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Inflation and the Changing Nature of Firm Price Adjustment: Six Decades Worth of Evidence

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Abstract

The frequency with which firms change prices crucially influences inflation dynamics. Using a unique firm-level dataset spanning more than six decades, this paper examines how firm price-setting behaviour has evolved across episodes of high inflation, including the recent COVID-19 inflation episode. Time-series analysis and probit modelling reveal that pricing behaviour has changed markedly since the high inflation episodes of the 1970s and 1980s. In the aggregate, the proportion of firms changing prices has become more highly correlated with inflation. At a firm level, the probability of price increases, conditional on inflation and cost increases, has risen. At the same time, the probability of price decreases when costs fall has fallen, making price adjustment increasingly asymmetric. This asymmetry is particularly pronounced among service-sector firms and at higher inflation levels. Reasons for these changes are evaluated including technological and societal changes, as well as the changing industrial structure of firms. Collectively, the findings imply that the Phillips Curve has become more nonlinear at higher levels of inflation and that the inflation accelerator operates more strongly than in the past.

Key words

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Inflation and price asymmetry

micro firm data

probit modelling

JEL Classification

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1. Introduction

Episodes of high inflation in the 1970s and 1980s generated a wave of theoretical and empirical research on price flexibility, with particular focus on the frequency and determinants of price adjustment. This research found the likelihood firms change prices increases with inflation, and high inflation can induce asymmetries in firms' pricing responses whereby firms are more likely to raise than lower prices when costs and demand conditions change. The recent return of high inflation, after decades of low and stable inflation in many advanced economies, has renewed interest in this topic. Understanding how general inflation influences the propensity of firms to adjust prices is a crucial micro-foundation for models that feature an inflation accelerator and a non-linear Phillips Curve. More broadly, studying the relationship between inflation and firms' price-setting behaviour is central to the optimal design of monetary policy.

Studies of the COVID inflation period find the frequency of price changes was higher than during the immediately preceding period of low inflation. However, little is known about how pricing behaviour during the recent high-inflation episode compares with earlier periods of elevated inflation in the 1970s and 1980s. Whether pricing behaviour was different during the recent COVID era inflation compared to earlier bouts of high inflation is the more relevant comparison given earlier evidence that pricing behaviour varies systematically with the level of inflation. In view of the potential influence of new technology, societal changes, and changes in institutional settings for monetary policy, this is an important omission from the literature.

This paper addresses this gap using a unique, consistently collected firm-level dataset covering more than six decades of New Zealand firms. The length and consistency of the dataset make it possible to compare firm price setting behaviour in the COVID-19 high-inflation episode with earlier high inflation episodes, something that is not feasible for most other countries. Further, the results generated in this paper will be applicable to many countries because New Zealand's inflation experience over the past six decades and during the COVID inflation episode, has been like that of many advanced economies around the world.

This paper contributes several important new empirical results on firm price change behaviour. One key finding is that firms' propensity to adjust prices has become increasingly sensitive to inflation over time. The frequency of price changes was much higher during the COVID inflation episode than during similar inflation episodes in the 1980s. Further, the probability that firms increase prices in response to cost and demand changes, conditional on inflation, has increased. The results, therefore, suggest the Phillips Curve has become more nonlinear at higher levels of inflation and the "inflation accelerator" operates more strongly than in the past.

Another important contribution of this paper is to document that the asymmetry in the response of price changes to cost and demand conditions has become more acute: price increases are now more likely, but price decreases less likely, when demand and cost conditions warrant adjustment. This shift is especially pronounced among firms in the service sector and at higher levels of inflation. A plausible explanation is a decline in the responsiveness of demand to price changes, making price increases more revenue-enhancing than price reductions. We attribute this reduced demand responsiveness, in part, to greater consumer inattention, reflecting higher labour force participation and, consequently, more time-constrained consumers. We also find that price adjustments have become smaller in magnitude but more frequent. Smaller, more frequent, price changes are not only more likely to escape the notice of increasingly time-constrained and inattentive consumers but are also more viable from a firm's point of view as technological advances have lowered menu costs and the costs of price review. The paper also contributes to a diverse literature using business surveys to understand business conditions and the impact of economic conditions on firm behaviour.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature. Section 3 describes the six decades of firm data used in this study. Section 4 assesses the relationship between inflation and the proportion of firms changing prices over the past six decades using time-series analysis. Estimates of the annual frequency (number) and magnitude of price changes are also generated and the metrics of pricing behaviour are compared across nine different inflation episodes, including the high inflation of the 1970s and 1980s and the COVID era. Section 5 introduces an ordered probit model to estimate conditional probabilities of price adjustment. This model is used to assess how firms' price responses to inflation and to firm idiosyncratic cost and demand conditions have changed, including during the COVID-era inflation. Reasons for the observed changes in firm pricing behaviour are discussed and econometrically evaluated in Sections 6 and 7. Concluding remarks are in Section 8.

2. Review of related literature

State-dependent pricing models have been shown to provide a suitable basis for explaining why the frequency of price change co-varies with inflation and how this can affect the pass-through of cost or demand changes to prices and inflation. The development of these models goes back to Mankiw (1985) and Ball and Mankiw (1994a). The models predict that in the event of small cost or demand changes shifting their desired prices, firms keep prices constant as the benefit from aligning prevailing prices to these desired prices is less than the menu cost incurred. But in the event of larger cost or demand changes causing a larger misalignment between prevailing and desired prices, firms will adjust their prices as the benefits to changing prices exceed the menu costs of price adjustment. These models imply that if the costs of price adjustment decline, the probability of a price adjustment in response to cost or demand changes increases. The models

also predict asymmetric behaviour whereby firms are less likely to adjust price downwards (than upwards) when cost and demand conditions warrant it, as inflation eventually erodes the gap between a firm's prevailing relative price and its desired (lower) relative price.

In a model of a monetary economy where firms are subject to idiosyncratic shocks as well as inflation and can only change prices by incurring a real menu cost, Golosov and Lucas (2007) show the fraction of firms that reprice in a period increases with the inflation rate. Blanco, *et al.* (2024a) develop a model of price change whereby firms sell a continuum of products and choose how many, but not which, prices to adjust in any period, subject to an adjustment cost. This choice is determined by balancing the price adjustment costs against the benefits of changing price and reducing resource misallocation within the firm. Higher inflation increases the marginal benefit of adjusting prices, thereby increasing the fraction of prices a firm changes.

These types of models can generate a feedback loop between inflation and the frequency or proportion of firms that change prices and create an "inflation accelerator" in response to shocks. This results in the slope of the Phillips curve increasing during periods of high inflation (Blanco, *et al.*, 2024a).[1] Using micro data from large panel surveys of UK and US firms, Bunn, *et al.* (2024) find that the response of firm prices to demand shocks is convex and this convexity is more pronounced when inflation is high. When incorporated in a DSGE model, this pricing behaviour generates a convex aggregate Phillips curve in response to demand shocks. These properties can have important implications for monetary policy. Karadi, *et al.* (2024) show that when there are menu costs of price adjustment causing endogenous variation in the frequency of price adjustment and a change in the slope of the Phillips curve, there is a nonlinearity in the sacrifice ratio (and the trade-off between inflation and the output gap) causing a nonlinearity of the optimal monetary policy rule. For large shocks to desired prices, the optimal monetary policy decision is to react more aggressively against inflation than in the case of small shocks or when firms use a time-dependent pricing rule. Hakamada and Walsh (2024) come to similar conclusions. Applying a calibrated New Keynesian model, they find that when agents form either rational expectations or use cognitive discounting, stronger and earlier policy responses to inflation moderate the overall losses across alternative loss functions.

A rich body of evidence using micro-data has accumulated showing the frequency of price changes varies with inflation. An early investigation by Cecchetti (1986) found higher inflation led to an increase in the frequency of changes in US newsstand prices of magazines from 1953 to 1979. Cecchetti speculated that while the evidence was for prices in only one industry, "it is extremely likely that the frequency of

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[1] Blanco, *et.al.* (2024a, p2) describe the inflation accelerator process as: "On the one hand, an increase in the fraction of price changes increases inflation, more so the higher the inflation rate to begin with. On the other hand, an increase in inflation increases the firms' incentives to adjust prices, further increasing the fraction of price changes." They show that this inflation accelerator effect is responsible for the bulk of the steepening of the Phillips curve for the USA during periods of high inflation.

adjustment for all prices in the economy increased over this period." (p271).[2] Subsequent research has corroborated this conjecture. Episodes of high inflation were a focus of several subsequent studies. Lach and Tsiddon (1992) found the monthly proportion of price changes in Israel rose from 46.5 per cent in 1978-79 when inflation was 77 per cent to 60.4 per cent in 1981-82 when inflation rose to 116 per cent. After controlling for changes in the basket of food products used in the Lach and Tsiddon study, Eden (2001) and Baharad and Eden (2004) also reported a strong co-variance between inflation and frequency of price changes during Israel's high inflation episodes during the 1980s and 1990s. Konieczny and Skrzypacz (2005) found the frequency of price changes co-varied with inflation during Poland's transition from a planned to a market economy in the early 1990s. Gagnon (2009) revealed that both the frequency and magnitude of price changes co-varied with inflation in Mexico when inflation rose from 6.8 per cent in 1994 to 41.8 per cent in 1995 and when it gradually fell to 4.9 per cent by 2002. Alvarez, *et al.* (2018) studied the frequency of price changes in Argentina during periods of low and very high inflation rates. They found that when inflation is low, the frequency and absolute size of price changes are insensitive to inflation. The frequency and average size of price changes rise with inflation, while when inflation is very high it dominates idiosyncratic shocks as an influence on price changes.

Another important question for inflation dynamics is whether there is asymmetry in the way price changes respond to positive and negative shocks to desired prices and whether this asymmetry is affected by inflation.[3] Early studies by Buckle and Carlson (1998, 2000a) revealed the importance of taking account of both price increases and price decreases and showed there were significant differences in price-setting behaviour across low- and high-inflation episodes. They showed that during high and variable inflation episodes in New Zealand in the 1970s and 1980s, firms were more likely at high rates of inflation to raise prices in response to positive cost and demand shocks, but less likely to lower prices in response to negative cost and demand shocks. Using data from large panel surveys of UK and USA firms, Bunn *et al.* (2024) find that firms are more likely to increase prices in response to positive demand shocks than to decrease prices in response to negative demand shocks, and this result is strongest in firms and industries with higher inflation. Nakamura and Steinsson (2008) found that while the frequency of USA price increases covaried strongly with inflation, the frequency of price decreases did not. Gagnon (2009) revealed that in Mexico, when inflation was low, the frequency of price increases and decreases partly offset each other. When inflation was high, fewer price decreases occurred, and the frequency of price increases rose.

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[2] Cecchetti's concluding remarks foreshadowed what is now taking place in the development of macro-economic models. He concluded "It is clear from this exercise that the frequency of price adjustment is determined endogenously in the economy. Any attempt to build a macroeconomic model of the inflationary process and macroeconomic adjustment must take account of this endogeneity" (1986, p272).

[3] Several studies found that prices can respond differently to increases in input costs than to decreases, though these studies do not evaluate whether the degree of asymmetry is systematically related to inflation. See for instance Pelzman (2000) and the references therein.

In the decades since these studies there have been many changes that may have affected price flexibility. These include advancements in information technology which both lower the costs of price changes and improve the quality and timeliness of cost and demand information for firms. There have been changes in the industrial structure of economies (*viz.* the growing importance of services), and changes to regulation of markets. Societal changes such as rising labour force participation affecting consumer attention, and certain information asymmetries difficult to overcome using information technology, also may have influenced firm pricing behaviour.

There is an emerging literature studying the frequency of price changes in recent years, including in the periods immediately prior to and during the COVID bout of high inflation. Using product level prices and drawing on the high inflation periods of the late 1970s and early 1980s, Nakamura, *et al*. (2018) found the frequency of price change was positively correlated with inflation. Based on data up to 2014, they conclude that the frequency of price change was lower in the latter part of their sample. However, this was a period of consistently low inflation which they acknowledge may have camouflaged an underlying trend change in pricing behaviour. The study by Gautier, *et al*. (2024) also examines pricing behaviour during the relatively low inflation decades prior to the COVID era. Using CPI micro data for eleven Euro countries between 2010 and 2019, they found the frequency of price changes "barely" changed with inflation and that changes in inflation were mostly caused by the size of price changes.

For the recent COVID inflation episode, Montag and Villar Vallenas (2023) found that relative to the two years preceding the pandemic, the frequency of price changes in the United States increased as inflation rose, and there were only relatively small increases in the magnitude of price changes. Bilyk, *et al*. (2024) reported similar pricing behaviour in Canada between January 1999 to January 2024. Using UK data, Blanco, *et al*. (2024b) showed that over the period 1998 to 2022, higher inflation was associated with more frequent price changes and only small changes in the magnitude of price changes. Cavallo, *et al*. (2024) reached similar conclusions using data from several European countries, the UK, and the US.

These studies reveal that during the COVID inflation period the frequency of price changes was higher relative to the recent past when inflation was much lower. But an important gap in understanding remains. Specifically, there is no evidence of how the sensitivity of the frequency of price changes during the COVID inflation period compares with earlier decades of similarly high inflation rates. This paper draws on a unique database of individual firm data and pricing decisions extending back six decades to the early 1960s to address this gap in the literature.

3. Micro firm data used to evaluate price changes by firms

There has been an upsurge in the use of information provided by surveys of firms' perceptions, expectations, decisions and activity levels. This genre of surveys is being used to understand for example, how prices respond to positive and negative demand shocks (Bunn, *et al.,* 2024), the characteristics and determinants

of firms' inventory contracts and how firms' expectations of inflation influence those contracts (Kumar and Wesselbaum, 2024), how firms form their macroeconomic expectations (Candia, *et al.*, 2023), and measuring and understanding business uncertainty (Altig, *et al.*, 2022; Ryan and Holmes, 2025).

The empirical results reported in this paper are based on individual firm pricing decisions derived from the New Zealand Institute of Economic Research's (NZIER) Quarterly Survey of Business Opinion (QSBO). This survey has collected information on New Zealand firms' decisions, the characteristics of each firm and their operating conditions, including changes in costs and demand, on a consistent basis since the early 1960s. It is one of the longest-running business surveys in the world.[4] The survey design is based on the "Konjunkturtest" or tendency survey developed by the Institute für Wirtschaftsforschung (IFO) in Munich.[5] Moreover, since the inception of the survey, the firm level data have been collected on a consistent basis using the same questions and survey method, and the firm level responses have been stored (on a confidential basis) after every survey.

The survey sample includes all New Zealand firms with more than 200 employees, and firms with less than 200 employees are sampled to mirror the size distribution of the population of New Zealand firms. Respondent firms represent the building, manufacturing, merchant, and service sectors of the economy and periodic resampling means the sample characteristics evolve with firm population characteristics.[6]

The QSBO collects qualitative data on firm experiences and expectations about various business metrics, including changes in prices, costs, and demand. The various metrics developed in this paper draw on responses to the following question (*sic*): *What has been your firms experience during the PAST THREE MONTHS?* Firms are given the option to respond: `Up', `Same', or `Down'.[7] The survey also collects information on firm characteristics, such as size and principal activity. Firms are classified into six size categories based on the number of employees (20 or less, 21–50, 51–100, 101–200, 201–500, and > 500). The dataset is not strictly a balanced panel. Firms in the services sector did not respond to the Survey until 1970Q1. Further, there are some quarters, very early in the sample period, where data are missing: 1971Q3 and 1972Q1 for service firms and 1967Q4 to 1969Q2, 1971Q3 and 1972Q1 for merchants.

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[4] Allen and O'Connor (2011).

[5] See Thiel (1992). The design and implementation of the QSBO was also inspired by surveys undertaken by the Confederation of Business Industries and the European Economic Commission (Gillion, 1964). Early research applying firm-level data created by these type of surveys is reviewed by Zimmermann (1999).

[6] Allen and O'Connor (2011, p.5) note "[t]he proportion of service firms in the survey has increased over time through resampling as they have become a larger part of the economy."

[7] The number of firm responses to the survey questions used in this study are in Table A1 in the Appendix. `Not applicable' is also an option. The firms are also asked their expectations for the future. These responses are not used in this paper.

One key metric for our analysis is the proportion of firms adjusting prices each quarter. Some studies examine the proportions of items or products whose prices are adjusted.[8] For example, the early study by Cecchetti (1986) used the prices of magazines sold at newsstands, Lach and Tsiddon (1992) utilised price quotations for 26 food products reported by a sample of stores collected by the Israel Central Bureau of Statistics to derive the CPI, Bils and Klenow (2004) used monthly prices of 350 non-shelter categories of USA goods and services collected by the BLS to construct the CPI. The study of price characteristics in USA by Nakamura and Steinsson (2008) utilised monthly product-level price data gathered by the BLS to construct the CPI and PPI. Similar types of product-level data were used in Gagnon's (2009) study of price setting behaviour in Mexico. Recent studies comparing the behaviour of prices quoted in on-line markets and in regular stores have tended to use product level prices (e.g., Gorodnichenko and Talavera, 2017; Hillen and Fedoseeva, 2021; Brown and MacKay, 2023).

In this study by moving up a level of aggregation to firm level data, there is a loss of information about the heterogeneity in pricing across different products in cases where firms sell multiple products or services.[9] On the other hand, the firm level data used in this study have the advantage that, in addition to price change information, it includes characteristics of the firm (e.g., type of industry and firm size) and information about economic conditions experienced by each firm in each quarter (e.g., changes in demand and costs). These data allow pricing decisions to be linked to economic conditions experienced by firms. Recent research suggests that idiosyncratic conditions experienced by firms are likely to be critical to understanding pricing behaviour and the frequency with which firms change prices. Nakamura and Steinsson (2008) observed that most models of price rigidity make the "simplifying assumption that price changes occur only in response to aggregate shocks" (p. 1442). They provide evidence that idiosyncratic shocks are important determinants of price changes. Gorodnichenko, *et al*. (2018) found online prices are not responsive to unanticipated aggregate economic conditions but respond promptly to idiosyncratic shocks.

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[8] Product and item level data are the most disaggregated price data. Statistics New Zealand class a 600ml soft drink as an item, the differing brands would constitute different products.

[9] However, even item or product level price data cannot identify how many times prices for an item change in a period if the data are not continuous or very high frequency.

Figure 1: Proportion of firms and CPI items that increased price per quarter
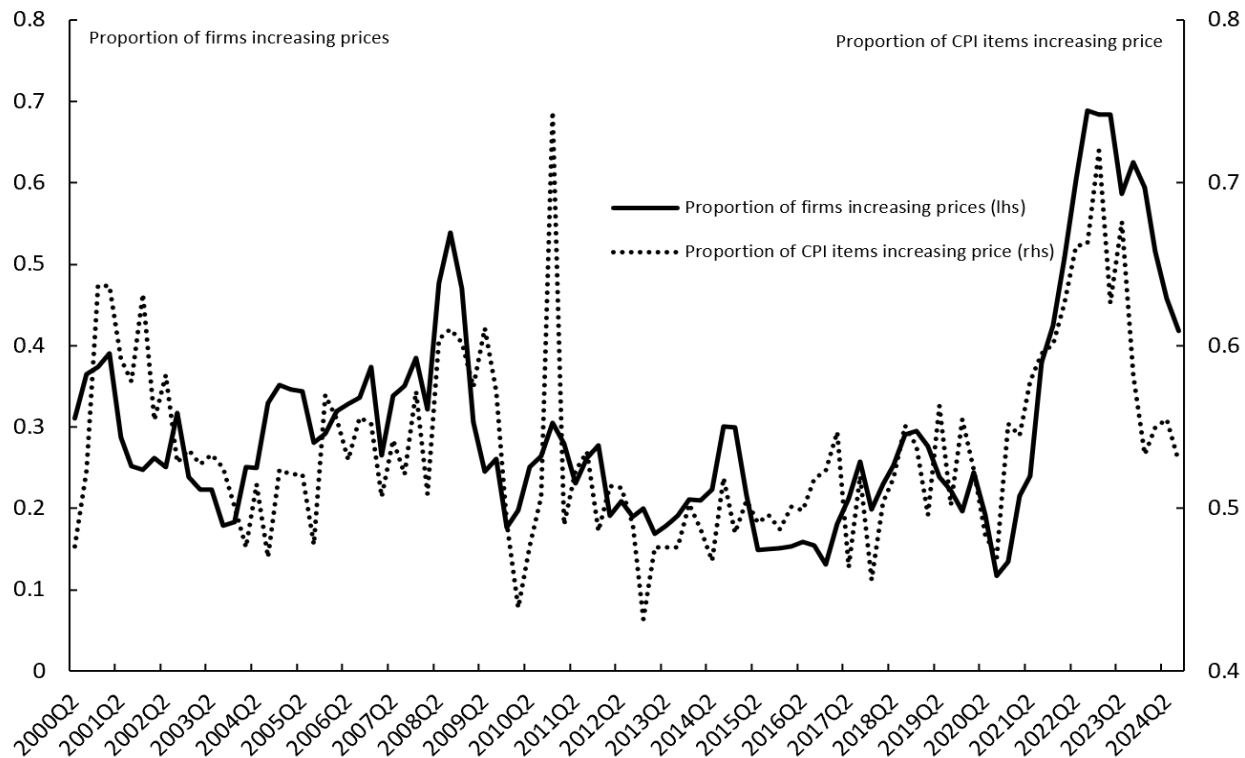
Notes: To derive the proportion of firms increasing prices we use the QSBO firm data provided by the New Zealand Institute of Economic Research. A value of 0.3 means 30% of firms surveyed in the quarter reported the direction of their prices as 'up'. The proportion of items increasing price per quarter uses data from Statistics New Zealand's Infoshare, *Consumer Price Index, Distribution of national item-level index movements from previous period*. In each quarter it takes the number of CPI items Statistics New Zealand reports as increasing in price and divides this number by the total number of items in the CPI for that quarter. So, a value of 0.3 means that 30% of items in the CPI increased in price that quarter.

Another advantage of the firm-level data used in this study is the unusually long (six decade) duration of this survey. This enables analysis of firm pricing behaviour spanning more periods and episodes of inflation than other studies, including item and product level studies. The long duration of the data used in this study contrasts with that of the publicly available metrics based on item level prices in New Zealand; these are only reported back to 2000Q2 by Statistics New Zealand. Nevertheless, as Figure 1 shows, the proportion of firms reporting price increases in the QSBO and the proportion of items in the CPI increasing in price over the period 2000Q2 to 2024Q3 move together very closely. The co-variation of the two series suggests the firm-level measures used in this paper capture key movements in item-level price changes over time. The correlation coefficient between the two series is +0.65. This increases to +0.69 when the 2010Q4

observations are excluded, the quarter when the Government increased the rate of Goods and Services Tax by 2.5 percentage points.[10]

4. Six decades of inflation and price changes by firms

The long duration of the survey data enables an analysis of the temporal behaviour of price changes by firms over six decades that span the high inflation of the 1970s and 1980s and the most recent bout of high inflation during the COVID era. Of particular interest is the comparison of the co-movement between the proportion of firms changing prices and inflation each quarter across the different inflation episodes.

4.1 Inflation and the proportion of firms changing prices

The time-series of the proportion of firms that change prices in each quarter (derived from the firm data explained in Section 3) and annual inflation since the early 1960s are shown in Figure 2. Panel (i) of Figure 2 shows all price changes (increases and decreases), Panel (ii) shows the proportion of firms that increased prices, and Panel (iii) shows the proportion of firms that decreased prices.

There are several notable features evident from Figure 2. First, there was a substantial decline in the proportion of firms changing prices in each quarter after the "Great Inflation" of the 1970s and 1980s. The proportion of firms changing prices each quarter during the last three decades was, in general, substantially lower than in the 1970s and 1980s. That is, until the recent COVID inflation era. The rise in the proportion of firms changing prices during the COVID era is particularly evident in the case of price increases shown in Panel (ii).

A second feature is the close relationship between annual inflation and the proportion of firms changing prices. This is consistent with the predictions of menu-cost based state-dependent pricing models of Ball and Mankiw (1994a), Golosov and Lucas (2007), and Blanco, *et al.* (2024a). There is a positive correlation between the proportion of firms changing prices (increases plus decreases) and inflation. This is dominated by the relationship between the proportion of firms increasing prices and inflation. The proportion of firms decreasing prices per quarter generally varies inversely with inflation.

There appears, however, to have been a shift in these relationships since the mid-1990s. This was after the introduction of inflation targeting and central bank operational independence when annual inflation fell rapidly to around 2 per cent per year, after averaging about 15 per cent in the previous decade. Thereafter, a given level of inflation has tended to be associated with a higher proportion of firms changing prices per quarter, especially a higher proportion increasing prices. Panel (iii) shows the rapid decline of inflation in

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[10] There is a spike in the item-level series in 2010Q4 and no corresponding spike in the firm-level series. In 2010Q4 the rate of Goods and Services Tax (GST, a comprehensive value-added tax), was increased from 12.5 to 15 per cent. The difference between the two series in this quarter suggests that when firms answer the question about whether they increased, decreased or did not change their prices, they are implicitly considering pre-tax prices. No other change to the rate of GST has occurred since 2000Q2.

the early 1990s was also associated with a substantial increase in the proportion of firms decreasing prices per quarter. But thereafter, there has been a lower tendency for price decreases.[11]

Figure 2: Inflation and the proportion of firms changing prices: 1963 to 2024
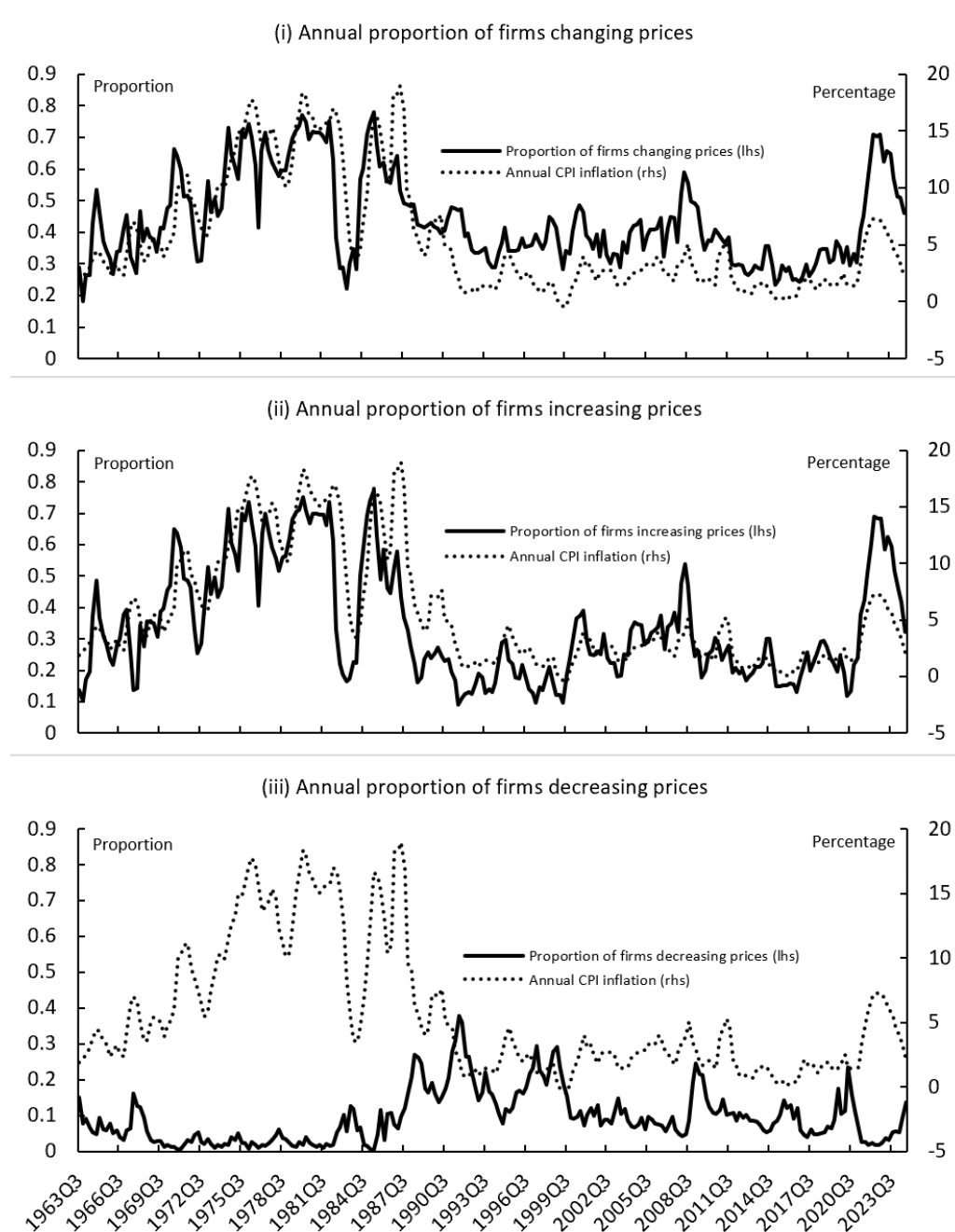
Notes: Panel (i) shows the proportion of all firms that either increase or decrease prices during the quarter. Panel (ii) is the proportion of firms increasing prices; Panel (iii) the proportion of firms decreasing prices. These proportions were derived using the QSBO data provided by the NZ Institute of Economic Research. Annual inflation in each panel is calculated using the Consumers Price Index from StatisticsNZ's Infoshare.

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[11] The correlation coefficient between inflation and proportion of firms changing prices (increases plus decreases) for the full period +0.77. This is dominated by the correlation between price increases and inflation where the correlation coefficient is +0.78. The correlation coefficient between price decreases and inflation is closer to zero in absolute terms at -0.47.

Also consistent with a change in the relationship between inflation and price changes is the comparison between the COVID and the 1970s and 1980s high inflation episodes. In the COVID era, the proportion of firms changing prices per quarter was as high as occurred in the 1970s and 1980s, even though peak inflation in the COVID era was half the peak rates of the 1970s and 1980s. This is particularly evident with price increases, though a change in the tendency for price decreases vis-a-vis inflation also seems to have occurred.

The evolving link between price changes and inflation is formally assessed by estimating a time-varying relationship between the proportion of firms adjusting prices and inflation using a 30-quarter rolling regression. This approach relaxes the restrictive assumption of parameter constancy and enables the detection of shifts in the relationship over time. A 30-quarter window was chosen as sufficiently short to capture persistent structural change in the relationship, yet long enough to smooth through transitory fluctuations in the relationship, perhaps arising from one-off events. The empirical specification is given by:

$$Firms\Delta^d_t = \beta^d_1 + \beta^d_{2,t}\pi_t + \epsilon^d_t \qquad (1)$$

where $Firms\Delta^d_t$ denotes proportion of firms changing prices in quarter t. The superscript d denotes the direction of change in prices (d=up, d=dn or d=(up+dn)). Accordingly, equation (1) is estimated separately for the proportion of firms increasing prices (d=up), decreasing prices (d=dn) and changing prices (d=(up+dn)). π_t denotes annual CPI inflation to quarter t. The coefficient $\beta^{(up+dn)}_{2,t}$ for example, estimates movement in the proportion of firms changing prices if inflation increases by one percent (as measured over the 30 quarter window ending in quarter t); an estimate for $\beta^{(up+dn)}_{2,t}$ of 0.2 would mean a one percent higher inflation rate is associated with 20 percent more firms changing prices in that 30-quarter window.[12]

Figure 3 shows three estimated time-varying relationships: Panel (i) shows the time-varying estimate of $\beta^d_{2,t}$ for inflation and the proportion of firms increasing or decreasing prices (d=up+dn); Panel (ii) shows the time-varying estimate of $\beta^d_{2,t}$ for price increases (d=up); and Panel (iii) is for price decreases (d=dn). The quarter on the horizontal axis represents the last quarter of the regression window.

A significant change over time in the relationship between the proportion of firms changing prices and inflation is evident from Figure 3. The estimates of $\beta^{(up+dn)}_{2,t}$ are substantially larger once the COVID era is included in the rolling regression window; indeed, the estimates are larger even than during much higher rates of inflation during the 1970s and 1980s. In fact, this rise in the sensitivity coefficient appears to have been present since the regression window ends around 2000. This suggests the relationship started to change in the 1990s, but low inflation during the subsequent three decades, the "Great Moderation", masked

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[12] There is endogeneity between the inflation rate and the proportion of firms changing prices, whereby changes in the rate of inflation induce a rise in the frequency of price changes, and this in turn affects the general rate of inflation. Nevertheless, estimation of the time-series model specified by equation (1) is indication of how this relationship has evolved over time.

evidence of a possible change in pricing behaviour, until the COVID episode of high inflation. The rise in the sensitivity coefficient indicates that the inflation accelerator (the endogenous relationship between inflation and price adjustments) has intensified, suggesting a steeper Phillips Curve at higher inflation levels.

The change in the relationship between inflation and the proportion of firms changing prices per quarter is especially evident for price increases. The time series estimates for $\beta^{(up)}_{2,t}$ indicate variation around 0.03 until the mid-1990s. Thereafter, the coefficient estimates start to increase and subsequently have on average been significantly higher than for prior decades. They are on average about twice as high since the mid-1990s than for previous decades, including during the high inflation episodes in the 1970s and 1980s.

The estimate of the coefficients for price decreases $\beta^{(dn)}_{2,t}$ is considerably smaller than for price increases. This coefficient also reveals a change occurring during the early 1990s, drifting from a near zero value to negative indicating that as inflation increases firms are less likely to drop their prices. During the GFC the coefficient estimates drifted back toward zero. Thereafter, the estimated negative coefficient $\beta^{(dn)}_{2,t}$ has again become on average, slightly larger. The respective time-varying estimates for $\beta^{d}_{2,t}$ for price increases and decreases suggest an asymmetry in the way price changes respond to inflation, as predicted by the model developed by Ball and Mankiw (1994a).

Evidence of price asymmetry reported here using firm level data is consistent with results using item level data reported by Nakamura and Steinsson (2008), Gagnon (2009) and Bunn, *et al*. (2024). Moreover, the results presented in Figure 3 indicate more acute price change asymmetry during the COVID era compared to the immediately previous low inflation years (i.e., more frequent price increases and less frequent price decreases occurred during the COVID inflation era). The presence of asymmetric price changes and comparison with comparable high inflation rates during the 1970s and 1980s is further evaluated in Section 5 using ordered probit estimates of the conditional probabilities of price changes.

Figure 3: Time-varying relationship between inflation and price changes by firms

(i) Estimated β2 for total price changes

(ii) Estimated β2 for price increases

(iii) Estimated β2 for price decreases
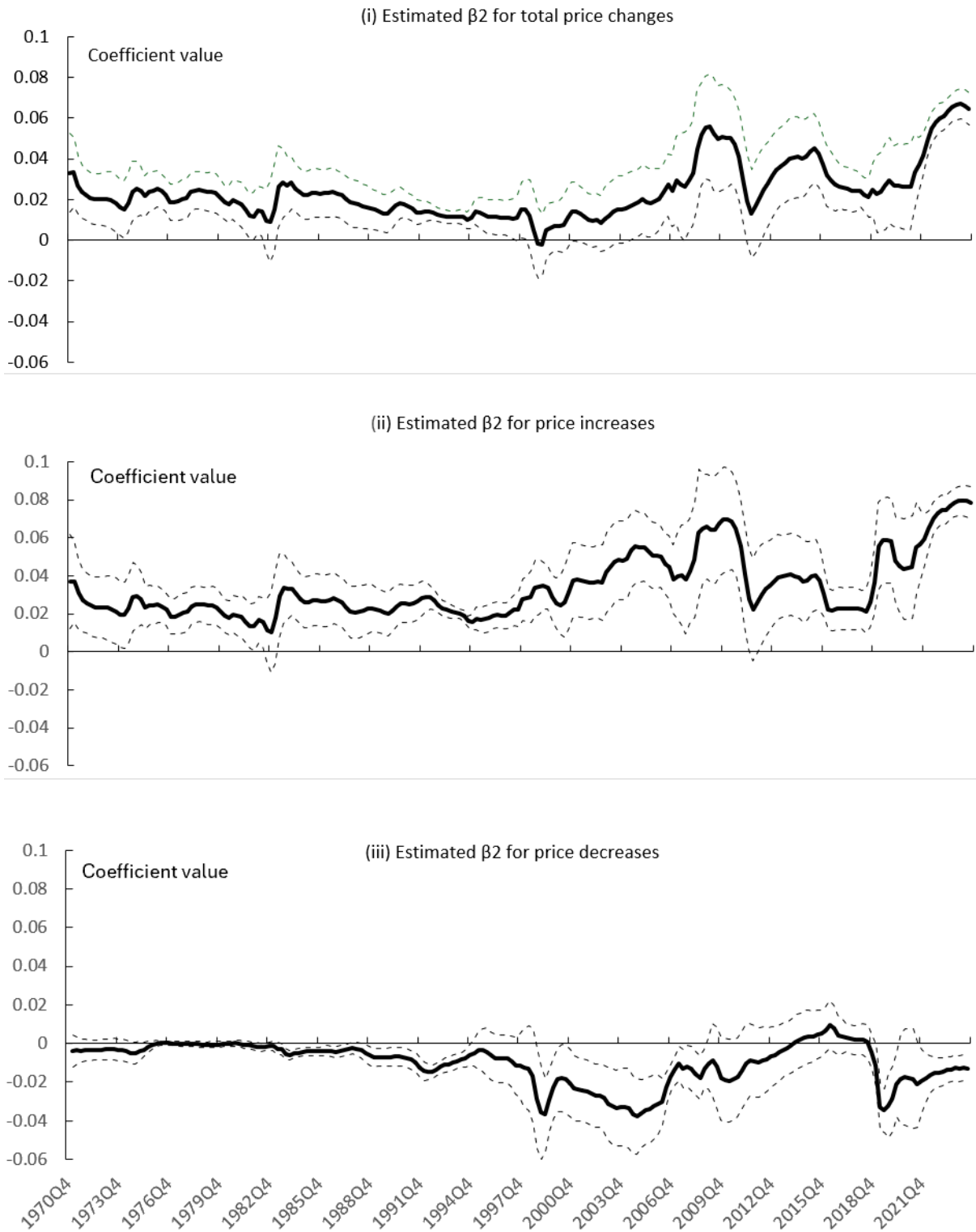
Notes: Solid lines are estimates of $\beta^d_{2,t}$ from equation 1. The estimates are based on 30-quarter rolling regressions and the quarter on the horizontal axis represents the final quarter in the estimation window. Dashed lines are the 95 per cent confidence intervals.

4.2 Magnitude and frequency of price changes and inflation

Additional metrics are constructed using the survey data to compare firm pricing behaviour over the different inflation episodes experienced during the past six decades. These include the average duration of prices, annual frequency (number) of prices changes, and average magnitude of each price change.

A measure of average price duration (PD) can be obtained by calculating $n/(p_{up} + p_{dn})$ in each quarter, where n is the number of months the survey covers ($n = 3$ in this case as it is a quarterly survey) and where p_{up} and p_{dn} are respectively the proportions of firms that answered they increased or decreased prices in the quarter. If $(p_{up} + p_{dn})$ is 0.5 (i.e., 50 percent of firms change prices in the quarter), the implied average price duration is six months (3/0.5).[13] Using the average duration of prices, the mean number of times the representative firm changes prices each year (N_p) can be estimated as: $N_p = 12/PD$. If in a given quarter, price duration is six months, this formula implies prices are changed twice a year, on average.

With an estimate of the average duration of prices (PD) and therefore the corresponding value N_p, it is possible to obtain an estimate of the average magnitude of each price adjustment. Recognising $(1 + M)^{N_p} = \pi + 1$, where M is the average magnitude of each price adjustment, it is possible to solve for M.[14] This estimate provides an approximation of the average magnitude of the price change by a firm over the 12 months up until the end of the quarter in question. This approach assumes the average annual percentage change in prices by firms for each year is equal to the percentage change in the selected price index used to derive the annual inflation rate (π), in this case the Consumers Price Index (CPI).[15]

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[13] This procedure is suggested in Buckle and Carlson [2000b, p61].

[14] Annual inflation reflects firms' price change decisions in the last four quarters, so the actual value for the number of price changes, N_p, used in calculating the magnitude of price adjustment is the average of the estimated number of price changes in the current quarter and the three quarters prior. Quarter-specific estimates that use quarterly inflation show similar trends to what is found with these year-to date measures, but they are much more volatile.

[15] The formula for calculating the magnitude of each price adjustment in a year has two components: N_p (estimate of the number of times prices per year) and π (annual CPI inflation). The CPI measures changes in consumer goods and services (including housing services) but not the prices of manufactured goods. However, as currently estimated, N_p is based in part on the price changing behaviour of firms in the manufacturing sector. The following alternative estimate of the magnitude of price change was undertaken to understand if the inclusion of manufacturing firms in the dataset to estimate N_p is material. N_p was calculated for each sector and an alternative overall value of N_p was calculated by excluding observations for manufacturing firms and weighting the merchant, services and building sector values of N_p by using the respective weights of goods, services and the purchase of new housing from the 2020 reweighting of the CPI. This alternative value of N_p was then used to calculate an alternative estimate of the magnitude of price changes. The resulting time series of the magnitude of price changes using the CPI weighting is almost identical to the series derived for this paper.

Table 1: Firm pricing behaviour by inflation periods

Inflation period	Time span	Average annual inflation	p_{up}	p_{up+dn}	Price duration, PD	Annual number of price changes, Np	Magnitude of price adjustment, M	Ratio of Np to M
		(%)	(proportion)	(proportion)	(months)	Np	(%)	Np/M
I	1963Q3-1967Q1	3.13	0.28	0.35	9.20	1.40	2.39	0.59
II	1967Q2-1973Q3	6.73	0.40	0.44	7.24	1.75	3.77	0.46
III	1973Q4-1983Q1	14.43	0.60	0.63	5.06	2.51	5.45	0.46
IV	1983Q2-1984Q2	5.09	0.26	0.34	9.61	1.38	4.22	0.33
V	1984Q3-1988Q3	12.67	0.49	0.59	5.24	2.36	5.11	0.46
VI	1988Q4-1990Q3	5.90	0.24	0.41	7.24	1.66	3.45	0.48
VII	1990Q4-2011Q1	2.27	0.24	0.39	7.89	1.56	1.44	1.08
VIII	2011Q2-2021Q1	1.45	0.21	0.30	10.10	1.21	1.15	1.05
IX	2021Q2-2024Q3	5.39	0.54	0.58	5.34	2.32	2.41	0.96

Notes: p_{up} is the average quarterly proportion of firms that increased prices; p_{up+dn} is the average quarterly proportion of firms that either increased or decreased (i.e., changed) prices. Price duration is calculated: $n/(p_{up} + p_{dn})$, where n is the number of months the survey covers (3 months). The number of price changes in a year, N_p, is calculated as 12/*price duration*. Magnitude of each price adjustment is calculated by solving the following equation $(1+M)^{N_p} = \pi+1$ for M each quarter, where π is annual inflation and N_p is the annual number of price changes (for the magnitude of each price adjustment calculations, the four quarter moving average of N_p is used, see footnote 14).

The estimated values for average duration of prices (*PD*), frequency of price changes (N_p), and magnitude of each price adjustment (*M*), are also shown in Table 1 for different inflation episodes since 1963. The time span for each inflation episode is determined by when annual inflation moves between two selected thresholds: five percent and 10 percent.[16] This results in nine inflation episodes since 1963 shown in the first two columns of Table 1. The following metrics are generated for each inflation episode. Columns three to six include respectively average annual inflation rates, average quarterly proportion of firms that increased prices (p_{up}), that changed prices (p_{up+dn}), and average price duration. Columns seven to eight

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[16] Some judgement is used for temporary inflation blips so to avoid an excessive number of periods containing a small number of quarters. Specifically, if inflation passes through a threshold in one direction, but reverses course for one or two quarters, before continuing in the original direction, this is ignored.

include period means of the annual number (frequency) and magnitude of each price adjustment.[17] Column nine gives the ratio of Np to M.

Table 1 supports the conclusions in Section 4.1 that there has been a change in pricing behaviour. This change is seen most clearly by comparing the most recent inflation periods VIII and IX with earlier periods of comparable average annual inflation rates. During the most recent high inflation episode of the COVID era (Period IX), the proportion of firms changing prices is considerably higher than during earlier periods with similar inflation rates (Periods IV and VI). This change is particularly noticeable for the proportion of firms increasing prices (p_{up}) which is twice as high in Period IX than in Periods IV and VI. The proportion of firms raising prices in Period IX is even higher than in Period II when average annual inflation was about 1.3 percentage points higher. The average annual proportion of firms changing prices (p_{up+dn}) and increasing prices (p_{up}) in Period IX is comparable with the much higher inflation periods in the 1970s and 1980s (Periods III and V). Consequently, the estimated annual number of price changes during the COVID era is higher and the duration of prices shorter than during earlier periods with similar inflation outcomes. Moreover, the average magnitude of each price change in the most recent Period IX at 2.41 per cent, is considerably smaller than in earlier periods with similar average inflation outcomes.

These pricing behavioural changes are not restricted to the COVID inflation episode. The average annual number of price changes during the years immediately prior to COVID (Period VIII: 2011Q2 to 2021Q1) when annual inflation averaged 1.45 per cent, is similar to that for Periods I (1963Q3 to 1967Q1) and IV (1983Q2-1984Q2) when average annual inflation was more than twice as high at 3.13 and 5.09 per cent respectively. As indicated by Figure 3, changes in pricing behaviour appears to have been occurring since the mid-1990s. This is illustrated further by taking the ratio of the number of price changes per year to the magnitude of price changes (N_p/M) shown in column 9 of Table 1. The average number of price changes per year has increased relative to the size of each price change after Period VI (1988Q4-1990Q3).

Using Table 1, the frequency and magnitude of price adjustments changed between Periods VIII and IX can be compared. Table 1 suggests the elevated levels of inflation during the COVID era arose more from an increase in the frequency of price changes than from a rise in the magnitude of price adjustments. This pattern is also evident in the quarterly estimates of the annual frequency of price changes and the magnitude of price changes reported in Figure A1. The quarterly estimates plotted in Figure A1 suggest that the magnitude of price changes was between 1 and 2 percent over 2019 and 2020 before peaking at 3.7 percent

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[17] As a robustness check, alternative estimates of the annual number of price changes were made by counting the number of price changes each year made by those firms that responded to all four surveys in a calendar year. A disadvantage of this approach is it only creates estimates of the number of annual price changes and the magnitude of price adjustments, for each calendar year rather than on a quarterly basis. Further, it relies on a smaller sample of firms: those that respond to all four surveys each year. Nevertheless, there is a strong correlation between the estimated metrics using this method and the method reported in the paper, particularly from period III onward.

in 2021Q4. These results are similar to those reported by Montag and Villar Vallenas (2023) for the USA derived using item-level prices. They find the magnitude of price changes remained relatively flat through 2019 and 2020, fluctuating between 1.5 and 2 per cent. Montag and Villar Vallenas (2023) report that the magnitude increased through 2021 reaching 4 percent early in 2022 before declining from mid-2022. Their measure of frequency implies firms changed prices about every ten months prior to the COVID inflation, then fell to five months (implying 2.4 price changes per year) during the peak of the COVID inflation, which is very similar to that shown in Table 1 (and in Figure A1) for New Zealand firms during the COVID inflation period.[18]

Inflation rates in New Zealand were similar to the USA during the period of Montag and Villar Vallenas (2023) study, which helps explain why our results are similar. The similarity also suggests that firm-level data used in this study provide a reliable basis for capturing the key insights obtained from item-level data. By using the firm-level data available since the early 1960s, however, it is possible to extend the comparison beyond the immediate pre-COVID period and provide further insight that studies such as that by Montag and Villar Vallenas (2023) cannot. The further insight is that firms changed prices as frequently during the COVID inflation era as they did during the much higher inflation periods in the 1970s and 1980s, but the average magnitude of price adjustment (the percentage change in price) was much smaller during the COVID inflation era. Price change frequency was generating more of the inflation dynamic during the COVID episode than during previous high inflation episodes. Furthermore, this changing pattern of behaviour is evident since the 1990s, but it was previously masked by low inflation.

5. Estimating the conditional probability of price changes by firms

The temporal analysis in Section 4 examined firms' pricing behaviour at the aggregate level. To understand what might be determining some of the changes in pricing behaviour observed in aggregate, Section 5 draws on the individual firm responses to estimate, using ordered probit models, how the probabilities of price change are affected by inflation, and by the individual demand and cost conditions experienced by firms as recorded in the QSBO firm-level database. This provides an insight into how inflation affects the propensity of firms to change prices in response to the idiosyncratic shocks experienced by individual firms.

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[18] These results for USA and New Zealand differ somewhat from Gagnon's (2009) findings for Mexico during its much larger fluctuations of inflation between 1994 and 2002 which ranged between 4.9 and 41.8 per cent. Gagnon found when inflation was relatively low (below 10 to 15 per cent) the frequency of price increases and decreases tended to offset each other, and the average magnitude of price changes correlated strongly with inflation. But when inflation rose above 10 to 15 per cent there were fewer price decreases and both the frequency and magnitude of price changes correlated with inflation.

5.1. Specification of an ordered probit model

The estimated probit model is set out in equation (2). Each firm's quarterly pricing decision (indexed as j) in quarter t is modelled as follows:

$$V_{j,t} = (b_1 + b_2\pi_t)Cup_{j,t} + (b_3 + b_4\pi_t)Dup_{j,t} + (b_5 + b_6\pi_t)Cdn_{j,t} + (b_7 + b_8\pi_t)Ddn_{j,t} +$$
$$Recent\,[(a_1 + a_2\pi_t)Cup_{j,t} + (a_3 + a_4\pi_t)Dup_{j,t} + (a_5 + a_6\pi_t)Cdn_{j,t} + (a_7 + a_8\pi_t)Ddn_{j,t}] \qquad (2)$$

where:

$V_{j,t}$ is a latent index of pricing pressure: i.e., higher values imply a greater probability of a price increase;[19]

Cup = cost increase (= 1 if the firm reports a cost increase, and = 0 otherwise),

Dup = demand increase (= 1 if the firm reports a demand increase, and = 0 otherwise),

Cdn = cost decrease (= −1 if the firm reports a cost decrease, and = 0 otherwise),

Ddn = demand decrease (= −1 if the firm reports a demand decrease, and = 0 otherwise);

π_t = annual CPI inflation rate for the year to quarter t.

Recent takes a value of one from 2011Q2, zero otherwise.

In addition to estimating the parameters set out in equation (2), there are two more parameters to estimate, k_1 and k_2, which define the threshold values. These threshold values partition the range of the unobservable index of the pressure to raise prices, $V_{j,t}$, allowing the probabilities of a firm increasing, not changing, and decreasing prices to be defined as $\Pr(V_{j,t} > k_1)$, $\Pr(k_1 > V_{j,t} > k_2)$ and $\Pr(V_{j,t} < k_2)$ respectively.

The specification of the ordered probit model is motivated by state-dependent pricing models, in particular the model of Ball and Mankiw (1994a). In the Ball and Mankiw model, θ is defined as the desired relative price and $q* = p+\theta$ as the desired nominal price, where p is the overall price level. Their model predicts that a firm will not change prices if:

$$AC > \left(\theta + \frac{\pi}{2}\right)^2 \qquad (3)$$

where AC = costs of price adjustment and π is inflation.[20] Equation (3) suggests for a given cost of price adjustment (AC), as inflation rises the probability of price adjustment will depend on the sign of the shock to the desired relative price. For a given shock that increases θ, the probability of a price increase will be positively correlated with inflation because at higher inflation the term $(\theta + \frac{\pi}{2})$ is more likely to exceed AC. For a given shock that decreases θ, the probability of a price reduction is negatively correlated with

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[19] See the discussion in Kennedy (2011, p258) for the motivation for this interpretation.
[20] Ball and Mankiw (1994a) focus on menu costs as the cost of price adjustment. As suggested in Section 6, it is reasonable to expect that there are more costs to price adjustment than just menu costs, such as information search costs, etc.

inflation. This is because the fall in θ is offset by higher inflation in the term $(\theta + \frac{\pi}{2})$, which means the term is less likely to exceed *AC*. It is assumed $\theta = f(c^+, d^+, X)$, where c denotes costs of production and supply of goods and services, d denotes demand for goods and services, and X is a vector of other factors that could influence the desired relative price. Because costs and demand changes are assumed to alter the desired relative price, they are included in the probit model set out in equation (2).[21]

Further, the preceding discussion suggests positive relative price shocks are more likely to lead to price adjustment than negative relative price shocks. It follows, therefore, that costs and demand changes should have asymmetric effects on prices: cost and demand increases are more likely to promote price adjustments than cost and demand decreases. Hence, in equation (2) the response of prices to cost and demand increases is modelled distinctly from the response to cost and demand decreases.[22] The above discussion also suggests that price adjustment is likely to depend on the level of inflation, therefore in equation (2) the response of price pressures to cost and demand increases and decreases is conditioned on inflation.[23]

For a given inflation rate and a given value of θ, equation (3) suggests as the costs of price adjustment (*AC*) decline, the probability of a price adjustment increases. This motivates the decision to introduce a time-dependent dummy variable from 2011Q2, to see if declining price adjustment costs (and other factors discussed in Sections 6 and 7) have changed the responsiveness of prices to demand and cost shocks. The decision to introduce a time-dependent dummy variable from 2011Q2, and well before the start of the COVID inflation period, is motivated by interest in understanding how firm pricing behaviour changes across different rates of inflation. If the dummy variable commenced around 2020 there would be too few periods with low inflation. It could also be argued that the time-dependent dummy be introduced in the 1990s when there seemed from analysis in Section 4, to be some evidence of the commencement of an increase in the sensitivity of firm price change behaviour to inflation. The reason for choosing the later start date is to ensure changes in the price-demand-cost dynamics captured with the *Recent* dummy variable are as contemporaneous as possible and provide insights pertinent for current monetary policy decision-making.[24]

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[21] In the next section we control for firm sector and size which are likely to be correlated with the components of X.

[22] As noted above, the threshold points (k_1 and k_2) in the Probit model define a range over which actual price will not change. This maps nicely to the Ball and Mankiw (1994a) model. Rearranging equation (3) means the range over which prices will not change can be defined as: $(-\sqrt{AC} - \pi/2) < ⟦\theta < (+\sqrt{AC} - \pi/2)$. θ is above the upper bound, a firm will raise price, and if θ is below the lower bound, a firm will lower price.

[23] Kumar and Wesselbaum (2024) imply an additional motivation for the assumption that price adjustment is likely to depend on the level of inflation. They find firms with higher inflation expectations make less use of contracts. If inflation and inflation expectations are correlated, periods of higher inflation should see less contract use, which will make prices more flexible.

[24] The specific choice of 2011Q2 was made to avoid a temporary blip in inflation owing to a GST change in 2010Q4 being included in the recent period. In the robustness tests, three alternative constructions of the *Recent* variable were evaluated: (i) where the *Recent* variable starts taking a value of one from 2020Q1 onward; (ii) from 2000Q1 onwards; and (iii) 1990Q1 onward. The key qualitative results identified in the subsequent discussion in this section hold under these three alternative constructions. The results of the estimations using these alternative constructions of the *Recent* variable are available from the authors on request. The broad conclusions concerning evidence of structural change in pricing behaviour are similar for each break-point period, except that the size of the change in the probit estimate of the coefficients for equation 2 are systematically

The probit model is estimated via maximum likelihood methods using individual firm data from 1963Q3 to 2024Q3, a period of 61 years. Testing revealed that the null hypothesis of homoskedasticity is rejected using the Likelihood Ratio test for the model estimated on the full dataset, as well as the models estimated on the sector-specific and size-specific datasets (see the Likelihood Ratio chi-square in Tables A2 and A3).[25] Therefore, the results presented in this paper are estimated using a version of the ordered probit model that allows for the variance to be a function of specified explanatory variables. In the model estimated on the full dataset in Section 5.2 the variance is modelled as a function of firm sector, firm size and the inflation rate. In the models estimated and reported in Sections 6 and 7 for each sector, the variance is modelled as a function of firm size and inflation. In the models estimated for firms in different employee size groups, the variance is modelled as a function of firm sector and inflation.[26]

5.2. Ordered probit model estimation results

Estimates of the coefficients of equation (2) for all firms in the sample are provided in Appendix Table A2. As noted earlier, the effects of the variables in equation (2) on the probability of price responses are also influenced by the positioning of the thresholds, k_1 and k_2.[27] The best way, therefore, to understand the effects of cost and demand conditions (and their interaction with inflation) on the direction of price change is using the conditional probabilities. Table 2 presents the conditional probabilities calculated using the ordered probit model specified by equation (2) and estimated on a dataset containing all firms.

Table 2 reveals a clear pattern whereby the conditional probability of a price increase rises as inflation rises, both before and after 2011Q2. For example, the estimated conditional probabilities of a price increase when costs and demand increase for the decades before 2011Q2 (Prob[Pup|Cup, Dup, R=0]) rise successively from 0.47 to 0.55 to 0.61 at successively higher inflation rates. This pattern is evident in Table 2 for all estimated conditional probabilities of a price increase. The results are consistent with the predictions of the menu-cost-based state-dependent pricing models discussed in Sections 2 and 5.1.

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smaller when *Recent* is set at 1990Q1. This observation is consistent with the conclusion in Section 4 drawn from the time-series analysis, that changes in pricing behaviour of firms started to take place after the mid-1990s.

[25] The Likelihood Ratio test statistic calculates by how much the likelihood improves in the model when heteroskedasticity is allowed for versus a model where the variance is assumed to homoskedastic. The specific formula for the test statistic is LR = -2(ln(L$_{Heteroskedastic}$) − ln(L$_{Homoskedastic}$)). If the null hypothesis is true, the Likelihood Ratio test statistic follows a chi-squared distribution with degrees of freedom equal to the number of additional variance parameters in the heteroskedastic version of the model. To test if the improvement in the likelihood is statistically significant (that is, if the null hypothesis of homoskedascity can be rejected), the Likelihood Ratio test statistic can be tested against the appropriate critical value from the Chi-squared distribution.

[26] The models were estimated using the hetoprobit command in Stata.

[27] An explanation of how these conditional probabilities are calculated is provided in Buckle and Carlson (2000a).

Table 2: Conditional probabilities of price changes for all firms: Pre- and Post-2011Q2

Type of conditional probability:	Probabilities:			Change in probabilities (R=1)-(R=0):		
	2%	5%	7%	2%	5%	7%
Probability firms increase prices:						
Prob[Pup|Cup, Dup, R=0]	0.47	0.55	0.61			
Prob[Pup|Cup, Dup, R=1]	0.48	0.73	0.85	*0.01***	*0.17****	*0.24****
Prob[Pup|Cup, Dnc, R=0]	0.44	0.52	0.57			
Prob[Pup|Cup, Dnc, R=1]	0.41	0.58	0.69	*- 0.04****	*0.06****	*0.12****
Prob[Pup|Cup, Ddn, R=0]	0.30	0.39	0.44			
Prob[Pup|Cup, Ddn, R=1]	0.36	0.60	0.75	*0.05****	*0.22****	*0.31****
Probability firms decrease prices:						
Prob[Pdn|Cdn, Dup, R=0]	0.29	0.25	0.23			
Prob[Pdn|Cdn, Dup, R=1]	0.22	0.09	0.05	*-0.07****	*-0.16****	*-0.18****
Prob[Pdn|Cdn, Dnc, R=0]	0.32	0.28	0.26			
Prob[Pdn|Cdn, Dnc, R=1]	0.28	0.18	0.13	*-0.03****	*-0.10****	*-0.13****
Prob[Pdn|Cdn, Ddn, R=0]	0.46	0.41	0.37			
Prob[Pdn|Cdn, Ddn, R=1]	0.32	0.16	0.09	*-0.13****	*-0.24****	*-0.28****

Notes: These conditional probabilities are derived from the coefficient estimates shown in Table A2 and are evaluated at the specific inflation rates of 2%, 5% and 7%. P=prices, C=costs, D=demand, up=increase, nc=no change, dn=down; hence for example Pup=Prices up, and so on. R=Recent and is the time contingent dummy variable which takes a value =1 from 2011Q2 and zero otherwise. Change (R=1)-(R=0) is the absolute change in the estimated conditional probability of a price change (under the equivalent cost and demand conditions) between Pre- and Post-2011Q2. Statistical significance is evaluated using the Delta method by applying the "margins" command in Stata and is denoted by asterisks: *** denotes $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Small differences between the recorded "Change (R=1)-(R=0)" and the respective recorded values of the reported conditional probabilities are due to rounding to the nearest digit at the second decimal point.

Furthermore, Table 2 also reveals a significant increase in the probability of a price increase in response to higher costs during the post-2011 years compared to the previous years, as inflation rises.[28] While the conditional probability of firms increasing prices when costs increase (for any demand situation) is broadly similar before and after 2011Q2 when annual inflation is at 2 per cent, when annual inflation is higher at 5 and 7 per cent the probability of a price increase is much higher after 2011Q2 than in earlier years. The differences between the Pre- and Post-2011Q2 estimates of conditional probabilities are shown in the right-hand side of Table 2 under the respective inflation rates. The increases in estimated conditional probabilities for the higher inflation rates are in general substantial and are statistically significant, providing further evidence of a structural change in pricing behaviour.

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[28] The statistical significance of the size of change in the estimated conditional probability of a price change between Pre- and Post-2011Q2 (and for alternative breakpoints) is evaluated by applying the Delta method (see Wooldridge, 2010) using the "margins" command in Stata.

In the case of conditional probabilities of a price decrease, there is a degree of symmetry with the patterns observed for price increases. In both periods the conditional probabilities of a price decrease systematically fall as inflation rises. For example, the estimated conditional probabilities of a price decrease when costs and demand decrease for the decades before 2011Q2 (Prob[Pdn|Cdn, Ddn, R=0]) fall successively from 0.46 to 0.41 to 0.37 at successively higher inflation rates. The same pattern is evident for all the estimates for the Post-2011Q2 years. These results are also consistent with the menu-cost-based state-dependent pricing models discussed in Sections 2 and 5.1. Moreover, the estimated probabilities are lower in the *Recent* period at all inflation rates and are successively much lower as inflation rises providing further evidence of structural change in pricing behaviour.

Table 2 reveals two further important results. First, it provides strong evidence of pricing asymmetry by firms: price increases are more likely than price decreases when conditions warrant them. This can be seen by comparing the estimated conditional probabilities for price increases and decreases under opposite cost and demand changes. For example, take the case where annual inflation is 7 per cent. The conditional probability of a price increase when costs and demand increase simultaneously (Prob[Pup|Cup, Dup]) is 0.61 for the Pre-2011Q2 years, while the conditional probability prices will decrease when costs and demand decline simultaneously (Prob[Pdn|Cdn, Ddn]) during these years is 0.37. This asymmetry is also evident in the Post-2011Q2 years where the equivalent estimated conditional probabilities are 0.85 and 0.09 respectively. Moreover, the degree of price asymmetry rises as inflation rises, as predicted in some menu cost-based pricing models (e.g., Ball and Mankiw, 1994a).

Table 2 also reveals that the degree of price asymmetry has increased in the Post-2011Q2 years, providing further evidence of a structural change in firm pricing behaviour. Take for example the case of 7 per cent annual inflation and the same set of conditional probabilities discussed in the previous paragraph. The conditional probability that prices will be increased by firms reporting both cost and demand increases (Prob[Pup|Cup, Dup]) has increased by 0.24 (0.85-0.61) between the two periods (i.e., Pre- (R=0) and Post-2011Q2 (R=1)). On the other hand, the conditional probability that prices will be reduced when costs and demand decline (Prob[Pdn|Cdn, Ddn]) between the Pre- (R=0) and Post-2011Q2 (R=1) has fallen by 0.28 (0.09-0.37). These temporal changes in the estimated conditional probabilities allow us to construct a measure of the intertemporal change in price asymmetry by differencing the changes in the relevant price-increase and price-decrease conditional probabilities. For example, when comparing the change in conditional probabilities for simultaneous cost and demand increases and simultaneous costs and demand decreases, at 7 per cent inflation the difference of the changes between Pre- and Post-2011Q2 is 0.52 (0.24 less -0.28); at 5 per cent inflation it is 0.41 (0.17 less -0.24); and at 2 per cent inflation it is 0.14 (0.01 less -0.13). There is a clear pattern of increased price asymmetry as inflation increases in recent years, and this change is more acute as inflation rises.

6. Menu costs, information technology, firm characteristics, and pricing behaviour

This section and the next will discuss and evaluate possible reasons why there has been a structural change in firm pricing behaviour. These structural changes include a rise in the tendency for firms to change prices as inflation increases (shown in Figure 3 and Table 2), a fall in the average magnitude of price adjustments, and a rise in the frequency of price changes (both shown in Table 1). The other structural change that has been revealed is an increase in price asymmetry whereby firms are more likely to raise prices than decrease price when demand and cost conditions change desired prices. In other words, prices have become more "flexible" upwards but more "sticky" downwards.

These changes in pricing behaviour of New Zealand firms have occurred when the internet has become much more widely available globally. This is transforming business and buyer behaviour. For example, Hillen and Fedoseeva (2021) cite evidence that by 2018 between 30 and 50 per cent of Americans purchased groceries online and online sales tripled between 2013 and 2018. They also report a marked increase in the popularity of online shopping during the COVID-19 pandemic.

The spread of digital capability has also been substantial in New Zealand during the past two decades. In 1994 only 3 per cent of the population had access to the internet. Access had grown to about 50 percent by 2000 and by 2022, the COVID inflation era, this proportion was nearly 96 per cent.[29] Adoption of digital technology by firms has been similarly rapid. In 2008 only 51 per cent of small New Zealand firms reported having a web presence, and by 2020 this proportion had risen to 71 per cent.[30] Hence, the digital capability of both firms and customers has increased rapidly in recent decades. As others have suggested, it seems reasonable to conjecture that technological developments have lowered costs and enabled prices to be more flexible and more responsive to inflation and other conditions that change desired prices.[31]

Most obviously technology will lower menu costs. When prices are posted electronically the physical cost of changing prices is negligible. This means menu costs are effectively eliminated as a constraint on price adjustment. However, Ball and Mankiw (1994b, p.114) "suspect that the most important costs of price adjustment are the time and attention required of management to gather the relevant information and to make and implement (pricing) decisions". To frame it in the language of Ball and Mankiw (1994a): firms need information and time to assess the gap between prevailing and desired prices, and therefore if a price

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[29]A time series of annual usage is available from: Internet users for New Zealand (ITNETUSERP2NZL) | FRED | St. Louis Fed.

[30] These percentages are the authors' calculations based on the Business Operations Survey data provided by the Statistics New Zealand's *Infoshare*. Small firms are defined here by those with 6 to 19 employees. An increase in web presence is also observed for larger firms, though for firms with more than 50 employees the percentage point increase is smaller because they had a proportionally higher rate of web presence in 2008.

[31] For example, Nakamura *et al*. [2018] comment: "Given all of the technological advancement that has occurred over the past half-century, it seems natural to conjecture that some of the costs of changing prices may have fallen, allowing prices to become more flexible." (p. 1969)

change is needed. We refer to the costs associated with collecting information to assess the gap between prevailing and desired prices, and the managerial time to make pricing decisions, as price review costs (see Alvarez *et al.*, 2011).

A more digitally connected world means that the information needed for a price review may be more up to date, and more accessible and cheaper to obtain, thereby lowering price review costs. The result is firms are willing to undertake price reviews more often, resulting in a dynamic of more frequent but smaller price changes. This dynamic is reinforced by technology reducing information uncertainty. Bhaduri and Falkinger (1990) note that firms are more likely to adjust prices when costs and demand change when the information on costs and demand is more complete and more certain. Improved quality of cost and demand information reduces the propensity to 'wait and see' when considering price adjustment. Better and more complete data may be particularly important for firms dependent on complex supply-chains for sources of production materials. For example, manufacturing and large merchant operations often depend on complex supply chains and just-in-time delivery processes, which benefit significantly from advanced tracking, automated data capture, and real-time analytics.

Dynamic pricing is an extreme case where firms can adjust prices by small amounts, often according to changing demand conditions owing to better real time information. It also allows firms to adjust prices to reflect the firm's real time costs and inventory levels, and competitor pricing decisions as well. Dynamic pricing automates pricing decisions by algorithmically collecting data and then algorithmically setting prices: the marginal time and attention required of managers in each price setting decision becomes negligible. Using a dataset of high-frequency prices from large online retailers selling brands of allergy drugs, Brown and MacKay (2023) observe that dynamic pricing and the use of pricing algorithms are becoming more prevalent. Cavallo (2018) reported that the frequency of price changes in multi-channel retailers has been increasing for 10 years, reducing the average duration of prices (excluding sales and temporary discounts) by around 50 per cent between 2008 to 2017. This was stronger in sectors where online retailers have high market shares, and among goods that can be easily found on Amazon.

Even if price responsiveness to competitor pricing behaviour is not automated, online markets change the competitive characteristics of markets increasing price flexibility. Online markets reduce consumer search costs and enhance the ability of buyers and sellers to observe the distribution of prices of specific goods and services. Gorodnichenko and Talavera (2017) and Gorodnichenko, *et al*. (2018) reported that price quotes in the USA and Canada found on internet marketing sites are more flexible and exhibit a greater rate of pass-through and faster convergence in response to nominal exchange rate changes relative to prices in regular stores.

Earlier studies have highlighted considerable heterogeneity in the frequency of price setting across types of products and industrial sectors (see for example: Nakamura and Steinsson, 2008; Gagnon, 2009; Klenow

and Malin, 2010). These differences reflect the diversity of pricing arrangements at the firm and product levels, as reflected for example in the study by Blinder (1994) and many subsequent studies. While advances in information technology are likely to have influenced pricing behaviour across all firms, their impact may differ by sector and firm size, further accentuating the heterogeneity in firm price setting behaviour. To explore this, we draw on the Business Operations Survey conducted by Statistics New Zealand, which provides information on firms' use of digital technologies and online retailing activities relevant to pricing decisions.[32]

Table 3 shows that most firms, regardless of size or sector, use the internet for purchasing and placing orders with suppliers. There are more pronounced differences in internet use for supplying goods to customers and for receiving orders or bookings. Merchant and Service firms sell more online than Builders or Manufacturers. Further, firms in these sectors are more likely to engage in sophisticated data driven decision making procedures (see the final column of Table 3) which increase the speed and lower the cost of price reviews. There is also a tendency for an increased online presence and the application of these sophisticated data driven decision making technologies to increase with firm size.

The discussion in this section points to two testable hypotheses. First, if menu and price review costs of price adjustment have declined, then prices should exhibit greater flexibility in both directions. However, the aggregate analysis in Section 5 shows increased upward flexibility, but not downward flexibility. The second hypothesis posits that larger firms, and firms in the service and merchant sectors, exhibit greater price flexibility owing to their stronger online presence and more extensive use of sophisticated data driven decision making procedures. To test this, the following subsections examine whether pricing behaviour differs systematically across firms of different sizes and sectors.

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[32] The Statistics New Zealand data are from the 2022 Business Operations Survey: https://www.stats.govt.nz/information-releases/business-operations-survey-2022

Table 3: Use of selected technologies by industrial sector and firm size

		Use of the internet for:			Use of:
		Purchasing or placing orders for goods & services	Supplying goods & services to customers	Receiving order reservations or bookings	Data and analytics or machine learning assisted decision making
Industrial sector: Builders		0.82	0.24	0.11	0.07
Manufacturers		0.94	0.33	0.26	0.10
	Merchants	0.94	0.51	0.51	0.13
	Services	0.84	0.49	0.33	0.15
Firm size:	6-19	0.83	0.38	0.28	0.10[a]
(Employees):	20-49	0.92	0.44	0.34	0.19[b]
	50-99	0.93	0.48	0.35	0.21[c]
	100+	0.93	0.54	0.38	0.30

Notes: The data columns show proportion of firms. The results in the first three data columns are drawn from StatisticsNZ 2022 Business Operations Survey (BOS). They are StatisticsNZ population estimates derived by weighting up responses, where the weights are based on firm population weights. StatisticsNZ selected a sample of 9081 businesses from a total BOS population of 48,092 businesses, and a response rate of 76.1 per cent. The "Education & Training, Health Care & Social Assistance, Arts & Recreation Services, and Other Services" industries were excluded from the calculations to align with the Service industries covered by the NZIER's QSBO survey. Results in the final data column are derived from a NZIER/Spark survey in September 2023 with a sample size of 1071 firm respondents; see Leung and Miller-Moore (2024). *a, b, c* indicate the proportions reported are for firms with 1-20, 21-50 and 51-100 employees.

6.1. Conditional probabilities of price changes by industrial sector

This section evaluates whether there are differences in pricing behaviour among firms by industrial sector. The estimated conditional probabilities of price changes by firms in each industry sector are then compared. In each case the estimates are derived for the Pre- and Post-2011Q2 periods based on the same combinations of events as shown in Table 2.

Table 4 shows for each industrial sector that the probability of a price increasing when costs increase (for all demand conditions) rises as inflation rises, both before and after 2011Q2. There are differences in the estimated probabilities of price change between sectors. The estimated conditional probabilities for Services and Merchants tend to be higher than for Manufacturers and Builders, especially at higher inflation rates and Post-2011Q2.[33]

The most striking feature of the results in Table 4 however, is the change in the estimates of the probability of prices increasing when costs increase for Services at higher inflation after 2011Q2. In all demand circumstances, the conditional probability of price increases by Service firms increases, whereas the directions of change are mixed and much smaller in all other sectors. Thus, the predominant reason for

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[33] An exception for Builders is evident in the Pre-2011Q2 period for demand increases, where the conditional probability of a price increase for Builders is similar to that for Merchant and Service firms.

the increase in conditional probabilities of price increases estimated for all firms Post-2011Q2 shown in Table 2, is due to changes in pricing behaviour by firms in the Services sector.

For the conditional probability of price decreases, there are differences in behaviour across industrial sectors. For the pre-2011 period, the conditional probabilities of price decreases do not always decline as inflation rises, and in some cases, notably for Builders, these increase in many instances. For Service firms the estimated probabilities tend to decline as inflation rises in the Pre-2011 period.

The striking feature of the results reported examining the conditional probability of a price decrease is again the change in price setting behaviour after 2011Q2. There is a marked decrease in the estimates of the probability of prices decreases when costs decrease for Services and Merchant firms after 2011Q2. This occurs for all inflation rates and is especially evident as inflation increases; these changes are statistically significant. This implies that the increase in the degree of 'downward stickiness' of prices in response to cost decreases in the recent period evident in Table 2 in the analysis of all firms, originates from changes in pricing behaviour of Services and Merchant firms.[34] Further, the effect of this change in sectoral pricing behaviour on aggregate firm pricing behaviour in New Zealand has been accentuated by the growth of Service firms as a share of all firms in the economy. In contrast, Builders are more likely since 2011Q2, to reduce prices when costs fall compared to the earlier period, though most of the estimated changes are not statistically significant. There is no significant change for Manufacturing firms. These results stand in stark contrast to the hypothesis set out earlier that increased digital capability should lead to more downward price flexibility and this downward flexibility should be most evident in the two sectors making the most use of online markets: services and merchants.

Finally, in Table 4, comparison of the conditional probabilities of a price decrease between the non-service sectors and service sectors in the most recent period, shows that the service sector is less likely to drop prices. One of the potential implications of this divergence is that as aggregate demand declines, the rate at which Services price inflation declines may be slower than the rate of decline of Goods price inflation. This pattern has been evident during the post-COVID disinflation in many countries, including in New Zealand (Antwis, 2024).

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[34] This result is similar to Gagnon's (2009) finding for services prices in Mexico between 1994 and 2002. He concluded "services price decreases are much less frequent than price increases, especially when inflation is high." (p 1242).

Table 4: Conditional probabilities of price changes by industrial sector: Pre- and Post-2011Q2

	Builders			Manufacturers			Merchants			Services		
	2%	5%	7%	2%	5%	7%	2%	5%	7%	2%	5%	7%
Probability firms increase prices (Pup) when costs increase (Cup) and….												
Dup,R=0	0.50	0.62	0.69	0.38	0.47	0.53	0.52	0.69	0.79	0.54	0.58	0.60
Dup,R=1	0.41	0.55	0.63	0.33	0.50	0.62	0.46	0.66	0.77	0.56	0.83	0.93
Change	*-0.09****	*-0.07****	*-0.06*	*-0.04****	*0.04*	*0.09****	*-0.06****	*-0.04*	*-0.02*	*0.02**	*0.25****	*0.33****
Dnc,R=0	0.40	0.51	0.58	0.34	0.41	0.46	0.44	0.61	0.71	0.55	0.57	0.58
Dnc,R=1	0.28	0.43	0.54	0.27	0.41	0.51	0.35	0.49	0.59	0.52	0.71	0.82
Change	*-0.12****	*-0.08****	*-0.04*	*-0.07****	*0.00*	*0.06***	*-0.09****	*-0.12****	*-0.12****	*-0.03****	*0.15****	*0.24****
Ddn,R=0	0.15	0.24	0.32	0.21	0.29	0.35	0.31	0.47	0.58	0.45	0.49	0.51
Ddn,R=1	0.12	0.23	0.33	0.17	0.29	0.38	0.27	0.44	0.56	0.49	0.78	0.91
Change	*-0.03***	*-0.01*	*0.01*	*-0.04****	*0.00*	*0.04*	*-0.04***	*-0.03*	*-0.02*	*0.04****	*0.29****	*0.39****
Probability firms decrease prices (Pdn) when costs decrease (Cdn) and….												
Dup,R=0	0.36	0.38	0.40	0.22	0.18	0.15	0.34	0.36	0.37	0.33	0.29	0.26
Dup,R=1	0.26	0.49	0.65	0.24	0.17	0.13	0.28	0.18	0.13	0.20	0.06	0.02
Change	*-0.09**	*0.11*	*0.25*	*0.02*	*-0.01*	*-0.02*	*-0.06***	*-0.18****	*-0.24****	*-0.13****	*-0.23****	*-0.24****
Dnc,R=0	0.46	0.49	0.52	0.25	0.22	0.20	0.42	0.45	0.46	0.33	0.30	0.28
Dnc,R=1	0.40	0.61	0.73	0.30	0.24	0.20	0.38	0.31	0.27	0.24	0.13	0.08
Change	*-0.06*	*0.11*	*0.22*	*0.06**	*0.02*	*0.00*	*-0.04*	*-0.13***	*-0.20***	*-0.09****	*-0.17****	*-0.20****
Ddn,R=0	0.76	0.76	0.76	0.39	0.33	0.29	0.56	0.59	0.61	0.42	0.37	0.33
Ddn,R=1	0.64	0.80	0.88	0.43	0.35	0.30	0.47	0.36	0.29	0.26	0.09	0.04
Change	*-0.12***	*0.04*	*0.12*	*0.04*	*0.02*	*0.01*	*-0.09****	*-0.23****	*-0.32****	*-0.16****	*-0.28****	*-0.30****

Notes: These conditional probabilities are derived from the coefficient estimates shown in Table A2 and are evaluated at the specific inflation rates of 2%, 5% and 7%. P=prices, C=costs, D=demand, up=increase, nc=no change, dn=down, hence for example Pup=Prices up, and so on. R=Recent is the time contingent dummy variable which takes a value=1 from 2011Q2 and zero otherwise. *Change* is the absolute change in estimated conditional probability of a price change (under the equivalent cost and demand conditions) between Pre- and Post-2011Q2. Statistical significance is evaluated using the Delta method by applying the "margins" command in Stata and is denoted by asterisks: *** denotes p < 0.01; ** p < 0.05; * p < 0.10. Small differences between the recorded "Change (R=1)-(R=0)" and the respective reported values of the conditional probabilities are due to rounding to the nearest digit at the second decimal point.

6.2. Conditional probabilities of price changes by firm size

It is apparent from Table 3 that larger firms are more likely to sell online and are more sophisticated in their data driven decision making. As was noted earlier, price flexibility would therefore be expected to have increased in larger firms. Figure 4 shows the differences in the conditional probabilities of price increases for small firms (20≥employees) and large firms (200<employees). The differences in conditional probabilities represent the differences between the periods before and after 2011Q2. They are reported for different annual inflation rates and for each industry sector.[35] The estimated probabilities for all cases are shown in Table A4.

Figure 4 shows that for the Services sector, both small and large firms have experienced an increase in their conditional probability of rising prices Post-2011Q2 compared to the earlier years, for inflation rates above 2 per cent. The size of the Post-2011Q2 change tends to be larger for small firms. The firm size differences are small however, and in the situation when both costs and demand increase, there is no discernible difference between large and small firms in the size of the change in conditional probabilities of price change between the two periods. We therefore do not observe the expected relationship between size and price flexibility in the Services sector. Something else might be at play. Specifically, if technology reduces the fixed cost component of price review and menu costs, this will disproportionately benefit smaller firms who do adopt digital technology (and digital technology is more widespread in the Services sector).[36] In the Services sector it may be the case two differing forces regarding digital capability are operating: a higher prevalence of digital capability in larger firms, but a disproportionate benefit from digital capability to smaller firms.

In contrast, for Merchant and Manufacturing firms, larger firms display a more substantial increase in price flexibility in an upward direction than smaller firms; this is consistent with the hypothesis that higher investment in digital technology by larger firms will lower price review and menu costs of price adjustment and increase price flexibility. Larger Merchant and Manufacturing firms manage long and complex supply chains to source their physical goods meaning the price review process requires more inputs of information and managerial time. By contrast smaller firms in these sectors are more likely to source locally. Consequently, when information technology enhances the timeliness and quality of information on changes in supply chain costs, it disproportionately lowers price review costs for larger firms in these sectors and increases their price flexibility.

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[35] The low count of large building firms in our sample means it is not appropriate to do the size analysis for firms in the building sector. Hence, both Figure 4 excludes Building sector firms.

[36] In the presence of fixed costs for price review and menu costs, the prices posted by smaller firms will still be less sensitive to cost and demand pressures in absolute terms.

Figure 4: Change in conditional probabilities of a price increase by firm size
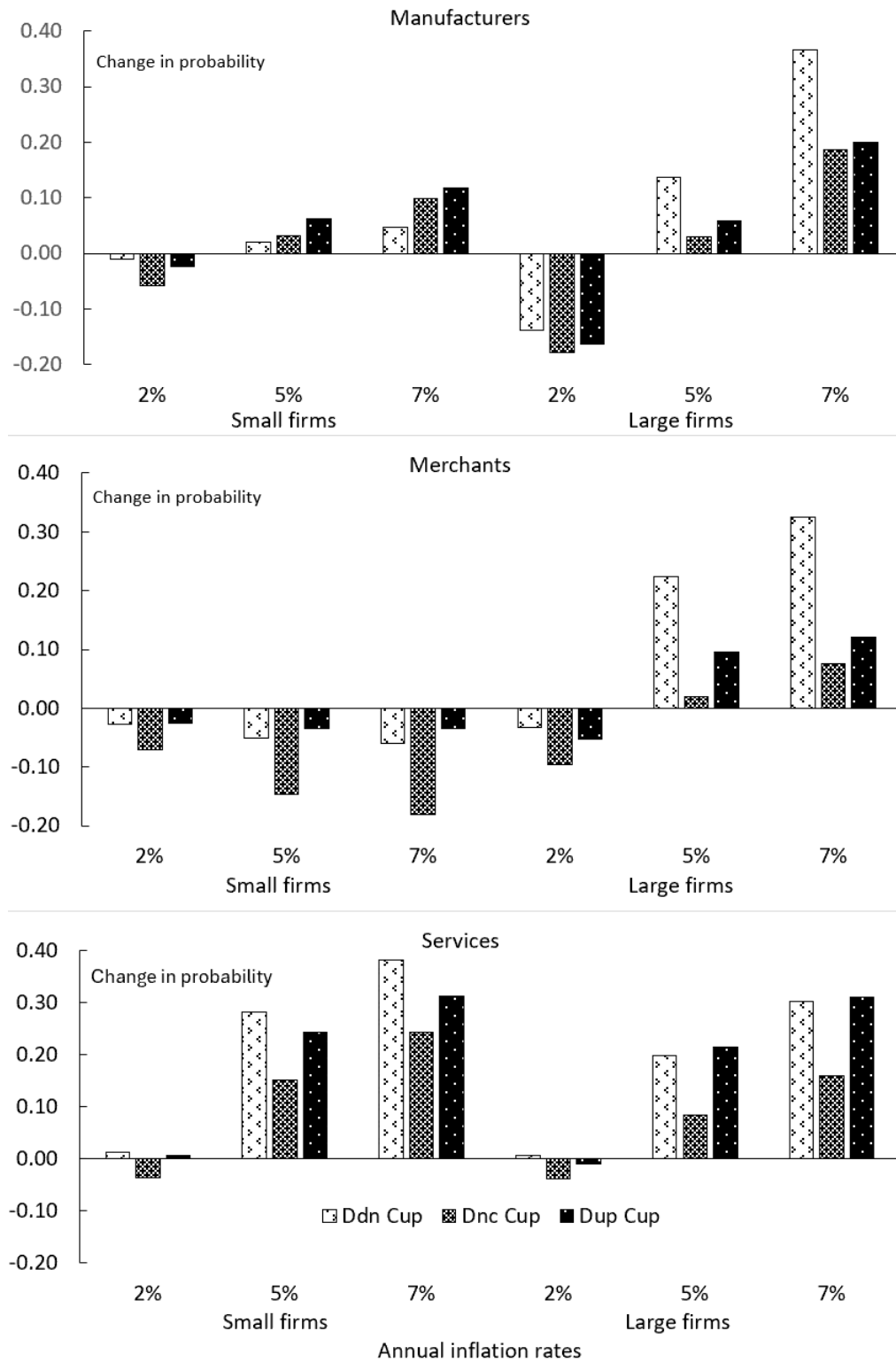
Notes: Derived from estimated conditional probabilities reported in Table A4. D=demand, C=costs, up=increase, nc=no change, dn=down, hence for example Dup=Demand up, Cup=Costs up, and so on.

Differences in estimated conditional probabilities of price decreases for large and small firms before and after 2011Q2 at different annual inflation rates and for each industry sector are also provided in Table A4. After disaggregating by sector and firm size, the number of counts of reported price decreases by firm size and sector during the Post-2011Q2 period are much smaller than during the Pre-2011 period. With this caution in mind, the results in Table A4 suggest that both small and large Services firms were less likely to drop their prices after 2011Q2. In the Merchant sector, smaller firms displayed more downward price stickiness in recent years compared to the earlier years, whilst for large firms an increase in downward price stickiness was only evident when both demand and costs fell. For Manufacturing firms, both small and large firms have become more responsive to reductions in costs and demand in recent years (consistent with price review and menu costs being lower) but, except for the demand down and cost down scenario, larger firms were more likely to drop prices than smaller ones. This is consistent with larger Manufacturing firms now having more real-time reliable information on supply chain costs and thus being more willing to act on the information.

7. Consumer behaviour, profit increases, and more acute price asymmetry

Technological changes are, of course, not the only possible explanation for why there have been changes in the conditional probability of price changes and an increase in the use of smaller but more frequent price changes. Moreover, technological change-based explanations predict increased price flexibility in both directions. It was observed in Section 5 that in aggregate, price flexibility has only increased in the upward, but not downward, direction; that is pricing behaviour has become more asymmetric. In this section, alternative explanations for why pricing asymmetry has become more acute are considered.

One alternative explanation draws on the idea of rational inattention by consumers to small price adjustments. Humans need to be selective in the information they process, otherwise they risk being overwhelmed (Sims, 2003). In the context of price adjustments, because tracking prices requires time and mental effort, consumers might be inattentive to small price changes. The result of this inattention is to push the elasticity of demand towards zero for small price changes. In such circumstances, Chen *et al.* (2008) and Levy *et al*. (2025) note that from a firm's point of view, small price increases might be valuable as they escape the notice of the customer and consequently elicit no demand response. By the same logic, small price decreases do not help the firm to increase demand because they too escape the notice of the customer. Levy *et al*. (2025, p2) states this means "the retailer has an incentive to make more frequent small price increases than decreases." That is, prices will display asymmetric behaviour. Using price scanner data, Chen *et al.* and Levy *et al*. confirm this prediction empirically. Small price increases occur more frequently than small price decreases. In a further test of the idea, Levy *et al*. predict pricing asymmetry should be negatively correlated with unemployment over the business cycle as unemployed people have more time to be attentive to price changes. They present empirical evidence that supports this conjecture.

Increased consumer inattention therefore may play a role in explaining the increased pricing asymmetry observed in the New Zealand firm pricing data. Owing to the length of the period subsamples (Pre- and Post-2011Q2), any increased inattention by consumers is unlikely to reflect business cycle induced differences in inattention as a result of unemployment in the two subsamples.[37] But perhaps an explanation lies in another labour market indicator: the participation rate.

In New Zealand, and like many other countries, there has been a rise in the percentage of woman of child-rearing age in the workforce. In 1986, in New Zealand, approximately 70 per cent of females between 25 and 49 years old were working. This percentage increased to just over 84 in 2024. Over the same period, the percentage of men working was relatively stable, falling slightly from 96 to 93 per cent.[38] These data suggest there has been a shift toward two parent working households. Given the competing demands on parental time in dual income households, it is reasonable to hypothesise that rising rates of two-parent working households may have contributed to greater household inattention to small price changes. In response to this increased inattention, smaller, more frequent price changes during periods of high inflation are optimal from the point of view of firms. Section 3 documents that in recent periods, the magnitude of price increases is smaller and more frequent for a given inflation rate, than in earlier decades. Further if, as argued above, increased inattention pushes the elasticity of demand on small price changes toward zero, it also suggests price increases should become more common, but price decreases less so. Again, this is consistent with what is observed in the more recent period (Post-2011Q2). Further, it is notable that this pricing asymmetry became more acute in the two sectors which are the most household facing: Merchants and Services.

Another possible explanation for the change in firm price setting behaviour relates to absolute and relative price confusion. When the price level is more volatile, which it is in periods of higher inflation, customers find it harder to distinguish between absolute and relative price changes. Scanlon (2024) presents a model which shows under such conditions, consumers are more likely to attribute a firm's price change to overall inflation rather than a shift in relative prices. This leads to a smaller demand response when relative price changes do occur and, as Scanlon shows, this allows firm markups to increase. In the most recent inflation episode, as a result of lost profits in 2020 when firms' trading was restricted by shelter-in-place (`lockdown') orders, perhaps firms were more willing than in the past to exploit this customer confusion (and perhaps reflecting increased consumer inattention as discussed in the previous paragraph) to restore profits and the firm balance sheet. Glover, *et al.* (2023) show that for the USA, firm mark-up growth contributed a "substantially larger contribution" to the rise of inflation in 2021 than during the preceding decade (p33).

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[37]Based on unemployment data from the Data1850 data source (https://www.nzier.org.nz/data-1850), the mean unemployment rate is comparable before and after 2011Q2 in our sample period (4.0 and 4.8 per cent, respectively).

[38] The data are sourced from Statistics New Zealand's Household Labour Force Survey via Infoshare. The figures presented are arithmetic averages across the participation rates reported for 25-29, 30-34,35-39,40-44 and 45-49 age groups for each gender. This is reported for 1986 as it is the first year Statistics New Zealand report age disaggregated data for participation rates.

Table 5: Conditional probabilities of profit increase when firms report no change in cost and demand:
Pre- and Post-2011Q2

Type of conditional probability:	Probability:			Change in probability (R=1)-(R=0):		
	2%	5%	7%	2%	5%	7%
Probability firms increase profit (all firms):						
Prob[Prup|Cnc, Dnc, R=0]	0.28	0.29	0.29			
Prob[Prup|Cnc, Dnc, R=1]	0.29	0.33	0.37	*0.00*	*.04****	*0.07****
Probability Builders increase profit:						
Prob[Prup|Cnc, Dnc, R=0]	0.26	0.27	0.28			
Prob{Prup|Cnc, Dnc, R=1]	0.22	0.29	0.33	*-0.03***	*0.02*	*0.06*
Probability Manufacturers increase profit:						
Prob[Prup|Cnc, Dnc, R=0]	0.30	0.30	0.30			
Prob{Prup|Cnc, Dnc, R=1]	0.28	0.30	0.31	*-0.02***	*0.00*	*0.01*
Probability Merchants increase profit:						
Prob[Prup|Cnc, Dnc, R=0]	0.31	0.32	0.33			
Prob{Prup|Cnc, Dnc, R=1]	0.32	0.37	0.42	*0.01*	*0.05***	*0.09****
Probability Services increase profit:						
Prob[Prup|Cnc, Dnc, R=0]	0.27	0.28	0.29			
Prob{Prup|Cnc, Dnc, R=1]	0.28	0.33	0.36	*0.01***	*0.05****	*0.07****

Notes: These conditional probabilities are derived from the coefficient estimates shown in Table A5 and are evaluated at the specific inflation rates of 2%, 5% and 7%. Pr=profitability, c=costs, d=demand, up=increase, nc=no change, dn=down; hence for example Prup=Profitability up, and so on. R=Recent and is the time contingent dummy variable which takes a value=1 from 2011Q2 and zero otherwise. Change (R=1)-(R=0) is the absolute change in the estimated conditional probability of a profit change (under the equivalent cost and demand conditions) between Pre- and Post-2011Q2. Statistical significance is evaluated using the Delta method by applying the "margins" command in Stata and is denoted by asterisks: *** denotes p <0.01; ** p <0.05; * p <0.10. Small differences between the recorded "Change (R=1)-(R=0)" and the respective recorded values of the reported conditional probabilities are due to rounding to the nearest digit at the second decimal point.

If firms have exploited consumer inattention or confusion during the recent high inflation, this should manifest in profit margins increasing as inflation rises. One test of this using the data available for this study is to evaluate changes in the conditional probability of profits increasing when costs and demand are unchanged (that is, under conditions where there is no change in the desired relative price).[39] The top panel of Table 5 shows the results for all firms. It is evident that there has been a significant change in the conditional probability of profits increasing as inflation rises. In the earlier decades, while the probability of an increase in profitability is positive, there is no discernible change as inflation rises. In the Post-2011Q2 period there is a systematic and significant rise in the probability of a rise in profitability as inflation increases. The changes between the Pre- and Post-2011Q2 periods

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[39] The QSBO questionnaire explained in Section 3 also asks firms to report their experience during the past three months concerning changes in profitability. This question was first included in 1969Q1 and has been included regularly since that date.

are statistically significant and consistent with the idea firms may be more inclined in recent years to exploit consumer confusion or inattention (or both).[40]

The other panels in Table 5 show the results for different types of firms. They reveal a significant difference in behaviour by firm type. For Merchant and Service firms there has been a significant increase during the Post-2011Q2 period in the probability that profits increase as inflation rises. There is no significant change by Builders and Manufacturers. The significant effect observed in the Merchant and Service sectors may arise because transactions in these sectors are typically smaller and involve a large variety of products, reducing consumers' incentive and ability to assess relative prices carefully and be attentive to price changes. In contrast, the larger transactions typical of Building and Manufacturing sectors encourage customers and firms to gather the necessary information to monitor prices carefully.

Institutional changes to monetary policy have taken place during the recent decades which might also be a factor contributing the changes in price adjustment behaviour that has been observed. Figure 2 showed a change in the relationship, in the aggregate, between the proportion of firms changing prices and inflation since the early 1990s. New Zealand implemented formal inflation targeting and central bank operational independence in 1989. If inflation targeting and central bank independence has better anchored inflation expectations, this means that in the event of a negative shock to relative prices, firms are less likely to expect general inflation to eventually restore the prevailing relative price to their desired lower relative price. This means firms are more likely to act and lower their relative prices themselves. If this reasoning is correct, inflation targeting and central bank independence should mean firm prices are more flexible in a downwards direction not less. This is not what we observe.

8. Conclusion

The frequency with which firms change prices has a critical influence on inflation dynamics. Using a unique database of micro firm-level information, this paper contributes new insights to the literature on price change in three important ways: (i) it reveals that the conditional probability of price change in response to cost and demand changes has changed in recent years; (ii) it documents that in the COVID inflation episode, firms changed their prices more often but by a smaller magnitude compared to previous comparable high inflation episodes; and (iii) it confirms prior findings of asymmetric pricing behaviour, but also finds that the asymmetric behaviour of the frequency of price changes has become more acute as inflation increases.

Time-series analysis reveals there has been an increase in the correlation between inflation and the proportion of firms changing prices since the early 1990s. This change has been masked by the long period of low inflation

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[40] The inattention and confusion channels posited here are likely enhanced by technology. Abrardi, *et al.* (2021) note dynamic pricing means consumers face constant price fluctuations. More generally, technology allows the implementation of more complex pricing strategies which make it harder for customers to isolate and respond to relative price movements.

after the early 1990s. This increased correlation is particularly evident when comparing behaviour during the COVID inflation era with behaviour during the high inflation episodes in the 1970s and 1980s. The proportion of firms changing prices during the COVID inflation episode was much higher than during earlier decades with similar average inflation rates and as high as the proportions observed during periods of much higher inflation during the 1970s and 1980s. This is especially evident with price increases, though a similar (inverse) pattern is evident with price decreases. The tighter correlation between the propensity of firms to change prices and inflation suggests the "inflation accelerator" is operating more strongly than in the past and the Phillips curve has become more nonlinear at higher levels of inflation.

Furthermore, the COVID era of inflation was not associated with a significant sustained rise in the magnitude of each price adjustment. The magnitude of price adjustments was on average, substantially smaller than occurred during earlier periods of high inflation. They were closer in magnitude to price adjustments during the low inflation of the "Great Moderation." This finding aligns with recent studies of the relative importance of the frequency and magnitude of individual price changes during the inflation experienced by the USA in the COVID era.

Ordered probit model estimates provide deeper insights into the reasons for these changes. There is a clear pattern whereby the probability of a price increase conditional on costs increasing (for any demand condition) rises as inflation rises. Moreover, the conditional probabilities are significantly higher in recent years, as inflation rises above 2 per cent. In the event of cost decreases, conditional probabilities of price decreases (for any change in demand) have fallen. This paper therefore reveals that pricing asymmetry has become more acute in recent years and this is especially evident during the COVID inflation era.

There are significant differences across industrial sectors and between small and large firms in the propensity to change prices. The rise in the conditional probability of price increases during the COVID inflation era compared to earlier episodes of similar inflation rates was much stronger among Services sector firms than for firms in other sectors. This tendency to increase prices has increased for both small and large firms in the Services sector and for larger firms in the Merchant and Manufacturing sectors. The conditional probability of firms decreasing prices in response to decreases in costs has fallen in the Services sector for small and large firms, and for small firms in the Merchants sector; this change is more evident at higher levels of inflation. The firm-level behavioural changes identified in this paper are most pronounced in the Services sector. Combined with the increasing prominence of Services in the overall economy, these changes have led to substantial shifts in aggregate pricing behaviour.

The rise in the conditional probability to increase prices is consistent with the idea that changes in information technology have the potential to both reduce the costs of price adjustment (both menu costs and price review costs) and reduce firms' propensity to 'wait and see' when considering price adjustment by improving the timeliness and quality of cost and demand information. The changes in pricing behaviour are also consistent with the growing body of evidence that online selling generates competitive pressures that result in more flexible prices

and greater pass-through of costs. These technologically based explanations, however, also predict that the conditional probability to decrease prices when cost and demand conditions warrant, should have increased. That is, prices should have also become more flexible downwards. We do not observe this. This decreased downward flexibility, and the increased use of smaller, but more frequent, price increases by firms is consistent, however, with a lower elasticity of demand to price changes. This lower elasticity of demand may reflect greater consumer inattention to small price changes, because of higher labour force participation and, consequently, more time-constrained households. The paper also reports a significant increase during recent years in the propensity for firms to increase profit margins as inflation increases under conditions when costs and demand do not change and therefore when there should be no change to firms' desired relative prices. This result is consistent with firms taking advantage of consumer relative and absolute price confusion or inattention (or both) to restore profits after COVID-19 related 'shelter-in-place' orders were lifted.

The results reported in this paper imply that inflation dynamics today, and certainly during the COVID inflation episode, are different to the dynamics of earlier decades. In view of the importance of price change frequency for understanding inflation dynamics, it would seem important that macroeconomic models, methods of forecasting of inflation, and the decision-making processes of central bank monetary policy committees recognise and adapt to these changes in pricing behaviour.

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Appendix

Table A1: Firm survey response counts by price, cost and demand sets, 1963 to 2024

Period:	1963Q3 to 2010Q4 (R=0)				2011Q1 to 2024Q3 (R=1)				1963Q3 to 2024Q3			
Inflation band: Price, cost, demand sets	%≤3	3<%<6	%≥6	Totals	%≤3	3<%<6	%≥6	Totals	%≤3	3<%<6	%≥6	Totals
Pup | Cup, Dup	1906	2095	4822	8823	1191	568	429	2188	3097	2663	5251	11011
Pup | Cup, Dnc	2361	2531	6576	11468	1667	1124	1058	3849	4028	3655	7634	15317
Pup | Cup, Ddn	1263	1340	3893	6496	996	796	663	2455	2259	2136	4556	8951
Pup | Cnc, Dup	823	396	363	1582	558	121	107	786	1381	517	470	2368
Pup | Cnc, Dnc	1008	517	404	1929	899	334	345	1578	1907	851	749	3507
Pup | Cnc, Ddn	428	233	213	874	391	145	185	721	819	378	398	1595
Pup | Cdn, Dup	268	96	98	462	59	16	#	7#	327	112	9#	53#
Pup | Cdn, Dnc	168	67	61	296	63	31	18	112	231	98	79	408
Pup | Cdn, Ddn	138	57	41	236	63	30	25	118	201	87	66	354
Total price increases	8363	7332	16471	32166	5887	3165	283#	1188#	14250	10497	1930#	4404#
Pnc | Cup, Dup	1389	1369	1992	4750	1216	276	67	1559	2605	1645	2059	6309
Pnc | Cup, Dnc	2149	1781	2507	6437	2411	578	278	3267	4560	2359	2785	9704
Pnc | Cup, Ddn	1408	1235	2142	4785	1251	422	205	1878	2659	1657	2347	6663
Pnc | Cnc, Dup	4485	2051	1520	8056	2930	329	99	3358	7415	2380	1619	11414
Pnc | Cnc, Dnc	9416	3890	2496	15802	9141	1545	537	11223	18557	5435	3033	27025
Pnc | Cnc, Ddn	3260	1591	1493	6344	2575	548	173	3296	5835	2139	1666	9640
Pnc | Cdn, Dup	854	286	147	1287	198	21	#	22#	1052	307	14#	150#
Pnc | Cdn, Dnc	755	215	132	1102	285	35	7	327	1040	250	139	1429
Pnc | Cdn, Ddn	411	168	106	685	197	49	15	261	608	217	121	946
Total no price changes	24127	12586	12535	49248	20204	3803	138#	2538#	44331	16389	1391#	7463#
Pdn | Cup, Dup	249	123	120	492	154	18	#	17#	403	141	125	66#
Pdn | Cup, Dnc	495	274	229	998	373	70	22	465	868	344	251	1463
Pdn | Cup, Ddn	630	392	409	1431	419	144	44	607	1049	536	453	2038
Pdn | Cnc, Dup	620	168	103	891	208	21	#	22#	828	189	10#	112#
Pdn | Cnc, Dnc	1062	373	180	1615	555	51	9	615	1617	424	189	2230
Pdn | Cnc, Ddn	1060	411	287	1758	474	64	19	557	1534	475	306	2315
Pdn | Cdn, Dup	567	140	74	781	112	10	#	12#	679	150	7#	90#
Pdn | Cdn, Dnc	618	156	90	864	191	15	#	21#	809	171	9#	107#
Pdn | Cdn, Ddn	728	235	156	1119	280	72	15	367	1008	307	171	1486
Total price decreases	6029	2272	1648	9949	2766	465	12#	335#	8795	2737	176#	1330#
Total counts by inflation band	38519	22190	30654		28857	7433	4333		67376	29623	34987	
Total responses per period				91363				40623				131986

Notes: Derived from the New Zealand Institute of Economic Research (NZIER) *Quarterly Survey of Business Opinion* database. P=prices, C=costs, D=demand, up=increase, nc=no change, dn=down; hence for example, Pup=Prices up, and so on. The two sub-periods list the response counts for the periods 1963Q3 to 2010Q4 (R=0) and 2011Q2 to 2024Q3 (R=1) referred to in Sections 5, 6 and 7 for analysis of the change in conditional probabilities of price and profitability changes. # denotes a digit between 0 and 9 and replaces the actual number of observations where that number is <6, to comply with the NZIER's data confidentiality requirements.

Table A2: Coefficient estimates from estimating equation 2: All firms and by sector

Coefficient	All	Builders	Manufacturers	Merchants	Services
b1(Cup)	0.613***	0.634***	0.598***	0.597***	1.115***
	(.013)	(.058)	(.027)	(.032)	(.025)
b2(π.Cup)	6.278***	10.808***	7.75***	18.461***	1.576***
	(.187)	(1.191)	(.33)	(.734)	(.322)
b3(Dup)	0.055***	0.284***	0.081***	0.238***	-.057**
	(.013)	(.067)	(.028)	(.042)	(.024)
b4(π.Dup)	0.657***	1.051	2.053***	1.201	1.862***
	(.19)	(1.417)	(.365)	(.753)	(.367)
b5(Cdn)	0.667***	0.88***	0.514***	0.679***	1.018***
	(.023)	(.149)	(.044)	(.061)	(.045)
b6(π.Cdn)	-3.288***	3.583	-4.226***	2.95*	-3.095***
	(.464)	(4.368)	(.774)	(1.551)	(1.181)
b7(Ddn)	0.388***	1.013***	0.581***	0.442***	0.309***
	(.015)	(.065)	(.031)	(.042)	(.026)
b8(π.Ddn)	-1.02***	-2.999***	-2.856***	0.489	-1.836***
	(.191)	(1.113)	(.357)	(.671)	(.428)
a1(Cup.Recent)	-.256***	-.515***	-.465***	-.268***	-.457***
	(.02)	(.087)	(.057)	(.051)	(.036)
a2(π.Cup.Recent)	8.123***	5.617**	9.247***	-2.396	18.139***
	(.501)	(2.233)	(1.584)	(1.567)	(.852)
a3(Dup.Recent)	0	0.234**	0.124*	0.014	-0.033
	(.023)	(.101)	(.066)	(.083)	(.037)
a4(π.Dup.Recent)	6.441***	-4.476	-0.081	4.885	9.18***
	(.736)	(3.509)	(2.341)	(3.089)	(1.125)
a5(Cdn.Recent)	0.078*	-.511*	0.326**	0.106	-0.058
	(.045)	(.304)	(.137)	(.138)	(.074)
a6(π.Cdn.Recent)	-8.409***	17.045	-4.764	-11.336**	-12.206***
	(1.548)	(11.531)	(6.024)	(5.739)	(2.414)
a7(Ddn.Recent)	-.136***	-.258***	-.159**	-0.096	-0.011
	(.023)	(.1)	(.07)	(.081)	(.038)
a8(π.Ddn.Recent)	-5.322***	1.533	3.004	-3.998*	-9.22***
	(.621)	(2.804)	(2.14)	(2.419)	(.987)
k_1 (down | nc)	-1.079***	-1.08***	-1.33***	-.999***	-1.468***
	(.014)	(.039)	(.022)	(.021)	(.016)
k_2 (nc | up)	0.881***	1.151***	1.28***	1.161***	1.005***
	(.012)	(.038)	(.022)	(.023)	(.013)
Observations	131,986	8,276	41,353	25,500	56,857
Likelihood Ratio chi^2	32,647	2,401	9,052	10,165	15,021
Prob>chi^2	0.000	0.000	0.000	0.000	0.000
Log likelihood	-104,178	-6,748	-32,976	-19,399	-42,034

Notes: C=costs, D=demand, up=increase, nc=no change, dn=down; hence for example, Cup=Costs up, and so on. Standard errors are reported in parentheses: ***p < 0.01; **p < 0.05; *p < 0.1. The model is estimated using the hetoprobit command in Stata which implements a version of the ordered probit model that allows for the variance to be a function of specified explanatory variables. In the model estimated on the full dataset the variance is modelled as a function of firm sector, firm size and the inflation rate; in the models estimated for each sector, the variance is modelled as a function of firm size (number of employees) and the inflation rate. Likelihood ratio chi-square is the Likelihood Ratio test statistic. The Likelihood Ratio test statistic calculates by how much the likelihood improves in the model when heteroskedasticity is allowed for versus a model where the variance is assumed to be homoskedastic. The specific formula for the test statistic is LR = -2(ln($L_{Heteroskedastic}$) − ln($L_{Homoskedastic}$)). If the null hypothesis is true, the Likelihood Ratio test statistic follows a chi-squared distribution with degrees of freedom equal to the number of additional variance parameters in the heteroskedastic version of the model. Prob>chi^2 is the probability based on the chi-squared distribution and the value of the Likelihood Ratio test statistic that one should accept the null hypothesis that there is no difference between the heteroskedastic version of the model and the homoskedastic version of the model in terms of likelihood.

Table A3: Coefficient estimates from estimating equation 2: Small and large firms

Coefficients	Builders		Manufacturers		Merchants		Services	
	Small	Large	Small	Large	Small	Large	Small	Large
b1(Cup)	.521***	.418**	.664***	1.236***	.482***	1.203***	1.052***	.887***
	(.091)	(.178)	(.047)	(.191)	(.042)	(.264)	(.033)	(.129)
b2(π.Cup)	13.632***	3.509*	7.633***	16.927***	18.711***	46.33***	1.479***	2.745***
	(2.26)	(1.857)	(.626)	(2.425)	(1.112)	(8.62)	(.405)	(.776)
b3(Dup)	.419***	.107	.076	.182	.213***	.499**	-.056*	.127**
	(.11)	(.077)	(.051)	(.118)	(.055)	(.207)	(.031)	(.051)
b4(π.Dup)	1.476	1.4	2.171***	4.523***	.639	2.77	1.93***	.26
	(2.762)	(1.398)	(.717)	(1.521)	(1.033)	(3.861)	(.497)	(.678)
b5(Cdn)	1.348***	.242	.469***	1.169***	.681***	1.272***	.75***	1.052***
	(.264)	(.157)	(.103)	(.205)	(.092)	(.331)	(.07)	(.156)
b6(π.Cdn)	-5.1	.445	.166	-15.724***	5.006**	5.79	1.637	-5.533***
	(7.604)	(4.014)	(2.09)	(3.273)	(2.157)	(7.027)	(2.082)	(1.912)
b7(Ddn)	1.185***	.352**	.651***	1.227***	.355***	1.187***	.239***	.268***
	(.108)	(.16)	(.054)	(.201)	(.052)	(.3)	(.031)	(.069)
b8(π.Ddn)	-2.529	-1.221	-4.215***	-5.528***	.441	5.451	-.993*	-2.393**
	(2.125)	(1.175)	(.683)	(1.545)	(.914)	(3.615)	(.533)	(.964)
a1(Cup.Recent)	-.263**	-.431*	-.445***	-2.841***	-.071	-1.562***	-.447***	-.343***
	(.122)	(.222)	(.081)	(.571)	(.061)	(.468)	(.04)	(.12)
a2(π.Cup.Recent)	3.16	5.594	10.888***	58.781***	-7.078***	38.314**	17.605***	11.626***
	(3.191)	(4.836)	(2.025)	(18.198)	(1.801)	(17.223)	(.937)	(4.081)
a3(Dup.Recent)	.131	.272	.174*	.114	.018	.098	-.041	-.151
	(.149)	(.184)	(.097)	(.467)	(.098)	(.563)	(.044)	(.097)
a4(π.Dup.Recent)	-5.316	-3.624	-1.519	6.021	5.917*	9.73	7.876***	11.613***
	(4.995)	(6.418)	(3.042)	(20.804)	(3.455)	(25.922)	(1.219)	(4.483)
a5(Cdn.Recent)	-1.032**	5.047	.447*	.818	-.242	.102	.169*	-.289
	(.435)	(730.724)	(.246)	(.636)	(.187)	(.813)	(.095)	(.185)
a6(π.Cdn.Recent)	45.066***	-405.811	-10.664	20.597	-9.312	6.938	-15.44***	-24.601**
	(17.241)	(54713.02)	(9.089)	(28.735)	(6.571)	(48.805)	(3.005)	(9.891)
a7(Ddn.Recent)	-.241*	-.145	-.287***	.621	-.001	.289	.042	.006
	(.138)	(.171)	(.099)	(.521)	(.091)	(.743)	(.042)	(.129)
a8(π.Ddn.Recent)	-.932	1.871	6.307**	-32.041	-5.613**	-36.665	-8.617***	-6.885
	(3.859)	(6.069)	(2.72)	(21.757)	(2.624)	(28.463)	(1.056)	(4.902)
K_1 (down |nc)	-1.301***	-.334**	-1.489***	-2.663***	-.927***	-2.232***	-1.42***	-1.111***
	(.073)	(.145)	(.047)	(.336)	(.033)	(.397)	(.027)	(.149)
k_2 (nc | up)	1.277***	.585**	1.434***	2.566***	1.068***	2.572***	.897***	1.03***
	(.072)	(.243)	(.046)	(.327)	(.037)	(.451)	(.019)	(.139)
Observations	5438	1011	15168	11185	13868	5516	37792	8215
Chi-squared	1391	369	2980	2581	5234	2379	10229	1916
Prob>chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	-4456	-813	-11264	-9662	-10531	-4226	-26783	-6849

Notes: Large firms are firms with more than 200 employees; small firms are firms with 20 or fewer employees. C=costs, D=demand, up=increase, nc=no change, dn=down; hence for example, Cup=Costs up, and so on. Standard errors are reported in parentheses: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. The model is estimated using the hetoprobit command in Stata which implements a version of the ordered probit model that allows for the variance to be a function of specified explanatory variables. The variance is modelled as a function of the inflation rate. Likelihood ratio chi-square is the Likelihood Ratio test statistic. The Likelihood Ratio test statistic calculates by how much the likelihood improves in the model when heteroskedasticity is allowed for versus a model where the variance is assumed to be homoskedastic. The specific formula for the test statistic is LR = -2(ln($L_{Heteroskedastic}$) – ln($L_{Homoskedastic}$)). If the null hypothesis is true, the Likelihood Ratio test statistic follows a chi-squared distribution with degrees of freedom equal to the number of additional variance parameters in the heteroskedastic version of the model. Prob>chi^2 is the probability based on the chi-squared distribution and the value of the Likelihood Ratio test statistic that one should accept the null hypothesis that there is no difference between the heteroskedastic version of the model and the homoskedastic version of the model in terms of likelihood.

Table A4: Conditional probabilities of price changes for small and large firms:
Pre- and Post-2011Q2

Type of Probability:	Sector	Size	Pre-2011Q2			Post-2011Q2		
			2%	5%	7%	2%	5%	7%

The probability of firms increasing prices (Pup) when costs increase (Cup) and …

Type of Probability:	Sector	Size	2%	5%	7%	2%	5%	7%
Dup	Manufacturers	small	0.35	0.44	0.50	0.33	0.50	0.61
Change (R=1)-(R=0)						*-0.02*	*0.06***	*0.12****
Dup		large	0.41	0.49	0.55	0.24	0.55	0.75
Change (R=1)-(R=0)						*-0.16****	*0.06*	*0.20**
Dup	Merchants	small	0.51	0.70	0.80	0.48	0.66	0.77
Change (R=1)-(R=0)						*-0.03*	*-0.04*	*-0.03*
Dup		large	0.52	0.70	0.79	0.46	0.79	0.91
Change (R=1)-(R=0)						*-0.05*	*0.10*	*0.12***
Dup	Services	small	0.57	0.60	0.63	0.57	0.85	0.94
Change (R=1)-(R=0)						*0.01*	*0.24****	*0.31****
Dup		large	0.52	0.55	0.57	0.51	0.76	0.88
Change (R=1)-(R=0)						*-0.01*	*0.21****	*0.31****
Dnc	Manufacturers	small	0.32	0.38	0.43	0.26	0.41	0.52
Change (R=1)-(R=0)						*-0.06****	*0.03*	*0.10****
Dnc		large	0.37	0.44	0.48	0.20	0.47	0.67
Change (R=1)-(R=0)						*-0.18****	*0.03*	*0.19*
Dnc	Merchants	small	0.43	0.62	0.73	0.36	0.47	0.55
Change (R=1)-(R=0)						*-0.07****	*-0.15****	*-0.18****
Dnc		large	0.44	0.62	0.72	0.35	0.63	0.80
Change (R=1)-(R=0)						*-0.10****	*0.02*	*0.08*
Dnc	Services	small	0.57	0.59	0.60	0.53	0.74	0.84
Change (R=1)-(R=0)						*-0.04****	*0.15****	*0.24****
Dnc		large	0.47	0.50	0.52	0.43	0.58	0.68
Change (R=1)-(R=0)						*-0.04*	*0.08**	*0.16***
Ddn	Manufacturers	small	0.18	0.26	0.32	0.17	0.28	0.37
Change (R=1)-(R=0)						*-0.01*	*0.02*	*0.05*
Ddn		large	0.24	0.32	0.37	0.11	0.46	0.74
Change (R=1)-(R=0)						*-0.14****	*0.14*	*0.37****
Ddn	Merchants	small	0.31	0.49	0.61	0.28	0.44	0.55
Change (R=1)-(R=0)						*-0.03*	*-0.05**	*-0.06*
Ddn		large	0.29	0.43	0.53	0.25	0.65	0.86
Change (R=1)-(R=0)						*-0.03*	*0.22***	*0.33****
Ddn	Services	small	0.49	0.52	0.54	0.50	0.80	0.92
Change (R=1)-(R=0)						*0.01*	*0.28****	*0.38****
Ddn		large	0.39	0.45	0.48	0.40	0.64	0.78
Change (R=1)-(R=0)						*0.01*	*0.20****	*0.30****

Table A4 (Cont.): Conditional probabilities of price changes for small and large firms:
Pre- and Post-2011Q2

			Pre-2011Q2			Post-2011Q2		
Type of Probability:	Sector	Size	2%	5%	7%	2%	5%	7%

The probability of firms decreasing prices (Pdn) when costs decrease (Cdn) and …

|			2%	5%	7%	2%	5%	7%
Dup	Manufacturers	small	0.19	0.18	0.18	0.21	0.14	0.10
Change (R=1)-(R=0)						*0.02*	*-0.03*	*-0.08*
Dup		large	0.25	0.19	0.16	0.36	0.34	0.33
Change (R=1)-(R=0)						*0.10***	*0.15*	*0.17*
Dup	Merchants	small	0.38	0.42	0.45	0.21	0.14	0.10
Change (R=1)-(R=0)						*-0.16****	*-0.28****	*-0.35****
Dup		large	0.33	0.34	0.35	0.32	0.30	0.28
Change (R=1)-(R=0)						*-0.01*	*-0.05*	*-0.07*
Dup	Services	small	0.27	0.27	0.27	0.20	0.06	0.02
Change (R=1)-(R=0)						*-0.08****	*-0.21****	*-0.24****
Dup		large	0.39	0.34	0.30	0.15	0.02	0.00
Change (R=1)-(R=0)						*-0.24****	*-0.32****	*-0.30****
Dnc	Manufacturers	small	0.22	0.22	0.22	0.28	0.19	0.14
Change (R=1)-(R=0)						*0.06*	*-0.03*	*-0.08*
Dnc		large	0.28	0.23	0.20	0.42	0.42	0.41
Change (R=1)-(R=0)						*0.14****	*0.18*	*0.21*
Dnc	Merchants	small	0.45	0.50	0.54	0.31	0.27	0.24
Change (R=1)-(R=0)						*-0.14****	*-0.24****	*-0.30****
Dnc		large	0.40	0.43	0.44	0.43	0.47	0.50
Change (R=1)-(R=0)						*0.03*	*0.05*	*0.06*
Dnc	Services	small	0.27	0.28	0.29	0.22	0.12	0.08
Change (R=1)-(R=0)						*-0.04***	*-0.16****	*-0.22****
Dnc		large	0.44	0.38	0.35	0.20	0.05	0.02
Change (R=1)-(R=0)						*-0.24****	*-0.33****	*-0.33****
Ddn	Manufacturers	small	0.37	0.34	0.32	0.39	0.30	0.25
Change (R=1)-(R=0)						*0.02*	*-0.03*	*-0.06*
Ddn		large	0.41	0.34	0.29	0.57	0.43	0.34
Change (R=1)-(R=0)						*0.15***	*0.09*	*0.05*
Ddn	Merchants	small	0.58	0.63	0.67	0.39	0.30	0.24
Change (R=1)-(R=0)						*-0.19****	*-0.34****	*-0.43****
Ddn		large	0.57	0.61	0.64	0.54	0.45	0.40
Change (R=1)-(R=0)						*-0.03*	*-0.16*	*-0.24*
Ddn	Services	small	0.34	0.35	0.35	0.25	0.09	0.04
Change (R=1)-(R=0)						*-0.09****	*-0.26****	*-0.32****
Ddn		large	0.52	0.43	0.38	0.22	0.04	0.01
Change (R=1)-(R=0)						*-0.29****	*-0.40****	*-0.37****

Notes: These conditional probabilities are derived from the coefficient estimates shown in Table A3 and are evaluated at the specific inflation rates of 2%, 5% and 7%. P=prices, C=costs, D=demand, up=increase, nc=no change, dn=down; hence for example, Dup=Demand up, and so on. Owing to a lack of large building firms in the sample, the size analysis for firms in the building sector is not undertaken. Large firms are firms with more than 200 employees; small firms are firms with 20 or fewer employees. Change (R=1)-(R=0) is the absolute change in the estimated conditional probability of a price change (under the equivalent cost and demand conditions) between Pre- and Post-2011Q2. Statistical significance is evaluated using the Delta method by applying the "margins" command in Stata and is denoted by asterisks: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Small differences between the recorded "Change (R=1)-(R=0)" and the respective recorded values of the reported conditional probabilities are due to rounding to the nearest digit at the second decimal point.

Table A5: Ordered probit estimation of equation 2 for profitability changes when firms report no change in cost and demand conditions: Pre- and Post-2011Q2

Coefficients	All firms	Builders	Manufacturers	Merchants	Services
Cnc	-.589***	-.485***	-.700***	-.565***	-.649***
	(.016)	(.06)	(.03)	(.036)	(.025)
π.Cnc	1.175***	1.224	.586	2.123***	1.424***
	(.227)	(.979)	(.386)	(.549)	(.43)
Cdn	.746***	.309**	1.336***	.606***	.586***
	(.03)	(.155)	(.051)	(.068)	(.052)
π.Cdn	1.961***	-5.721	1.131	.833	.305
	(.601)	(3.988)	(,866)	(1.311)	(1.484)
Dnc	.957***	.839***	.889***	.923***	1.204***
	(.019)	(.065)	(.031)	(.037)	(.027)
π.Dnc	-.413***	.186	-1.232***	-.409	.124
	(.174)	(.793)	(.325)	(.318)	(.372)
Ddn	-2.212***	-2.094***	-2.079***	-2.036***	-2.732***
	(.034)	(.081)	(.042)	(.057)	(.04)
π.Ddn	1.944***	2.502***	1.848***	1.12**	2.35***
	(.242)	(.77)	(.385)	(.544)	(.564)
Cnc.Recent	-.029	-.141	-.039	-.089	.037
	(.023)	(.09)	(.059)	(.065)	(.035)
π.Cnc.Recent	2.343***	1.033	.184	1.563	2.172***
	(.654)	(2.601)	(2.139)	(2.304)	(.923)
Cdn.Recent	-.081	-.318	-.17	.15	-.015
	(.058)	(.317)	(.142)	(.158)	(.087)
π.Cdn.Recent	-15.691***	6.956	-10.415	-8.144	-16.766***
	(2.141)	(10.356)	(6.732)	(5.889)	(3.207)
Dnc.Recent	-.053**	-.113	-.094	.013	-.077**
	(.023)	(.09)	(.058)	(.053)	(.035)
π.Dnc.Recent	2.356***	5.297***	2.59	3.928***	2.175***
	(.555)	(2.029)	(1.6)	(1.442)	(.828)
Ddn.Recent	.144***	.169	.291***	.089	.231***
	(.032)	(.111)	(.075)	(.094)	(.048)
π.Ddn.Recent	-4.235***	-4.597*	-3.921*	-.589	-6.614***
	(.793)	(2.6)	(2.153)	(2.289)	(1.193)
k1 (down | nc)	-.024***	-.874***	-.905***	-.649***	-.551***
	(.004)	(.041)	(.022)	(.027)	(.016)
k2 (nc | up)	.077***	1.141***	.88***	1.071***	1.376***
	(.002)	(.047)	(.021)	(.03)	(0.2)
Observation	125363	7864	36886	24134	56479
Chi-squared	36779	2402	10263	4027	21125
Prob>chi2	0.000	0.000	0.000	0.000	0.000
Log likelihood	-111704	-6467	-33573	-22947	-48072

Notes: These estimated versions of equation 2 for profitability changes include the combination of reported demand and cost conditions Cnc, Cdn and Dnc, Ddn, where nc=no change. Standard errors are reported in parentheses: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. Model is estimated using the hetoprobit command in Stata which implements a version of the ordered probit model that allows for the variance to be a function of specified explanatory variables. In the model estimated on the full dataset the variance is modelled as a function of firm sector, firm size and the inflation rate. Likelihood ratio chi-square is the Likelihood Ratio test statistic. The Likelihood Ratio test statistic calculates by how much the likelihood improves in the model when heteroskedasticity is allowed for versus a model where the variance is assumed to be homoskedastic. The specific formula for the test statistic is LR = -2(ln($L_{Heteroskedastic}$) − ln($L_{Homoskedastic}$)). If the null hypothesis is true, the Likelihood Ratio test statistic follows a chi-squared distribution with degrees of freedom equal to the number of additional variance parameters in the heteroskedastic version of the model. Prob>chi^2 is the probability based on the chi-squared distribution and the value of the Likelihood Ratio test statistic that one should accept the null hypothesis that there is no difference between the heteroskedastic version of the model and the homoskedastic version of the model in terms of likelihood.

Figure A1: The duration of prices and the average magnitude of each price adjustment
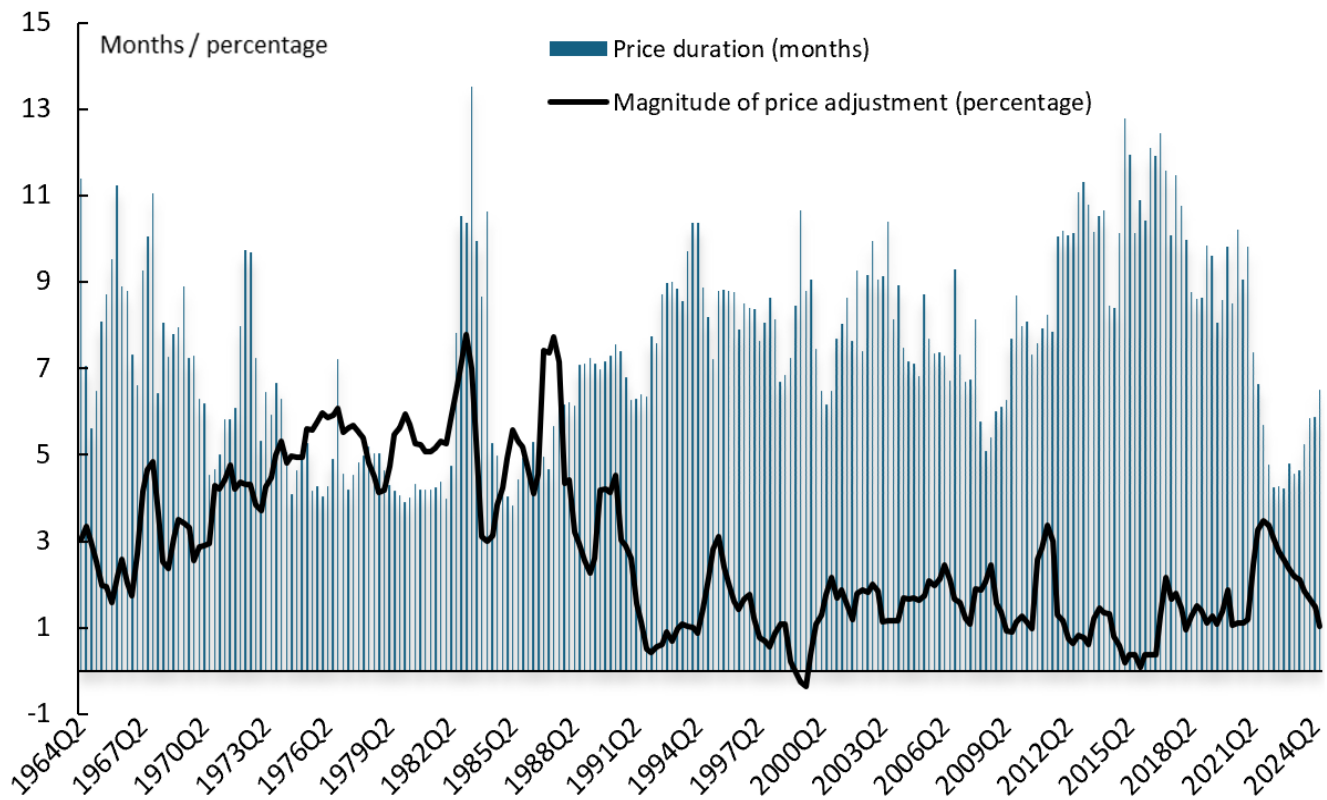
Notes: Authors' own calculations using QSBO and Statistics NZ data and the method explained in Section 4.2.