# Inflation dynamics

by

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# Abstract

This thesis studies inflation dynamics, investigating both reasons why prices change, and why they sometimes do not. It investigates four areas that are of interest to monetary policy makers, but where our knowledge is incomplete.

The first area investigated is the causes of price stickiness at the firm level. Insight is given by a large survey of price-setting behaviour of New Zealand firms. There is a large degree of heterogeneity in price-setting practices between, and within, sectors. Explicit contracts, implicit contracts and strategic complementarity are the most widely recognised causes of price rigidity. Menu costs and sticky information are not widely recognised.

The second area investigated is how exporters price, and in particular the decisions over currency of invoice and whether to differentiate prices across markets. In sharp contrast to commonly held views, we find that primary sector firms do differentiate prices across markets. Indeed, these firms are more likely to do so in New Zealand than firms in other sectors. Larger, and more productive firms, are more likely to differentiate prices.

This thesis then studies the influence that global inflation factors have on domestic inflation. A CPI database for 223 countries and territories extends the previous research, which focuses on high income countries. Global factors explain a large share of the variance of national inflation rates in advanced countries, but not for less developed countries. More generally, global factors have greater influence in countries with higher GDP per capita, financial development and central bank transparency. Global factors explain a large share of the variance of food and energy prices but a much smaller share of the variance of other sub-components.

Finally, this thesis carries out the first systematic analysis of the impact on inflation of disasters caused by natural hazards. There is a large degree of heterogeneity, with disasters having little significant effect in advanced countries, but having effects that can persist for years in developing economies. There are also differences between types of disasters and sub-indices of inflation. Storms have a short-run impact on food price inflation that lasts for the first two quarters, before being reversed in the subsequent two. Earthquakes reduce CPI inflation excluding food, housing and energy.

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# Disclaimer

The opinions, findings, recommendations and conclusions expressed here are those of the author and not necessarily those of the Reserve Bank of New Zealand, nor Statistics New Zealand. Statistics NZ and the Reserve Bank of New Zealand take no responsibility for any omissions or errors in the information contained here.

Access to data used in this study was provided by Statistics NZ in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular business or organisation. The results in this paper have been confidentialised to protect individual businesses from identification.

Careful consideration has been given to the privacy, security, and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from www.stats.govt.nz.



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# Contents

# Chapter 1

# Introduction

Inflation dynamics – when, why and by how much prices change – is a key concern of monetary policy makers, especially given the widespread adoption of inflation targeting. In the quarter of a century since it was first introduced by the Reserve Bank of New Zealand in 1989, all the major central banks have adopted some form of inflation target. Yet the transmission of monetary policy to inflation is subject to "long, variable and uncertain" lags (Friedman, 1961), requiring monetary policy makers to pay close attention to the drivers of inflation and to understand the inflation process.

The literature on inflation, and monetary policy more generally, is vast. Rather than attempt to review such a large literature, this thesis instead focuses on four areas that are of interest to monetary policy makers, but where our knowledge is incomplete. The aim of the analysis here is to reduce these gaps in our knowledge through answering four questions: *Why are prices sticky*? *How do exporters set their prices*? *What is the role of global inflation factors in driving domestic inflation*? *What is the impact of disasters on inflation*? These questions are answered in turn in the following chapters of this thesis.

The first question relates to what causes firms to change prices, and why they choose at times to not change. The aggregation of individual firm decisions across the economy results in the measured inflation rate.

The existence of rigidities – price stickiness – at the level of the firm has an important bearing on the ability of monetary policy to affect output. While many theories abound on the causes of price stickiness, differentiating between the competing theories is more problematic. Analysing the responses to the first price-setting survey carried out in New Zealand provides insight to the underlying causes of price stickiness.

How exchange rate movements pass into prices has bearing on monetary policy transmission. It is a widely attested phenomenon that movements in the domestic prices of internationally traded goods are much smaller than the corresponding move in the exchange rate, particularly in more developed economies. There are a number of potential causes of this exchange rate 'disconnect', with the focus here on how exporters set prices.

The influence of global factors on domestic inflation extends beyond movements in exchange rates. Recent research has found that movements in global inflation factors can account for a large share of the variance of national inflation rates. Yet the literature to date has for the most part focused on a small group of high income countries. A CPI database of 223 countries and territories, collected from national and international sources, allows this question to be investigated at a truly global level.

The final question studied in this thesis is how disasters caused by natural hazards – such as earthquakes, storms and floods – affect inflation. Of the four gaps in our knowledge studied here, the effect of disasters is probably the most significant. Despite the frequency of these events throughout the world, and the potential for massive economic disruption, very little is known about the impact on prices. The analysis here is the first systematic attempt to quantify the impact of disasters on inflation.

## 1.1 Why are prices sticky?

Modern macroeconomic models, such as the Dynamic Stochastic General Equilibrium (DSGE) models commonly used by central banks, are 'micro-founded', which is to say derived from the optimising behaviour of individual agents in the economy. Such models are typically unable in pure form to match the persistence witnessed in real world data. As a result, the models used by central banks incorporate a number of rigidities to increase the persistence of variables, notably inflation (for example, see Christiano et al., 2005; Smets and Wouters, 2007; Kamber et al., 2015).

These rigidities are often implemented in an ad hoc fashion, and the purpose of chapter 2 is to investigate the types of nominal rigidities that delay firms from changing price. The responses to a 2010 purpose-built survey on price-setting by New Zealand firms provide the basis for this analysis. Using surveys to understand firms pricing behaviour is not new – Hall and Hitch (1939) developed the now-familiar kinked demand curve from the responses to their survey. The use of surveys was reinvigorated by Blinder et al. (1998) and there have been recent country surveys for the euro area (Fabiani et al., 2006) and the United Kingdom (Greenslade and Parker, 2012). The survey used here is the first such survey for New Zealand.

The advantage of behavioural surveys is that they allow the differentiation between competing theories that are unobservable in the micro price data. For example, it is not possible to tell using price quote data whether prices remain unchanged because of explicit, formal contracts, or because of firms' perception of the level of competition. Similarly, by asking firms separately about the timing of price reviews (when firms assess available information to decide on what the optimal price is) and actual price changes it is possible to differentiate between theories that rely on rigidities at different points in the pricing process.

The responses to the survey point to a wide heterogeneity in pricing behaviour by New Zealand firms. There is a notable divergence between sectors, but also *within* sectors, with many sectors having both firms that reset prices on a daily basis and those that reset prices less frequently than annually. The median number of times a New Zealand firms reviews its prices is twice per year, but the median number of changes is one.

In terms of the underlying causes of price stickiness, the rigidity that firms were most likely to cite as being 'very important' for not changing prices is explicit contracts. Implicit contracts, where the firm wishes to maintain an ongoing relationship and does not wish to antagonise its customers, was the second most recognised reason. Firms selling to households and individuals were less likely overall to cite these reasons, suggesting that price stickiness is more a function of producer rather than retail, prices. There is little support in the responses for two popular theoretical justifications for stickiness – menu costs and sticky information.

## 1.2 How do exporters set their prices?

It is a well documented fact that domestic prices of internationally traded goods move by less than the exchange rate. This incomplete pass-through, frequently termed 'exchange rate disconnect' is the subject of a large literature. There are a number of reasons why the dynamics of traded goods price inflation and the exchange rate may differ. In chapter 3 we consider two of these channels: *local currency pricing*, where exporters choose to price in currencies other than their own, and *pricing to market* where firms choose to vary mark-ups and the price of their product, expressed in common currency terms, differs between countries.

The responses of a survey of 1281 New Zealand exporters are used to study the factors that contribute to the decisions of exporters to invoice in foreign currency and to price to market. There are a number of advantages to using surveys relative to the unit record customs data more commonly used in the literature. First, the survey explicitly asks firms whether the price (in domestic currency terms) is the same across all markets. Customs data do not, of themselves, include information on the domestic market, so is unable to identify cases where the export price (even if common to all foreign destinations) is different from the domestic price.

Second, the survey used here covers the service sector. Customs data require the physical movement of goods across borders, so is silent on the pricing behaviour of service sector firms, who account for a significant share of advanced countries exports. Third, the survey directly asks firms the reasons for choosing to differentiate prices between markets. It also provides other information on the exporters to permit a more thorough understanding of the firm characteristics that contribute to the decisions on invoice currency and whether to price to market.

The responses point a large majority of primary sector firms pricing to market. Indeed, even accounting for other firm characteristics, primary sector firms are *more* likely to price to market than firms in other sectors. This finding is in stark contrast to the assumption in the literature that the price for such products is determined by the balance of international demand and supply and is consequently the same across countries.

In terms of firm characteristics, larger and more productive firms are more likely to price to market. Primary sector firms aside, there is no difference across sectors of firms' decision to price to market once other firm characteristics are accounted for. Conversely, the sector that a firm operates in has a large bearing on the decision on currency of invoice.

## 1.3 What is the role of global inflation factors in driving domestic inflation?

The past decade has witnessed large movements in international commodity prices, which have affected domestic consumer prices, particularly the prices for food and energy. Recent research has highlighted the role of global factors in determining domestic inflation, with the share of inflation variance explained by global factors estimated as high as 70 percent (Ciccarelli and Mojon, 2010).

The literature on the subject has to date mostly focused on a small group of advanced economies. To consider 'global' inflation in a truly global context, chapter 4 details the collection of a database of quarterly consumer price indices for headline (all items), food, housing, energy and the remainder of the index. The database covers 223 countries and territories over the period 1980 to 2012. While headline figures are readily available from international sources such as the IMF's *International Financial Statistics*, the majority of sub-indices had to be obtained from national sources. Every feasible effort has been made to make the sub-indices comparable between countries by adhering as closely as possible to internationally recognised classifications.

This database is used to construct a number of measures of global inflation. These measures do explain a large share of the variance of national inflation rates in advanced economies, confirming the previous findings in the literature. However, as the level of development decreases, so does the share of national inflation explained by global inflation. Very little of the variance of low income countries is explained by the global measure.

Analysis by sub-index suggests global measures mostly account for movements in food and energy prices, which are also the most volatile sub-indices. In terms of explaining differences across countries, greater GDP per capita, higher financial development and higher central bank transparency are all associated with a greater influence of global factors. These findings confirm the existence of global factors influencing domestic inflation rates, but also suggest the observed large share in advanced economies is also a function of the success of monetary policy in reducing domestically generated variation.

## 1.4 What is the impact of disasters on inflation?

The final question investigated in this thesis is the impact of large shocks on inflation. The DSGE models used by central banks are linearised around steady state and are therefore ill suited for considering the impact of a large shock that moves the economy far from steady state. Yet these large shocks can have massive implications for welfare. Barro (2009) estimates the welfare cost of these rare, but extreme, events at 20 percent of output, far beyond the 1.5 percent estimated welfare cost of normal business cycle fluctuations.

Chapter 5 studies the impact on inflation dynamics of one class of large shocks – large disasters caused by natural hazards, such as earthquakes, storms and floods. In the context of complex economic interrelationships, studying these shocks is appealing since the underlying hazard is unrelated to the economy. Much progress has been made in recent years in understanding the impact of such disasters on output (e.g. Noy, 2009; Loayza et al., 2012; Fomby et al., 2013), yet little is known about the impact on inflation. Indeed, Cavallo and Noy (2011) in their recent survey of the literature on disasters point to the effect on prices as being one of the main remaining gaps in our knowledge of disasters. The analysis in chapter 5 is the first systematic study undertaken of the impact of disasters on inflation.

The analysis combines two large databases. The first is the database on consumer prices, whose collection is set out in chapter 4. This database is the only one with widespread coverage of CPI sub-indices. Differing types of disasters may have distinct effects on individual sub-indices. The second database is the EM-DAT database collected by the Centre for Research on the Epidemiology of Disasters at the University of Louvain. It contains information on a wide range of disasters, including number of people killed, number of people affected and (less frequently) damage caused. This database is widely used in the literature and is the only one with widespread coverage that is publicly available at this time.

The analysis confirms a wide heterogeneity in the impact of disasters. The impact of disasters in advanced countries is for the most part insignificant, whereas in developing countries the impact is significant and can last for several years following the disaster. There is also heterogeneity in the impact by type of disaster and by CPI sub-index. For example, storms have a short-run impact on food price inflation that lasts for six months before being reversed in the subsequent six-month period. Earthquakes reduce CPI inflation excluding food, housing and energy.

# Chapter 2

# Why are prices sticky?

## 2.1 Introduction

Price-setting behaviour of firms determines inflation dynamics and is of crucial importance for monetary policy. Nominal rigidities in prices affect monetary policy's ability to influence real activity.[1] For example, suppose the money supply doubles. The efficient response is for all prices in the economy to double, and real quantities to remain unaffected. But if prices do not immediately adjust to the doubling of the money supply, then falls in nominal interest rates translate into falls in *real* interest rates, stimulating the economy and increasing output until prices adjust.

Great progress in our understanding of the firm-level drivers of price rigidity has been made in recent years, principally using the price quotes used in the construction of consumer and producer price indices.[2] These studies provide useful information on the timing and size of price changes, which allows indirect empirical estimation of the relevance of competing theories.

[1] Recent work by Bhattarai et al. (2014) finds that the source of the shock and the response of monetary policy can affect the impact of price flexibility on output.

[2] See Klenow and Malin (2010) and Nakamura and Steinsson (2013) for excellent summaries of the micro price data literature.

This chapter takes an alternative identification approach by analysing the responses to a survey that directly asks firms about their pricing behaviour. The advantage of behavioural surveys is that they allow the differentiation between competing theories that are unobservable in the micro price data. For example, it is not possible to tell using price quote data whether prices remain unchanged because of explicit, formal contracts, or the effects of firms' perception of the level of competition. Similarly, by asking firms separately about the timing of price reviews (when firms assess available information to determine what the optimal price is) and actual price changes it is possible to differentiate between theories that rely on rigidities at different points in the pricing process.

The use of surveys to answer questions about pricing behaviour was reinvigorated by Blinder (1991) and Blinder et al. (1998), who survey US firms on their price-setting behaviour and the sources of price stickiness. There have been several follow-up surveys in other countries, including surveys for Sweden (Apel et al., 2005), Canada (Amirault et al., 2006), the euro area (Fabiani et al., 2006), Australia (Park et al., 2010) and the United Kingdom (Greenslade and Parker, 2012).

The New Zealand survey is the largest country survey carried out to date, with a markedly superior response rate (see table 2.10 in the appendix). It has more than twice the respondents of the next largest survey, and over 25 times the number of respondents in Blinder (1991). It is also the first such survey that covers all non-government sectors in the economy. The survey was carried out in 2010 under the auspices of Statistics New Zealand's annual Business Operations Survey.

The survey contained a number of questions around pricing behaviour. Put simply, a firm's optimal price will change when supply and / or demand conditions in a firm's market change. Not changing price when the optimal price changes means that there is some form of rigidity preventing prices from changing. This article focuses on the questions relating to how frequently firms review and change prices, and the factors that prevent more frequent changes – i.e. the causes of price rigidity. The theories of price rigidity of particular focus are:

**Explicit contracts** : where the firm agrees with its customers to fix the price of its good or service for a period of time. Contributions to this theory include Fischer (1977) and Barro (1977).

**Implicit contracts** : where firms are reluctant to increase prices since this might encourage customers to search for a new supplier (see Okun, 1981). This theory also considers concepts of 'fairness' – that customers accept price increases caused by increases in costs, but are 'angered' by price increases following higher demand (e.g. Rotemberg, 2005).

**Strategic complementarity** : where the optimal price for a firm is a function of its competitors' prices. Ball and Romer (1990) show that strategic complementarity can increase nominal rigidity and Gertler and Leahy (2008) show that when strategic complementarity is strong enough price stickiness in a state-dependent model can match that of a time-dependent model. Indirect attempts to estimate the extent of strategic complementarity (e.g. Kryvtsov and Midrigan, 2013; Bils et al., 2012) find little or no evidence of its presence.

**Menu costs** : are costs involved in actually changing price (e.g. Sheshinski and Weiss, 1977; Akerlof and Yellen, 1985; Mankiw, 1985). In the presence of such costs prices, firms will typically only change once the optimal price diverges sufficiently from the current price, resulting in sticky prices.

**Sticky information** : There are a number of theories that point to the review stage as the source of price stickiness. These theories posit that the costs of gathering and processing the information required to assess the optimal price prevent the regular updating of prices.

Mankiw and Reis (2002) propose a model of sticky information. In this model, firms receive infrequent updates to the information required to assess optimal prices. In the absence of new information, firms continue along their previous pricing schedule – a case of 'sticky price plans' rather than sticky prices. It follows that firms with sticky information would change more frequently than review prices since planned changes would take place even in the absence of new information.

**Multi-product firms** : recent research highlights that the price-setting practices of multi-product firms diverge from those firms selling just one product, resetting prices more frequently, and carrying out a greater proportion of smaller price changes (Bhattarai and Schoenle, 2014). Midrigan (2011) models multi-product firms assuming economies of scope in price-setting – once a firm changes one price it is able to reset its price for its other products without further costs. Alvarez and Lippi (2014) demonstrate analytically that such behaviour in multi-product firms increases the size and duration of output effects from a monetary shock.

Studies of price-setting behaviour in New Zealand have to date been rare. Buckle and Carlson (2000) use qualitative survey responses to Quarterly Survey of Business Opinion (QSBO). They find that large firms (as measured by number of employees) change prices more frequently than smaller firms, which they attribute to lump sum menu costs that are proportionately larger for smaller firms. Coleman and Silverstone (2007) also use data from the QSBO, finding considerable heterogeneity in price-setting behaviour.

The survey analysed here is the first purpose-designed behavioural survey carried out in New Zealand, and is superior to the QSBO for the purposes of understanding firms' price-setting behaviour in a number of dimensions. First, the questions are specifically designed to elicit the underlying causes of price stickiness, including understanding the differing influences on the review and change stages of the price-setting process. Second, there are a markedly higher number of respondents. Finally, the firms are carefully stratified and sampled across all private sector industries to accurately represent the make-up of firms in the New Zealand economy.

The responses to the survey point to large heterogeneity in price-setting behaviour both within and between sectors. Most sectors had some firms that did not change price over the previous year, as well as some firms that change price on a daily frequency. The median number of price reviews is twice over the previous year, but the median annual number of price changes is one. There is also marked heterogeneity in price-setting behaviour by firm size, with larger firms resetting prices more frequently. This is in line with the previous research on New Zealand and with the findings of Goldberg and Hellerstein (2009). Multi-product firms reset prices more frequently, even taking into account other firm characteristics. Price stickiness is more prevalent in firm-to-firm transactions, with those firms selling to households and individuals changing prices more frequently.

Explicit and implicit contracts are the most cited reasons for firms to leave prices unchanged. This is an important finding since such contracts are not reported in the micro price data, and evidence in the literature on their existence is sparse. Strategic complementarity, where a firm's optimal price depends on its competitors' prices, is also commonly cited as being very important in preventing price increases. Physical (menu) costs involved in changing prices are rarely viewed as being important. There is little support for the costs of gathering information having an impact on the frequency of reviews.

## 2.2 Survey design and characteristics of respondents

### 2.2.1 Survey design

The data used here originate from the 2010 Business Operations Survey carried out by Statistics New Zealand in August 2010.[3] The module on price and wage setting was funded by the Reserve Bank of New Zealand, the University of Tasmania and Victoria University of Wellington. The author provided advice on questions to the Reserve Bank, who set the preliminary questions. These preliminary questions were then trialled by Statistics New Zealand to test for comprehension. The survey was administered by Statistics New Zealand, with access to the individual repsonses provided under the Statistics Act 1975.

The target population was businesses on Statistics New Zealand's Business Frame with an annual GST turnover greater than NZD 30,000 and at least 6 employees. Firms operating in public administration and safety were excluded, as were local government enterprises, the central bank and non-profit institutions in the service of households. The final estimated population size of firms was 35,307 enterprises. The sample design was a two-level stratification, firstly by Australia and New Zealand Standard Industrial Classification 2006 (ANZSIC06) industrial sector, and then by firm size within each sector, as determined by number of employees. The four employment size groups were small (6-19 employees), medium 1 (20-29 employees), medium 2 (30-49 employees) and large (50+ employees). The reporting stratification for publication is slightly different from that used in the sample stratification, with the firm employment sizes used here be-

[3]See http://www.statistics.govt.nz/browse_for_stats/businesses/business_growth_and_innovation/business-op-survey-2010-tables.aspx for a full description of the survey. A full copy of the survey questionnaire is available at http://www2.stats.govt.nz/domino/external/quest/sddquest.nsf/12df43879eb9b25e4c256809001ee0fe/6233ea80fe191165cc25777d007a8490/$FILE/BOS%202010_Sample.pdf

ing: small (6-19 employees), medium (20-100 employees) and large (100+ employees).

The survey was sent to a random sample of firms within this sampling frame. Firms were asked to report on the most recently completed financial year prior to the sampling date. The survey had 5369 replies, a response rate of 81.8 percent and comprising approximately one firm in seven of the total population of firms.

One problem associated with surveys is the bias associated with self-selection of responses. The mitigating factor for this survey is that firms are legally obliged to respond to survey requests from Statistics New Zealand, which reduces the incidence of self-reporting bias. The response rate for this survey is far superior to the response rates of other surveys in the literature, which are typically below 50 percent (see table 2.10 in the appendix).

To reduce the impact of any sample composition bias, the results presented here have been re-weighted to represent the population of firms, using weights provided by Statistics New Zealand. These weights are calculated within each industry and firm size stratum such that multiplying each firm in the sample by its weight will deliver the number of firms in the total population in each stratum. The mean weight of firms is 6.6, with around 80 percent of firms having a weight less than 10. That the vast majority of individual firm weights are close to the overall sample to population ratio suggests that the sample stratification was successful in delivering a representative sample.

It should be noted that these weights deliver aggregate and sectoral statistics that are firm-count weighted, so emphasise the behaviour of the more numerous smaller firms. Firms with more employees in general have a greater share of sector value added than those with fewer, so a sector aggregate based on output (perhaps of more interest to macroeconomic policymakers) could potentially differ from the results shown here. To account for this potential difference, the aggregate results for each question are also presented using employment weights, calculated by dividing the aggregate employment in each stratum derived from Statistics New Zealand's 2010 Business Demography Survey by the number of firms in that stratum.[4] Data for output by employment size and by industry are unfortunately not available.

### 2.2.2 Relevance of survey questions for price-setting behaviour of respondents

Economic theory on pricing concentrates on profit-maximising firms that are able to determine their own price. Previous surveys (e.g. Blinder et al., 1998; Amirault et al., 2006; Greenslade and Parker, 2012) consequently excluded firms in certain sectors from their sample, notably in primary industries and in the health and education sectors. Prices in primary industries[5] were assumed by these authors to be set by the balance of supply and demand in international markets and firms consequently assumed to be price-takers. Similarly, firms operating in the health and education sectors often have some form of regulatory control over pricing.

The New Zealand survey includes these sectors in its sampling frame, but asks firms who reviews and sets the prices. For the primary sectors, the assumption made by previous papers has some validity – less than half of the firms in the primary sectors set their own prices. Three quarters of firms surveyed in the health and education sectors set their own prices, although the survey excludes local government enterprises, such as public hospitals, which account for a large share of activity in those sectors. The

[4] Pre-school and school education and hospitals were excluded on the assumption that the majority of employment within these industries would primarily be in the state sector.

[5] Respondents have been grouped into broad sectors to aid presentation of results. These broad sectors are primary (agriculture, fishing, forestry and extraction), industry (manufacturing, electricity, gas and other fuels), distribution (wholesale and retail), government services (health and education) and private services (all remaining service sectors)

share of businesses that set their own prices within the other sectors is much higher – reaching 95 percent for industry and construction. In the following analysis, the data presented relate only to those firms that are responsible for setting their own prices.

### 2.2.3 Customer groups

The survey indicated that a large proportion of transactions takes place between firms. 57 percent of respondents identified other businesses as the main customers for their product or service. Of those business customers, firms outside of the business group are the largest customer type, followed by retailers and wholesalers. Households are the next largest customer group, with 45 percent of respondents.

Firms in the industry sector are much less likely to sell to individuals or households, with 87 percent of these firms selling primarily to businesses. A fifth of firms in the government services sector sold their product or service primarily to the government. In terms of firm size, smaller firms are more likely to sell direct to households, whereas a higher proportion of larger firms sold to retailers and other businesses.

There is a large degree of continuing customer relationships, with three quarters of firms having at least half of their customers return for repeat business. This high degree of repeat customers is consistent with the customer markets theory of pricing, (see e.g. Bils, 1989). Firms whose main customers are households are less likely to have repeat customers – only 62 percent of these firms had more than half their customers returning, compared with 87 percent of firms with other main customer types.

## 2.3 Frequency of price reviews and changes

The literature on price setting makes the distinction between two stages of the process for setting prices. In the first stage, the firm gathers information as to what the optimal price (or potentially the optimal pricing strategy) may be. In the second stage, the firm decides on whether it should change its current price to, or at least towards, this optimal price. The advantage of a behavioural survey over price-quote data is that it permits understanding of these two stages separately.

### 2.3.1 Are prices time or state dependent?

There are some costs associated with reviewing and changing prices, which are discussed in greater detail below. As a result of these costs, most firms do not continuously adjust prices.[6] The literature differentiates between two forms of price setting: *time-dependent* and *state-dependent* pricing. Time-dependent pricing is where price resets happen as a function of time. In some models the time between price reset is fixed, e.g. Taylor (1980), in others the opportunity to reset prices is random, (e.g. Calvo, 1983). In state-dependent models, the price is changed in reaction to shocks. Such models typically assume a cost of changing prices, (e.g. Sheshinski and Weiss, 1977; Dotsey et al., 1999). The consequence of these costs is that firms do not change prices until a shock occurs that is large enough to create sufficient divergence between the current and optimal price for it to be worthwhile to change price.

The survey asked firms whether they reviewed prices at regular intervals, in response to specific events, or a combination of the two strategies. A quarter of firms review prices at regular intervals only, 15 percent did so in response to events, and the majority (61 percent) use the combined strategy. These response rates are similar across sectors and firm sizes. This suggests that using time-dependent pricing in a model of the economy is appropriate in 'normal' times, but there is a risk that price-setting behaviour could deviate markedly from model predictions in the presence

[6]As shown below, 5 percent of firms review their prices daily, which could be viewed as effectively continuous.

of large shocks.

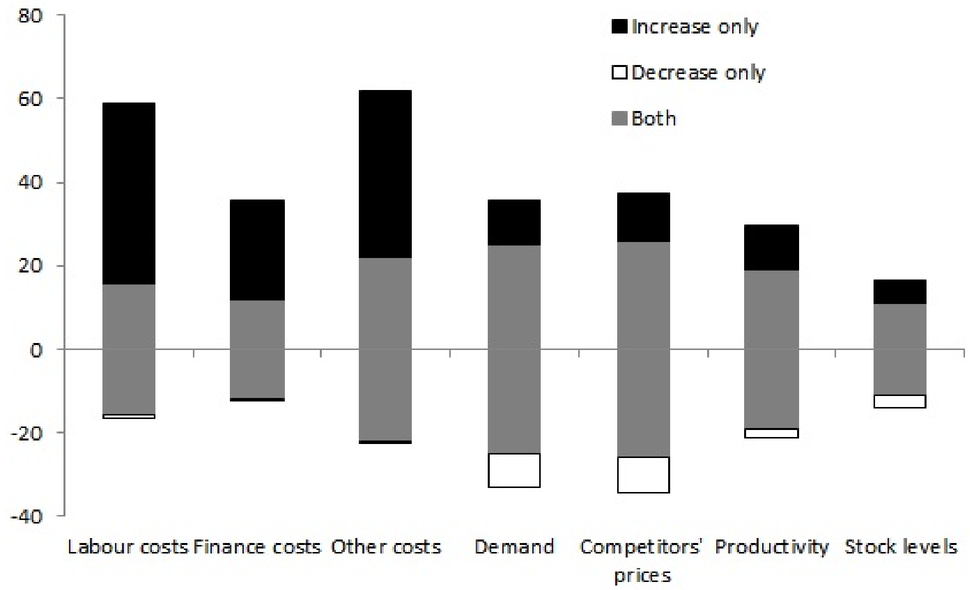
### 2.3.2 What factors influence prices?

Firms were asked which factors were important for price setting, indicating whether these factors were always important, or whether there is an asymmetry between increases and falls in these factors. Figure 2.1 sets out the average response, with a larger bar indicating a greater proportion of firms citing this factor as being important for price changes. 'Other costs' (e.g. purchases of goods form suppliers, rent) are viewed as the most important factor affecting prices, followed by labour costs, competitors' prices and demand. Productivity, finance costs and the number of competitors are seen as important factors by just over half of firms. However, the majority of firms did not view inventories as an important factor affecting prices.

There are some notable asymmetries, with costs in particular being more important for price rises than price falls. The number of firms citing costs as being important for price increases is noticeably larger than the proportion of firms citing these reasons as being important for only price falls. This asymmetry of responses for the importance of costs is in keeping with the findings of Coleman and Silverstone (2007).

Conversely, the number of firms citing demand as being important for only price increases is approximately the same as those who said it only affected price decreases. The response that demand is important for both price increases and decreases is much bigger than either of the previous one-sided responses, implying a symmetric response. Given this symmetric response to changes in demand, there may not be much difference in price-setting behaviour through the cycle. These results for the importance of demand contrast with the findings of Coleman and Silverstone (2007), who find that demand changes are far more important for price decreases than increases.

Figure 2.1: Factors that affect price changes (percent of firms citing factor as important for price changes)




To some extent, asymmetry in response to costs may reflect the evolution of such costs. Nominal wages rarely fall, so respondents may not have experience of price setting following lower labour costs. Further, while labour costs may be important for the price level of a firm, it does not necessarily translate into more frequent price resets. Only 7 percent of firms in the sample reset wages more frequently than once per year, with 30 percent doing so less frequently than annually (Armstrong and Parker, 2016).

The survey took place in August 2010, immediately following the global financial crisis. Financing costs for banks had increased, and were passed on to some customers, although these increases were offset to an extent by the low Official Cash Rate of the Reserve Bank of New Zealand. Half of firms had no change to their interest rates or fees, whereas 31 percent faced an increase, and 18 percent had a decrease. Unlike labour costs (with downward nominal wage rigidity), the asymmetry in response to finance costs cannot be attributed to one-sided evolution of the relevant cost. That said, firms that had experienced increased interest rates or fees over the previous year were more likely to indicate that finance costs were important for price increases than firms that had experienced constant or falling interest rates. This evidence is in line with the role played by financial frictions in pricing behaviour found by Gilchrist et al. (2015).

Other costs include raw materials and other intermediate inputs. Sectors where a high percentage of firms reported 'other costs' as not affecting price changes tended to be those with a low share of intermediates in gross output. Similar to finance costs, the costs of inputs can fluctuate both positively and negatively. There appears to be little relationship between the reported asymmetry of pricing responses by firms and the fluctuations in input prices for their industry over the previous five years.

### 2.3.3 How frequent are price reviews?

Firms that claimed some form of time dependence in their price reviewing process were asked to give the frequency at which prices are reviewed. The responses display considerable heterogeneity; 10 percent of firms review prices at least weekly, whereas a third of firms review prices either yearly or less frequently (table 2.1). There are also large divergences in the responses by firm size and sector. Larger firms are likelier to review prices at more frequent intervals than small firms. Firms in the distribution sector review prices more frequently – a quarter of these firms review prices at least weekly, compared with 6 percent of private services firms and 9 percent of firms in industry.

Table 2.1: Frequency of price reviews (percent of firms)

| | Daily | Weekly | Monthly | Quarterly | Half-yearly | Annually | Less than annual | Specific events only |
|---|---|---|---|---|---|---|---|---|
| *Firm size* | | | | | | | | |
| Small | 5 | 6 | 13 | 14 | 14 | 28 | 5 | 16 |
| Medium | 5 | 4 | 14 | 15 | 14 | 31 | 4 | 13 |
| Large | 9 | 10 | 13 | 14 | 11 | 31 | 2 | 10 |
| *Sector* | | | | | | | | |
| Primary | 5 | 12 | 6 | 16 | 8 | 28 | 5 | 22 |
| Industry | 5 | 4 | 12 | 17 | 15 | 27 | 6 | 14 |
| Distribution | 12 | 14 | 18 | 15 | 13 | 12 | 2 | 15 |
| Private serv. | 3 | 3 | 10 | 15 | 14 | 36 | 5 | 14 |
| Gov't serv. | 0 | 0 | 2 | 6 | 12 | 61 | 9 | 10 |
| *Overall* | | | | | | | | |
| Pop. wgt. | 5 | 5 | 13 | 14 | 14 | 29 | 5 | 15 |
| Emp. wgt. | 6 | 8 | 13 | 13 | 12 | 32 | 4 | 12 |

The effect of these factors on the frequency of price review can be estimated using an ordered probit model. Firms are aggregated into three categories, based on the frequency of review: frequent (daily, weekly, monthly), medium (quarterly and half yearly) and slow (annual or less frequent). Table 2.2 shows the estimated average marginal effects for this model. A model with seven categories (daily, weekly, monthly, quarterly, half-yearly, annually, less frequent than annual) yields qualitatively similar results.

Taking into account other characteristics of the firms, large firms are more likely to review more frequently than small firms. A large firm is 4 percent more likely than a small firm to review prices at frequent intervals. This finding is in keeping with the cross-sectional results, but the estimated magnitude is somewhat small, suggesting that large firms have other characteristics beyond size that contribute to more frequent reviews.

The sector that the firm operates in appears to have the greatest bear-

Table 2.2: Average marginal effects on frequency of review

| Evaluated at: | Frequent | Medium | Slow |
|---|---|---|---|
| *Firm size* | | | |
| Small | *reference* | *reference* | *reference* |
| Medium | 0.004 | 0.001 | −0.005 |
| Large | 0.042** | 0.009** | −0.051** |
| *Sector* | | | |
| Primary | *reference* | *reference* | *reference* |
| Industry | 0.029 | 0.006 | −0.035 |
| Construction | 0.158** | 0.006 | −0.164** |
| Distribution | 0.237** | −0.011 | −0.225** |
| Private services | −0.061** | 0.023** | 0.084** |
| Gov't services | −0.195** | −0.159** | 0.354** |
| *Main customer* | | | |
| Firms within group | *reference* | *reference* | *reference* |
| Households | 0.071** | 0.017** | −0.088** |
| Retailers | 0.006 | 0.001 | −0.008 |
| Firms outside group | 0.015 | 0.004 | −0.019 |
| Government | 0.006 | 0.001 | −0.007 |
| *Perceived performance* | | | |
| Lower profitability | −0.015 | −0.004 | 0.018 |
| Higher profitability | −0.008 | −0.002 | 0.010 |
| Lower productivity | −0.002 | −0.001 | −0.003 |
| Higher productivity | 0.042** | 0.010** | −0.052** |
| Perceived competition | 0.041** | 0.010** | −0.051** |
| Multiple products | 0.056** | 0.014** | −0.069** |

Notes: *Significant at 5 percent and ** at 1 percent. Frequent review firms are those that review at daily, weekly or monthly frequency, 'medium' firms are those that review at half-yearly or quarterly frequency. 'slow' firms review prices annually or less frequently.

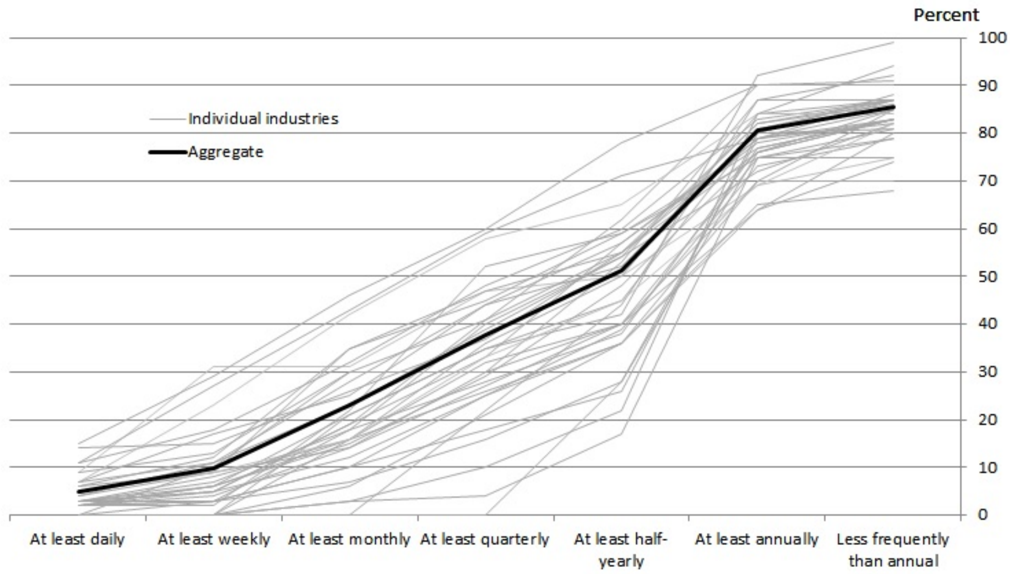
ing on frequency of price reviews. Firms in distribution and construction review prices more frequently, even accounting for customer type and perceived competition (see below). Conversely, firms in the service sectors review prices less frequently. This may be due to the relatively higher share of labour costs for these firms. Armstrong and Parker (2016) find that wages are reviewed infrequently in New Zealand, with only 7 percent of firms changing wages more frequently than annually, and 30 percent of firms doing so less frequently than annually. Firms whose main customers are households are more likely to review at high frequencies, but other types of customers do not appear to affect the frequency of review.

Firms were asked how they perceived their profitability and productivity relative to other firms in their sector.[7] Perceived profitability appears to have no effect on the frequency of price reviews. However, firms that believe they are more productive than their competitors are more likely to review prices at more frequent intervals than firms who believe their productivity to be in line with the sector average. The responses to the profitability and productivity questions are closely aligned, so considering profitability by itself is significant. Firms selling more than one product review prices more frequently for their main product or service than firms selling just one product (see section 2.4.5 below for a more detailed discussion of multi-product firms).

The wide heterogeneity of price reviews between industries is displayed in figure 2.2, which shows the cumulative share by frequency of reviews for each of the 36 industries. Furthermore, there is wide heterogeneity within industries, with most industries containing firms that review prices daily and those that do so less frequently than annually.

[7] Fabling et al. (2012) find that these perceptions of relative productivity align with actual relative productivity.

Figure 2.2: Cumulative distribution of firms, by frequency of price review




## 2.3.4 How frequent are price changes?

Firms were asked how many times they changed prices in the most recent financial year. The picture is one of notable price rigidity. Around a quarter of firms had not changed prices, and a further 36 percent changed prices only once (table 2.3). Only 12 percent of firms changed prices more than six times over the previous year, with a further 12 percent changing it between three and six times. Larger firms change prices more frequently than smaller firms, resulting in an employment-weighted overall result slightly more flexible than a firm-count weighted one.

Split by sector, prices are notably stickier among service-sector firms. Only 8 percent of firms in government services, and 34 percent of firms in private services change prices more than once. This contrasts with the distribution sector, where 60 percent of firms change prices more than once.

An ordered probit was carried out to investigate the factors that influ-

Table 2.3: Frequency of price changes, last financial year (percent of firms)

| | Zero | Once | Twice | 6 times or less | 26 times or less | 182 times or less | More than 182 times |
|---|---|---|---|---|---|---|---|
| *Firm size* | | | | | | | |
| Small | 26 | 36 | 16 | 12 | 5 | 3 | 2 |
| Medium | 21 | 37 | 17 | 13 | 7 | 4 | 2 |
| Large | 15 | 36 | 12 | 15 | 8 | 7 | 6 |
| *Sector* | | | | | | | |
| Primary | 26 | 31 | 15 | 11 | 8 | 6 | 2 |
| Industry | 21 | 40 | 18 | 11 | 5 | 2 | 3 |
| Distribution | 16 | 24 | 18 | 19 | 10 | 8 | 4 |
| Private services | 27 | 39 | 17 | 10 | 4 | 2 | 1 |
| Government services | 29 | 63 | 6 | 2 | 0 | 0 | 0 |
| *Overall* | | | | | | | |
| Firm pop. weighted | 24 | 36 | 16 | 12 | 6 | 4 | 2 |
| Employment weighted | 20 | 37 | 14 | 14 | 7 | 5 | 4 |

ence the number of price changes over the previous year. Firms were split into three categories: sticky (two price changes or less), medium (3 - 26 price changes) and flexible (more than 26 price changes).[8] The results for price changes are unsurprisingly similar to those for price reviews, given the likely endogeneity of the decision to review prices (table 2.4).

There is a clear difference in results by firm size, with large firms the most likely to appear in the flexible category, followed by medium-sized firms, and then small firms. Firms in construction are 9 percent less likely to be in the sticky category, relative to primary sector firms and distribution firms are 17 percent less likely. Firms in private services are 11 percent more likely than primary firms to be in the sticky category, and government services firms are fully 31 percent more likely. These estimated marginal effects are large, and suggest that the sector that the firm operates in plays a very important role in deciding the frequency of price changes. To an extent, sector should be expected to have an impact. To the extent that a firm's optimal price depends on the prices of competitors (see section 2.4.2 below), it is unlikely to be optimal for a firm to reset its price less frequently than annually when the competitors do so daily.

Firms selling to households and those facing higher perceived competition are more likely to appear in the flexible category. Similarly those firms who believe they are more productive than their competitors and those firms selling multiple products made more frequent price changes.

### 2.3.5 Comparison with surveys of other economies

The large heterogeneity in the frequency of price changes is a feature of previous price-setting surveys (table 2.5). The median number of price changes over one year by a New Zealand firm is one, which is similar to that found in other small open economies. But there appears to be a greater level of price stickiness, with only 40 percent resetting prices more

[8] A seven category ordered probit delivers similar qualitative results.

Table 2.4: Average marginal effects on frequency of price change

| Evaluated at: | Flexible | Medium | Sticky |
|---|---|---|---|
| *Firm size* | | | |
| Small | *reference* | *reference* | *reference* |
| Medium | 0.032** | 0.031** | −0.063** |
| Large | 0.069** | 0.056** | −0.125** |
| *Sector* | | | |
| Primary | *reference* | *reference* | *reference* |
| Industry | −0.020 | −0.016 | 0.037 |
| Construction | 0.054* | 0.031* | −0.085* |
| Distribution | 0.120** | −0.051** | −0.171** |
| Private services | −0.057** | −0.056** | 0.113** |
| Gov't services | −0.123** | −0.187** | 0.310** |
| *Main customer* | | | |
| Firms within group | *reference* | *reference* | *reference* |
| Households | 0.023* | 0.020* | −0.043* |
| Retailers | 0.007 | 0.006 | −0.012 |
| Firms outside group | 0.017 | 0.015 | −0.032 |
| Government | −0.007 | −0.006 | 0.014 |
| *Perceived performance* | | | |
| Lower profitability | 0.001 | 0.001 | −0.002 |
| Higher profitability | −0.010 | −0.009 | 0.019 |
| Lower productivity | −0.000 | −0.000 | 0.001 |
| Higher productivity | 0.025** | 0.021** | −0.047** |
| Perceived competition | 0.027** | 0.023** | −0.050** |
| Multiple products | 0.034** | 0.029** | −0.063** |

Notes: *Significant at 5 percent and ** at 1 percent. 'Sticky' firms changed prices two times or less, 'medium' changed 3 - 26 times and flexible changed more than 26 times.

Table 2.5: International comparison of frequency of price changes per year (percent of firms)

| Price changes per annum | New Zealand | Australia | Canada | Euro area | United Kingdom[(a)] | United States |
|---|---|---|---|---|---|---|
| $\geq 4$ | 24 | 33[(b)] | 59 | 14 | 30 | 35 |
| 2-3 | 16 | 12[(b)] | 8 | 20 | 18 | 16 |
| 1 | 36 | 40 | 27 | 39 | 39 | 39 |
| $< 1$ | 24 | 15 | 8 | 27 | 13 | 10 |
| Median | 1 | 1 | 4 | 1 | 1 | 1.4 |

Notes: (a) The responses for the United Kingdom have been adjusted for the actual number of price changes made by firms that responded 'irregularly' or 'other' to the frequency of price changes. (b) Estimate, based on Park et al. (2010) Graph 1, p11. Sources: Australia (Park et al., 2010), Canada (Amirault et al., 2006), the euro area (Fabiani et al., 2006), the United Kingdom (Greenslade and Parker, 2012), the United States Blinder et al. (1998).

than once, compared with 48 percent in the United Kingdom, 51 percent in the United States and 67 percent in Canada. Similarly, 24 percent of firms did not reset prices in the previous year, compared with 13 percent in the United Kingdom, 10 percent in the United States and 8 percent in Canada.

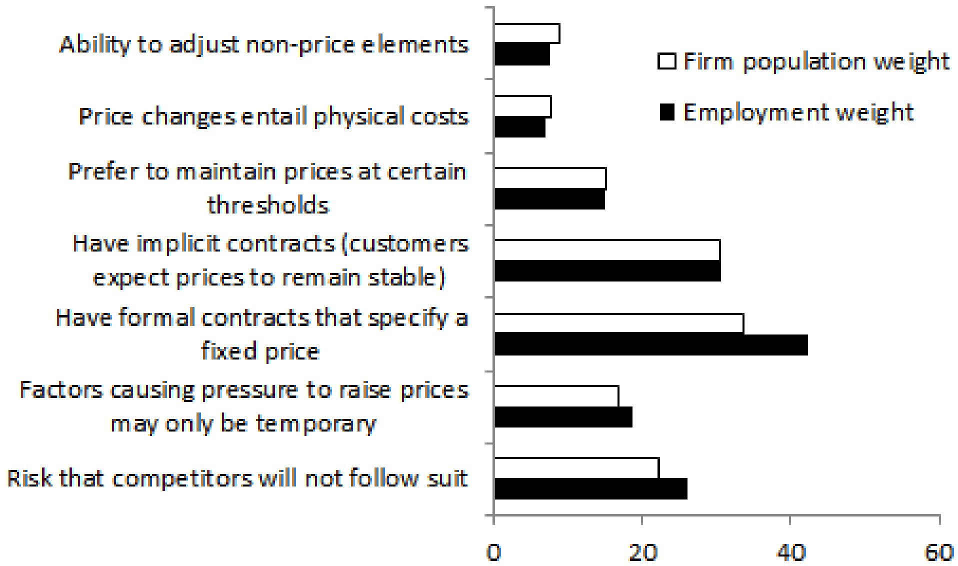
As noted above, the New Zealand survey draws responses from a wider range of sectors than previous surveys in other countries. This raises the possibility that differences between surveys may arise from differences in sectoral composition between economies, or between sampling strategies. But comparing the responses of individual sectors in New Zealand, the euro area and the United Kingdom still highlights divergence. For example only 17 percent of distribution firms in the euro area change prices more than 3 times a year, compared with 41 percent in New Zealand and 54 percent in the United Kingdom. These results suggest that the differences between country survey results are not solely down to differences in sectoral composition.

## 2.4 Sources of price rigidity

There are many potential reasons proposed in the literature on the causes of price stickiness. Since many of these theories are observationally equivalent using price quote data, it has been difficult to differentiate between them. The advantage of a survey is that it is possible to ask firms to rate some of these factors in terms of their importance in preventing price increases, and their impact on the price review process.

Explicit and implicit contracts are most widely recognised as being 'very important' for causing price stickiness (figure 2.3). Strategic complementarity is the third most recognised. Physical menu costs are not widely perceived as being a factor preventing price increases.

Figure 2.3: Factors that prevent price increases (percent of firms citing factor as 'very important')




In the rest of this section, differing theories of price stickiness are explored in greater detail using firms' responses to the survey.

### 2.4.1 Explicit and implicit contracts

There is little empirical evidence for explicit contracts – studies based on price quotes are unable to distinguish whether a price remains unchanged because of a contract or otherwise.

Firms were asked what proportion of customers are on long-term (at least one year) contracts. Half of firms had no customers on long-term contracts, whereas a fifth had more than half of their customers on such contracts. Use of long-term contracts is more prevalent among larger firms, with 29 percent of large firms having the majority of their customers on long-term contracts compared with 18 percent of small firms.

Firms that have a majority of their customers on long-term contracts exhibit a greater degree of price stickiness. Only 27 percent of firms with the majority of their customers on long-term contracts changed price more than once, compared with 39 percent of firms who had a minority of customers on long-term contracts and 45 percent of firms with no long-term contracts.[9]

Table 2.6 shows the average marginal effects from an ordered probit on the proportion of customers that a firm has on long-term fixed price contracts. Firms were split into three categories: those with no customers on fixed price contracts, those with a minority of customers on long-term contracts (50 percent or less), and those with a majority (51 percent or more). Larger firms are 13 percent more likely than small firms to have the majority of customers on long-term contracts. This increased likelihood for long-term contracts is interesting, given that larger firms in general change prices more frequently than small firms. There may be some legal costs involved in setting up contracts, which may provide a barrier to smaller firms.

There are some differences by sector, with firms in the services sectors more likely to use long-term contracts, but those in the distribution sector

[9] 7 percent of firms answered 'don't know' to this question. The price change behaviour of these firms was similar to those who answered 'none'.

Table 2.6: Average marginal effects on proportion of customers on long-term contracts

| Evaluated at: | None | Minority | Majority |
|---|---|---|---|
| *Firm size* | | | |
| Small | *reference* | *reference* | *reference* |
| Medium | −0.084** | 0.013** | 0.071** |
| Large | −0.145** | 0.014** | 0.131** |
| *Sector* | | | |
| Primary | *reference* | *reference* | *reference* |
| Industry | 0.047 | −0.011 | −0.036 |
| Construction | −0.069 | 0.009 | 0.060 |
| Distribution | 0.127** | −0.038** | −0.088** |
| Private services | −0.138** | 0.007 | 0.132** |
| Gov't services | −0.163** | 0.002 | 0.161** |
| *Main customer* | | | |
| Firms within group | *reference* | *reference* | *reference* |
| Households | 0.224** | −0.025** | −0.199** |
| Retailers | 0.032 | −0.004 | −0.028 |
| Firms outside group | 0.045* | −0.005* | −0.040* |
| Government | −0.130** | 0.014** | 0.115** |
| *Perceived performance* | | | |
| Lower profitability | 0.014 | −0.002 | −0.012 |
| Higher profitability | −0.006 | 0.001 | 0.005 |
| Lower productivity | 0.004 | −0.000 | −0.004 |
| Higher productivity | −0.044** | 0.005** | 0.039** |
| Perceived competition | 0.035** | −0.004** | −0.031** |
| Multiple products | 0.026 | −0.003 | −0.023 |

Note: *Significant at 5 percent and ** at 1 percent.

less likely. Customer type has a large bearing on use of long-term contracts. Firms selling to households are 22 percent more likely to have no customers on long-term contracts. As noted above, households are less likely to be repeat customers. Firms selling to the government are 12 percent more likely to have the majority of customers on fixed-term contracts, perhaps a function of government procurement practices.

Even in the absence of binding legal contracts, firms may choose to not change their price to protect ongoing relationships with customers, termed 'implicit' contracts. Implicit contracts are the second most commonly cited factor for preventing price increases, with 31 percent of firms citing it as being 'very important'. If firms have implicit contracts and are reluctant to change prices for fear of losing customers, then they are unlikely to react to temporary changes in factors causing price changes, since the loss of customers will likely outweigh the profit gain for the temporary change in prices. This hypothesis is confirmed in the survey responses: 29 percent of firms who cite implicit contracts as 'very important' also cite not increasing prices because the factors causing the price increase are temporary as being 'very important'. Only 9 percent of firms who placed less importance on implicit contracts cite temporary factors as 'very important'.

### 2.4.2 Strategic complementarity (risk that competitors will not follow suit)

The optimal price for a firm may depend on the prices set by other firms, termed strategic complementarity. For example, following a positive monetary shock the optimal price will rise. Following such a shock, firms should increase prices once they have the ability to reset. Yet if other firms in the sector have yet to reset their price, customers could mistake the price increase as a real increase, resulting in lower market share. In this scenario the firms who are able to reset may choose not to do so, creating stickiness in prices.

Strategic complementarity is the third most common factor cited by firms as being 'very important' in preventing price increases. It is cited by 22 percent of firms, rising to 26 percent of firms weighted by employment. This strategic complementarity is reflected in the method firms chose to set their prices. The dominant price setting method (53 percent of firms) for firms citing strategic complementarity as 'very important' is 'influence of competitors' prices'. For firms that do not cite strategic complementarity as important, only 23 percent use this pricing strategy. The importance of strategic complementarity is also reflected in firms' response to the importance of competitors' prices in determining price changes. Only 3 percent of firms who view strategic complementarity as 'very important' view competitors' prices as being important for neither price increases or decreases, compared with 28 percent of other firms.

### 2.4.3 Menu costs (price changes entail physical costs)

Taking the narrowest definition of menu costs – the cost of physically changing prices – there is little evidence that it is a major factor. Just 8 percent of firms cite menu costs as being 'very important', the least recognised factor in the survey.

Firms were also asked about the importance of pricing thresholds (e.g. keeping prices at $4.99 rather than $5). Such pricing thresholds would act in a similar fashion to menu costs, delaying a price change until the optimal price moves sufficiently far from the current price to cross the next pricing threshold. Widening the definition of menu costs to include pricing thresholds results in 16 percent of firms citing menu costs as being very important in preventing price increases – still less important than the other factors discussed above.

Some authors interpret menu costs as being the cost of managerial time and gathering information (e.g. Ball and Mankiw, 1994). Such an interpretation suggests that the costs lie at the review, not price change, stage.

Section 2.4.4 below considers whether the price review stage is the source of price stickiness.

### 2.4.4 Sticky information

There is little support for sticky information in the survey. Price reviews are notably more frequent than price changes. The number of firms that review prices at least every month is double the number of firms that actually change them. 60 percent of firms review prices at least every six months, but only 42 percent of firms change prices that frequently. Overall, the median number of reviews is twice per year, but the median number of changes is just once.

Table 2.7 shows the responses of firms to both the frequency of review and price change questions. The sticky information quadrant lies below the diagonal, shaded in light grey. Just 7 percent of firms lie in this area. The sticky prices area, defined here as changing prices less frequently than reviewing them, is shaded in dark grey. Nearly half – 47 percent – of New Zealand firms fall in this category. Of the remaining 31 percent of firms that review prices on a regular basis, most change prices once or not at all over the preceding year. This evidence points to sticky prices, rather than sticky information being the primary cause of nominal price rigidity in New Zealand.

To further underline this finding, firms were asked to explain why reviews were not carried out more frequently, and given a range of options. The most frequently cited reason was that factors affecting pricing decisions do not change more frequently (table 2.8). The second most-cited reason was that the firm would not change prices more frequently – again highlighting stickiness in the price change stage of the price-setting process. The unavailability of information required to carry out the review was cited by only a small number of firms.

Table 2.7: Frequency of price reviews and changes (percent of firms)

| | Price changes | | | | | | |
|---|---|---|---|---|---|---|---|
| Price reviews | More than 182 times | 182 times or less | 26 times or less | 6 times or less | Twice | Once | Zero |
| Daily | 2 | 1 | 1 | 1 | 0 | 0 | 0 |
| Weekly | 0 | 1 | 2 | 1 | 1 | 0 | 1 |
| Monthly | 0 | 0 | 2 | 4 | 3 | 2 | 1 |
| Quarterly | 0 | 0 | 0 | 2 | 5 | 5 | 1 |
| Half-yearly | 0 | 0 | 0 | 1 | 4 | 6 | 3 |
| Annually | 0 | 0 | 0 | 1 | 2 | 18 | 9 |
| Less frequently than annually | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Specific events only | 0 | 0 | 1 | 2 | 1 | 4 | 6 |

### 2.4.5 Multi-product firms

Firms were asked to respond to the survey in terms of their most important product. They were also asked whether the pricing strategy were representative of their other products. 23 percent of firms only sold one product. There is a marked divergence by firm size, with only 11 percent of large firms selling just one product.

Firms selling multiple products change prices more frequently than those selling a single product. 29 percent of firms selling a single product change price more than once, whereas 43 percent of multi-product firms change the price of their main product more than once. As shown in table 2.4 above, this more frequent price resetting persists even once other factors, such as firm size and sector, are taken into account.

These results on the frequency of price resets by multi-product firms affirm the findings of Bhattarai and Schoenle (2014). Conversely, their proposed mechanism – economies of scope in price resets resulting in lower

Table 2.8: Reasons for not reviewing prices more frequently (percent of firms)

| | Factors affecting decisions don't change more frequently | Would not change prices more frequently | Other reason | Cost of managerial time | Information not available more frequently | Other costs of review process | Cost of non-managerial time |
|---|---|---|---|---|---|---|---|
| *Firm size* | | | | | | | |
| Small | 53 | 29 | 22 | 9 | 6 | 6 | 3 |
| Medium | 57 | 30 | 22 | 10 | 8 | 6 | 4 |
| Large | 55 | 36 | 22 | 16 | 8 | 11 | 7 |
| *Sector* | | | | | | | |
| Primary | 50 | 29 | 25 | 4 | 7 | 5 | 1 |
| Industry | 55 | 29 | 21 | 12 | 6 | 6 | 3 |
| Distribution | 56 | 28 | 17 | 10 | 7 | 4 | 5 |
| Private services | 53 | 32 | 24 | 10 | 5 | 7 | 5 |
| Government services | 54 | 35 | 23 | 7 | 7 | 3 | 3 |
| *Price review frequency* | | | | | | | |
| Daily | 29 | 34 | 26 | 12 | 8 | 5 | 6 |
| Weekly | 47 | 12 | 30 | 11 | 9 | 2 | 6 |
| Monthly | 63 | 21 | 14 | 13 | 11 | 8 | 5 |
| Quarterly | 61 | 31 | 14 | 14 | 7 | 8 | 7 |
| Annual | 52 | 37 | 25 | 6 | 4 | 6 | 3 |
| Less than annual | 53 | 23 | 37 | 7 | 2 | 5 | 2 |
| Specific events | 46 | 25 | 35 | 6 | 5 | 6 | 2 |
| *Overall* Firm population weighted | 54 | 30 | 22 | 10 | 6 | 6 | 4 |
| Employment weighted | 55 | 32 | 23 | 12 | 7 | 9 | 5 |

Note: more than one response was possible.

menu costs – is not supported by the responses to the survey. Multi-product firms are more likely to cite menu costs as a reason for not re-setting prices more frequently (table 2.9). Costs of managerial and non-managerial time are also more commonly cited by multi-product firms as factors for not reviewing prices more frequently. This higher response rate by multi-product firms for these factors also holds in general when further splitting by firm size or frequency of price changes (tables 2.11 and 2.12 in the appendix).

Table 2.9: Importance of menu costs for single and multi-product firms (percent citing factor as 'very important')

| | Single product | Multi-product |
|---|---|---|
| *Reasons for not reviewing more frequently* | | |
| Cost of managerial time | 5 | 11 |
| Cost of non-managerial time | 2 | 4 |
| Other costs of the review process | 7 | 6 |
| *Reasons for not changing price more frequently* | | |
| Price changes entail physical costs | 7 | 8 |
| Prefer to maintain prices at certain thresholds | 11 | 16 |

## 2.5 Implications for monetary policy in New Zealand

The findings from the survey have a number of implications for monetary policy. The relatively sticky nature of price-setting in New Zealand implies a potential for real effects of shocks, and a role for monetary policy in macroeconomic stabilisation. The difference in behaviour of multiproduct firms reaffirms this result, even in the presence of state-dependent pricing (see Alvarez and Lippi, 2014; Midrigan, 2011).

Explicit contracts are the factor most widely recognised as being very important for preventing price changes. Wages are also typically only reset infrequently. Erceg et al. (2000) show that when there are long-term contracts in both product and labour markets, monetary policy is unable to recreate the flex-price equilibrium. In the presence of such rigidities, a strict inflation targeting regime can lead to large welfare losses. Taking into account wage and/or output deviations from optimum markedly improves welfare. Barro (1977) points out that it matters for monetary policy whether these contracts specify just price, or also volumes, with the first case being most important for monetary policy. The survey is unclear as to which type of contract is used.

The existence of firms using state-dependent rather than time-dependent pricing can result in asymmetric reaction to shocks at both the firm and macroeconomic level. For example, Devereux and Siu (2007) develop a dynamic general equilibrium model of time-dependent firms which are also able to react to specific shocks (which describes the price-setting practices of the majority of firms in this survey). In their model firms react asymmetrically to shocks, with positive cost shocks more likely to cause firms to change prices than negative cost shocks. This asymmetry of responses to cost shocks is supported by the results here.

Further, Devereux and Siu (2007) find non-linearities in response to monetary policy, with positive monetary policy shocks resulting in smaller output expansions than contractions caused by a negative monetary policy shock of the same magnitude. This suggests that monetary policy may have to work harder to stabilise output following a negative shock than in response to a positive shock.

The heterogeneity of price setting behaviour between sectors also has implications for the policy trade-off between inflation and output volatility. Imbs et al. (2011) estimate sectoral Phillips curves for 16 industries in France. They show that there is aggregation bias in the estimation of the aggregate Phillips curve, such that for given values of volatility in inflation and nominal interest rates the aggregate model suggests up to double the volatility in the output gap.

With heterogeneity in sectoral stickiness, there arises the question of which prices monetary policy should target. Aoki (2001) and Benigno (2004) show in a two sector or two region model, respectively, that monetary policy should focus on the relatively sticker sector / region to maximise welfare. The relatively stickier sectors have been highlighted here, and broadly correlate with the sectors included in the non-tradable index of inflation.

Finally, there may be valuable information for forecasting purposes in the difference in evolution of inflation between sectors. Millard and O'Grady (2012) construct a DSGE model with a sticky price and a flexible price sector. They show that the flexible price sector may help provide monetary policy makers with a more accurate estimate of the output gap, whereas the sticky price sector may provide better guidance on medium-term inflation expectations.

## 2.6 Conclusion

How firms set prices determines inflation dynamics within the economy and is important for understanding the monetary transmission mechanism and for microfoundations of price setting in macro models. This paper brings new insights into price-setting behaviour, using a large survey of New Zealand firms. This is the first behavioural survey for New Zealand, and the first survey internationally to cover all non-government sectors.

The survey results indicate that New Zealand firms are rarely strictly state-dependent price setters, but mostly use a mixed strategy of both reviewing prices periodically and also in response to specific events. The median number of price reviews is twice per year, but the median number of changes is just one. The perception of more intense competition and greater productivity are associated with more frequent repricing. Conversely, sectors where there are a larger number of repeat customers exhibit greater price rigidity.

There is marked heterogeneity in price-setting behaviour across firm sizes, with large firms reviewing and changing prices more frequently. Multi-product firms reset prices more frequently, even accounting for other firm characteristics. Yet these firms cite menu costs as a factor preventing price increases more frequently than single product firms, contrary to the assumption used in the literature.

Intermediate goods seem to exhibit higher price stickiness, while firms that sell direct to households appear to price more flexibly. This suggests that a focus on the flexibility of goods in the Consumer Price Index may underestimate the degree of price stickiness in the economy. The most recognised reasons for price stickiness are explicit and implicit contracts and strategic complementarity. Pure menu costs – treated as the physical cost of changing prices – are not widely recognised as an impediment to changing prices. Similarly, sticky information does not appear to be the main driver of nominal rigidities.

## 2.A Appendix – additional tables

Table 2.10: Respondents to selected previous price-setting surveys

| Country | Authors | Sample frame | Respondents (response rate, %) |
|---|---|---|---|
| Australia | Park et al. (2010) | CB contacts | 700 (unknown) |
| Canada | Amirault et al. (2006) | CB contacts | 170 (unknown) |
| Euro area$^{(a)}$ | Fabiani et al. (2006) | various | 11,150 (46) |
| New Zealand | | Nat. Stat. Inst. | 5369 (82) |
| Sweden | Apel et al. (2005) | Nat. Stat. Inst. | 626 (49) |
| United Kingdom | Greenslade and Parker (2012) | CB contacts | 693 (30) |
| United States | Blinder et al. (1998) | 3rd party database | 200 (61) |

Note: (a) The individual country surveys ranged from 330 to 2070 respondents. The response rate ranged from 30 percent to 69 percent.

Table 2.11: Importance of menu costs for single and multi-product firms, by firm size (percent citing factor as 'very important')

| | Single | | | Multi | | |
|---|---|---|---|---|---|---|
| | S | M | L | S | M | L |
| *Reasons for not reviewing more frequently* | | | | | | |
| Cost of managerial time | 4 | 6 | 11 | 10 | 11 | 17 |
| Cost of non-managerial time | 2 | 3 | 6 | 4 | 5 | 7 |
| Other costs of the review process | 7 | 5 | 5 | 5 | 7 | 12 |
| *Reasons for not changing price more frequently* | | | | | | |
| Price changes entail physical costs | 7 | 4 | 8 | 8 | 7 | 7 |
| Prefer to maintain prices at certain thresholds | 12 | 7 | 9 | 17 | 15 | 17 |

Table 2.12: Importance of menu costs for single and multi-product firms, by number of price changes (percent citing factor as 'very important')

| | Single | | | Multi | | |
|---|---|---|---|---|---|---|
| | 0-1 | 2-26 | 27+ | 0-1 | 2-26 | 27+ |
| *Reasons for not reviewing more frequently* | | | | | | |
| Cost of managerial time | 2 | 7 | 5 | 17 | 13 | 9 |
| Cost of non-managerial time | 1 | 4 | 2 | 7 | 5 | 3 |
| Other costs of the review process | 2 | 11 | 6 | 9 | 7 | 5 |
| *Reasons for not changing price more frequently* | | | | | | |
| Price changes entail physical costs | 1 | 11 | 6 | 8 | 9 | 7 |
| Prefer to maintain prices at certain thresholds | 19 | 20 | 8 | 15 | 21 | 14 |

## 2.B Appendix – survey questionnaire

### Section C: Price and Wage Setting

1 Section C should be completed by the General Manager

### Definition

2 The following section asks about factors that are important when this business reviews and sets prices. To answer these questions, apply the following definition.

**Main product**: The product (good or service) or product group from which this business gets its largest share of revenue.

If this business does not have a main product (eg in the case of large-format retail stores), provide answers that are most representative of this business's price-setting process.

3 **Mark one oval. Which of the following is the main customer group that pays for this business's main product (good or service)?**
**Note:** This can be different to the end users of the product (eg government-funded services).
o individuals or households
o businesses within the business group (eg subsidiaries or parent companies)
o retailers or wholesalers outside the business group
o other businesses outside the business group
o government

4 **Please estimate what proportion of this business's customers have the prices they pay set by long-term (at least one year) formal contracts?**
o 0%
o 25% or less
o 50% or less
o 51% or more
o don't know

5 **Please estimate what proportion of this business's customers return for repeat business?**

- o 0%
- o 25% or less
- o 50% or less
- o 51% or more
- o don't know

6 For the following questions, please apply the definition of main product provided in **2**.

7 **Are all customers charged the same price for this business's main product (good or service)?**

- o yes
- o no, but fixed pricing schedules are used for specific types of customers (eg preset volume discounts)
- o no, prices are set on a case-by-case basis

8 **Mark one oval. Who reviews and sets the price of this business's main product**

- o this business $\rightarrow$ go to **9**
- o a parent business $\rightarrow$ go to **23**
- o other $\rightarrow$ go to **23**

9 **Mark one oval. When does this business typically review the price of its main product?**

**Note:** The review process must be sufficiently thorough that a price change could result.

- o at regular intervals only, regardless of specific events
- o generally at regular intervals, but also in response to specific events (eg a substantial increase in costs)
- o in response to specific events only $\rightarrow$ go to **11**

10 **Approximately how often does this business regularly review the price of its main product?**

- o daily
- o weekly
- o monthly
- o quarterly
- o half-yearly
- o annually
- o less frequently than annually

11 **Mark all that apply. Which of the following are important reasons why this business does not review prices more frequently?**

- o cost of managerial staff time
- o cost of non-managerial staff time
- o other costs of the review process
- o the factors affecting pricing decisions do not change more frequently
- o the information used to inform pricing decisions is not available more frequently
- o would not change prices more frequently
- o other reasons

12 **Approximately how much staff time in total is spent on an average price review of this business's main product?**

***Include*** both managerial and non-managerial staff hours.

**Note:**

• if this business has staff whose full-time job is reviewing prices, you may enter the number of these staff members, instead of total staff hours spent on a price review.

• if less than one hour in total is spent on an average price review, please write 1.

| | | | |
|---|---|---|---|
| | total staff hours | ___ | hrs |
| **OR** | number of staff whose full-time job is reviewing prices | ___ | staff |

13 **Mark all that apply. If during a price review, it becomes apparent that a relatively large price change may occur, is extra time spent on the review process?**

- o yes, extra managerial time
- o yes, extra non-managerial time
- o no extra time is spent on the review process
- o don't know

14 **During the last financial year, how many times did this business change the price of its main product?**

- o zero
- o once
- o twice
- o 6 times or less
- o 26 times or less
- o 182 times or less
- o more than 182 times

Apply the definition of main product provided in **2**

15 **For a typical price change of this business's main product, approximately how many hours in total are spent explaining the change to customers?**
***Include*** both managerial and non-managerial staff hours.
**Note:**If the answer is 'zero', please write ***0*** . If less than one hour in total is spent on explaining the change, please write ***1*** .

total staff hours ___ hrs

16 **How important are temporary price reductions (ie sales) to the pricing strategy of this business?**

- o not at all important
- o a little important
- o moderately important
- o very important
- o don't know

17 **Mark one oval. Which of the following methods <u>best</u> describes how this business sets the price of its main product?**

- o rule of thumb (eg change by a fixed amount or in accordance with inflation)
- o costs plus a profit margin (a mark-up over costs)
- o the influence of competitors' prices (eg matching market prices)
- o other

18 **Mark one oval. Do the pricing decisions for this business's main product primarily rely on:**

o current economic conditions
o expected future economic conditions (eg likely demand, cost projections)
o current and expected future economic conditions are equally important
o don't know

19 **Mark one oval for each item listed. How important are the following factors when considering price changes for this business's main product?**

| | only important for price increases | only important for price decreases | important for both price increases and decreases | not important for either | don't know |
|---|---|---|---|---|---|
| a change in labour costs | o | o | o | o | |
| a change in financing costs | o | o | o | o | o |
| a change in other costs (eg purchase of goods from suppliers, rent) | o | o | o | o | o |
| a change in demand | o | o | o | o | o |
| a change in competitors' prices | o | o | o | o | o |
| a change in productivity | o | o | o | o | o |
| a change in stock levels | o | o | o | o | o |
| a change in the number of competitors | o | o | o | o | o |

20 **Mark one oval for each item listed. How important are the following considerations in preventing this business from raising the price of its main product?**

| | not important | moderately important | very important | don't know |
|---|---|---|---|---|
| the risk that competitors will not follow suit | o | o | o | o |
| the factors causing pressure to raise prices may only be temporary | o | o | o | o |
| formal contracts specifying a fixed price | o | o | o | o |
| implicit contracts (customers expect prices to remain stable) | o | o | o | o |
| preference for maintaining prices at certain thresholds (eg $4.99 rather than $5.00) | o | o | o | o |
| price changes entail "physical" costs (eg printing catalogues) | o | o | o | o |
| the ability to adjust non-price elements (eg the level of after-sales service) | o | o | o | o |

21 **Mark one oval. Do the customers of this business view price increases resulting from increased costs as:**

o less acceptable than price increases resulting from increased demand
o more acceptable than price increases resulting from increased demand
o no different to price increases resulting from increased demand
o don't know

22 **Mark one oval for each item listed. Comparing the current pricing practices of this business with two years ago, which, if any, of the following have changed?**

| | decreased | stayed the same | increased | don't know |
|---|---|---|---|---|
| proportion of customers on long-term (at least one year) contracts | o | o | o | o |
| frequency of price reviews | o | o | o | o |
| frequency of price changes | o | o | o | o |
| profit margin | o | o | o | o |
| sensitivity of customers to price changes | o | o | o | o |

22 **Are the answers provided for this business's main product representative of the pricing process used for other products?**

o yes

o no

o This business only sells one product

22 **Has this business conducted, or is in the process of conducting, a price review specifically because of the announced GST increase?**

o yes

o no, but this business plans to

o no, and this business does not expect to

# Chapter 3

# How do exporters set their prices?

## 3.1 Introduction

How exporters set prices in foreign markets and the widely attested disconnect between exchange rate movements and the local price of traded goods are the subject of a large literature. This paper contributes to that literature by analysing the responses to a large behavioural survey of 1281[1] exporting New Zealand firms. The use of surveys is relatively rare in the literature, which typically focuses on unit record customs data.

We focus on two main channels of incomplete pass-through of exchange-rate movements to domestic prices: *pricing to market* (PTM) and *local currency pricing* (LCP). PTM is where a firm optimally chooses to differentiate prices across destinations, resulting in variable mark-ups. LCP is where a firm invoices its customers in foreign markets in a different currency to its own, producer, currency. Traditionally in the literature, the other currency was taken to be that of the destination market (hence 'local'), but more recently the literature also considers the use of third-party, or 'vehicle', currencies. These two channels of incomplete pass-through are related in

[1]This number, and other firm counts appearing in this paper, has been randomly rounded to base three in accordance with Statistics New Zealand's policies for publishing summaries of confidential responses.

practice, although not exclusively so. The majority of respondents to the survey that invoice in producer currency also charge the same price across destinations, and the majority of those that invoice in other currencies also typically price to market.

This paper makes a number of contributions to the literature. First, we find that primary producers do price to market, in stark contrast to what is commonly believed. Second, we demonstrate that service sector firms also price to market, a new finding for the literature that hitherto has concentrated on goods exporters. Finally, we investigate the firm characteristics that underly firms' decisions on currency of invoice and pricing to market. We find larger firms, and more productive firms, to be more likely to price to market. The sector the firm operates in has a significant bearing on the choice of invoice currency.

The commonly held view on primary exports is that such products are homogenous, and that the price is determined by the balance of international demand and supply, and hence the same across countries. The responses analysed here do not support this view. New Zealand primary exporters not only price to market, but are more likely to do so than firms in all other sectors, even taking into account other firm characteristics.

This result may be a consequence of the type of primary products exported by New Zealand, which for the main part are agricultural in nature. Agricultural products have greater potential for product differentiation (such as by taste, appearance, safety of consumption, or being free range) than other primary products such as metals. Primary sector firms are more likely than firms in other sectors to cite 'customer characteristics' as being 'very important' for determining price across markets. New Zealand exporters also account for a large market share in the exports of certain primary products, including milk, sheep meat and kiwifruit. This high market share may well provide some pricing power. In common with the literature, we show that primary products are frequently invoiced in vehicle currencies, most notably the US dollar.

There are a number of advantages in the use of a survey to consider firm decisions on export pricing relative to the unit record customs data that are widely used in the literature. First, the survey explicitly asks firms whether the price (in domestic currency terms) is the same across all markets, both foreign and domestic. Customs data do not, of themselves, include information on the domestic market, so are unable to identify cases where the export price (even if common to all foreign destinations) is different from the domestic price. Second, the survey used here covers the service sector. Customs data require the physical movement of goods across borders, so is silent on the pricing behaviour of service sector firms, who account for a significant share of advanced countries' exports. Third, the survey directly asks firms the reasons for choosing to differentiate prices between markets. It also provides other information on the exporters to permit a more thorough understanding of the firm characteristics that contribute to the decisions on invoice currency and whether to price to market.

Service sector exports account for a fifth of total New Zealand exports, and for a significant share of exports of other advanced economies. Despite this significant share of exports, there is scant evidence in the literature on how service sector firms price exports. We provide evidence that some service sector firms invoice in currencies other than the New Zealand dollar and also price to market. Once other firm characteristics are taken into account, the export pricing behaviour of service sector firms is not significantly different from manufacturers.

Recent research has highlighted the role of firm characteristics in the decisions over currency of invoice and whether to differentiate prices between markets. Using the survey responses, we find that the sector the firm operates in has a significant impact on the currency of invoice. Neither size of the firm nor productivity relative to competitors have a systematic bearing on the choice of currency of invoice. Conversely, larger firms are more likely to price to market, as are more productive firms. Taking into account these firm characteristics, the firm's sector does not affect the decision to price to market, with the sole exception of firms in the primary sector.

Survey data are not without disadvantages. The identification of price differentiation does require that firms act in the way that they respond to the survey. More importantly, PTM requires the exact same product to be sold at different prices in different markets. It is not uncommon for firms to differentiate between markets by sending different varieties to different destinations. The survey requests that the firm answers the question in terms of its main product, but it is possible that respondents did not carefully distinguish between the exact products sold in each market. Finally, as with all surveys, the quality of the responses rely on the quality of the survey itself. The large number of respondents, the detailed stratification of the sample, and the very high response rate (82 percent) of the survey used here provide comfort. That said, there is a marked lacuna in the coverage of firms selling to tourists located in New Zealand, who are exporters but do not always recognise themselves as such.

### 3.1.1 Related literature

The literature on the so-called 'exchange rate disconnect', where domestic prices for traded goods vary by less than the exchange rate is large, and is surveyed in Burstein and Gopinath (2013). Within this large literature, this paper is most closely related to studies of two particular channels – pricing to market and local currency pricing (and more broadly the choice of invoice currency). Recent work has highlighted the role of firm characteristics in the operation of these channels.

The theory of pricing to market dates back to the models of Dornbusch (1987) and Krugman (1987), and was first modelled in a general equilibrium framework by Betts and Devereux (1996). In monopolistically competitive markets firms set prices, and hence mark-ups, in relation to the elasticities of demand for their product. If an exporter wishes to maintain market share in an export market, it will lower its mark-up when the exporter's currency appreciates against that of the market in question, which is to say it will choose to price to market. Atkeson and Burstein (2008) develop the pricing to market framework, demonstrating the role of trade costs in the decision to price to market. In their framework, larger firms are more likely to price to market.

A small number of recent papers have considered the role of firm characteristics on the decision of whether to price to market. Berman et al. (2012) study pricing by French exporters using unit record customs data. They provide evidence that high-performing firms maintain prices in foreign markets when the currency depreciates, increasing mark-ups at the cost of smaller change in export volumes. Amiti et al. (2014) study the impact of imported intermediates on export prices. They show that more productive firms, and those with a larger market share exhibit a lower exchange rate pass-through. Firms with low market share pass through exchange rate movements in almost their entirety, whereas the firms with the highest market share pass on around half of the exchange rate movement. Li et al. (2015) and Chatterjee et al. (2013) similarly find a key role for firm productivity in determining exchange-rate pass-through.

The widespread use of customs data in the literature results in most papers considering only the prices of goods that are internationally traded, and not any potential differences between how an exporter prices in the domestic and foreign markets. One rare exception is Fitzgerald and Haller (2014), who study pricing by Irish manufacturers exporting to the United Kingdom, using matched priced data from the Producer Price Index. For exporters invoicing in local currency, relative mark-ups between the domestic and the foreign market move one-for-one with the exchange rate.

A few general surveys about price-setting behaviour have also asked about export pricing. Greenslade and Parker (2010) survey the price-setting behaviour of UK firms and find that three quarters of exporters price to market. Exchange rate changes and transportation costs are cited as the most important factors in deciding on price within markets. Some of the country surveys reported in Fabiani et al. (2006) also enquire about export pricing, finding that half of firms price to market, even when exporting within the euro area. However, these surveys had a lower number of respondents than the New Zealand survey (Greenslade and Parker, 2010, had responses from 128 exporters), and lower response rates (typically around a third).

Several authors have investigated the role of currency of invoice on exchange-rate pass-through (ERPT). Theories of endogenous currency choice include minimising currency volatility (Donnenfeld and Haug, 2008), low macroeconomic volatility (Devereux et al., 2004) and choosing a currency with low transaction costs (Devereux and Shi, 2013). Gopinath et al. (2010) observe differential ERPT for US importers dependent on the currency of invoice. They use this finding to motivate a theory of endogenous currency choice. Using customs unit record data, they show that differences in pass-through for (US) dollar and non-dollar denominated imports persist through several rounds of price adjustments, suggesting differences in desired pass-through between firms.

Goldberg and Tille (2008) use data on 24 countries to demonstrate a 'coalescing' effect where firms choose an invoice currency to minimise price movements relative to their competitors. Thus exporters to the United States choose to invoice in US dollars to help maintain their prices relative to domestic US firms. Similarly, exporters of homogenous goods, such as commodities, choose a common currency, usually the US dollar. Gopinath et al. (2010) similarly find that imports of homogenous goods to the United States are more likely to be invoiced in US dollars.

Goldberg and Tille (2009) use unit record customs data for Canadian imports to demonstrate that exporters tend to use the currency of the country that dominates the industry in which they operate. Large shipments into Canada are more likely to be priced in Canadian dollars than smaller ones, especially if the exporter has a large market share. Goldberg and Tille (2013) formalise this finding in a theoretical model of bargaining between exporters and importers over price and invoice currency.

There have been a small number of surveys that consider firm choices over the currency of invoice. Friberg and Wilander (2008) survey 256 Swedish goods exporters, using a stratified sample in similar fashion to that carried out here. Their survey questions focus on the various stages of invoicing, to a greater degree than covered in the survey here, although with less attention to pricing to market. They conclude that both the price and currency of invoice are subject to negotiation between the importer and exporter, using a survey of Swedish exporters. They also find that large orders are more likely to be invoiced in local currency, as are exports to large countries. The survey in Friberg and Wilander (2008) has a markedly smaller number of respondents to the survey used in this paper, and does not cover the service sector. There are no breakdowns by sector given, so it is unknown whether behaviour differs between sectors indeed there is no breakdown of behaviour by sector in Friberg and Wilander (2008).

Ito et al. (2012) survey a small number of Japanese manufacturing exporters and find invoicing in local currency is typical when exporting to advanced countries, whereas firms with highly differentiated goods or dominant global market shares are more likely to invoice in yen, even when exporting to advanced countries.

Martin and Méjean (2012) study a survey of euro-area manufacturers and find that large companies are more likely to both invoice in foreign currency and to hedge exchange rate risk. The survey used here does not give evidence on whether the respondents use financial instruments to hedge, but does provide information on primary and service sectors as well as pricing to market behaviour that the survey in Martin and Méjean (2012) does not. Evidence for New Zealand suggests the hedging strategies of exporters (at the very least, those to Australia) vary over time, and are related to perceptions of exchange rate momentum (Fabling and Grimes, 2015).

For New Zealand, there is little previous firm-level evidence on export pricing. Fabling and Sanderson (2015) examine exchange rate pass-through using shipment-level export data. They combine the approaches of Gopinath et al. (2010) and Berman et al. (2012) by considering the impact of both firm characteristics and currency of invoice. Similar to Gopinath et al. (2010) they find that short- and long-run pass-through differs by currency of invoice. They also find that higher-performing firms are more likely to absorb exchange rate fluctuations in their margins, in line with Berman et al. (2012). However, within currency groups, they find little role for firm characteristics. That is to say, the differences in observed pass-through by firm type is entirely explained by the choice of invoice currency with higher performing firms electing to invoice in local currency, with direct implications for pass-through.

## 3.2 New Zealand exports

This section briefly describes New Zealand's main exports to provide context for the remainder of the paper. We use 2010 data to be contemporaneous with the survey, but the main exports and main destinations are little changed in the most recent data. New Zealand is a commodity exporter, with over half of exports by value occurring in the primary sector. Agricultural products dominate these primary sector exports, although there are also important contributions from forestry and crude petroleum. New Zealand's biggest export is dairy, which accounts for 18.7 percent of all exports (table 3.1). Not only is dairy important for New Zealand exports, but New Zealand plays a significant role in world dairy exports. At the time the survey used in this paper was carried out, New Zealand accounted for 55 percent of world exports of whole milk powder and 58 percent of world butter exports (USDA, 2014). Around 90 percent of New Zealand dairy ex-

Table 3.1: Major New Zealand exports and main merchandise export destinations in 2010

| Product | Share | Destination | Share |
|---|---|---|---|
| Dairy | 18.7 | Australia | 23.0 |
| Meat | 9.1 | China, PR | 11.1 |
| Tourism | 7.8 | United States | 8.6 |
| Wood | 5.3 | Japan | 7.8 |
| Transportation | 4.4 | United Kingdom | 3.5 |
| Mineral fuels | 3.7 | Korea, Rep. of | 3.2 |
| Education travel services | 3.2 | Indonesia | 2.1 |
| Machinery | 3.1 | India | 2.1 |
| Fruit and nuts | 2.6 | Hong Kong (SAR) | 2.0 |
| Beverages, liquor | 2.4 | Taiwan | 1.9 |

Source: Statistics New Zealand (2011).

ports are carried out by one company – the dairy co-operative Fonterra.

New Zealand's second biggest export is meat, notably beef and lamb. New Zealand is a major world exporter of sheep meat; according to data from the United Nation's Food and Agriculture Organisation, New Zealand accounts for more than a third of overall world exports in sheep meat, and a higher share of world lamb exports. New Zealand also accounts for around a third of world kiwifruit exports. As with dairy, New Zealand kiwifruit exports are for the most part carried out by a single co-operative, Zespri, which markets all exports outside of those to Australia.

Service sector exports account for over a fifth of total exports. New Zealand's principal exports of services are tourism, transportation and education travel services. Tourism represents the spending of non-residents within New Zealand. As noted below, since the expenditure takes place within New Zealand, not all firms recognise these sales as exports. Transportation includes not just sea freight, but also transport of foreign tourists by resident airlines. Education travel services is the provision of education within New Zealand to non-residents, such as foreign residents attending university in New Zealand.

Australia is the biggest destination for New Zealand's merchandise exports, accounting for around a quarter of exports. China is the second largest export partner, and is the main destination for dairy exports. The United States is the third largest destination. Emerging markets in South East Asia combined account for around a third of exports.

## 3.3 Business Operations Survey

This paper uses the responses to module on price and wage setting in the 2010 Business Operations Survey carried out by Statistics New Zealand.[2] The survey sample was stratified by industry and firm size (see Parker, 2014, for a fuller description of the survey design) . The survey had 5369 responses, which is approximately one seventh of the total population of firms in New Zealand with at least 6 employees and 30,000 annual GST (New Zealand equivalent of Value Added Tax) turnover. The high response rate of 81.8 percent is explained by the legal requirement for firms to respond to survey requests by Statistics New Zealand. Of these respondents, 1281 self-identified as being exporters. The survey questions on how exports are priced are provided in the appendix.

Results in the tables are weighted using the stratification weights provided by Statistics New Zealand, in order to represent the averages for the population of private sector New Zealand firms. Since export volumes tend to be dominated by larger firms, the summary tables also include a total figure weighted by employment share. This employment share is calculated using average employment by industry and firm size strata: small

[2] A full copy of the survey questionnaire is available at http://www2.stats.govt.nz/domino/external/quest/sddquest.nsf/12df43879eb9b25e4c256809001ee0fe/6233ea80fe191165cc25777d007a8490/$FILE/BOS%202010_Sample.pdf.

(6-19 employees), medium (20-100 employees) and large (100+ employees).

Firms were asked who reviews and sets the price for the firm's main products. The vast majority – 82 percent – set their own price. A further 8 percent have their price set by their parent firm. The remaining 10 percent of firms selected 'other' for the price setter. Firms that were majority owned by foreigners were more likely to have prices set by the parent – 23 percent versus 7 percent for domestically owned firms.

It is worth noting that the survey relies on firms self-identifying as exporters. In general, the proportion of exporting firms by sector within the survey is well correlated with the share of that sector's output that is exported, according to the 2007 input-output tables. There are a few exceptions, most notably in accommodation and food services where 29 percent of sector output is exported, but firms did not identify themselves as exporters. Since these firms export by providing services to non-residents physically located within New Zealand (i.e. tourists) they may not consider themselves to be exporters. This hypothesis is supported by the 73 percent of firms in that sector who responded that they derived some share of their revenue from tourism. Overall, 33 percent of firms self identified as being either exporters or selling to tourists.

## 3.4 Export-pricing behaviour

Overall, 15 percent of firms identify themselves as exporting (table 3.2). A large proportion of firms in agriculture and manufacturing self-identified as exporting. There were also a large proportion of firms in certain service sectors – mostly those that had other businesses as their main customer – that self-identified as exporters. For example, half of firms in the computer design industry exported, with 11 percent of firms in the sector exporting more than 75 percent of their output. Conversely firms in construction and certain service sectors, mostly those serving households or individuals, rarely export.

The 36 industries in the sample are grouped in the rest of the paper to facilitate the presentation of the results, with the groupings set out in table 3.2. Service sectors have been split between business services and personal services, determined by their main customer. Sectors where the most firms report 'individuals or households' as their main customer have been allocated to personal services, whereas those sectors where most firms report other businesses as their main customer have been allocated to business services.[3]

### 3.4.1 Currency of invoice

Firms were asked in what currency they predominantly invoiced. The four options given were *currency of the destination market*, *New Zealand dollar*, *United States dollar*, *other*.[4] Half of firms invoice in New Zealand dollars, with the remaining firms roughly evenly split between currency of destination and vehicle currencies (table 3.3). These responses closely match the results found by Friberg and Wilander (2008) for Swedish exporters.

Manufacturers are the most likely to invoice in the destination currency, whereas firms in the primary sector are the most likely to price in US dollars. Two thirds of firms in the distribution sector price in New Zealand dollars. Use of vehicle currencies other than the US dollar is rare. There is a noticeable difference in currency of invoice for those firms that do not set their own price. In particular, the majority of such firms use vehicle currencies. The use of vehicle currencies is most pronounced when the

[3]In what follows, the results for 'other industry' and 'personal services' have been omitted from the tables given the low number of exporters within these sectors. However, all exporters are included in the 'overall' figures.

[4]The intention of the ordering of the question was for firms that export to the United Stated and invoice in US dollars would selected currency of the destination market, but it is possible that some firms in this scenario selected US dollars. In any case, the share of respondents that principally invoice in US dollars far exceeds the share of exports that goes to the United States.

Table 3.2: Share of firms that export and share of output exported by sector[a]

| Industry name | Number of firms | Firms that export (%) | Share of sales exported: 25% or less | 50% or less | 75% or less | More than 75% |
|---|---|---|---|---|---|---|
| **Primary** | **3216** | **28** | **4** | **2** | **2** | **20** |
| *Agriculture* | 2103 | 40 | 6 | 3 | 3 | 29 |
| *Commercial fishing*[b] | 42 | 29 | 0 | 0 | 7 | 14 |
| *Forestry & logging* | 210 | 6 | 0 | 0 | 4 | 0 |
| *Agr., forestry, & fishing support serv.* | 762 | 2 | 0 | 0 | 0 | 2 |
| *Mining* | 99 | 18 | 3 | 0 | 6 | 6 |
| **Manufacturing** | **5016** | **36** | **19** | **6** | **5** | **5** |
| *Food, beverage, & tobacco* | 921 | 46 | 16 | 11 | 11 | 8 |
| *Textile, clothing, footwear, & leather* | 357 | 48 | 29 | 10 | 3 | 5 |
| *Wood & paper product* | 528 | 28 | 17 | 2 | 5 | 4 |
| *Printing, publishing, & recorded media* | 306 | 17 | 12 | 3 | 1 | 0 |
| *Petroleum, coal, chemical, & assoc. prod.* | 414 | 63 | 39 | 10 | 7 | 7 |
| *Non-metallic mineral product* | 165 | 18 | 18 | 2 | 0 | 0 |
| *Metal product* | 912 | 21 | 15 | 4 | 1 | 1 |
| *Transport and ind. machinery & equip.* | 831 | 36 | 17 | 6 | 5 | 8 |
| *Other machinery & equipment* | 210 | 57 | 29 | 9 | 0 | 20 |
| *Other manufacturing* | 369 | 33 | 19 | 6 | 4 | 4 |
| **Other industry** | **3582** | **2** | **1** | **0** | **0** | **0** |
| *Electricity, gas, water, & waste services*[b] | 114 | 8 | 3 | 0 | 3 | 0 |
| *Construction* | 3468 | 2 | 1 | 0 | 0 | 0 |
| **Distribution** | **7077** | **20** | **15** | **1** | **1** | **2** |
| *Machinery & equipment wholesaling* | 903 | 36 | 31 | 0 | 0 | 4 |
| *Other wholesale trade* | 1959 | 40 | 31 | 3 | 1 | 5 |
| *Retail trade* | 4215 | 7 | 5 | 0 | 1 | 0 |
| **Business services** | **6807** | **16** | **8** | **2** | **2** | **3** |
| *Transport, postal, & warehousing* | 1362 | 9 | 2 | 3 | 2 | 2 |
| *Publishing* | 120 | 23 | 13 | 3 | 0 | 3 |
| *Motion picture* | 135 | 16 | 11 | 2 | 2 | 0 |
| *Telecommunications*[b] | 87 | 28 | 17 | 3 | 0 | 3 |
| *Auxiliary finance* | 303 | 13 | 12 | 0 | 1 | 0 |
| *Other professional scientific* | 2907 | 15 | 8 | 3 | 1 | 4 |
| *Computer systems design* | 558 | 49 | 26 | 4 | 8 | 11 |
| *Administrative & support services* | 1335 | 9 | 5 | 1 | 1 | 2 |
| **Personal services** | **9609** | **2** | **1** | **0** | **0** | **1** |
| *Accommodation & food services* | 4194 | 0 | 0 | 0 | 0 | 0 |
| *Finance* | 159 | 4 | 0 | 0 | 2 | 2 |
| *Insurance*[b] | 45 | 7 | 7 | 0 | 0 | 0 |
| *Rental, hiring, & real estate services* | 804 | 3 | 3 | 0 | 0 | 0 |
| *Education & training* | 717 | 7 | 2 | 0 | 0 | 5 |
| *Health care & social assistance* | 2226 | 0 | 0 | 0 | 0 | 0 |
| *Arts & recreation services* | 486 | 2 | 1 | 0 | 1 | 1 |
| *Other services* | 978 | 5 | 4 | 0 | 0 | 0 |
| **Overall** | **35307** | **15** | **8** | **2** | **2** | **4** |

Notes: (a) Shows share of firms in each sector that export and proportion of firms in each sector by share of output exported. Rows may not correctly sum due to rounding, or where results are suppressed to protect the anonymity of individual respondents.
(b) The number of respondents for these sectors is low, so results should be treated with caution.

Table 3.3: Predominant currency of invoice for export market contracts (percent of firms)

| | Destination | NZD | USD | Other |
|---|---|---|---|---|
| **Firm size** | | | | |
| Small | 26 | 50 | 20 | 4 |
| Medium | 34 | 45 | 19 | 3 |
| Large | 29 | 41 | 26 | 4 |
| **Sector** | | | | |
| Primary | 32 | 18 | 44 | 9 |
| Manufacturing | 36 | 44 | 17 | 4 |
| Distribution | 25 | 65 | 9 | 1 |
| Business services | 23 | 51 | 22 | 4 |
| **Price reviewer / setter** | | | | |
| Firm itself | 29 | 54 | 15 | 2 |
| Domestic parent | 20 | 26 | 47 | 6 |
| Foreign parent | 8 | 20 | 43 | 29 |
| Other | 37 | 14 | 44 | 10 |
| **Overall** | 29 | 48 | 20 | 4 |
| **Employment weight** | 29 | 44 | 25 | 3 |

Note: Firms were asked to mark one response. A small number of firms marked more than one, particularly those where the price-setter was 'other'. The multiple responses have been retained.

price is set by a foreign parent – 72 percent of these firms price in vehicle currencies.

To understand the influence of firm characteristics on the choice of invoice currency, we carry out a number of multinomial probit models. A multinomial probit extends the standard probit model framework to consider the case where there are more than two choices and where there is no particular order between the choices.[5] We allocate the predominant currency of invoice between three categories – New Zealand dollar, currency of the destination market and vehicle currencies. For each multinomial probit there are two equations, estimating the impact of firm characteristics on the decision to invoice in, respectively, the destination currency and an invoice currency, relative to the base currency choice, New Zealand dollars. In terms of firm characteristics, the reference firm is taken to be a small manufacturer. To mitigate potential mis-specification of the error terms such as heteroscedasticity, the multinomial probits are estimated using White (1980) robust standard errors.

The average marginal effects from the multinomial probits are shown in tables 3.4 and 3.5. Table 3.4 shows the impact of firm characteristics on the likelihood a firm chooses to invoice in destination currency relative to New Zealand dollars. Table 3.5 shows the impact on the choice to invoice in a vehicle currency relative to New Zealand dollars. The parameter estimates from the underlying equations are provided in the appendix.

Column (1) displays the average marginal effects from a multinomial probit that uses the sector the firm operates in, its size and share of production that is exported as explanatory variables for the choice of currency of invoice. The sector that a firm operates in has a large bearing on invoicing in the destination currency, with all sectors being less likely than manufacturers to choose this currency of invoice. Primary sector firms are more likely to choose to invoice in vehicle currencies than manufac-

[5]The estimation of probit models is briefly outlined in the appendix. See Greene (2012) (p.752-5) for a more detailed exposition of multinomial probits.

Table 3.4: Average marginal effects from multinomial probits on predominant currency of invoice – destination currency relative to New Zealand dollars

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Sector** – Primary | −0.122** | −0.127** | −0.128** | −0.127** |
| Manufacturing | *reference* | *reference* | *reference* | *reference* |
| Other industry | −0.208* | −0.191* | −0.195* | −0.193* |
| Distribution | −0.091* | −0.066 | −0.061 | −0.066 |
| Business services | −0.091* | −0.066 | −0.065 | −0.070* |
| Personal services | −0.270** | −0.261** | −0.240** | −0.262** |
| **Size** – Small | *reference* | *reference* | *reference* | *reference* |
| Medium | 0.054 | 0.072* | 0.062* | 0.072* |
| Large | −0.001 | 0.031 | 0.018 | 0.030 |
| **Export share** | 0.001** | 0.002** | 0.002** | 0.002** |
| **Foreign owned** | | −0.121** | −0.119** | −0.121** |
| **Price set by foreign parent** | | −0.083 | −0.071 | −0.084 |
| **Main customer type** | | | | |
| Households | | | −0.091 | |
| Business within group | | | −0.043 | |
| Retailer / wholesaler | | | 0.032 | |
| Other business outside group | | | *reference* | |
| Government | | | 0.075 | |
| **Productivity rel. to competitors** | | | | |
| Lower | | | | 0.003 |
| On par / don't know | | | | *reference* |
| Higher | | | | 0.011 |
| N | 1281 | 1281 | 1281 | 1281 |

Note: * Significant at 5 percent level, ** Significant at 1 percent level. Average marginal effects show the percentage point increase in probability of selecting to invoice in respectively currency of destination and vehicle currencies relative to choosing to invoice in New Zealand dollars of a one unit increase in the explanatory variable. Underlying estimation coefficients given in table 3.9 in the appendix.

Table 3.5: Average marginal effects from multinomial probits on predominant currency of invoice – vehicle currencies relative to New Zealand dollars

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Sector** – Primary | 0.169** | 0.171** | 0.172** | 0.172** |
| Manufacturing | *reference* | *reference* | *reference* | *reference* |
| Other industry | 0.140 | 0.131 | 0.115 | 0.133 |
| Distribution | −0.038 | −0.041 | −0.039 | −0.042 |
| Business services | 0.006 | −0.004 | −0.021 | −0.005 |
| Personal services | −0.008 | −0.015 | −0.014 | −0.011 |
| **Size** – Small | *reference* | *reference* | *reference* | *reference* |
| Medium | 0.018 | 0.016 | 0.019 | 0.014 |
| Large | 0.076* | 0.077* | 0.087* | 0.077* |
| **Export share** | 0.003** | 0.003** | 0.003** | 0.003** |
| **Foreign owned** | | −0.001 | −0.003 | −0.001 |
| **Price set by foreign parent** | | 0.152* | 0.142* | 0.155* |
| **Main customer type** | | | | |
| Households | | | −0.041 | |
| Business within group | | | −0.003 | |
| Retailer / wholesaler | | | −0.073** | |
| Other business outside group | | | *reference* | |
| Government | | | −0.031 | |
| **Productivity rel. to competitors** | | | | |
| Lower | | | | 0.062 |
| On par / don't know | | | | *reference* |
| Higher | | | | 0.026 |
| Observations | 1281 | 1281 | 1281 | 1281 |

Note: * Significant at 5 percent level, ** Significant at 1 percent level. Average marginal effects show the percentage point increase in probability of selecting to invoice in respectively currency of destination and vehicle currencies relative to choosing to invoice in New Zealand dollars of a one unit increase in the explanatory variable. Underlying estimation coefficients given in table 3.9 in the appendix.

turers. Medium-sized firms are more likely than small firms to invoice in the destination currency, and large firms are more likely to invoice in vehicle currencies. However, there is not a systematic relationship between firm size and invoice choice as large firms are as likely as small firms to invoice in destination currency, and medium-sized firms are as likely as small firms to invoice in vehicle currencies.

Firms that export a greater share of their production are more likely to invoice in foreign currencies. A 10 percent increase in the share of production that is exported increases the probability of invoicing in the destination currency by 1 percent, and the probability of invoicing in vehicle currencies by 3 percent. This finding is in line with that of Fabling and Sanderson (2015), who find that firms with high export receipts are more likely to use local or vehicle currencies.

The impact of foreign ownership is considered in the equation reported in column (2). We construct a dummy variable equal to 1 if the firm is 51 percent or more owned by an overseas firm and zero otherwise. A second dummy variable is constructed that takes the value of 1 if the firm's price is both set by the parent, and that parent is foreign, and zero in all other cases. Foreign-owned parents are around 12 percent less likely than domestic owned firms to price in the currency of the destination market, although vehicle currency use is the same. Fabling and Sanderson (2015) similarly find that foreign-owned firms are more likely to use producer currency pricing. However, when the price setter is also taken into account, firms where the foreign parent sets the price are 15 percent more likely to use vehicle currencies than where the foreign-owned firm sets its own price.

Column (3) includes the firm's main customer type as an additional explanatory variables, using a dummy variable equal to 1 if the firm ticked the respective customer type as its main customer, and 0 otherwise.[6] Be-

[6]Firms were asked to select *one* main customer type, but a small number ticked more than one option. These multiple responses have been maintained.

yond firms selling to retailers / wholesalers being less likely to use vehicle currencies, customer type appears to have little impact on the choice of invoice currency.

Column (4) includes the impact of firm perceptions of productivity relative to competitors on currency choice. We use the responses made by firms in an earlier part of the survey on their perceptions of relative productivity. Firms were given four options: *lower than competitors*, *on a par with competitors*, *higher than competitors* and *don't know*. Fabling et al. (2012) demonstrate that firm responses to the BOS on their perceptions of relative productivity are representative of actual productivity differentials. The included explanatory variables are a dummy variable that takes the value of 1 if the firm believes its productivity to be lower than its competitors and zero otherwise, and the equivalent for firms that believe they have higher productivity than their competitors. The results show that the perception of relative productivity has no significant impact on the choice of currency of invoice.

### 3.4.2 Pricing across markets

Firms were asked whether the New Zealand dollar price of their main product was the same across different countries, including sales in New Zealand and all export markets. Responses were roughly evenly split between those firms that had the same price across markets and those that differentiated, with 48 percent differentiating (table 3.6). The share of firms differentiating is markedly lower than the recent UK survey where three quarters of firms differentiated prices between foreign markets (Greenslade and Parker, 2010, p.26), but in line with the euro area, where approximately 50 percent of firms differentiate prices across markets (Fabiani et al., 2006, p.21). As noted previously, there are a number of firms that sell to tourists, but do not self identify as exporters. Assuming those firms set the same price to domestic and tourists, the overall share of exporters

Table 3.6: Proportion of firms where the price (in New Zealand dollars) is not the same across countries

| | % | | % |
|---|---|---|---|
| **Firm size** | | **Productivity relative to competitors** | |
| Small | 45 | Lower | 57 |
| Medium | 51 | On par / don't know | 44 |
| Large | 61 | Higher | 54 |
| **Sector** | | **Invoice currency** | |
| Primary | 75 | Currency of destination | 64 |
| Manufacturing | 50 | New Zealand dollar | 29 |
| Distribution | 37 | US dollar | 68 |
| Business services | 42 | Other vehicle | 62 |
| **Overall** | **48** | **Employment weight** | **57** |

that do not differentiate increases to around three quarters – in line with the recent UK survey.

Larger firms are more likely to differentiate prices – 61 percent of large firms differentiated compared with 45 percent of small firms. Weighted by employment shares, 57 percent of firms differentiated price across markets. In terms of sectors, firms in manufacturing are split evenly, but firms in the distribution and business services sectors are more likely to have the same New Zealand dollar price across countries. The striking finding is that three quarters of firms in the primary sector differentiate prices. This is a higher share than any other industry, and in contradiction to the assumption made in previous surveys that prices in this sector are determined by the balance of international supply and demand.

There is a strong, but not perfect, correlation between currency of invoice and the decision to differentiate prices. 71 percent of firms that invoice in New Zealand dollars charge the same price to all countries. Conversely around two thirds of firms that invoice in other currencies differentiate prices.

To understand the joint influence of firm characteristics on the decision to differentiate prices between markets, we carry out a number of probit regressions. The explanatory variable is a dummy variable that takes the value of 1 if the firm differentiates the price of its main product across markets and a value of 0 otherwise. The reference firm is a small manufacturer selling to businesses outside its group other than retailers or wholesalers. The results are unweighted, and full parameter estimates of the underlying probit models are included in the appendix. The probits are estimated using White (1980) robust standard errors. Table 3.7 shows the average marginal effects from these regressions.

Column (1) provides the average marginal effects from a probit model that uses the sector the firm operates in, firm size and the share of output that is exported as explanatory variables. Larger firms are more likely to differentiate prices, with a medium-sized firm 11 percent more likely to differentiate prices than a small firm, and a large firm 20 percent more likely to differentiate. That larger firms are more likely to price to market is consistent with the implications of the model of Atkeson and Burstein (2008), and recent empirical studies of the influence of firm characteristics on the decision to price to market. Firms are more likely to differentiate prices the greater the share of their output that is exported. A 10 percentage point increase in the share of output that is exported increases the likelihood of differentiating prices by 2 percent.

The sector that the firm operates in has an important influence on the decision to differentiate prices. Firms operating in other industry and personal services are less likely than manufacturers to differentiate prices. Conversely firms in the primary sector are more likely to differentiate, even taking into account firm size and export share. This result appears somewhat counter-intuitive since primary products are normally assumed to be homogenous commodities with the price set by the balance of international supply and demand. Indeed, earlier surveys of price setting

Table 3.7: Average marginal effects of firm characteristics on pricing to market

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Sector** | | | | |
| Manufacturing | *reference* | *reference* | *reference* | *reference* |
| Primary | 0.126* | 0.128* | 0.127* | 0.116* |
| Other industry | −0.207* | −0.152 | −0.159 | −0.136 |
| Distribution | −0.062 | −0.060 | −0.063 | −0.066 |
| Business services | −0.067 | −0.037 | −0.042 | −0.016 |
| Personal services | −0.145* | −0.110 | −0.112 | −0.038 |
| **Size** | | | | |
| Small | *reference* | *reference* | *reference* | *reference* |
| Medium | 0.105** | 0.101** | 0.100** | 0.081* |
| Large | 0.200** | 0.192** | 0.192** | 0.171** |
| **Export share** | 0.002** | 0.002** | 0.002** | 0.001* |
| **Main customer** | | | | |
| Households | | −0.046 | −0.047 | −0.008 |
| Business within group | | −0.011 | −0.008 | 0.008 |
| Retailer / wholesaler | | 0.070* | 0.073* | 0.083** |
| Other business outside group | | *reference* | *reference* | *reference* |
| Government | | −0.070 | −0.070 | −0.084 |
| **Productivity rel. to competitors** | | | | |
| Lower | | | −0.005 | −0.018 |
| On par / don't know | | | *reference* | *reference* |
| Higher | | | 0.069* | 0.058* |
| **Invoice currency** | | | | |
| Destination market | | | | 0.278** |
| New Zealand dollars | | | | *reference* |
| Vehicle currency | | | | 0.268** |
| Observations | 1281 | 1281 | 1281 | 1281 |
| Observed frequency | 53 | 53 | 53 | 53 |
| Predicted frequency | 58 | 57 | 57 | 57 |
| Log likelihood | -837 | -833 | -830 | -780 |
| Pseudo $R^2$ | 0.05 | 0.06 | 0.06 | 0.12 |
| Pearson $Chi^2$ | 560 (0.14) | 869 (0.14) | 1020 (0.21) | 1140 (0.27) |

Note: * Significant at 5 percent level, ** significant at 1 percent level. Average marginal effects show the percentage increase in the probability of choosing to differentiate prices of a one unit increase in the explanatory variable. Underlying estimation coefficients given in table 3.11 in the appendix.

explicitly excluded primary firms on the basis of this assumption (see e.g. Blinder et al., 1998; Fabiani et al., 2006; Greenslade and Parker, 2010).

There are a number of candidate explanations for why New Zealand primary firms are more likely to differentiate prices. First, as noted in section 3.2, New Zealand has a large share of world exports of a number of its main primary exports, including milk powder, lamb meat and kiwifruit. In both the models of Atkeson and Burstein (2008) and Amiti et al. (2014), a larger market share results in a greater degree of price differentiation.

The second explanation relates to the nature of New Zealand's main primary exports. Primary exports are generally assumed to be homogenous and invariant to origin – a copper rod is the same worldwide irrespective of where the ore was mined. Crude oil varies along two principal dimensions: viscosity and sulphur content. Agricultural products, conversely, have the potential for a wider differentiation along a number for dimensions, including appearance, taste, and inputs used. Auer and Chaney (2009) develop a model where even under perfect competition differing tastes of consumers can lead to pricing-to-market behaviour, with PTM more prevalent for higher quality goods.

There are a number of examples where this applies to New Zealand's agricultural exports. New Zealand lambs are free range, grass fed, are not injected with growth hormones and the geographic isolation has protected New Zealand from diseases such as scrapie and foot and mouth. This allows the lamb meat to be marketed overseas as a clean, green brand (Clemens and Babcock, 2004). Exports of infant formula to China increased markedly after the 2008 Sanlu scandal, where a Chinese-based company mixed melamine with infant formula, resulting in six deaths and 50,000 babies hospitalised. New Zealand infant formula was seen as a 'safe' source, with New Zealand formula reaching prices of $70 in China, compared with $20 in the domestic market (Galtry, 2013). Zespri focuses on the health benefits when marketing kiwifruit, and its own market research has indicated that repeat sales are heavily influenced by customer experiences of taste and consistency (Zespri, 2010, p. 15). Zespri also has a large research programme to establish new cultivars, such as the gold kiwifruit SunGold®, which receives a much higher return than the standard green cultivar.

The role of quality and country of origin in determining agriculture prices has been noted previously, if not necessarily recently, in the literature. Lord (1989) notes the impact of product differentiation on the export price elasticities of Latin American agricultural exports. Other authors have noted the impact of quality for a number of agricultural commodities, including coffee (Marshall, 1983), cocoa (Curtis and Scheu, 1987) and wheat (Grennes et al., 1978).

Column (2) provides the average marginal effects from a probit model that also includes the main customer type of the firm. The reference category is a business outside the firm's group, other than a retailer or wholesaler. For the most part, the type of main customer has little bearing on the decision to differentiate prices, the sole exception being firms that mainly sell to retailers and wholesalers. Such firms are 7 percent more likely to differentiate prices than those selling to other types of firm. This finding is in line with the model of Corsetti and Dedola (2005), where the presence of additive distribution costs result in variable mark-ups at the producer level.

Recent research on the impact of firm characteristics has highlighted the role of productivity in the decision to differentiate prices. Column (3) shows the results from a model that includes dummy variables for firms with lower and higher productivity relative to their competitors, as used in the multinomial probit in section 3.4.1. In line with the previous findings in the literature, high productivity firms are more likely to differentiate prices, by 7 percent relative to firms who perceive their productivity to be on a par with their competitors.

Finally, column (4) presents the results from a probit model that additionally includes the currency of invoice as explanatory variables. The reference category is invoicing in New Zealand dollars. We include a dummy variable that takes the value of 1 if the firm invoices in the currency of the destination and 0 otherwise and another dummy variable which takes the value of 1 if the firm invoices in US dollars or other vehicle currencies and 0 otherwise. For both invoicing dummy variables, the firms that invoiced in currencies other than New Zealand dollars were markedly more likely to differentiate prices, even when controlling for the other characteristics discussed above. The strength of the marginal response does suggest that the decisions on whether to differentiate prices and the currencies of invoice are related and not independent. Given this potential endogeneity, the exact coefficient estimates should be treated with caution.

Throughout the individual models presented in table 3.7 there are a number of consistent conclusions that can be drawn on the firm characteristics that bear on the decision to differentiate prices. In keeping with the recent literature on the subject, we find that firms that are larger, export a greater share of their production, sell to retailers or wholesalers and are more productive are more likely to differentiate prices. In contrast to the literature, we also find that firms in the primary sector are more likely to differentiate prices than other types of firms, even when accounting for these other firm characteristics.

### 3.4.3 Factors influencing price differentiation across markets

Those firms that differentiate were asked to indicate the importance of a number of potential factors for determining price in the foreign market, rating each of the given list of factors as *not important*, *moderately important*, *very important*, or *don't know*.

The factors most commonly cited as being 'very important' for determining prices are exchange rate movements, the level of competition in the market and transport costs (table 3.8). These three factors rank highest across sectors and firm sizes. Tax system of destination market was the factor least recognised as being 'very important' for determining price. Customer characteristics and cyclical fluctuations in demand are important for primary firms, but less so for firms in other sectors.

## 3.5 Conclusion

This paper studies how exporters set prices, focusing in particular on the decisions over which currency to use for invoicing and whether to price to market. It uses the responses to a large behavioural survey of New Zealand exporters, an alternative, complementary approach to the widespread use of unit-record customs data in the literature. The survey asks firms to consider prices in both the domestic and all foreign markets, allowing for a more accurate study of pricing to market than the straight use of customs data, which does not consider the domestic market.

The analysis here demonstrates that firm characteristics play a statistically significant role in the decision to differentiate prices. Larger firms are more likely to price to market, as are those that have the perception that they are more productive. Conversely, once other characteristics are taken into account, the sector that the firm operates in has no significant impact on the likelihood that a firm differentiates prices between countries, with the exception of firms in the primary sector. That primary sector firms price to market (let alone are *more* likely to do so than firms in other sectors) contrasts sharply with the widely held assumption that these products are priced in international markets.

Since customs data rely on the physical shipment of goods, the literature is silent on the export pricing behaviour of service sector firms, who represent a large share of exports of developed economies. We demonstrate that these firms do price to market, although their behaviour is not significantly different from those of manufacturers.

Finally, the survey responses enable a better understanding of the fac-

Table 3.8: What determines prices across countries?

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| **Firm size** | | | | | | | | |
| Small | 71 | 55 | 45 | 41 | 39 | 37 | 36 | 15 |
| Medium | 67 | 60 | 54 | 35 | 37 | 37 | 33 | 20 |
| Large | 64 | 62 | 51 | 36 | 32 | 37 | 32 | 16 |
| **Sector** | | | | | | | | |
| Primary | 79 | 74 | 55 | 59 | 61 | 66 | 66 | 23 |
| Manufacturing | 70 | 58 | 51 | 33 | 32 | 29 | 23 | 13 |
| Distribution | 63 | 48 | 53 | 35 | 31 | 27 | 28 | 36 |
| Business services | 59 | 43 | 24 | 24 | 20 | 16 | 17 | 17 |
| **Overall** | 69 | 57 | 48 | 39 | 37 | 37 | 35 | 17 |
| **Employment weight** | 63 | 61 | 50 | 39 | 35 | 42 | 35 | 17 |

Note: Firms were asked to cite each factor separately. Table shows share of firms that differentiate across markets citing factor as 'very important'.

1: Exchange rate movement
2: Level of competition in the market
3: Transport costs
4: Regulations
5: Tariff
6: Customer characteristics
7: Cyclical fluctuation in demand
8: Tax system of destination market

tors that influence firms' decisions on pricing in foreign markets. Exchange rate movements are the most cited factor as being very important for determining the price within market. The level of competition in the market and transport costs are also widely recognised. Cyclical fluctuations in demand and the tax system of the destination market are less widely recognised as being very important for setting the price within market.

## 3.A Appendix – probit estimation

This appendix briefly outlines the estimation of probit models.[7] The basic probit model is used in situations where the variable in question has two possible outcomes (typically recorded as 0 and 1). For example, in section 3.4.2 we model the firm's choice between charging the same price to all markets, or differentiating prices. The model assumes that the choice, $Y$ is a function of a number of explanatory factors, $X$ specifically:

$$Pr(Y = 1 \mid X) = \Phi(X'\beta) \tag{3.1}$$

where $Pr$ is the probability and $\Phi$ is the cumulative normal distribution. An alternative way of expressing 3.1 is to assume there is some unobserved, latent variable, $Y^*$, such that

$$Y^* = X'\beta + \epsilon \tag{3.2}$$

where $\epsilon \sim N(0, 1)$. Then $Y$ is an indicator of whether the latent variable $Y^*$ is positive:

$$Y = \begin{cases} 1 & \text{if } Y^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{3.3}$$

The log likelihood function for a sample of $n$ observations, $\{y_i, x_i\}_{i=1}^n$, is given by:

$$\ln L = \sum_{i=1}^{n} \Big( y_i \ln \Phi(x_i'\beta) + (1 - y_i) \ln \big(1 - \Phi(x_i'\beta)\big) \Big) \tag{3.4}$$

Maximum likelihood estimation is used to derive an estimate for $\beta$. The coefficients from these estimations follow in this appendix. However, since the coefficients from these estimations refer to the effect of the explanatory variables on the latent variable, their interpretation is not straightforward. Instead we prefer to present the average marginal effect (see tables 3.4, 3.5 and 3.7), which is to say the effect that changing the explanatory has on

[7] See Greene (2012, Ch.17) for a more detailed description.

the probability of choosing outcome 1, averaged across all observations. These marginal effects are expressed as the change in probability associated with a one unit change in the explanatory variable.

Table 3.9: Invoice currency mulitnomial probit – currency of destination coefficients

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Primary | $-0.184$ | $-0.220$ | $-0.228$ | $-0.219$ |
| | (0.229) | (0.228) | (0.231) | (0.228) |
| Other industry | $-0.773$ | $-0.713$ | $-0.786$ | $-0.717$ |
| | (0.478) | (0.479) | (0.472) | (0.476) |
| Distribution | $-0.507^{**}$ | $-0.406^{*}$ | $-0.378^{*}$ | $-0.409^{*}$ |
| | (0.163) | (0.165) | (0.166) | (0.166) |
| Business services | $-0.376^{**}$ | $-0.339^{*}$ | $-0.361^{*}$ | $-0.346^{*}$ |
| | (0.144) | (0.146) | (0.153) | (0.146) |
| Personal services | $-1.529^{**}$ | $-1.521^{**}$ | $-1.369^{**}$ | $-1.515^{**}$ |
| | (0.334) | (0.343) | (0.351) | (0.342) |
| Medium | $0.304^{*}$ | $0.391^{**}$ | $0.349^{*}$ | $0.387^{**}$ |
| | (0.139) | (0.141) | (0.142) | (0.141) |
| Large | 0.167 | $0.337^{*}$ | 0.297 | $0.338^{*}$ |
| | (0.157) | (0.162) | (0.165) | (0.162) |
| Export share | $0.014^{**}$ | $0.015^{**}$ | $0.016^{**}$ | $0.015^{**}$ |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Foreign owned | | $-0.605^{**}$ | $-0.603^{**}$ | $-0.603^{**}$ |
| | | (0.138) | (0.138) | (0.138) |
| Foreign parent sets prices | | $-0.048$ | $-0.008$ | $-0.044$ |
| | | (0.384) | (0.385) | (0.383) |
| Households | | | $-0.555^{*}$ | |
| | | | (0.219) | |
| Business within group | | | $-0.221$ | |
| | | | (0.188) | |
| Retailer / wholesaler | | | $-0.018$ | |
| | | | (0.120) | |
| Government | | | 0.302 | |
| | | | (0.277) | |
| Lower productivity | | | | 0.164 |
| | | | | (0.229) |
| Higher productivity | | | | 0.117 |
| | | | | (0.123) |
| Constant | $-0.663^{**}$ | $-0.641^{**}$ | $-0.577^{**}$ | $-0.681^{**}$ |
| | (0.144) | (0.145) | (0.157) | (0.149) |
| Observations | 1281 | 1281 | 1281 | 1281 |
| Log likelihood | -1260 | -1246 | -1237 | -1245 |

*, ** significant at 5 percent and 1 percent level respectively.
White (1980) robust standard errors in parentheses.

Table 3.10: Invoice currency multinomial probit – vehicle currency coefficients

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Primary | $0.552^{*}$ | $0.545^{*}$ | $0.545^{*}$ | $0.549^{*}$ |
| | (0.218) | (0.218) | (0.221) | (0.219) |
| Other industry | 0.209 | 0.202 | 0.116 | 0.206 |
| | (0.380) | (0.380) | (0.408) | (0.382) |
| Distribution | $-0.416^{*}$ | $-0.382^{*}$ | $-0.358^{*}$ | $-0.388^{*}$ |
| | (0.179) | (0.181) | (0.181) | (0.181) |
| Business services | −0.159 | −0.185 | −0.270 | −0.192 |
| | (0.151) | (0.153) | (0.159) | (0.153) |
| Personal services | −0.604 | −0.627 | −0.587 | −0.610 |
| | (0.324) | (0.320) | (0.325) | (0.320) |
| Medium | 0.228 | 0.254 | 0.251 | 0.244 |
| | (0.147) | (0.148) | (0.150) | (0.149) |
| Large | $0.400^{*}$ | $0.485^{**}$ | $0.513^{**}$ | $0.487^{**}$ |
| | (0.162) | (0.167) | (0.171) | (0.167) |
| Export share | $0.020^{**}$ | $0.0208^{**}$ | $0.020^{**}$ | $0.020^{**}$ |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Foreign owned | | $-0.299^{*}$ | $-0.305^{*}$ | $-0.297^{*}$ |
| | | (0.141) | (0.142) | (0.141) |
| Foreign parent sets price | | 0.634 | 0.619 | $0.654^{*}$ |
| | | (0.333) | (0.336) | (0.333) |
| Households | | | $-0.450^{*}$ | |
| | | | (0.223) | |
| Business within group | | | −0.120 | |
| | | | (0.190) | |
| Retailer / wholesaler | | | $-0.328^{*}$ | |
| | | | (0.131) | |
| Government | | | 0.012 | |
| | | | (0.297) | |
| Lower productivity | | | | 0.349 |
| | | | | (0.230) |
| Higher productivity | | | | 0.171 |
| | | | | (0.128) |
| Constant | $-1.216^{**}$ | $-1.179^{**}$ | $-1.007^{**}$ | $-1.241^{**}$ |
| | (0.154) | (0.154) | (0.167) | (0.159) |
| Observations | 1281 | 1281 | 1281 | 1281 |
| Log likelihood | -1260 | -1246 | -1237 | -1245 |

*, ** significant at 5 percent and 1 percent level respectively.
White (1980) robust standard errors in parentheses.

Table 3.11: Differentiation across markets probit coefficients

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Primary | 0.346* | 0.353* | 0.351* | 0.337* |
| | (0.146) | (0.148) | (0.147) | (0.154) |
| Other industry | −0.551* | −0.404 | −0.423 | −0.388 |
| | (0.273) | (0.281) | (0.280) | (0.278) |
| Distribution | −0.162 | −0.158 | −0.166 | −0.066 |
| | (0.109) | (0.110) | (0.110) | (0.115) |
| Business services | −0.174 | −0.098 | −0.110 | −0.045 |
| | (0.094) | (0.098) | (0.098) | (0.100) |
| Personal services | −0.381* | −0.290 | −0.296 | −0.108 |
| | (0.188) | (0.193) | (0.191) | (0.192) |
| Medium | 0.277** | 0.267** | 0.267** | 0.230* |
| | (0.091) | (0.092) | (0.092) | (0.093) |
| Large | 0.531** | 0.512** | 0.513** | 0.489** |
| | (0.103) | (0.105) | (0.105) | (0.107) |
| Export share | 0.006** | 0.006** | 0.006** | 0.003* |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Households | | −0.124 | −0.126 | −0.0243 |
| | | (0.132) | (0.131) | (0.137) |
| Businesses within group | | −0.031 | −0.022 | 0.024 |
| | | (0.117) | (0.117) | (0.120) |
| Retailers and wholesalers | | 0.189* | 0.196* | 0.238** |
| | | (0.079) | (0.079) | (0.082) |
| Government | | −0.189 | −0.188 | −0.241 |
| | | (0.185) | (0.184) | (0.185) |
| Lower productivity | | | −0.012 | −0.053 |
| | | | (0.155) | (0.163) |
| Higher productivity | | | 0.185* | 0.168* |
| | | | (0.0802) | (0.0818) |
| Destination currency | | | | 0.801** |
| | | | | (0.091) |
| Vehicle currency | | | | 0.772** |
| | | | | (0.097) |
| Constant | −0.355** | −0.421** | −0.474** | −0.839** |
| | (0.095) | (0.103) | (0.106) | (0.115) |
| Observations | 1281 | 1281 | 1281 | 1281 |
| Log likelihood | -837 | -833 | -830 | -780 |
| Pseudo $R^2$ | 0.05 | 0.06 | 0.06 | 0.12 |
| Pearson $Chi^2$ | 560 (0.14) | 869 (0.14) | 1020 (0.21) | 1140 (0.27) |

*, ** significant at 5 percent and 1 percent level respectively.

White (1980) robust standard errors in parentheses.

## 3.B Appendix – survey questionnaire

### Section C: Price and Wage Setting

# 1 Section C should be completed by the General Manager

### Definition

2 The following section asks about factors that are important when this business reviews and sets prices. To answer these questions, apply the following definition.

**Main product**: The product (good or service) or product group from which this business gets its largest share of revenue.

If this business does not have a main product (eg in the case of large-format retail stores), provide answers that are most representative of this business's price-setting process.

### Exporting

25 **During the last financial year, did this business have any sales of goods or services that came from exports?**

o yes → go to **26**
o no → go to **32**

26 For the following questions, the **New Zealand dollar price** refers to the price of the product when converted to New Zealand dollars.

27 **Is the New Zealand dollar price of this business's main product the same across different countries?**
***Include*** sales in New Zealand and all export markets

o yes → go to **29**
o no → go to **28**

28 **Mark one oval for each item listed. How important are the following factors in determining differences in the New Zealand dollar price across countries?**

| | not important | moderately important | very important | don't know |
|---|---|---|---|---|
| exchange rate movements | o | o | o | o |
| tariffs | o | o | o | o |
| tax system of the destination market | o | o | o | o |
| customer characteristics (eg consumer tastes, standards of living) | o | o | o | o |
| cyclical fluctuations in demand (eg markets are at different points in the business cycle) | o | o | o | o |
| level of competition in the market | o | o | o | o |
| regulations | o | o | o | o |
| transport costs | o | o | o | o |

29 **Mark one oval. What is the predominant currency of invoice for this business's export market contracts?**
o currency of the destination market (eg Australian dollars when exporting to Australia)
o New Zealand dollar
o United States dollar
o other

30 **How high would the New Zealand dollar have to appreciate before this business would raise prices?**

percent appreciation in the New Zealand dollar ___ %

or o appreciations are always passed on to export prices because the New Zealand dollar price is held fixed → go to **32**

o there is no scope to raise export prices → go to **32**

31 **Would the resulting rise in export prices match the exchange rate appreciation recorded in question 30?**

o yes

o no, the rise in export prices would be smaller

o no, the rise in export prices would be larger

# Chapter 4

# Global inflation: the role of food, housing and energy prices

## 4.1 Introduction

The beginning of the 21st Century was marked by low and stable inflation across the developed world, and reduced inflation in the developing world. This stability has been threatened since the mid-2000s by volatility in commodity prices, most notably food and energy, causing concern for policymakers (See, among others, Bernanke, 2008; IMF, 2008; ECB, 2008). Since mid-2014, falling energy prices have once more been at the forefront of policymakers' minds. Research into the effects of these movements in commodity prices on domestic inflation has generally been restricted to a small sample of typically advanced countries, owing principally to a lack of readily available data.

This paper makes two main contributions. First, it constructs a dataset for consumer prices for 223 countries and territories[1] for the period 1980-

[1] The official status of the countries and territories included here varies from internationally recognised sovereign states to overseas regions, dependencies, territories and autonomous regions. The term 'country' is used hereafter for brevity, and is in keeping with the practice of the World Bank.

2012. For headline inflation alone this is wider coverage than existing datasets. In addition to headline consumer prices, this dataset also contains, where publicly available, the sub-indices for food, housing and energy, along with a core index excluding these sub-indices. Existing datasets for these sub-indices rarely extend beyond a small number of advanced countries. Every effort has been made to standardise the indices using the international standard Classification of Consumption according to Purpose (COICOP) in order to aid comparisons.

The second main contribution of this paper is to use this dataset to consider the role of food, housing and energy prices in driving global co-movement in consumer prices. Recent literature has noted how movements in national inflation rates can be explained in large part by movements in global inflation factors, most notably for advanced economies. That analysis is extended here in two dimensions – first by considering a more diverse group of countries, including low income countries which have for the most part been ignored by the literature to date. Second, greater consideration is given to the role of sub-components in generating co-movement in inflation. Analysis of sub-components has to date been limited to a small number of countries, given the lack of comparable international datasets.

There is a growing recent literature on the influence of global inflation factors on national inflation rates. The seminal contribution to this literature is Ciccarelli and Mojon (2010), who study the headline inflation rates for 22 OECD countries over the period 1960-2008. They establish that almost 70 percent of the variance of national inflation rates can be explained by a common, global factor. They demonstrate that including this global factor improves the forecasting performance of augmented Phillips curves.

Eickmeier and Pijnenburg (2013) similarly augment the Phillips curves of 24 OECD countries with global factors, finding a role for the common global component in domestic inflationary pressures. Neely and Rapach

(2011) decompose the inflation rates of 64 (mostly high income) countries into global, regional and domestic factors, finding that the global factor accounts for 36 percent of total inflation variance and regional factors a further 16 percent. Their regions are geographic in nature, so can include diverse economies such as the United States and Barbados in one group. The divide is also somewhat arbitrary at times – grouping English-speaking Caribbean nations into North America and Spanish-speaking ones into Latin America.

There have been a small number of studies that have studied the influence of global factors beyond just headline inflation. Mumtaz and Surico (2012) use a dynamic factor model to investigate the influence of global inflation factors on a wide range of price indices for 10 advanced economies. Their analysis suggests that the comovement in the series has increased since the 1980s. Karagedikli et al. (2010) study the global component of 28 matched product categories for 14 advanced countries. They allow for a global inflation factor, category-specific factors and individual country factors. They find that category-specific factors account for a large share of variance of products that are exposed to international trade.

Förster and Tillmann (2014) use the four-level dynamic hierarchical model proposed by Moench et al. (2013) to disentangle the effects of CPI sub-components, specifically food, energy and the remainder of the index, for a group of 40 countries, all but six of which are high income. Förster and Tillmann find common factors explain large shares of the variance for energy and food, but not for the remainder of the index. We extend their analysis in section 4.4.4 below to a markedly wider sample of countries and also by including CPI housing inflation.

The following analysis extends the literature by considering the influence of global factors on national inflation rates for a far broader, and more diverse, group of countries. We confirm the findings of Ciccarelli and Mojon (2010) that global factors can explain a large majority of the variance of national inflation rates for advanced countries. We also demonstrate that this finding does not generalise to less developed countries. For medium income countries the share of national inflation variance explained by global factors is in the order of 15 to 20 percent, falling to around 10 percent for low income countries.

There are a number of potential country characteristics that could explain the differing effects of global inflation factors on national inflation rates. Considered individually, lower average inflation, lower inflation volatility and higher trade openness appear to increase the influence of global factors. However, when considered in a multivariate framework, these factors are not significant. Instead it is higher GDP per capita, deeper financial development and more transparent monetary policy that explain a greater role for global inflation factors. Relatively rich countries with deep domestic capital markets and good monetary policy are likely to be better able to mitigate idiosyncratic, domestic shocks. The apparent greater influence of global factors in these countries appears to be a function of this reduced idiosyncratic volatility.

In terms of sub-components of consumer prices, there is a more marked influence of global energy and food prices on the respective national inflation rates. Housing prices appear for the most part idiosyncratic and unrelated to global factors. Global factors can explain a greater share of the variance of national inflation for advanced countries for all sub-components. This finding demonstrates that the greater explanatory power of global factors is not a function of differing consumption patterns between high and low income countries.

## 4.2 Data

### 4.2.1 Desired series

This paper uses consumer prices for nearly all sovereign states, territories and geographically distinct autonomous regions (e.g. French overseas regions such as Réunion). Ultimately, CPI figures were found for 223 countries.[2] The coverage roughly coincides with the countries in the World Bank's *World Development Indicators* database.

The data are at quarterly frequency to maximise coverage. Many countries only publish at this frequency, particularly developing ones. For those countries that publish monthly, the quarterly index value is calculated as the average of the monthly outturns, in keeping with standard international practice. For example, the annual inflation rate for 2012Q4 is calculated as the average index level for October to December 2012 over the average index level for October to December 2011, rather than just the end-quarter index values of December 2012 over December 2011.

Differences in exact definitions of CPI can render cross-country comparisons difficult. The scope of items covered and the exact structure of sub-indices differs between countries. Where possible, the indices used here are standardised using the international standard Classification of Consumption according to Purpose (COICOP).[3] COICOP is used for a number of modern CPIs, including the European Union's Harmonised Index of Consumer Prices. The desired COICOP categories are:

**Headline (CPI)** : the all items index. The COICOP classification does not include mortgage payments, which have been excluded, where possible, from the national indices that include them.

**Food (CPIF)** : COICOP 01.1 food purchased for consumption at home.

**Housing (CPIH)** : COICOP 04.1-04.4 rents, maintenance and repair of dwellings, water supply and local authority taxes based on housing.

**Energy (CPIE)** : COICOP 04.5 electricity, gas and other fuels and

[2] Of widely recognised sovereign states, only Eritrea, the People's Democratic Republic of Korea, Turkmenistan, Uzbekistan and the bulk of Somalia are missing here.

[3] See http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5 for a description of the categories.

COICOP 07.2.2 fuels and lubricants for operation of personal transport equipment.

For countries that do not publish on a COICOP basis, the closest sub-index to the desired COICOP category was used, except where that closest series remains far from the desired definition. For example, food and non-alcoholic beverages was used in place of food, the series for electricity, gas and other fuels was deemed sufficient for CPI energy. Conversely, the full transport category was deemed too far removed from fuels and lubricants given it includes public transport, purchase of vehicles, tax on vehicles and spare parts. An online data appendix sets out the exact series used for each country.[4]

Not all statistical agencies publish CPI at a detailed level. Many only publish at the 12 COICOP division level, which means it is not possible to separate out housing and energy. For these countries, COICOP division 04 - Housing, water, electricity, gas and other fuels is used for a combined housing and energy series (CPIHE). For countries where separate housing and energy series are available, CPIHE combines the estimates for housing and energy.

National statistical agencies periodically rebase and re-reference their CPI series.[5] For the most part, an overlapping period is published for both the new and old series, allowing for the two series to be spliced together. In some cases there are no overlapping observations, but the old series has data covering the reference period for the new series. For example, the new series may only be published from 2008Q1, but is referenced to 2007=100 and the old series has observations for 2007. For the small number of cases where no overlap exists, the old and new series have been

[4]The appendix is available at https://sites.google.com/site/milesparkereconomics/CPIsources.pdf.

[5]Technically, the base refers to the period where the underlying expenditure used to calculate the weights takes place. The reference period is the period when the index is set to equal 100, or occasionally 1000. Since these periods often coincide, the use of the term 'base' for both is common practice.

linked using the average growth of the relevant period in the preceding and subsequent five years. All such cases are noted in the online data appendix under the relevant country. The data have been re-referenced to 2010=100 (with a few exceptions of countries that do not have 2010 data).

Also included in the accompanying data are the weights of the sub-indices in the total index. Weights for CPI sub-indices are typically estimated using surveys of household spending. The frequency with which weights are updated varies between countries, with updates usually more frequent in advanced countries. Where weights are not published, estimates are derived using ordinary least squares. The online data appendix notes the cases when this method is used.

Core inflation indices are constructed using the sub-indices and weights. The accompanying dataset contains series on CPI excluding food (CPIxF), excluding energy (CPIxE), excluding housing (CPIxH) and excluding housing and energy (CPIxHE). The data also include series for CPI excluding food and energy (CPIxFE). This measure is commonly used internationally as a measure of core, or underlying, inflation. The final core measure, discussed in more detail below, is CPI excluding food, housing and energy (CPIxFHE).

To calculate a core measure it is necessary to unchain the relevant indices by setting the base period equal to 100. This unchaining is required for each change in weight. The unchained indices are then weighted together using the current period weights. Finally, the unchained core indices are once more chain-linked together. As an example, the formula for calculating CPI excluding food and energy is shown below.

$$CPI\text{x}FE_t = \frac{100\left(100 \cdot \frac{CPI_t}{CPI_b}\right) - wF\left(100 \cdot \frac{CPIF_t}{CPIF_b}\right) - wE\left(100 \cdot \frac{CPIE_t}{CPIE_b}\right)}{100 - wF - wE}$$

Where $CPI_t$, $CPIF_t$ and $CPIE_t$ are the current index numbers for overall, food and energy prices, $CPI_b$, $CPIF_b$ and $CPIE_b$ are the index numbers for the base period – the quarter immediately before the change to the current weights – and $wF$ and $wE$ are the current weights for food and energy. The weight of headline CPI is 100.

### 4.2.2 Sources

There are a number of international databases with CPI data. The *International Financial Statistics* published by the International Monetary Fund contain data on overall CPI for most member countries. The *Laborstats* database of the International Labour Organisation has indices for overall CPI and CPI food. Neither of these sources has information on the other sub-indices, nor on the weights.

The *Main Economic Indicators* of the Organisation for Economic Co-operation and Development contain more detailed information on sub-indices, including energy, and weights for its (advanced economy) members. There are also a number of regional organisations with CPI data for several countries, including the Economic and Statistical Observatory for sub-Saharan Africa (AFRISTAT) and the Secretariat of the Pacific Community. Two major international subscription databases were also used – Thomson Reuters Datastream and Haver Analytics.

For the most part, the sub-indices and weights must be obtained from national sources. When particular series were not all available on the website of the national statistical agency nor the central bank, both were contacted to request the data. A number of these institutions provided the requested data and have been noted in appendix 4.B.

There are data for headline CPI for 127 countries in 1980Q1, and for over 200 countries by 1998Q1. Coverage of CPI food is also extensive. The availability of CPI energy and CPI housing is mostly restricted to high income countries in the first half of the period. The combined housing and energy series is more widely available, as noted above.

There are a number of reasons why the panel is not fully balanced, despite these systematic attempts to obtain the relevant CPI data. First, country formation during the sample period creates periods of no data pre-independence. Examples include the states formed from the break-up of the Soviet Union and later of Yugoslavia, as well as several newly independent states (e.g. Timor-Leste, South Sudan). Second, it was not always possible to obtain information on previous vintages of CPI for all countries – the records have not all been digitised or made available online. Furthermore, some countries did not publish CPI data on a quarterly or higher frequency throughout the sample (e.g. United Arab Emirates, Greenland). Finally, other breaks in collection have been caused by war, disasters or a lack of personnel at statistical agencies.

Related to issues around data availability are issues surrounding data quality. There has been a recent public case surrounding the accuracy of the official inflation data in Argentina, and the reliability of data in countries such as Greece, Hungary and Ukraine (Michalski and Stoltz, 2013). Beyond countries carrying out systematic fraud of the inflation numbers, there is also the risk of measurement error in the calculation of the indices. For the CPI, measurement error is likely to come in two forms: unrepresentative price quotes and incorrect household expenditure shares. Undertaking a sufficiently large number of geographically dispersed price quotes should help with the former problem, and regularly updating weights should help with the latter.

The IMF maintains standards with regards the publication of "comprehensive, timely, accessible and reliable" data under the Dissemination Standards Bulletin Board.[6] But even these standards may not provide a full quantitative measure of quality. For example, New Zealand does not qualify for the lowest tier of the IMF's standards, along with Eritrea, North Korea and Somaliland, yet its process for CPI construction compares favourably to those (and many other) countries. Similarly, prior to 2002 the US only updated its weights around once per decade, far short of the yearly updating common in many countries. The US CPI is con-

[6]See http://dsbb.imf.org/

structed from around 81,000 price quotes per month, compared with 41,000 for Botswana, a much smaller, less populous and poorer country.

Early vintages of the Penn World Tables (see Summers and Heston, 1984) contained a variable for data quality, although the exact formula is not published and in the authors' own words is calculated in 'quite a subjective way'. This includes assuming that countries with higher GDP per capita have better quality data. Dawson et al. (2001) note that eliminating all but the countries with the highest data quality from the Penn World Tables removes two thirds of the countries, and most of the cross-sectional variation. In the absence of any realistic quantitative measure of data quality, the analysis here takes the published indices at face value. If data quality is positively correlated with income, as Summers and Heston (1984) assert, then the differing results by income found below may in part arise from issues surrounding data quality.

## 4.3 Evolution of inflation since 1980

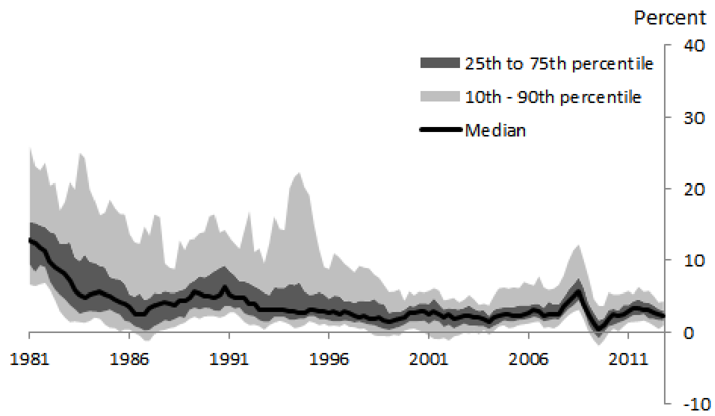
### 4.3.1 Distribution of country headline inflation rates

There is a marked difference in headline CPI inflation between high income countries and less developed countries. For high income countries, there was a period of disinflation through the first half of the 1980s (figure 4.1). Inflation in these countries settled at low and stable rates from the early 1990s through to the middle of 2007. In the 15 year period between 1992Q3 and 2007Q3, the median inflation rate for high income countries ranged between 1.4 and 3.2 percent. This period is also remarkable for the reduction in the right-hand skew of the distribution of country inflation rates.

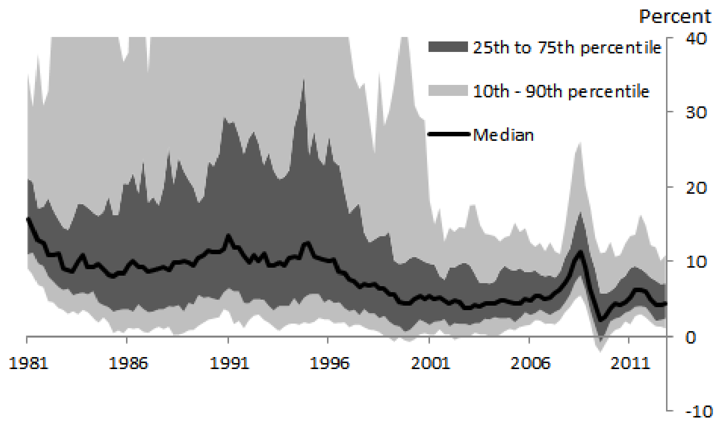
That period of inflation stability was followed by increased volatility during the global financial crisis (GFC) with a sharp peak in inflation, followed by an immediate trough. Inflation in 2011 and 2012 appears more

Figure 4.1: Distribution of annual overall CPI inflation

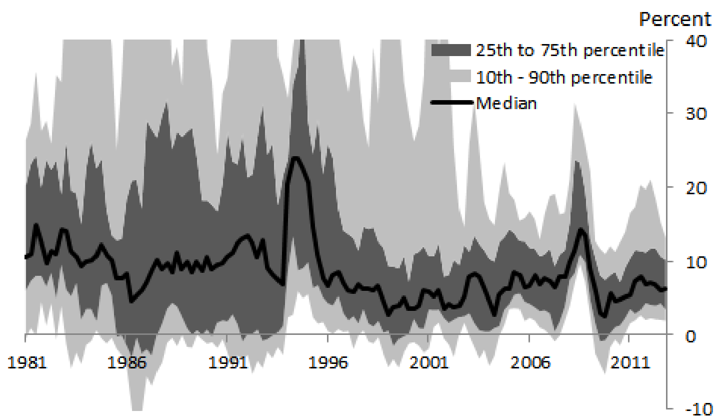
(a) High income




(b) Middle income




(c) Low income



in keeping with the pre-GFC distribution.

The median inflation for middle income countries follows a similar pattern to high income countries, albeit at a higher rate overall. The disinflation of the early 1980s is less marked, and continues through to 2000. This disinflationary period was accompanied by a reduction in skew. The period 2000-2007 appears to be a period of relative stability in inflation. The volatility around the GFC is more marked.

Inflation for low income countries is more volatile than for high or middle income countries. The median inflation rate follows a similar path to that of middle income countries, but with a greater variance. Deflation is more common in low income countries than in high or middle income countries. Indeed, there are periods when the 25th percentile lies below zero. There is a sharp spike in inflation in the early 1990s, in part reflecting the high inflation rates as former Soviet Union states transitioned from command to market economies.

### 4.3.2 Sub-indices

This section considers whether the evolution of CPI inflation noted in section 4.3.1 above is attributable to movements in any particular sub-index. In particular, are movements in the overall index dominated by the evolution of prices for food, housing and energy, or by the remainder of the index?

The evolution of food price inflation mirrors that for overall CPI. For middle and low income countries this is perhaps not surprising given the weight of food in the total index (see section 4.3.4 below). There is a marked run-up in food price inflation worldwide immediately prior to the GFC, which quickly reversed following the collapse of Lehman Brothers in September 2008. This period is the most marked episode of volatility for high income countries, and appears to be a major contributing factor to movements in the headline index. For middle and low income countries, the food price inflation rate is higher on average, more volatile and more dispersed.

The median rate of housing inflation in high income countries displays less volatility than food price inflation. The median housing inflation rate, and indeed the interquartile range, is not affected around the time of the GFC, in contrast to the volatility witnessed with food price inflation. It also contrasts with the widespread increase, and reversal, in house prices at that time. The housing component of the CPI is principally rents, and the lack of increase in the CPI component in line with house prices is consistent with evidence that house prices over the period became divorced from historic relationships with rents (e.g. OECD, 2012).

The energy sub-index is the most volatile of the sub-indices studied here, and also the most prone to outright price falls. There have been a number of cycles in energy prices since the early 1980s. This is most obvious in higher income countries where the distribution of inflation rates is tight relative to the volatility of the median. The outcomes are more dispersed for middle and low income countries (note there are few observations for these countries in the early part of the period).

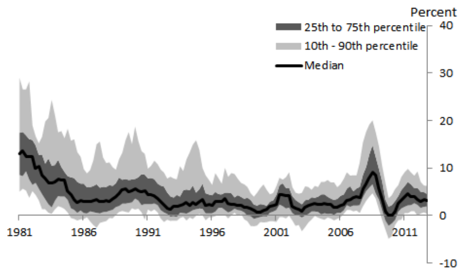
For high income countries, the remainder of the CPI – the index excluding food, housing and energy – has been low and stable for most of the period. The outcomes across countries are similar, with very little dispersion in inflation rates. A minority of high income countries had an increase in CPIxFHE inflation immediately prior to the GFC, but in general this sub-index did not exhibit the same volatility around the GFC that the other sub-indices did. The stability in the CPIxFHE inflation rate was less evident in middle and low income countries.

### 4.3.3 Inflation volatility

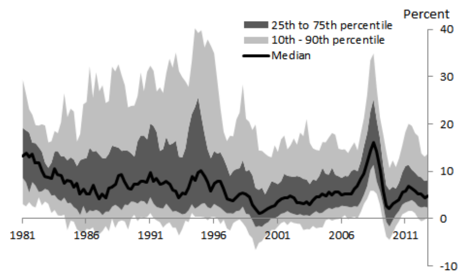
Table 4.1 shows the mean, median and standard deviation of inflation for the period 1981-2012, split by country income level and by sub-index. In

Figure 4.2: Distribution of annual inflation of CPI sub-indices

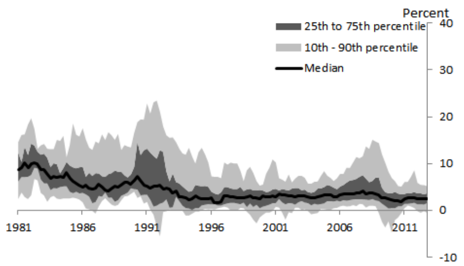
(a) Food - high income



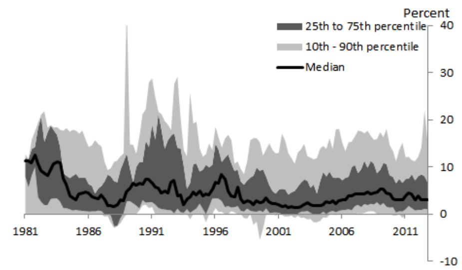

(b) Food - middle/low income



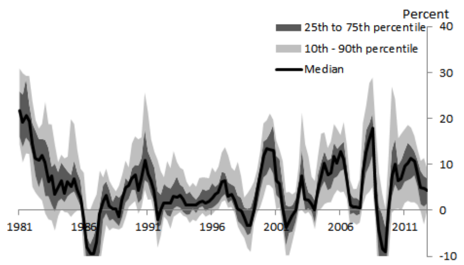

(c) Housing - high income



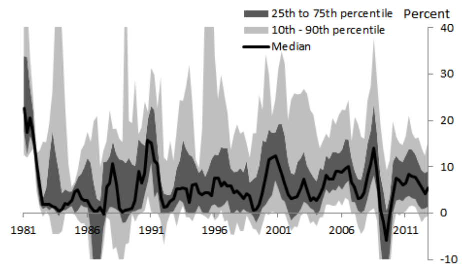

(d) Housing - middle/low income



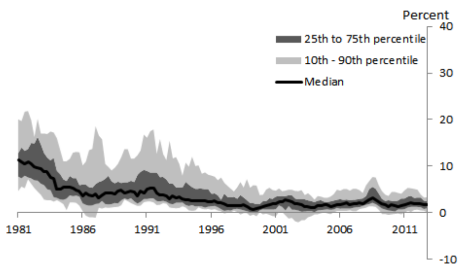

(e) Energy - high income



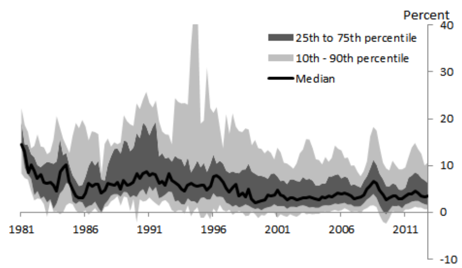

(f) Energy - middle/low income




(g) CPIxFHE - high income




(h) CPIxFHE - middle/low income



order to remove the influence of a small number of extreme outliers, we exclude periods of hyperinflation from the analysis. Following Fischer et al. (2002), we define this as the quarter when the annual inflation rate exceeds 100 percent until the annual rate again drops below 100 percent.

Headline inflation averaged 4.9 percent over the whole period for high income countries. For middle and low income countries, the mean inflation rate was double that at 9.9 percent. As noted above, there was disinflation over the course of the three decades studied here, in both high income and middle/low income countries.

The energy sub-index exhibited the highest average rate of inflation, followed by food, then housing and finally the remainder of the index. Note the populations are not the same across sub-indices, so the sub-indices do not 'add up' to the headline result. In particular, there is a reporting bias, with those countries that provide separate information on housing and energy likely to be more economically developed and in general exhibit lower overall inflation.

Inflation volatility exhibits similar patterns to the mean rates. The standard deviation of inflation rates is lower for high income countries than for middle and low income countries. The standard deviation falls through the period under analysis. In terms of the sub-indices, energy is the most volatile, followed by food, then housing. Not only do the remaining items of the index have the lowest rates of inflation, they also have the lowest variance.

### 4.3.4 Expenditure weights

How households allocate expenditure has been the subject of a large literature dating back to Engel (1857). Engel's Law states that as households become richer, the share of their spending devoted to food declines: food has an income elasticity of less than 1. Research has extended to considering more categories of expenditure than just food, but in general focuses at

Table 4.1: Mean, median and standard deviation of inflation, by country type

| | Full sample | | 1980-1991 | | 1992-2006 | | 2007-2012 | |
|---|---|---|---|---|---|---|---|---|
| Income | H | M/L | H | M/L | H | M/L | H | M/L |
| **Mean** | | | | | | | | |
| Headline | 4.9 | 9.9 | 7.9 | 13.7 | 3.8 | 9.4 | 3.3 | 7.0 |
| Food | 4.5 | 8.7 | 7.1 | 10.8 | 3.1 | 7.9 | 4.7 | 8.6 |
| Housing | 4.4 | 6.3 | 7.8 | 7.7 | 3.7 | 5.4 | 3.5 | 7.1 |
| Energy | 5.3 | 8.0 | 5.5 | 8.1 | 4.9 | 9.1 | 5.8 | 6.8 |
| CPIxFHE | 3.5 | 6.0 | 7.0 | 9.3 | 2.7 | 6.1 | 2.4 | 5.2 |
| **Median** | | | | | | | | |
| Headline | 3.0 | 6.1 | 5.1 | 9.1 | 2.5 | 5.2 | 2.8 | 5.5 |
| Food | 3.1 | 5.8 | 5.1 | 8.1 | 2.2 | 4.7 | 3.8 | 6.5 |
| Housing | 3.3 | 3.6 | 6.4 | 5.6 | 3.0 | 2.7 | 2.9 | 4.1 |
| Energy | 4.3 | 5.9 | 4.8 | 5.4 | 3.5 | 6.3 | 5.9 | 5.6 |
| CPIxFHE | 2.3 | 4.0 | 5.2 | 6.8 | 1.9 | 3.8 | 1.9 | 3.9 |
| **Standard deviation** | | | | | | | | |
| Headline | 7.8 | 13.6 | 11.0 | 16.5 | 6.5 | 13.8 | 2.9 | 7.2 |
| Food | 6.1 | 12.1 | 8.4 | 13.6 | 4.5 | 12.7 | 5.1 | 9.3 |
| Housing | 5.2 | 17.6 | 6.3 | 8.9 | 4.8 | 9.6 | 4.4 | 25.1 |
| Energy | 9.2 | 13.8 | 10.8 | 11.1 | 7.6 | 13.6 | 10.3 | 14.3 |
| CPIxFHE | 4.7 | 8.6 | 6.0 | 13.3 | 4.3 | 9.5 | 2.3 | 6.1 |

Note: H: high income countries; M/L: middle and low income countries.

the level of the individual household, using surveys of household expenditure. These same surveys are typically used to construct the expenditure weights in the CPI. These expenditure weights are used to combine the individual price series to form the overall index.

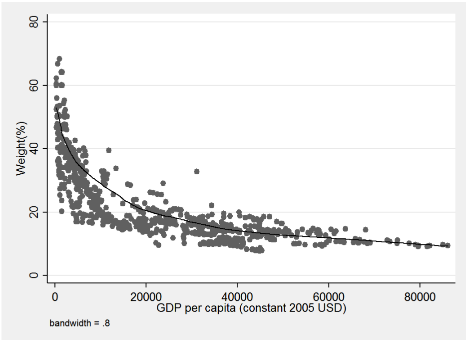
Despite the large literature at the household level, international comparisons of expenditure shares have been rare. Notable exceptions include Seale and Regmi (2006) who study expenditure shares for 114 countries and Kaus (2013) who studies 50 countries using UN data over the course of 50 years. These authors study a finer breakdown of expenditure weights by type than covered here, but have a markedly smaller coverage of countries. Only Anker (2011), who studies the food share of consumption, approaches the country coverage.

Comparisons between countries suffer from a number of potential problems. First, the exact nature of expenditure needs to be standardised across countries. For example, some countries include restaurants and cafés in their CPI food index. Second, transport costs, tariffs, taxes and subsidies can affect the relative price of goods and services between countries, and hence consumption shares. For example, petrol is frequently subsidised in developing countries, but taxed in advanced countries (Kojima, 2013). In some advanced countries the tax share of the price paid by consumers for petrol can exceed 40 percent. This difference is also true over time – changes in world commodity prices for oil and food can affect the relative price of these goods.

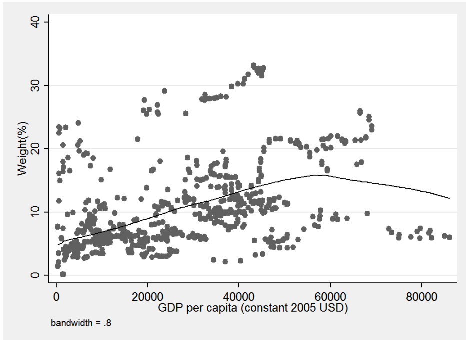
Finally, the frequency of updating expenditure weights varies between countries. Since household expenditure surveys are expensive, updating tends to be more frequent in high income economies. The longer between updates, the less likely the index represents true household spending. New expenditure surveys also allow for the incorporation of new goods and services, such as mobile phones, internet broadband providers and pet insurance. Infrequent weight updates in some countries means that there are several income observations for the same expenditure share.

Figure 4.3: Engel curves for CPI components, updated weights

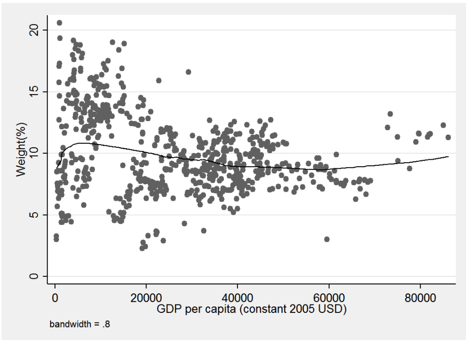
(a) Food




(b) Housing




(c) Energy




(d) CPIxFHE

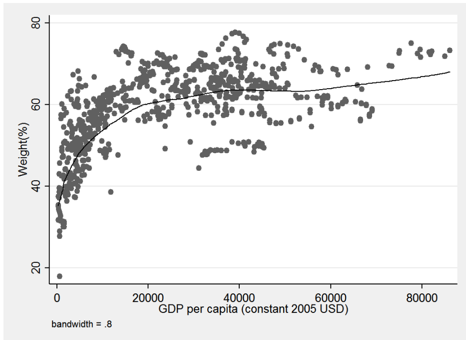



Figure 4.3 shows international Engel curves for food, housing, energy, and the remaining items of consumer spending. These curves match the share of expenditure on these items, as measured by their weight in the CPI, against the average per capita income of the country. As noted above in section 4.2.1, every effort has been made to put the series on as consistent a basis as possible. The scatterplots show the respective weights only when updated, to avoid the aforementioned problem with income changing over the period between updates. Scatterplots using just the 2010 Q4 data (see figure 4.7 in appendix 4.A) yield qualitatively similar results to the entire sample, suggesting that shifts in relative prices are of secondary importance to shifts in income.

The Engel curves are fitted in a non-parametric fashion, using locally weighted scatterplot smoothing (LOWESS, Cleveland, 1979). LOWESS is a local linear estimator using the tricube kernel function to calculate sufficiently smooth weights for neighbouring observations.

For food, there is a clear negative slope to the cross-country Engel curve; the relationship between income and the expenditure share of food across countries replicates that observed at the household level. For the most part the Engel curve for energy is downward sloping – a 'necessity' in the parlance of the literature. For the poorest countries, the Engel curve for energy is upward sloping, suggesting that these countries are income constrained and consuming less energy than desired.

The Engel curve for housing is upward sloping, implying that housing is a 'luxury'. While shelter is a basic necessity, countries with higher incomes can devote a greater share of income on larger, and better quality housing. The remaining items of consumer spending also have an upward sloping Engel curve. The results here are qualitatively similar to the results found by Kaus (2013) for a much smaller sample of countries.

## 4.4 Measures of global inflation

This section uses the data described above to consider the extent to which national inflation rates can be explained by measures of global inflation.

### 4.4.1 Headline

Like Ciccarelli and Mojon (2010), we consider three estimates of global headline inflation:

1. The median country-level inflation rate.
2. The average country-level inflation rate, weighted by GDP, and
3. A measure based on principal components analysis.

The median inflation rate is calculated separately for each quarter from 1981Q1 to 2012Q4. It uses all available national headline inflation rates for each quarter, so the sample changes over time. The GDP-weighted average inflation rate weights together available headline inflation rates for each quarter by real GDP (in 2005 US dollars) from the World Bank's *World Development Indicators*. Since the raw calculated series is heavily influenced by a small number of countries experiencing hyperinflation, the series used here excludes countries in quarters where their headline inflation exceeds 100 percent. Such episodes are rare, and account for less than 2 percent of the total.

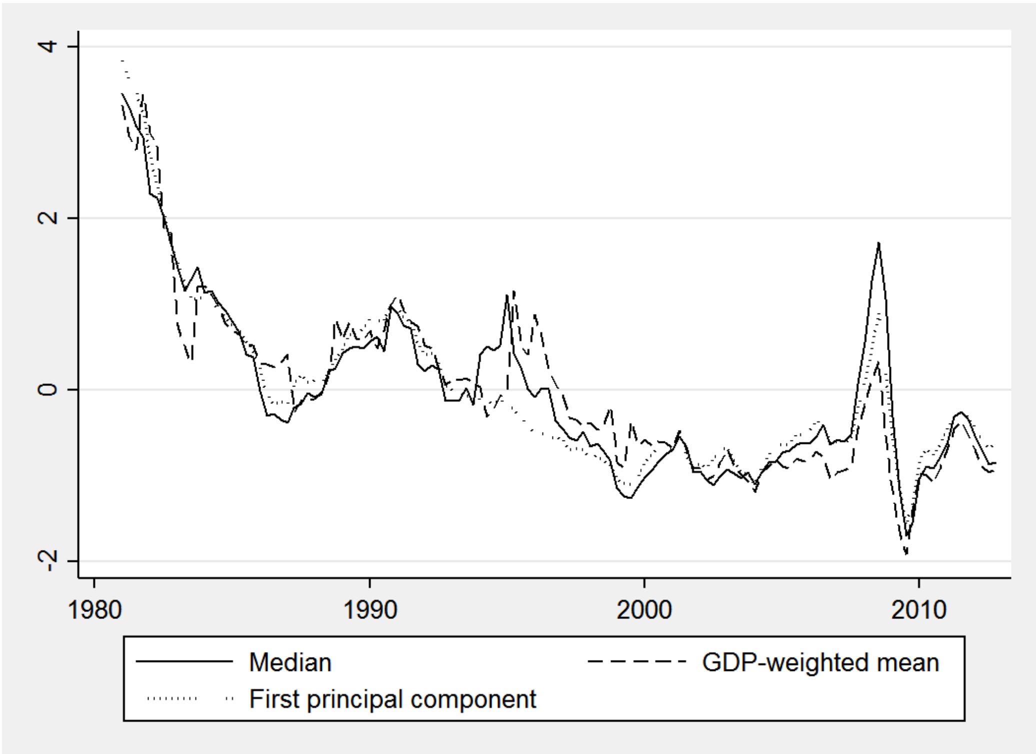
The third measure is based on a static principal component approach (See Stock and Watson, 2002). This approach models the $nx1$ vector of national inflation rates, $\Pi_t$, as being comprised of two parts:

$$\underset{n\times 1}{\Pi_t} = \underset{n\times 1}{\Lambda}\underset{i\times 1}{f_t} + \underset{n\times 1}{\epsilon_t} \tag{4.1}$$

where the first part is the effect of the common, global factor $f_t$. $\Lambda$ is the loading – the extent to which each country's inflation rate reacts to the global factor. The second term, $\epsilon_t$, is the idiosyncratic component, representing the shocks to inflation that are domestic in nature. $f_t$ and $\epsilon_t$ are assumed to be orthogonal, and $\epsilon_t$ is assumed to be normally distributed. The estimation of the static factors requires a balanced panel, so the inflation rates of the 104 countries for which there are observations of annual inflation in every quarter are used. These inflation rates are then de-meaned and standardised to have unit variance before the factors are estimated. The first principal component – the factor that explains the greatest share of the total variance – is taken as the measure of global inflation.

Figure 4.4 shows these three measures of global inflation. All three measures display the main features of inflation through the period – the disinflation through the 1980s and 1990s, the relatively low and stable inflation of the early 2000s and the sharp volatility around the time of the GFC. Overall, the three measures track reasonably closely through time,

Figure 4.4: Measures of global inflation




Note: The median and GDP-weighted measures have been de-meaned and standardised for the figure.

Table 4.2: Share of inflation variance explained by measures of global inflation (percent)

| | Median | Weighted mean | Principal components |
|---|---|---|---|
| **Median** | | | |
| Advanced | 62.1 | 64.6 | 71.4 |
| Other high income | 31.9 | 24.4 | 26.9 |
| Medium income | 17.6 | 15.8 | 14.7 |
| Low income | 11.1 | 6.0 | 7.9 |
| **Mean** | | | |
| Advanced | 60.3 | 59.0 | 68.5 |
| Other high income | 32.7 | 30.3 | 34.1 |
| Medium income | 20.2 | 19.6 | 19.7 |
| Low income | 15.4 | 12.6 | 13.0 |

with the exception of the mid 1990s. This may be a function of the different samples, since a number of countries enter the sample over that period (notably the transition economies of Eastern Europe) that are picked up in the median and weighted mean series, but not the principal component measure.

Table 4.2 shows the share of the variance of national inflation that is explained by each of the three measures of global inflation. Countries are divided into four groups by income levels. Advanced countries make up the first group, defined as high income countries that were members of the OECD in 1990, essentially the countries incorporated in the analysis by Ciccarelli and Mojon (2010). The second group are the remaining countries classified as 'high income' by the World Bank that are not also classified as advanced. The final two categories are those countries classified by the World Bank as middle and low income. The variance shares are calculated by obtaining the $R^2$ from a regression of each national inflation rate on the global inflation measure and a constant.[7]

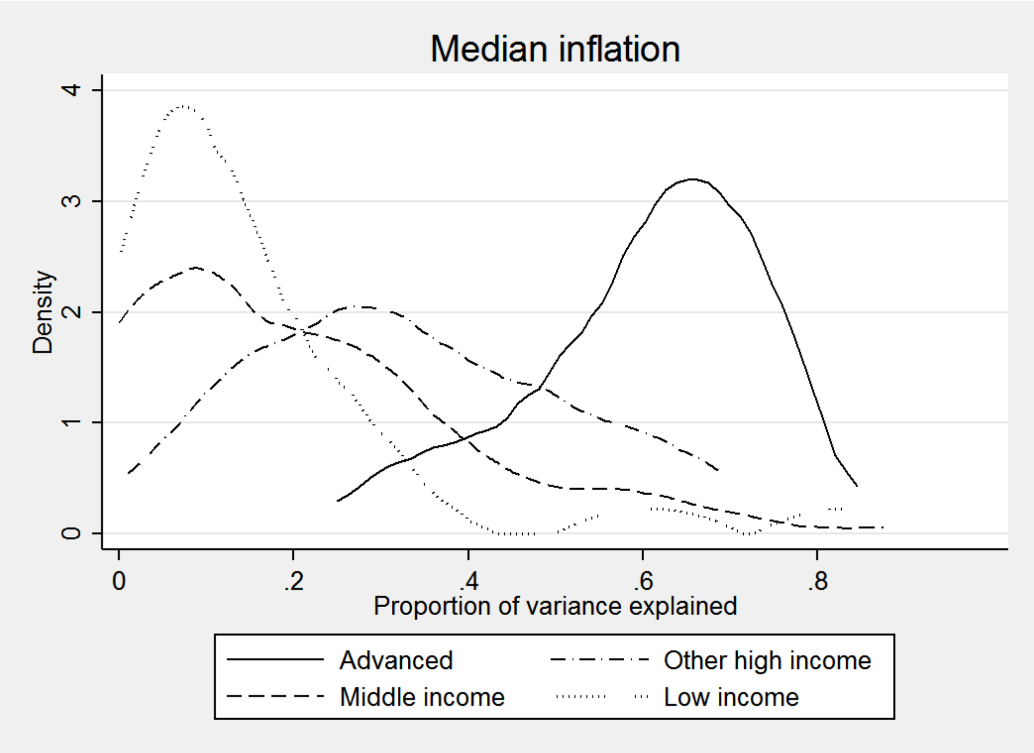
The advanced income countries are mostly the same countries as the 22 countries studied by Ciccarelli and Mojon (2010). The share of inflation variance of advanced countries explained by global factors is high – around two thirds, and in line with the findings of Ciccarelli and Mojon (2010). These findings, however, do not generalise to less developed economies. The three measures of global inflation explain a much smaller share of the variance of inflation rates of other countries – on average around a third of the variance of other high income countries, a fifth of the variance of middle income countries and slightly more than a tenth of the variance of low income countries.

The divergence between country groups of the share of variance of national inflation rate explained by the median global inflation measure is shown clearly in figure 4.5, which shows the kernel densities of the distribution by country type. There is a clear negative correlation between income and share of inflation variance explained by the global factors. The kernel densities by country type for the mean and principal components measures (not reported here) are broadly similar.

Ciccarelli and Mojon conclude that there is a need for international policy co-ordination between monetary policy makers. The evidence presented here suggests that advanced countries are better at eliminating idiosyncratic volatility, so the remaining volatility derives from movements in global factors, potentially related to commodity factors. The next section considers what can be learned by considering the sub-components of consumer prices.

[7]For those countries whose inflation rates are used to calculate the principal component measure, the method used here is equivalent to the $\lambda_i^2 var(f_t)/var(\pi_{it})$ more typically used for principal components. This latter method cannot be used since the factor loadings, $\lambda_i$ do not exist for those countries not used in the calculation of the principal component measure.

Figure 4.5: Kernel density of share of variance explained by median global inflation measure



### 4.4.2 Sub-components

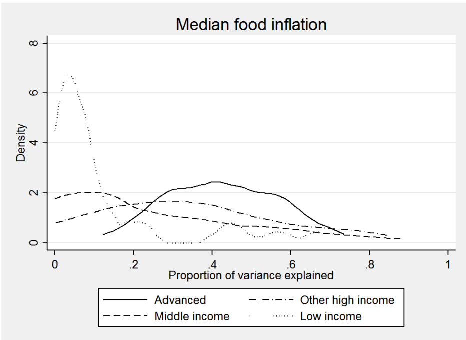
As shown in section 4.3.4 above, the weights of the sub-indices vary markedly between countries, so differences in the proportion of domestic inflation variance explained by global factor might simply be a function of differing consumption baskets. To test that hypothesis, we investigate the relationship between global factors and the individual sub-indices. Analogous to the method used above for headline CPI, we calculate the median global inflation rate for food, housing, energy and CPIxFHE. We then regress the national inflation rates for these sub-indices on their respective global counterparts to estimate the proportion of national variance that can be explained by the global factor.

Figure 4.6 shows the kernel densities for the proportion of national inflation explained by global factors, split by country type and sub-component. Global factors appear to explain a greater proportion of inflation variance for advanced countries than for less developed countries for all sub-components. This demonstrates that the greater share of headline inflation variance explained by global factors for these countries is not just an artefact of the composition of the index.

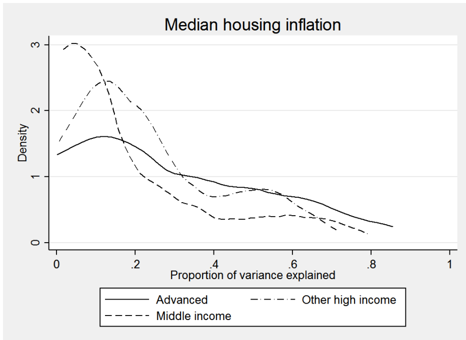
In terms of sub-components, the variance of national energy price inflation is the most explained by the global median. For advanced countries variance in food and CPIxFHE inflation is also explained in large part by global factors. Conversely, global factors do not appear to explain a large proportion of housing price inflation for any country group. It appears therefore that the divergence between countries of the influence of global factors is not a function of index composition and the differing consumption patterns that underlie that composition, but are instead a function of other country characteristics.

Figure 4.6: Kernel density of share of variance explained by global median inflation, by subcomponent

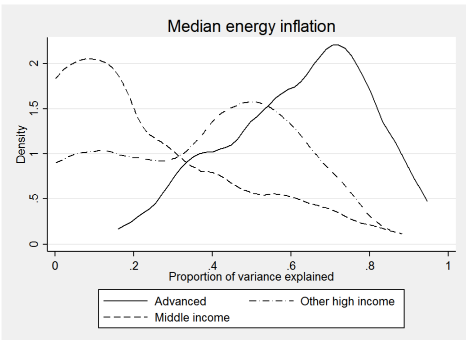
(a) Food



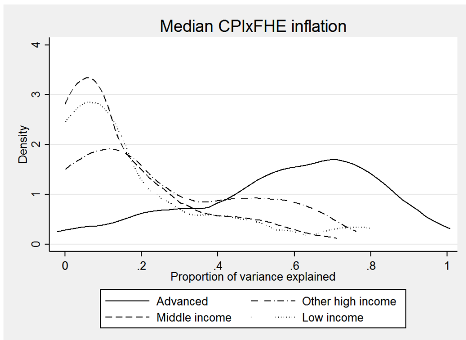

(b) Housing




(c) Energy




(d) CPIxFHE



### 4.4.3 Country characteristics

What explains the divergence in the proportion of national inflation variance explained by global inflation? As shown in section 4.4.2, differing consumption patterns are not the principal cause. There are a number of additional country characteristics that could potentially explain a greater or lesser influence of global factors on domestic inflation. We consider nine such factors in this section, extending the work of Neely and Rapach (2011).

The nine characteristics considered here are (1) the average headline inflation rate (2) inflation volatility as measured by the standard deviation (3) average real GDP per capita (4) trade openness, as measured by the trade share of GDP from the World Bank *World Development Indicators* (5) average government share of GDP from the World Bank *World Development Indicators* (6) financial development, measured by the domestic credit provided by financial sector as a share of GDP from the World Bank *World Development Indicators*[8] (7) the Chinn and Ito (2006) index of capital account openness (8) the Ilzetzki et al. (2004) measure of de facto exchange rate regime (9) The average Dincer and Eichengreen (2014) central bank transparency index. There is a close correlation between transparency and independence of central banks, so we use transparency here since this index is available for a larger sample of central banks.

In a similar fashion to Neely and Rapach (2011) we regress the proportion of each country's national inflation rate explained by global median inflation on each of the characteristics in turn using a bivariate regression, then on all seven characteristics. The model of the bivariate regression is:

$$G_i = \alpha + \beta_j Z_{j,i} + e_i \tag{4.2}$$

where $G_i$ is the proportion of the inflation variance of country $i$ ($i$ =

[8] The liquid liabilities measure used by Neely and Rapach (2011) gives similar results, but is available for far fewer countries.

1,2,...,223) explained by the global median, and $Z_{j,i}$ is the average value for characteristic $j$ ($j$ = 1,2,...,9) in country $i$ for the period where inflation data is available for country $i$. The multivariate regression is given by:

$$G_i = \alpha + \sum_{j=1}^{9} \beta_j Z_{j,i} + e_i \tag{4.3}$$

We estimate equations 4.2 and 4.3 using ordinary least squares and White (1980) heteroskedasticity-consistent standard errors. The explanatory variables studied here vary both cross-sectionally and over time. Given that for each country we only have one observation for $G_i$, we are only able to use the average of each explanatory variable over the period for which inflation data exist. Unfortunately, this does not allow for consideration of the time-varying component. That said, time variation is of second order of importance compared with the cross-sectional variation; the average variance over time for each country for each variable is markedly smaller than the variance of country averages. The results of the bivariate and multivariate regressions are presented in table 4.3.

For the bivariate equations, average inflation and inflation volatility are negatively related to $G_i$ and significant at the 1 percent level. This means that global factors explain less of national inflation variance in countries with higher average inflation, or greater volatility of inflation. GDP per capita, financial development, capital account openness and central bank transparency are positively related to $G_i$ and again significant at the 1 percent level. The more freely floating the country's exchange rate, the smaller the influence of global inflation on domestic inflation. There is some evidence that increased trade openness increases the influence of global factors on domestic inflation, but this effect appears small (increasing trade openness by 50 percent of GDP increases the share of inflation explained by global factors by 3 percentage points), and is only significant at the 10 percent level. The size of government appears to have no impact on $G_i$.

Table 4.3: Cross-sectional regression results for country characteristics that explain link between national and global inflation

| | Bivariate regressions | | | | Multivariate regressions | | | |
|---|---|---|---|---|---|---|---|---|
| Country characteristic | Slope | $t$-stat | $N$ | $\overline{R}^2$ | Slope | $t$-stat | $N$ | $\overline{R}^2$ |
| Average inflation | -0.0003 | $-2.71^{***}$ | 222 | 0.03 | 0.0001 | 0.07 | 127 | 0.53 |
| Inflation volatility | -0.0001 | $-2.84^{***}$ | 222 | 0.02 | -0.0002 | $-0.83$ | | |
| GDP per capita | 0.0732 | $9.07^{***}$ | 199 | 0.27 | 0.0394 | $2.50^{**}$ | | |
| Trade openness | 0.0006 | $1.85^{*}$ | 190 | 0.01 | -0.0000 | $-0.13$ | | |
| Government size | 0.0025 | 1.04 | 187 | 0.00 | -0.0034 | $-1.03$ | | |
| Financial development | 0.0027 | $8.28^{***}$ | 182 | 0.28 | 0.0014 | $3.90^{***}$ | | |
| Capital acct. openness | 0.0653 | $5.46^{***}$ | 175 | 0.22 | -0.0070 | $-0.55$ | | |
| De facto exchange rate | -0.0543 | $-3.32^{***}$ | 184 | 0.28 | -0.0463 | $-2.22^{**}$ | | |
| CB transparency | 0.0387 | $7.51^{***}$ | 138 | 0.28 | 0.0213 | $3.49^{***}$ | | |

Note: $F$-statistic, testing a null hypothesis that the slope coefficients for the multivariate regression are jointly zero is 35.29***. $t$-stats and $F$-stat calculated based on the White (1980) heteroskedasticity-consistent standard errors and covariance matrix respectively. *, **, *** denote significance at the 10%, 5% and 1% levels respectively.

When the country characteristics are jointly considered in the multivariate model, only GDP per capita, financial development the de facto exchange rate regime and central bank transparency remain significant. Higher income, and greater availability of credit enables such economies to reduce the impact of domestic shocks. Similarly, a flexible exchange rate insulates domestic prices from shifts in global inflation. Better monetary policy, as indicated by higher transparency, also reduces the idiosyncratic part of national inflation variation. With the idiosyncratic component reduced, the influence of global factors on national inflation becomes relatively greater.

### 4.4.4 A dynamic hierarchical factor model for global inflation

The disadvantage of the measures used in section 4.4.1 is that they treat all components of the CPI in equivalent fashion. Yet global shocks can have differing effects on sub-components. For example the greater integration of China into the global economy has depressed the prices of manufactured goods and at the same time put upward pressure on commodity prices. Increased global liquidity over the 2000s put upward pressure on housing, food and energy prices, pressure which abated dramatically following the crisis in 2008/2009. To take into account these potential differences in spillovers, we use an alternative modelling strategy for global inflation, by using the dynamic hierarchical factor model developed by Moench et al. (2013). As noted above, this has been used by Förster and Tillmann (2014) for a group of 40, mostly high income, countries. We extend their analysis by including a much larger sample of countries, and by examining the housing sub-component of the CPI.

**Model**

The model has a hierarchical structure of order four. Specifically, at time $t$, let $F_t$ denote the global factor that captures movements in inflation common to all sub-indices and all countries. $G_{bt}$ are the factors that capture variations in sub-indices, indexed by $b$ and $H_{bst}$ are the factors that capture the variations in country group $s$ in the CPI sub-index block $b$. The structure of the model is give by:

$$Z_{bsnt} = \Lambda_{Zbsn} H_{bst} + u_{Zbsnt} \tag{4.4}$$

$$H_{bst} = \Lambda_{Hbs} G_{bt} + u_{Hbst} \tag{4.5}$$

$$G_{bt} = \Lambda_{Gb} F_t + u_{Gbt} \tag{4.6}$$

where $Z_{bsnt}$ represents an observation for country $n$ in country group (sub-block) $s$ of the CPI sub-index (block) $b$ at period $t$. $\Lambda_{Zbsn}$, $\Lambda_{Hbs}$ and $\Lambda_{Gb}$ are constant factor loadings. One useful feature of this model is that the total number of time series, $N_{bs}$ can differ between blocks $b$ and sub-blocks $s$, allowing for different coverage of sub-indices by country group. The global factor is dynamic and assumed to follow an autoregressive process of order one:

$$F_t = \rho_F F_{t-1} + \epsilon_{Ft} \tag{4.7}$$

We make the following assumptions to match persistence in the data:

$$u_{Zbsnt} = \rho_{Zbsn} u_{Zbsn(t-1)} + \epsilon_{Zbsnt} \tag{4.8}$$

$$u_{Hbst} = \rho_{Hbs} u_{Hbs(t-1)} + \epsilon_{Hbst} \tag{4.9}$$

$$u_{Gbt} = \rho_{Gb} u_{Gb(t-1)} + \epsilon_{Gbt} \tag{4.10}$$

with $\epsilon_{jt} \sim N(0, \sigma_j)$ for $j = Zbsn$, $Hbs$, $Gb$, $F$. All residuals $\epsilon_{jt}$ are uncorrelated across $j$ and $t$. For identification purposes,the first entries of $\Lambda_{Zbsn}$, $\Lambda_{Hbs}$ and $\Lambda_{Gb}$ are set equal to 1, and the variances $\sigma^2_{Hbs}$, $\sigma^2_{Gb}$, $\sigma^2_F$ to 0.1.

Since the hierarchical nature of the model imposes vertical dependency of the factors, along with the time-varying intercepts from equations 4.8 to 4.10, the model is estimated using Markov Chain Monte Carlo methods and the Kalman filter. In brief, each factor is first drawn conditional on the other factors and parameters. Then the factor loadings, autoregressive parameters and sub-block level variances $\sigma^2_{Zbsn}$ are drawn conditional on the factors estimated in the first step.[9] After the first 50,000 draws are discarded as burn-in, a further 50,000 draws are carried out, storing every fiftieth draw. The 1,000 stored draws are used to calculate the posterior means shown below.

The advantage of the hierarchical nature of the model is that it allows for global factors to affect all sub-indices in each country, but does not allow for idiosyncratic factors affecting, say, energy prices to affect other indices. By imposing this hierarchy it is possible to isolate the contribution of each individual factor for individual time series, something not possible under joint modelling of global and regional factors. In particular this allows the analysis of differing contributions of global factors in energy prices to variance in high and middle income countries as against global food price factors in these groups of countries. The main disadvantage of the method is that it is computationally intensive, requiring a day to estimate. The other disadvantage is that we impose the country groupings between high, middle and (in some sub-blocks) low income. This is somewhat arbitrary and there could be countries which are more accurately included into other groups, or may differ in groups depending on the sub-index in question.

We choose the following ordering for the estimation: the first block is CPI excluding food, housing and energy, the second block is CPI housing followed by CPI energy with the final block being CPI food. For the sub-blocks, the countries are grouped by income, rather than the grouping by geographical region that is used by e.g. Neely and Rapach (2011). We believe that commonalities associated with income and macroeconomic institutions are likely to be stronger than those associated with geographic location, a belief reinforced by the findings in section 4.4.3.

[9]Moench et al. (2013) set out in full detail the MCMC approach and the use of the filter. The estimation of the model here is made with the help of the MATLAB code available on Serena Ng's website.

Consider Australia and New Zealand: these two countries are small, open advanced economies whose monetary policy has been based on inflation targeting for the period in question. These characteristics are common with many other geographically distant high income countries – Canada, Sweden, Norway, the United Kingdom to name but a few. Neighbouring countries to Australia and New Zealand in Oceania, such as Fiji, Samoa and Tonga, are small island developing states with markedly different economic characteristics.

The sub-blocks are ordered by high income countries first and medium income countries second. For the CPIxFHE and CPIF blocks there are sufficient observations to have sub-blocks for low income countries. To maximise the sample, the analysis is run on annual inflation starting in 2001Q1 and ending in 2012Q4.

The factor model set out above assumes that the underlying data series are stationary. There are a large number of studies on the stationarity of inflation rates, with the evidence inconclusive. Several authors finding inflation to exhibit some form of non-stationarity (e.g. King et al., 1991; Baba et al., 1992; Johansen, 1992), while others argue that inflation is stationary (e.g. Rose, 1988; Culver and Papell, 1997). We first test for stationarity of the series using an Augmented Dickey-Fuller (ADF) test, using both one and two lags (table 4.4). For CPI excluding food, housing and energy, we find significant evidence to reject the null of non-stationarity for around half the countries at the 5 percent significance level using two lags. The results for housing are similar. We find significant evidence to reject the null of non-stationarity of energy prices for all but one country, and also reject the null for a large proportion of food price series.

ADF tests have low power, and struggle to reject the null hypothesis when roots are stationary, but close to unity. This is particularly the case in short time samples such as the one used here. Given this lack of power for the ADF test, we adopt two panel methods for testing for stationarity. The first is the LLC test (Levin et al., 2002) for panel stationarity. The LLC test is

Table 4.4: Tests for stationarity

| | *ex* Food, housing & energy | Housing | Energy | Food |
|---|---|---|---|---|
| No. of countries | 96 | 62 | 63 | 148 |
| ADF(1) 1% | 9 | 2 | 3 | 9 |
| ADF(1) 5% | 24 | 7 | 22 | 19 |
| ADF(2) 1% | 29 | 5 | 51 | 62 |
| ADF(2) 5% | 53 | 24 | 62 | 114 |
| LLC | $-18.50^{**}$ | $-10.33^{**}$ | $-24.01^{**}$ | $-27.70^{**}$ |
| CIPS | $-2.43^{**}$ | $-2.10$ | $-2.73^{**}$ | $-2.79^{**}$ |

Notes: ADF(1) is an Augmented Dickey-Fuller test with one lagged coefficient, ADF(2) has two lagged coefficients. Numbers reported for the ADF tests are the number of countries which reject the null of non-stationarity at respectively the 1 percent and 5 percent levels of significance. LLC is the Levin et al. (2002) test for panel stationarity, CIPS is the panel unit root test of Pesaran (2007) that accounts for cross-sectional dependence. For both LLC and CIPS the null hypothesis is that all panels are non-stationary. *, ** denote significance at 5 and 1 percent level respectively.

less commonly used in the literature because it requires a balanced panel and has the restrictive hypotheses that each panel (i.e. country) is non-stationary versus the alternative that all are stationary. LLC recommend using the test for panels of n between 10 and 250 and T between 25 and 250, which range covers the data here. The LLC test is significant at the 1 percent level for all series used here.

The second panel unit root test used here is the CIPS test of Pesaran (2007). If there is cross-sectional dependence between countries,[10] then the LLC test is not properly specified, exhibits downward bias and lacks power. The CIPS test explicitly accounts for cross-sectional dependence. For three of the series considered here, the CIPS test rejects the null of non-stationarity at the 1 percent level of significance. The test statistic for CPI housing inflation lies just outside the 5 percent significance level of -2.12. Given the low power of the ADF tests, and the clear results from the panel unit root tests it is reasonable to assume that the inflation rates in the panel are stationary and that the DHFM is appropriate.

**Results**

Table 4.5 reports the proportion of the variance of each sub-block explained by the different hierarchical levels of the model. The first observation is that the idiosyncratic component accounts for the majority of the variance in each sub-block, with the sole exception of high income countries' CPI energy. For these countries, global factors explain just over half of the variance, split between the global factor (16.4 percent), the energy sub-index (18.6 percent) and the high income countries' energy price factor (19.1 percent). For middle income countries, the idiosyncratic component of CPI energy explains a much larger (82.3 percent) share of total variance. The difference in the share of variance explained by common factors may arise because of differences in regulation. Regulated fixed prices and subsidies

[10]Chapter 5 discusses cross-sectional dependence between countries in more detail.

Table 4.5: Decomposition of variance from dynamic hierarchical factor model (percent)

| Block | Subblock | N | Global | CPI subindex | Country group | Idiosyncratic |
|---|---|---|---|---|---|---|
| CPIxFHE | High | 48 | 2.1 | 1.4 | 1.1 | 95.5 |
| CPIxFHE | Middle | 38 | 5.7 | 3.6 | 1.5 | 89.1 |
| CPIxFHE | Low | 10 | 5.1 | 3.2 | 2.7 | 89.0 |
| CPIH | High | 44 | 0.8 | 1.7 | 0.7 | 96.7 |
| CPIH | Middle | 18 | 0.0 | 0.1 | 9.9 | 90.0 |
| CPIE | High | 45 | 16.4 | 18.6 | 19.1 | 46.0 |
| CPIE | Middle | 18 | 7.1 | 8.0 | 2.7 | 82.3 |
| CPIF | High | 59 | 7.5 | 11.1 | 11.9 | 69.5 |
| CPIF | Middle | 68 | 9.0 | 13.3 | 1.0 | 76.7 |
| CPIF | Low | 21 | 3.2 | 4.7 | 9.6 | 82.4 |

Note: CPIxFHE: CPI excluding food, housing and energy prices; CPIH: CPI housing; CPIE: CPI Energy; CPIF: CPI food.

for fuel are relatively common in emerging and developing countries (Kojima, 2013), but less so in advanced countries.

Common factors also account for a relatively large share of the variance of food price inflation – around a third for high income countries and around a quarter for middle income countries. For both these groups of countries, the food sub-index factor accounts for at least 10 percent of the total variance. Yet even over a period marked by large volatility in world food commodity prices, the idiosyncratic components explained the majority of the variance. As with energy, the common factors for food explained a greater share of the variance for high income countries than for relatively poorer countries. This may be a result of higher food import shares for richer countries, and the existence of food price regulation in some countries.

For housing and for CPIxFHE, the common factors explain little of the variance. For high income countries, the common factors explain 3.3 percent of the variance of CPI housing and 4.5 percent of the variance of CPIxFHE. For middle and low income countries, the proportion explained by common factors is in the order of 10 percent.

It is clearly important to consider the role of sub-components when assessing the extent of influence by global factors, given the divergent shares explained by common factors. For high income countries, common factors explain a large share of the variance of food and energy prices. This is perhaps understandable since there is a common world oil price, and central banks typically 'look through' the first round effects from movements in commodity prices. Given these components are also more volatile that the other components of the CPI, it follows that these factors account for a large share of total CPI variance.

Monetary policy makers in advanced countries have been successful in eliminating the domestic, idiosyncratic fluctuations in inflation. The main source of remaining inflation variance in advanced countries is the movements in commodity prices, notably food and energy. In lower-income countries, monetary policy makers have been less successful in eliminating the influence of domestic factors on inflation, resulting in a proportionately smaller influence from global factors.

## 4.5 Conclusion

This paper sets out the construction of a comprehensive dataset of consumer prices for 223 countries and territories for the period 1980-2012. The dataset includes, where publicly available, the sub-indices for food, housing and energy, together with their respective weights in the overall index. Comparable international datasets for these sub-indices are rare, and almost exclusively confined to advanced economies. As a consequence, research on inflation, and in particular its sub-components, has typically been confined to a small number of relatively rich countries.

There are a number of stylised facts on the cross-section and time-series properties of inflation provided by the dataset. Global inflation fell through the early part of the period studied, particularly in high income countries, and was relatively stable until the period around the recent global financial crisis. This recent volatility was mostly attributable to food and energy prices. Food and energy prices are the most volatile sub-indices, and also exhibit the highest average inflation over the past three decades. Inflation in consumer prices excluding food, housing and energy is comparatively low and stable. The share of food in total expenditure falls as income rises; the share of housing increases.

Using this dataset we extend the literature on the role of global inflation factors on national inflation rates to a larger, and more diverse, group of countries. We confirm the findings of Ciccarelli and Mojon (2010) that global factors can explain around 70 percent of the variance of advanced economies' inflation. However, we find that this conclusion does not generalise to a more diverse group of countries than that originally considered. The amount of national inflation variance explained by global factors declines markedly for lower income countries.

The extent that national inflation variance can be explained by global factors does not appear to be solely a function of the composition of the index. Global factors can explain a greater share of the variance of the sub-indices for food, energy, and CPI excluding food, housing and energy in higher income countries than in middle and low-income countries. Using an alternative approach of the dynamic hierarchical factor model of Moench et al. (2013) we show that common factors are important for explaining energy and, to a lesser extent, food prices.

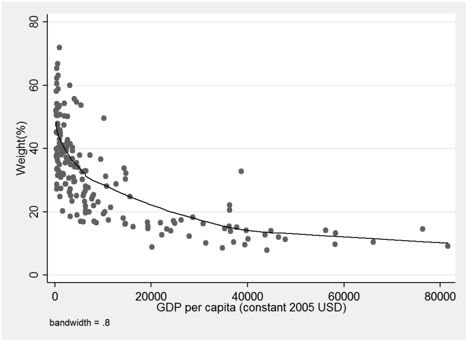
There are a number of country characteristics that explain a greater apparent influence of global factors. In particular, higher GDP per capita, greater financial development and greater central bank transparency are associated with a greater share of national inflation variance explained by global factors. This suggests that advanced countries are more successful at eliminating domestic sources of inflation variation, resulting in a greater proportionate role for global factors.

Ciccarelli and Mojon (2010) conclude their paper with a view that inflation should be modelled, to some extent, as a global rather than a local phenomenon. We agree that common global elements exist, notably in food and energy prices, but conversely argue that such considerations become important only once domestic sources of inflation instability are eliminated.

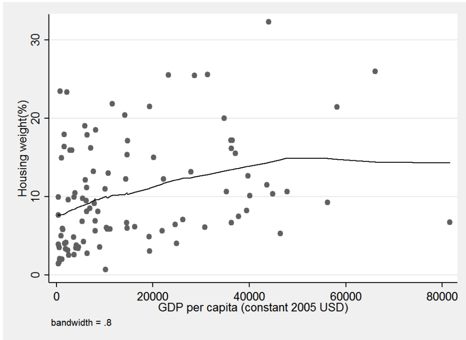
## 4.A Appendix – additional figures

Figure 4.7: Engel curves for CPI components, 2010Q4 weights

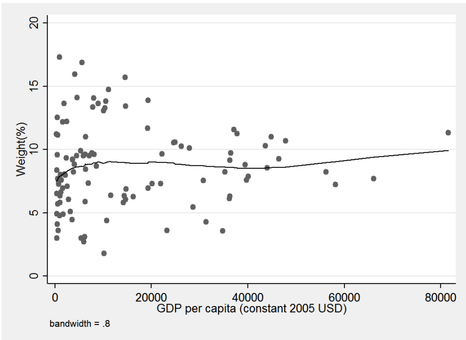
(a) Food



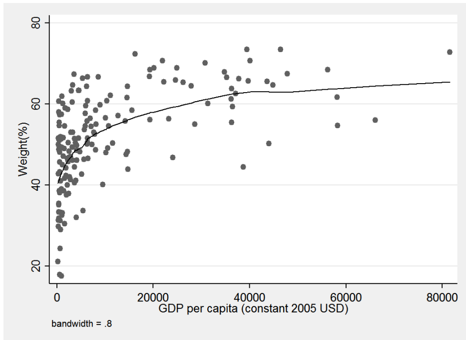

(b) Housing




(c) Energy




(d) CPIxFHE



## 4.B Appendix – CPI data coverage

The author gratefully acknowledges the assistance provided by the relevant national (*) central bank and (†) statistical agency. Indices: CPI: headline, CPIF: CPI food, CPIH: CPI housing, CPIE: CPI energy, CPIHE: CPI housing and energy, CPIxFE: CPI excluding food and energy, CPIxFHE: CPI excluding food, housing and energy.

| Country | CPI | CPIF | CPIH | CPIE | CPIHE | CPIxFE | CPIxFHE |
|---|---|---|---|---|---|---|---|
| Afghanistan | 04Q2 | | | | | | |
| Albania | 93Q1 | 01Q1 | | | 01Q1 | | 01Q1 |
| Algeria | 80Q1 | 90Q1 | | | 02Q1 | | 02Q1 |
| Amer. Samoa | 83Q1 | 83Q1 | | | 99Q1 | | 99Q1 |
| Andorra | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| Angola | 98Q1 | 00Q1 | | | | | |
| Anguilla | 98Q1 | 00Q4 | 00Q4 | 00Q4 | 00Q4 | 00Q4 | 00Q4 |
| Antigua & Barb. | 94Q1 | 94Q1 | 0Q4 | 00Q4 | 00Q4 | 00Q4 | 00Q4 |
| Argentina | 80Q1 | 93Q1 | | | 93Q1 | | 93Q1 |
| Armenia * | 95Q1 | 95Q1 | | 98Q1 | | 06Q1 | |
| Aruba | 84Q1 | 84Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 |
| Australia | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Austria† | 80Q1 | 80Q1 | 96Q1 | 80Q1 | 80Q1 | 80Q1 | 96Q1 |
| Azerbaijan | 91Q1 | 98Q1 | | | | | |
| Bahamas | 80Q1 | 86Q1 | | | | | |
| Bahrain | 80Q1 | 85Q3 | | | 07Q3 | | |
| Bangladesh | 93Q3 | 93Q3 | | | 08Q1 | | 08Q1 |
| Barbados* | 80Q1 | 85Q1 | 85Q1 | 85Q1 | 85Q1 | 85Q1 | 85Q1 |
| Belarus* | 91Q1 | 02Q1 | | | | | |
| Belgium | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 84Q1 | 80Q1 | 80Q1 |
| Belize* | 83Q1 | 85Q1 | | | 90Q4 | | 90Q4 |
| Benin | 92Q1 | 97Q1 | | 03Q1 | 97Q1 | 98Q1 | 97Q1 |
| Bermuda | 82Q1 | 82Q1 | | | | | |
| Bhutan | 03Q2 | 03Q2 | | | | | |
| Bolivia | 80Q1 | 88Q1 | 88Q1 | 88Q1 | 88Q1 | 88Q1 | 88Q1 |
| Bonaire | 96Q2 | 96Q2 | | | 96Q2 | | 96Q2 |
| Bosnia Herz. | 05Q1 | 05Q1 | | | 05Q1 | | 05Q1 |

| Country | CPI | CPIF | CPIH | CPIE | CPIHE | CPIxFE | CPIxFHE |
|---|---|---|---|---|---|---|---|
| Botswana | 80Q1 | 80Q4 | | | 04Q3 | | 04Q3 |
| Brazil | 80Q1 | 94Q4 | | | 94Q4 | | 94Q4 |
| Br. Virgin Is. | 85Q1 | 85Q1 | | | | | |
| Brunei | 83Q1 | 83Q1 | 06Q1 | 06Q1 | 06Q1 | 06Q1 | 06Q1 |
| Bulgaria | 91Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| Burkina Faso | 80Q1 | 82Q4 | | 03Q1 | 97Q1 | 00Q1 | 97Q1 |
| Burundi† | 80Q1 | 09Q1 | | | 09Q1 | | 09Q1 |
| Cambodia | 94Q4 | 00Q1 | | | 00Q1 | | 00Q1 |
| Cameroon | 80Q1 | 94Q1 | | | 94Q1 | | 94Q1 |
| Canada* | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Cape Verde | 92Q1 | 05Q4 | | | | | |
| Cayman Is. | 80Q1 | 84Q3 | | | 08Q2 | | 08Q2 |
| Central Afr. Rep. | 81Q1 | 81Q1 | | | 06Q1 | | 06Q1 |
| Chad | 82Q4 | 88Q1 | | | 06Q1 | 95Q1 | 06Q1 |
| Chile | 80Q1 | 80Q1 | 89Q1 | 89Q1 | 89Q1 | 80Q1 | 89Q1 |
| China | 84Q1 | 93Q1 | | | 01Q1 | 93Q1 | 01Q1 |
| Colombia | 80Q1 | 88Q1 | | | 88Q1 | 99Q1 | 88Q1 |
| Comoros | 90Q1 | 92Q1 | 92Q1 | 92Q1 | 92Q1 | 92Q1 | 92Q1 |
| Congo (Brazz.) | 80Q1 | 80Q1 | | | 90Q1 | | 90Q1 |
| Congo, DR | 80Q1 | | | | | | |
| Cook Is. | 80Q1 | 80Q1 | 06Q1 | 06Q1 | 06Q1 | 06Q1 | 06Q1 |
| Costa Rica | 80Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 |
| Cote dIvoire | 80Q1 | 97Q1 | | 03Q1 | 97Q1 | 97Q1 | 97Q1 |
| Croatia† | 94Q1 | 94Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| Cuba | 00Q1 | 00Q1 | | | | | |
| Curaçao | 80Q1 | 90Q4 | | | 96Q1 | | 96Q1 |
| Cyprus | 80Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 |
| Czech Republic | 93Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 |
| Denmark† | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Djibouti | 99Q3 | 99Q3 | | | 99Q3 | | 99Q3 |
| Dominica | 80Q1 | 85Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 |
| Dominican Rep. | 80Q1 | 91Q1 | | | 91Q1 | 91Q1 | 91Q1 |
| Ecuador | 80Q1 | 81Q1 | | | 97Q1 | | 97Q1 |
| Egypt | 80Q1 | 95Q1 | | | 03Q2 | 04Q1 | 03Q2 |
| El Salvador | 80Q1 | 80Q1 | | | 93Q1 | | 93Q1 |
| Eq. Guinea | 85Q1 | | | | | | |
| Estonia | 96Q1 | 96Q1 | 98Q1 | 98Q1 | 96Q1 | 98Q1 | 98Q1 |
| Ethiopia | 80Q1 | 80Q1 | | | | | |
| Falkland Is. | 82Q1 | 82Q1 | | | | | |
| Faroe Is. | 83Q1 | 83Q1 | 83Q1 | 83Q1 | 83Q1 | 83Q1 | 83Q1 |

| Country | CPI | CPIF | CPIH | CPIE | CPIHE | CPIxFE | CPIxFHE |
|---|---|---|---|---|---|---|---|
| FS Micronesia | 00Q2 | 00Q2 | 00Q2 | 00Q2 | 00Q2 | 00Q2 | 00Q2 |
| Fiji*† | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Finland | 80Q1 | 80Q1 | 96Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| France | 96Q1 | 80Q1 | 96Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| French Guiana | 80Q1 | 80Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| French Polynesia | 80Q1 | 81Q1 | 81Q1 | 81Q1 | 81Q1 | 81Q1 | 81Q1 |
| Gabon | 80Q1 | 90Q3 | | | 90Q3 | | 90Q3 |
| Gambia | 80Q1 | 80Q1 | | | | | |
| Georgia† | 97Q1 | 97Q1 | 04Q1 | 04Q1 | 00Q1 | 04Q1 | 00Q1 |
| Germany | 80Q1 | 80Q1 | 91Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Ghana* | 80Q1 | 84Q1 | | | 97Q4 | | 97Q4 |
| Gibraltar | 80Q1 | 80Q1 | | | 80Q1 | | 80Q1 |
| Greece | 80Q1 | 80Q1 | 96Q1 | 89Q1 | 80Q1 | 89Q1 | 80Q1 |
| Grenada | 80Q1 | 01Q1 | | | 01Q1 | | 01Q1 |
| Guadeloupe | 80Q1 | 80Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| Guam | 80Q1 | 80Q1 | 96Q3 | 96Q3 | 86Q2 | 96Q3 | 86Q2 |
| Guatemala | 80Q1 | 90Q1 | | | 01Q1 | 95Q1 | 01Q1 |
| Guernsey | 80Q1 | | | | | | |
| Guinea | 87Q1 | 87Q1 | | | 03Q1 | 03Q1 | 03Q1 |
| Guinea Bissau | 86Q1 | 86Q1 | | 03Q1 | 97Q1 | 03Q1 | 97Q1 |
| Guyana | 94Q1 | 94Q1 | | | 01Q1 | | 01Q1 |
| Haiti | 80Q1 | 81Q1 | | | 99Q1 | | 99Q1 |
| Honduras | 80Q1 | 80Q1 | | | 00Q1 | 00Q2 | 00Q1 |
| Hong Kong | 80Q4 | 82Q1 | 82Q1 | 82Q1 | 82Q1 | 82Q1 | 82Q1 |
| Hungary† | 80Q1 | 92Q1 | 01Q1 | 92Q1 | 01Q1 | 92Q1 | 01Q1 |
| Iceland | 80Q1 | 80Q1 | 96Q1 | 93Q1 | 93Q1 | 93Q1 | 93Q1 |
| India | 80Q1 | 80Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 |
| Indonesia | 80Q1 | 80Q1 | 99Q2 | 99Q2 | 96Q1 | 91Q1 | 96Q1 |
| Ireland | 80Q1 | 80Q1 | 96Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Iran | 80Q1 | 82Q1 | | | 06Q2 | | 06Q2 |
| Iraq | 04Q1 | 04Q1 | 04Q1 | 09Q1 | 04Q1 | 04Q1 | 04Q1 |
| Isle of Man† | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Israel | 80Q1 | 86Q1 | 86Q1 | 86Q1 | 86Q1 | 86Q1 | 86Q1 |
| Italy | 80Q1 | 80Q1 | 96Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Jamaica | 80Q1 | 80Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 |
| Japan* | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Jersey | 89Q1 | 00Q2 | 83Q1 | 83Q1 | 83Q1 | 83Q1 | 83Q1 |
| Jordan | 80Q1 | 80Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| Kazakhstan | 94Q1 | 97Q4 | | | 08Q1 | 03Q1 | 08Q1 |
| Kenya* | 80Q1 | 80Q1 | 80Q1 | 90Q1 | 90Q1 | 90Q1 | 90Q1 |

| Country | CPI | CPIF | CPIH | CPIE | CPIHE | CPIxFE | CPIxFHE |
|---|---|---|---|---|---|---|---|
| Kiribati | 83Q1 | 88Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 |
| Kosovo | 02Q3 | 02Q3 | | | 02Q3 | | 02Q3 |
| Korea | 85Q1 | 81Q1 | 85Q1 | 85Q1 | 85Q1 | 80Q1 | 85Q1 |
| Kuwait | 80Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 |
| Kyrgyzstan | 95Q1 | 03Q1 | 03Q1 | 03Q1 | 03Q1 | 03Q1 | 03Q1 |
| Lao PDR | 93Q2 | 00Q1 | | | | | |
| Latvia | 92Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 |
| Lebanon | 00Q1 | 08Q1 | 08Q1 | 08Q1 | 08Q1 | 08Q1 | 08Q1 |
| Lesotho | 80Q1 | 84Q1 | | | 02Q1 | | 02Q1 |
| Liberia | 01Q1 | 06Q1 | | | 06Q1 | | 06Q1 |
| Libya | 01Q1 | 04Q1 | | | 04Q1 | | 04Q1 |
| Lithuania | 92Q2 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 |
| Luxembourg | 80Q1 | 80Q1 | 96Q1 | 80Q1 | 96Q1 | 80Q1 | 96Q1 |
| Macau | 88Q1 | 89Q1 | | | 01Q1 | | v |
| Macedonia | 96Q1 | 96Q1 | 05Q1 | 05Q1 | 05Q1 | 05Q1 | 05Q1 |
| Madagascar | 80Q1 | 80Q1 | | 01Q1 | 01Q1 | | 01Q1 |
| Malawi | 80Q1 | 91Q1 | | | 01Q1 | | 01Q1 |
| Malaysia | 80Q1 | 80Q1 | 05Q1 | 05Q1 | 84Q1 | 94Q1 | 84Q1 |
| Maldives | 85Q1 | 85Q1 | | | 85Q1 | | 85Q1 |
| Mali | 87Q3 | 90Q1 | | 03Q1 | 97Q1 | 03Q1 | 97Q1 |
| Malta | 80Q1 | 80Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 |
| Marshall Is. | 91Q4 | 91Q4 | | | 03Q1 | | 03Q1 |
| Martinique | 80Q1 | 80Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| Mauritania | 85Q3 | 04Q1 | 04Q1 | 06Q2 | 04Q1 | 04Q1 | 04Q1 |
| Mauritius | 80Q1 | 87Q3 | 87Q3 | 87Q3 | 87Q3 | 87Q3 | 87Q3 |
| Mexico† | 80Q1 | 89Q1 | 89Q1 | 89Q1 | 89Q1 | 89Q1 | 89Q1 |
| Moldova* | 93Q4 | 95Q1 | 99Q1 | 99Q1 | | 99Q1 | |
| Mongolia | 91Q4 | 96Q1 | 05Q4 | 05Q4 | 96Q1 | 05Q4 | 96Q1 |
| Montenegro† | 01Q1 | 05Q1 | 07Q1 | 07Q1 | 07Q1 | 07Q1 | 07Q1 |
| Montserrat† | 92Q1 | 92Q1 | 89Q1 | 89Q1 | 89Q1 | 89Q1 | 89Q1 |
| Morocco | 80Q1 | 80Q1 | | | 90Q1 | | 90Q1 |
| Mozambique | 94Q1 | 94Q1 | | | 94Q1 | | 94Q1 |
| Myanmar | 80Q1 | 80Q1 | | | | | |
| Namibia | 80Q1 | 80Q1 | | | 01Q1 | | 01Q1 |
| Nauru† | 08Q4 | 08Q4 | 08Q4 | 08Q4 | 08Q4 | 08Q4 | 08Q4 |
| Netherlands | 80Q1 | 80Q1 | 96Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Nepal | 80Q1 | 80Q1 | | | | | |
| New Caledonia | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| New Zealand† | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Nicaragua | 92Q1 | 00Q1 | | | | 99Q1 | |

| Country | CPI | CPIF | CPIH | CPIE | CPIHE | CPIxFE | CPIxFHE |
|---|---|---|---|---|---|---|---|
| Niger | 80Q1 | 80Q1 | | 03Q1 | 97Q1 | 98Q1 | 97Q1 |
| Nigeria | 80Q1 | 80Q1 | | | 03Q1 | 03Q1 | 03Q1 |
| Niue | 80Q1 | 80Q1 | 92Q1 | | 92Q1 | | 92Q1 |
| Norfolk Is. | 90Q4 | 90Q4 | | | | | |
| N. Mariana Is. | 88Q2 | 88Q2 | | | 88Q2 | | 88Q2 |
| Norway† | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Oman | 90Q1 | 90Q1 | 04Q4 | 04Q4 | 04Q4 | 04Q4 | 04Q4 |
| Pakistan | 80Q1 | 81Q3 | 98Q2 | 98Q2 | 98Q2 | 98Q2 | 98Q2 |
| Palau | 00Q2 | 00Q2 | 00Q2 | | 00Q2 | | 00Q2 |
| Palestinian Terr. | 97Q1 | 97Q1 | | | 07Q1 | | 07Q1 |
| Panama | 80Q1 | 80Q1 | 07Q1 | 07Q1 | 03Q1 | 07Q1 | 03Q1 |
| Papua New Guinea* | 80Q1 | 80Q1 | 89Q1 | 89Q1 | 80Q1 | 89Q1 | 80Q1 |
| Paraguay | 80Q1 | 83Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 |
| Peru | 80Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 |
| Philippines | 80Q1 | 80Q1 | | | 94Q1 | 00Q1 | 94Q1 |
| Poland | 88Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 |
| Portugal | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Puerto Rico | 80Q1 | 84Q1 | 84Q1 | 84Q1 | 84Q1 | 84Q1 | 84Q1 |
| Qatar | 02Q1 | 02Q1 | | | 02Q1 | | 02Q1 |
| Réunion | 80Q1 | 80Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 | 98Q1 |
| Romania* | 90Q4 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 |
| Russian Fed. | 92Q1 | 02Q1 | 02Q1 | 02Q1 | 02Q1 | 02Q1 | 02Q1 |
| Rwanda | 80Q1 | 85Q1 | | 06Q1 | 06Q1 | 06Q1 | 06Q1 |
| St Helena† | 82Q4 | 82Q4 | 89Q4 | 89Q4 | 89Q4 | 89Q4 | 89Q4 |
| St Kitts & Nevis | 80Q1 | 83Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 |
| St Lucia | 80Q1 | 84Q2 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 |
| St Pierre & Miq. | 97Q1 | 97Q1 | 04Q4 | 04Q4 | 05Q1 | 05Q1 | 05Q1 |
| St Vincent & Gren. | 80Q1 | 86Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 | 01Q1 |
| San Marino | 83Q2 | 83Q2 | | | | | |
| Samoa† | 81Q1 | 81Q1 | | | 90Q1 | | 90Q1 |
| São Tomé & Prín. | 93Q1 | 96Q4 | | | 96Q4 | | 96Q4 |
| Saudi Arabia | 80Q1 | 84Q1 | | | 99Q1 | | 99Q1 |
| Senegal | 80Q1 | 80Q1 | | 03Q1 | 97Q1 | 97Q1 | 97Q1 |
| Serbia | 95Q1 | 01Q1 | 04Q1 | 04Q1 | 01Q1 | 01q3 | 04Q1 |
| Seychelles† | 80Q1 | 86Q1 | 86Q1 | 86Q1 | 86Q1 | 86Q1 | 86Q1 |
| Sierra Leone | 80Q1 | 93Q1 | 05Q1 | 05Q1 | 05Q1 | 05Q1 | 05Q1 |
| Singapore | 83Q1 | 80Q1 | 83Q1 | 83Q1 | 83Q1 | 83Q1 | 83Q1 |
| Sint Maarten | 80Q1 | 07Q1 | 07Q1 | 07Q1 | 07Q1 | 07Q1 | 07Q1 |
| Slovak Republic | 91Q1 | 91Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 | 96Q1 |
| Slovenia | 93Q1 | 93Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 | 00Q1 |

| **Country** | **CPI** | **CPIF** | **CPIH** | **CPIE** | **CPIHE** | **CPIxFE** | **CPIxFHE** |
|---|---|---|---|---|---|---|---|
| Solomon Islands | 80Q1 | 80Q1 | | | 07Q1 | | 07Q1 |
| Somaliland | 07Q1 | 10Q1 | 10Q1 | 10Q1 | | | |
| South Africa*† | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| South Sudan | 07Q2 | 07Q2 | | | 07Q2 | 07Q2 | 07Q2 |
| Spain | 80Q1 | 84Q1 | 84Q1 | 80Q1 | 80Q1 | 80Q1 | 84Q1 |
| Sri Lanka† | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Sudan | 80Q1 | | | | | | |
| Suriname | 80Q1 | 96Q1 | | | | | |
| Swaziland | 80Q1 | | | | | | |
| Sweden | 80Q1 | 80Q1 | 96Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Switzerland | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Syria | 80Q1 | 80Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 | 95Q1 |
| Taiwan | 80Q1 | 81Q1 | 81Q1 | 81Q1 | 81Q1 | 81Q1 | 81Q1 |
| Tajikistan | 00Q1 | 00Q1 | 02Q1 | 00Q1 | 02Q1 | 00Q1 | 02Q1 |
| Tanzania | 80Q1 | 98Q2 | 02Q1 | 02Q1 | 02Q1 | 02Q1 | 02Q1 |
| Thailand | 80Q1 | 85Q1 | 80Q1 | 80Q1 | 80Q1 | 85Q1 | 85Q1 |
| Timor-Leste | 03Q2 | 03Q2 | 03Q2 | 03Q2 | 03Q2 | 03Q2 | 03Q2 |
| Togo | 80Q1 | 97Q1 | | 03Q1 | 97Q1 | 97Q1 | 97Q1 |
| Tonga* | 80Q1 | 80Q1 | 06Q1 | 06Q1 | 06Q1 | 06Q1 | 06Q1 |
| Trinidad & Tob. | 80Q1 | 80Q1 | 04Q1 | 04Q1 | 04Q1 | 04Q1 | 04Q1 |
| Tunisia | 80Q1 | 01Q1 | 06Q1 | 06Q1 | 01Q1 | 06Q1 | 01Q1 |
| Turkey | 80Q1 | 99Q1 | 03Q1 | 99Q1 | 03Q1 | 99Q1 | 03Q1 |
| Tuvalu | 87Q4 | 87Q4 | 96Q2 | 96Q2 | 96Q2 | 96Q2 | 96Q2 |
| Uganda | 81Q1 | 97Q3 | 05Q3 | 05Q3 | 97Q3 | 05Q3 | 97Q3 |
| Ukraine | 94Q1 | 02Q1 | 02Q1 | 02Q1 | 02Q1 | 02Q1 | 02Q1 |
| Utd. Arab Emir. | 08Q1 | 08Q1 | | | 08Q1 | | 08Q1 |
| United Kingdom | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| United States | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 | 80Q1 |
| Uruguay* | 80Q1 | 93Q2 | 97Q1 | 97Q1 | 93Q2 | 97Q1 | 93Q2 |
| Vanuatu | 81Q1 | 81Q1 | | | 81Q1 | | 81Q1 |
| Venezuela | 80Q1 | 97Q1 | 99Q1 | 00Q1 | 00Q1 | 99Q1 | 00Q1 |
| Viet Nam | 90Q1 | 98Q1 | | | 91Q1 | | 98Q1 |
| Wallis & Futuna | 99Q4 | 99Q4 | 99Q4 | 99Q4 | 99Q4 | 99Q4 | 99Q4 |
| Yemen | 01Q1 | | | | | 05Q1 | |
| Zambia | 85Q1 | 04Q1 | | | | | |
| Zimbabwe | 80Q1 | 90Q1 | | | | | |

# Chapter 5

# What is the impact of disasters on inflation?

## 5.1 Introduction

Disasters caused by natural hazards have the potential to cause massive economic disruption, and often are accompanied by a significant human toll. Recent examples of disasters include: earthquakes in Japan, Chile, Haiti and New Zealand in 2010 and 2011; the devastation of Vanuatu by Cyclone Pam in 2015; The 2011 floods in Thailand; ongoing drought in California and the eruption of Eyjafjallajökull in Iceland in 2010. With greater concentrations of population and activity in vulnerable regions, the incidence of economically significant disasters is increasing (Cavallo and Noy, 2011). Barro (2009) estimates the welfare cost of these rare, but extreme, events at 20 percent of output, far beyond the 1.5 percent estimated welfare cost of normal business cycle fluctuations.

Until recently, our understanding of the economic impact of disasters was limited. Progress has been made over the past decade in investigating the impact of disasters on output, but this incipient literature remains silent on the impact on prices. Cavallo and Noy (2011) in their recent survey of the literature on disasters point to the effect on prices as being one of the main remaining gaps in our knowledge. The aim of this paper is to address that lacuna by systematically analysing the effects of disasters on inflation.

Understanding the effect on prices provides monetary policy makers with greater guidance on how to set policy in the immediate aftermath of the disaster. There are a number of other benefits in knowing the likely path for inflation following a disaster: it can help with estimating the insurance costs for rebuild or cash settlement; it provides aid donors with a metric for determining the value of cash donations or gifts in kind; it assists fiscal authorities with calculating the future costs of the rebuild programme. Finally, the path for inflation has implications for the exchange rate and capital account policies.

We combine two sets of data to undertake the analysis here. The first is the EM-DAT database collected by the Centre for Research on the Epidemiology of Disasters at the University of Louvain. This contains information on a wide range of disasters, including number of people killed, number of people affected and (less frequently) damage caused. This data set is widely used in the literature and is the only one with widespread coverage that is publicly available.

The second data set is the consumer price data presented in chapter 4. These data cover consumer prices for 223 countries and territories over the period 1980-2012. We restrict our sample to those countries with at least 40 quarterly observations, resulting in 212 included in the analysis here. The data include information on headline consumer prices, as well as sub-indices for food, housing, energy and the remainder of the index. The panel is not balanced, with coverage for the sub-indices less complete for less developed countries. Nonetheless, coverage of sub-indices far exceeds any other database for consumer prices.

Previous studies have highlighted a large heterogeneity in the impact of disasters on output, particularly between advanced and developing countries. The impact on inflation is similarly diverse. Disasters on average have negligible impact on inflation in advanced countries, but typically increase inflation in developing countries. That said, the impact for severe disasters (those in the upper quartile) is larger, and significant even in high income countries.

The impact of diasters on inflation differs by sub-index. The impact on food price inflation is in general positive, if short lived. The impact on housing and other sub-indices is in general negative. Differences in expenditure weights on these sub-indices will in part explain the differences witnessed in headline inflation numbers by level of development.

Earthquakes do not significantly affect headline inflation, but do significantly reduce CPI inflation excluding food, housing and energy. Storms cause an immediate increase in food price inflation for the first six months, although this impact is reversed in the subsequent two quarters, resulting in no significant impact over the entire first year, or beyond. Floods increase headline inflation in the quarter that the flooding occurs in middle and low income countries, but have no significant impacts in subsequent quarters. In high income countries, the impact on headline inflation is negative, although insignificant. Droughts increase headline inflation for a number of years.

## 5.2 How disasters may affect prices

As noted above, there has yet to be a systematic review of the impact of disasters on prices. Nonetheless, evidence from the literature on the impact on economic activity and a small number of case studies provide some guide to the potential channels of impact. The literature on other sources of major economic dislocation is also instructive. Rockoff (2015) studies the impact of US wars on inflation. He notes that wars against minor powers has little effect on inflation, but that (larger) wars against major powers have a strong, positive influence on inflation. Nonetheless, once the war has finished, prices tend to fall towards their pre-war levels. Prices can also fall following financial crises (e.g. see Kindleberger, 1978; Mishkin, 1992), notably the deflation in the Great Depression, following Japan's crisis in the 1990s and the low rates of inflation currently witnessed in advanced countries following the global financial crisis of 2007-2008.

### 5.2.1 Short-run impacts

Disasters affect economic activity via a number of channels in the short run. The immediate direct impact of diasters can cause death and injury to people, and cause damage to buildings, transport infrastructure and livestock. The destruction of harvests or housing can create shortages, pushing up the price of remaining food or houses. The size of the increase in prices may depend on market power of firms and perceptions of customers – it may not be in the long-run interest of a firm to be seen to be profiteering from customers' misery. Rotemberg (2005, p.835) notes examples of customer protests at prices increases following the 1994 earthquake in the Los Angeles area.[1]

Beyond the direct impact, other businesses and households may be indirectly affected, such as being unable to bring goods to market due to lack of transport infrastructure. For example, farmers may react to the shortage of feed caused by a drought by slaughtering livestock. This could potentially reduce meat prices in the near term, but increase them in the medium term as farmers act to rebuild livestock numbers once the drought has ended. If the disruption to economic activity is sufficiently large it may reduce demand for goods and services from sectors not directly affected. This lower demand could reduce the prices in these other sectors.

There are a number of papers that aim to quantify the impact of disasters on economic activity. Noy (2009) examines the impact of 507 disasters

[1] In some jurisdictions it is illegal to increase prices of certain goods, termed 'price gouging', in the immediate aftermath of a disaster (Gerena, 2004).

over the period 1970-2003, finding a significant impact on GDP. The effect is greater for smaller and for less developed countries. Higher per capita income, literacy rates and institutional capacity help to mitigate the impact. The impact of disasters appears to differ by type of disaster. Raddatz (2009) finds that climatic disasters (storms, floods, droughts and extreme temperatures) have a significant negative impact on GDP, mostly in the year of the disaster. Other disasters are not found to have a significant impact.

A number of authors also consider the impact of disasters on differing sectors of the economy. Loayza et al. (2012) find no significant effect on overall GDP using five-year growth averages over the period 1961-2005, although droughts are negative and storms and floods are positive. Droughts and storms negatively affect agricultural output, whereas floods are positive. The authors suggest that this positive effect may derive from plentiful rainfall providing benefit to crops that outweighs the localised damage from flooding, and the additional nutrients that aid the following season. Furthermore, cheaper electricity from more abundant hydropower aids industry. Nonetheless, this positive effect disappears in the presence of more severe flooding. Fomby et al. (2013) find that earthquakes affect agricultural production in developing countries, potentially a result of damaged infrastructure. Fomby et al. (2013) also find differing impacts of disasters depending on their severity.

Small-scale studies of individual disasters, or small groups, point to differing inflation impacts by type of disaster. The most comprehensive study to date, Heinen et al. (2015), considers the impact of hurricanes and floods on the inflation rates of 15 Caribbean islands. Damaging hurricanes increased monthly headline CPI inflation by 0.05 percentage points, with a greater effect on impact on food prices. More damaging hurricanes have a proportionately higher impact on inflation, with the implied inflationary impact of the largest hurricane in their sample being 1.4 percentage points on monthly headline CPI inflation. Flooding had an average 0.083

percentage point impact on inflation, with the implied largest effect 0.604 percentage points. The impact of both hurricanes and floods takes place in the month of the event, with no significant effects in subsequent months.

In terms of case studies of individual events or countries, Laframboise and Loko (2012) estimated that headline inflation increased by an additional 2 percent in Pakistan following the severe floods of 2010. Abe et al. (2014) find little increase in prices following the Great East Japan earthquake of 2011. Reinsdorf et al. (2014) compare this earthquake with the Chilean earthquake of 2010 using online data for supermarkets. Their data point to a sharp fall in product availability in the immediate aftermath of both earthquakes, without concurrent increases in price.

Doyle and Noy (2015) find no significant aggregate impact on New Zealand consumer prices from the Canterbury earthquakes of 2010 and 2011. At a disaggregated level, Parker and Steenkamp (2012) and Wood et al. (2016) find large increases in rents and construction costs within Canterbury, consistent with restricted housing supply following the widespread destruction of the housing stock. Munoz and Pistelli (2010) investigate the impact on inflation of a small number of large earthquakes, by comparing inflation outturns with a forecast based on information prior to the event. While they find that some earthquakes resulted in higher inflation, it was by no means universal. Given their small sample of events they were unable to explain the causes of this different response.

Kamber et al. (2013) study the impact of droughts on New Zealand, using measures of rainfall and soil moisture deficit in a VAR framework. Their findings suggest a drought of the magnitude of that of early 2013 raises CPI food prices by around 1.0 - 1.5 percent. In particular, milk cheese and eggs prices increase by 3 percent, reflecting the importance of dairy in domestic agriculture. Wholesale electricity prices increase by as much as 8 percent following such a drought, as lower lake levels increase the cost of hydroelectricity, although this cost increase does not appear to pass through to retail. Conversely, depressed economic activity results in falling prices for other non-tradable sectors, resulting in no significant impact on overall CPI. Buckle et al. (2007) similarly found no significant overall impact on consumer prices from droughts in New Zealand.

### 5.2.2 Medium-run impacts

There may be some longer-lasting impacts on prices beyond the immediate destruction and disruption. The destruction of ports and infrastructure may disrupt imports, driving up the price for those goods which are imported. Conversely, the lack of ports for export may lead to a domestic oversupply and price falls in goods normally exported. International investors may also choose to withdraw capital from a country recently hit by a disaster, pushing down on the exchange rate and increasing the cost of imports. Ramcharan (2007) finds that in flexible exchange rate regimes, the real exchange rate depreciates by 10.25 percent in the year following a windstorm. The exchange rate effect is uncertain, however, since domestic investors repatriating foreign investments could lead to an exchange rate appreciation; the yen appreciated sharply in the immediate aftermath of the 2011 Tōhoku earthquake (Neely, 2011).

Over the medium term, as resources are allocated to damage and reconstruct destroyed buildings and infrastructure there may be a 'demand surge', placing upward pressure on prices. Keen and Pakko (2011) calibrated a DSGE model to simulate the impact of Hurricane Katrina. In their simulation, the destruction of capital stock and temporary fall in productivity causes firms to raise prices, resulting in higher inflation

However, this demand surge is not certain. The incidence of a disaster may cause revisions of people's perception of disaster risk and cause outward migration. Boustan et al. (2012) find outward migration from areas affected by tornadoes, Hornbeck (2012) from heavily eroded counties in the Dust Bowl era, and Hornbeck and Naidu (2014) document substantial outward migration following the 1927 Mississippi floods. Coffman and

Noy (2012) use synthetic control methods to estimate a 12 percent drop in population on the island of Kauai in Hawaii, following Hurricane Iniki. The population of New Orleans fell sharply following Hurricane Katrina (Vigdor, 2008), although the destruction of housing stock was far greater, resulting in higher house prices and rents. The destruction of disasters may also create poverty traps where households are unable to regain previous wealth and income (Carter et al., 2007). Such scenarios would put downward pressure on prices over the medium term in areas affected by disasters, although it is less certain the extent to which this affects the overall national price level.

Taking the above factors into consideration, the overall impact of disasters on inflation is ambiguous. The prior research on activity suggests there may be at the very least differences in the impact of disasters on inflation: by type of disaster; between the short and medium term; by different sub-component of the inflation basket; by level of development, and; by severity of the disaster. The analysis that follows accounts for these differing potential effects in turn.

## 5.3 Data and method

### 5.3.1 Disasters

The most widely used source for disasters is the EM-DAT database collected by the Centre for Research on the Epidemiology of Disasters at the University of Louvain. The database covers disaster events which meet one of the following criteria: ten or more people killed; 100 or more people affected; declaration of a state of emergency; or call for international assistance. Alongside the date of the disaster, the EM-DAT database also includes information on the number of people killed and the number of people affected. For a smaller set of disasters the database includes an estimate of the damage caused.

It is worth noting that the EM-DAT database measures the *ex post* effects of disasters, which as shown in Noy (2009) and elsewhere depend on a number of country specific factors such as institutions. The relevant institutional factors, for example good economic governance, may also affect inflation dynamics. To understand the impact of the underlying natural hazards, it is necessary to have data on the event in question, such as wind speed, rainfall, or intensity of ground shaking. Heinen et al. (2015) use such a dataset for their study of windstorms and floods for a select group of Caribbean islands. The GeoMet database used by Felbermayr and Gröschl (2014) does have sufficiently widespread geophysical and meteorological data for the analysis here, but is not publicly available at this time.

Only disasters with likely macroeconomic effects are considered here, namely: earthquakes, storms, floods, droughts and other disasters (mass movements, insect infestations, extreme temperatures, volcanoes and wildfires). In order to estimate the effect of disasters on inflation, we require the quarter in which the disaster took place. The EM-DAT database does not always have precise start dates for droughts (even to the three-month period required) so as a consequence many droughts have been dropped from the analysis.

Even with these selection criteria, there are a large number of disasters in the EM-DAT database which are small relative to the overall size of the country and are unlikely to have any discernable macroeconomic effects. To aid estimation, only disasters with at least major impact are considered in the analysis below. To estimate the severity of the impact of the disasters we construct an impact variable for each disaster, calculated in a similar fashion to Fomby et al. (2013).

The impact variable used in this paper is:

$$IMP'_{i,t} = (EQIMP_{i,t}, STIMP_{i,t}, FLIMP_{i,t}, DRIMP_{i,t}, OTIMP_{i,t})' \quad (5.1)$$

where $EQIMP$, $STIMP$, $FLIMP$, $DRIMP$ and $OTIMP$ represent the respective total impact of earthquakes, wind storms, floods, droughts and other disasters. $IMP_{i,t}$ is calculated as:

$$IMP_{i,t}(k) = \sum_{j=1}^{J} intensity_{i,t,j}^{k} \tag{5.2}$$

where

$$\begin{aligned} intensity_{i,t,j}^{k} &= 100 * \frac{fatalities_{i,t,j}^{k} + 0.3 * total\ affected_{i,t,j}^{k}}{population_{i,t,j}}, \text{ if } intensity > 0.1 \\ &= 0 \quad \text{otherwise} \end{aligned} \tag{5.3}$$

and $J$ is the total number of each type-$k$ events (k=1,2,3,4,5 and responds to earthquakes, wind storms, floods, droughts and other disasters respectively) that took place in each country $i$ in quarter $t$. The creation of $IMP_{i,t}$ can be described by the following steps. First, for each disaster the intensity was calculated by dividing the number of fatalities and 30 percent of the total people affected by the population. Where this intensity is smaller than 0.1 percent, the impact is set to zero (equation 5.3). Then for each country, the total impact for each type of disaster is calculated as the sum of the intensities of each such disaster that occurred in each country for each quarter (equation 5.2).

The criteria on disasters discussed above, together with the availability of consumer price data (see section 5.3.2), result in a total of 1349 disasters in 163 countries. Table 5.1 shows the incidence of disasters by type and by country development. Floods and storms are the most frequently occurring disasters that meet the criteria for inclusion. Measured droughts are rare in advanced countries (following Noy (2009) we take these to be high income members of the OECD in 1990) and other high income countries, with only three in the sample, compared with 124 in middle income countries.

Table 5.1: Incidence of disasters

| | Earthquakes | Storms | Floods | Droughts | Other | Total |
|---|---|---|---|---|---|---|
| **Number** | | | | | | |
| Advanced | 17 | 14 | 9 | 2 | 5 | 47 |
| Other high income | 3 | 39 | 21 | 1 | 3 | 67 |
| Middle income | 47 | 288 | 433 | 124 | 29 | 921 |
| Low income | 6 | 57 | 155 | 90 | 6 | 314 |
| Total | 73 | 398 | 618 | 217 | 43 | 1349 |
| **75th percentile** | | | | | | |
| Advanced | 1.19 | 0.66 | 0.40 | | 1.68 | 1.09 |
| Other high income | | 1.26 | 0.28 | | | 0.94 |
| Middle income | 0.93 | 1.56 | 0.89 | 5.47 | 1.20 | 1.46 |
| Low income | 0.53 | 1.26 | 0.92 | 6.68 | 8.25 | 2.75 |
| Total | 0.95 | 1.33 | 0.87 | 5.79 | 1.95 | 1.64 |
| **90th percentile** | | | | | | |
| Advanced | 2.07 | 1.69 | 1.09 | | 5.10 | 4.63 |
| Other high income | | 3.89 | 0.53 | | | 3.67 |
| Middle income | 2.34 | 6.12 | 2.43 | 10.75 | 2.38 | 4.53 |
| Low income | 13.47 | 3.83 | 3.28 | 14.34 | 12.24 | 7.00 |
| Total | 2.63 | 4.37 | 2.48 | 12.00 | 5.10 | 4.99 |

Notes: countries within advanced and other high income groups set out in table 5.7 in the appendix. 75th and 90th percentile impact as calculated per equations (5.2) and (5.3). Measured in percent of population. Impact omitted where there are fewer than 5 events.

The impact on inflation is likely to depend on the size of the disaster. We follow Cavallo et al. (2013) and focus here on large disasters in the 75th and 90th percentiles. The 75th percentile disaster is approximately the impact of Hurricane Earl on Antigua and Barbuda in 2010. The hurricane affected around 6 percent of the population and did damage estimated to be around 1 percent of GDP. The 90th percentile is approximately the impact of the 2010 earthquake in Chile, which killed 562 people, affected 2.7 million (16 percent of the population) and had estimated damages of 17 percent of GDP.

### 5.3.2 Consumer prices

As noted in section 5.2 above, different types of disasters may affect different prices, with the prices for food, housing (including rent) and energy being the most commonly cited in the literature. Commonly used international databases, such as the *International Financial Statistics* of the International Monetary Fund and the*World Development Indicators* of the World Bank, typically contain information on just the overall, headline CPI index. Information on the sub-indices is normally only available from national sources.

The consumer price data used here are taken from the dataset in chapter 4. This dataset contains CPI for 223 countries and territories on a quarterly basis for the period 1980-2012. The series contained are the overall index (CPI) the sub-indices for food (CPIF), housing (CPIH), energy (CPIE), and all remaining items in the index (CPIxFHE). Coverage for CPIH and CPIE is relatively sparse relative to the other indices, so a combined housing and energy index is also included (CPIHE) which has observations for a greater number of countries.

We drop countries for which there are fewer than 40 quarters of CPI data. This results in 212 countries with observations for headline CPI. The average number of quarters of headline CPI data per country is 105. Fewer countries have data for the sub-indices, and the length of coverage is also typically shorter, particularly for less developed countries.

### 5.3.3 Method

To estimate the impact of disasters on inflation, we run a panel regression of the form:

$$\pi_{i,t} = \sum_{j=0}^{p} \beta_j D_{i,t-j} + \mu_i + \lambda_t + \nu_{it} \quad (5.4)$$

where $\pi_{i,t}$ is quarterly log difference in CPI in country $i$ in quarter $t$. We multiply the inflation rate by 100 to give coefficients that are in units of percentage points for ease of reading. $D_{i,t}$ is a vector of variables capturing the impact of disasters. The analysis that follows also considers the impact on the inflation rate for food, housing, energy and cpi excluding food housing and energy, respectively $\pi^f_{i,t}$, $\pi^h_{i,t}$, $\pi^e_{i,t}$, $\pi^{xfhe}_{i,t}$. We consider both the impact of all disasters combined, and the five types of disasters (earthquakes, wind storms, floods, droughts and other) individually as described in section 5.3.1 above. The parameters $\mu_i$ and $\lambda_t$ are fixed effects for country and time respectively. The country fixed effects capture the time invariant characteristics of each country that explain differences in average inflation rates between countries. The time fixed effects capture global factors that affect all countries, such as global developments in output growth and commodity prices or the Great Moderation. The occurrence of disasters is assumed to be exogenous, and unaffected by current or previous values of CPI.

One potential problem with this estimation is that CPI data is typically seasonal, which increases the variance of the underlying series. There are a number of approaches to eliminate this seasonality. The first is to use a seasonal adjustment process, the most widely used of which is the Census Bureau's X12. However, X12 uses both forward and backward looking filters, which violates the exogeneity assumption over CPI and disasters.

The use of country seasonal dummies for each quarter is also unsatisfactory for our purposes if disasters do have an impact on CPI, but are concentrated in particular quarters. Consider windstorms, whose incidence is for the most part concentrated to certain times of the year. In such cases, the seasonal dummy will absorb some of the true impact of disasters. Such quarterly dummies are also unsatisfactory if the seasonal pattern changes over time. Given these problems, we use the non-seasonally adjusted data. The time fixed effects dummies already included do account for the average seasonal pattern across countries, and are robust to changing seasonal patterns, but are unable to account for differences in seasonal patterns across countries.[2]

Standard panel estimation assumes that the errors, $\nu_{it}$, are not correlated cross-sectionally, i.e.:

$$\rho_{ij} = \rho_{ji} = corr(\nu_{it}, \nu_{jt}) = 0 \qquad \text{for} \qquad i \neq j \tag{5.5}$$

However, such an assumption may not be valid when macroeconomic time series are used. Close trade ties and other economic interactions between spatially grouped countries are likely to result in positive cross-correlations. To test the null hypothesis of cross-sectional independence we use the Pesaran (2004) test, which is the most appropriate given the unbalanced nature of the CPI dataset, and the large N relative to T. We obtain a test statistic of 205, which is significant evidence against the null of cross-sectional independence. The average absolute pairwise cross-sectional correlation is 0.302. A positive cross-sectional correlation results in substantial downward bias to the standard errors calculated using standard panel estimation techniques. To account for this large cross-sectional correlation, and any potential serial correlation, we use Driscoll and Kraay (1998) adjusted standard errors in the estimations that follow.[3]

[2]For robustness, we also estimate using country seasonal dummies and using data seasonally adjusted using X12 (not reported). The results using the seasonally adjusted data are qualitatively similar to those presented here.

[3]The Pesaran (2004) test is carried out in Stata using the xtcsd command of Hoyos and

## 5.4 Results

This section describes the results from the regression described above in equation (5.4). We initially consider the aggregate impact of all disasters combined on inflation. Given the potential for heterogeneity of impact, as discussed in section 5.2, we then analyse in turn the effects on inflation by type of disaster, by level of development and by severity of disaster. To verify the robustness of our findings, we also consider two alternative specifications of impact – damage relative to GDP and considering just the number of disasters rather than differentiating by impact.

### 5.4.1 Aggregate impact of disasters on inflation

We first estimate equation (5.4) on the aggregate impact of all disasters, which is to say $D_{i,t}$ is the sum by country and by quarter of the impact across all types of disaster. We include up to 11 lags, since we find joint significance up to three years following the incidence of the disaster. Further lags are not individually or jointly significant. The individual coefficients from the estimation are included in table 5.8 in the appendix. To aid assessment of the impact of a typical disaster, we multiply the coefficients by the impact value of the 75th and 90th percentile disasters (see table 5.1) to give the estimated effect on inflation of these disasters. These estimated impact results are shown in table 5.2.

Our results estimate that a disaster in the 75th percentile would have a contemporaneous (i.e. quarter 0) impact on headline inflation of 0.26 percentage points (pp). There is a further significant impact of 0.18pp on headline inflation in the quarter immediately following the disaster (quarter 1). Since exact timing of effects may differ between individual disasters, we combine the coefficients for quarters 2 and 3. The impact at this horizon is positive, but insignificant. The combined impact on inflation of

Sarafidis (2006). The estimation using Driscoll and Kraay (1998) adjusted standard errors is implemented using the xtscc command developed by Hoechle (2007).

Table 5.2: Estimated inflation impact of disasters

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| **75th percentile** | | | | | |
| Quarter 0 | 0.264** | 0.164** | −0.069 | −0.149 | 0.016 |
| Quarter 1 | 0.184* | 0.158* | −0.058 | −0.149 | −0.101* |
| Quarters 2-3 | 0.159 | −0.219* | −0.231*** | −0.117 | −0.121 |
| Year 1 | 0.607* | 0.102 | −0.359** | −0.414 | −0.206* |
| Year 2 | 0.910 | −0.030 | −0.351* | 0.150 | −0.142 |
| Year 3 | 0.769* | 0.274 | −0.131 | 0.203 | 0.034 |
| **90th percentile** | | | | | |
| Quarter 0 | 0.799** | 0.497** | −0.210 | −0.451 | 0.048 |
| Quarter 1 | 0.557* | 0.479* | −0.175 | −0.451 | −0.306* |
| Quarters 2-3 | 0.483 | −0.666* | −0.702*** | −0.355 | −0.366 |
| Year 1 | 1.840* | 0.310 | −1.088** | −1.257 | −0.624* |
| Year 2 | 2.760 | −0.089 | −1.063* | 0.456 | −0.431 |
| Year 3 | 2.331* | 0.832 | −0.398 | 0.617 | 0.104 |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.050 | 0.042 | 0.046 | 0.171 | 0.054 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Shows estimated impact for 75th and 90th percentile disaster. Underlying regression coefficients in table 5.8 in appendix. Quarter 0 is the quarter the disaster takes place. Year 1 is quarters 0 through 3 combined, year 2 is quarters 4 through 7, year 3 is quarters 8 through 11.

the 75th percentile disaster for the first year (quarters 0 through 3) is estimated to be 0.61pp. The impact over the second year (quarters 4 through 7) is estimated to be 0.91pp, although this is not significant. Finally, the impact over the third year (quarters 8 through 11) is significant, and estimated to be 0.77pp.

Turning to the sub-indices, there is a positive and significant contemporaneous impact on food prices of 0.16pp, and a similar impact in the first quarter following the disaster. However, in the subsequent two quarters there is a negative and significant impact on inflation, such that the overall impact on food prices over the first year is insignificant and close to zero. There is no significant impact on food prices beyond the first year.

Housing inflation is significantly reduced in the aftermath of disasters, by 0.36pp and 0.35pp in the first two years following the disaster. There is no significant impact on energy prices. CPI inflation excluding food, housing and energy is significantly lower in the aftermath of disasters, by an estimated 0.21pp in the first year for the 75th percentile disaster. There is no significant impact beyond the first year. Table 5.2 also includes the estimated figures for the 90th percentile disaster. Since this involves multiplying the underlying coefficients by a larger impact coefficient, the overall pattern of effects and significance are unchanged from the 75th percentile case.

Strictly speaking, it is not possible to draw conclusions from the individual sub-indices for the overall impact on headline inflation. The samples differ for each sub-index because of the lack of availability of some sub-indices. In particular, the sub-indices for housing and energy are frequently unavailable outside of high income countries. There is also a noticeable difference in relative weights in the sub-indices between countries. For example, the weight of food in the index is around 10-15 percent in advanced countries, but frequently exceeds 50 percent in low income countries (see chapter 4). For the purposes of robustness, we include the estimation results on a balanced panel of 78 countries over the period 1996-

2012 for the sub-indices for food, the combined housing and energy sub-index and CPIxFHE (see table 5.9 in the appendix). The sample in this balanced panel is heavily biased towards high income countries, and the estimates are similar in nature to those for this group of countries (see section 5.4.3).

### 5.4.2 Impact by type of disasters

As noted above in section 5.2, disasters have heterogeneous impacts on activity, dependent on type. To test whether this finding also holds for inflation, we re-estimate equation (5.4) with separate impact variables of each type of disaster. The coefficients from this estimation are shown in tables 5.10 through 5.14 in the appendix. The results are summarised in table 5.3. We again multiply the coefficients by the impact of the 75th percentile disaster of the relevant type. The 'other' category of disasters has almost no significant coefficients, perhaps unsurprising given the diversity of disasters within the category, so these disasters are unreported in table 5.3.

Earthquakes do not have a significant impact on headline or food inflation at any horizon. An earthquake in the 75th percentile is estimated to increase housing inflation in the first quarter after it takes place by 0.18pp and energy inflation in that quarter by 0.79pp. These increases appear to be unwound in subsequent quarters, with the estimated impact over the first year combined not significantly different from zero. CPI inflation excluding food, housing and energy is significantly reduced by earthquakes in each of the three years following the disaster, by 0.63pp, 0.45pp and 0.36pp respectively.

Storms are estimated to have a contemporaneous positive impact on headline inflation, and a positive impact the following quarter, although insignificant in both cases. The second quarter following the storm is negative and significant. Overall, the estimated impact for the 75th percentile

Table 5.3: Impact on inflation by type of disaster

| | Headline | Food | Housing | Energy | CPI ex FHE |
|---|---|---|---|---|---|
| **Earthquakes** | | | | | |
| Quarter 0 | 0.228 | 0.238 | −0.031 | −0.287 | −0.092 |
| Quarter 1 | 0.047 | −0.084 | 0.183* | 0.785** | −0.234*** |
| Quarters 2-3 | −0.025 | −0.165 | −0.194 | −0.473 | −0.302*** |
| Year 1 | 0.250 | −0.012 | −0.043 | 0.024 | −0.628*** |
| Year 2 | 0.364 | 0.273 | 0.026 | 1.931 | −0.450*** |
| Year 3 | 0.220 | 0.397 | −0.261 | −0.736 | −0.357* |
| **Storms** | | | | | |
| Quarter 0 | 0.101 | 0.155* | −0.085 | −0.523 | 0.021 |
| Quarter 1 | 0.056 | 0.216* | −0.039 | −0.318 | −0.099 |
| Quarters 2-3 | −0.156 | −0.332*** | −0.260** | 0.003 | −0.063 |
| Year 1 | 0.001 | 0.038 | −0.384 | −0.838 | −0.140 |
| Year 2 | −0.124 | −0.008 | −0.641*** | 0.075 | −0.113 |
| Year 3 | −0.067 | 0.059 | −0.387* | 0.161 | 0.201 |
| **Floods** | | | | | |
| Quarter 0 | 0.378* | 0.144 | −0.079 | −0.242 | −0.145 |
| Quarter 1 | 0.170 | 0.071 | −0.069 | −0.327 | −0.159* |
| Quarters 2-3 | 0.368 | −0.163 | −0.005 | −0.246 | −0.028 |
| Year 1 | 0.916 | 0.051 | −0.153 | −0.815 | −0.332* |
| Year 2 | 1.652 | −0.029 | −0.329 | 1.207** | −0.061 |
| Year 3 | 1.465 | 0.255 | −0.118 | −0.051 | 0.045 |
| **Droughts** | | | | | |
| Quarter 0 | 1.359* | 0.540 | −0.114 | 0.225 | 0.138 |
| Quarter 1 | 1.300* | 0.398 | −0.295 | −0.243 | −0.170 |
| Quarters 2-3 | 1.975 | −0.088 | −0.683** | −0.554 | −0.648** |
| Year 1 | 4.634* | 0.850 | −1.092 | −0.573 | −0.680 |
| Year 2 | 7.066 | 0.131 | −0.697 | −0.725 | −0.207 |
| Year 3 | 5.212** | 1.735 | −0.380 | 1.168 | −0.131 |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.055 | 0.045 | 0.050 | 0.174 | 0.060 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Shows estimated impact for 75th percentile disaster. Underlying regression coefficients in tables 5.10 through 5.14 in appendix. Quarter 0 is the quarter the disaster takes place. Year 1 is quarters 0 through 3 combined, year 2 is quarters 4 through 7, year 3 is quarters 8 through 11.

storm over the first year is 0.00pp. There is no significant impact on headline inflation in subsequent years. There is a significant impact on food price inflation during the first year. A 75th percentile storm significantly increases food price inflation by 0.16pp contemporaneously and by a further 0.22pp in the first quarter following the storm. These increases are unwound in the subsequent two quarters, leaving the total estimated impact over the first year to be insignificantly different from zero. Storms reduce housing price inflation in the three years that follow, by 0.38pp, 0.64pp and 0.39pp respectively, although only the second year is significant. The impact on other sub-indices is insignificant.

The 75th percentile flood is estimated to have a positive and significant contemporaneous impact on headline inflation of 0.38pp. There is estimated to be a positive impact on headline inflation throughout the first three years following the flood, although this is not significant. Energy price inflation is estimated to be lower for the first year, before rebounding in the following year. This would be consistent with plentiful rainfall lowering hydroelectric generation costs in the near term. The 75th percentile flood is estimated to have no significant impact on food or housing price inflation. Inflation in the remainder of the index is estimated to be lower by 0.33pp in the first year following the flood.

The 75th percentile drought is estimated to increase headline inflation by 1.36pp in the start quarter, and by 1.30pp in the subsequent quarter.[4] The impact on food price inflation is typically positive, although insignificant. The impact on housing and CPIxFHE price inflation is negative, significantly so in the second and third quarters following the start of the drought.

[4]Note that unlike the other disasters considered here, droughts may continue for several quarters, indeed even years. The 75th percentile drought is also much greater in impact than the 75th percentile of the other disasters.

### 5.4.3 Impact by level of development

Previous research has highlighted that disasters have greater impact on activity in developing economies than in advanced economies (Noy, 2009; Raddatz, 2009; Fomby et al., 2013). We investigate whether this finding holds for the impact on inflation by estimating equation (5.4) separately for advanced countries, other high income countries and for the remaining countries. There are insufficient observations for low income countries, particularly for the sub-indices, to merit estimating these countries separately. The estimated impact for the 75th percentile disaster in each country group is shown in table 5.4. The underlying coefficient estimates are provided in tables 5.15, 5.16 and 5.18 in the appendix. Given the relative lack of individual sub-indices for housing and energy in middle and low income countries, we use the combined housing and energy sub-index that is more widely available in these countries.

Disasters do not have significant impact on either headline, food or energy price inflation in advanced countries. Housing price inflation is significantly lower in the second year after the disaster, by 0.25pp for the 75th percentile disaster. CPIxFHE inflation is significantly lower in the first year following the disaster, by 0.09pp.

In other high income countries, the 75th percentile disaster is estimated to increase headline inflation 2.97pp over the first year, but only the increase in quarters 2 and 3 is significant. There are significant increases in the second and third year after the disaster, by 0.95pp and 0.69pp respectively. Food price inflation is significantly increased in the first two years following the disaster, conversely energy prices fall. There are no significant impacts on the other sub-indices.

There are insufficient events to consider the impact by disaster separately for advanced and other high income countries, so table 5.17 in the appendix considers the impact by type of disaster for all high income countries. The 75th percentile earthquake in high income countries has no significant effect on headline inflation, but significantly reduces CPIxFHE

Table 5.4: Impact of disasters by level of development

**Advanced countries**

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| Quarter 0 | 0.005 | 0.054 | −0.126 | −0.050 | −0.007 |
| Quarter 1 | −0.017 | 0.097* | −0.018 | −0.143 | −0.034 |
| Quarters 2-3 | −0.076* | −0.074 | −0.080 | −0.061 | −0.049 |
| Year 1 | −0.088 | 0.076 | −0.224 | −0.254 | −0.091* |
| Year 2 | −0.054 | −0.162* | −0.251* | −0.221 | −0.017 |
| Year 3 | 0.124 | 0.121 | 0.229 | 0.143 | 0.067 |
| Observations | 2783 | 2741 | 2167 | 2715 | 2591 |
| $R^2$ | 0.302 | 0.247 | 0.172 | 0.507 | 0.361 |

**Other high income countries**

| | Headline | Food | Housing | Energy | CPI ex FHE |
|---|---|---|---|---|---|
| Quarter 0 | 1.066 | 0.135 | −0.013 | −2.454** | 0.045 |
| Quarter 1 | 1.144 | 0.297 | 0.060 | −0.525* | −0.175 |
| Quarters 2-3 | 0.755* | 0.353 | 0.034 | 0.949* | −0.075 |
| Year 1 | 2.965 | 0.785* | 0.081 | −2.031** | −0.205 |
| Year 2 | 0.950* | 0.915*** | 0.084 | 0.221 | −0.195 |
| Year 3 | 0.691* | 0.070 | 0.078 | −0.169 | 0.101 |
| Observations | 4887 | 4106 | 2486 | 2465 | 2852 |
| $R^2$ | 0.093 | 0.134 | 0.116 | 0.295 | 0.139 |

**Middle and low income countries**

| | Headline | Food | Housing & Energy | CPI ex FHE |
|---|---|---|---|---|
| Quarter 0 | 0.267** | 0.177** | 0.056 | 0.022 |
| Quarter 1 | 0.176* | 0.160* | −0.043 | −0.079 |
| Quarters 2-3 | 0.179 | −0.230* | 0.051 | −0.142 |
| Year 1 | 0.621* | 0.107 | 0.065 | −0.200 |
| Year 2 | 1.005 | −0.022 | −0.001 | −0.121 |
| Year 3 | 0.831** | 0.306 | −0.080 | 0.053 |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.057 | 0.042 | 0.064 | 0.057 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Shows estimated impact for disaster in 75th percentile. Underlying regression coefficients in tables 5.15, 5.16 and 5.18 in appendix. Quarter 0 is the quarter the disaster takes place. Year 1 is quarters 0 through 3 combined, year 2 is quarters 4 through 7, year 3 is quarters 8 through 11.

inflation by 1.43pp in the first year, by 1.62 in the second year and by 1.61pp in the third year . The 75th percentile storm has a positive impact on headline inflation. Over the first year, the estimated impact is 4.59pp, although this is insignificant. For the second and third year the impact is positive and significant at 1.50pp and 0.96pp respectively. Food price inflation is higher by 0.96pp in the first year and by 1.27pp in the second year.

For middle and low income countries, the 75th percentile disaster is estimated to increase headline inflation by 0.62pp in the first year, by (an insignificant) 1.01pp in the second year and by 0.83pp in the third year. By sub-component, food price inflation is significantly higher in the quarter that the disaster takes place and in quarter 1. But in the subsequent two quarters, this higher inflation is partly reversed, such that the combined impact for the first year is insignificant. Disasters do not have significant impact on the other sub-components in middle and low income countries. Split by type of disaster (see table 5.19 in the appendix), earthquakes lower CPIxFHE inflation, and the 75th percentile drought has a large and positive impact on headline inflation: 4.99pp in the first year, 7.34pp (insignificant) in the second year and 5.37pp in the third year.

### 5.4.4 Impact by severity of disaster

Given the heavily skewed distribution of disaster impacts, it is possible that there are non-linearities in their effect on inflation. We construct a series for the impact of severe disasters, $SEVIMP_{t,i}$ in an analogous fashion to equations (5.2) and (5.3), but set the cutoff threshold to be the 75th percentile of the distribution. Thus the upper quartile of disasters – 337 disasters in total – are classified as 'severe'. We then estimate equation (5.4) including both $IMP_{t,i}$ and $SEVIMP_{t,i}$ in the vector of impact variables, $D_{i,t}$. The estimated coefficients on the $IMP_{t,i}$ variables represent the impact of major disasters (those in the first three quartiles of disaster impact) on inflation. The coefficients on $SEVIMP_{t,i}$ capture any additional effect on inflation from severe disasters.

Given that the effect of disasters differs by level of development (section 5.4.3), we estimate high income countries separate from middle and low income countries. Table 5.5 shows the estimated impact on inflation of a (severe) disaster in the 90th percentile, split by level of development.

For high income countries, there is a significant positive impact on inflation in the first two years following a severe disaster (table 5.21 in the appendix). The impact on housing price inflation is negative for the first two years. A split by disaster type is not worthwhile for high income countries. There are only 23 severe disasters, and individual types are concentrated in certain countries. For example, the four earthquakes are split evenly between Chile and New Zealand, with the two New Zealand earthquakes taking place less than six months apart.

For middle and low income countries, there are a number of significant coefficients on the severe disaster variables. The reversal in the impact on headline and food price inflation typically seen in quarters 2 and 3 is not as pronounced, and is no longer significant. The impact on the other sub-indices is more positive for severe relative to major disasters, significantly so in the third year following the disaster, although the aggregate impact of severe disasters on these sub-indices remains insignificant. The impact of severe disasters by type of disaster in middle and low income countries is similar in pattern to that when all disasters are combined (table 5.24 in the appendix).

### 5.4.5 Alternative measures

For the purposes of robustness, we also consider alternative measures of the impact of disasters that have been used in studies of the impact on output. The first measure uses the information contained in the EM-DAT database on damage. We calculate an intensity measure as the ratio of

Table 5.5: Impact of severe disasters on inflation

**High income countries**

| | Headline | Food | Housing | Energy | CPI ex FHE |
|---|---|---|---|---|---|
| Quarter 0 | 1.647 | 0.183 | −0.488** | −3.732 | 0.103 |
| Quarter 1 | 1.961 | 0.480 | −0.130 | −0.374 | −0.490 |
| Quarters 2-3 | 0.397 | −0.104 | −0.509** | 0.583 | −0.224 |
| Year 1 | 4.004* | 0.558 | −1.128*** | −3.523 | −0.611 |
| Year 2 | 0.887* | 0.717 | −0.758* | −0.624 | −0.656* |
| Year 3 | 0.410 | −0.751 | 0.236 | −0.131 | −0.181 |
| Observations | 7670 | 6847 | 4653 | 5180 | 5443 |
| $R^2$ | 0.077 | 0.136 | 0.103 | 0.340 | 0.160 |

**Middle and low income countries**

| | Headline | Food | Housing & Energy | CPI ex FHE |
|---|---|---|---|---|
| Quarter 0 | 0.619* | 0.550** | 0.293 | 0.036 |
| Quarter 1 | 0.469 | 0.413* | −0.100 | −0.269 |
| Quarters 2-3 | 0.627 | −0.468 | 0.188 | −0.348 |
| Year 1 | 1.715 | 0.496 | 0.381 | −0.581 |
| Year 2 | 3.227 | −0.059 | −0.009 | −0.339 |
| Year 3 | 2.671* | 1.123 | −0.041 | 0.263 |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.058 | 0.044 | 0.066 | 0.059 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Shows estimated impact for disaster in 90th percentile. Underlying regression coefficients in tables 5.20 through 5.23 in appendix. Quarter 0 is the quarter the disaster takes place. Year 1 is quarters 0 through 3 combined, year 2 is quarters 4 through 7, year 3 is quarters 8 through 11.

measured damage to GDP, using annual GDP data from the World Bank's *World Development Indicators*. To account for the potential contemporaneous impact of the disaster on output we use the GDP figure from the year prior to the disaster. As with our previous intensity measure, we set the intensity of a disaster to zero if the ratio of damage to GDP is less than 0.1 percent. Given the lower level of coverage for damages in the EM-DAT database, we have estimates for the damage intensity for 525 disasters that meet the threshold.

We estimate equation (5.4) using the intensity measure based on damage. The estimated impact for the 75th percentile disaster on the damage measure is markedly smaller than that based on the population-based intensity (table 5.6). There is no significant impact on headline inflation in the first two years following the disasters. The qualitative impact on food prices is similar - higher inflation in the quarter that the disaster takes place and the first quarter after, followed by lower inflation in the succeeding two quarters. The impact on housing is negative, although insignificant. Finally the impact on CPIxFHE inflation is negative in the first two years, significantly so in the second year.

There are a number of reasons why the estimated impact differs between the two measures of intensity. The intensity measure based on population has an upper bound of 100 (where the disaster kills the entire population), with the highest calculated intensity in our panel being 47. Conversely, damages can exceed annual GDP, with the highest damage intensity in the panel 221. Excluding the 11 disasters that exceed a damage intensity of 50, the short-run impact on inflation of the two measures of intensity is closer.

The smaller coverage of the disaster intensity measure also biases the estimation in two dimensions. First, coverage for damage intensity is patchier in middle and low income countries, which have a different profile for the inflation impact than high income countries. There is a further composition bias, given that droughts, which typically have a more

Table 5.6: Impact of disasters on inflation - alternative measures

**Damage relative to GDP**

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| Quarter 0 | 0.041 | 0.080*** | −0.133 | 0.629 | −0.002 |
| Quarter 1 | 0.014 | 0.042 | 0.086 | 0.571 | −0.038 |
| Quarters 2-3 | −0.020 | −0.113** | −0.036 | −0.499 | −0.027 |
| Year 1 | 0.034 | 0.009 | −0.083 | 0.701 | −0.066 |
| Year 2 | 0.142 | −0.005 | −0.302 | 2.203* | −0.050* |
| Year 3 | 0.175* | 0.161* | −0.131 | −0.468 | 0.092 |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.047 | 0.042 | 0.044 | 0.172 | 0.053 |

**Number of disasters - high income countries**

| | Headline | Food | Housing | Energy | CPI ex FHE |
|---|---|---|---|---|---|
| Quarter 0 | 0.477 | 0.277 | 0.109 | −0.804* | −0.076 |
| Quarter 1 | 0.815* | 0.595* | 0.400 | −0.329 | 0.151 |
| Quarters 2-3 | 0.642 | 0.051 | 0.312 | 0.579 | −0.041 |
| Year 1 | 1.934** | 0.923* | 0.820 | −0.553 | 0.033 |
| Year 2 | 0.087 | 0.195 | −0.610 | −0.719 | −0.114 |
| Year 3 | 0.007 | 0.222 | −0.188 | −0.168 | 0.386 |
| Observations | 7670 | 6847 | 4653 | 5180 | 5443 |
| $R^2$ | 0.076 | 0.134 | 0.099 | 0.336 | 0.159 |

**Number of disasters - middle and low income countries**

| | Headline | Food | Housing & energy | CPIxFHE |
|---|---|---|---|---|
| Quarter 0 | 0.578* | 0.319** | −0.229 | −0.024 |
| Quarter 1 | 0.212 | 0.051 | −0.128 | −0.126 |
| Quarters 2-3 | −0.175 | −0.681** | −0.259 | −0.308** |
| Year 1 | 0.615 | −0.311 | −0.616 | −0.458** |
| Year 2 | 1.383 | −0.177 | −0.082 | −0.128 |
| Year 3 | 1.702 | 0.147 | −0.760** | −0.413 |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.056 | 0.043 | 0.065 | 0.057 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Shows estimated impact for disaster in 75th percentile of damage caused. Underlying regression coefficients in tables 5.25 through 5.27 in appendix. Quarter 0 is the quarter the disaster takes place. Year 1 is quarters 0 through 3 combined, year 2 is quarters 4 through 7, year 3 is quarters 8 through 11.

positive inflationary impact, are proportionately less represented in the damage data. Further, the lack of coverage of the damage caused by disasters introduces measurement error, since some observations are now incorrectly classified as being disaster free.

Given the lack of coverage for damage, we also estimate equation (5.4) using the number of disasters as our measure of intensity, which has been used previously as a measure of impact (see, e.g. Skidmore and Toya, 2002). This alternative estimation calculates the average impact for all disasters and does not allow for varying impacts by size of disaster. The results are summarised in table 5.6, with separate estimations for high income countries and middle and low income countries. The results for high income countries are for the most part qualitatively similar to the those estimated under the original specification. Headline and food price inflation is positively affected over the course of the first year. Energy price inflation is lower on impact. Conversely, housing price inflation is no longer significantly affected.

For middle and low income countries, the familiar pattern of food price inflation initially higher, before reversal in quarters 2 and 3 is evident. There is a negative impact on CPIxFHE inflation in the first year.

## 5.5 Conclusion

This paper has analysed the impact of disasters on inflation, using a panel of consumer price indices for 212 countries. It is the first to systematically analyse this impact, with previous studies confined to case studies of a small number of events, or to small geographical regions. The findings point to a considerable heterogeneity in the impact of disasters by type of disaster, by sub-index of CPI, by level of development and by timing.

There is a clear differentiation in the inflation impact of disasters by level of development. The impact of disasters in advanced countries is for the most part insignificant, and even where there is a significant impact on a sub-index, its magnitude is negligible. Conversely, the impact for less developed countries is more marked, with significant effects on headline inflation persisting even three years post-disaster. That said, there is a significant impact in high income countries from severe disasters (those in the upper quartile).

In terms of sub-indices, the impact on food price inflation is in general positive, if short lived. The impact on housing and other sub-indices is in general negative. Differences in expenditure weights on these sub-indices will in part explain the differences witnessed in headline inflation numbers by level of development.

Earthquakes do not significantly affect headline inflation, but do significantly reduce CPI inflation excluding food, housing and energy. Storms cause an immediate increase in food price inflation for the first six months, although this impact is reversed in the subsequent two quarters, resulting in no significant impact over the entire first year, or beyond. Floods increase headline inflation in the quarter that the flooding occurs in middle and low income countries, but have no significant impacts in subsequent quarters. In high income countries, the impact on headline inflation is negative, although insignificant. Droughts increase headline inflation for a number of years.

As noted above, there is the potential for endogeneity between the scale of the disaster and the impact of inflation. It would be useful to consider the impact on inflation using the underlying natural hazard – the *ex ante* strength of the event, rather than the *ex post* observed impact on people and property. The data for natural hazards collected byFelbermayr and Gröschl (2014) is not currently publicly available, but is scheduled to be so in early 2016. Once those data are publicly available it would be a useful extension of this paper to consider the impact of natural hazards on inflation.

## 5.A Appendix – country classifications

Table 5.7: Country groupings

| | | | |
|---|---|---|---|
| **Advanced** | | | |
| Australia | France | Japan | Spain |
| Austria | Germany | Luxembourg | Sweden |
| Belgium | Greece | Netherlands | Switzerland |
| Canada | Iceland | New Zealand | United Kingdom |
| Denmark | Ireland | Norway | United States |
| Finland | Italy | Portugal | |
| **Other high income** | | | |
| Andorra | Cyprus | Korea Rep | Russian Federation |
| Antigua and Barbuda | Czech Republic | Kuwait | San Marino |
| Aruba | Equatorial Guinea | Latvia | Saudi Arabia |
| Bahamas | Estonia | Lithuania | Singapore |
| Bahrain | Faeroe Islands | Macau | Sint Maarten |
| Barbados | French Polynesia | Malta | Slovakia |
| Bermuda | Guam | New Caledonia | Slovenia |
| Brunei Darussalam | Guernsey | North. Mariana Is. | St Kitts and Nevis |
| Cayman Islands | Hong Kong | Oman | Trinidad and Tobago |
| Chile | Isle of Man | Poland | Uruguay |
| Croatia | Israel | Puerto Rico | |
| Curacao | Jersey | Qatar | |

| | | | |
|---|---|---|---|
| **Middle income** | | | |
| Albania | El Salvador | Macedonia, FYR | Sao Tome et Principe |
| Algeria | FS Micronesia | Malaysia | Senegal |
| American Samoa | Fiji | Maldives | Serbia |
| Argentina | Gabon | Marshall Is. | Seychelles |
| Armenia | Georgia | Mauritania | Solomon Islands |
| Azerbaijan | Ghana | Mauritius | South Africa |
| Belarus | Grenada | Mexico | Sri Lanka |
| Belize | Guatemala | Moldova | St Lucia |
| Bolivia | Guyana | Mongolia | St Vincent & Gren. |
| Botswana | Honduras | Montenegro | Sudan |
| Brazil | Hungary | Morocco | Suriname |
| Bulgaria | India | Namibia | Swaziland |
| Cameroon | Indonesia | Nicaragua | Syria |
| Cape Verde Is. | Iran | Nigeria | Thailand |
| China, PR | Jamaica | Pakistan | Tonga |
| Colombia | Jordan | Palau | Tunisia |
| Congo | Kazakhstan | Palestinian Territories | Turkey |
| Costa Rica | Kiribati | Panama | Tuvalu |
| Cote d'Ivoire | Kosovo | Papua New Guinea | Ukraine |
| Djibouti | Kyrgyzstan | Paraguay | Vanuatu |
| Dominica | Lao, PDR | Peru | Venezuela |
| Dominican Rep. | Lebanon | Philippines | Viet Nam |
| Ecuador | Lesotho | Romania | Yemen |
| Egypt | Libya | Samoa | Zambia |
| | | | |
| **Low income** | | | |
| Bangladesh | Congo, DR | Madagascar | Sierra Leone |
| Benin | Ethiopia | Malawi | Tajikistan |
| Burkina Faso | Gambia, The | Mali | Tanzania |
| Burundi | Guinea | Mozambique | Togo |
| Cambodia | Guinea Bissau | Myanmar | Uganda |
| Central African Republic | Haiti | Nepal | Zimbabwe |
| Chad | Kenya | Niger | |
| Comoros | Liberia | Rwanda | |

## 5.B Appendix – regression coefficients

Table 5.8: Impact of disasters on inflation – regression coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| totimp | 0.160** | 0.100** | −0.042 | −0.090 | 0.010 |
| | (0.055) | (0.035) | (0.045) | (0.094) | (0.033) |
| $totimp_{t-1}$ | 0.112* | 0.096* | −0.035 | −0.090 | −0.061* |
| | (0.051) | (0.040) | (0.031) | (0.086) | (0.029) |
| $totimp_{t-2}$ | 0.069 | −0.067 | −0.069** | −0.128* | −0.035 |
| | (0.070) | (0.043) | (0.022) | (0.064) | (0.031) |
| $totimp_{t-3}$ | 0.028 | −0.067 | −0.071*** | 0.056 | −0.038 |
| | (0.052) | (0.037) | (0.018) | (0.075) | (0.034) |
| $totimp_{t-4}$ | 0.095 | −0.010 | −0.085** | 0.028 | 0.022 |
| | (0.099) | (0.029) | (0.026) | (0.078) | (0.025) |
| $totimp_{t-5}$ | 0.121 | −0.056 | −0.037 | 0.030 | −0.070 |
| | (0.117) | (0.037) | (0.028) | (0.061) | (0.037) |
| $totimp_{t-6}$ | 0.162 | 0.024 | −0.074* | 0.014 | −0.017 |
| | (0.099) | (0.047) | (0.035) | (0.056) | (0.018) |
| $totimp_{t-7}$ | 0.175 | 0.024 | −0.017 | 0.020 | −0.022 |
| | (0.151) | (0.031) | (0.027) | (0.032) | (0.020) |
| $totimp_{t-8}$ | 0.150 | 0.035 | −0.077 | 0.088 | 0.065 |
| | (0.085) | (0.053) | (0.046) | (0.097) | (0.039) |
| $totimp_{t-9}$ | 0.117 | 0.035 | 0.061 | −0.067* | −0.073 |
| | (0.085) | (0.051) | (0.080) | (0.028) | (0.052) |
| $totimp_{t-10}$ | 0.125 | 0.014 | 0.004 | −0.006 | 0.050 |
| | (0.065) | (0.060) | (0.030) | (0.048) | (0.057) |
| $totimp_{t-11}$ | 0.075 | 0.084 | −0.068* | 0.110 | −0.021 |
| | (0.052) | (0.048) | (0.027) | (0.154) | (0.020) |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.050 | 0.042 | 0.046 | 0.171 | 0.054 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

Table 5.9: Impact of disasters on inflation, balanced panel regression coefficients

| | Headline | Food | Housing & energy | CPIxFHE |
|---|---|---|---|---|
| totimp | 0.009 | 0.037 | −0.008 | −0.046 |
| | (0.036) | (0.099) | (0.059) | (0.079) |
| $\text{totimp}_{t-1}$ | 0.048 | 0.192 | −0.113 | −0.077 |
| | (0.052) | (0.101) | (0.070) | (0.049) |
| $\text{totimp}_{t-2}$ | −0.062 | −0.005 | −0.070 | −0.109* |
| | (0.049) | (0.129) | (0.057) | (0.053) |
| $\text{totimp}_{t-3}$ | −0.133* | −0.209* | 0.021 | −0.087 |
| | (0.056) | (0.093) | (0.061) | (0.088) |
| $\text{totimp}_{t-4}$ | 0.007 | −0.087 | 0.085 | 0.066 |
| | (0.031) | (0.091) | (0.069) | (0.060) |
| $\text{totimp}_{t-5}$ | −0.040 | 0.018 | −0.072 | −0.103** |
| | (0.031) | (0.070) | (0.068) | (0.037) |
| $\text{totimp}_{t-6}$ | −0.132*** | −0.158* | −0.122* | −0.126*** |
| | (0.033) | (0.065) | (0.059) | (0.033) |
| $\text{totimp}_{t-7}$ | −0.062 | −0.133** | 0.036 | −0.019 |
| | (0.032) | (0.045) | (0.088) | (0.032) |
| $\text{totimp}_{t-8}$ | −0.031 | −0.113* | −0.046 | 0.046 |
| | (0.034) | (0.056) | (0.057) | (0.045) |
| $\text{totimp}_{t-9}$ | −0.054 | 0.051 | −0.096 | −0.152*** |
| | (0.050) | (0.102) | (0.087) | (0.040) |
| $\text{totimp}_{t-10}$ | −0.069 | −0.035 | −0.029 | −0.103 |
| | (0.037) | (0.067) | (0.052) | (0.053) |
| $\text{totimp}_{t-11}$ | −0.091** | −0.115** | −0.160** | −0.032 |
| | (0.027) | (0.041) | (0.059) | (0.031) |
| Observations | 5226 | 5226 | 5226 | 5226 |
| $R^2$ | 0.077 | 0.086 | 0.131 | 0.039 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

Table 5.10: Impact of disasters by type: earthquake coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| eqimp | 0.239 | 0.249 | −0.033 | −0.301 | −0.096 |
| | (0.124) | (0.126) | (0.121) | (0.417) | (0.054) |
| $eqimp_{t-1}$ | 0.050 | −0.088 | 0.191* | 0.822** | −0.245*** |
| | (0.160) | (0.133) | (0.084) | (0.278) | (0.047) |
| $eqimp_{t-2}$ | −0.021 | −0.102 | −0.084 | −0.044 | −0.175*** |
| | (0.153) | (0.106) | (0.100) | (0.233) | (0.047) |
| $eqimp_{t-3}$ | −0.005 | −0.071 | −0.119* | −0.452 | −0.141*** |
| | (0.135) | (0.058) | (0.051) | (0.346) | (0.039) |
| $eqimp_{t-4}$ | 0.140 | 0.098 | 0.059 | −0.131 | −0.147** |
| | (0.130) | (0.100) | (0.080) | (0.339) | (0.044) |
| $eqimp_{t-5}$ | 0.109 | 0.061 | 0.033 | 0.787 | −0.107* |
| | (0.115) | (0.100) | (0.083) | (0.539) | (0.043) |
| $eqimp_{t-6}$ | 0.095 | 0.118 | −0.042 | 0.646 | −0.099 |
| | (0.127) | (0.194) | (0.057) | (0.616) | (0.058) |
| $eqimp_{t-7}$ | 0.037 | 0.009 | −0.023 | 0.719 | −0.119*** |
| | (0.135) | (0.127) | (0.064) | (0.933) | (0.033) |
| $eqimp_{t-8}$ | 0.001 | 0.043 | −0.131 | −0.469 | −0.119 |
| | (0.155) | (0.087) | (0.134) | (0.453) | (0.064) |
| $eqimp_{t-9}$ | 0.091 | 0.002 | −0.007 | −0.424 | −0.133** |
| | (0.139) | (0.109) | (0.066) | (0.247) | (0.045) |
| $eqimp_{t-10}$ | 0.052 | 0.151 | −0.118 | −0.525** | −0.077 |
| | (0.157) | (0.110) | (0.094) | (0.158) | (0.046) |
| $eqimp_{t-11}$ | 0.086 | 0.220 | −0.018 | 0.648 | −0.044 |
| | (0.157) | (0.184) | (0.085) | (1.210) | (0.063) |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.055 | 0.045 | 0.050 | 0.174 | 0.060 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.10 through 5.14 estimated jointly.

Table 5.11: Impact of disasters by type: storm coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| stimp | 0.076 | 0.117* | −0.064 | −0.394 | 0.016 |
| | (0.053) | (0.053) | (0.060) | (0.418) | (0.048) |
| $stimp_{t-1}$ | 0.042 | 0.163** | −0.029 | −0.240 | −0.074 |
| | (0.053) | (0.059) | (0.080) | (0.188) | (0.058) |
| $stimp_{t-2}$ | −0.062* | −0.125* | −0.097* | −0.221 | 0.019 |
| | (0.030) | (0.050) | (0.042) | (0.135) | (0.060) |
| $stimp_{t-3}$ | −0.056 | −0.126* | −0.099** | 0.223 | −0.066* |
| | (0.046) | (0.051) | (0.032) | (0.189) | (0.029) |
| $stimp_{t-4}$ | −0.034 | −0.017 | −0.132** | 0.116 | −0.027 |
| | (0.024) | (0.029) | (0.041) | (0.080) | (0.021) |
| $stimp_{t-5}$ | −0.040 | −0.026 | −0.138*** | −0.050 | −0.051 |
| | (0.031) | (0.050) | (0.022) | (0.101) | (0.034) |
| $stimp_{t-6}$ | 0.021 | 0.063 | −0.135*** | −0.122 | −0.000 |
| | (0.052) | (0.063) | (0.028) | (0.078) | (0.034) |
| $stimp_{t-7}$ | −0.040 | −0.026 | −0.079*** | 0.112 | −0.006 |
| | (0.037) | (0.044) | (0.022) | (0.080) | (0.047) |
| $stimp_{t-8}$ | −0.009 | 0.006 | −0.096* | 0.094 | 0.117 |
| | (0.052) | (0.097) | (0.038) | (0.080) | (0.067) |
| $stimp_{t-9}$ | −0.024 | 0.089 | −0.017 | −0.131 | −0.080 |
| | (0.023) | (0.085) | (0.064) | (0.122) | (0.114) |
| $stimp_{t-10}$ | −0.029 | −0.065 | −0.061 | 0.108 | 0.116 |
| | (0.020) | (0.044) | (0.035) | (0.155) | (0.107) |
| $stimp_{t-11}$ | 0.011 | 0.014 | −0.117** | 0.051 | −0.001 |
| | (0.036) | (0.037) | (0.038) | (0.111) | (0.041) |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.055 | 0.045 | 0.050 | 0.174 | 0.060 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.10 through 5.14 estimated jointly.

Table 5.12: Impact of disasters by type: flood coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| flimp | 0.433* | 0.165 | −0.091 | −0.277 | −0.166 |
| | (0.170) | (0.105) | (0.090) | (0.211) | (0.108) |
| $flimp_{t-1}$ | 0.194 | 0.081 | −0.079 | −0.374 | −0.182** |
| | (0.193) | (0.108) | (0.083) | (0.516) | (0.064) |
| $flimp_{t-2}$ | 0.190 | −0.219 | 0.012 | −0.322 | −0.012 |
| | (0.278) | (0.186) | (0.061) | (0.258) | (0.069) |
| $flimp_{t-3}$ | 0.232 | 0.032 | −0.017 | 0.040 | −0.020 |
| | (0.189) | (0.159) | (0.091) | (0.300) | (0.079) |
| $flimp_{t-4}$ | 0.166 | 0.012 | −0.059 | 0.165 | 0.051 |
| | (0.216) | (0.111) | (0.077) | (0.198) | (0.065) |
| $flimp_{t-5}$ | 0.395 | −0.145 | −0.081 | 0.492* | −0.110* |
| | (0.413) | (0.088) | (0.075) | (0.206) | (0.046) |
| $flimp_{t-6}$ | 0.858 | −0.033 | −0.177 | 0.554** | −0.022 |
| | (0.654) | (0.105) | (0.091) | (0.196) | (0.056) |
| $flimp_{t-7}$ | 0.471 | 0.132 | −0.060 | 0.171 | 0.011 |
| | (0.282) | (0.112) | (0.114) | (0.221) | (0.059) |
| $flimp_{t-8}$ | 1.169 | 0.194 | −0.105 | −0.415 | 0.314* |
| | (0.677) | (0.103) | (0.089) | (0.259) | (0.155) |
| $flimp_{t-9}$ | 0.237 | −0.100 | 0.100 | 0.182 | −0.056 |
| | (0.322) | (0.084) | (0.179) | (0.225) | (0.108) |
| $flimp_{t-10}$ | 0.134 | 0.056 | 0.010 | 0.170 | −0.064 |
| | (0.227) | (0.142) | (0.119) | (0.359) | (0.049) |
| $flimp_{t-11}$ | 0.136 | 0.141 | −0.139 | 0.004 | −0.143** |
| | (0.132) | (0.131) | (0.077) | (0.161) | (0.043) |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.055 | 0.045 | 0.050 | 0.174 | 0.060 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.10 through 5.14 estimated jointly.

Table 5.13: Impact of disasters by type: drought coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| drimp | 0.235* | 0.093 | −0.020 | 0.039 | 0.024 |
| | (0.109) | (0.054) | (0.077) | (0.050) | (0.035) |
| $\text{drimp}_{t-1}$ | 0.224* | 0.069 | −0.051 | −0.042 | −0.029 |
| | (0.102) | (0.081) | (0.038) | (0.107) | (0.030) |
| $\text{drimp}_{t-2}$ | 0.199 | −0.026 | −0.057* | −0.098 | −0.072** |
| | (0.129) | (0.104) | (0.026) | (0.087) | (0.024) |
| $\text{drimp}_{t-3}$ | 0.142 | 0.011 | −0.061** | 0.002 | −0.039 |
| | (0.081) | (0.055) | (0.023) | (0.073) | (0.025) |
| $\text{drimp}_{t-4}$ | 0.251 | 0.028 | −0.077* | −0.047 | 0.021 |
| | (0.210) | (0.046) | (0.033) | (0.086) | (0.041) |
| $\text{drimp}_{t-5}$ | 0.307 | −0.071 | −0.023 | −0.026 | −0.016 |
| | (0.250) | (0.053) | (0.027) | (0.065) | (0.029) |
| $\text{drimp}_{t-6}$ | 0.257 | 0.008 | −0.035 | −0.028 | −0.016 |
| | (0.184) | (0.073) | (0.029) | (0.047) | (0.025) |
| $\text{drimp}_{t-7}$ | 0.404 | 0.057 | 0.015 | −0.025 | −0.024 |
| | (0.306) | (0.085) | (0.020) | (0.041) | (0.016) |
| $\text{drimp}_{t-8}$ | 0.210 | 0.063 | −0.022 | 0.142 | −0.005 |
| | (0.112) | (0.046) | (0.029) | (0.129) | (0.030) |
| $\text{drimp}_{t-9}$ | 0.270 | 0.019 | −0.003 | −0.033 | −0.040 |
| | (0.152) | (0.077) | (0.049) | (0.036) | (0.023) |
| $\text{drimp}_{t-10}$ | 0.284** | 0.094 | −0.014 | −0.056 | 0.031 |
| | (0.107) | (0.112) | (0.027) | (0.068) | (0.033) |
| $\text{drimp}_{t-11}$ | 0.136 | 0.124 | −0.026 | 0.149 | −0.008 |
| | (0.103) | (0.108) | (0.026) | (0.223) | (0.021) |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.055 | 0.045 | 0.050 | 0.174 | 0.060 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.10 through 5.14 estimated jointly.

Table 5.14: Impact of disasters by type: other disaster coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| otimp | −0.205 | −0.153 | −0.034 | 0.072 | 0.085 |
| | (0.192) | (0.205) | (0.079) | (0.254) | (0.161) |
| $\text{otimp}_{t-1}$ | −0.252 | −0.001 | 0.016 | −0.021 | 0.096 |
| | (0.200) | (0.187) | (0.056) | (0.146) | (0.175) |
| $\text{otimp}_{t-2}$ | −0.009 | 0.415 | −0.133 | −0.082 | −0.202 |
| | (0.134) | (0.242) | (0.078) | (0.082) | (0.113) |
| $\text{otimp}_{t-3}$ | −0.217 | −0.116 | −0.054 | −0.032 | 0.131 |
| | (0.260) | (0.136) | (0.052) | (0.182) | (0.378) |
| $\text{otimp}_{t-4}$ | −0.269 | −0.369 | −0.014 | 0.248 | 0.317 |
| | (0.190) | (0.220) | (0.106) | (0.282) | (0.236) |
| $\text{otimp}_{t-5}$ | −0.238 | −0.023 | 0.115 | 0.273 | −0.457 |
| | (0.159) | (0.054) | (0.141) | (0.308) | (0.460) |
| $\text{otimp}_{t-6}$ | −0.295 | −0.148 | −0.169 | 0.288 | −0.031 |
| | (0.168) | (0.121) | (0.171) | (0.146) | (0.035) |
| $\text{otimp}_{t-7}$ | −0.110 | 0.079 | −0.051 | 0.015 | −0.063 |
| | (0.208) | (0.145) | (0.101) | (0.157) | (0.067) |
| $\text{otimp}_{t-8}$ | $-0.258^{*}$ | $-0.291^{***}$ | −0.301 | 0.064 | −0.015 |
| | (0.122) | (0.049) | (0.277) | (0.185) | (0.040) |
| $\text{otimp}_{t-9}$ | −0.302 | −0.121 | 0.600 | $-0.316^{*}$ | −0.240 |
| | (0.171) | (0.304) | (0.640) | (0.124) | (0.160) |
| $\text{otimp}_{t-10}$ | −0.087 | 0.010 | 0.176 | 0.053 | −0.086 |
| | (0.128) | (0.227) | (0.263) | (0.145) | (0.115) |
| $\text{otimp}_{t-11}$ | 0.043 | 0.255 | −0.177 | −0.154 | −0.034 |
| | (0.248) | (0.225) | (0.128) | (0.171) | (0.091) |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.055 | 0.045 | 0.050 | 0.174 | 0.060 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.10 through 5.14 estimated jointly.

Table 5.15: Impact of disasters in advanced countries – regression coefficients

| | (1)<br>Headline | (2)<br>Food | (3)<br>Housing | (4)<br>Energy | (5)<br>CPIxFHE |
|---|---|---|---|---|---|
| totimp | 0.005 | 0.049 | −0.116 | −0.046 | −0.007 |
| | (0.034) | (0.043) | (0.066) | (0.068) | (0.023) |
| totimp$_{t-1}$ | −0.016 | 0.089* | −0.016 | −0.132 | −0.032 |
| | (0.021) | (0.041) | (0.070) | (0.084) | (0.024) |
| totimp$_{t-2}$ | −0.038 | −0.096 | 0.014 | −0.152 | −0.032 |
| | (0.024) | (0.059) | (0.042) | (0.172) | (0.033) |
| totimp$_{t-3}$ | −0.032 | 0.028 | −0.088** | 0.096 | −0.013 |
| | (0.034) | (0.081) | (0.028) | (0.067) | (0.031) |
| totimp$_{t-4}$ | 0.003 | 0.019 | −0.109* | −0.101 | −0.021 |
| | (0.036) | (0.050) | (0.042) | (0.095) | (0.030) |
| totimp$_{t-5}$ | −0.039 | −0.127 | −0.092 | −0.179** | 0.016 |
| | (0.026) | (0.073) | (0.072) | (0.054) | (0.037) |
| totimp$_{t-6}$ | 0.018 | −0.042 | −0.010 | 0.197 | −0.023 |
| | (0.036) | (0.040) | (0.039) | (0.107) | (0.029) |
| totimp$_{t-7}$ | −0.033 | 0.000 | −0.020 | −0.120* | 0.013 |
| | (0.033) | (0.062) | (0.032) | (0.048) | (0.035) |
| totimp$_{t-8}$ | 0.018 | 0.033 | 0.135 | −0.010 | −0.031 |
| | (0.034) | (0.056) | (0.171) | (0.035) | (0.024) |
| totimp$_{t-9}$ | 0.044* | −0.011 | 0.169 | 0.034 | 0.041 |
| | (0.021) | (0.059) | (0.190) | (0.064) | (0.043) |
| totimp$_{t-10}$ | 0.009 | 0.036 | −0.110 | 0.032 | 0.007 |
| | (0.038) | (0.033) | (0.114) | (0.067) | (0.048) |
| totimp$_{t-11}$ | 0.042 | 0.053 | 0.018 | 0.076 | 0.044 |
| | (0.035) | (0.064) | (0.082) | (0.073) | (0.024) |
| Observations | 2783 | 2741 | 2167 | 2715 | 2591 |
| $R^2$ | 0.302 | 0.247 | 0.172 | 0.507 | 0.361 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

Table 5.16: Impact of disasters in other high income countries – regression coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| totimp | 1.139 | 0.144 | −0.014 | −2.621** | 0.048 |
| | (1.006) | (0.121) | (0.033) | (0.850) | (0.089) |
| $totimp_{t-1}$ | 1.222 | 0.317 | 0.064 | −0.561* | −0.187 |
| | (1.038) | (0.161) | (0.099) | (0.248) | (0.107) |
| $totimp_{t-2}$ | 0.368* | 0.275** | 0.147 | 0.059 | −0.182* |
| | (0.147) | (0.103) | (0.078) | (0.182) | (0.077) |
| $totimp_{t-3}$ | 0.439 | 0.102 | −0.111 | 0.954*** | 0.102 |
| | (0.253) | (0.115) | (0.152) | (0.280) | (0.119) |
| $totimp_{t-4}$ | 0.400* | 0.340* | 0.026 | 0.233 | −0.104 |
| | (0.186) | (0.141) | (0.050) | (0.140) | (0.056) |
| $totimp_{t-5}$ | 0.161 | −0.062 | 0.035 | 0.148 | −0.145 |
| | (0.116) | (0.126) | (0.053) | (0.167) | (0.114) |
| $totimp_{t-6}$ | 0.187* | 0.270* | −0.010 | −0.249 | 0.044 |
| | (0.082) | (0.132) | (0.048) | (0.259) | (0.136) |
| $totimp_{t-7}$ | 0.266 | 0.430*** | 0.039 | 0.104 | −0.004 |
| | (0.153) | (0.090) | (0.054) | (0.163) | (0.062) |
| $totimp_{t-8}$ | 0.273 | 0.087 | 0.089 | −0.152 | 0.044 |
| | (0.197) | (0.112) | (0.101) | (0.384) | (0.046) |
| $totimp_{t-9}$ | 0.075 | −0.228 | 0.005 | −0.096 | 0.051 |
| | (0.080) | (0.122) | (0.065) | (0.159) | (0.081) |
| $totimp_{t-10}$ | 0.172* | 0.196 | 0.054 | 0.514 | −0.062 |
| | (0.067) | (0.121) | (0.043) | (0.335) | (0.094) |
| $totimp_{t-11}$ | 0.217* | 0.019 | −0.064 | −0.447* | 0.075 |
| | (0.101) | (0.130) | (0.080) | (0.178) | (0.106) |
| Observations | 4887 | 4106 | 2486 | 2465 | 2852 |
| $R^2$ | 0.093 | 0.134 | 0.116 | 0.295 | 0.139 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

Table 5.17: Impact of disasters in high income countries, by type of disaster

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| **Earthquakes** | | | | | |
| Quarter 0 | 0.237 | −0.493 | −0.156 | −1.055* | −0.247 |
| Quarter 1 | 0.511 | 0.803 | 0.486*** | 0.678** | −0.327 |
| Quarters 2-3 | 0.170 | 0.940 | −0.162 | −0.732** | −0.852** |
| Year 1 | 0.917 | 1.250 | 0.167 | −1.109 | −1.427** |
| Year 2 | 0.131 | 0.647 | −0.134 | −0.814 | −1.621*** |
| Year 3 | 0.847 | 1.688 | −0.071 | −4.991*** | −1.614*** |
| **Storms** | | | | | |
| Quarter 0 | 1.622 | 0.269 | −0.034 | −3.414*** | 0.160 |
| Quarter 1 | 1.736 | 0.297 | −0.052 | −0.931*** | −0.139 |
| Quarters 2-3 | 1.232* | 0.396 | 0.002 | 1.683*** | 0.135 |
| Year 1 | 4.590 | 0.963** | −0.084 | −2.661*** | 0.156 |
| Year 2 | 1.497* | 1.266*** | −0.026 | 0.544 | 0.128 |
| Year 3 | 0.958* | −0.079 | −0.122 | −0.013 | 0.327 |
| **Floods** | | | | | |
| Quarter 0 | −0.191 | −0.080 | 0.017 | 0.405 | −0.548** |
| Quarter 1 | 0.039 | 0.320 | 0.066 | 0.264 | −0.282 |
| Quarters 2-3 | −0.656 | −0.873* | 0.129 | −2.785 | −0.732 |
| Year 1 | −0.807 | −0.633 | 0.212 | −2.117 | −1.561* |
| Year 2 | −1.687 | −1.170 | 0.217 | −0.302 | −0.926 |
| Year 3 | −1.903 | −1.022 | 0.353 | 0.279 | −0.286 |
| Observations | 7670 | 6847 | 4653 | 5180 | 5443 |
| $R^2$ | 0.086 | 0.143 | 0.106 | 0.353 | 0.164 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Underlying regression estimates available on request.

Table 5.18: Impact of disasters in middle and low income countries – regression coefficients

| | Headline | Food | Housing & Energy | CPIxFHE |
|---|---|---|---|---|
| totimp | 0.158** | 0.104** | 0.033 | 0.013 |
| | (0.058) | (0.036) | (0.030) | (0.037) |
| $totimp_{t-1}$ | 0.104* | 0.094* | −0.025 | −0.047 |
| | (0.051) | (0.042) | (0.032) | (0.029) |
| $totimp_{t-2}$ | 0.073 | −0.070 | −0.004 | −0.033 |
| | (0.074) | (0.046) | (0.027) | (0.032) |
| $totimp_{t-3}$ | 0.032 | −0.066 | 0.035 | −0.051 |
| | (0.055) | (0.038) | (0.028) | (0.043) |
| $totimp_{t-4}$ | 0.101 | −0.012 | 0.002 | 0.019 |
| | (0.102) | (0.030) | (0.035) | (0.029) |
| $totimp_{t-5}$ | 0.135 | −0.051 | 0.033 | −0.059 |
| | (0.121) | (0.038) | (0.028) | (0.041) |
| $totimp_{t-6}$ | 0.173 | 0.025 | −0.021 | −0.020 |
| | (0.102) | (0.047) | (0.027) | (0.018) |
| $totimp_{t-7}$ | 0.185 | 0.025 | −0.014 | −0.011 |
| | (0.156) | (0.031) | (0.028) | (0.020) |
| $totimp_{t-8}$ | 0.155 | 0.041 | 0.066 | 0.066 |
| | (0.088) | (0.053) | (0.051) | (0.040) |
| $totimp_{t-9}$ | 0.124 | 0.036 | −0.053 | −0.065 |
| | (0.087) | (0.052) | (0.033) | (0.049) |
| $totimp_{t-10}$ | 0.131 | 0.014 | −0.042* | 0.049 |
| | (0.068) | (0.063) | (0.020) | (0.057) |
| $totimp_{t-11}$ | 0.080 | 0.091 | −0.018 | −0.018 |
| | (0.053) | (0.050) | (0.040) | (0.020) |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.057 | 0.042 | 0.064 | 0.057 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

Table 5.19: Impact of disasters in middle and low income countries, by type

| | Headline | Food | Housing & Energy | CPIxFHE |
|---|---|---|---|---|
| **Earthquakes** | | | | |
| Quarter 0 | 0.230 | 0.253* | 0.073 | −0.083 |
| Quarter 1 | 0.028 | −0.125 | −0.022 | −0.205*** |
| Quarters 2-3 | 0.005 | −0.224 | −0.210*** | −0.241*** |
| Year 1 | 0.262 | −0.096 | −0.159 | −0.530*** |
| Year 2 | 0.413 | 0.221 | 0.017 | −0.348** |
| Year 3 | 0.264 | 0.321 | −0.327* | −0.267 |
| **Storms** | | | | |
| Quarter 0 | 0.044 | 0.181* | 0.032 | 0.023 |
| Quarter 1 | −0.017 | 0.220* | −0.067 | −0.076 |
| Quarters 2-3 | −0.216* | −0.378*** | 0.095 | −0.123 |
| Year 1 | −0.189 | 0.023 | 0.060 | −0.176 |
| Year 2 | −0.186 | −0.046 | −0.054 | −0.140 |
| Year 3 | −0.118 | 0.065 | −0.061 | 0.245 |
| **Floods** | | | | |
| Quarter 0 | 0.404** | 0.155 | −0.007 | −0.141 |
| Quarter 1 | 0.192 | 0.084 | −0.006 | −0.157** |
| Quarters 2-3 | 0.381 | −0.159 | 0.002 | −0.007 |
| Year 1 | 0.978 | 0.080 | −0.012 | −0.305 |
| Year 2 | 1.790 | 0.018 | −0.015 | −0.025 |
| Year 3 | 1.552 | 0.276 | −0.387 | 0.041 |
| **Droughts** | | | | |
| Quarter 0 | 1.453* | 0.517 | 0.297 | 0.149 |
| Quarter 1 | 1.376* | 0.391 | −0.103 | −0.098 |
| Quarters 2-3 | 2.165 | 0.058 | −0.067 | −0.590* |
| Year 1 | 4.994* | 0.966 | 0.128 | −0.540 |
| Year 2 | 7.359 | 0.292 | 0.246 | −0.028 |
| Year 3 | 5.374* | 1.856 | −0.109 | −0.099 |
| Observations | 14680 | 12031 | 7262 | 7157 |
| $R^2$ | 0.063 | 0.045 | 0.068 | 0.065 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Underlying regression estimates available on request.

Table 5.20: Impact of severe disasters in high income countries – major disaster coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| totimp | −0.060 | 0.041 | 0.778* | 0.047 | −0.106 |
| | (0.196) | (0.344) | (0.374) | (0.261) | (0.487) |
| $totimp_{t-1}$ | 0.218 | 1.305* | 1.219* | −0.168 | 0.776 |
| | (0.301) | (0.613) | (0.486) | (0.298) | (0.502) |
| $totimp_{t-2}$ | 0.097 | −0.176 | 1.273* | −0.010 | 0.114 |
| | (0.238) | (0.375) | (0.601) | (0.317) | (0.627) |
| $totimp_{t-3}$ | 0.014 | 0.628 | 0.263 | 0.713 | 0.198 |
| | (0.213) | (0.355) | (0.593) | (0.496) | (0.337) |
| $totimp_{t-4}$ | 0.156 | 0.383 | −1.154 | −0.207 | −0.244 |
| | (0.132) | (0.437) | (0.729) | (0.226) | (0.374) |
| $totimp_{t-5}$ | 0.039 | −0.152 | −0.960* | −0.205 | −0.017 |
| | (0.114) | (0.382) | (0.446) | (0.188) | (0.286) |
| $totimp_{t-6}$ | 0.092 | −0.375 | −0.728 | −0.030 | −0.330 |
| | (0.151) | (0.436) | (0.370) | (0.740) | (0.330) |
| $totimp_{t-7}$ | −0.167 | −0.350 | −0.389 | 0.291 | −0.019 |
| | (0.188) | (0.335) | (0.348) | (0.440) | (0.199) |
| $totimp_{t-8}$ | 0.012 | 0.584 | −0.541 | 0.092 | 0.096 |
| | (0.171) | (0.440) | (0.409) | (0.215) | (0.284) |
| $totimp_{t-9}$ | −0.101 | 0.851* | −0.474 | −0.171 | 0.443 |
| | (0.241) | (0.339) | (0.478) | (0.379) | (0.271) |
| $totimp_{t-10}$ | −0.127 | −0.343 | −0.330 | −0.073 | 0.217 |
| | (0.127) | (0.281) | (0.385) | (0.297) | (0.292) |
| $totimp_{t-11}$ | −0.257 | −0.304 | −0.245* | −0.557 | −0.010 |
| | (0.141) | (0.206) | (0.107) | (0.481) | (0.090) |
| Observations | 7670 | 6847 | 4653 | 5180 | 5443 |
| $R^2$ | 0.077 | 0.136 | 0.103 | 0.340 | 0.160 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.20 and 5.21 estimated jointly.

Table 5.21: Impact of severe disasters in high income countries – severe disaster coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| totsevimp | 0.483 | 0.006 | −0.904* | −1.007 | 0.133 |
| | (0.385) | (0.352) | (0.383) | (0.946) | (0.504) |
| totsevimp$_{t-1}$ | 0.286 | −1.181 | −1.252* | 0.072 | −0.902 |
| | (0.519) | (0.611) | (0.488) | (0.338) | (0.503) |
| totsevimp$_{t-2}$ | −0.104 | 0.219 | −1.290* | −0.226 | −0.205 |
| | (0.312) | (0.394) | (0.605) | (0.367) | (0.653) |
| totsevimp$_{t-3}$ | 0.095 | −0.698 | −0.377 | −0.326 | −0.165 |
| | (0.241) | (0.366) | (0.583) | (0.603) | (0.351) |
| totsevimp$_{t-4}$ | −0.048 | −0.229 | 1.133 | 0.208 | 0.197 |
| | (0.165) | (0.444) | (0.749) | (0.286) | (0.374) |
| totsevimp$_{t-5}$ | −0.055 | −0.026 | 0.886 | 0.131 | −0.078 |
| | (0.134) | (0.379) | (0.454) | (0.238) | (0.288) |
| totsevimp$_{t-6}$ | −0.038 | 0.428 | 0.677 | 0.035 | 0.322 |
| | (0.167) | (0.462) | (0.375) | (0.758) | (0.330) |
| totsevimp$_{t-7}$ | 0.249 | 0.506 | 0.340 | −0.383 | −0.001 |
| | (0.198) | (0.373) | (0.349) | (0.448) | (0.196) |
| totsevimp$_{t-8}$ | 0.017 | −0.643 | 0.632 | −0.087 | −0.144 |
| | (0.190) | (0.447) | (0.404) | (0.342) | (0.307) |
| totsevimp$_{t-9}$ | 0.012 | −1.128** | 0.524 | 0.084 | −0.476 |
| | (0.255) | (0.345) | (0.477) | (0.405) | (0.279) |
| totsevimp$_{t-10}$ | 0.203 | 0.509 | 0.254 | 0.386 | −0.253 |
| | (0.134) | (0.297) | (0.406) | (0.448) | (0.341) |
| totsevimp$_{t-11}$ | 0.345* | 0.282 | 0.241 | 0.292 | 0.080 |
| | (0.137) | (0.202) | (0.151) | (0.519) | (0.121) |
| Observations | 7670 | 6847 | 4653 | 5180 | 5443 |
| $R^2$ | 0.077 | 0.136 | 0.103 | 0.340 | 0.160 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.20 and 5.21 estimated jointly.

Table 5.22: Impact of severe disasters in middle and low income countries – major disaster coefficients

| | Headline | Food | Housing & energy | CPIxFHE |
|---|---|---|---|---|
| totimp | 0.886 | 0.069 | −0.257 | 0.072 |
| | (0.823) | (0.165) | (0.153) | (0.130) |
| $totimp_{t-1}$ | 0.376 | 0.308 | −0.156 | 0.019 |
| | (0.243) | (0.195) | (0.207) | (0.142) |
| $totimp_{t-2}$ | −0.152 | −0.634** | −0.202 | −0.143 |
| | (0.191) | (0.188) | (0.125) | (0.090) |
| $totimp_{t-3}$ | −0.002 | −0.305 | 0.109 | −0.213 |
| | (0.198) | (0.173) | (0.151) | (0.108) |
| $totimp_{t-4}$ | −0.129 | 0.041 | −0.055 | 0.030 |
| | (0.230) | (0.155) | (0.132) | (0.118) |
| $totimp_{t-5}$ | 0.161 | 0.070 | 0.063 | 0.096 |
| | (0.176) | (0.209) | (0.107) | (0.148) |
| $totimp_{t-6}$ | −0.017 | −0.143 | −0.036 | −0.171 |
| | (0.183) | (0.233) | (0.138) | (0.189) |
| $totimp_{t-7}$ | −0.208 | −0.142 | −0.018 | −0.152 |
| | (0.193) | (0.131) | (0.176) | (0.092) |
| $totimp_{t-8}$ | −0.073 | −0.198 | −0.173 | −0.058 |
| | (0.215) | (0.152) | (0.092) | (0.185) |
| $totimp_{t-9}$ | −0.066 | −0.039 | −0.294* | −0.200 |
| | (0.227) | (0.201) | (0.118) | (0.116) |
| $totimp_{t-10}$ | −0.035 | −0.267 | −0.169* | −0.143 |
| | (0.206) | (0.215) | (0.079) | (0.088) |
| $totimp_{t-11}$ | −0.177 | −0.469* | −0.312*** | −0.045 |
| | (0.154) | (0.181) | (0.074) | (0.083) |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.058 | 0.044 | 0.066 | 0.059 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.22 and 5.23 estimated jointly.

Table 5.23: Impact of severe disasters in middle and low income countries – severe disaster coefficients

| | Headline | Food | Housing & energy | CPIxFHE |
|---|---|---|---|---|
| totsevimp | $-0.765$ | $0.038$ | $0.314^{*}$ | $-0.065$ |
| | (0.836) | (0.170) | (0.157) | (0.127) |
| $\text{totsevimp}_{t-1}$ | $-0.285$ | $-0.228$ | $0.136$ | $-0.071$ |
| | (0.257) | (0.192) | (0.210) | (0.151) |
| $\text{totsevimp}_{t-2}$ | $0.240$ | $0.597^{**}$ | $0.210$ | $0.115$ |
| | (0.202) | (0.199) | (0.129) | (0.101) |
| $\text{totsevimp}_{t-3}$ | $0.036$ | $0.250$ | $-0.080$ | $0.173$ |
| | (0.195) | (0.169) | (0.152) | (0.130) |
| $\text{totsevimp}_{t-4}$ | $0.240$ | $-0.059$ | $0.059$ | $-0.012$ |
| | (0.227) | (0.166) | (0.132) | (0.119) |
| $\text{totsevimp}_{t-5}$ | $-0.027$ | $-0.128$ | $-0.031$ | $-0.165$ |
| | (0.169) | (0.213) | (0.109) | (0.161) |
| $\text{totsevimp}_{t-6}$ | $0.199$ | $0.176$ | $0.016$ | $0.158$ |
| | (0.177) | (0.228) | (0.147) | (0.195) |
| $\text{totsevimp}_{t-7}$ | $0.410^{*}$ | $0.172$ | $-0.000$ | $0.150$ |
| | (0.206) | (0.133) | (0.167) | (0.097) |
| $\text{totsevimp}_{t-8}$ | $0.236$ | $0.247$ | $0.251^{*}$ | $0.129$ |
| | (0.204) | (0.167) | (0.109) | (0.184) |
| $\text{totsevimp}_{t-9}$ | $0.197$ | $0.074$ | $0.249^{*}$ | $0.140$ |
| | (0.204) | (0.219) | (0.106) | (0.137) |
| $\text{totsevimp}_{t-10}$ | $0.172$ | $0.291$ | $0.132$ | $0.202$ |
| | (0.219) | (0.256) | (0.079) | (0.103) |
| $\text{totsevimp}_{t-11}$ | $0.265$ | $0.580^{**}$ | $0.308^{**}$ | $0.026$ |
| | (0.167) | (0.205) | (0.096) | (0.088) |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.058 | 0.044 | 0.066 | 0.059 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported. Coefficients in tables 5.22 and 5.23 estimated jointly.

Table 5.24: Impact of severe disasters in middle and low income countries, by type of disaster

| | Headline | Food | Housing & energy | CPIxFHE |
|---|---|---|---|---|
| **Earthquakes** | | | | |
| Quarter 0 | 0.529 | 0.643* | 0.177 | −0.184 |
| Quarter 1 | −0.165 | −0.300 | −0.136 | −0.493** |
| Quarters 2-3 | 0.005 | −0.627 | −0.492* | −0.631** |
| Year 1 | 0.369 | −0.284 | −0.451 | −1.308*** |
| Year 2 | 1.296 | 0.243 | 0.015 | −0.955** |
| Year 3 | 1.069 | 0.848 | −0.744 | −0.682 |
| **Storms** | | | | |
| Quarter 0 | 0.104 | 0.655* | 0.091 | 0.041 |
| Quarter 1 | −0.064 | 0.741* | −0.250 | −0.276 |
| Quarters 2-3 | −0.709 | −1.299*** | 0.380 | −0.442 |
| Year 1 | −0.669 | 0.098 | 0.221 | −0.676 |
| Year 2 | −0.563 | −0.139 | −0.218 | −0.473 |
| Year 3 | −0.370 | 0.306 | −0.197 | 0.898 |
| **Floods** | | | | |
| Quarter 0 | 1.141** | 0.343 | 0.223 | −0.416 |
| Quarter 1 | 0.662 | 0.317 | 0.118 | −0.414* |
| Quarters 2-3 | 1.339 | −0.108 | −0.070 | 0.200 |
| Year 1 | 3.143 | 0.552 | 0.271 | −0.630 |
| Year 2 | 5.160 | 0.122 | −0.008 | 0.024 |
| Year 3 | 4.130 | 0.690 | −0.834 | 0.210 |
| **Droughts** | | | | |
| Quarter 0 | 1.957* | 1.141 | 0.949* | 0.108 |
| Quarter 1 | 2.396 | 0.264 | −0.068 | −0.250 |
| Quarters 2-3 | 4.309 | 0.972 | −0.088 | −1.020* |
| Year 1 | 8.662* | 2.378 | 0.793 | −1.162 |
| Year 2 | 15.317 | 0.567 | 0.456 | −0.098 |
| Year 3 | 11.454** | 4.589 | 0.476 | 0.027 |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.066 | 0.052 | 0.075 | 0.069 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Underlying regression estimates available on request.

Table 5.25: Impact of disasters, damage to GDP – regression coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| totdam | 0.012 | 0.024*** | −0.039 | 0.186 | −0.001 |
| | (0.009) | (0.007) | (0.025) | (0.138) | (0.004) |
| $\text{totdam}_{t-1}$ | 0.004 | 0.012 | 0.025 | 0.169 | −0.011 |
| | (0.006) | (0.007) | (0.023) | (0.100) | (0.007) |
| $\text{totdam}_{t-2}$ | −0.003 | −0.018** | −0.003 | −0.136 | 0.000 |
| | (0.009) | (0.006) | (0.035) | (0.090) | (0.008) |
| $\text{totdam}_{t-3}$ | −0.003 | −0.015 | −0.007 | −0.012 | −0.008 |
| | (0.007) | (0.008) | (0.035) | (0.055) | (0.005) |
| $\text{totdam}_{t-4}$ | 0.008 | 0.004 | −0.074 | 0.263 | −0.005 |
| | (0.012) | (0.007) | (0.045) | (0.158) | (0.003) |
| $\text{totdam}_{t-5}$ | 0.011 | −0.002 | −0.032 | −0.005 | −0.006 |
| | (0.013) | (0.009) | (0.023) | (0.068) | (0.005) |
| $\text{totdam}_{t-6}$ | 0.009 | −0.001 | 0.013 | 0.141 | 0.002 |
| | (0.011) | (0.008) | (0.030) | (0.107) | (0.004) |
| $\text{totdam}_{t-7}$ | 0.013 | −0.002 | 0.003 | 0.254 | −0.005 |
| | (0.015) | (0.005) | (0.019) | (0.165) | (0.005) |
| $\text{totdam}_{t-8}$ | 0.020 | 0.018** | −0.085** | 0.001 | 0.017 |
| | (0.011) | (0.006) | (0.032) | (0.109) | (0.012) |
| $\text{totdam}_{t-9}$ | 0.024* | 0.033* | 0.020 | −0.061 | −0.004 |
| | (0.010) | (0.015) | (0.036) | (0.100) | (0.020) |
| $\text{totdam}_{t-10}$ | 0.005 | −0.003 | 0.034 | −0.060 | 0.016 |
| | (0.005) | (0.012) | (0.028) | (0.069) | (0.016) |
| $\text{totdam}_{t-11}$ | 0.004 | −0.001 | −0.008* | −0.018 | −0.002 |
| | (0.008) | (0.006) | (0.004) | (0.020) | (0.004) |
| Observations | 22471 | 18933 | 8191 | 9167 | 12639 |
| $R^2$ | 0.047 | 0.042 | 0.044 | 0.172 | 0.053 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

Table 5.26: Impact of disasters by number in high income countries – regression coefficients

| | Headline | Food | Housing | Energy | CPIxFHE |
|---|---|---|---|---|---|
| totnum | 0.477 | 0.277 | 0.109 | −0.804* | −0.076 |
| | (0.315) | (0.215) | (0.157) | (0.387) | (0.137) |
| $totnum_{t-1}$ | 0.815* | 0.595* | 0.400 | −0.329 | 0.151 |
| | (0.361) | (0.263) | (0.225) | (0.565) | (0.193) |
| $totnum_{t-2}$ | 0.363 | −0.003 | 0.244 | −0.329 | −0.081 |
| | (0.278) | (0.157) | (0.177) | (0.564) | (0.142) |
| $totnum_{t-3}$ | 0.279 | 0.054 | 0.068 | 0.909* | 0.040 |
| | (0.172) | (0.171) | (0.271) | (0.402) | (0.115) |
| $totnum_{t-4}$ | 0.126 | 0.245 | −0.092 | −0.126 | −0.192 |
| | (0.143) | (0.235) | (0.229) | (0.288) | (0.136) |
| $totnum_{t-5}$ | −0.081 | −0.101 | −0.289 | −0.192 | −0.053 |
| | (0.168) | (0.244) | (0.175) | (0.268) | (0.157) |
| $totnum_{t-6}$ | 0.008 | 0.060 | −0.202 | −0.548 | 0.126 |
| | (0.125) | (0.197) | (0.139) | (0.454) | (0.167) |
| $totnum_{t-7}$ | 0.033 | −0.009 | −0.026 | 0.147 | 0.005 |
| | (0.160) | (0.190) | (0.160) | (0.350) | (0.131) |
| $totnum_{t-8}$ | −0.024 | 0.126 | 0.062 | 0.118 | −0.084 |
| | (0.191) | (0.173) | (0.216) | (0.305) | (0.131) |
| $totnum_{t-9}$ | 0.066 | 0.242 | 0.019 | −0.034 | 0.213 |
| | (0.225) | (0.249) | (0.183) | (0.398) | (0.153) |
| $totnum_{t-10}$ | 0.010 | 0.047 | −0.038 | 0.005 | 0.145 |
| | (0.146) | (0.197) | (0.195) | (0.303) | (0.161) |
| $totnum_{t-11}$ | −0.046 | −0.193 | −0.230 | −0.257 | 0.112 |
| | (0.192) | (0.203) | (0.231) | (0.325) | (0.125) |
| Observations | 7670 | 6847 | 4653 | 5180 | 5443 |
| $R^2$ | 0.076 | 0.134 | 0.099 | 0.336 | 0.159 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

Table 5.27: Impact of disasters by number in middle and low income countries – regression coefficients

| | Headline | Food | Housing & energy | CPIxFHE |
|---|---|---|---|---|
| totnum | 0.578* | 0.319** | −0.229 | −0.024 |
| | (0.227) | (0.120) | (0.136) | (0.093) |
| $totnum_{t-1}$ | 0.212 | 0.051 | −0.128 | −0.126 |
| | (0.233) | (0.131) | (0.104) | (0.073) |
| $totnum_{t-2}$ | −0.204 | −0.612*** | −0.156 | −0.107 |
| | (0.214) | (0.179) | (0.109) | (0.084) |
| $totnum_{t-3}$ | 0.029 | −0.068 | −0.103 | −0.200** |
| | (0.216) | (0.171) | (0.075) | (0.073) |
| $totnum_{t-4}$ | 0.171 | 0.109 | −0.159 | 0.086 |
| | (0.254) | (0.090) | (0.090) | (0.112) |
| $totnum_{t-5}$ | 0.236 | −0.277* | 0.040 | −0.050 |
| | (0.289) | (0.128) | (0.073) | (0.082) |
| $totnum_{t-6}$ | 0.412 | −0.118 | 0.080 | −0.131 |
| | (0.274) | (0.127) | (0.097) | (0.075) |
| $totnum_{t-7}$ | 0.564 | 0.109 | −0.043 | −0.034 |
| | (0.369) | (0.091) | (0.099) | (0.069) |
| $totnum_{t-8}$ | 0.622 | 0.213 | −0.078 | 0.084 |
| | (0.365) | (0.132) | (0.068) | (0.189) |
| $totnum_{t-9}$ | 0.326 | −0.045 | −0.240* | −0.296*** |
| | (0.289) | (0.130) | (0.111) | (0.081) |
| $totnum_{t-10}$ | 0.343 | −0.150 | −0.125 | −0.118 |
| | (0.252) | (0.121) | (0.116) | (0.108) |
| $totnum_{t-11}$ | 0.410* | 0.129 | −0.317*** | −0.082 |
| | (0.200) | (0.121) | (0.090) | (0.062) |
| Observations | 14801 | 12086 | 7301 | 7196 |
| $R^2$ | 0.056 | 0.043 | 0.065 | 0.057 |

Notes: *, **,*** significant at 5, 1 and 0.1 percent level respectively. CPIxFHE is consumer prices excluding food, housing and energy. Driscoll and Kraay (1998) standard errors in parentheses. Country and quarterly time fixed effects included but not reported.

# Chapter 6

# Conclusions and areas for future research

This thesis investigates four areas of incomplete knowledge surrounding inflation dynamics that are of interest to monetary policy makers. To investigate these areas, four questions are asked: *Why are prices sticky*? *How do exporters set their prices*? *What is the role of global inflation factors in driving domestic inflation*? *How do disasters affect inflation*? The answers to those questions are summarised below, together with ideas for future research based on these findings.

## 6.1 Why are prices sticky?

The extent of price stickiness in the economy has bearing on inflation dynamics and the ability of monetary policy to affect real activity. There are a number of theories on the causes of this stickiness, but differentiating between them is not straightforward, even with data on firms' prices. A large survey of New Zealand firms provides insight into the pricing behaviour of firms, and the reasons for which they may choose to not change prices.

The responses to the survey point to a wide heterogeneity in pricing behaviour by New Zealand firms. There is a notable divergence between sectors, but also *within* sectors, with many sectors having both firms that reset prices on a daily basis and those that reset prices less frequently than annually. The median number of times a New Zealand firms reviews its prices is twice per year, but the median number of changes is one.

In terms of the underlying causes of price stickiness, the rigidity that firms were most likely to cite as being 'very important' for not changing prices is explicit contracts. Implicit contracts, where the firm wishes to maintain an ongoing relationship and does not wish to antagonise its customers, was the second most recognised reason. There is little support in the responses for two popular theoretical justifications for stickiness – menu costs and sticky information.

One interesting finding from this research is that there is a greater degree of price stickiness in firm-to-firm relationships than firm to consumer. This suggests that stickiness is more prevalent in producer than in consumer prices. According to the literature, monetary policy should target the sector with relatively stickier prices (see, e.g. Aoki, 2001; Benigno, 2004). This raises the question whether inflation targets should be set in terms of *producer* rather than *consumer* prices. An avenue for further research would be to explicitly model these stylised facts for New Zealand in a DSGE model that explicitly accounts for the two sectors and relative stickiness to investigate the implications for monetary policy.

## 6.2 How do exporters set their prices?

The literature on how exchange rate movements affect domestic prices is vast. That there is a disconnect between the domestic price of internationally traded goods and exchange rate movements is a widespread empirical observation. The causes of that disconnect are less certain, and a number of theories have been advanced. A survey of export pricing behaviour is used to examine the pricing behaviour of firms along two dimensions: the choice over currency of invoice and the choice of whether to differentiate prices across markets.

Contrary to the common assumption in the literature, primary sector firms do differentiate their prices across markets, even when other firm characteristics such as size and productivity are taken into account. Primary sector firms are also more likely to invoice in third-party, or vehicle, currencies. This finding accords with previous research.

The advantage of using a survey is that it also allows consideration of service sector firms, which have been largely ignored in the literature. Trade in services is a sizeable and growing share of exports for advanced economies. Service sector firms appear to differentiate prices in a similar fashion to manufacturers.

As noted in chapter 3, one of the problems associated with surveys is whether respondents act in the way that they report. One avenue for future research would be to take these survey responses and match them to firms within Statistics New Zealand's micro data laboratory. That would enable the matching of survey responses (complete with behavioural drivers unobservable in the price data) with the relevant price data.

## 6.3 What is the role of global inflation factors in driving domestic inflation?

With many goods traded on international markets, it is unsurprising that there is some influence of international prices on domestic prices. Recent research on advanced economies has suggested that these global inflation factors can explain a large share of national inflation variance – perhaps as high as 70 percent. The weakness of the global inflation literature to date is that it has been concentrated on a relatively small number of rich countries. This thesis has widened the scope of the analysis by constructing a consumer price database for 223 countries and territories, using national and international sources.

The wider sample of countries provides contrasting results. That global factors can explain a large share of inflation variance in advanced countries is confirmed, but the result does not generalise for less developed countries. Only a small share of inflation variance in low income countries can be explained by global factors. More generally, higher income per capita, greater financial development and greater central bank transparency are associated with a greater explanatory role for global factors. In terms of sub-components, global factors account for a large share of the variance of food and energy prices, but a smaller share of the variance of other sub-components.

There are a number of avenues for future research that are made possible by the data collected and presented in chapter 4. The persistence of inflation has important implications for the conduct of monetary policy, and the costs of disinflation (see Fuhrer and Moore, 1995). The literature focuses on headline inflation, but the data here provide the ability to extend the literature by determining whether persistence is driven by particular sub-indices. There is also a debate whether persistence has changed (e.g. Cogley and Sargent, 2002; Pivetta and Reis, 2007; Stock and Watson, 2007; Ho et al., 2009). It may be possible to determine structural breaks in headline inflation more accurately using the information contained across sub-indices.

## 6.4 What is the impact of disasters on inflation?

Disasters caused by natural hazards have the potential to cause massive economic disruption. To date, little is known about the impact of these disasters on prices and the analysis here is the first systematic assessment of the impact of disasters on inflation. How prices change following a disaster is clearly of relevance for policymakers when considering how to react in the immediate aftermath, but is also important for *ex ante* planning.

Two databases are combined in the analysis here to determine the impact of disasters on inflation. The findings point to a wide degree of heterogeneity of impact. The impact of disasters on inflation in advanced countries is almost exclusively negligible and insignificant. In developing countries, disasters have the potential to cause lingering periods of inflation several years after the event. There are also differences in impact by type of disaster and by the sub-index. With greater certainty around the impact on prices, it will be possible in future research to consider how monetary policy should react to disasters, one of the main remaining gaps in the literature on disasters.

As noted in chapter 5, the implications of disasters for monetary policy is one of the main lacunae in the literature. The research presented here provides a the first step in understanding those implications. To provide more concrete guidance for monetary policy makers faced with large disasters, future research could construct a general equilibrium model to consider optimal responses, using the results found here.

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