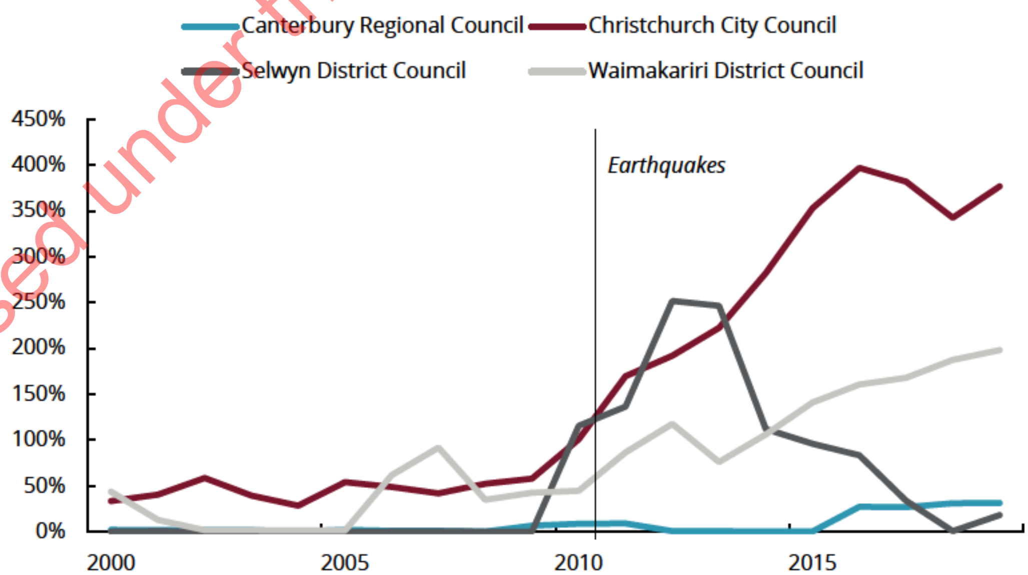
Development contributions per consented dwelling



Source: Statistics NZ, Sense Partners

Figure 19: Councils raised debt to pay for the larger infrastructure costs of the rebuild

Term Debt to Rates



Source: Statistics NZ, Sense Partners

2. Key messages from interviews

20 interviews with people directly involved at the time

We conducted interviews with experts and policymakers who were involved with all aspects of housing response in the Greater Christchurch. We conducted 14 interviews in person in Christchurch over a two-day period in May 2021, and a further six interviews over zoom or in person in Wellington.

Most interviews were recorded and transcribed with permission. When interviewees preferred not to be recorded, we used post-interview memos to complete the analysis.

We used a conversational interviewing approach. When we asked open-ended questions to collect rich qualitative data, which was then analysed methodically. We sought to understand the context, the tensions, why and how things evolved before and after the earthquakes.

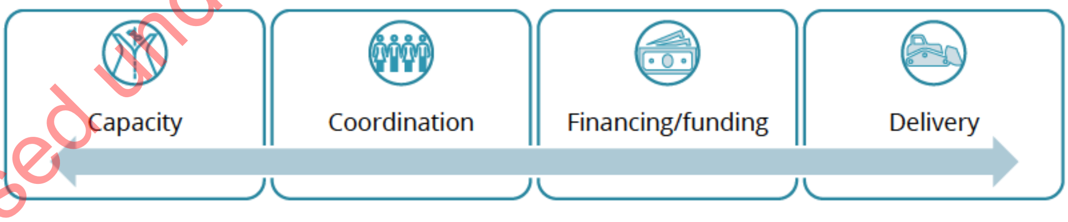
Our analysis of the conversations revealed 195 themes and subthemes. We then coded and summarised them in the following sections. We organised the key lessons by broad interest area.

An organising framework

We adapt the following broad infrastructure delivery framework to describe the messages we heard from the interviews. There are often four key challenges:

1. Capacity (for example geographic constraints, which limit suitable land for housing)
2. Coordination between agents (such as local governments, central government agencies, and developers)
3. Financing and funding (for infrastructure, development and mortgages)
4. Delivery (ability to deliver consents, infrastructure and houses).

Figure 20: The key ingredients for successful delivery on housing and other infrastructure



Source: Adapted from Ives et al. (2017)

Canterbury benefited from most of these challenges being dealt with relatively well.

3. Significant capacity

Several elements combined to present significant capacity in the region that helped make housing relatively affordable compared with the rest of New Zealand.

Amenable geography

The Canterbury region has very favourable geography, with relatively flat land contiguous to- and between- existing towns and townships.

Flat and open landscape means there is significant land that can be used for residential purposes. There was existing zoned land that had not yet been developed when the earthquakes hit. This was used up quickly, and further land had to be zoned and serviced (connected to necessary infrastructure). Our interviewees said:

> *"...you know in Christchurch, there is ample flat land"*

> *"There was already some headroom in land & infrastructure"*

Competitive land markets

The greenfield land markets in Selwyn and Waimakariri were described as competitive. The periphery of Christchurch was described by some as more tightly held, with few landowners holding most of the land. But others disagreed and said there was sufficient land zoned with credible infrastructure plans. One person noted:

> *"Initially it was developer led rezoned land to Selwyn council led land release. Landowners were typically happy so we didn't see much NIMBYism."*

Identifying land for growth

The effect of earlier coordination, the pre-existing UDS which had set out where growth should take place, and the use of CERA powers to reduce timeframes for plan changes and consents resulted in rapid land release across the region.

Massive tracts of new land were zoned, based on the Urban Development Strategy that had already been developed in prior years. Some described it as releasing decades of land in one go:

> *"Land did not trickle out, it was an oomph".*

Some interviewees noted while greenfield development scaled up swiftly, brownfield development remained difficult. In part, because of significant damage of built-up areas in Christchurch City, and because insurers were wary of apartments, and the demand from customers was standalone houses. One interviewee suggested:

> *"We have a lot more greenfields than we would have had if we hadn't had a disaster, and we have a lot more land rezoned than otherwise."*

However, interviewees also noted ongoing issues in developing brownfield sites, such as amalgamating sites, and creating sufficient competitive tension to deliver houses at scale, rather than trickle them out. Use it or lose it rights to develop the land, and more developers to create competition (as done in Hobsonville) were suggested as potential solutions to improve future brownfield developments. More competition within local land markets would have lowered housing costs.

Land quality issues became important after the earthquakes. Good geotechnical advice on land quality was needed. Some areas were more prone to liquefaction and or were less stable, requiring more expensive infrastructure works, increasing development and house costs. In this context, authoritative geotechnical information had a public good element, reducing uncertainty that could help enable the investment needed for development.

Ultimately these land quality issues generated demand in relatively stable areas such as Selwyn District and was a key contributing factor to where growth was accommodated.

On the surface, the issues that relate to land quality pertain only to the Christchurch experience after the earthquakes. But resolving improves the competitiveness of land markets that should be expected to lower land prices and consequently the cost of new housing.

The motorway plan was already in place

While there is an abundance of land, central government investment in motorways in Canterbury massively improved connectivity and reduced travel times. This improved the proposition of more distant locations such as Rolleston and Rangiora.

Motorway connections between Christchurch City, Selwyn District and Waimakariri District significantly improved travel times and thus the economic distance between these places. The functional labour market area spans across these three districts – meaning demand for housing can be met across the broader geography beyond political boundaries. This created a significant outlet for demand. Christchurch City Council area lost over 23,000 homes – meaning new supply for many years was replacing lost stock, rather than net new additions. In contrast, new supply in Selwyn and Waimakariri Districts were largely net new supply.

Improved transport links made places at the periphery more attractive and competitive, not just in price but also amenity. Motorways were described as the “safety valve” for growth and were up and running relatively quickly:

> *“The interesting thing about transport is because there was the UDS, they had already started doing their thinking and they didn't really need us to kind of truncate anything, because they had plans in place. What they did is they did it quicker. So instead of taking 15 years to have a new motorway here, they were like, oh, okay, we need to do this in five.”*

Institutional capacity and culture

Dealing with growth requires the capacity and culture in institutions to come up with ‘good’ solutions and find a way through conflict.

Typically, many policies are needed to come together for intensification to occur. Density was desired by the local authorities in principle, but not sustained in the face of vocal opposition, from some affected parties. Benefits of intensification tended to be distributed across many parties but the costs of intensification more acutely felt by a few, affected parties.

We were told of differences in cultures of local authorities. For example, many developers and planners said some councils took a pro-growth partnership approach to finding ways to make developments happen. Other councils were said to be less constructive so a range of views were expressed to in our interviews:

> *"...we saw significant community engagement."*
>
> *"All were easy to work with in the beginning..."*
>
> *"I kept thinking, why are they afraid to zone land?"*
>
> *"Planning organisations, for policy reasons, feel it is their job to constrain growth. They feel it is bad.*

4. Coordination

Coordination prior to the quake

A long process of coordination across Christchurch City Council, Selwyn District Council, Waimakariri and other parties such as Environment Canterbury, Canterbury District Health Board, and Waka Kotahi led to an Urban Development Strategy. The parties had been working together under the Greater Christchurch Partnership (and its previous forms), to establish common ground across stakeholders. This collaboration culminated in the Urban Development Strategy (a broad spatial plan to accommodate future growth). This spatial plan was to be the critical blueprint for the recovery.

The Urban Development Strategy was going through the Environment Court to be made operational as the Regional Policy Statement (RPS) when the earthquakes happened. There were legal challenges based on where the boundaries were drawn and other matters.

The RPS designated infrastructure boundaries, while also allowing sufficient housing supply for the next 50 years. It established agreed areas of future growth. This was a new approach of in the region required by central government agencies to deliver on the planned motorway development under the Roads of National Significance (RONS).[3]

So, when the earthquakes hit, the region already had agreement about where future growth should occur.[4] Many suggested this agreement was essential:

> *"I guess the good thing about the earthquakes is we've got Greater Christchurch Partnership. Everybody knows it's a good idea."*
>
> *"Meant we weren't starting from scratch - the fact the UDS had been done was really useful."*
>
> *"I think that that the decision to create the urban development strategy was the best thing that we could have done. It was thinking three to four decades out, into the future."*

Urban planning in the region had been changing well before the earthquake. The relationships between Christchurch City Council, Waimakariri District Council, Selwyn District Council, Canterbury Regional Council, and government could be adversarial. Councils sometimes opposed zoning changes within other council areas. Transport decisions across the region would sometimes not be agreed between affected councils.

[3] The process had also included community consultation and had been accompanied by structure plans in some places like Lincoln and Rolleston. Selwyn for example had already started investing in infrastructure, such as its modular sewerage plant, which allowed it to grow with sudden increase in demand after the quakes.
[4] When the earthquakes hit, the UDS was not in operation. The UDS was delayed by litigation in the Environment Court that some suggested originated from a fear of missing out on land appreciation from upzoning.

Coordination immediately after the quake

There was a great deal of coordination that took place after the earthquakes. For example, the Ministry of Education delivered schools in Rolleston for planned population growth.

But there were also examples of lack of coordination – for example the motorway build was not coordinated with plans for public transport.

The Redzone was a major risk factor – because the responsibility and liability were spread across many parties, but central government intervention dealt with a large liability, giving confidence for homeowners, insurers, and developers to go ahead with other areas. The uncertainty of how insurance markets would respond to outcomes shaped policy.

Coordination across some topics remains challenging

There also areas that are difficult to coordinate. Many said there remains poor incentives for information sharing between councils. How to pay for regional assets was controversial. Deciding who should pay for densification also proved contentious. We were told Selwyn District Council and Waimakariri District Council wanted to help provide an environment that retain people with the region. This justification was used to help release land quickly for development and to encourage greenfield builds.

> *"There should have been a conversation across all of Canterbury, about paying for regional assets that are going to be located obviously, in the city. And there's been nothing, it's never been raised."*

Several developers and planners cited the ease of working with some councils. A partnership approach, involving all stakeholders early in the process, meant working together to find ways of making things happen, rather than stopping activity.

The use of special powers to override local co-ordination failure:

CERA powers were widely recognised as useful in aiding the recovery. Described a *"serious asset"* in cutting across the RMA and necessary to *"get things done"*, many interviewees acknowledge the value of these tools.

The powers were concentrated on rebuild efforts around the CBD primarily while the Land Use Recover Plan (LURP) was used to fast track the UDS that resulted in directed amendments to district plans, or in the case of Christchurch City, a full district plan review.

The main thrust of the changes to the district plan was to make provisions simpler. It removed the right for changes to be notified and consenting matters were removed. One planner gave an example of urban design matters in the CBD being reduced from 21 matters to 7.

The effect was a timeline for a plan change decreased from 2-3 years to months.

> *"We got an application in and had in in front of a panel of commissioners, and within 3 days, they made a decision. It was amazing. We worked with them beforehand to make sure it was all in line. Let's make sure we're all saying yes. Which is almost unheard of under the RMA."*

In addition, the special powers were also used to free up greenfield land for development. In general the special powers relaxed constrains about where building could take place rather than relaxing the type of building form that could take place. For example, the LURP specified:

- Christchurch City Council to zones areas near the Upper Styx River and Highfield for greenfield development;
- Waimakariri District Council to include zoning for greenfield development in West Rangiora and Oxford Road; and
- Selwyn District Council to prioritise greenfield development at Prebbleton, Rolleston and Lincoln.

The circumstances that led to the creation of CERA are rare and unlikely to hold much specific information for other councils looking to improve housing affordability. The consensus from our interviews was progress was made quickly when relationships were strong and coordination effective.

5. Funding/financing

Infrastructure funding used standard funding arrangements

Local governments used typical funding and financing arrangements to fund infrastructure. Councils used development contributions, debt and rates in different mixes across the 3 territorial authorities, to fund subdivisions and house building. At least for these councils, access to funding and finance did not prohibit growth.

Large insurance pay-outs created a secure source of demand. This new money (over $11b) created confidence among investors in subdivisions and housing developments, particularly after some developers found it hard to access credit immediately after the earthquakes.

Some effort was made to attract private funding for anchor projects, originally via the Christchurch Central Development Unit and then via Ōtākaro – but it was modest.

Some innovation took place, mitigating risks

Some innovation occurred, mitigating the usual risks for many councils, who do not want to spend too much capital too early, in case new ratepayers don't turn up. We were told:

> *"...there was probably risk management from the council in terms of not overexposing themselves to investing in infrastructure without knowing that all this development was going to happen."*

Examples of innovation include the development in Waimakariri that used overland pipes and didn't have complete driveways at time of opening. Selwyn's modular waste-water facility allowed it to grow the infrastructure with demand, without a big upfront cost.

Transport infrastructure

A wider perspective on infrastructure, which allows for changing land use, can increase the availability of land that can be developed.

Motorways were already planned but were brought forward. These signalled to those buying further out that transport was coming. This increased demand for housing in more distant locations, and developers tell us the majority of houses were sold off the plan. Several interviewees noted the lack of investment in public transport, lack of co-ordination and need for sequencing with land use planning.

6. Delivery

The immediate recovery

The supply of housing was ultimately very responsive, initially through direct interventions to repair and then replace the housing stock, and later through deregulation.

Part of moving quickly was about restoring confidence in Christchurch city in the aftermath of the disaster. Early concerns included population and capital flight, with 15% GDP losses. Interviewees also feared insurance market collapse. The Red Zone – a decisive central government intervention – reduced uncertainty for insurance companies. Many suggested government handled the red zone well and recognised local government could not have achieved these outcomes alone.

Anchor projects aimed to retain business investment in Christchurch. Some of the timelines were deliberately optimistic to signal and attract investment. There were issues with procurement going to international designers for these projects.

These impacts are important context for understanding housing outcomes in the region after the earthquakes. But the impacts of policies to help speed up development once the initial recovery took hold, hold broader lessons for other local councils.

Speeding up development

Deregulation to speed up supply and cut red tape also occurred. In the immediate aftermath of the earthquake, deregulation was prioritised to speed up the rebuild. For example, the UDS was adopted. This provided clarity of rules-based criteria with limited grounds for appeals but there was a recognised tension between following democratic process, versus objective outcomes desired. Decisions were centralised, and engagement truncated.

The provisions in the LURP were described in one interview as "just disastrous" and out of step with the Māori Land Court. So while cutting red tape to speed development helped bring on housing supply, the Christchurch experience suggests other councils should expect trade-offs when reducing regulation.

But interventions that retained competition between developers, either by using multiple developers to create competitive tension (as in Hobsonville, for example) or having timestamps on the lot development were the most successful.

The construction sector was able to scale quickly, supported by incoming labour and good relationships with councils. The attitude by developers was to get it done. Small builders scaled to meet the demand. But there was little time and incentive to invest in innovation. Any innovation occurred in the speed of delivery rather than quality in quality of development. A wide range of interviewees regretted not building back better or reimagined.

Emerging issues

Some practices will hurt future innovation. For example, restrictive covenants were used by developers to create certainty for buyers. For example, from the risk of an apartment building going up next door – which were difficult to insure immediately after the earthquakes. Or relocatable houses, which may have impacted on typology and tenure of houses in the neighbourhood.

These covenants could impinge in future density provisions, which may enable better public transport or suitable housing for older people, to allow people to age in place. Other councils seeking to improve housing affordability might want to consider the impact on housing affordability from these types of restrictions.

Many developers shared emerging frustration with councils. Resource and building consent processes have slowed, reducing the flexibility of housing supply to respond to strong demand. We were told that today:

> *"It's the building consenting side that's slow. For us it's not just about how much money it costs but also how long it takes. The uncertainty with that timeframe can be quite frustrating. The development contributions are factored into the prices – but the uncertainty is what is bumps pricing."*

Staff turnover was a commonly cited challenge across all councils. This was recognised by council employees. Selwyn was an exception during the rebuild, with a small team of longstanding planners who lived and worked in the region. Interviewees suggested this aided in fast turnarounds and consistency of decision making.

7. Modelling impacts

Our approach

Our work points to the interaction of several factors to release housing supply. Each housing region needs to find local solutions to the pre-conditions to capacity, coordination, funding and financing and delivery issues that enable new supply to be released to the market.

But housing markets differ across New Zealand in terms of demand and supply characteristics. To tease out the opportunity from getting it right and increasing supply for New Zealand regions, we use a simple spatial model that allows variation in supply and demand across regions to show the gains in affordability from getting it right.

Importantly, our modelling strategy allows for spillovers across housing regions. Increases in supply in one part of the country are allowed to impact on housing affordability in other regions, but ultimately the data determines how large these impacts can be.

The Canterbury earthquakes represent a large shock to the economy. Lots of dislocation and important timing effects make detailed modelling demanding in terms of the assumptions and caveats that need to be employed. Rather than take a detailed structural approach (see for example, the models developed by Bramley 2013 or Grimes et al. 2013) we strip the model back in terms of the number of variables and instead focus on spillovers across markets.

Throughout, the results reflect market dynamics over the past 30 years.

Some caveats

Modelling the quantitative impact of the Christchurch earthquakes and subsequent policy response is fraught. The earthquakes are a large economic shock with several moving parts including large shifts in population, reductions in the housing stock and the location of economic activity.

It is well-known that structural models based on linear approximations to a non-linear world are only valid in the presence of small shocks.[5] Here we have a large shock – earthquakes, such that structural models are unlikely to be able to replicate the data.

Moreover, our structural break modelling shows the possibility of breaks at several potential breakpoints across many housing market variables, although no date stands out as a single breakpoint. This makes inferences potentially unreliable, but the battery of structural break tests provides no clear best alternative framework.

We present our structural break modelling work in Appendix E and proceed to look at the impacts of structural shocks on housing outcomes in Christchurch, focussing on both rents and house prices as measures of housing affordability.

[5] See Couper and Wolman 2003 for example.

Uncertainty

One of the key features of our VAR modelling is the use of confidence intervals to show uncertainty about the impact of shocks of housing outcomes – house price growth and growth in rents. VAR models are notorious for producing wide confidence intervals. This is because very few restrictions are imposed on the VAR model.

This has the advantage of allowing the VAR model to accommodate a variety of models or economic theories. For example, the VAR model can simultaneously accommodate theories that immigrants rent and then purchase houses, driving up house price growth and fewer New Zealanders leaving generates pent-up demand. We need not specific which theory dominates.

It is standard not to remove insignificant parameters from the VAR model. The confidence intervals use random samples of the full set of parameters – producing wide intervals.

To show the uncertainty associated with the impulse response functions, one approach is to use theory (asymptotic theory) to suggest how wide the confidence intervals should be. A second approach is to simply simulate the model thousands of times and produce confidence intervals based on the simulated draws.

We take this approach to show the uncertainty with the impulse response functions. Wide confidence intervals on impulse response functions are a typical feature of VAR models. This stems from the flexible functional form that imposes little structure (perhaps other than linearity and variable choice) with the consequence that many variables and parameters enter generate the impulse responses. Small samples also drive the wide confidence intervals.[6]

The data

Key variables

At a minimum, we want to describe the impact of changes in housing supply on affordability. We choose to measure affordability in terms of not just house prices but also the cost of renting. So, we work with both REINZ house prices indices and MBIE's tenancy bond database.

We also need to capture demand and supply-side drivers. On the demand side, we use the volume of sales as a proxy for demand using REINZ data. We expect the volume of sales to be higher in periods of high demand but the measure is imperfect and only shows the measure of demand that can be met with current supply in the market. So we augment our demand measure with models that also contain migration (measured at the national level), and local measures of income growth and changes in jobs using LEED data on jobs and incomes.

In terms of supply, our ideal measure would be additions to the housing stock. But the number of new residential buildings is not available at the local council with a long time series. so we use data on new residential consents. This data is monthly since the early 1990s.

Finally, credit conditions have eased over the past twenty years, decreasing the cost of borrowing for housing. We include the nominal interest rate to capture this effect and the nominal exchange rate to help trace the strength of the economy.

[6] See Kilian1988.

Spatial data

We are concerned with not just the Christchurch market, but also Selwyn and Waimakariri. Moreover, we want to know if other housing markets could realise a similar change to housing supply for Christchurch, what likely impacts might be in other markets.

Expanding the set of data to every local council would generate over 400 variables – too many to monitor let along model, even with methods suitable for large data sets. Some of the data for smaller councils also contains long periods with relatively few sales or new rental tenancy data, making it difficult to interpret impacts.

So, to minimise the number of variables, we only include councils that are part of tier one shared urban areas identified by the Ministry of Housing and Urban Development. This helps our method to capture influences from the largest housing markets.

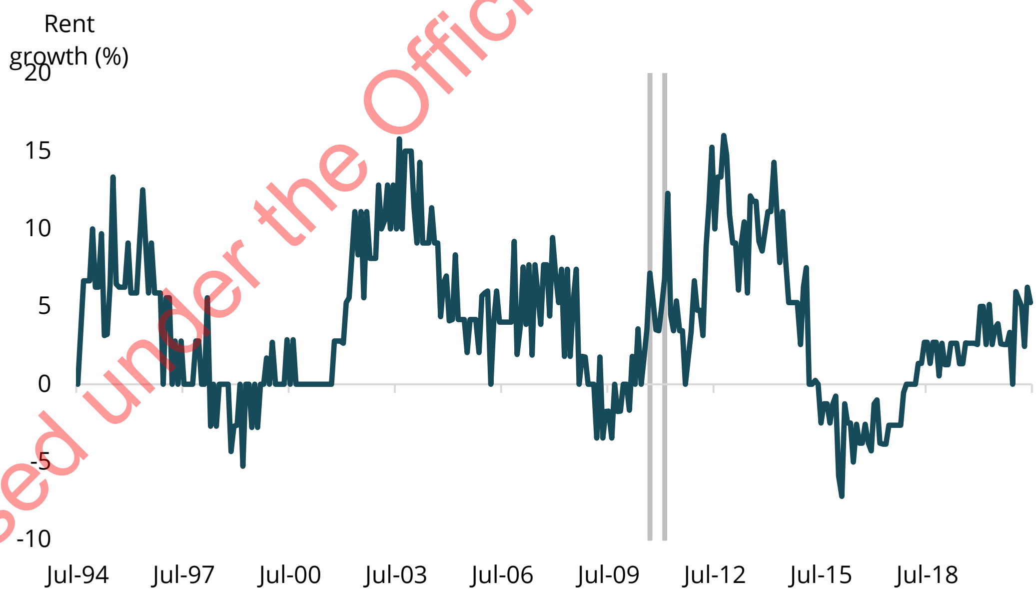
Stationarity

We test for stationarity of each of the variables in our dataset using the Phillips-Perron test. Since our focus is isolating the impact of changes in supply, rather than the parameter estimates of themselves, the order of integration of the data is not a showstopper – we could estimate the model in levels. [7]

Seasonality

We seasonally adjust our data where appropriate using the widely used X13 seasonal adjustment programme. We graph the data in Figure 21 to Figure 26.

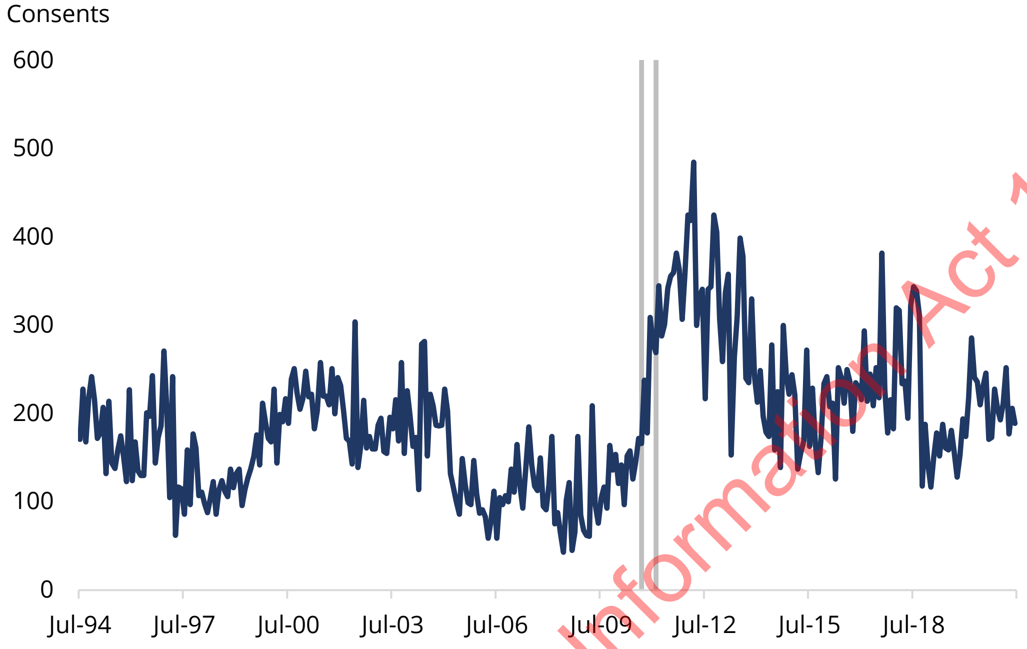
Figure 21: Annual growth in rents shows a cyclical pattern less pronounced after 2015



Source: MBIE Rental tenancy database

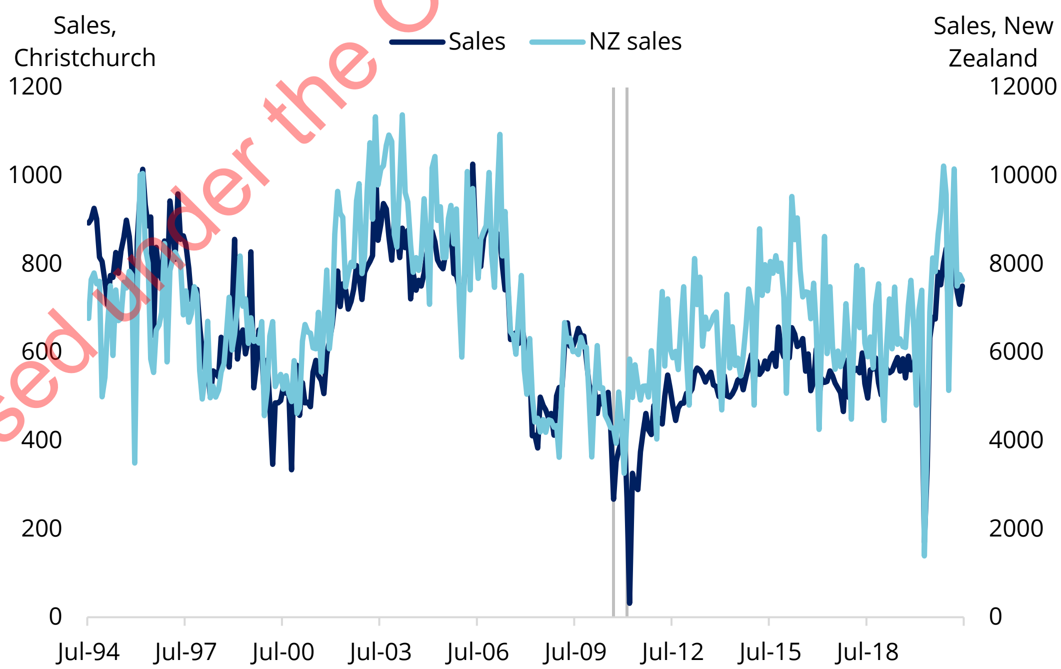
[7] To impose the Minnesota prior in our BVAR model, we need to shrink the parameter space towards growth rates that have no persistence, or levels that take the same value as the previous period. So, we test for stationarity (see Appendix F) and work in growth rates of each series or express the variable relative to another nonstationary variable to induce stationarity.

Figure 22: Pace of new consents accelerates in 2012 and 2013 to replace existing stock
New residential consents for new builds, Christchurch City



Source: Statistics New Zealand

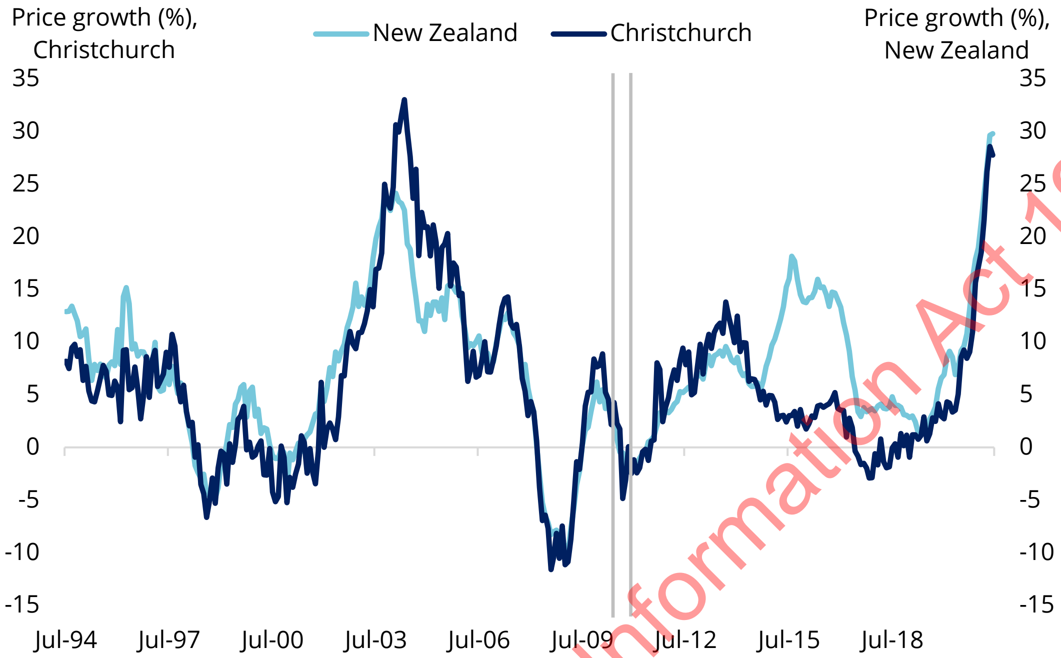
Figure 23: Market turnover much lower after the GFC and spikes lower in March 2011
Sales, Christchurch City vs New Zealand



Source: Real Estate Institute of New Zealand

Figure 24: Between 2014 and 2020 price growth was more muted than elsewhere

Annual growth in the REINZ house price index, Christchurch City



Source: Real Estate Institute of New Zealand

Figure 25: The cost of borrowing has declined

Ninety-day interest rate

Source: Reserve Bank of New Zealand

Figure 26: The exchange rate helps account for external shocks
Nominal Trade-Weighted Index

Source: Reserve Bank of New Zealand

Our model

Our objective is to understand the impact on housing supply on housing affordability. We work with a simple linear model that seeks to identify likely quantitative impacts of the changes in housing supply brought about by the factors identified in the qualitative section.

More specifically, we set up a Bayesian VAR model and use consents per thousand residents to proxy the supply-side. We are primarily interested on the impact on house prices and use the REINZ house price index deflated by the consumer price index. We also include the nominal interest rate to account for decreases in the cost of borrowing and increases in the ease of access to credit over the past twenty-five years. Our dataset starts in the mid-1990s with the beginning of monthly observations in house prices.

We use a Vector Autoregression (VAR) model to estimate the impact of changes in housing supply on house prices. Vector-autoregression models are a standard modelling technology, widely used within macroeconomics.[8] Relative to structural models, one of the chief benefits of adopting the framework is the limited structure a modeller needs to impose on the data, allowing the underlying characteristics of the data to show.

The technique has also been used to study dynamics in many housing markets.[9] Moreover, Doyle and Noy 2015 use the VAR approach to look at the impacts of the Christchurch

[8] See Sims 1980, Runkle 1987 and Barsky and Kilian 2004 for applications in macroeconomics.
[9] For example, Pesaran and Yamagata 2011 use a rich VAR framework to study the UK housing market, Balcilar, Gupta and Miller 2014 study US housing dynamics during the Great

earthquakes and find surprising low impacts of the earthquakes on inflation and economic activity. We discuss the technical elements of the econometric model in Box A.

Although the modelling framework is flexible, with little structure imposed on the underlying coefficients of the VAR model, several ongoing changes in the underlying economic environment suggests identifying the impacts of supply shocks with much precision is difficult.

For example, existing literature points to the impact of insurance pay-outs on the prices of housing in different parts of Christchurch and changing transport patterns are likely to matter.[10] Bond and Dermisi 2007 show the number of properties destroyed in the earthquakes impacted on house prices in area.[11] The large changes in demographics immediately after the earthquakes also suggests instability in the underlying housing market dynamics.

These instabilities are confirmed by a battery of structural break tests we perform on the data we set out in Appendix E. In general, these tests show evidence of structural breaks across each of the housing series that enter the model (when we work with a broad set of data from Christchurch, Selwyn and Waimakariri).

But no single datapoint stands out as a clear candidate for splitting the data sample or for including dummy variables. There is no clear break in the data at the time of either major earthquake that hit the Christchurch region. Instead, each aspect of the housing market (the rental market, house prices, consenting activity, sales activity) appears to have different underlying dynamics. So we proceed without a structural break at the time of the earthquakes.

Size of the shock

Our supply shock measure is the monthly change in consenting activity that does not neatly translate to interpretable measure. So we scale our shock to return an increase of 1,000 dwellings over a year. Figure 27 helps to show the size of this shock against the behaviour of consenting activity in Christchurch. The shock is not as large as the increase in consenting activity over the period 2015-2016. Some of this increase in consenting activity is endogenous or explained by the model and is correlated with a general increase in consenting activity at this time across New Zealand. The remainder of the movement is exogenous.

Depression, Valadkhani, Costello and Ratti 2016 look at housing dynamics in 4 of the largest Australian cities and Cipollini and Parla 2020 study shocks in the Italian housing market.

[10] See Nguyen et al. 2020 and Yonson et al. 2020

[11] Houses price impacts are measures across three areas (Technical category 1, technical category 2 and technical category 3) that vary with respect to earthquake resilience (see https://ccc.govt.nz/consents-and-licences/land-and-zoning/technical-categories-map).

Box A: The Econometric approach

The Vector autoregression model

We use Bayesian techniques to estimate a standard VAR model, that is:

$$y_t = c + \sum_{k=1}^{p} A_k y_{y-k} + \varepsilon_t \text{ for } t = 1,2, \dots T$$

where y_t is a $n \times 1$ vector of all the variables we are concerned with, in our case, house prices and rents (our measures of affordability), consents per 1000 people (our measure of supply), sales (our measures of demand) and the interest rate (to proxy the cost of borrowing).

The matrices contained in A_k capture the relationships between our variables and ε_t are the errors associated with each variable. These errors should be mean zero and be well-behaved for statistical purposes with no autocorrelation or heteroscedasticity. The error terms have a variance-covariance matrix defined by

$$\sum = [\varepsilon_t \varepsilon_t']$$

We can also write the model in short form notation:

$$Y + XA + \epsilon_t$$

where $Y = (y_{1t}, \dots y_t)', X = (X_1, \dots X_t)'$ where $(y_{1,t} \dots y_{n,t})', X_t = (X_1, \dots, X_t)'$ with $y_t = (y_{1,t} \dots y_{n,t})'$ and $X_t = (1, y_{t-1}' \dots y'_{t-p})', A = (c, A_1 \dots A_p)'$ and $\epsilon = (\varepsilon_1 \dots \varepsilon_T)'$.

Bayesian estimation with prior information

Then to impose the standard Minnesota prior routinely used to estimate large Bayesian VAR models, we append dummy observations to Y and X, following the methods in Banbura et al. 2010 and Giannone, Lenza and Primiceri 2015 that have been applied to many studies, including structural analysis of housing data (see Luciani 2015 for example) and to New Zealand macroeconomic data in the past (Bloor and Matheson 2010).

This allows us to model more variables than we have observations, avoiding the curse of dimensionality. More technically, as described in Barboza and Vasconcelos 2019, our priors have the following moments:

$$E[(A_k)_{ij}] = \begin{cases} \delta_i, & j = 1, k = 1 \\ 0, & otherwise \end{cases}, \quad V[(A_k)_{ij}] = \begin{cases} \frac{\lambda^2}{k^2}, & j = i \\ \frac{\lambda^2 \sigma_i^2}{k^2 \sigma_j^2}, & otherwise \end{cases}$$

This implies that the hyperparameter, λ, controls the influence of the prior on the data. Low values of λ represent relatively high influence of the prior on the model – when $\lambda = 0$ the posterior is the prior and the data are ignored.

High values of λ correspond to prior information that takes a low weight – when $\lambda = \infty$ the prior is ignored, and the data is returned.

We conduct all estimation using the BVAR package in the R programming language provided by Kuschnig and Vashold 2019.

Estimating the weight on the prior

To estimate the weight on the prior, we follow Banbura et al. 2010 and others and first estimate a small VAR that contains the key variables we are concerned with. In our case, we focus on Christchurch city and include rents, prices, sales, and consents for this council along with the nominal interest rate. The parameter δ is set to 1 for non-stationary variables and 0 for stationary variables.

This is the standard Minnesota prior and implies that a prior, the underlying data are best represented as random walks. This prior turns out to have good properties for forecasting data but allows for more complicated dynamics when suggested by the data.

To complete the econometric specification, note that the Normal inverted Wishart prior is:

$$vec(A)|\Sigma \sim N(vec(A_0), \Sigma \otimes \Omega_0)$$

with $\Sigma \sim iW(S_0, \alpha_0)$.

The parameters A_0, Ω_0, S_0 and α_0 need to meet the conditions for the Minnesota prior (see previous page) are met. Dummy observations ensure these conditions are met and are generated by:

$$Y_d = \begin{pmatrix} \frac{diag(\delta_1\sigma_1, \dots, \delta_n, \sigma_n)}{\lambda} \\ 0_{n(p-1)\times n} \\ diag(\sigma_1, \dots, \sigma_n) \\ 0_{1\times n} \end{pmatrix}, \quad X_d = \begin{pmatrix} J_p \otimes diag(\sigma_{1,\dots,}\sigma_n)\lambda & 0_{np\times 1} \\ 0_{n\times np} & 0_{n\times 1} \\ 0_{1\times np} & \rho \end{pmatrix}$$

$J_p = diag(1,2, \dots, p)$ and ρ is a small number set to 0.1.

Next, the dummy variables are appended to the model such that:

$$Y_* = X_* A + \epsilon_*$$

Where $Y_* = (Y'Y_d')'$, $XX_* = (X'X_d')'$ and $\epsilon_* = (\epsilon'\epsilon_d')'$. The posterior, or combination of data and prior is then:

$$vec(A)|\Sigma, Y \sim N\left(vec(\tilde{A}), \Sigma \otimes (X_*'X_*)^{-1}\right),$$

$$\Sigma|Y \sim iW\left(\tilde{\Sigma}, T_d + 1 + T - np\right)$$

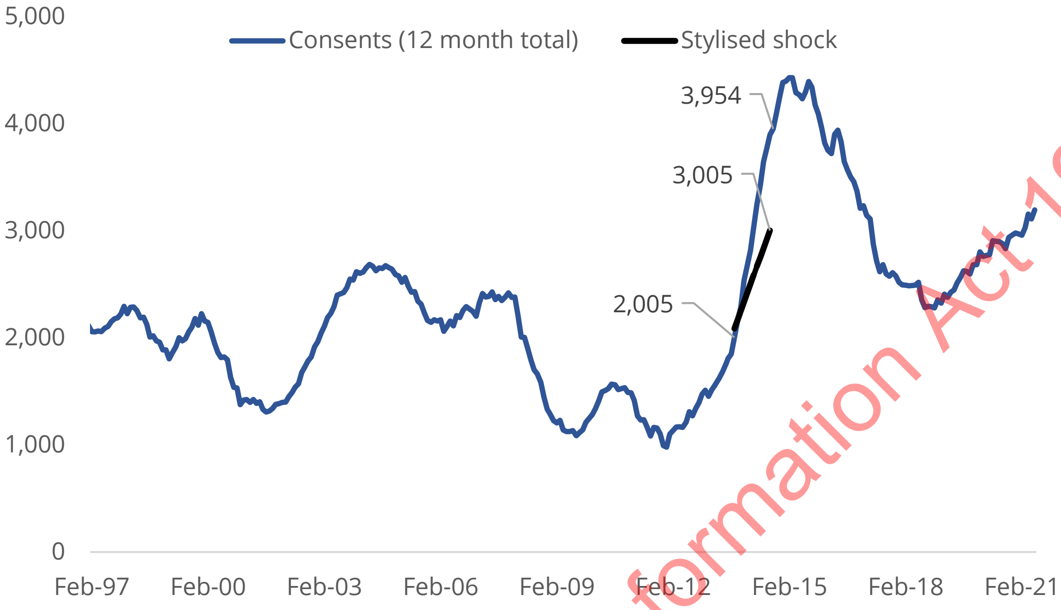
Where $\tilde{A} = (X_*'X_*)^{-1}X_*'Y_*$, that is, the OLS estimates for the combination of the prior and data.

Identifying structural shocks

We follow other researchers and identify the supply shock by ordering the data by slow moving series (rents), supply shock (consents data), fast moving series (prices and interest rates). Rents are set only periodically so are likely to be slow to respond to economic conditions. In contrast, prices should be set by internalising all relevant economic information.

We use the 90-day interest rates which should be tightly influenced by monetary policy, that is set in response to all available economic data, so should be one of the last variables in our ordering for identification purposes.

Figure 27: We calibrate our supply shock to 1,000 new dwelling consents in year
Stylised representation of the supply shock



We use the shock to map out likely impacts from the factors that enabled housing supply after the earthquakes – getting right capacity, coordination, funding and financing and delivery. Since interpretation of the shock is critical to our analysis, we lay out how to interpret shock from VAR models on Box B.

Model robustness

There are alternative definitions of both the demand and supply side that could help reveal underlying dynamics. To ensure our results are robust to small changes in model specification, we set up a series of models and test the response of housing outcomes to a housing supply shock within each model.

Spatial dimension

One set of models tests the importance spatial dimension. We expect that spillovers could be important and set out a set of models that expands the local councils in each model from:

- Small (Christchurch data only – sales, consents, prices and rents and macro data, 6 variables in total)
- Medium (Sales, consents, prices, and rents data for the shared urban area, that is Christchurch, Selwyn and Waimakariri and macro data, 14 variables in total)
- Large (Sales, consents, prices, and rents data for the shared urban area, that is Christchurch, Selwyn, Waimakariri but also larger housing markets that are Auckland, Hamilton, Tauranga and Wellington and macro data, 28 variables in total).

Box B: Shocking stories: impacts of VAR shocks

Telling stories one data series at a time

Understanding shocks is a core part of our modelling technique. So, it's worth spending some time to understand how we use shocks to construct a narrative for the dynamic interactions of the housing market.

VAR models typically contain many variables. But we can begin by setting out an *autoregression*, where the value of a series, such as house price growth, depends only on its past value, that is:

$$(1) \qquad \Delta hp_t = \beta_1 \Delta hp_{t-1} + \varepsilon_t$$

where Δhp_t is house price growth, Δhp_{t-1} is the lag of house price growth and ε_t is the shock term. This regression says house price growth is defined by only two elements, the regression of its current value on previous house price growth, Δhp_{t-1} and the shock. In this model, the shock is simply the house price growth that cannot be predicted by the past value of house price growth alone.

This simple model allows us to tell stories about the sequence of shocks that have driven house price inflation and the likely path of house price inflation. Of course, house price inflation has many drivers. So, an autoregression can only take us so far. We need to extend the model to include a vector of drivers, that is, we build a *vector autoregression* or VAR model.

Vector-autoregressions model the dynamic interactions of several variables

The simplest or *reduced form* vector autoregressive model simply extends by adding the autoregressive model by including drivers that form a system of equations, that is:

$$(2) \qquad \Delta hp_t = \beta_{11}\Delta hp_{t-1} + \beta_{12}\Delta y_{t-1} + \beta_{13}r_{t-1} + \varepsilon_{1t}$$

$$(3) \qquad \Delta y_t = \beta_{21}\Delta hp_{t-1} + \beta_{22}\Delta y_{t-1} + \beta_{23}r_{t-1} + \varepsilon_{2t}$$

$$(4) \qquad r_t = \beta_{31}\Delta hp_{t-1} + \beta_{32}\Delta y_{t-1} + \beta_{33}r_{t-1} + \varepsilon_{3t}$$

where we assume house price growth is related to economic growth, Δy_t and the real interest rate, r_t. But the model in equations (2) to (4) comes with some drawbacks. First, there is no allowance for contemporaneous relationships: for example, economic growth only hits house prices with a lag. But perhaps most importantly, the error terms $\varepsilon_{1t}, \varepsilon_{2t}$ and ε_{3t} are correlated. So, we cannot specify the impacts on the system from individual shocks.

Structural VARs are needed if we want to talk about causality

Building structural VARs can help. By imposing restrictions on the parameters in the model, that is, by setting specific parameters to zero or other values, we can unravel the correlation in the error terms to identify causal links across the variables we seek to model.

The restrictions come from both economic theory and knowledge of the timing of different variables. For example, often interest rates are allowed to respond contemporaneously to most variables since monetary policy can observe and then respond to the economy quickly. And typically exchange rates are allowed to respond to all variables contemporaneously since financial markets embody up-to-date information.

With impacts of individual shocks in hand, we can then test impacts of specific shocks, such as an unexpected increase in the interest rate, or a one-off boost to economic growth.

Structural VARs are a common tool within macroeconomics. For example, in a series of papers spanning many years,[12] Treasury have used structural VARs to model the impact of fiscal policy on the economy.

What determines the size of the shocks?

VAR models describe each variable in terms of impacts from previous values and the previous values of other variables in the system. But the VAR Model will not capture all variation, so shocks are needed to recover the variation unexplained by the model.[13] In general, the greater the number of variables that are included in the model, the smaller the size of the shocks.

Interpreting shocks in VAR models – looking at impulse responses

Since the shocks are exogenous to the VAR model, we can measure the effect of an exogenous change to a particular variables, such as the interest rate, on the other variables in the system.

Economists have favoured using one standard deviation of the shock as a meaure of the size of each shock but the size of the shock can always be altered to match a particular quantity. Often interest rate shocks are scaled to 25 basis point shocks – the typical movement of policy interest rates by central banks and shocks can be scaled to a set number over a particular period.

For example, Figure 28 shows the Reserve Bank testing the impact of an immigration shock, scaled to a 1 percent increase in the population over 5 years.[14] Figure 29 shows the response of real house prices – an increase of just over 8 percent (in real terms) after 60 months or 5 years.

Figure 28: Reserve Bank uses an immigration shock of 1% population. growth over 5 years

Net migration New Zealand

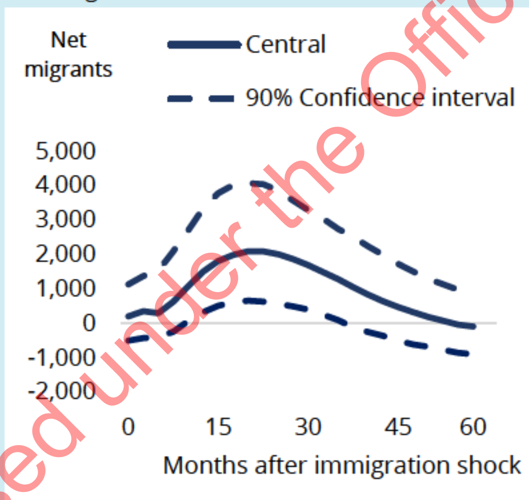
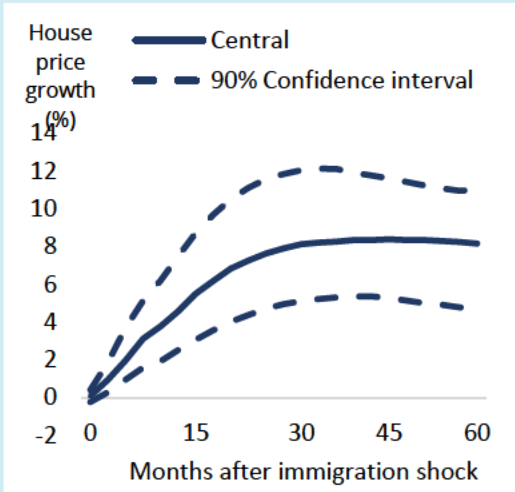


Figure 29: Immigration shock drives up real house prices after 5 years

Real house prices, New Zealand



Relative house price dynamics

To help isolate impacts on local housing markets, for each model specification above (small, medium, large) we also explore a variant where house price growth is expressed relative to

[12] See Buckle et al. 2002, Parkyn and Vehbi 2014 and Lyu 2021.
[13] One analogy is the shims or wedges used to fill small gaps between timbers or doors.
[14] See McDonald 2013.

growth at a national level. This specification holds the promise of isolating impacts of local changes in housing supply by removing movements in house prices across New Zealand.

Within this class of models, we also test a variant that allows for *all* housing market variables – including prices, rents, consents, and sales – to be expressed relative to national averages. This variant is of particular interest since it holds the promise of identifying local impacts versus movements in housing that are generated by national drivers of housing dynamics.

Proxies for demand

Since demand is difficult to measure directly, we explore the impacts of including several variables that might be proxies for underlying demand. So, within our base model we include on the dynamics of the model, particularly by including variables that might proxy demand.

It is well known that immigration can impact on house prices.[15] But regional migration data is only available at low frequencies high and with a considerable lag. So instead, we include the growth rate of national net migration. We expect the national net migration rate to be correlated with migration flows in the Christchurch region.

Demand for housing is also likely to be correlated with incomes. Rather than use GDP data that is only produced on an annual basis for New Zealand's regions, we use income data and data on the number of jobs within each local council as a proxy for demand.[16]

Impact of the earthquakes

Conceptually, our analysis focusses on supply changes as a one-off exogenous shock enabled by a range of factors that increased housing supply across a short period of time.

An alternative approach would be to take the view that the earthquakes permanently changed the responsiveness of housing supply. We think this is unlikely. Today, most of the land use regulations, consenting requirements and funding have in common with the period prior to and the earthquakes than the period immediately after the earthquakes.

We reserve structural change analysis for large, permanent changes to land use regulation – supported by the range of factors necessary to put housing –that might be expected to have permanent changes to the range of elements needed to construct housing.

To test the sensitivity of our analysis to this assumption, we also test a model estimates solely on data after the earthquakes, from March 2011 to June 2021.

Time to build

Our measure of consenting activity is a proxy for supply. Houses that are built would be a better measure but is unavailable at a granular level. To test the sensitivity of the model to this proxy we use consents lagged six months to better match the time from consenting activity to building a new house.

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[15] See McDonald 2013 for example.
[16] Our data source is the Statistics New Zealand's Linked Employer-Employee Database.

In total, we test impacts of 12 variations from our core model and also present the results from an average across all 12 models (see Figure 30).

Figure 30: We test our results across 12 different model specifications

Model	Description	Key data
Central model (Model 1)	Christchurch data only – sales, consents, prices and rents and macro data, 6 variables in total	Uses relative rents and house prices
Model 2	Christchurch data only – sales, consents, prices and rents and macro data, 6 variables in total	Doesn't use relative rents prices or prices
Model 3	Medium (Sales, consents, prices, and rents data for the shared urban area, that is Christchurch, Selwyn and Waimakariri and macro data, 14 variables in total)	Uses relative rents and house prices
Model 4	Medium (Sales, consents, prices, and rents data for the shared urban area, that is Christchurch, Selwyn and Waimakariri and macro data, 14 variables in total)	Doesn't use relative rents prices or prices
Model 5	Large (Sales, consents, prices, and rents data for Christchurch, Selwyn, Waimakariri but also Auckland, Hamilton, Tauranga and Wellington, 28 variables in total).	Uses relative rents and house prices
Model 6	Large (Sales, consents, prices, and rents data for Christchurch, Selwyn, Waimakariri but also Auckland, Hamilton, Tauranga and Wellington, 28 variables in total).	Doesn't use relative rents prices or prices
Post-quake	Christchurch data only – sales, consents, relative prices and relative rents and macro data, 6 variables in total	Estimated on post-quake period: Mar 2011 to Jun 2021
Migration model	Christchurch data only – sales, consents, relative prices and relative rents and macro data, 6 variables in total	Adds national net migration data
Jobs model	Christchurch data only – sales, consents, relative prices and relative rents and macro data, 6 variables in total	Adds LEED data on jobs at council level
Income model	Christchurch data only – sales, consents, relative prices and relative rents and macro data, 6 variables in total	Adds LEED data on income for councils
Relative model	Christchurch data only – sales, consents, relative prices and relative rents and macro data, 6 variables in total	Adds LEED data on jobs at council level
Time to build	Christchurch data only – sales, consents, relative prices and relative rents and macro data, 6 variables in total	Lag consents six months
Model average	Describes an average of outcomes across all 12 models	

8. Our results

Housing affordability improves following a shock to housing supply in our core model

Our central model starts small and includes just six variables: rents, consents, sales, prices data, the nominal TWI and the nominal interest rate. To try and isolate movements in housing affordability that are due to local factors, we specify both rents and prices relative to national averages.

Figure 31 shows the impact of the monthly shock to the change in consents we use a proxy for supply. We scale the shock to deliver 1,000 new dwelling consents in the year after the shock.[17] This means the shock represents about 200 new consents in the first month – a little higher than the average month over the time period we consider. Since the shock persists over time, new consents total 1,000 over the year after the initial shock.

Figure 32 shows the shock has a small impact on sales activity. Sales average just over 760 each month over our time period and the shock to consents only lift sales by about 25 sales a month. Note that we present 50, 80 and 90 percent confidence intervals alongside the central estimate for every response to the shock. There is considerable uncertainty surrounding the impact of the shock to consents on sales activity.

We show the critical impacts on housing affordability in Figure 33 and Figure 34. Figure 33 shows that the growth of rents falls substantially after the shock, declining by 1.75 percent a year after the shock before returning to 0 about six years or 72 months after the initial shock. The level of rents is permanently lower. The uncertainty bands suggest statistically significant declines in rents between one and two years after the shock.

In terms of house prices, Figure 34 shows that house price inflation declines after the housing supply shock with house price inflation down about 2.4 percent a year after the shock. Again house price inflation returns to its previous level about six years after the initial shock. Since the growth rate of prices is never positive, we can conclude the relative price level is permanently lower after shock.[18] The declines in house price inflation are significant at any point three to thirty months after the initial shock.

The response of the shock needs careful interpretation. Ideally, we would work with the number of new buildings added to the stock of homes each month. However, this variable is not readily available, so we work with consents instead.

But at least initially consents are likely to pick up beliefs of developers about house price growth without the price-depressing impact bringing a new build to market could be expected

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[17] One standard devation of the monthly shock reutrns a value of about 0.14 or about 50 new dwelling in the month. This value implies about one-in-three consents would be generate by the shock in an average month. We approximately triple the size of this shock, producing a sequence of consents that sum to 1,000 over the course of one year.
[18] We specify some variables in some models relative to movements in national house prices. Since our model has nothing to say about the evolution of national house prices, any statement about absolute price movements needs to add in prior beliefs about how national house prices evolve.

to make. So, we take some of the increase in house prices with a grain of salt and assess impacts on housing affordability across both rents and prices.

Figure 31: We scale the shock to deliver 1,000 new consents over a year

Christchurch consents (per 1,000 people) response to consents shock (per 1,000 people)

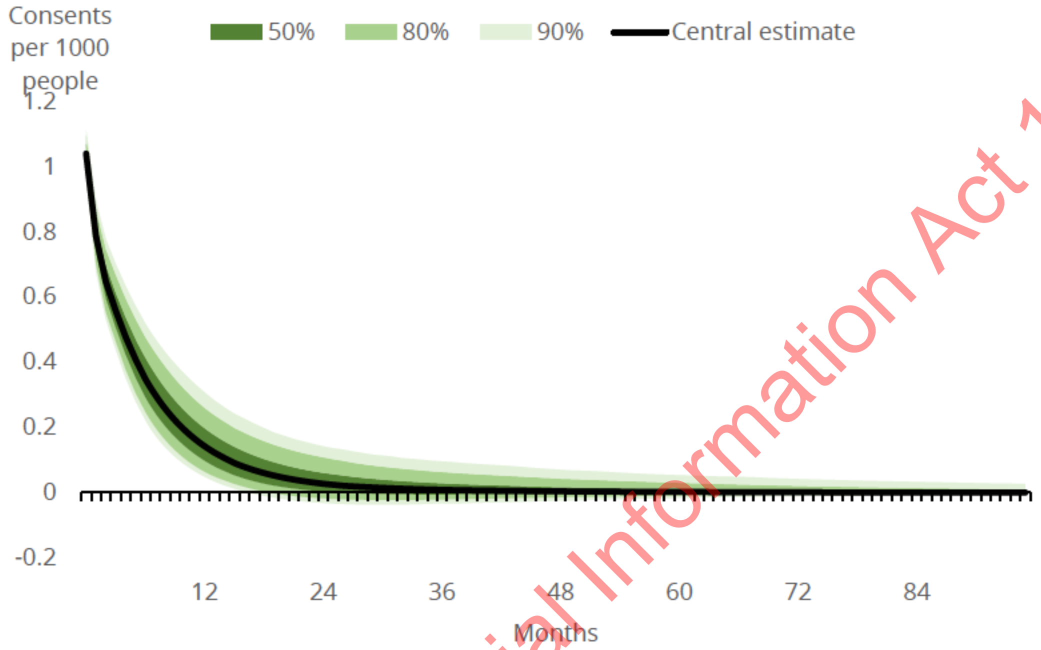


Figure 32: Sales increase a little before returning to previous activity levels

Christchurch sales per 1,000 people, response to Christchurch consents shock (per 1,000 pop)

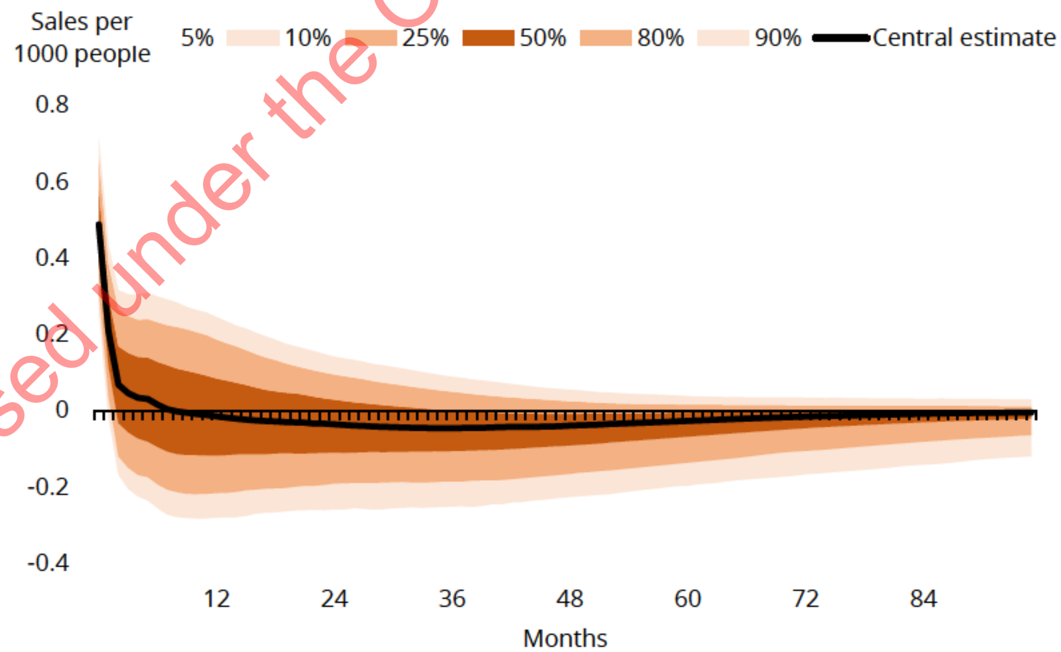


Figure 33: Growth in rents declines relative to NZ average before returning to past growth

Christchurch (TA) relative rent growth response to Christchurch consents shock (per 1,000 pop)

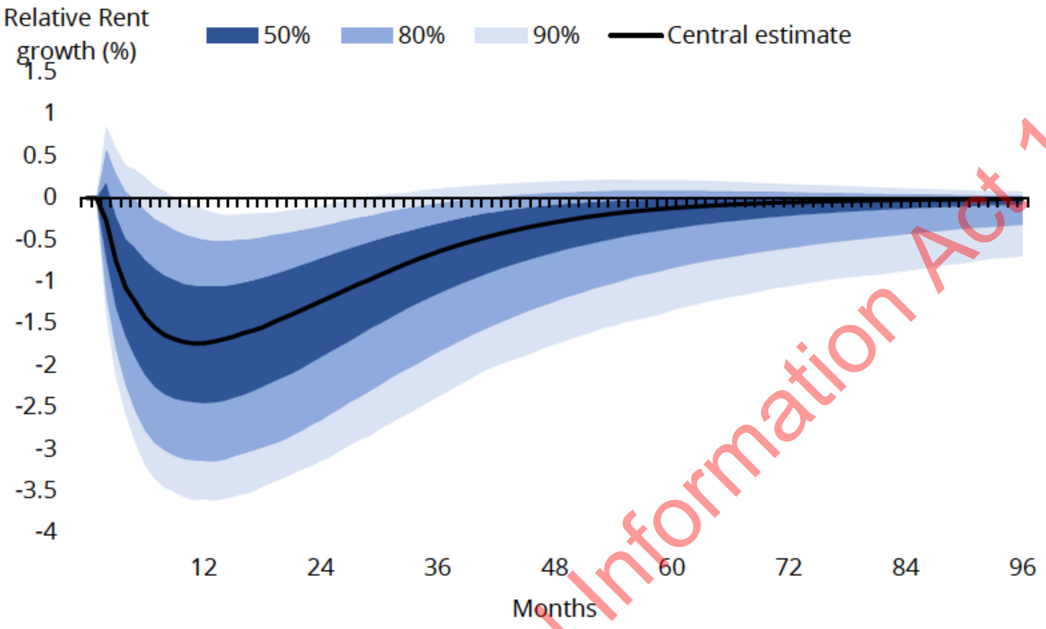
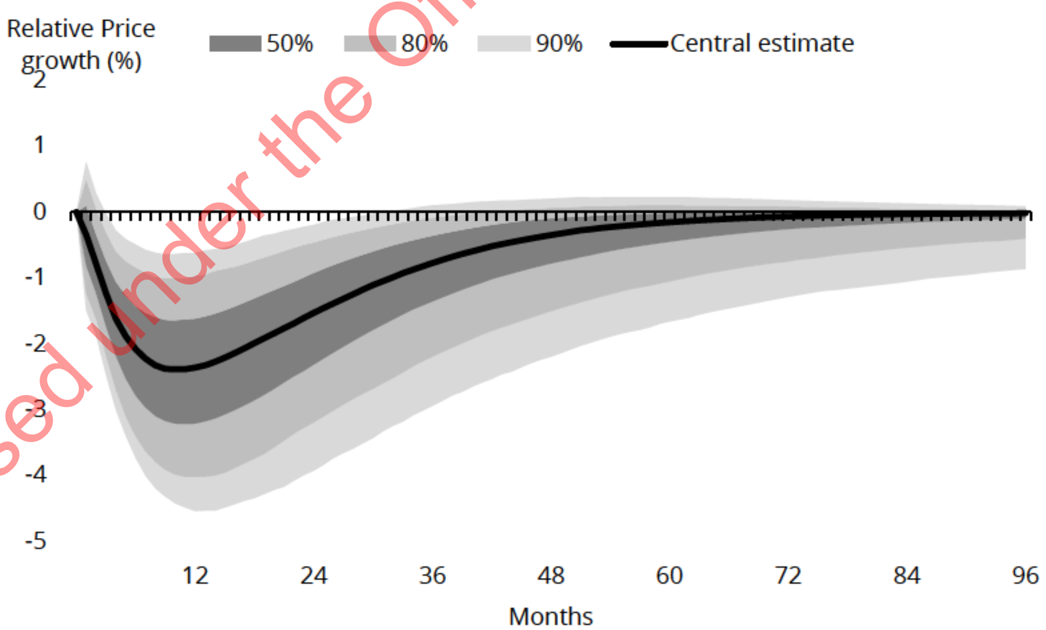


Figure 34: House price inflation decreases after the consents shock

Christchurch house price growth (relative to NZ average) response to Christchurch consents shock (per 1,000 pop)



Rather than present a long list of impulse responses for each of our 12 models we show the central estimates the impact of the supply shock on the change in rents and house price inflation for each model in Figure 35. Then we map out a path for the level of rents and the level of house prices in Figure 44.

Figure 35 shows that for every model, the growth rate of rents follows the same general pattern: an initial decline that about one year (or twelve months) after the initial shock, followed by a gradual increase in the growth rate back towards zero. This pattern produces a decline in the *level* of rents of about 3 percent on average that we see in Figure 44.

Figure 35: Impact of the supply shock on change in rents and house price inflation

Months	3	6	9	12	24	36	48	60	72	84	96
Model						Rents					
Central model	-0.750	-1.431	**-1.687**	**-1.735**	**-1.238**	-0.646	-0.292	-0.122	-0.052	-0.025	-0.013
Model 2	-0.461	-1.067	-1.341	-1.452	-1.255	-0.768	-0.368	-0.145	-0.056	-0.020	-0.011
Model 3	-0.690	-1.198	-1.256	-1.203	-0.821	-0.434	-0.193	-0.083	-0.036	-0.020	-0.011
Model 4	-0.535	-1.044	-0.978	-0.781	-0.353	-0.196	-0.076	-0.021	-0.001	0.002	0.001
Model 5	-0.604	-1.082	-1.250	-1.370	-1.266	-0.701	-0.294	-0.107	-0.036	-0.024	-0.022
Model 6	-0.298	-0.803	-0.923	-0.976	-1.078	-0.778	-0.466	-0.280	-0.153	-0.093	-0.045
Post-quake	-0.734	-1.122	-1.058	-0.868	-0.383	-0.172	-0.057	-0.013	-0.002	-0.001	0.000
Migration model	-0.119	-0.125	-0.128	-0.114	-0.052	-0.023	-0.008	-0.002	0.000	0.000	0.000
Jobs model	-0.119	-0.183	-0.211	-0.230	-0.285	-0.200	-0.077	-0.021	-0.005	0.000	0.000
Income model	-0.934	-1.784	-2.073	-2.132	-1.570	-0.855	-0.260	-0.041	-0.006	-0.005	-0.004
Relative model	-0.732	**-1.375**	**-1.603**	**-1.660**	**-1.286**	-0.728	-0.334	-0.142	-0.059	-0.026	-0.014
Time to build	-0.768	**-1.431**	**-1.655**	**-1.697**	**-1.283**	-0.715	-0.331	-0.139	-0.059	-0.027	-0.014
Model average	-0.562	-1.054	-1.180	-1.185	-0.906	-0.518	-0.230	-0.093	-0.039	-0.020	-0.011
						Prices					
Central model	-1.236	**-2.086**	**-2.379**	**-2.362**	**-1.529**	-0.774	-0.348	-0.154	-0.067	-0.031	-0.016
Model 2	0.914	1.001	0.626	0.173	-1.289	-1.322	-0.889	-0.500	-0.242	-0.116	-0.051
Model 3	-0.617	-1.261	-1.556	-1.619	-1.115	-0.568	-0.252	-0.112	-0.051	-0.026	-0.014
Model 4	1.735	1.799	1.270	0.615	-0.503	-0.376	-0.132	-0.027	0.000	0.001	0.000
Model 5	-0.997	-1.454	-1.619	-1.567	-0.921	-0.406	-0.172	-0.078	-0.037	-0.026	-0.022
Model 6	0.513	0.370	0.016	-0.247	-0.712	-0.446	-0.255	-0.292	-0.214	-0.120	-0.036
Post-quake	0.907	0.938	0.639	0.269	-0.381	-0.223	-0.052	0.002	0.007	0.003	0.001
Migration model	0.093	0.104	0.086	0.054	-0.030	-0.021	-0.004	0.002	0.002	0.001	0.000
Jobs model	0.174	0.140	0.032	-0.095	-0.318	-0.212	-0.153	-0.098	-0.050	-0.022	-0.009
Income model	1.018	0.795	0.207	-0.414	-1.636	-1.109	-0.448	-0.161	-0.050	-0.017	-0.010
Relative model	-1.196	**-2.021**	**-2.317**	**-2.343**	**-1.614**	-0.851	-0.390	-0.165	-0.071	-0.032	-0.017
Time to build	-1.186	**-2.036**	**-2.338**	**-2.357**	**-1.631**	-0.852	-0.387	-0.167	-0.072	-0.035	-0.018
Model average	0.010	-0.309	-0.611	-0.824	-0.973	-0.597	-0.290	-0.146	-0.070	-0.035	-0.016

NB. Results significant at the ten percent level use bold font.

The results for the change in house prices are a little more mixed. After twelve months, four of the twelve models actually show mild increases in house price inflation but on average house price inflation is negative after twelve months. The decline persists for some years before returning to zero about 5 to 8 years after the initial shock.

The paths for house price inflation in Figure 35 generally implies a fall in the level of house prices. On average house prices decline by 2.3 percent by the end of our simulation. The level of rents falls by about 2.3 percent. We present these results in Appendix G.

Isolating local impacts also shows enabling housing supply improves affordability

One of our model specifications uses not just movements in house prices and rents relative to the rest of New Zealand, but for sales and consents too. We find that model produces similar impacts to our central model specification. Declines in house price inflation and rental prices growth are significant after twelve months.

Small impacts from New Zealand's larger housing regions

Understanding if housing supply shocks that originate in one jurisdiction have wider impacts is critical not just for understanding the Christchurch recovery but for housing policy right across New Zealand. Correctly identifying any spillovers is important from a policy perspective. If housing supply in one region has no spillover impacts to other regions, then national interests in local housing policies are limited – costs and benefits of good policy only accrue to the local region. Instead, if spillovers are significant, then there is a case for central government to enable regional housing supply responses that have impacts outside of the region.

Here our focus is on Christchurch. We tested models that started with our central specification one city at a time, augmented the model with consenting activity from each other tier city, that is Auckland, Hamilton, Tauranga and Wellington. These models always resulted in wide confidence intervals and impacts that were small in economic terms. This is likely due to the distance between Christchurch and these markets.

Local housing market shocks show some moderate impacts from spillovers

We also examine shocks supply from Selwyn District Council and Waimakariri District Council. Separate shocks do not have particularly well-defined dynamics: impulse responses have wide confidence intervals. We also tested the impact of a joint shock to consenting activity in the Selwyn and Waimakariri District Councils. We sum consents over both councils and divide through by the total population to create the same consent per 1,000 people we used to proxy supply in the case of Christchurch. We also expand the shock by the same ratio that we apply to the Christchurch shock. This implies fewer total consents compared to Christchurch but a material ramping up of supply in both Districts.

Figure 36 shows growth in rents increases a little initially before declining about a year after the initial shock. The level of rents is essentially at the same point by the end of the period.

Figure 36: Rents increase at first but then decline in after the local supply shock

Christchurch rents growth response to Selwyn-Waimakariri consents shock (per 1,000 pop)

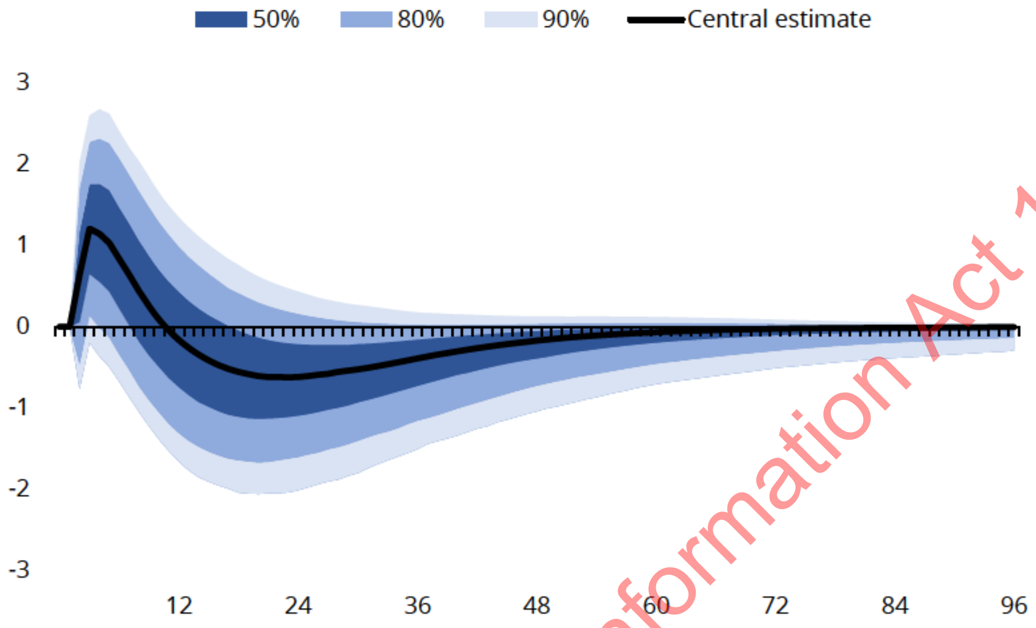
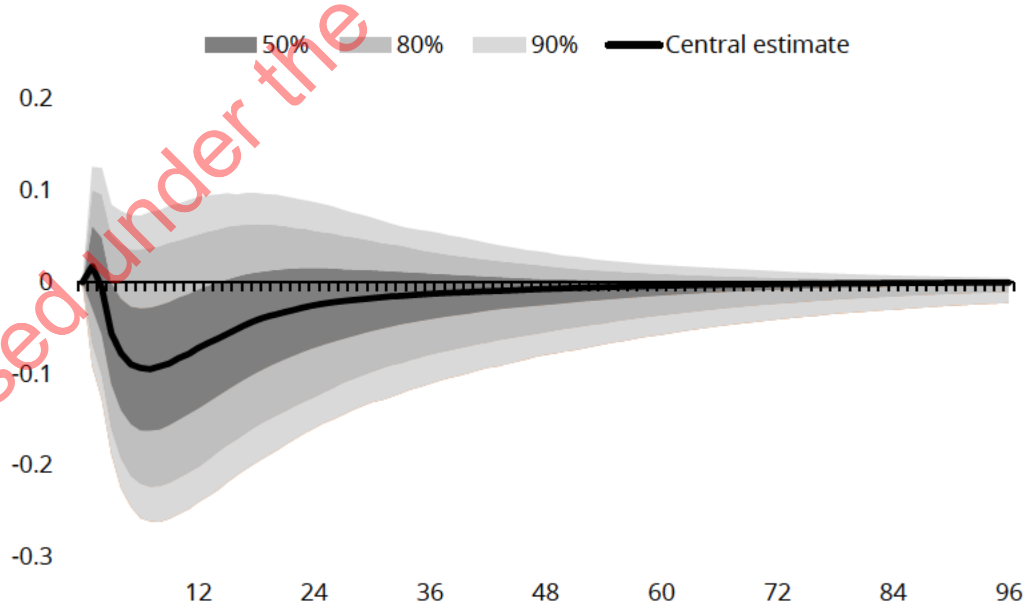


Figure 37 shows that house price inflation falls after the combined consents shock in Selwyn District and Waimakariri District. However, the confidence intervals are wide – only the 50 percent band sits under zero. This suggests caution in inferring too much from the model.

Figure 37: House price inflation in Christchurch declines after the supply shock next door

Christchurch house price inflation after the Selwyn-Waimakariri consents shock (per 1000 pop)



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Appendix A: Briefing note to interviewees

Kia ora [Recipient name]

Thank you for participating in our research interviews next week. We are looking forward to learning from your expertise.

This memo frames the context and issues we are grappling with.

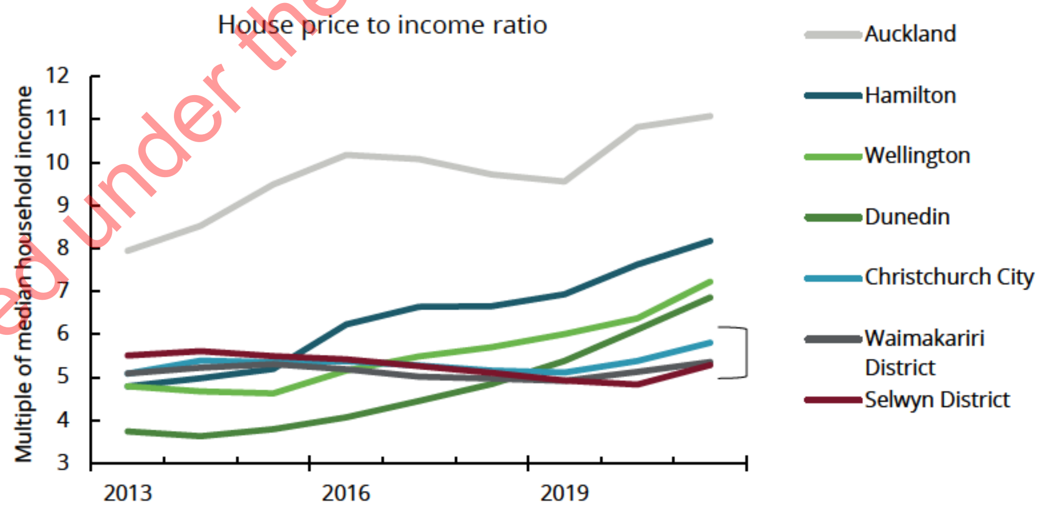
DPMC has commissioned Sense Partners to better understand the lessons from Christchurch's post-quake recovery in housing and infrastructure. Specifically, what we can generalise for housing and infrastructure for other cities.

We are interviewing 25 selected experts from Christchurch and Wellington to complement detailed quantitative analysis by our team. Your contribution will help us glean a richer story on what happened in Christchurch and why.

The interviews will last 45-50 minutes and take the form of a relaxed, open conversation with Shamubeel Eaqub and myself. I will be in touch to confirm meeting rooms/zoom links and to answer any questions left unanswered here. Otherwise, we look forward to seeing you next week.

Context for the interview

Christchurch has maintained housing affordability relative to incomes when other urban centres have not. Selwyn and Waimakariri have experienced significant population growth without corresponding increases in house prices, meaning housing and infrastructure has kept pace. This has been unusual in New Zealand over recent decades.



We want to know how much of this was due to:

(1) plans and policies that were already in place

(2) things that were sped up or disrupted by the earthquake

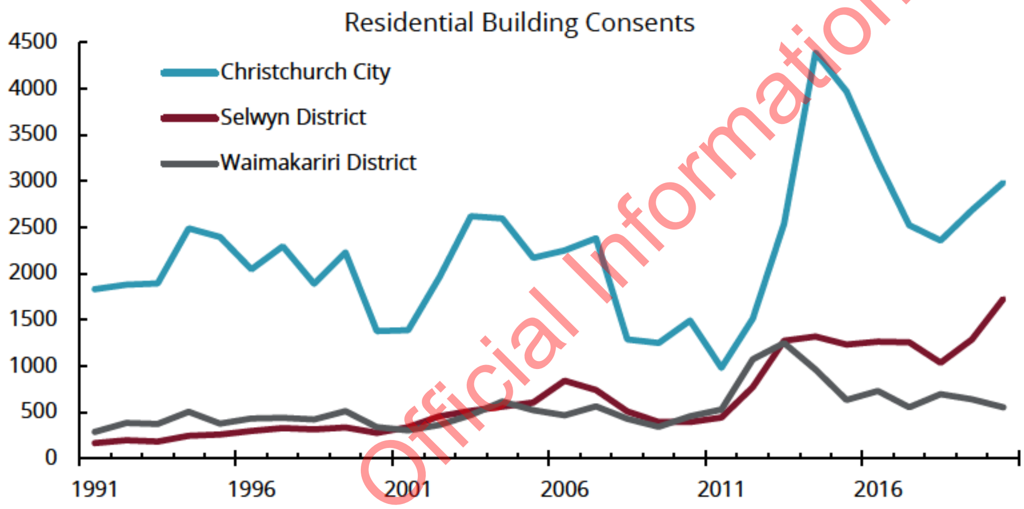
(3) the different policy tools and levers used after the earthquake

(4) changed conditions due to insurance funds

The heart of the research is to see whether housing affordability was a context-specific outcome, or if there are generalisable policy lessons here for other New Zealand cities.

We understand that the three councils acted in sometimes different ways throughout the rebuild, in consenting, infrastructure delivery, funding and financing, use of special powers, etc.

This natural experiment is particularly interesting – it creates an opportunity to see what policies supported the rebuild and what held it back. Your insights on how the various councils responded, the dynamics they faced, and what could have been better will support this.



Aim for the interview

Throughout the interview, we will be curious about your experience of the rebuild, the conversations you were hearing on housing policy at the time and how these changed, your perception of risk appetite across different stakeholders, and other perspectives on policy coordination and levers.

The idea is to have a very open conversation that speaks to your knowledge and the 2009-2014 period. There is no need to brush up on areas that did not concern you at the time.

The findings will be compiled in a report for DPMC to be published later in the year. To support this, we will record the interviews, but only use recognisable quotes in the final report with your permission. Please let us know if you have any concerns.

Thank you again for agreeing to participate – we are looking forward to it. Any questions before then, please reach out.

Ngā mihi,

Rosie Collins (Economist, Sense Partners) and Shamubeel Eaqub (Partner, Sense Partners)

Appendix B: Draft interview protocol

Research topic: Policy lessons for affordability in Christchurch

Research questions:

- What local or central government policy changed in the raw land conversion > consenting > infrastructure provision > financing > delivery process after the earthquakes that kept housing affordable?
- How did the actions of surrounding regions affect your own district?
- What was the role of sequencing and central government in supporting local processes?

Introduction (5 minutes). Trust setting and background to research purpose.

- We're doing work for DPMC to unpick what happened in the rebuild in terms of policy and how the government supported you
- This will feed into a document that will help future research on the lessons of infrastructure delivery during a rebuild and the policy to support this.

Open-ended conversation (20 minutes). Unpack stories around roles after the earthquake and redirect conversation to how policies changed.

- What was your role after the Christchurch earthquakes?
- What changed for you and your district in that rebuild time?
- What were some of the conversations on housing policy at the time?
- How did you find barriers on getting things done?
- How quickly did these things (policy actions) happen?
- What policy was already in place to help you in the rebuild?
- What do you think the role of transport/consenting/xyz policy was in the rebuild?

Clean up (10 minutes). Get more specific on policies that were useful in streamlining the rebuild.

- What do you think the role of sequencing these policies were for the rebuild and getting to affordability?
- How do you feel investor certainty was affected by these policies? Could more have been done?
- How did investors fare over this time period?
- Were there any specific policies that really helped or hindered affordability?
- How confident are you that Christchurch can maintain affordability now? Why?
- Could you elaborate on what could have been done better?

Wrap up (5-10 minutes). Reveal that we're hoping to tease out the lessons for affordability.

- There are theories that Christchurch's affordability stemmed from how quickly it could release land. Do you think this explains it, or was it something else?
- How would you sum up the lessons for affordability from your perspective?
- Is there anything else you think we should know?
- Is there any other person you think we should speak to?

Appendix C: Interviewee list

Cabinet

Gerry Brownlee

Christchurch City Council

Mayor Lianne Dalziel

s 9(2)(a)

Selwyn District Council

Mayor Sam Broughton

s 9(2)(a)

s 9(2)(a)

s 9(2)(a)

Waimakariri District Council

s 9(2)(a)

Ngāi Tahu

s 9(2)(a)

s 9(2)(a)

CERA

John Ombler

s 9(2)(a)

s 9(2)(a)

GCP

s 9(2)(a)

Private Planners

s 9(2)(a)

s 9(2)(a)

Developers/Other

s 9(2)(a)

s 9(2)(a)

Urban Designers/Other

s 9(2)(a)

s 9(2)(a)

s 9(2)(a)

Appendix D: Interview process

Interview process

- Designed the interview protocol
- Selected interviewees based on recommendations of others
- Conducted interviews using open-ended questions
- Transcription and coding of key themes (194 subthemes after analysis)
- Reviewed codebook and collapsed and organised themes into report narrative

Appendix E: Testing for breaks

Approach

Overview

Testing for a break or change in the behaviour of a data series requires first specifying a model of how the series behaves over time. We consider breaks as changes in the behaviour of individual parameters in the model or a change in the overall model. Without specifying a model means a lack of precision about what type of break we are looking for and leaves us without any theory to test or inform with data.

In terms of timing of breaks, on one hand we know with certainty the timing of the Christchurch earthquakes - the initial earthquake hitting west of Christchurch on Saturday 4 September and the subsequent earthquake occurring at 12:51pm, Tuesday 22 February 2011.

But on the other hand, we know relatively little about the timing of the impact of the earthquakes on the broader set of economic and housing related variables we seek to model. So rather than impose a particular date as a candidate break, we use tests that generalise across a range of possible breakdates.

Modelling the data

The series we are interested in directly or indirectly relate to housing affordability: (i) sales, (ii) house prices, (iii) consents, and (iv) population data. To test for breaks in these series, we set up simple univariate models of the form

$$y_t = \alpha + \rho_i y_{t-i} + e_t$$

where y_t is the data series we are immediately concerned with, α is a constant, y_{t-i} captures lags of the variables with ρ_i the parameters associated with each lag such that the error term e_t is not autocorrelated, ensuring the properties we need to make inference on the parameter estimates.[21]

$$Ee_t^2 = \sigma^2$$

The second equation suggests that y_t should be stationary to ensure a constant variance and we can difference y_t when necessary. A structural break occurs if one of the parameters in the model changes at a particular point in time.

The break tests

If we know the date of the break, then the standard approach is to carry out an *F*-test by comparing the differences of the size of the errors between a model that allows parameters to change at a fixed points in time against the size of the errors from a model with constant parameters. Allowing for additional parameters will never increase the size of errors. But material breaks in the parameters return much smaller errors relative to the model without

[21] This set up follows Hansen 2001, Hansen 1992 and 1997.

parameter break. This generates a large *F*-statistic that can then be compared standard distributions (χ^2 distribution) to test for significance.

Allowing for time-varying parameters works well when market conditions or relationships slowly evolve over time. But policy changes can bring about rapid changes such that it can be useful to characterise the market as having two or more distinct 'regimes.

To this end we consider a simple model:

$$y_t = \alpha + \rho y_{t-1} + e_t \quad (3)$$

where $y_t$is one of each of the key variables we examine. We then apply several tests to equation (3) that look for evidence of structural breaks.

We begin by running a series of estimates of equation (3) over not just the entire sample period, but over a sequence of two subperiods, defined by a breakpoint or breakdate that begins near the start of the series and finishes close to the end of the series.

If a particular breakdate is a significant feature, then regressions that include the necessary breakdate will provide a better fit than regressions with a poor choice of breakdate. This suggests estimating regressions over two subsamples, that is:

$$y_t^1 = \alpha_1 + \rho_1 y_{t-1}^1 + e_t^1 \quad (4a)$$

$$y_t^2 = \alpha_2 + \rho_2 y_{t-1}^2 + e_t^2 \quad (4b)$$

where equation (4a) is the regression over the subsample 1 defined by the breakdate and the equation (4b) is the regression over the second subsample defined by the choice of breakdate.

The null hypothesis is that there is no difference in the parameters across the two sub-samples in equation (4a) and equation (4b). To form the test statistics, let SSE_1 be the sum of square errors in equation (4a) and SSE_2 be the sum of squared errors in equation (4b) with $n_1$the number of observations in subperiod 1 and n_2 the number of observations in subperiod 2 with k, the total number of regressors. Then we can write the Chow test statistics as:

$$Chow = x = \frac{(SSE - (SSE_1 + SSE_2))/k}{(\mathrm{SSE}_1 + SSE_2)/(n_1 + n_2 - 2k)}$$

where SSE is the sum of squared errors over the entire period.[22]

More formally, we estimate Chow tests over the entire set of parameters and check the significance of the F-test of the additional parameters associated with the break date against a distribution, suitably modified for the rolling sequences of breakdates.

A second test relates to the size (more precisely, the variance) of the residuals when using alternative breakpoints. Breakpoints that are likely candidates should have a lower variance

[22] The earlier Chow 1960 test examines a single known break point. The Quandt (1960) expands the set-up to breaks of an unknown point in time but only later econometric research (see Andrews and Ploberger 1994 for example) shows the underlying distribution of this test.

than other break dates. A breakpoint that is well-identified is then likely to have a sharp V-shaped profile when plotted against the error variance.

If many alternative breakpoints are all equally likely, the variance of the errors will be reasonably flat. So plotting the error variance against a moving breakpoint can help reveal a point of structural change. Rather than plot the variance directly, we opt to express the variance as a ratio relative p to the variance in the initial period.

Other tests seek to examine whether specific parameters are constant over time. Here we test stability of the constant parameter on its own, but tests of the lags of each variable are in principle available.[23] We show the results of these test for Christchurch in Figure 38 to Figure 41. We summarise the results for all three local councils in Figure 42.

Results

Consents

The results are mixed for consent data from Statistics New Zealand on new residential builds. Christchurch shows some weak evidence of a break. Selwyn shows signs of a break early on the period we consider and well before the Christchurch earthquakes. In contrast, Waimakariri District shows clear indication of a break late in the data sample. New Zealand shows no break in consenting behaviour across the sample.

Sales

Christchurch shows no break in the sales activity data series. Selwyn shows a break in the pattern of sales. Waimakariri District shows no break. New Zealand shows no evidence in a break in the sales data provided by REINZ at any point since the mid-1990s.

When interpreting these findings It is worth considering the small scale of both Selwyn District and Waimakariri District in the earlier part of the sample. A small number of properties or new development brought to market can make a stark spike in the data series. Although this increases the underlying variance of the series these properties could produce a break in the series that relates to the lumpiness of activity.

Rents

Using the Chow test there is clear evidence of a break in the Christchurch rents series near the time of the GFC. Selwyn District shows a break a little later, around 2014 rather than near the GFC or the timing of the earthquakes. Waimakariri shows weak evidence of a break in rents. There is evidence of a break in rents in the national rental market around the time of the GFC.

House prices

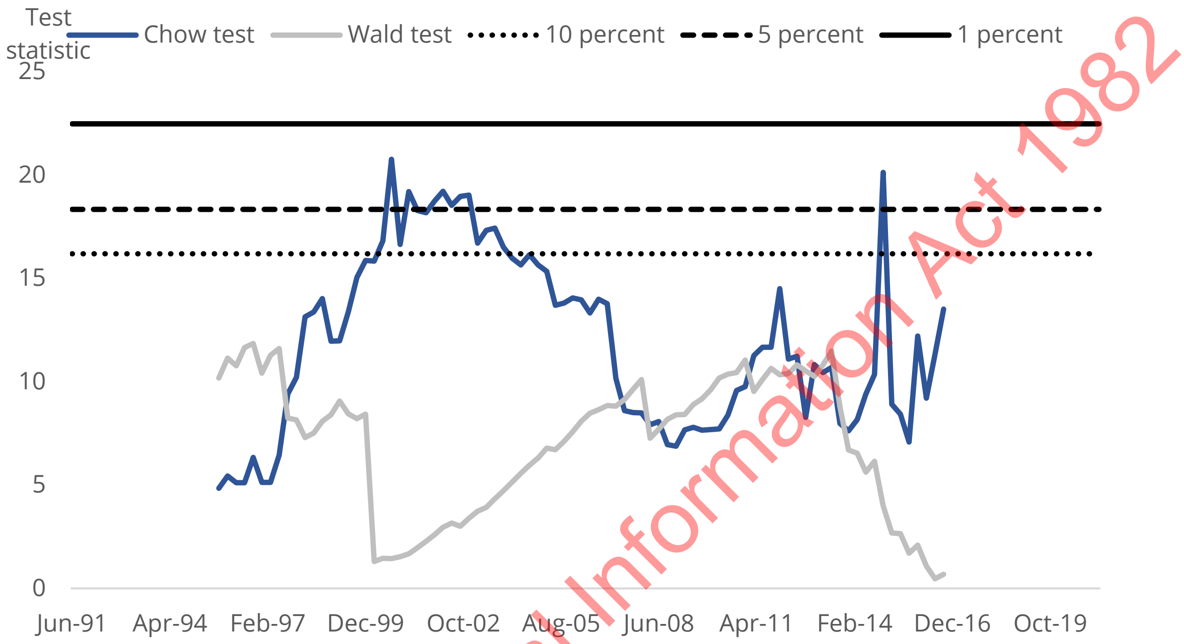
Christchurch show a break in house prices in almost any point after 2010 using the Chow test. Something changed in the behaviour of Christchurch house prices in the second decade after the turn of the century. Selwyn District and Waimakariri District show evidence of structural breaks in the early part of the sample. New Zealand appears to have a break in the house price series.

[23] These are tests provided by Nyblom 1989 and Hansen 1992.

Chow and Wald tests, results for consents

Figure 38: Christchurch consents show no little statistical indication of a structural break

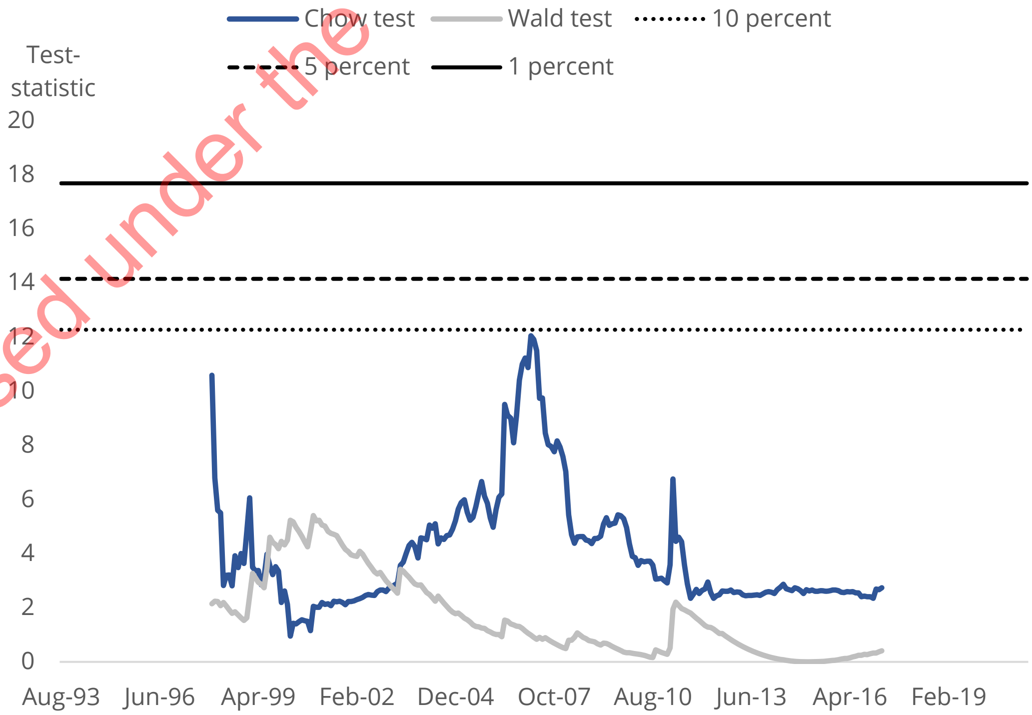
Chow and Wald tests for Christchurch consents, new residential builds (Statistics New Zealand)



Chow and Wald tests results for sales

Figure 39: Christchurch sales show little indication of a structural break

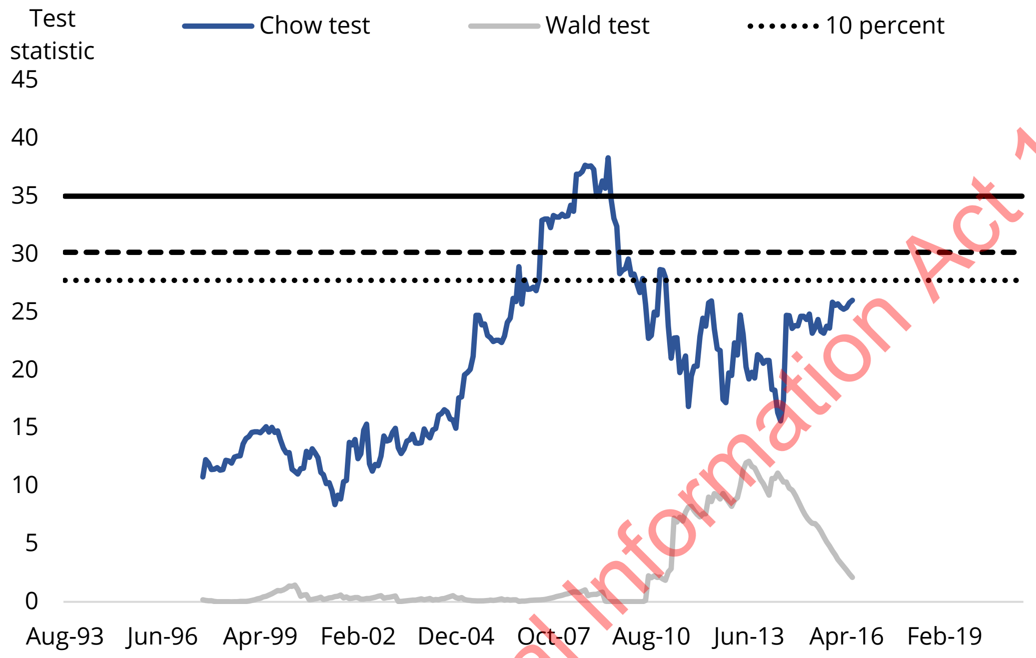
Chow and Wald tests for Christchurch sales volumes (REINZ)



Chow and Wald tests results for rents

Figure 40: Chow test suggests a structural break in Christchurch rents around the GFC

Chow and Wald tests for Christchurch rents (MBIE)



Chow and Wald tests results for house prices

Figure 41: Christchurch prices show structural breaks at several points after the quakes

Chow and Wald tests for Christchurch house prices (REINZ)

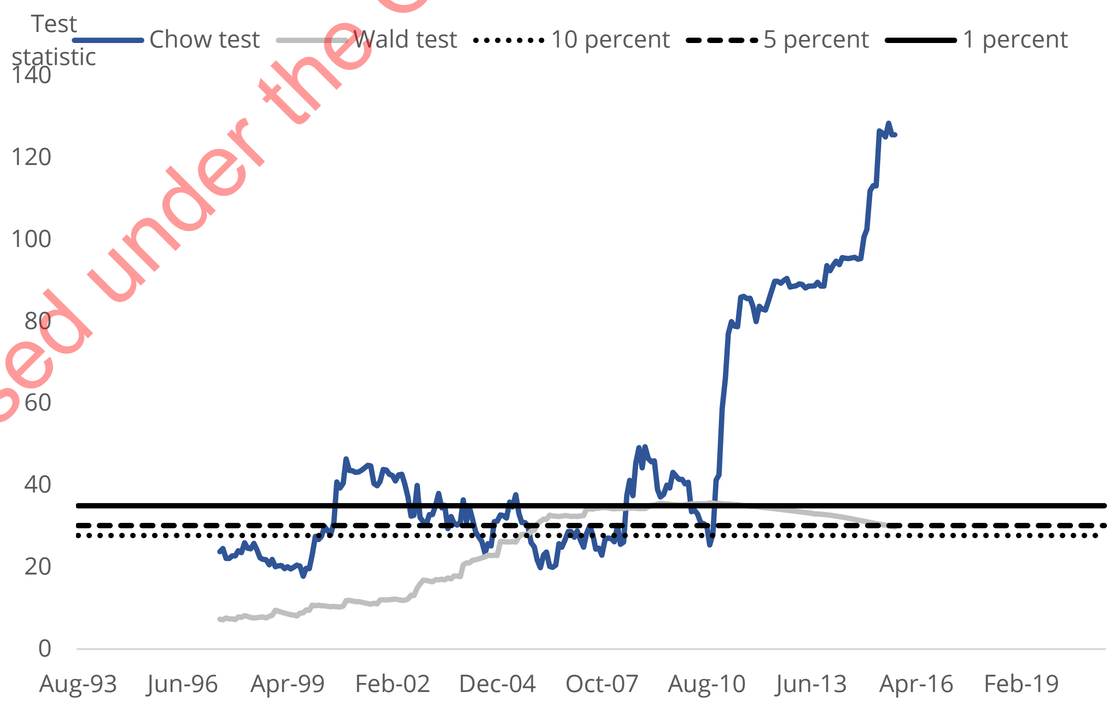


Figure 42: Summary table of structural break results

	Constant			Model			Variance		
	Stat	*p*-val	Date	Stat	*p*-val	Date	Stat	*p*-val	Date
Sales									
Christchurch									
Sup-W	7.586	(0.080)*	Oct-11	16.421	(0.047)†	May-02	5.405	(0.208)	May-05
Exp-W	1.382	(0.115)	Oct-11	4.104	(0.125)	May-02	1.171	(0.154)	May-05
Selwyn									
Sup-W	1.393	(0.158)	Oct-15	5.925	(0.000)‡	Feb-05	18.930	(0.004)	Jun-06
Exp-W	4.848	(0.038)†	Oct-15	2.574	(0.040)†	Feb-05	7.516	(0.000)‡	Jun-06
Waimakariri									
Sup-W	3.209	(0.512)	May-06	3.421	(0.824)	May-06	4.382	(0.320)	May-02
Exp-W	0.370	(0.561)	May-06	0.819	(0.635)	May-06	0.877	(0.236)	May-02
New Zealand									
Sup-W	4.724	(0.278)	Mar-07	6.186	(0.388)	Mar-07	2.054	(0.772)	Mar-17
Exp-W	0.566	(0.393)	Mar-07	1.833	(0.216)	Mar-07	0.286	(0.662)	Mar-17
House prices									
Christchurch									
Sup-W	2.087	(0.764)	Jul-16	48.980	(0.000)	Feb-05	26.775	(0.000)	Mar-12
Exp-W	0.227	(0.749)	Jul-16	20.130	(0.000)	Feb-05	10.194	(0.000)	Mar-12
Selwyn									
Sup-W	2.475	(0.670)	Nov-13	128.405	(0.000)	May-16	35.709	(0.000)	May-11
Exp-W	0.573	(0.388)	Nov-13	59.682	(0.000)	May-16	16.459	(0.000)	May-11
Waimakariri									
Sup-W	2.506	(0.663)	Dec-05	48.770	(0.000)	Jul-16	78.778	(0.000)	Jan-12
Exp-W	0.237	(0.734)	Dec-05	19.993	(0.000)	Jul-16	36.207	(0.000)	Jan-12
New Zealand									
Sup-W	4.930	(0.255)	Jul-16	66.157	(0.000)	Jul-16	18.704	(0.000)	Mar-09
Exp-W	0.636	(0.348)	Jul-16	28.431	(0.000)	Jul-16	7.074	(0.000)	Mar-09
Relative prices									
Sup-W	14.190	(0.004)	May-12	17.226	(0.004)	Dec-11	38.016	(0.000)	Sep-13
Exp-W	3.948	(0.004)	May-12	6.686	(0.002)	Dec-11	15.513	(0.000)	Sep-13
Consents									
Christchurch									
Sup-W	8.929	(0.043)	Dec-12	20.775	(0.019)	Sep-00	11.857	(0.011)	Nov-99
Exp-W	1.838	(0.064)	Dec-12	7.866	(0.010)	Sep-00	4.457	(0.001)	Nov-99
Selwyn									
Sup-W	16.156	(0.001)	Mar-12	52.574	(0.000)	Mar-12	20.899	(0.001)	Jun-03
Exp-W	4.971	(0.000)	Mar-12	21.827	(0.000)	Mar-12	8.844	(0.000)	Jun-03
Waimakariri									
Sup-W	9.810	(0.029)	Sep-11	25.229	(0.000)	Jun-14	16.276	(0.001)	Dec-05
Exp-W	2.797	(0.020)	Sep-11	8.887	(0.001)	Jun-14	7.000	(0.000)	Dec-05
New Zealand									
Sup-W	6.894	(0.111)	Jun-11	7.879	(0.215)	Jun-12	5.746	(0.180)	Mar-95
Exp-W	1.762	(0.071)	Jun-11	2.338	(0.125)	Jun-12	1.545	(0.093)	Mar-95

	Constant			Model			Variance		
	Stat	*p*-val	Date	Stat	*p*-val	Date	Stat	*p*-val	Date
Population									
Christchurch									
Sup-W	3.540	(0.450)	2013	16.994	(0.005)	2013	1.757	(0.846)	2001
Exp-W	0.687	(0.320)	2013	5.621	(0.005)	2013	0.611	(0.363)	2001
Selwyn									
Sup-W	8.496	(0.005)	2013	34.832	(0.000)	2001	10.615	(0.020)	2016
Exp-W	2.016	(0.005)	2013	14.534	(0.000)	2001	2.975	(0.016)	2016
Waimakariri									
Sup-W	2.116	(0.757)	2011	7.156	(0.277)	2011	12.368	(0.009)	2001
Exp-W	0.311	(0.629)	2011	1.335	(0.369)	2011	4.530	(0.001)	2001
New Zealand									
Sup-W	15.502	(0.002)	2014	48.569	(0.000)	2014	1.264	(0.959)	2003
Exp-W	4.973	(0.000)	2014	21.398	(0.000)	2014	0.284	(0.665)	2003
Relative population									
Sup-W	1.680	(0.865)	2011	71.245	(0.000)	2013	1.506	(0.907)	2016
Exp-W	0.517	(0.428)	2011	32.733	(0.001)	2013	0.661	(0.334)	2016
Rents									
Christchurch									
Sup-W	4.569	(0.296)	Feb-13	38.315	(0.007)	Mar-10	12.128	(0.010)	Apr-14
Exp-W	0.450	(0.482)	Feb-13	15.781	(0.006)	Mar-10	3.358	(0.010)	Apr-14
Selwyn									
Sup-W	17.826	(0.000)	Jan-14	42.003	(0.002)	Jul-14	16.494	(0.001)	Mar-07
Exp-W	6.015	(0.000)	Jan-14	17.104	(0.002)	Jul-14	6.950	(0.000)	Mar-07
Waimakariri									
Sup-W	3.494	(0.458)	Feb-13	31.796	(0.050)	Feb-13	1.881	(0.815)	Feb-07
Exp-W	0.533	(0.416)	Feb-13	12.002	(0.067)	Feb-13	0.278	(0.673)	Feb-07
New Zealand									
Sup-W	4.569	(0.296)	Feb-13	38.315	(0.007)	Mar-10	12.128	(0.010)	Apr-14
Exp-W	0.450	(0.483)	Feb-13	15.781	(0.006)	Mar-10	3.358	(0.009)	Apr-14

Appendix F: Testing for nonstationarity

Before turning to the results of the modelling we first test the stationarity of the series we use. A range of tests and strategies are available to test for stationarity. Here we rely on the widely used Phillips-Perron test of stationarity which has a null of nonstationarity.[24]

The level of sales is stationary for all the local councils we consider. Rents is well-known to be nonstationary, so we test for stationarity of rent growth. Aside from Auckland, we can reject the null hypothesis of nonstationarity of rent growth at the 5% level. We reject nonstationary of rent growth at the ten percent level so proceed on the basis that rent growth is nonstationary for all councils.

We reject nonstationary of consents and consents per 1,000 residents for all councils. We reject nonstationarity of price growth for all councils but Hamilton and Christchurch. Rather than take a further transformation of these series we assume prices are stationary in growth rates for all councils but also work with house prices for each local council relative to movements in national house prices. We reject the null of nonstationarity for relative prices and include rents relative to the national level of rents to test robustness of our results.

Figure 43 shows that we cannot reject nonstationarity for both the nominal TWI and 90-day interest rate. Although a common finding, this suggests the real interest rate is likely to be nonstationary if the Reserve Bank is credibly targeting a stable inflation target. This means our model will trace the impact of changes in the cost of credit rather than the level of the cost of credit and the change in external economic conditions, as proxied by the exchange rate.

Figure 43: Order of integration of our datasets

Type	Location	Statistic	Stationary at 5%
	Demand variables		
Sales	Auckland	-41.856***	Yes
Sales	Christchurch City	-36.552***	Yes
Sales	Waimakariri District	-46.872***	Yes
Sales	Selwyn District	-138.78***	Yes
Sales	Kapiti Coast District	-64.724***	Yes
Sales	Porirua City	-236.073***	Yes
Sales	Lower Hutt City	-105.561***	Yes
Sales	Upper Hutt City	-193.546***	Yes
Sales	Wellington City	-111.148***	Yes
Sales	Western BOP	-70.889***	Yes
Sales	Tauranga City	-32.496***	Yes
Sales	Waikato District	-106.536***	Yes
Sales	Hamilton City	-59.518***	Yes
Sales	Waipa District	-94.846***	Yes
Rent growth	Auckland	-20.721*	No
Rent growth	Waimakariri District	-204.553***	Yes

[24] See Phillips and Perron 1988.

Type	Location	Statistic	Stationary at 5%
Rent growth	Christchurch City	-47.57***	Yes
Rent growth	Selwyn District	-241.278***	Yes
Rent growth	Kapiti Coast District	-317.989***	Yes
Rent growth	Porirua City	-341.385***	Yes
Rent growth	Lower Hutt City	-240.586***	Yes
Rent growth	Wellington City	-342.24***	Yes
Rent growth	Western BOP	-283.141***	Yes
Rent growth	Tauranga City	-85.991***	Yes
Rent growth	Waikato District	-266.258***	Yes
Rent growth	Waipa District	-258.79***	Yes
Rent growth	Hamilton City	-100.559***	Yes
Rent growth	Upper Hutt City	-328.035***	Yes
Supply variables			
Consents	Auckland	-66.815***	Yes
Consents	Waimakariri District	-122.177***	Yes
Consents	Christchurch City	-97.35***	Yes
Consents	Selwyn District	-37.789***	Yes
Consents	Kapiti Coast District	-266.927***	Yes
Consents	Porirua City	-214.889***	Yes
Consents	Upper Hutt City	-278.257***	Yes
Consents	Lower Hutt City	-246.119***	Yes
Consents	Wellington City	-318.707***	Yes
Consents	Western BOP	-132.207***	Yes
Consents	Tauranga City	-173.202***	Yes
Consents	Waikato District	-67.542***	Yes
Consents	Hamilton City	-147.86***	Yes
Consents	Waipa District	-193.248***	Yes
Consents per 1000	Auckland	-49.989***	Yes
Consents per 1000	Waimakariri District	-120.136***	Yes
Consents per 1000	Christchurch City	-82.959***	Yes
Consents per 1000	Selwyn District	-108.348***	Yes
Consents per 1000	Kapiti Coast District	-263.373***	Yes
Consents per 1000	Porirua City	-259.258***	Yes
Consents per 1000	Upper Hutt City	-300.284***	Yes
Consents per 1000	Lower Hutt City	-274.356***	Yes
Consents per 1000	Wellington City	-319.824***	Yes
Consents per 1000	Western BOP	-131.641***	Yes
Consents per 1000	Tauranga City	-162.696***	Yes
Consents per 1000	Waikato District	-149.396***	Yes
Consents per 1000	Hamilton City	-174.096***	Yes
Consents per 1000	Waipa District	-258.581***	Yes
Prices			
Relative price	Auckland	-40.085***	Yes
Relative price	Christchurch City	-28.397**	Yes

Type	Location	Statistic	Stationary at 5%
Relative price	Waimakariri District	-167.648***	Yes
Relative price	Selwyn District	-355.133***	Yes
Relative price	Kapiti Coast District	-119.612***	Yes
Relative price	Lower Hutt City	-45.407***	Yes
Relative price	Upper Hutt City	-83.37***	Yes
Relative price	Wellington City	-37.07***	Yes
Relative price	Western BOP	-282.475***	Yes
Relative price	Tauranga City	-47.772***	Yes
Relative price	Waikato District	-71.796***	Yes
Relative price	Waipa District	-116.713***	Yes
Relative price	Hamilton City	-63.626***	Yes
Relative price	Porirua City	-144.353***	Yes
Price growth	Auckland City	-23.792**	Yes
Price growth	Christchurch City	-9.491	No
Price growth	Waimakariri District	-100.432***	Yes
Price growth	Selwyn District	-346.612***	Yes
Price growth	Kapiti Coast District	-59.706***	Yes
Price growth	Lower Hutt City	-21.744**	Yes
Price growth	Upper Hutt City	-54.558***	Yes
Price growth	Wellington City	-13.554	No
Price growth	Western Bay of	-159.395***	Yes
Price growth	Tauranga City	-10.489	No
Price growth	Waikato District	-35.242***	Yes
Price growth	Waipa District	-55.443***	Yes
Price growth	Hamilton City	-14.386	No
Price growth	Porirua City	-84.766***	Yes
Macroeconomic data			
Macro data	Nominal TWI	-12.959	No
Macro data	90-day interest rate	-15.152	No

Appendix G: Impacts on the level of rents and house prices

Figure 44: Impact of the supply shock to the levels of rents and house prices over time

Months	3	6	9	12	24	36	48	60	72	84	96
Model						Rents					
Central model	-0.085	-0.397	-0.801	-1.230	-2.704	-3.582	-4.000	-4.179	-4.256	-4.290	-4.306
Model 2	-0.035	-0.249	-0.562	-0.915	-2.286	-3.249	-3.765	-3.988	-4.074	-4.107	-4.121
Model 3	-0.073	-0.346	-0.658	-0.962	-1.950	-2.538	-2.819	-2.942	-2.994	-3.020	-3.033
Model 4	-0.047	-0.287	-0.541	-0.752	-1.254	-1.507	-1.634	-1.674	-1.681	-1.680	-1.679
Model 5	-0.079	-0.321	-0.618	-0.950	-2.306	-3.241	-3.687	-3.855	-3.913	-3.939	-3.961
Model 6	-0.022	-0.195	-0.419	-0.659	-1.684	-2.615	-3.196	-3.544	-3.741	-3.857	-3.916
Post-quake	-0.072	-0.329	-0.604	-0.836	-1.397	-1.649	-1.752	-1.778	-1.784	-1.785	-1.786
Migration model	-0.007	-0.035	-0.068	-0.097	-0.174	-0.209	-0.223	-0.227	-0.227	-0.227	-0.227
Jobs model	-0.016	-0.059	-0.110	-0.166	-0.431	-0.682	-0.809	-0.849	-0.860	-0.862	-0.861
Income model	-0.123	-0.518	-1.015	-1.541	-3.362	-4.511	-4.989	-5.097	-5.112	-5.116	-5.121
Relative model	-0.080	-0.385	-0.770	-1.180	-2.652	-3.596	-4.071	-4.278	-4.365	-4.402	-4.420
Time to build	-0.084	-0.399	-0.798	-1.218	-2.703	-3.638	-4.108	-4.314	-4.400	-4.438	-4.456
Model average	-0.058	-0.284	-0.560	-0.843	-1.837	-2.494	-2.823	-2.959	-3.014	-3.039	-3.053
						Prices					
Central model	-0.197	-0.662	-1.234	-1.820	-3.714	-4.764	-5.256	-5.472	-5.567	-5.610	-5.630
Model 2	0.172	0.417	0.609	0.691	-0.057	-1.434	-2.497	-3.140	-3.484	-3.645	-3.718
Model 3	-0.095	-0.362	-0.729	-1.128	-2.488	-3.266	-3.632	-3.792	-3.864	-3.898	-3.917
Model 4	0.309	0.777	1.147	1.356	1.180	0.705	0.471	0.407	0.398	0.400	0.400
Model 5	-0.175	-0.501	-0.897	-1.291	-2.496	-3.092	-3.345	-3.451	-3.501	-3.529	-3.552
Model 6	0.099	0.211	0.247	0.205	-0.367	-0.921	-1.245	-1.524	-1.772	-1.939	-2.009
Post-quake	0.165	0.414	0.602	0.698	0.519	0.201	0.079	0.062	0.069	0.074	0.075
Migration model	0.017	0.044	0.067	0.083	0.082	0.055	0.045	0.045	0.047	0.048	0.048
Jobs model	0.037	0.075	0.092	0.079	-0.184	-0.447	-0.622	-0.745	-0.815	-0.847	-0.861
Income model	0.233	0.457	0.561	0.509	-0.754	-2.180	-2.887	-3.149	-3.237	-3.264	-3.276
Relative model	-0.192	-0.641	-1.198	-1.776	-3.723	-4.855	-5.402	-5.642	-5.742	-5.786	-5.808
Time to build	-0.194	-0.647	-1.210	-1.793	-3.740	-4.877	-5.423	-5.664	-5.766	-5.812	-5.835
Model average	0.033	0.021	-0.065	-0.214	-1.054	-1.712	-2.037	-2.185	-2.258	-2.295	-2.313