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Passing the Buck: Impacts of Commodity Price Shocks on Rural Outcomes

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Abstract
Producers of agricultural commodities treat world commodity prices as exogenous. Prices facing regional producers can also be considered exogenous when we aggregate producers over small districts, and even across New Zealand. Through estimation of a vector autoregressive (VAR) model, under a minimal set of restrictions and through institutional knowledge, we estimate the causal impact of exogenous commodity price innovations on a set of community outcomes. We find the conventional approach of restricting the focus to national effects is insufficient to understand such dynamics, and future analysis and policy should consider sub-national responses. By extending the framework to a VAR on panel data covering all, or a sub-sample, of New Zealand TLSs over 1991-2011, we find that an increase in commodity prices leads to a permanent increase in housing investment and house prices across the country. However there is a significant degree of spatial distribution in effects. Contrary to our hypothesis, we find that rural communities are in fact the most insulated from commodity price shocks, with small and insignificant effects in both outcomes. Instead, due to constrained short-run rural employment and indirect redistribution through increased expenditure, it is urban areas that experience the most significant increases in housing investment, and the lion's share of house price appreciation.

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1. Introduction

We analyse the impact of major external shocks on rural communities. Rural community outcomes are affected by developments in a range of external factors. These factors are often transmitted to rural communities by way of returns to rural producers. External factors may include international developments that show up as commodity price changes, or they may reflect domestic policy choices such as regulation of water use, water quality or greenhouse gas emissions. Generally, such factors will be reflected in rural productive land values.

Our focus is to understand the extent to which profitability shocks that affect farmers are passed through to their local communities. Housing in rural communities is one critical set of assets that is likely to be affected, with housing values reflecting widespread community impacts. Housing developments, both in terms of price and new construction activity, therefore provide useful summary indicators of the reactions of a local economy to a shock.

We estimate a set of vector autoregressive (VAR) models to simulate the effects of a world commodity price shock on house construction and house prices within New Zealand. First, we analyse the impacts at a national level. At this level, we may expect to see only muted (if any) response to these variables in response to a commodity price shock as much of the economy is directly unaffected by a commodity price shock, and further analysis at this level involves a relatively small sample. In addition, monetary and fiscal policy responses may occur following a shock that over time offset the positive or negative impacts of the external shock. Consistent with such a macroeconomic response, we find only small nation-wide effects of a commodity price shock on national housing outcomes.

We develop the approach further by estimating the VAR models as a panel across a number of samples of communities, defined here as rurally-dominated Territorial Local Authorities (TLAs); the shares of land value attributed to commodity production within TLAs are used to determine whether a local authority is considered rural, quasi-rural or urban and we consider analysis on each classification, as well as a sample of all communities. Even if there is an offsetting macroeconomic response to a shock, we may observe positive or negative impacts on rural TLAs since their producers are directly affected by the shock. In turn, the local workforce and service providers may be affected by the producers who have been directly affected by the commodity price shock. These effects will be reflected in population movements (and hence house construction) and in the prices that people are prepared to bid to live in the community (i.e. house prices). However, we find evidence that rural communities are the most insulated from commodity price innovations; housing outcomes follow similar dynamics across most community classifications, whilst the magnitude of effects and associated statistical significance of responses are decreasing in a community's commodity production share of land value. Thus we find urban areas experience very strong house price growth and a noticeable increase in housing investment. This highlights the short-run constraints on employment in rural communities, and the indirect income effect experienced by urban areas realised through increased rural demand for professional services and luxury goods.

The paper first sets out our data and methodology. A brief descriptive analysis of key features of the national data follows. We then present results from the national level VARs prior to presenting the results from the TLA panel VARs across various subsamples. It is these latter results that form our key focus. A brief set of conclusions, with suggestions for extensions to the analysis, completes the paper.

2. Data

The empirical analysis detailed in this study draws upon a combination of freely available series and derived variables. All series used are of quarterly frequency (in some cases having been converted to quarterly frequency where quarterly data were not available). We consider the period from 1991Q1, which marks the period following the formation of Territorial Local Authorities (TLAs), to 2011Q3. The TLAs form the cross-sectional units in the sub-national panel data analysis, where we use the official boundaries directly preceding the amalgamation of Auckland's seven TLAs; thus we bundle Christchurch City and Banks Peninsula as a single TLA. The series used in the analysis are described in Table 1. For an in-depth discussion of each series see Appendix A in the case that the series is publicly available or Appendix B, for the derived series.

Impulse response functions (IRFs), based on vector autoregressive models (VARs), are the key analytical tool used in this study. However, these functions are only valid in the neighbourhood of the steady state. By examining the stationarity of each series we can determine whether such a condition is applicable; if each series is individually stationary then a linear combination of each must also be stationary. The significance levels for the null hypothesis of a unit root using an augmented Dickey-Fuller test on each series measured at the national level, in both levels and changes, appears in Table 2**Error! Reference source not found.**. The results of he stationarity tests suggest that the level of each national series has a unit root, whilst the change in each national series is stationary.

Thus the VAR modelling approach and the interpretation of the resulting impulse responses requires that we analyse a system of equations in the change in each series. That is, we shall consider the effect of a one-off shock to the change in world commodity prices, interpreted as a permanent change in the level of commodity prices, on the change in national housing consents relative to the housing stock (a measure of housing investment), and the change in national house and national farm prices. One potential transmission mechanism through which international price innovations affect a small open economy is through the exchange rate. As exchange rate movements are not central to this paper, we include the exchange rate as a control variable in the model however we omit the effect of a change in commodity prices on the change in the (national) exchange rate when we consider the impact on outcomes, and further, ignore the direct effect exchange rate shocks.

We extend this framework at the sub-national level. Given the weak evidence of national level impacts, we repeat the analysis through a panel VAR, where TLAs comprise the cross-sectional unit of observation. Our prior is that rural communities will be more responsive to commodity price shocks than non-rural communities. A comparison of dynamic responses across all TLAs, as well as sub-samples of such, can be used to test this hypothesis. Again, we require stationarity of all series to allow for interpretation of impulse response functions. We can test the stationarity of each series, both in levels and in changes, however we time- and Helmert-differencing each series as this will be the form relevant to the Panel VAR analysis, and denote this by a tilde on top of each series. We use the Im-Pesaran-Shin (IPS) and Levin-Lin-Chu (LLC) panel unit root tests, each of which has a null of a unit root. The associated p-values of the tests, for each series in differences, across all districts, are shown in Table 3.

The results reject the null hypothesis of non-stationarity for the change variables under both tests on all series, suggesting analysis of relative changes through IRFs based on a panel VAR is valid.

3. Methodology

The analysis primarily employs vector auto-regression (VAR) analysis, a time-series econometric technique, to indicate the effect of commodity price movements on our focal outcomes. Our analysis is conducted at both a national level and at a sub-national (panel TLA) level.

At the national level we posit that commodity prices can affect each focal outcome contemporaneously and with lags, so we allow for the full effect of a world commodity price shock to be realised over several periods. Commodity prices may also impact on the exchange rate contemporaneously and over time, which can further affect focal outcomes. Accordingly, we adopt the following compact form of the unrestricted structural model, expressed here using national level variables:

$$\begin{bmatrix} 1 & \beta_{12} & \beta_{13} \\ \beta_{12} & 1 & \beta_{23} \\ \beta_{13} & \beta_{32} & 1 \end{bmatrix} \begin{bmatrix} PCom_t \\ XE_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \alpha_{PCom,t} \\ \alpha_{XE,t} \\ \alpha_{Y,t} \end{bmatrix} + \sum_{s=1}^{S} \begin{bmatrix} \gamma_{11,s} & \gamma_{12,s} & \gamma_{13,s} \\ \gamma_{12,s} & \gamma_{22,s} & \gamma_{23,s} \\ \gamma_{13,s} & \gamma_{32,s} & \gamma_{33,s} \end{bmatrix} \begin{bmatrix} PCom_{t-s} \\ XE_{t-s} \\ Y_{t-s} \end{bmatrix} + \begin{bmatrix} \varepsilon_{PCom,t} \\ \varepsilon_{XE,t} \\ \varepsilon_{Y,t} \end{bmatrix}$$

where $Y_t \in \{HC_t/H_t\, , \ln PH_t\, , \ln PF_t\}$, and each vector is a (3x86)x1 column vector, implying the matrices are (3x86)x(3x86) block matrices populated by the relevant coefficients.

Note that to keep the VAR analysis manageable, we include each element of Y_t in separate VARs (together with commodity prices and the exchange rate). Given the feedback in the system, that is the contemporaneous correlations between dependent variables and the indirect effect of innovations across equations, we cannot estimate this equation as it stands. Instead we consider the reduced form specification, by pre-multiplying the equation by the inverse of the coefficient matrix of current realisations.

$$\begin{bmatrix} PCom_t \\ XE_t \\ Y_t \end{bmatrix} = \begin{bmatrix} 1 & \beta_{12} & \beta_{13} \\ \beta_{12} & 1 & \beta_{23} \\ \beta_{13} & \beta_{32} & 1 \end{bmatrix}^{-1} \begin{bmatrix} \alpha_{PCom,t} \\ \alpha_{XE,t} \\ \alpha_{Y,t} \end{bmatrix} + \sum_{s=1}^{S} \begin{bmatrix} 1 & \beta_{12} & \beta_{13} \\ \beta_{12} & 1 & \beta_{23} \\ \beta_{13} & \beta_{32} & 1 \end{bmatrix}^{-1} \begin{bmatrix} \gamma_{11,s} & \gamma_{12,s} & \gamma_{13,s} \\ \gamma_{12,s} & \gamma_{22,s} & \gamma_{23,s} \\ \gamma_{13,s} & \gamma_{32,s} & \gamma_{33,s} \end{bmatrix} \begin{bmatrix} PCom_{t-s} \\ XE_{t-s} \\ Y_{t-s} \end{bmatrix}$$
$$+ \begin{bmatrix} 1 & \beta_{12} & \beta_{13} \\ \beta_{12} & 1 & \beta_{23} \\ \beta_{13} & \beta_{32} & 1 \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_{PCom,t} \\ \varepsilon_{XE,t} \\ \varepsilon_{Y,t} \end{bmatrix}$$
$$= \begin{bmatrix} a_{PCom,t} \\ a_{XE,t} \\ a_{Y,t} \end{bmatrix} + \sum_{s=1}^{S} \begin{bmatrix} g_{11,s} & g_{12,s} & g_{13,s} \\ g_{12,s} & g_{22,s} & g_{23,s} \\ g_{13,s} & g_{32,s} & g_{33,s} \end{bmatrix} \begin{bmatrix} PCom_{t-s} \\ XE_{t-s} \\ Y_{t-s} \end{bmatrix} + \begin{bmatrix} e_{PCom,t} \\ e_{XE,t} \\ e_{Y,t} \end{bmatrix}$$

In this fashion, a structural model includes $\frac{n(n-1)}{2}$ more parameters than is contained within the reduced form specification, where n is the number of dependent variables in the system, which in our case is 3.Thus we require at least 3 restrictions to identify the structural form parameters. A common solution to identifying the structural parameters from the reduced form estimation is to use the type of recursive model first proposed in Sims (1980) involving the imposition of certain theory-based restrictions.

There exist several obvious restrictions to employ from economic theory. In a competitive market, a producer has no ability to affect prices. If international agricultural commodity markets are competitive, New Zealand commodity producers should exhibit no influence over the respective international agricultural price. Woods and Coleman (2012) consider the extent to which New Zealand influences international commodity prices and find that there is little or no evidence of any influence. A natural restriction therefore is to restrict the contemporaneous effect of changes to each of the New Zealand outcome variables on international commodity prices to be zero. Similarly, we impose the restriction that domestic variables do not impact contemporaneously on the exchange rate. Finally, we allow world commodity price shocks to impact contemporaneously on New Zealand's exchange rate while imposing the restriction that New Zealand's exchange rate does not impact contemporaneously on world commodity prices (which are assumed to be set through global supply and demand). Whilst one could also expect that international commodity prices and exchange rates follow a random walk process, we impose as few restrictions as possible, and instead let the data speak. Thus, the national level VAR has the following specification:

$$\begin{bmatrix} \Delta lnPCom_t \\ \Delta lnXE_t \\ \Delta Y_t \end{bmatrix} = \begin{bmatrix} lnPCom_t \\ lnXE_t \\ Y_t \end{bmatrix} - \begin{bmatrix} lnPCom_{t-1} \\ lnXE_{t-1} \\ Y_{t-1} \end{bmatrix}$$

$$= \underline{\alpha_0^N} + \sum_{s=1}^{S} \underline{\Gamma_s^N} \begin{bmatrix} \Delta lnPCom_{t-1} \\ \Delta lnXE_{t-1} \\ \Delta Y_{t-1} \end{bmatrix} + \underline{v_t}$$

where $\begin{bmatrix} \Delta lnPCom_t \\ \Delta lnXE_t \\ \Delta Y_t \end{bmatrix}$ is a (3x86)x1 vector of national observations of changes in the log commodity price, the log exchange rate, and the change in an outcome comprising of either the housing investment rate, the log of the house price index, or the log of farm prices, $\underline{\alpha_0^N}$ is a (3x86)x1 block vector comprising a constant for each series, S is a chosen lag length, $\underline{\Gamma_s^N}$ is a (3x86)x(3x86) block matrix comprising a coefficient for each combination of current and lagged series, and $\underline{v_t}$ is a (3x86)x1 vector of errors, whilst the N superscript implies the national coefficients.

A central requirement of applying VAR analysis to panel data is that each cross-sectional-time observation has the same data generating process. This is unlikely to hold in practice. We can exploit the panel structure of the sub-national dataset to allow for heterogeneity along several dimensions. Firstly, districts may experience common period-specific shocks, for example, due to macroeconomic conditions or seasonality. Secondly, we allow districts to have a different change in each series, to approximate systematic effects such as the declining and inkling preference of districts such as Kawerau and Queenstown-Lakes, respectively, over the sample period, as evidenced in population and housing market trends. Then we believe the sub-national series evolve via the following process.

$$\begin{bmatrix} \Delta lnPCom_{it} \\ \Delta lnXE_{it} \\ \Delta Y_{it} \end{bmatrix} = \underline{\alpha_0^S} + \sum_{s=1}^{S} \underline{\Gamma_s^S} \begin{bmatrix} \Delta lnPCom_{i,t-1} \\ \Delta lnXE_{i,t-1} \\ \Delta Y_{i,t-1} \end{bmatrix} + \underline{\beta_i^S} + \underline{\mu_t^S} + \underline{v_{it}}$$

where $\begin{bmatrix} \Delta lnPCom_{it} \\ \Delta lnXE_{it} \\ \Delta Y_{it} \end{bmatrix}$ is a (3x86x72)x1 vector of sub-national observations of changes in the log commodity price, the log exchange rate, and the change in an outcome comprising of either the housing investment rate or the log of the house price index, $\underline{\alpha_0^N}$ is a (3x86x72)x1 block vector comprising a constant for each series, s is a chosen lag length, $\underline{\Gamma_s^N}$ is a (3x86x72)x(3x86x72) block matrix comprising a coefficient for each combination of current and lagged series, $\underline{\beta_i^S}$ is a (3x86x72)x1 block vector of an district specific constant for each series, $\underline{\mu_t^S}$ is a (3x86x72)x1 block vector of period-specific constants, and $\underline{v_{it}}$ is a (3x86x72)x1 vector of errors, whilst the S superscript implies the sub-national coefficients.

To estimate the model in the presence of such period-specific shocks we subtract the period-specific mean from each series. Further, each district may experience different rates of change in variables due to district-specific factors, for example house price growth may differ systematically between districts due to land or construction constraints. The conventional methodology to remove such area fixed effects would be to first- or mean-difference each district series however with lagged dependent variables any differencing would introduce a correlation between the error term and the lagged dependent regressor. The solution we employ is to consider a Helmert transformation of the data, essentially a forward-mean differencing over each district series, following the discussion set out in Love (2011) and detailed in Hamilton (1994). Thus we estimate the following panel VAR,

$$\begin{bmatrix} \Delta ln\widetilde{PCom}_{it} \\ \Delta \widetilde{lnXE}_{it} \\ \Delta \tilde{Y}_{it} \end{bmatrix} = \begin{bmatrix} \Delta ln\widetilde{PCom}_{it} \\ \Delta \widetilde{lnXE}_{it} \\ \Delta \tilde{Y}_{it} \end{bmatrix} - \begin{bmatrix} \Delta lnPCom_{t} \\ \Delta lnXE_{t} \\ \Delta Y_{t} \end{bmatrix}$$

$$= \underline{\beta_0^S} + \sum_{s=1}^{S} \underline{\Theta_s^S} \begin{bmatrix} \Delta ln\widetilde{PCom}_{i,t-1} \\ \Delta \widetilde{lnXE}_{i,t-1} \\ \Delta \tilde{Y}_{i,t-1} \end{bmatrix} + \underline{\varepsilon_{it}}$$

where $\Delta\tilde{X}_{it}$ represents the time and Helmert differenced series, $\underline{\beta_0^N}$ is a (3x86x72)x1 block vector comprising a constant for each series, s is a chosen lag length, $\underline{\Gamma_s^N}$ is a (3x86x72)x(3x86x72) block matrix comprising a coefficient for each combination of current and lagged series, and $\underline{\varepsilon_{it}}$ is a (3x86x72)x1 vector of errors, whilst the S superscript implies the sub-national coefficients.

Use of different information criteria (e.g. the Akaike Information Criterion or the Schwarz-Bayesian Information Criterion) indicate different optimal lag length choices from each other and different lag lengths depending on which outcome variable is included in the VAR. Rather than be driven by a single criterion, we adopt a lag length of 4 quarters as an a priori reasonable lag length, given quarterly data, for the dynamic interactions of the variables in our system. (We have also used 8 lags; responses are generally show less significance and more variability in the dynamics reflecting the greater number of estimated parameters; these results are not reported here.)

4. Descriptive Analysis

Before we consider the results of any dynamic relationship, it is useful to examine the co-movements in the focal series and in international prices. First, we consider the exchange rate. The relevant exchange rate for analysis such as this is not clear. Whilst a general exchange rate, which may fit urban communities well, exists in the Reserve Bank's measure of the United States dollar to New Zealand dollar (USD/NZD) exchange rate, this may be less relevant to commodity producers. Alternatively we could consider a broader export-oriented exchange rate in the Trade-Weighted Index however this still fails to completely capture the relevance to domestic commodity producers, which is essential given the central question of this study. Thus we turn to a commodity price focused, implied exchange rate. The measure considers the rate implied by the ANZ's measure of the World Commodity price component indices relevant to New Zealand, expressed in international prices, relative to the same index expressed in New Zealand dollars. We weight each relative component index by land value weights where the land value weights (which sum to one) reflect the value of land devoted to each of the four commodity classes (dairy, meat and wool, forestry, and horticulture). We use this variable in our TLA analysis (since we do not have export weights by TLA) and so, for practical reasons, this is our preferred measure. Alternatively, we could ignore weights, and simply consider the ratio of the ANZ World Commodity price index, expressed in international prices, relative to the same index expressed in New Zealand dollars. The three series are depicted in Figure 1. As expected, there is a high degree of correlation between the three exchange rate measures, supporting the validity of the derived exchange rate in our analysis.

We also consider co-movements over time between the natural logarithm of our derived exchange rate index and the natural logarithm of the derived national commodity price index. From the data description, the derived national commodity price is a weighted variable with weights derived from land values devoted to each of the four commodity groups and from non-commodity use. The latter has the consumer price index (CPI) attributed to it, and the weighted sum variable is then divided by the CPI; as a result it does not vary as strongly as does a raw commodity price index. We consider the natural log on the prior that percentage changes in commodity prices have a relationship between percentage changes in the exchange rate. The comovements are detailed in Figure 2. The two series are generally strongly positively correlated, other than some short-term negative correlations occurring prior to 1993Q4 and the period 1998Q3-2002Q3. Then if community outcomes are affected by commodity price movements, it will be important to control for exchange rate movements in the analysis.

Now consider how each focal outcome moves with both commodity prices at the national level. First consider the housing investment rate, depicted in Figure 3, where the upper graph plots the trends in the natural logarithm levels, whilst the lower graph depicts the trends in series changes. A general relationship is apparent in levels. Both series experience strong growth from the beginning of the period to the late 1990's, from the late 1990's to 2000's commodity prices are relatively flat whilst housing investment is also flat, although there is significant noise. Then as the global recession loomed both commodity prices and housing investment fell, with partial and full recovery in housing investment and commodity prices respectively. It is more difficult to discern a relationship between commodity price changes and the change in housing investment over the sample period; as housing investment is a noisy series, this is amplified when we consider changes, however we still see that growth in each series is increasing during much of the 1990's, as during the mid-2000's period, with a similar dynamics in the recovery following the global recession. The weaker relationship is not unsurprising; whilst commodity price shocks represent an income effect the set of factors that determine the propensity to build is much wider, including labour costs and the health of the domestic banking sector. Further, given commodity prices are likely to represent a stronger income effect in commodity producing areas such effects may wash out at the national level.

Next consider the relative trends in national house prices, depicted in Figure 4, where the upper graph plots the natural log of commodity price and national house price levels, whilst the lower graph depicts the change in the log transformed series. There is a strong positive correlation between the national commodity price index and the house price index, and a broadly similar trend t that seen in Figure 3. Both series are trending upwards for much of the 1990's, flat around the year 200, increasing during the mid 2000's period. As we consider the lower panel the relationship becomes even stronger. We see strong relative growth in one series is generally coupled with strong relative growth in the other. Of course this may simply pick up the price appreciation in a number of asset markets during the 2000's, thus care will be required for correct interpretation of the analysis that follows.

Finally, consider the analogous trends for the national farm price per hectare index, displayed in Figure 5. Perhaps surprisingly, there is little evidence of a relationship between national farm price changes and either commodity price or exchange rate changes. Variability and measurement difficulties in the farm price data may be one reason behind this lack of close co-movement. Another could be that farm prices are driven as much by other factors (e.g. credit availability) as they are by commodity returns.

5. National VAR Results

In this section we present the results of a parametric examination of the changes in several focal New Zealand aggregate outcomes due to changes in international commodity prices, controlling for exchange rate movements as one potential transmission mechanism. The impact of such innovations on the national housing investment rate, the national house price index, and national farm price per hectare are depicted in Figures 6, 7 and 8 respectively.

The left panel of each figure depicts the evolution of the commodity price index as a result of this shock. As expected graph the analogous results for each outcome are not noticeably different since commodity prices are the shock variable and we expect little, if any, feedback from the remaining variables in the model to international commodity prices (consistent with our exogeneity assumption). A one standard deviation increase in the change in the log commodity price index is equivalent to an initial 0.69% increase in the derived world-price denominated national commodity price index. The dynamic series (represented as a dashed line in the graph) reflects the impact on the change in the natural log of the derived exchange rate, relative to its pre-shock value. By attaching a 90% confidence interval around the dynamic response, depicted as the shaded region, we can consider the statistical significance of responses. We see the dynamic response rises by a statistically significant 0.69% in period 0, the time of the shock. We find that the long-run change is comprised of further significant increases in each of the three periods following the shock, as well as a degree of correction with significant price reductions in the following 4 periods. Given the evidence of stationarity of the series in changes, it must return to zero, thus we see that the dynamic response thereafter oscillates insignificantly around zero.

By considering the cumulative effect, which is the sum of the dynamic responses, depicted as a solid line, we estimate the implied long-run change in the level of the national commodity price index. We find that a 0.69% increase in the commodity price in period 0, leads to a larger point-estimate increase in the commodity price index after 40 quarters. The fact that the long-run effect differs from the immediate effect suggests a degree of persistence in the changes and reflects the auto-regressive nature of the model, where shocks affect future realisations. International prices are expected to follow a random walk, or one could profit from exploiting any such pattern. However given the partially offsetting effects in periods 4 to 8, and the precision of all dynamic point-estimates, the long-run effect is not significantly different from the short-run effect. Thus, by imposing only a minimal set of restrictions, our model produces results that are consistent with theory.

The analysis suggests that a one standard deviation increase in the change in log commodity prices immediately appreciates the exchange rate, with no evidence of feedback from exchange rate movements to future commodity price levels, a result consistent with New Zealand acting as a price-taker in international commodity markets. The long-run evidence suggests a 1% increase in commodity prices leads to a 1% increase in the exchange rate, and there is no feedback from outcomes to the exchange rate. However, exchange rate comovements are not central to this paper, thus we omit the results of a change in commodity prices on the change in the (national) exchange rate; the results add support to the validity of our methodology, but distract from the intended message. This paper further abstracts from the potential direct effect exchange rate shocks can have on community outcomes.

We now consider the impact of international price innovations on each focal outcome.

5.1. Impact on Housing Investment

First consider the impact of a one standard deviation increase in the change in the log transformed commodity price index on the national housing construction rate; the associated impulse response functions is displayed in the right hand panel of Figure 6.

Given that we normalise housing consents by the existing housing stock (which approximates the percentage change in the housing stock) to define the housing investment rate, we are working with very small responses. A 0.69% initial increase in international commodity prices results in almost no immediate change in the national housing investment rate, which is unsurprising given that there exists a lag between observing the shock, the decision to build, application of a housing consent, and finally official approval (which is the series utilised). The dynamic series increases slightly in the two quarters following the shock, but exhibits a large decrease 4 quarters after the shock, and thereafter fluctuates around zero. By examining the cumulative response we estimate a point estimate of the long-run decrease in the national construction rate of less than 0.01%. At no point over the 40 quarters is the response in normalised housing consents significantly different from zero. However, the price of commodities is most relevant to commodity producing areas; thus we may lose the direct effect on such areas by aggregating the response to the national level, and as a result observe no effect. This hypothesis is tested in Section 6, where we consider the response to international price innovations across multiple sub-samples of communities.

5.2. Impact on House Prices

In Figure 7 we depict the results pertinent to the commodity price innovation, where the second panel depicts the response of the national house price index. The initial response in house prices to a 0.69% commodity price increase is an increase in the national house price index by 0.18% however this response is not significant. In fact there is no significant reaction in any of the following two periods, which would allow for a lag between shocks and gains to be realised and pressure on local markets to be observed. Instead, we find evidence that there are significant reductions in house prices at the national level between the 3rd and 6th quarters following the shocks. The dynamic responses suggest that long-run house prices are 1.97% lower than their value prior to the commodity price shock. However, by considering the significance of the dynamic responses we would estimate a significantly lower house price index between 5 and 8 quarters following the commodity price shock, and a long-run effect that is not significantly different from zero, implying no long-run effect of commodity shocks on nationally aggregated house prices. As with the housing investment analysis, the national data may mask house price impacts in regions most exposed to commodity production; we address the impact of commodity price shocks on sub-national house prices in section 6.2.

5.3. Impact on Farm Prices

Finally, we consider the impact of a one standard deviation increase in commodity prices on the national farm price per hectare, depicted in the right hand panel of Figure 8.

A 0.69% increase in commodity prices has little effect on national farm prices initially as agents evaluate whether the shock is permanent or transitory; the point-estimate on the change in contemporaneous is -0.31%. Given we shock the change in commodity prices, this represents a permanent increase, as this becomes apparent farm returns increase which leads to an appreciation of long-run farm prices 1.3% above their pre-shock price level. However, we note the dynamic response is insignificant at all quarters following the shock. Then we see that international commodity price innovations put upward pressure on farm prices, however the changes are not statistically significant given the noise in the underlying farm samples data. In spite of the noisy data, the lack of significance is a little surprising given we examine national farm price per hectare, which is a weighted sum of the average farm per hectare sales price across the commodity groups contained within the ANZ Commodity Price Index, where the weights are the proportion of land value devoted towards a given commodities production and must sum to one. Then we should not see a washing out at the national level. This provides justification for handling the underlying data with greater care, to tease out the fundamental relationship between farm prices and returns to production.

6. Sub-national Panel VAR Results

The national level analysis in the previous section failed to find significant results of commodity price shocks on national outcomes in the long-run. However, the national level analysis is conducted on a small dataset, where the signal-to-noise ratio is likely to be large given the discussion in the descriptive analysis section. Then to explore whether the results are the result of a small number of observations we estimate an analogous VAR model over the period 1991Q1-2011Q3, which includes a cross-sectional dimension of observations from every TLA in New Zealand.

Another explanation for the lack of power to identify effects at a national level is that there exist significant effects amongst a sub-sample of TLAs however as we aggregate over the entire country these area-specific sensitivities are washed out. To test such a hypothesis we conduct further Panel VAR analysis, selecting on subsamples where TLA's are defined as rural (where the average proportion of land value over the period exceeds 44%), quasi-rural (where the average proportion of land value over the period exceeds 20% but is less than or equal to 44%), or urban (all others). Table 5 lists all TLAs along with their average proportion of land value attributed to commodity production over the sample period and the corresponding classifications. The boundary weights are partly chosen to place a similar number of the 72 TLAs in each classification; there are 23 urban TLAs, 21 quasi-rural TLA's and 28 rural TLAs. However this is balanced by ensuring the classification of each TLA is consistent with a generally accepted notion of a TLAs primary productive activity.

The sub-national analysis follows a similar structure as that laid out in the national VAR analysis; we consider the impact of a one standard deviation innovation in the sub-national commodity price on the local housing investment rate and house prices. Note however, that we ignore farm prices at a local level, as the data is sparse at the sub-national level, so any useful estimation would involve the national average sales prices and different weights for which the analysis has already been discussed. Further, farm sales occur largely in rural areas, so any estimation of the impact on farm prices is an estimation of the impact on a rural outcome.

To constrain the focus of this paper, we include the change in the sub-national derived exchange rate as a control variable in the estimation of the impact of price innovation on sub-national outcomes as it is one potential transmission mechanism through which we observe some or no effect on local outcomes, but we do not include their impulse response functions in the graphs below, nor do we allow them to enter as shock variables. The central question to this paper concerns the impact of commodity price shocks on rural outcomes.

6.1. Impact on Housing Investment

A one standard deviation shock to the change in the underlying, that is time- and Helmert-differenced, sub-national commodity price, and the effects on the long-run commodity price and housing investment over all TLAs is depicted in Figure 9.

The left panel shows the effect the shock has on the sub-national commodity price. The shock is equivalent to a 1.72% increase in the sub-national commodity price. Given the expansion of the dataset along the cross-sectional dimension with respect to the national analysis we see that the point-estimate is larger, and unsurprisingly, much more precise. Because the series is stationary in changes, we see the dynamic response tends back towards zero over the next 4 quarters and thereafter fluctuates about zero. This leads to a post-shock commodity price that is 2.57% above the pre-shock value, and interestingly the cumulative effect is significantly different from the initial response, suggesting there is a degree of persistence in commodity price changes.

The right panel shows the price shock coincides with a small and negative, but significant, reduction in housing investment. However, given the time required to observe and evaluate a shock, apply for a consent, and finally obtain official approval (which is the series used in the derivation of the housing investment rate), and assuming effects are unanticipated, we place little weight on this effect. More importantly, we observe a significant increase in housing investment one-period after the shock, which would follow the aforementioned theory. This is the only point at which we observe a significant dynamic response, thus whether we include the contemporaneous effect or not, the lack of precision of lagged effects means the long-run housing investment rate is not significantly different from its pre-shock value. Through analysis at a sub-national level we find there is a dynamic effect of commodity prices on sub-national housing investment, which was not the case under the national analysis, however it remains to identify the broad areas in which this response is observed.

Figure 10 depicts the impact of a commodity price shock, where the analysis is restricted to the sub-sample of rural communities; those with high levels of commodity production, and thus areas that are most directly affected by commodity price innovations. We find that a permanent increase in local commodity prices has an almost identical effect on the point-estimates of housing investment in rural TLAs' as that observed across all TLA's; there is a negative contemporaneous effect on the rural housing investment rate, after which we see a pronounced rise, and then gentle convergence back towards zero, to completely offset the reduction. However, the reduced sample size compared to the all TLAs sample, and relatively more volatile consents data in rural districts, means the dynamic responses are insignificant in all periods following the shocks, implying the housing investment rate in rural TLA's is invariant to permanent commodity price movements.

Figure 11 depicts the housing investment response to a permanent commodity price shock amongst quasi-rural TLA's. The dynamic response in quasi-rural communities is very similar to the previous two cases. A permanent increase in commodity prices is associated with a contemporaneous reduction in the housing investment rate, whilst we estimate an increase in the housing investment rate one period after the price shock. The effect is realised over a much shorter horizon however, with all the gains coming one period after the shock and some correction in future periods likely due to intertemporal substitution in the decision to build. The observed increase is of only a slightly greater magnitude than that observed in the previous two cases, and is significant. By considering the cumulative effect, which includes the initial reduction, we find no evidence of change in the housing investment rate in the long-run, although the effect would almost be significant if we consider only lagged responses. Then we find, interestingly, as we reduce the proportion of land value attributed towards commodity production, which internalises the profitability of commodity production, the responsiveness of housing investment increases. Does this hold as we consider urban areas?

Figure 11 depicts the housing investment response to a permanent commodity price shock amongst urban TLAs. A one standard deviation increase in the change in the urban commodity price permanently increases the local commodity price, and has a dynamic effect very similar to that of both rural and quasi-rural districts. Interestingly, there is no significant effect on the contemporaneous housing investment rate, as should be expected. We find evidence of an increase in the investment rate one-period after the shock that is slightly more pronounced, and slightly more significant than that seen in the other case, but the general trends are remarkably similar. We note however, that given the relative imprecision of the dynamic effects, we fail to find any evidence of a change in the long-run housing investment rate amongst rural TLA's, consistent with what was seen in all other cases.

Then we conclude that the effect of commodity price innovations on housing investment is well distributed across the country, however it is the indirect effect, or feedback from areas with high levels of commodity production which experience an income effect and leads to increased consumption of more general goods and services to those with a lower level, on less intensive commodity producing areas that experiences the greatest increases in housing investment following a commodity price shock. Given the evidence of long-run housing consents as a strong predicted of long-run population change this leads one to conclude that the relative population growth is strongest in urban areas, suggesting that commodity price increases contributes to urbanisation of rural of rural communities.

6.2. Impact on House Prices

Now consider the effect a one standard deviation shock to the change in the underlying, i.e. time- and Helmert-differenced, sub-national commodity price, and the effects on the long-run commodity price and house price levels.

For all TLA's, the case is depicted in Figure 13. Given a 1.72% increase in local commodity prices we estimate a contemporaneous reduction in the house price level, although this is an imprecise estimate and is not significant. However, in the 2^{nd} and 5^{th} periods following the permanent increase in commodity prices we find there is a significant increase in house prices, a lag which would be consistent with the time taken to realise gains and for higher income levels to feed through to housing market activity. The dynamic process suggests there is a 2.56% increase in long-run sub-national commodity prices, which drives a statistically significant 0.21%

increase in sub-national house prices in the long-run. This is a very different result from that estimated through national aggregates, which predicted a much larger and significant reduction in national house prices. The disagreement in results further highlights the benefits of conducting this analysis at a sub-national level. Thus we delve further into the data, to consider which categories of TLAs, partitioned by commodity production levels, are experiencing the house price growth.

Figure 14 depicts the analogous results for the sub-sample of rural districts; the TLA's with the highest degree of commodity production. The dynamic process of rural house prices is very similar to that witnessed across all TLAs. The relatively large permanent increase in the local commodity price index appears to have no contemporaneous effect on house prices, whilst house prices increase in the 2nd, 4th and 5th periods following the shock, although these effects are just outside the confidence interval.We also estimate a reduction in the house price level in the 3rd period following the shock, a result broadly similar to, but more pronounced than that estimated across all TLAs. There is no significant change in the dynamic response in any period, which results in a long-run house price amongst rural districts which is not significantly different from its pre-shock value. Thus the broad trend point-estimate house prices changes are similar between rural communities and the larger sample of all TLAs, but it is not rural communities that contribute to the significant response in sub-national house prices.

Figure 15 displays the results of the analysis for quasi-rural districts. Again the dynamic quasi-rural results are very similar to that seen under the analysis of all TLAs, as well as the rural district results. We find that a permanent increase in commodity prices has no significant effect on contemporaneous quasi-rural house prices, whilst there is a further reduction in the following period that is only just outside the confidence interval, whereas the positive and negative movements in the 3rd and 4th quarters after the shock, respectively, are significant at the 95% level. The combination of dynamics leads to an estimated reduction in quasi-rural house prices, which is significantly lower that the pre-shock level in the 2nd and 3rd quarters after the shock, but the long-run difference between house prices and pre-shock house prices is not significant amongst quasi-rural TLA's. Thus we see a similar pattern in quasi-rural house price dynamics, but again this is not the category which is driving the sub-national house price growth.

Finally consider the impact of a permanent commodity price shock on urban house prices. A permanent increase in commodity prices has little effect on contemporaneous house prices in urban areas however, that is where the similarities between the responses in urban and more rural community end. In each of the following 6 quarters we estimate a significant increase in urban house prices. The combination of dynamics, from an initial 1.46% increase in the urban commodity price indices, leads to a long-run house price level that is 0.99% above the pre-shock level, and highly significant. The difference in house price responses across TLA's classifications is astounding, whilst there is little effect on the long-run house prices of commodity producing areas there is a pronounced increase in long-run house prices amongst urban areas. One potential caveat to such results is this may pick up the general comovements in commodity and asset markets and not imply causal estimates, such comovements were particularly witnessed during the 2000's, and investment properties are more common in urban areas. Thus further research is required to disentangle the effects, where one possible solution is to use specific commodity group shocks.

The analysis of this section leads one to conclude that rural districts are the most insulated from commodity price shocks, an initially counter-intuitive result. However employment growth is heavily constrained in rural districts in the short-run, thus there is less potential for an income effect to be widely distributed through a community. The income effect is realised as an increase in the rural demand for goods and services, such as new motor vehicles and professional or business services, which are directly or indirectly linked to urban organisations. Thus the results are surprising, yet plausible. We find that all of the pressure on housing markets witnessed at the national level is realised in urban TLA's.

7. Conclusion

This paper considers the dynamic response in a number of community outcomes, to a truly exogenous innovation. Through a time-series econometric technique, with a minimal set of restrictions and institutional knowledge we estimate the causal impact of commodity price innovations has on local housing construction, to approximate changing lifestyle preferences and internal migration, house prices, to consider the effects the spatial dispersion of income effects, and farm prices, as a direct measure of endogenous local profitability.

A significant amount of research into commodity price effects in small open economies has centred on national effects. Our analysis, when conducted at the highly aggregated national level leads to insignificant national responses. This is due to both a small sample size, as well as ignoring the spatial distribution of benefits, which is lost under aggregation.

We then suggest that the analysis should be performed through panel VAR, to increase sample size along the cross-sectional dimension, and to allow one to consider different sub-samples to identify region-specific responses.

The results of such analysis are appealing. By increasing the sample size along the cross-sectional dimension we find evidence that commodity prices lead to a broad increase in housing investment and house prices, a intuitive result that was not confirmed under national level analysis. However given the structure of our model we can disentangle effects across districts.

We find that rural communities are the most insulated from international commodity price innovations; given short-run constraints on rural employment etc, and the and the associated increased demand goods and services provided to rural districts by major organizations, such as car dealerships and accountancy firms, which are generally based in major cities or to which the profits are repatriated, there is little effect of commodity price shocks on this set of rural outcomes. Rather, the responsiveness in housing investment follows the same trend across all commodity production intensity defined sub-samples, however the magnitude and significance of the response is decreasing in a communities relative commodity production. Further, urban areas experience the lion's share of house price inflation following commodity price shocks. Thus, future analysis and policy should consider international price effects at a sub-national level, and give greater consideration to the indirect and redistributive effects associated with exogenous price innovations.

References

Grimes, A., Holmes, F., & Bowden, R. (2000). *An ANZAC Dollar: Currency Union and Business Development*, Wellington: Institute of Policy Studies.

Hamilton, J. D. (1994).*Time Series Analysis*. Princeton: Princeton University Press.

Love, I., and Ziccino., L. (2006) Financial Development and Dynamic Investment Behavior: evidence from Panel VAR. *The Quarterly Review of Economics and Finance*, 46 (2006), 190-210.

Sims,. C. (1980). Macroeconomics and Reality. *Econometrica, 48*, 1-48.

Woods, D., & Coleman., A. (2012). Price, Quality, and International Agricultural Trade. *Motu Working Paper* 12-08, Motu Economic and Public Policy Research, Wellington.

8. Appendix A: Available Data Series

The rate at which the housing stock expands is a key indicator of a regions growth and appeal, however there does not exist an official sub-national series of the dwelling stock at a quarterly interval. To approximate the level increases we recognise that the housing stock can only increase through the building of a new dwelling, which requires obtaining a building consents in accordance with the Building Act 2004. Thus we draw upon the quarterly series of the number of all residential building consents issued by each TLA for each quarter. However, we require a normalisation of the level increases. The most reliable series of sub-national dwelling counts occurs every 5 years, through the Census. Thus at each censal point in time the sub-national housing stock is obtained from the Censal final count of occupied private dwellings. The two series together are combined to derive a quarterly series of the housing stock at a TLA level, explained in Section 9.1.

To consider the effect of commodity price shocks, we need a commodity price series. We draw upon the easily obtainable ANZ Commodity Price Index, which includes an aggregate index, as well as indices for each broad component categories; Meat, skins and wool, Dairy, Horticultural products, forestry products, seafood, and aluminium. Further, the aggregate series are expressed both in New Zealand and US dollars, whilst the component series are expressed as a New Zealand dollar series and the international component series is calculated from prices in 5 different currencies, reflecting different markets centrality. The ratio of world to domestic price series reflects relative prices, thus we can derive a commodity production focused exchange rate at the national level, as well as one tat is sub-nationally specific. How the component series are combined to form a regional commodity price index or exchange rate is discussed in Sections 9.2 and 9.3 respectively.

Quotable Value New Zealand, (QVNZ) holds a large about of property related data. QVNZ adjusts raw residential property sales prices at the TLA level to compile a quality-adjusted price index across all residential properties for each TLA; this series will comprise the second key indicator of a community's desirability or wealth changes. However they also hold the sales price for farms disaggregated across TLAs with a category related to primary farm activity, as well as the total land value in a TLA attributed to a wide range of activities. Given farm sales are not common, especially at a sub-national level, we use the national average sale price per hectare, to control for the effect of changing lot sizes on the sales price, for each ANZ Commodity Price Index component category. The activity specific land value data is used as a proportion, relative to total TLA land value, to derive weights that explain the intensity to which a community is attached to different commodity markets. These weights allow us to construct a regionally specific weighted sum of commodity specific farm prices, exchange rates and commodity prices.

The above discussion relates to all series used directly or indirectly in this paper, however a further key indicator of rural outcomes is their population expansion/ contraction rate, and yet there was no discussion of sub-national population above. Unfortunately, an official series of sub-national population is unavailable between censal observations. However, as is highlighted in Figure 17, which shows over the period 1991Q1-2006Q1 the number of residential building consents issued is highly correlated with long-run population change at the sub-national level. Thus, we can interpret medium to long term changes in building activity as indicative of the long-run population change.

9. Appendix B: Data Derivation

This section details the derivation of the series used in the analysis of this paper for the series that are generated by the authors.

9.1. Sub-national Dwelling Stock

The level of housing consents issued in a quarter is an unsatisfying measure of local expansion. Rather one will require a normalisation to understand the rate of expansion, a compare rates across communities. As with population, no official sub-national series of dwellings is currently available between censal observations, thus we shall estimate one.

The dwelling stock can change between quarters for two reasons; (1) previously existing stock is no longer available, perhaps through complete depreciation or destruction the dwelling becomes uninhabitable, or conversion to a commercial property, or (2) new stock is constructed, which will be some proportion of outstanding issued consents. Assuming there exists a lag of two quarters between the issuing a building consents and habitation of a new dwelling, following convention (cite?), and for tractability ignoring issued consents from all other periods, we have the following theoretical identity of the housing stock,

$$H_{it} = (1 - \delta_{it})H_{i,t-1} + \theta_{it}HC_{i,t-2}$$

where H_{it} is the level of eth housing stock in TLA i at period t, δ_{it} is the proportion of the previous quarters housing stock that is no longer inhabitable, θ_{it} is the proportion of $HC_{i,t-2}$ is the number of residential building consents issied in TLA i in period $t-2$, and θ_{it} is the fraction of such consents that are successfully converted to housing stock in period t.

Two restrictions will be required to estimate this relationship. Firstly, one cannot estimate both a time-area varying destruction and consent conversion rate, thus we will treat one as a constant. Whilst there does exist reasons to allow both to vary, we choose to freely estimate the conversion rate. Secondly, given we only observe the dwelling stock at censal points it is necessary to treat the consent-to-dwelling conversion rate as constant for a TLA for the 20 quarters between such observations. Then, given the restrictions, through recursive substitution we obtain the following system of equations,

$$H_{it} = (1 - \delta)^{20}H_{i,t-20} + \theta_{it}\sum_{s=0}^{19}\delta^{20-s}HC_{i,t-22+s}$$

where $t \in \{1996Q1, 2001Q1, 2006Q1\}$.

The results obtained from non-linear least squares estimation of the above equation are reported in Table 5 as the depreciation rate over a censal period (20 quarters) and the average conversion rate for a censal period and a given urban/quasi-rural/rural classification, as defined in Section 6. Whilst the majority of conversion rates exceed 1, thus preventing us describing them as truly conversion rates, this will not of concern. Rather we have developed a series that is consistent with the only observed data we hold, and importantly for an empirical study of dynamics, we obtain sensible dynamics through use of quarterly consents data.

9.2. Region Specific Commodity Price Index

We recognise that a bundle of prices pertaining to those important to each community will vary spatially. The Waikato Regional Council is consists of, amongst others, Hamilton City, South Waikato District, and Matamata-Piako District. The primary activity in each community within the same regional council highlights the spatial differences; Hamilton City is a largely urban area, whilst South-Waikato has a large degree of dairy farms, whilst Matamata–Piako has a large degree of sheep-beef farms. Then to consider the effect of commodity prices on communities we need to scale the impact of prices for activities that are important to each community. An obvious way to weight each commodity series is through the proportion of land value attributed to that activity, which internalises the profitability of each activity through land prices. Thus we define the community-specific commodity price index as the weighted sum of world commodity prices, with the remainder of land value being attributed to more general activities thus this proportion weights the domestic Consumer Price Index (CPI), which is all deflated by the CPI to consider purchasing power. Then the commodity price for a community i, which can be either New Zealand or a TLA, in period t is given by:

$$PCom_{it} = \sum_{j \in ANZ} \left(\frac{LV_{ijt}}{LV_{it}} . \frac{ANZ_{jt}^{W}}{CPI_t} \right) + \left(1 - \sum_{j \in ANZ} \frac{LV_{ijt}}{LV_{it}} \right) \left(. \frac{CPI_t}{CPI_t} \right)$$

where j is an index for the ANZ component series, LV_{ijt} is the land value attributed to activity j in community i, period t, LV_{it} denotes the total land value of TLA i in period t, ANZ_{jt}^{W} denotes the index of the j^{th} component of the ANZ World commodity price series, and CPI_t denotes the national Consumer Price Index in period t. Note that the derivation is identical for both national and sub-national communities, we simply use different weights.

9.3. Region Specific Exchange Rate

As with the commodity price, the relative prices that are important to a community vary significantly across boundaries. Thus we construct a series of weighted relative prices in an analogous fashion to that seen in the previous sub-section. However, there as this is a commodity price induced paper, we need to carefully consider what relative prices are relevant to non-commodity activities. One option would be to use the NZD/USD exchange rate however as we saw in Figure 1, the ration of the World to NZ aggregate Commodity Price Indices closely follows that exchange. Thus we use only the relative commodity prices, and restrict the commodity weights to add up to one. Then the derived exchange rate for a community i, again this can be either the national aggregate or a TLA, in period t is:

$$XE_{it} = \sum_{j \in ANZ} \left(\frac{LV_{ijt}}{\sum_{j \in ANZ} LV_{ijt}} . \frac{ANZ_{jt}^{W}}{ANZ_{jt}^{NZ}} \right)$$

where the variable definitions are as above, and ANZ_{jt}^{NZ} is the j^{th} component of the ANZ New Zealand dollar denominated Commodity Price Index.

9.4. Region Specific Farm Price

Given there are only a small number of farm sales per quarter across New Zealand it is infeasible to use region-specific data when constructing that regions farm price series. In fact, there still exists a degree of noise in the national series and some cleaning of the data could be beneficial. Instead, we take all farm sales in a quarter from across the country, and for each commodity category featured in the ANZ commodity price index we take the average sales price per hectare. Then a regions inferred farm price per hectare is simply the weighted sum of the category's average sales price per hectares, where the weights across commodity categories must sum up to one. Then the farm price in community i, period t, is given by:

$$PF_{it} = \sum_{j \in ANZ} \left(\frac{LV_{ijt}}{\sum_{j \in ANZ} LV_{ijt}} . \frac{FSP_{jt}}{FS_{jt}} \right)$$

where the definitions are as above, and FSP_{jt} is the sum of farm sales prices across the country for activity j in period t, FS_{jt} is the sum of land size in hectares across all farms sold in category j, period t.

Table 1: Data Series Used

Series	Notation	Source
Sub-national New Residential Building Consents	HC_{it}	Statistics New Zealand
Sub-national Housing Stock	H_{it}	Derived
National World Commodity Price Index	$PCom_t$	ANZ Commodity Price Index
Sub-national World Commodity Price Index	$PCom_{it}$	Derived
Commodity Price Index Implied Exchange Rate	XE_{it}	ANZ Commodity Price Index
Sub-national House Sales Price Index	PH_{it}	QVNZ
National Farm Sales Price per Hectare	PF_t	QVNZ
Sub-national Farm Price per Hectare	PF_t	Derived
Sub-national Land Values	LV_{it}	QVNZ

Table 2: National Series Stationarity Test Results

Series	Levels	Changes
$\ln PCom_t$	0.882	0.000*
$\ln XE_t$	0.39	0.000*
HC_{it}/H_{it}	0.144	0.000*
$\ln PH_t$	0.818	0.024*

Table 3: Sub-National Series Unit Root Test Results (p-values)

Series	LLC	P(LLC)	IPS	P(IPS)
$\ln\widetilde{PCom}_{it}$	-33.4261	(0.0000)	-33.5647	(0.0000)
$\widetilde{\ln XE}_{it}$	-59.3646	(0.0000)	-58.3633	(0.0000)
$\widetilde{HC_{it}/H_{it}}$	-95.8176	(0.0000)	-97.06	(0.0000)
$\widetilde{\ln PH}_{it}$	-77.1981	(0.0000)	-78.3104	(0.0000)

Table 4: New Zealand Territorial Local Authorities (TLAs), their average land value proportion attributed to commodities, and corresponding sub-sample classifications.

Sub-sample	TLA Name	Land Value Proportion in Commodities	TLA Name	Land Value Proportion in Commodities
Urban	North Shore City	0.0012	Wellington City	0.0015
	Lower Hutt City	0.0017	Auckland City	0.0018
	Christchurch City	0.0106	Tauranga District	0.0114
	Upper Hutt City	0.0117	Nelson City	0.0155
	Porirua City	0.0167	Hamilton City	0.0169
	Waitakere City	0.0221	Palmerston North City	0.0383
	Manukau City	0.0463	Napier City	0.0491
	Kawerau District	0.056	Kapiti Coast District	0.0569
	Invercargill City	0.0579	Papakura District	0.0633
	Thames-Coromandel District	0.0755	Dunedin City	0.0766
	Queenstown-Lakes District	0.0769	Rodney District	0.1341
	New Zealand	0.1593		
Quasi-Rural	Taupo District	0.2045	Whangarei District	0.2088
	Rotorua District	0.2265	Tasman District	0.2428
	Marlborough District	0.2509	Wanganui District	0.2871
	New Plymouth District	0.2889	Grey District	0.2929
	Buller District	0.2942	Kaikoura District	0.2947
	Timaru District	0.3421	Far North District	0.3444
	Masterton District	0.3846	Westland District	0.3864
	Hastings District	0.4014	Western Bay of Plenty District	0.405
	Central Otago District	0.4051	Franklin District	0.4071
	Gisborne District	0.4337	Waimakariri District	0.4348
	Horowhenua District	0.4397		
Rural	Opotiki District	0.4434	Whakatane District	0.472
	Mackenzie District	0.4759	Selwyn District	0.4815
	Waipa District	0.5446	Wairoa District	0.546
	Waitaki District	0.5581	Kaipara District	0.559
	Waikato District	0.5613	Ruapehu District	0.6116

Hurunui District	0.6201	Ashburton District	0.6249
Hauraki District	0.6259	South Wairarapa District	0.6302
Manawatu District	0.6516	Gore District	0.6578
Carterton District	0.6594	Central Hawke's Bay District	0.7027
Waitomo District	0.7049	Matamata-Piako District	0.7116
Southland District	0.718	Clutha District	0.7378
Stratford District	0.7758	South Waikato District	0.783
Rangitikei District	0.7893	Otorohonga District	0.8007
Tararua District	0.801	South Taranaki District	0.832
Waimate District	0.8454		

Table 5: Dwelling Stock Estimation Results

	Urban	Quasi-Rural	Rural
δ	0.006	0.006	0.006
$\overline{\theta_{1996Q1}}$	0.883	1.160	1.000
$\overline{\theta_{2001Q1}}$	1.081	1.085	0.852
$\overline{\theta_{2006Q1}}$	1.293	1.198	1.074

Figure 1: Alternative Exchange Rates over Time

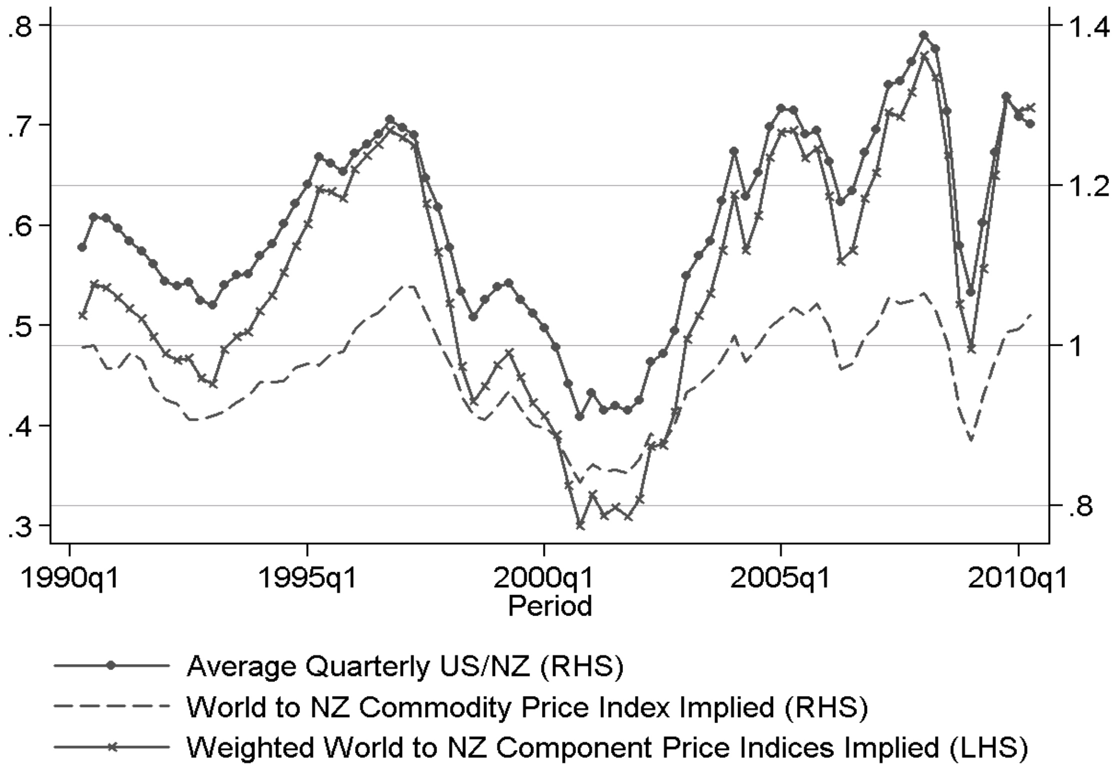

Figure 2: National Commodity Price Index and Preferred Exchange Rate over Time

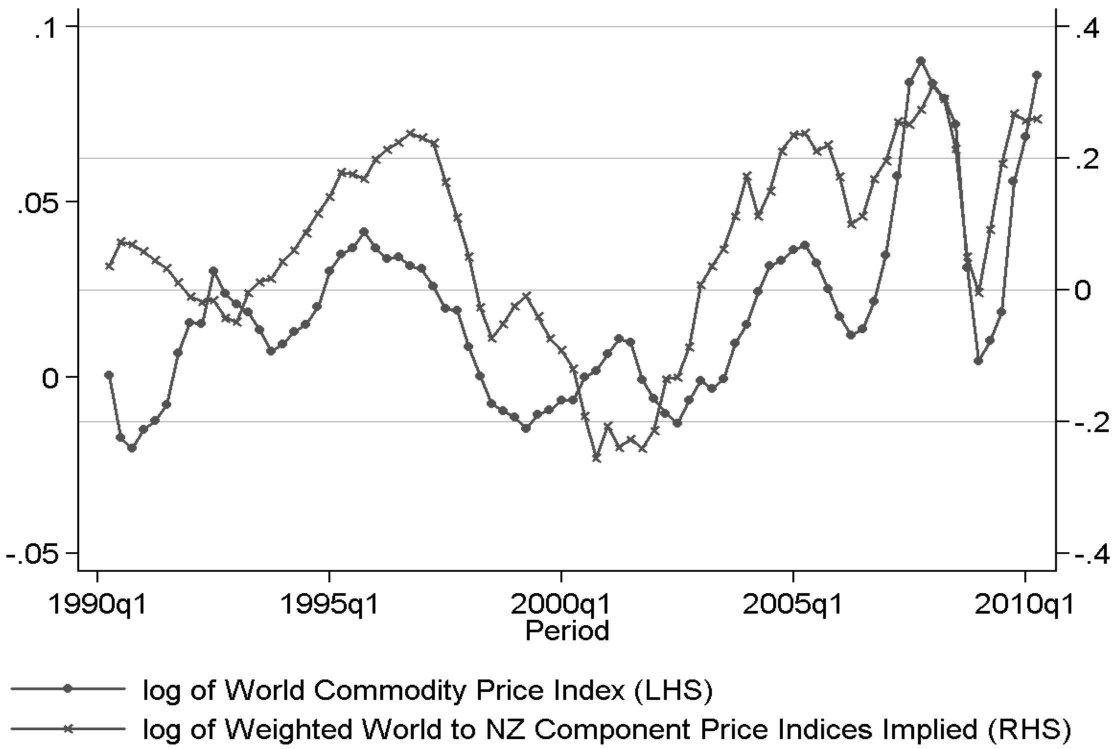

Figure 3: National Commodity Price, Exchange Rate and Housing Investment Rate over Time

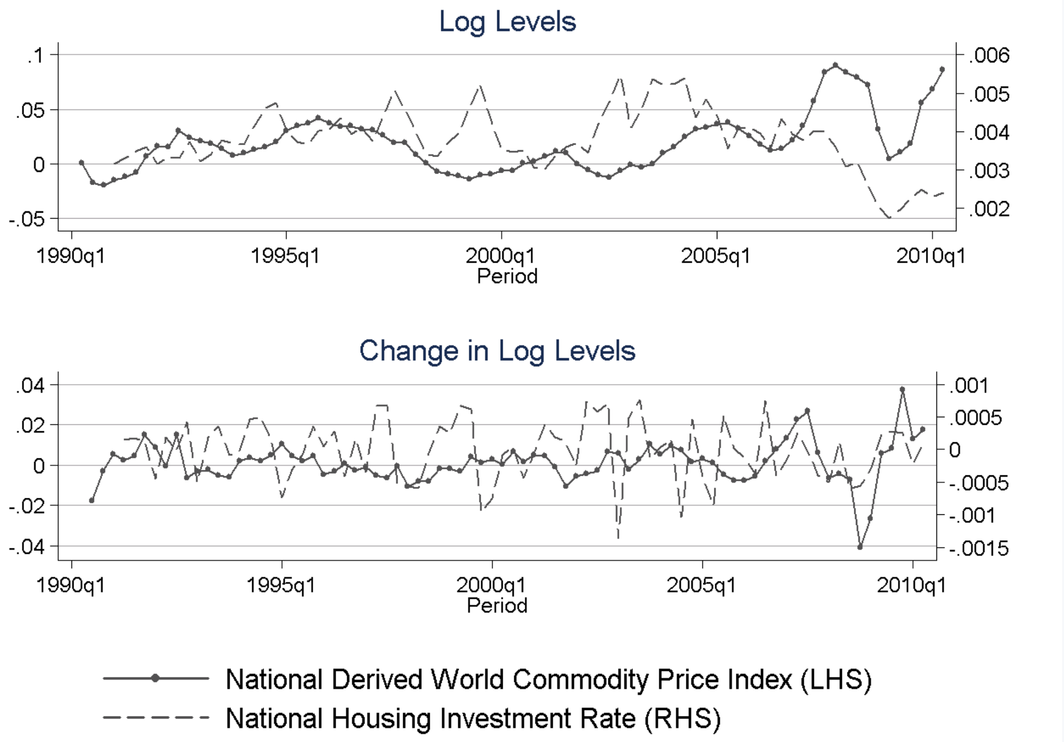

Figure 4: National Commodity Price, Exchange Rate and House Price Index over Time

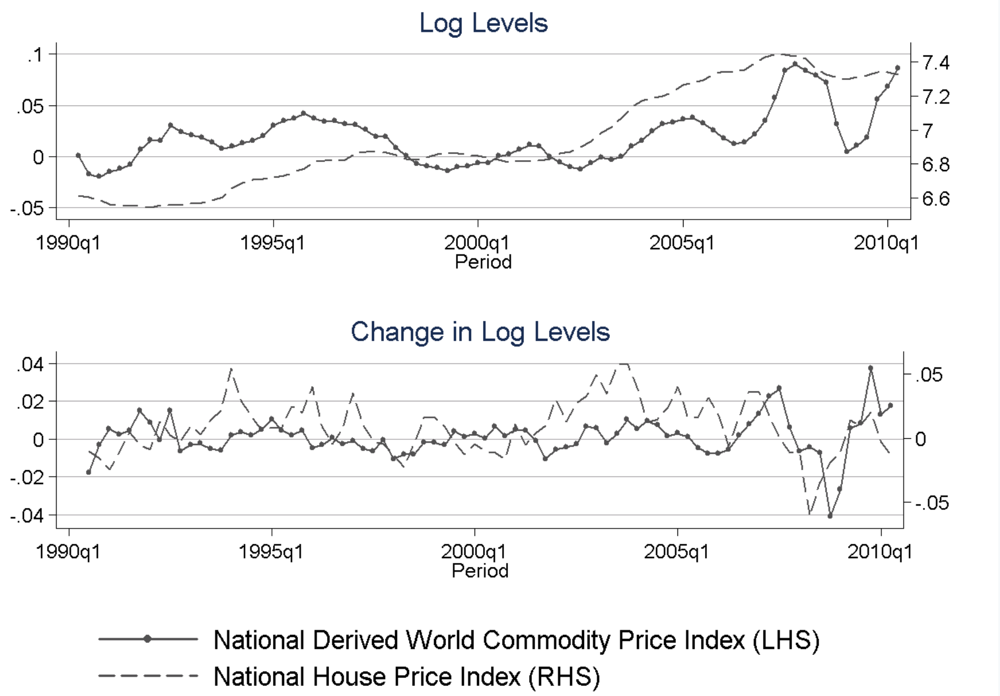

Figure 5: National Commodity Price, Exchange Rate and Farm Price per Hectare over Time

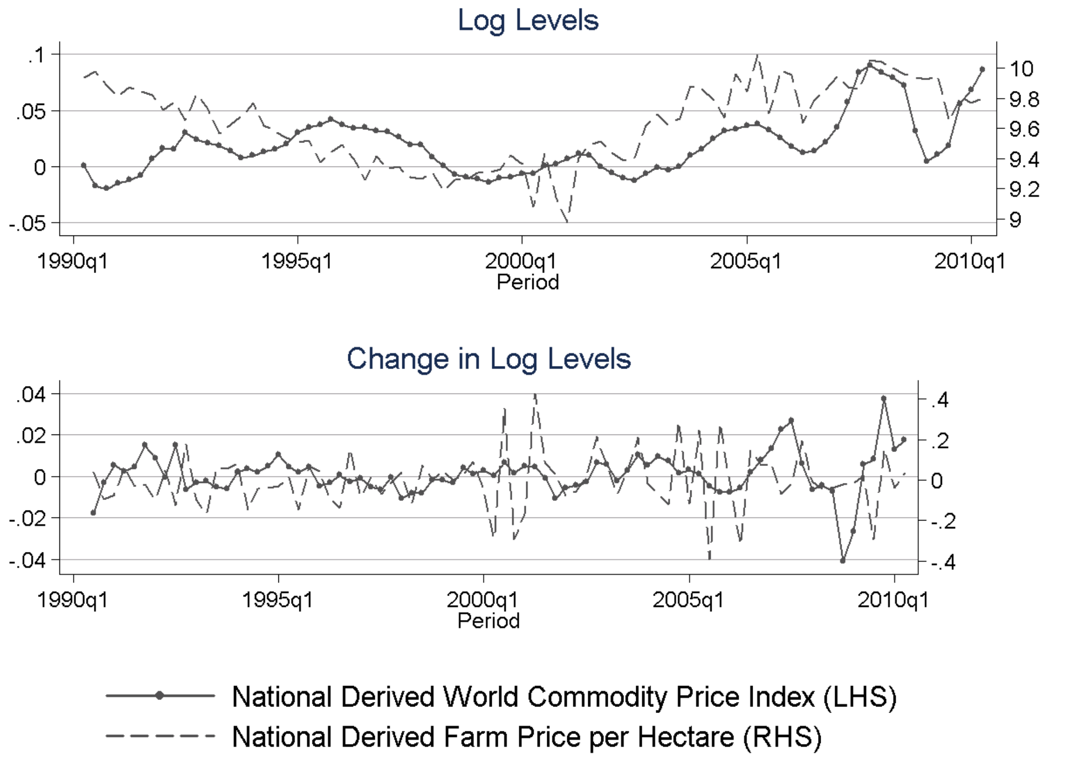

Figure 6: Result of a shock to the change in log commodity prices, on the change in national housing investment

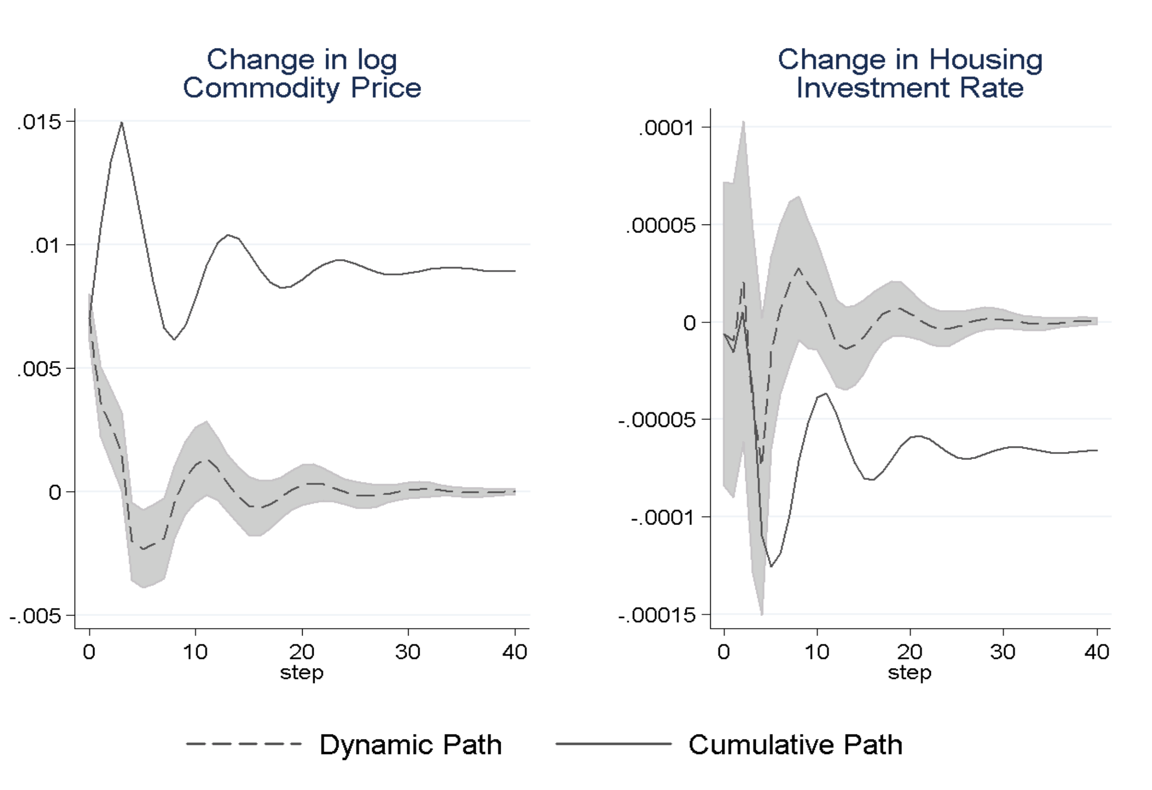

Figure 7: Result of a shock to the change in log commodity prices, on the change in the log national house price index

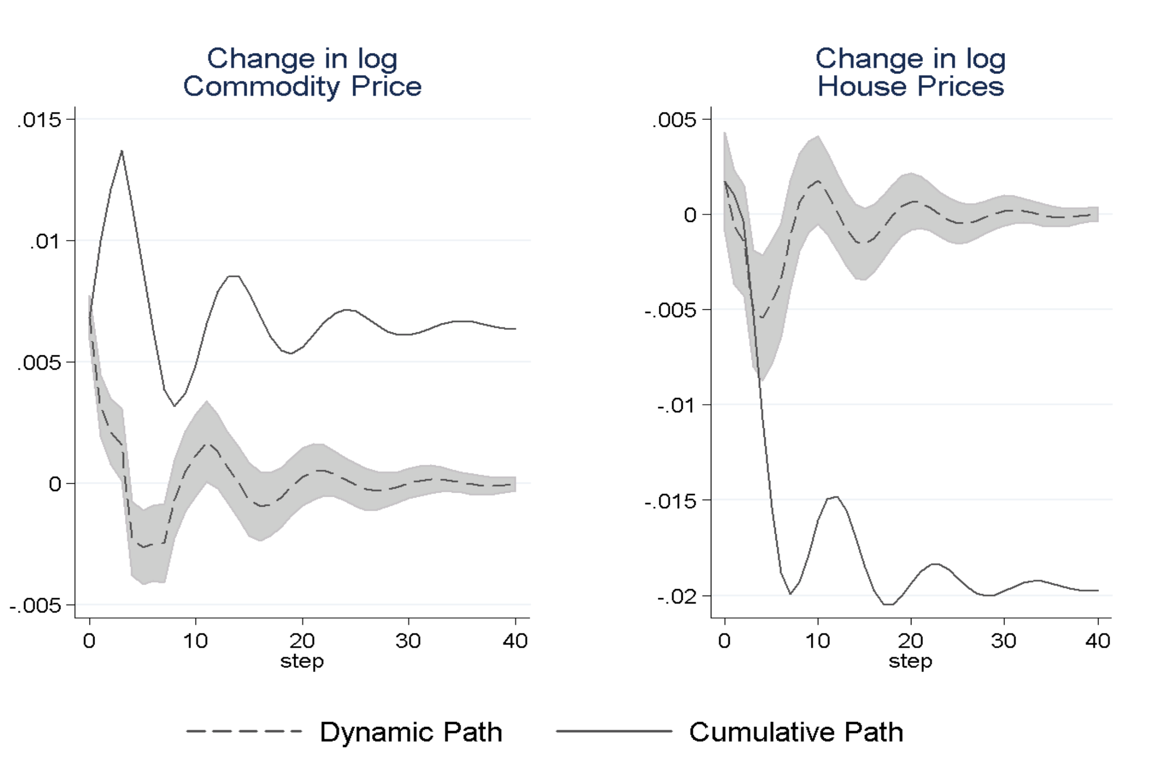

Figure 8: Result of a shock to the change in log Commodity Prices, on the change in log Farm Price

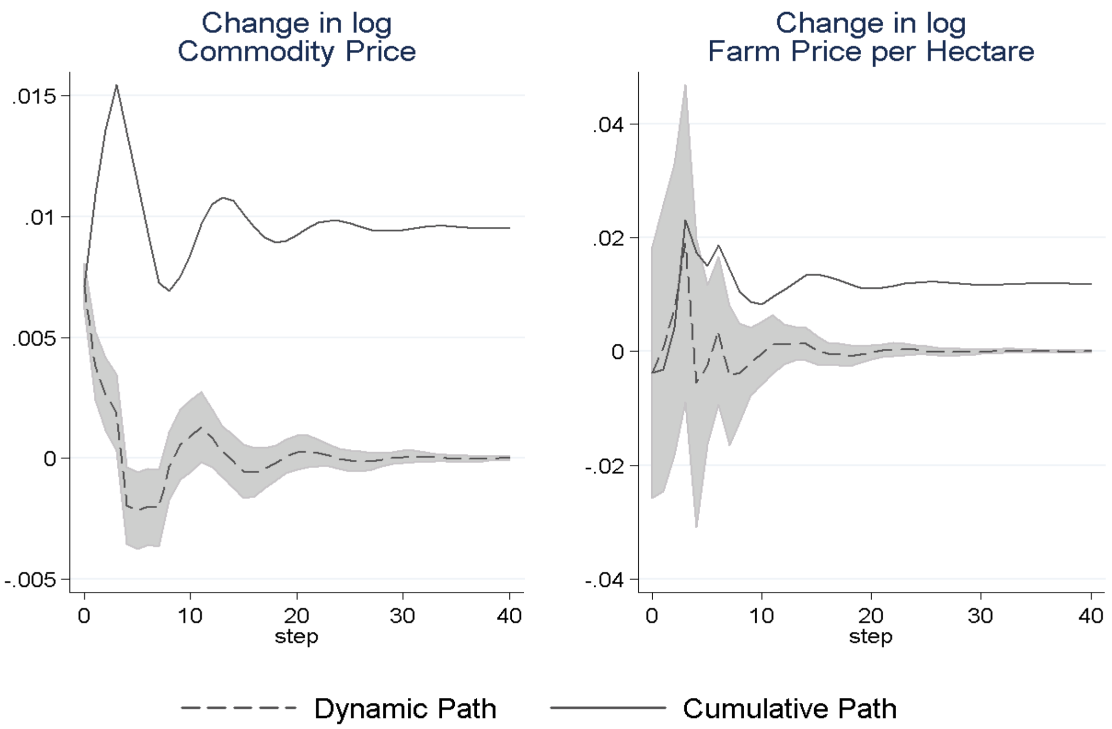

Figure 9: Result of a shock to the change in log Commodity Prices, on the housing investment rate

All TLA's, 4 lags

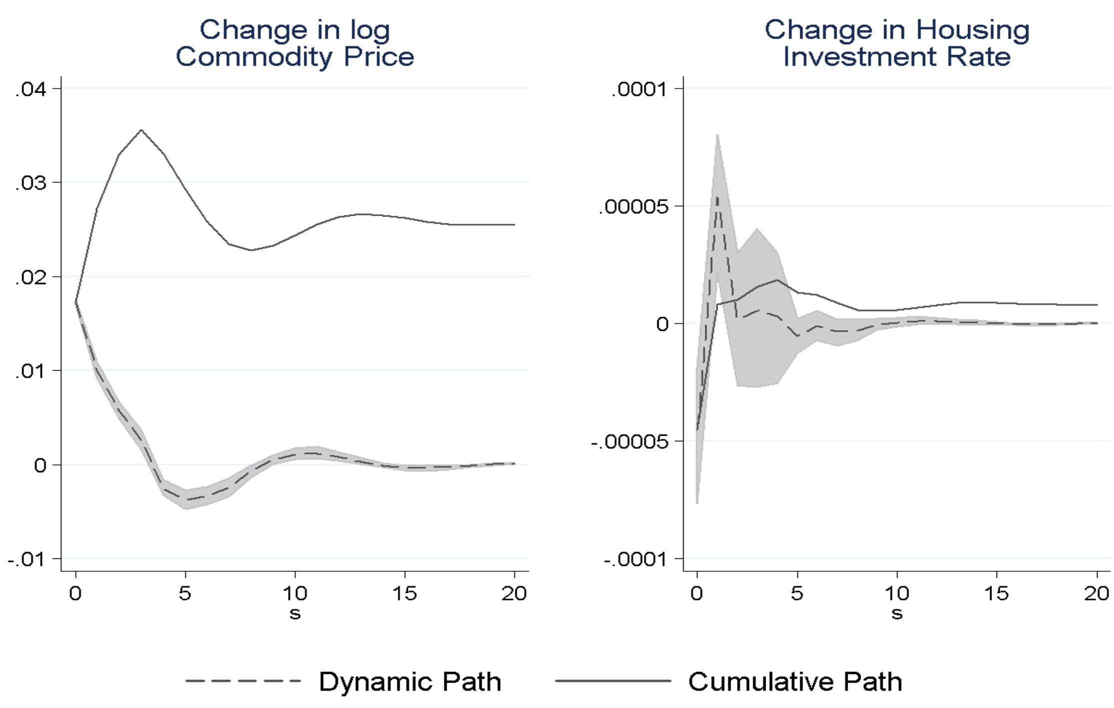

Figure 10: Result of a shock to the change in log Commodity Prices, on the change in Housing Investment.

Rural TLA's, 4 lags

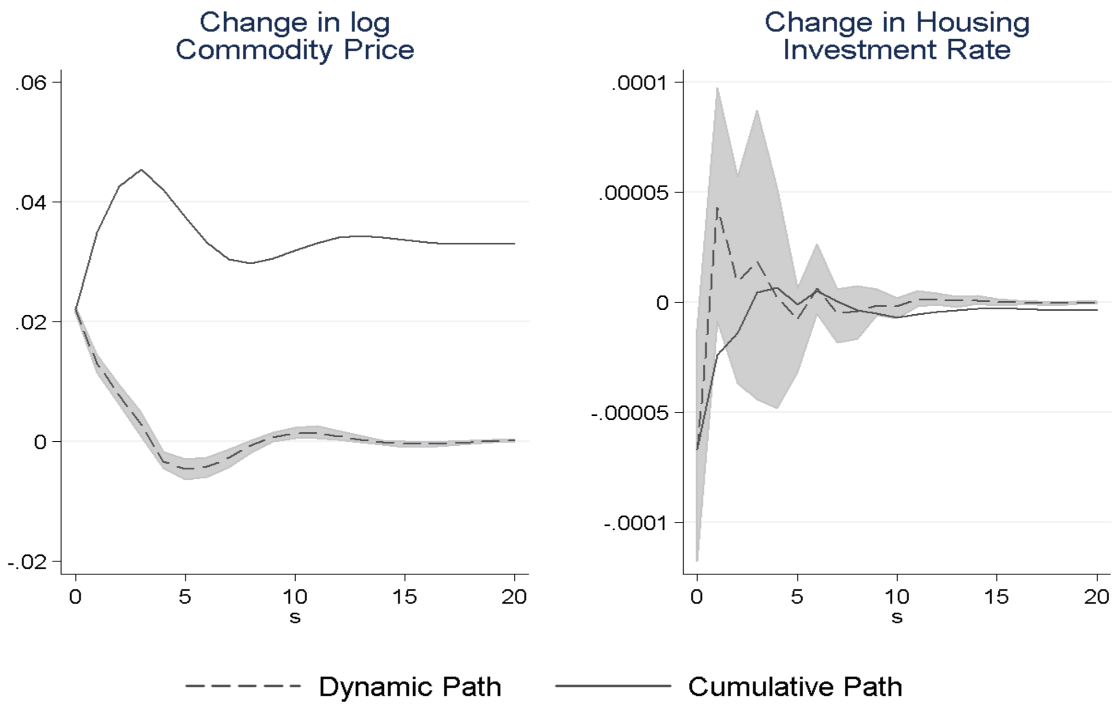

Figure 11: Result of a shock to the change in log Commodity Prices, on the change in Housing Investment.

Quasi-Rural TLA's, 4 lags

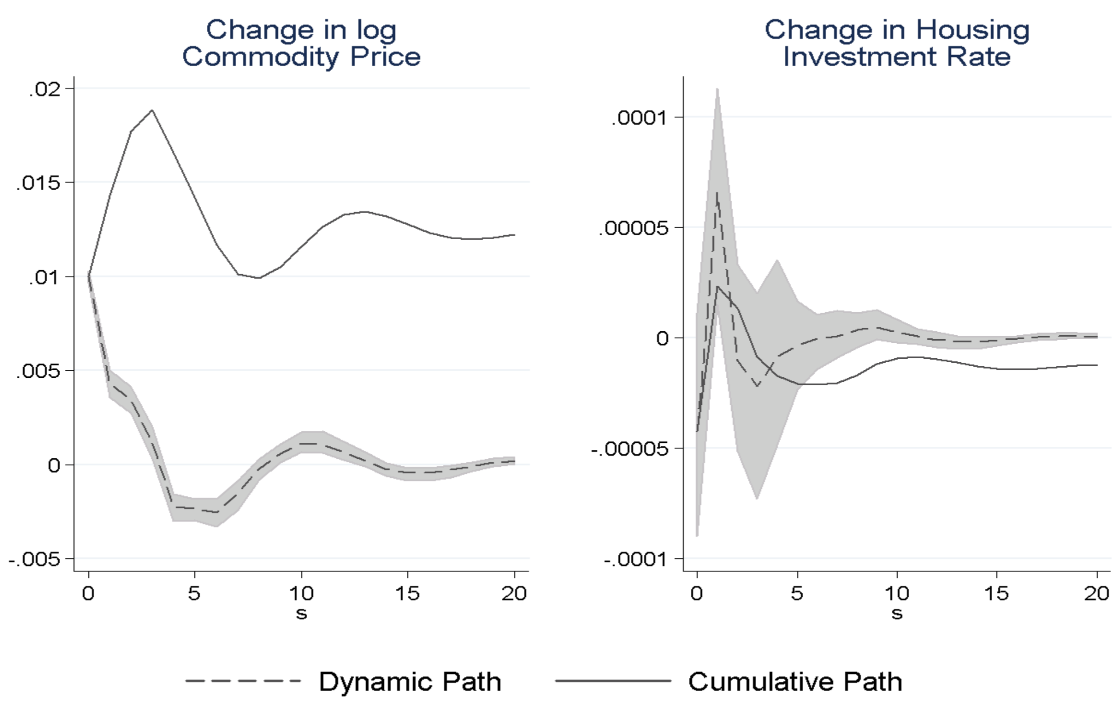

Figure 12: Result of a shock to the change in log Commodity Prices, on the change in Housing Investment.

Urban TLA's, 4 lags

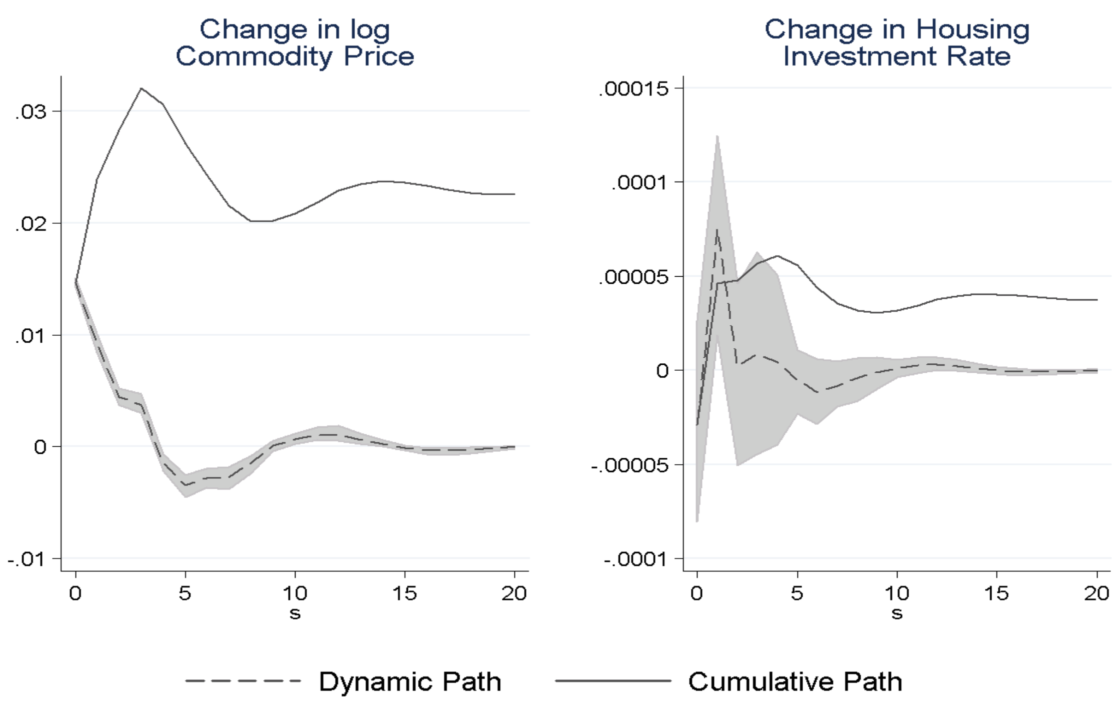

Figure 13: Result of a shock to the change in log Commodity Prices, on the change in House Prices.

All TLA's, 4 lags

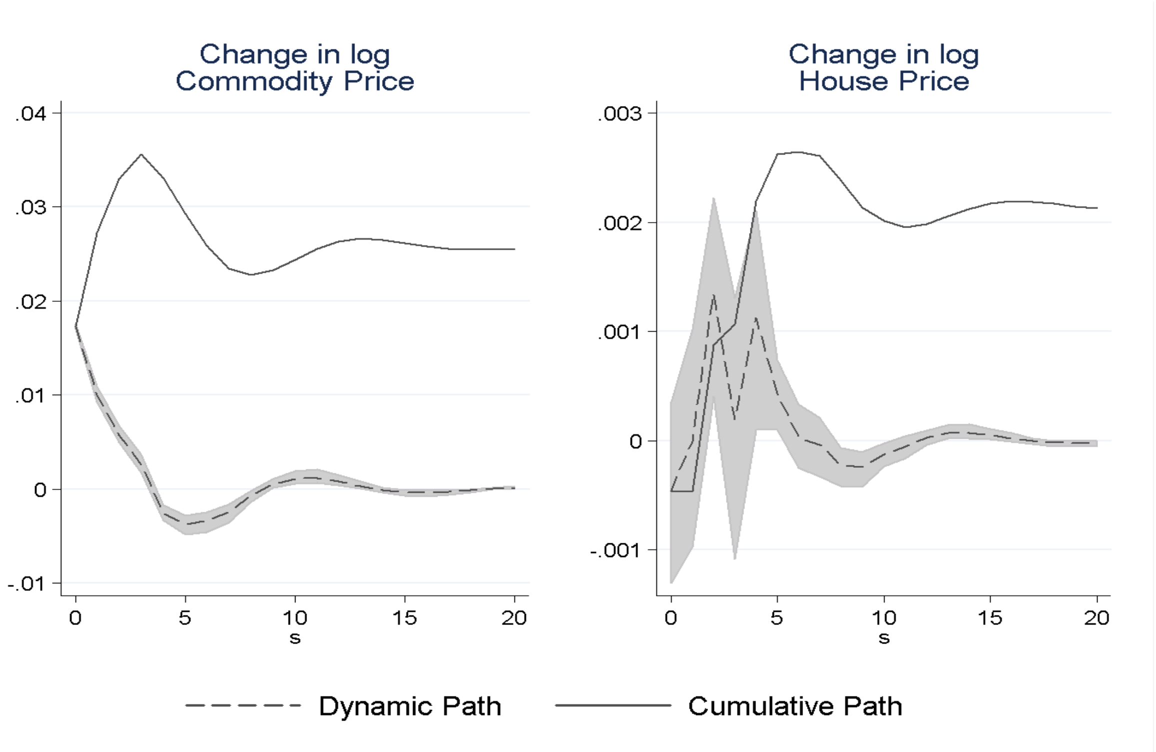

Figure 14: Result of a shock to the change in log Commodity Prices, on the change in House Prices.

Rural TLA's, 4 lags

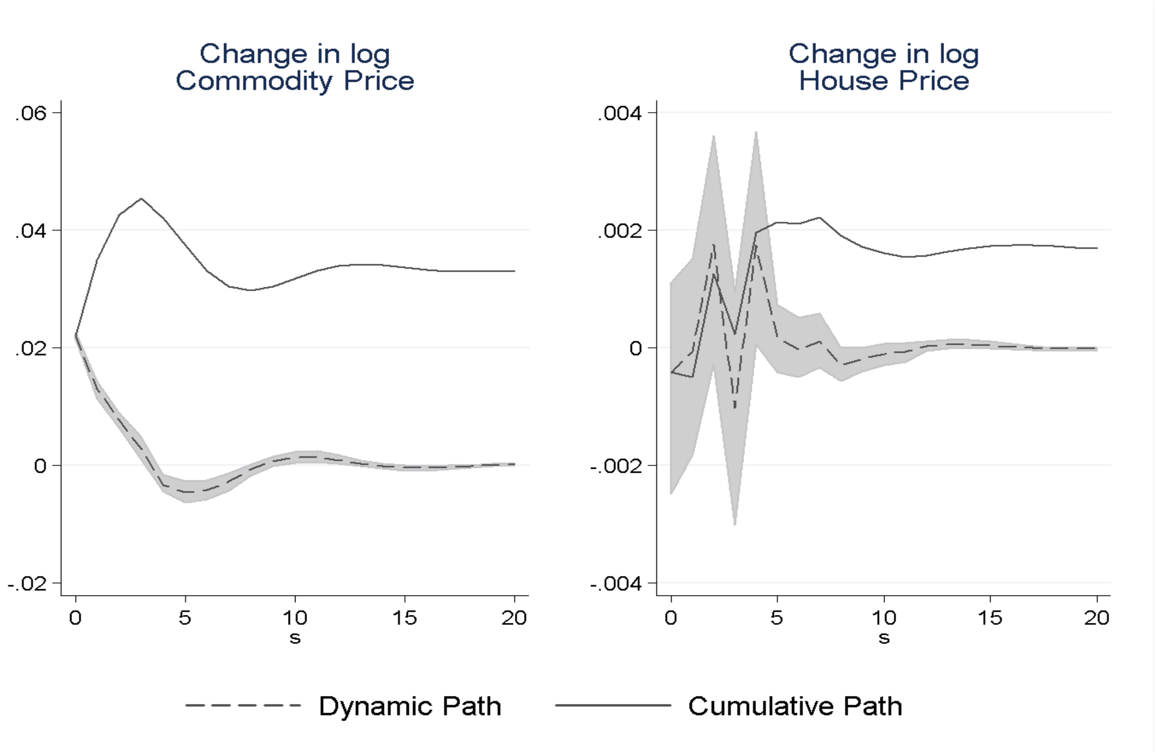

Figure 15: Result of a shock to the change in log Commodity Prices, on the change in House Prices.

Quasi-Rural TLA's, 4 lags

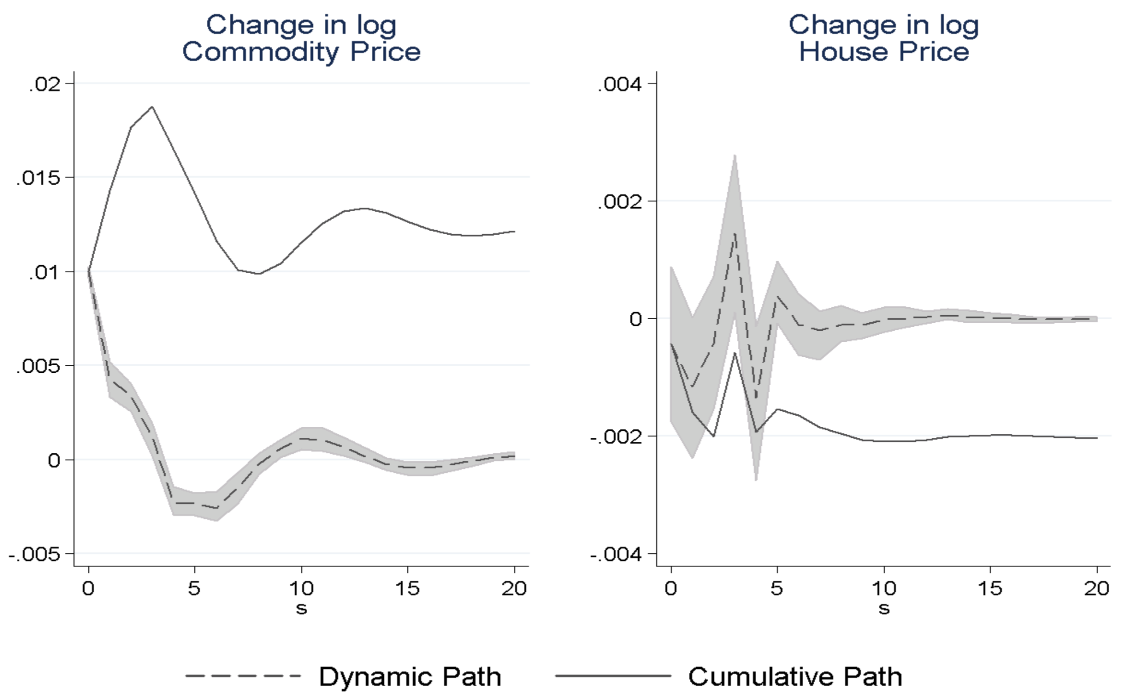

Figure 16: Result of a shock to the change in log Commodity Prices, on the change in House Prices.

Urban TLA's, 4 lags

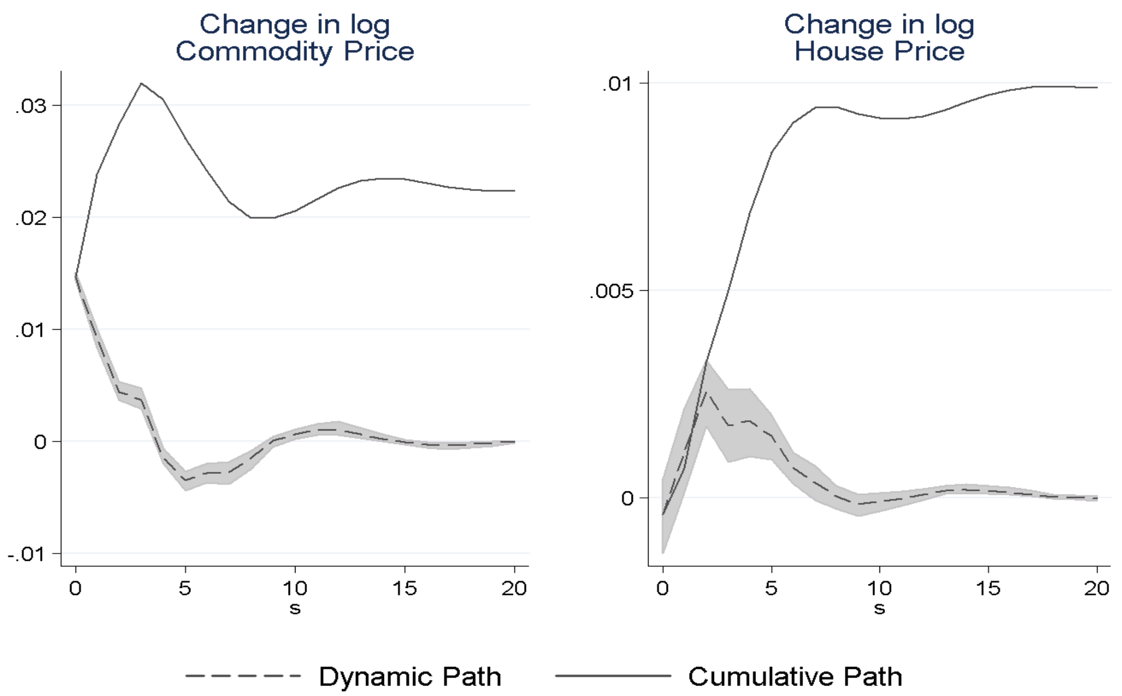

Figure 17: Housing Consents Issued vs. Population Change by TLA, 1991Q1 – 2006Q1