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Keywords: flexible prices, flexible output, marginal costs, Calvo staggered pricing

JEL classification: C80, E31, E32

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Measuring Flexible Prices, Flexible Output and Marginal Costs using Survey Data *

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Abstract

This technical note provides new economic measures of the flexible price level, flexible output level and marginal costs for the UK. Using a straightforward decomposition from first principles this technical note shows that the flexible price level in period t is a weighted average of the period t and $t-1$ price levels - where the weights are determined by the proportion of firms adjusting their price. Similarly, the flexible output level in period t is a weighted average of the period t and $t-1$ output levels - where the weights are determined by the proportion of firms altering their production plans. For the proportion of firms which do not alter their production plans, straightforward calculus shows their change in average costs is proportional to marginal costs. Using a unique dataset (of firm-level survey responses on changes in price and output), this technical note constructs flexible price indices, flexible output indices and marginal cost indices for the UK.

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1 Introduction

This technical note provides new measures of the flexible price level, flexible output level and marginal costs for the UK. Due to the presence of nominal rigidities, firms only infrequently adjust their prices. This prevalence of sticky prices means that in any period the aggregate price level is a weighted average of the flexible price (chosen by adjusting firms) and the previous period's price level (for those firms which do not adjust) - where the weights are determined by the proportion of firms adjusting and not adjusting their price each period (respectively). The same decomposition also holds true for output - output in any period is a weighted average of the flexible level of output (chosen by firms who alter their production plans) and last period's output (where firms leave production plans unaltered). Both of these results are based on a straightforward decomposition from first principles of the aggregate price and output levels. However, they can also be derived from the underlying microfoundations of the standard New Keynesian framework. Furthermore, straightforward calculus shows that for firms that do not alter their production plans, the direction of change in the average cost per unit of output is the same as marginal cost.

These insights are only available if there exists information on the regularity with which firms adjust their prices or alter their production plans. Fischer (1977) and Taylor (1979) assume changes in price are deterministic - being driven by the expiration of multi-period contracts or pre-existing firm commitments. In the Fischer (1977) specification prices are predetermined, with price-setters in period t (which constitute half of all firms) setting prices for $t+1$ and $t+2$. Thus the aggregate price level in t is composed (using equal weight) of prices set in $t-1$ and $t-2$. The Taylor (1979) specification assumes prices are fixed for the duration of the contract - price-setters in period t set a fixed price for t and $t+1$ (assuming the contract lasts for two periods). In contrast to the deterministic nature of price changes in Fischer (1977) and Taylor (1979), Calvo (1983) assumes price changes occur stochastically. Specifically, they follow a Poisson process - meaning individual firms have the same probability of changing prices each period, irrespective of when it last changed prices. As in Taylor (1979), prices remain fixed between adjustments in Calvo (1983). Fischer (1977), Taylor (1979) and Calvo (1983) are time-dependent pricing models - firms only change their prices at designated times (due to the existence of multi-

period contracts or firm commitments) and not based on the economic environment. In contrast, in state-dependent pricing models (such as Caplin and Spulber (1987) and Golosov and Lucas (2007)) firms adopt an Ss price-setting rule. When the difference between the firm's actual and desired price reaches the trigger level s, firms adjust their price (irrespective of when it last adjusted). This adjustment is such that the difference between the firm's actual and desired price equals the target level S. In contrast to time-dependent models, the proportion of price-adjusting firms is not fixed across periods. Empirical evidence on how often firms adjust prices is mixed. For example, Rotemberg and Woodford (1997), Clarida et al. (1999) and Erceg et al. (2000) suggest firms change their prices once a year. Using Bureau of Labour Statistics data, Mark Bils and Klenow (2004) find prices change around every 4.3 months (or 5.5 months if temporary sales are excluded), Klenow and Kryvtsov (2008) find prices change every 4 to 7 months while Nakamura and Steinsson (2008) find (excluding product substitutions) prices last around 8 to 11 months.

Measuring when firms adjust their price and alter their production plans are key components in calculating the flexible price level, flexible output level and marginal costs. This data is typically not available in official datasets or company accounts and existing empirical research does not provide conclusive evidence. However, using a unique dataset of firm-level survey responses (provided by the Confederation of British Industry (CBI)), this technical note has access to a reliable measure of the proportion of firms which adjust their prices and alter their production plans each quarter. Combining, this unique dataset with official statistics (from the Office for National Statistics (ONS)) allows for new and accurate measurement of the flexible price level, flexible output level and marginal costs to be constructed (for more than 90% of UK private sector activity). The remainder of this technical note is ordered as follows: Section 2 shows how a straightforward decomposition from first principles of the aggregate price and output levels is used to define the flexible price index, flexible output index and marginal cost index; Section 3 shows how this decomposition is consistent with the microfoundations of the New Keynesian Model; the data sources are discussed in Section 4 while Section 5 presents the new measures of the flexible price level, flexible output level and marginal costs for the UK. Section 6 concludes.

2 Defining Flexible Prices, Flexible Output and Marginal Costs

2.1 Defining Flexible Prices through Price Index Decompositions

The purpose of this section is to define a flexible price index through a simple decomposition of the aggregate price index. In what follows, it is assumed all firms are of equal size[1] and that price indices are constructed as geometric averages[2]. Note no assumption is made regarding firm behaviour on price setting or market structure. Equation 1 defines the aggregate price index (p_t) as the average of individual firm prices ($p_t(i)$) [3]:

$$p_t = \frac{1}{N_t}\sum_{i=1}^{N_t} p_t(i) \tag{1}$$

where i denotes individual firms and N_t is the total number of firms.

2.1.1 Case One: Flexible Price Index based on the Proportion of Firms who Change Prices

For any period t, Equation 2 shows the aggregate price index is composed of the subset of firms who adjust their price in period t (A_t) and the subset of firms who do not adjust their price in t ($\neg A_t$).

$$\begin{aligned} p_t &= \frac{1}{N_t}\sum_{i\in A_t} p_t(i) + \frac{1}{N_t}\sum_{i\in \neg A_t} p_t(i) \\ &= \frac{1}{N_t} n_{A_t}\overline{p}_t^{A} + \frac{1}{N_t} n_{\neg A_t}\overline{p}_t^{\neg A} \end{aligned} \tag{2}$$

where for period t n_{A_t} is the number of firms who adjust their prices, $\overline{p}_t^{A}$ is the average price of adjusting firms, $n_{\neg A_t}$ is the number of firms who do not adjust their and $\overline{p}_t^{\neg A}$ is the average price of non-adjusting firms. Note that $\frac{1}{N_t} n_{A_t}$ is the proportion of adjusting

[1] This decomposition can be adapted to use weighted averages in place of simple averages, to accommodate firms of different sizes.

[2] Thus, indices are defined by the mean of the log of individual prices.

[3] Throughout, lower case letters denote the log of their uppercase counterpart. For example, $p_t = log(P_t)$, where P_t is the aggregate price level.

firms, while $\frac{1}{N_t} n_{\neg A_t} = 1 - \frac{1}{N_t} n_{A_t}$ is the proportion of non-adjusting firms. Denote these as λ_t^p and $(1 - \lambda_t^p)$, respectively. Assuming firms that do or do not adjust prices are chosen randomly, implies $\overline{p_t}^{\neg A} = p_{t-1}$. Then, $q_t = \overline{p}_t^A$ is the flexible price index. Thus, the (log) aggregate price level (p_t) in period t is a weighted average of firms period t (log) flexible price level and the (log) price level in period $t-1$ - with the weights determined by the proportion of firms adjusting their price in period t, λ_t^p (see Equation 3).

$$p_t = \lambda_t^p q_t + (1 - \lambda_t^p) p_{t-1} \tag{3}$$

Simple manipulation of Equation 3 provides an expression for the (log) flexible price level in period t (Equation 4).

$$q_t = \frac{1}{\lambda_t^p} \left(p_t - (1 - \lambda_t^p) p_{t-1} \right) \tag{4}$$

Thus, the (log) flexible price index is a weighted average of the current (log) price level and last period's (log) price level - with weights determined by the proportion of firms that adjust prices this period. Note that straightforward manipulation of Equation 3 yields Equation 5.

$$\pi_t = \lambda_t^p (q_t - p_{t-1}) \tag{5}$$

where $\pi_t = p_t - p_{t-1}$ is the period t inflation rate. Equation 5 shows that inflation in period t depends on the proportion of firms adjusting from last period's price to their new flexible price in period t.

2.1.2 Case Two: Flexible Price Index based on the Proportion of firms who Change Prices with Indexation

Section 2.1.1 assumed firms either did or did not adjust their prices. An alternative specification is that all firms change their prices - but some only match an aggregate index (through simple indexation), while the others fully adjust their prices. Denote the latter subset as A_t, while the former are denoted $\widetilde{\neg A}_t$. Then, Equation 1 can be rewritten

as Equation 6:

$$\begin{aligned} p_t &= \frac{1}{N_t}\sum_{i\in A_t} p_t(i) + \frac{1}{N_t}\sum_{i\in\widetilde{\neg A}_t} p_t(i) \\ &= \frac{1}{N_t} n_{A_t}\overline{p}_t^{A} + \frac{1}{N_t} n_{\widetilde{\neg A}_t}\overline{p}_t^{\widetilde{\neg A}} \end{aligned} \tag{6}$$

where for period t $\widetilde{\lambda}_t^p = \frac{1}{N_t} n_{A_t}$ is the proportion of firms that *fully* adjust their prices and $(1-\widetilde{\lambda}_t^p) = \frac{1}{N_t} n_{\widetilde{\neg A}_t}$ is the proportion of firms that match their prices to an aggregate index[4].

The relationship between the aggregate price level (p_t) and the flexible price index given indexation (q_t^{index}) now depends on which target aggregate index is used by the indexing firms. For example, if the indexing firms attempt to keep pace with aggregate prices (i.e. $\overline{p}_t^{\widetilde{\neg A}} = p_t$) then Equation 6 reduces to Equation 7

$$p_t = \overline{p}_t^{A} = q_t^{index} \tag{7}$$

and the aggregate price is entirely driven by the firms who do change prices.

Alternatively (and more realistically), following Christiano et al. (2005), let the $(1-\widetilde{\lambda}_t^p)$ of non-adjusting firms index to lagged inflation $(p_{t-1}+\pi_{t-1})$. Note that the $(1-\widetilde{\lambda}_t^p)$ of firms, despite no longer having fixed prices (as in Section 2.1.1), are not adjusting to their flexible price - rather, they are letting it vary as per the inflationary environment[5]. This alteration is designed to account for inflation inertia (the fact that disinflation should be costly, in terms of output) by giving a role to past inflation in price setting behaviour[6]. Then, the aggregate price index can be written as Equation 8.

$$p_t = \widetilde{\lambda}_t^p q_t^{index} + (1-\widetilde{\lambda}_t^p)(p_{t-1}+\pi_{t-1}) \tag{8}$$

Solving Equation 8 for q_t^{index} yields Equation 9, which shows the (log) flexible price now

[4]Note in this context, a firm-level survey question asking whether a firm changed it's price in period t is interpreted as asking if the firm changed their price *relative to the indexed value* and gives a measure of $\widetilde{\lambda}_t^p$.

[5]By indexing to lagged (rather than contemporaneous) inflation, this implies firms' information set is not continually updated.

[6]Note that in contrast to Christiano et al. (2005) the proportion of firms that adjust their prices is not assumed constant.

also depends on last period's inflation - as well as the current and lagged (log) price levels (as in Equation 4).

$$q_t^{index} = \frac{1}{\widetilde{\lambda}_t^p}\left(p_t - (1-\widetilde{\lambda}_t^p)(p_{t-1}+\pi_{t-1})\right) \tag{9}$$

2.1.3 Case Three: Flexible Price Index based on Industry Characteristics

Consider Equation 10, which decomposes the aggregate price index p_t (Equation 1) into two sectors:

$$\begin{aligned} p_t &= \frac{1}{N_t}\sum_{i\in F} p_t(i) + \frac{1}{N_t}\sum_{i\in S} p_t(i) \\ &= \omega_t^F \overline{p}_t^F + \omega_t^S \overline{p}_t^S \end{aligned} \tag{10}$$

where sector F consists mainly of firms that do adjust prices, sector S consists mainly of firms that do not adjust prices, $\omega_t^F = \frac{n_{Ft}}{N_t}$ the weight of sector F, $\omega_t^S = \frac{n_{St}}{N_t}$ the weight of sector S, $\overline{p}_t^F$ is the average price of sector F firms and $\overline{p}_t^S$ is the average price of sector S firms. Using the decomposition of Equation 2 and Equation 3, Equation 10 can be rewritten as Equation 11.

$$\begin{aligned} p_t = \omega_t^F &\left(\lambda_t^F \overline{p}_t^{F,A} + (1-\lambda_t^F)\overline{p}_t^{F,\neg A}\right) \\ &+ \omega_t^S \left(\lambda_t^S \overline{p}_t^{S,A} + (1-\lambda_t^S)\overline{p}_t^{S,\neg A}\right) \end{aligned} \tag{11}$$

Note by definition $\lambda_t^F \approx 1$ and $\lambda_t^S \approx 0$. Also the fraction of firms that change in the economy as a whole is $\lambda_t^p \approx \omega_t^F$ - and no additional information on who changes prices is needed as this is given by the size of sector F. Thus, Equation 11 collapses and the flexible price index (q_t^{class}) is defined as the average price of firms in the mainly-changing sector ($\overline{p}_t^F$) - see Equation 12.

$$q_t^{class} = \overline{p}_t^F \tag{12}$$

2.2 Defining Flexible Output and Marginal Costs through an Output Index Decomposition

Equation 13 defines the aggregate output index (y_t) as the average of individual firm output ($y_t(i)$) [7].

$$y_t = \frac{1}{N_t} \sum_{i=1}^{N_t} y_t(i) \tag{13}$$

The decomposition from first principles utilised to derive Equation 3 from Equation 1 can also be applied to Equation 13 to derive Equation 14.

$$y_t = \lambda_t^y x_t + (1 - \lambda_t^y) y_{t-1} \tag{14}$$

where y_t is the (log) aggregate output level in period t, λ_t^y is the proportion of firms that alter output in period t, $(1 - \lambda_t^y)$ are the proportion of firms that leave output unchanged from period $t-1$ and x_t is the (log) flexible level of output (chosen by firms which alter their production plans). Equation 14 shows the (log) aggregate output level in period t is a weighted average of firms period t (log) flexible output level and the (log) output level in period $t-1$ - with the weights determined by the proportion of firms altering their production plans in period t (λ_t^y). Simple manipulation of Equation 14 provides an expression for the (log) flexible output level in period t (Equation 15).

$$x_t = \frac{1}{\lambda_t^y} \left(y_t - (1 - \lambda_t^y) y_{t-1} \right) \tag{15}$$

Thus, the (log) flexible output index is a weighted average of the current (log) output level and last period's (log) output level - with weights determined by the proportion of firms that alter output this period.

The $(1 - \lambda_t^y)$ proportion of firms that leave output unchanged from period $t-1$, provide a valuable insight into marginal costs (ϕ_t). Consider Equation 16, which shows (with no assumptions regarding functional form) that in any period t the average cost of production (AC_t) is the total cost of production (TC_t) divided by the quantity produced (Y_t) - where

[7] As in Section 2.1 it is assumed all firms are of equal size, output indices are constructed as geometric averages and no assumption is made regarding firm behaviour on price setting or market structure.

total costs consist of fixed (FC_t) and variable (VC_t) costs.

$$AC_t = \frac{TC_t}{Y_t} = \frac{FC_t + VC_t}{Y_t} \tag{16}$$

Totally differentiating Equation 16 yields Equation 17.

$$\Delta AC_t = \frac{1}{Y_t}\Delta FC_t + \frac{1}{Y_t}\Delta VC_t - \frac{1}{Y_t^2}(FC_t + VC_t)\Delta Y_t \tag{17}$$

where $\Delta Z_t = Z_t - Z_{t-1}$, for $Z_t \in \{FC_t, VC_t, Y_t\}$. For the $(1 - \lambda_t^y)$ of firms that do not alter production plans, $\Delta Y_t = 0$ - meaning the final term in Equation 17 disappears. Furthermore, given no change in production it is very unlikely that fixed costs can dramatically change - implying $\Delta FC_t = 0$ in Equation 17. Thus, for firms which do not alter their output between period t and $t-1$ the relation in Equation 18 holds true.

$$\Delta AC_t\big|_{\Delta Y_t=0} = \frac{1}{Y_t}\Delta VC_t \propto \phi_t \tag{18}$$

where ϕ_t are marginal costs in period t. The first relation in Equation 18 states that for firms which do not alter their output between period t and $t-1$ ($\Delta Y_t = 0$), changes in average cost ($\Delta AC_t\big|_{\Delta Y_t=0}$) approximate changes in variable cost (ΔVC_t). The second relation of Equation 18 states that changes in variable cost (ΔVC_t) are proportionate to marginal costs (ϕ_t) - since output remains unchanged between $t-1$ and t. Intuitively, if firms are facing higher (lower) average cost without changing their output quantities, then they must be facing increased (decreased) marginal costs. When output remains unchanged, increased (decreased) average costs imply increased (decreased) marginal costs. Thus, Equation 18 shows the direction of change in the average cost is the same as marginal cost. Then, given qualitative data on average costs per unit of output (where firms only specify if average costs went "up" or "down"), marginal cost is defined using the balance statistic (Equation 19).

$$\phi_t = \frac{\Delta AC_t^+\big|_{\Delta Y_t=0}}{\Delta AC_t\big|_{\Delta Y_t=0}} - \frac{\Delta AC_t^-\big|_{\Delta Y_t=0}}{\Delta AC_t\big|_{\Delta Y_t=0}} \tag{19}$$

where in period t $\frac{\Delta AC_t^+\big|_{\Delta Y_t=0}}{\Delta AC_t\big|_{\Delta Y_t=0}}$ is the proportion of firms reporting their average costs per

unit of output went "up" and $\frac{\Delta AC_t^- \big|_{\Delta Y_t=0}}{\Delta AC_t \big|_{\Delta Y_t=0}}$ is the proportion of firms reporting their average costs per unit of output went "down".

3 Linking the Decomposition with Microfoundations

The decomposition from first principles in Section 2.1 and Section 2.2 made no assumptions regarding firm behaviour on price setting or market structure. However, the key outcomes from this decomposition exercise (Equation 4, Equation 9 and Equation 15) are consistent with the microfoundations of price-setting firms in a monopolistically competitive market. This section will demonstrate this with respect to Equation 4 - but the methodology can straightforwardly be applied to Equation 9 or Equation 15. This setup follows Blanchard and Kiyotaki (1987), Woodford (1996), Yun (1996), Rotemberg and Woodford (1997) and Chari et al. (2000) - with the models in Caballero and Engel (1993), Galı and Gertler (1999), Aoki (2001), Mankiw and Reis (2002), Christiano et al. (2005), Bakhshi et al. (2007) also based on this setup.

The economy is populated with infinitely lived households, firms and government. There exists a continuum of monopolistically competitive, intermediate goods firms (indexed $i \in [0, 1]$) that each produce a single differentiated good (of which it is the only producer[8]) - resulting in a continuum of differentiated goods ($Y_t(i)$). Household utility and firm investment depend on the single final good (Y_t) - produced by final goods firms by aggregating the intermediate (differentiated goods), which are sold to households at price P_t. Following Dixit and Stiglitz (1977) aggregate output is defined by the Constant Elasticity of Substitution (CES) aggregator in Equation 20:

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{20}$$

where $\varepsilon > 1$ is the constant elasticity of substitution among the intermediate goods, $Y_t(i)$ is the demand for good i and $P_t(i)$ is the price of good i set by firm i.

[8]Thus good produced by firm i is also denoted by i.

3.1 The Final Goods Firm Maximisation Problem

Equation 21 defines the *final* goods firms maximisation problem, subject to the constraint in Equation 20.

$$maxP_tY_t - \int_0^1 P_t(i)Y_t(i)di \tag{21}$$

Note the intermediate goods firm maximisation problem (Equation 21) can be rewritten as Equation 22.

$$maxP_t \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} - \int_0^1 P_t(i)Y_t(i)di \tag{22}$$

where the constraint (Equation 20) is substituted directly into the maximisation problem. Differentiating with respect to $Y_t(i)$ yields:

$$P_t(i) = P_t \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{1}{\varepsilon-1}} Y_t(i)^{-\frac{1}{\varepsilon}} \tag{23}$$

This also holds true for good j:

$$P_t(j) = P_t \left(\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{1}{\varepsilon-1}} Y_t(j)^{-\frac{1}{\varepsilon}} \tag{24}$$

Then:

$$\frac{P_t(i)}{P_t(j)} = \frac{P_t(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di)^{\frac{1}{\varepsilon-1}} Y_t(i)^{-\frac{1}{\varepsilon}}}{P_t(\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj)^{\frac{1}{\varepsilon-1}} Y_t(j)^{-\frac{1}{\varepsilon}}} \tag{25}$$

which can be rewritten as Equation 26:

$$P_t Y_t^{\frac{1}{\varepsilon}} Y_t(j)^{-\frac{1}{\varepsilon}} P_t(i) = P_t Y_t^{\frac{1}{\varepsilon}} Y_t(i)^{-\frac{1}{\varepsilon}} P_t(j) \tag{26}$$

by noting that Equation 20 can be rewritten as:

$$Y_t^{\frac{1}{\varepsilon}} = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{1}{\varepsilon-1}} \tag{27}$$

Multiply the LHS and RHS of Equation 26 by $Y_t(j)Y_t(i)^{\frac{1}{\varepsilon}}$, integrate out good j and note that Equation 20 can be rewritten as:

$$Y_t^{\frac{\varepsilon-1}{\varepsilon}} = \int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \tag{28}$$

to obtain Equation 29:

$$\int_0^1 P_t(j)Y_t(j)dj = P_t(i)Y_t(i)^{\frac{1}{\varepsilon}}Y_t^{\frac{-1}{\varepsilon}} \tag{29}$$

To remove the integral from Equation 29, first note that:

$$\begin{aligned}
\int_0^1 P_t(j)Y_t(j)dj &= \int_0^1 P_t\left(\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}}di\right)^{\frac{1}{\varepsilon-1}} Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}}dj \\
&= \int_0^1 P_t Y_t^{\frac{1}{\varepsilon}} Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}}dj \\
&= P_t Y_t^{\frac{1}{\varepsilon}} \int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}}dj \\
&= P_t Y_t^{\frac{1}{\varepsilon}} Y_t^{\frac{\varepsilon-1}{\varepsilon}} \\
&= P_t Y_t
\end{aligned} \tag{30}$$

Substituting into Equation 29 yields Equation 31:

$$P_t Y_t = P_t(i)Y_t(i)^{\frac{1}{\varepsilon}}Y_t^{\frac{\varepsilon-1}{\varepsilon}} \tag{31}$$

Multiplying the LHS and RHS of Equation 31 by $Y_t^{\frac{1-\varepsilon}{\varepsilon}}$, then take LHS and RHS to the power ε and a small minor algebraic manipulation yields Equation 32 - the solution to the intermediate goods firms maximisation problem, which defines the demand of good i, $Y_t(i)$.

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} Y_t \tag{32}$$

To derive the aggregate price level, recall that:

$$P_t Y_t = \int_0^1 P_t(i)Y_t(i)di \tag{33}$$

Substituting in Equation 32, this becomes:

$$\int_0^1 P_t(i)\left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} Y_t di = P_t^{\varepsilon} Y_t \int_0^1 P_t(i)P_t(i)^{-\varepsilon}di \tag{34}$$

Minor algebraic adjustment yields Equation 35 - which defines the aggregate price level, P_t.

$$P_t = \left(\int_0^1 P_t(i)^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}} \tag{35}$$

3.2 Intermediate Goods Firms Staggered Price Setting

In any time period t, $\lambda_t^p \in [0,1]$ denotes the proportion of firms that adjust their period $t-1$ price, while due to the presence of nominal rigidities $(1-\lambda_t^p)$ of firms do not adjust prices in period t - they stick with their $t-1$ price. Note that $\lambda_t^p = 1$ when there is complete price flexibility, while $\lambda_t^p = 0$ indicates complete price rigidity. Thus, $\lambda_t^p(1 + \sum_{k=1}^{\infty} \prod_{j=1}^{k}(1-\lambda_{t+j})(k+1))$ is the average duration of the price[9], while $\prod_{j=1}^{k}(1-\lambda_{t+j})$ is the (in expectation) probability firm i will not change price until period k [10]. This is based on the Calvo (1983) staggered price setting framework. However, Calvo (1983) and studies utilising the Calvo setup - Kimball (1995), Roberts (1995), Yun (1996), Clarida et al. (1999), Galı and Gertler (1999), Aoki (2001), Mankiw and Reis (2002), Christiano et al. (2005), Bakhshi et al. (2007), Dupor et al. (2010) and Coibion et al. (2018) to name a few - assume the proportion of firms which adjust prices each period is fixed (i.e. they use λ^p). In contrast, this technical note allows the proportion of adjusting firms to vary from period to period (i.e. λ_t^p is used).

Due to the staggered price setting behaviour of *intermediate* goods firms, the aggregate price level in period t (P_t) consists of the subset of flexible prices chosen by adjusting firms and the subset of old prices chosen by non-adjusting firms. Let $Q_t(i)$ be the flexible price chosen by adjusting firm i (and $P_{t-1}(i)$ the price of non-adjusting firm i). Since all *intermediate* goods firms face the same maximisation problem they set the same flexible

[9] In t λ_t^p of firms reset their prices. In $t+1$ $(1-\lambda_{t+1})$ of firms do not adjust, of which λ_t^p changed their price in t $(\lambda_t^p(1-\lambda_{t+1})$. In $t+2$ $(1-\lambda_{t+2})$ of firms do not adjust, of which $\lambda_t^p(1-lambda_{t+1})$ have not changed their price since t $(\lambda_t^p(1-\lambda_{t+1})(1-\lambda_{t+2})$ of firms in $t+2$ have not changed price since $t)$. In $t+k$ $(1-\lambda_{t+k})$ of firms do not adjust, of which $\lambda_t^p(1-\lambda_{t+1})...(1-\lambda_{t+k-1})$ have not changed their price since t $(\lambda_t^p(1-\lambda_{t+1})(1-\lambda_{t+2})...(1-\lambda_{t+k-1})(1-\lambda_{t+k})$ of firms in $t+k$ have not changed price since $t)$.

[10] Suppose firm changes price in t. The probability the firm doesn't change price in $t+1$ is $(1-\lambda_{t+1})$, the probability the firm doesn't change price in $t+2$ is $(1-\lambda_{t+2})$,..., the probability the firm doesn't change price in $t+k$ is $(1-\lambda_{t+k})$. Let $\mathbb{P}(x)$ denote the probability that event x occurs. Thus, $\mathbb{P}$(firm doesn't change price until$t+k)$ = $\mathbb{P}$(firm doesn't change price in$t+1)\mathbb{P}$(firm doesn't change price in$t+2)$...$\mathbb{P}$(firm doesn't change price in$t+k) = (1-\lambda_{t+1})(1-\lambda_{t+2})...(1-\lambda_{t+k}) = \prod_{j=1}^{k}(1-\lambda_{t+j})$.

price when adjusting their price - so $Q_t(i) = Q_t$ [11]. In addition, the non-adjusting price index equates to the lagged price level, by the law of large numbers. Let $A(t) \subseteq [0,1]$ be the set of firms changing prices and $\neg A(t) \subseteq [0,1]$ be the set of firms keeping prices unchanged in period t. Then Equation 35 can be rewritten as Equation 36.

$$P_t = \left(\int_{A(t)} Q_t(i)^{1-\varepsilon} di + \int_{\neg A(t)} P_{t-1}(i)^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}} \tag{36}$$

Note the aggregate price level (Equation 35) can be rewritten as:

$$P_t^{1-\varepsilon} = \left(\int_0^1 P_t(i)^{1-\varepsilon} di \right) \tag{37}$$

Combining this with Equation 36 yields:

$$P_t = (\lambda_t^p Q_t^{1-\varepsilon} + (1-\lambda_t^p) P_{t-1}^{1-\varepsilon})^{\frac{1}{1-\varepsilon}} \tag{38}$$

Taking the LHS and RHS to the power $(1-\varepsilon)$ yields Equation 39.

$$P_t^{1-\varepsilon} = \lambda_t^p Q_t^{1-\varepsilon} + (1-\lambda_t^p) P_{t-1}^{1-\varepsilon} \tag{39}$$

Equation 39 is a Constant Elasticity of Substitution (CES) price index. Note if $\varepsilon = 0$ then Equation 39 becomes a Laspeyres index.

Divide LHS and RHS of Equation 39 by $P_{t-1}^{1-\varepsilon}$ to obtain Equation 40.

$$\left(\frac{P_t}{P_{t-1}} \right)^{1-\varepsilon} = \lambda_t^p \left(\frac{Q_t}{P_{t-1}} \right)^{1-\varepsilon} + (1-\lambda_t^p) \tag{40}$$

[11] Note if it is assumed, since firms only infrequently adjust their prices, that when they do get the opportunity to adjust they choose their optimal price, then Q_t is also the optimal price level.

Log-linearising Equation 40 around the zero-inflation steady-state[12] yields:

$$\begin{aligned}\Pi^{1-\varepsilon} + (1-\varepsilon)\Pi^{-\varepsilon}(\Pi)(log(\Pi_t) - log(\Pi)) = ((1-\lambda_t^p) + \lambda_t^p(\frac{Q}{P})^{1-\varepsilon}) \\ + (1-\varepsilon)(\lambda_t^p)(\frac{Q}{P})^{-\varepsilon}\frac{1}{P}Q(log(Q_t) - log(Q)) \\ - (1-\varepsilon)(\lambda_t^p)(\frac{Q}{P})^{-\varepsilon}\frac{Q}{P^2}P(log(P_{t-1}) - log(P))\end{aligned} \tag{41}$$

Collection of like terms and cleaning yields Equation 42 - which is the same as Equation 5, thus yielding the same specification for q_t as Equation 4.

$$\pi_t = \lambda_t^p(q_t - p_{t-1}) \tag{42}$$

4 Data

As stated in the introduction, there are two primary data sources for this technical note - the CBI suite of business surveys (for the proportion of firms that adjust prices (λ_t^p) and alter output (λ_t^y) in period t and the directional change of average cost for firms which do not alter their output $\Delta AC_t\big|_{\Delta Y_t=0}$) and the ONS (for the aggregate price level, p_t and p_{t-1}, and aggregate output level, y_t and y_{t-1}).

4.1 The Confederation of British Industry (CBI) Dataset

4.1.1 A Brief Overview of the Survey Suite

A full in-depth discussion of the CBI suite of business surveys is found in Lee et al. (2020). What follows is based on this discussion paper. The CBI dataset consists of firm-level survey responses to the CBI Industrial Trends Survey (ITS), the Distributive Trades Survey (DTS) and the Services Sector Survey (SSS)[13] which cover the manufacturing, service and distributive trades sectors (respectively). Specifically, the ITS primarily covers grouped SIC07 level C (manufacturing), but also contains responses from SIC07 B (mining and quarrying)[14]; the DTS covers solely grouped SIC07 level G (wholesale and retail trade;

[12]Let $\Pi_t = \frac{P_t}{P_{t-1}}$. Then, in the zero-inflation steady-state $\Pi_t = 1$ which implies $P_t = P_{t-1} = Q_t \forall t$. Zero-inflation steady-state denoted by no subscripts.

[13]The CBI also conducts the Financial Services Survey (FSS) - however this is excluded from this study as the sample of firms surveyed is smaller than the others.

[14]Note the ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33.

repair of motor vehicles and motorcycles) while the SSS covers grouped SIC07 levels H to S (excluding K (financial and insurance activities) which is covered in the FSS)[15]. Note that the ITS and SSS primarily use old SIC07 classifications - see Appendix A for details on how these are converted to SIC07. Minor cleaning of the survey suite is discussed in Appendix B.

The ITS (the oldest survey) has been running since 1958 while the youngest survey (the SSS) started in 1998. These industrial sectors constitute more than 90% of UK private sector activity. Participation in survey waves is voluntary (not limited by CBI membership). While each survey is conducted monthly, once a quarter the CBI also conducts an *enhanced* survey with additional questions (from both the CBI and the Bank of England). Collection for the survey published in month t begins around the final week of month $t-1$ with publication of results around the final week of month t.

4.1.2 Sample Frame

Firm-level price realisations are collected once a quarter via the supplement CBI questions in the *enhanced* ITS, SSS and DTS. While output realisations are measured monthly, to maintain consistency with the price realisation series only the quarterly returns are utilised. Average cost realisation data is also only available once a quarter, and only for manufacturing firms (i.e. it is taken from the enhanced ITS). Question 12a, 5a and 6a of the enhanced ITS, SSS and DTS (respectively) ask firms whether their selling price went up, stayed the same or went down over the past three months. Question 8, 3a and 2a of the enhanced ITS, SSS and DTS (respectively) asks the equivalent question regarding output[16], while question 11 of the enhanced ITS refers to average costs per unit of output[17]. Data on firm level price and output realisations in the CBI dataset is available from

[15]Note while the SSS (in theory) covers SIC07 H to S, in practice there are only responses for firms in SIC07 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96.

[16]Output refers to production in the ITS, volume of business in the SSS and volume of sales in the DTS

[17]The exact wording of the enhanced ITS question 12a/8/11 is: "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to average selling prices at which domestic orders (sales) are booked/volume of output (i.e. production)/average costs per unit of output". The exact wording of the enhanced SSS question 5a/3a is: "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months with regard to average selling prices/volume of business". The exact wording of the enhanced DTS question 6a/2a is: "how have your average selling prices/volume of sales for the past three months changed and what do you expect to occur in the next three months".

2000Q1, 2005Q4 and 2003Q4 for the manufacturing, service and distributive trades sectors (respectively)[18]. Realised average cost per unit of output data in the ITS is available from 2000Q1 onwards. Note that based on the argument outlined in Appendix C the total manufacturing sector can be split into two groups: primary manufacturing (mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors)[19] and secondary manufacturing (food, clothing, chemicals, computers, electrical equipment and transport equipment)[20].

The sample size (i.e. number of firm responses) each quarter for the total manufacturing, primary manufacturing, secondary manufacturing, service and distributive trades sectors are plotted in Figure 1a to Figure 1c. Evidently total manufacturing has the largest sample size - even with the continuous decline in survey responses since the end of 2001, the ITS still exhibits a strong survey completion record. The sample sizes of primary and secondary manufacturing are also both substantial, exhibiting a similar pattern to the total manufacturing sample size time path. While neither the SSS nor the DTS have as many survey respondents as the ITS (with the exception of the COVID-19 pandemic), the sample size for the services sector only falls below 100 after 2020, while the distributive trades sample size only falls below 100 responses per quarter during 2019[21]. Furthermore, there is a notable increase in the services and distributive trades sample size during the onset of the COVID-19 pandemic - a trend particularly noticeable in the former.

4.1.3 Measuring when Firms Change Prices

Figure 2a to Figure 2c depict λ^p and λ_t^p for the total manufacturing, primary manufacturing, secondary manufacturing, services and distributive trades sectors[22]. Table 1 presents the corresponding summary statistics.

[18]The enhanced SSS dataset is unavailable prior to 2005Q4. While data for the enhanced DTS is available from 2000Q1, question 6a on price realisations and question 2a on output realisations were only added to the survey from 2003Q4 onwards.

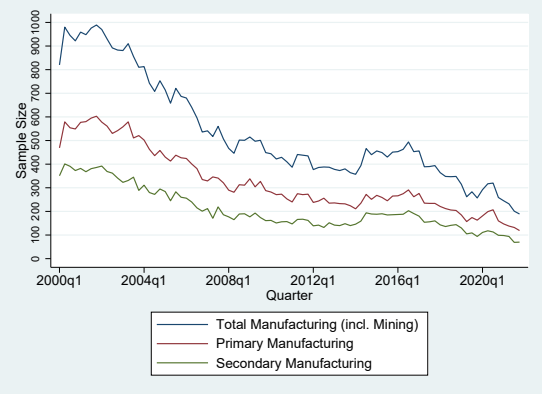
[19]Grouped SIC07 levels B, CC, CD, CG, CH CK and CM.

[20]Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL

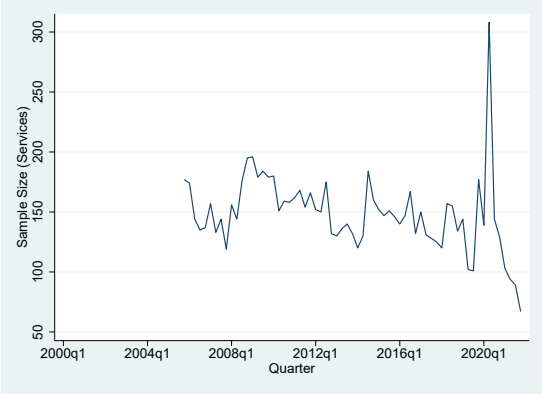
[21]Figure 1b only depicts the sample size based on firms which provided their industrial classification - which constitutes around 84% of total respondents to the enhanced SSS.

[22]Note λ_t^p for the total manufacturing, primary manufacturing, secondary manufacturing and services sectors is calculated as a weighted average of $\lambda_t^p(j)$, where j are the contributing two-digit SIC07 levels that compose the relevant aggregate industrial sector and are also recorded in the ITS or SSS. The weights used are the same weights used by the ONS to create aggregate price levels. See Appendix D for comparison between weighted and unweighted series.

Figure 1: Sample Size in Each Industrial Sector



(a) Manufacturing Sector



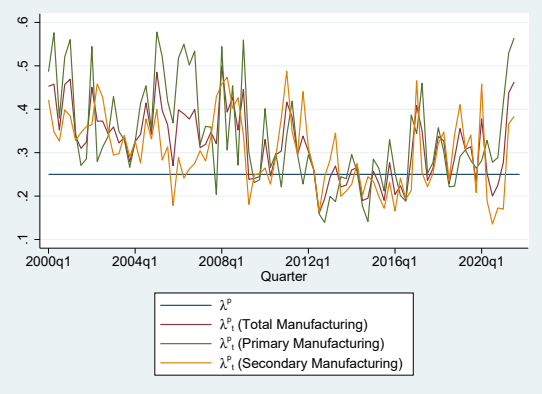
(b) Services Sector

(c) Distributive Trades Sector

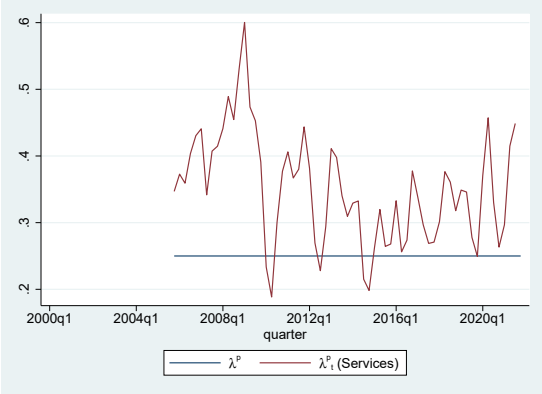
Note: Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM), and secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Total manufacturing is the sum of primary and secondary manufacturing. Data from the manufacturing sector is taken from the enhanced Industrial Trends Survey (ITS). Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. Services is grouped SIC07 H to S, with data taken from the enhanced Services Sector Survey (SSS). Note the enhanced SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96. Distributive trades is grouped SIC07 G, with data taken from the enhanced Distributive Trades Survey (DTS). Firm survey responses are available from 2000Q1, 2005Q4 and 2003Q4 for the ITS, SSS and DTS (respectively).

For total manufacturing, primary manufacturing and secondary manufacturing λ_t^p is calculated using the proportion of firms which answered "up" or "down" (i.e. they adjusted their price) in the price realisation question in the ITS survey wave $t+1$. This reflects the timing of the ITS - firms are asked starting during the last week of quarter t and continuing into the early weeks of quarter $t+1$, their price realisation for the previous three months (which corresponds to quarter t). While the enhanced SSS and DTS are conducted once a quarter, they do not correspond to calendar quarters - and are instead conducted in the middle of each quarter. Thus, survey wave τ covers the first month of quarter t and the last two months of quarter $t-1$. Accordingly, for the services and

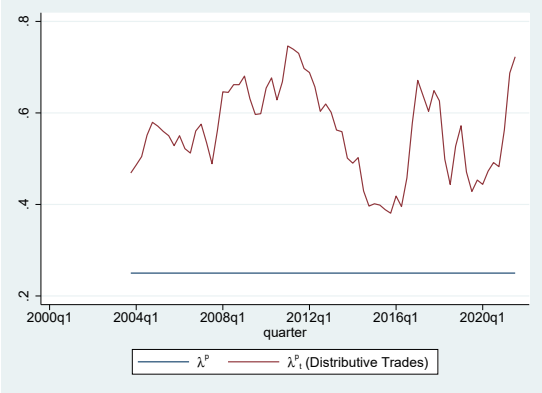
Figure 2: Proportion of Firms Adjusting Prices Each Quarter (λ_t^p)



(a) Manufacturing Sector



(b) Services Sector



(c) Distributive Trades Sector

Note: λ^p assumes a fixed proportion of firms change prices each quarter (set at 0.25 on the assumption that firms change prices once a year). λ_t^p (Total Manufacturing) is the time-varying proportion of total manufacturing firms changing prices each quarter. λ_t^p (Primary Manufacturing) is the time-varying proportion of primary manufacturing firms changing prices each quarter. λ_t^p (Secondary Manufacturing) is the time-varying proportion of secondary manufacturing firms changing prices each quarter. λ_t^p (Services) is the time-varying proportion of services firms changing prices each quarter. λ_t^p (Distributive Trades) is the time-varying proportion of distributive trades firms changing prices each quarter. Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM). and secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Total manufacturing is the sum of primary and secondary manufacturing. Data measuring when manufacturing firms change prices is taken from the enhanced Industrial Trends Survey (ITS), where question 12a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to average selling prices at which domestic orders (sales) are booked". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. Services is grouped SIC07 H to S. Data measuring when services firms change prices is taken from the enhanced Services Sector Survey (SSS), where question 5a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months with regard to average selling prices". Note the enhanced SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96. Distributive trades is grouped SIC07 G. Data measuring when distributive trades firms change prices is taken from the enhanced Distributive Trades Survey (DTS), where question 6a asks "how have your volume of sales for the past three months changed and what do you expect to occur in the next three months". Firm survey responses are available from 2000Q1, 2005Q4 and 2003Q4 for the ITS, SSS and DTS (respectively).

distributive trades sector λ_t^p is calculated as the weighted proportion of firms which answered "up" or "down" (i.e. they adjusted their price) in the price realisation question in the SSS or DTS survey waves τ and $\tau + 1$ (respectively). The weights used to construct λ_t^p are, following Bachmann and Elstner (2015), determined by the number of months

Table 1: λ_t^p Summary Statistics

	(1) Mean	(2) Standard Deviation	(3) Minimum	(4) Maximum
λ^p	0.25	0.00	0.25	0.25
λ_t^p (Total Manufacturing)	0.33	0.08	0.16	0.50
λ_t^p (Primary Manufacturing)	0.35	0.12	0.14	0.58
λ_t^p (Secondary Manufacturing)	0.31	0.08	0.14	0.49
λ_t^p (Services)	0.35	0.08	0.19	0.60
λ_t^p (Distributive Trades)	0.56	0.09	0.38	0.75

Note: λ_t^p is the proportion of firms which adjust their price each quarter. λ^p is a constant set at 0.25 - based on the assumption firms adjust their price once a year. Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e. grouped SIC07 levels B, CC, CD, CG, CH CK and CM). Secondary manufacturing is secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. Services is grouped SIC07 levels H to S. Note the enhanced SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96. Distributive trades is grouped SIC07 level G.

each survey wave covers. Specifically, let Λ_τ^p be the proportion of firms in survey wave τ that changed their prices during $\tau - 1$. Then for calendar quarter t the survey waves of interest are τ and $\tau + 1$. Thus, $\lambda_t^p = \frac{1}{3}\Lambda_\tau^p + \frac{2}{3}\Lambda_{\tau+1}^p$. For each industrial sector, λ^p is set at 0.25 (following standard practice in the literature)[23].

In each industrial sector it is clear the assumption of a fixed λ^p at 0.25 is not consistent with actual firm behaviour - especially in distributive trades. In fact, the average value of λ_t^p in each sector is at least 0.31. On average secondary manufacturing firms changes prices the least, while distributive trade firms change prices the most. In contrast to expected (see, for example Klenow and Malin (2010)), firms in the service sector do not adjust their prices less frequently than manufacturing firms. On average, they adjust prices as frequently as primary manufacturing firms - although service firms adjusted prices more frequently between 2007 and 2010. Note that for each industrial aggregate, there is a notable decrease in the number of firms adjusting their prices between 2012 and 2016. In fact, this is the only period for each of the manufacturing aggregates that λ_t^p is consistently below 0.25 - and again, firms in the service sector continue to adjust prices more frequently during this period. Despite this large drop, there is still a substantial proportion of adjusting firms in the distributive trades sector (0.38). For both the primary and secondary manufacturing sectors, λ_t^p broadly follows the same time-path as for total manufacturing. For example λ_t^p (Total Manufacturing) has a correlation of 0.86 with λ_t^p (Primary Manufacturing) and 0.74 with λ_t^p (Secondary Manufacturing) - although the correlation between λ_t^p (Primary Manufacturing) and λ_t^p (Secondary Manufacturing) is

[23]This is based on the assumption, that with quarterly data, firms change their prices once a year.

not as strong (0.29).

4.1.4 Measuring when Firms Change Output

Figure 3a to Figure 3c depict λ_t^y for the total manufacturing, primary manufacturing, secondary manufacturing, services and distributive trades sectors. Calculation of λ_t^y is the same as λ_t^p for each industrial sector[24]. Table 2 presents the corresponding summary statistics.

Table 2: λ_t^y Summary Statistics

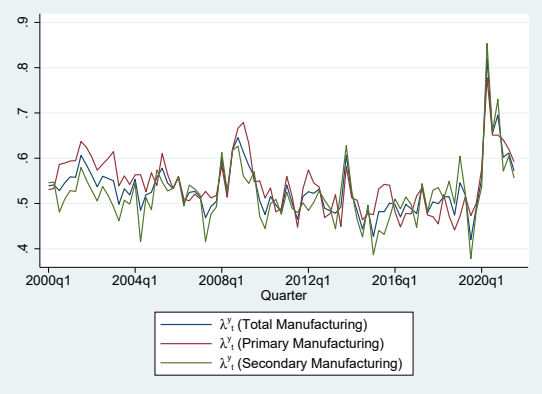
	(1) Mean	(2) Standard Deviation	(3) Minimum	(4) Maximum
λ_t^y (Total Manufacturing)	0.53	0.05	0.42	0.82
λ_t^y (Primary Manufacturing)	0.55	0.06	0.44	0.78
λ_t^y (Secondary Manufacturing)	0.52	0.06	0.38	0.85
λ_t^y (Services)	0.52	0.14	0.21	0.83
λ_t^y (Distributive Trades)	0.76	0.05	0.68	0.90

Note: λ_t^y is the proportion of firms which alter their output each quarter. Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e. grouped SIC07 levels B, CC, CD, CG, CH CK and CM). Secondary manufacturing is secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. Services is grouped SIC07 levels H to S. Note the enhanced SSS only has firms responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96. Distributive trades is grouped SIC07 level G.

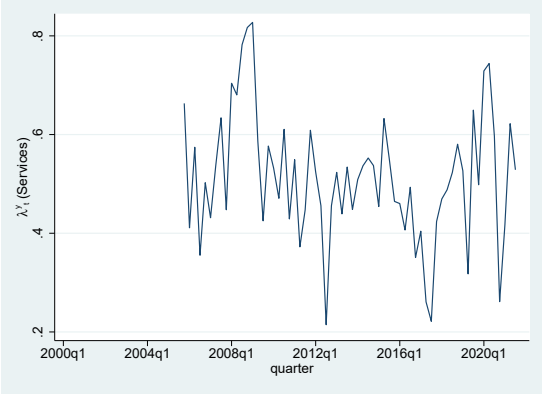
On average, at least half of firms in each industrial aggregate alter their output each quarter (however this figure jumps to 76% for distributive trades firms alone), while the services sector exhibits the greatest volatility. Both 2008 and 2020 (corresponding to significant changes in the economic environment) see large increases in the proportion of firms altering their output - with the alterations being greater in 2020 for the manufacturing and distributive trade sectors. For the $(1-\lambda_t^y)$ of firms in the total manufacturing, primary manufacturing and secondary manufacturing sectors that do not alter their production plans, Figure 4 depicts the proportion of firms that stated their period t average cost per unit of output went "up" or went "down". The time-path of the proportion of firms which state their average costs per unit of output went "up" is broadly the same for each manufacturing aggregate - in fact, the correlation of AC (up, Total Manufacturing) with AC (up, Primary Manufacturing) and AC (up, Secondary Manufacturing) is 0.98 and 0.96 (respectively). The same is also true for firms which report their average costs per unit of output went "down" - with a correlation of 0.95 between AC (up, Total

[24]See Section 4.1.3 for discussion on weights and timing of surveys.

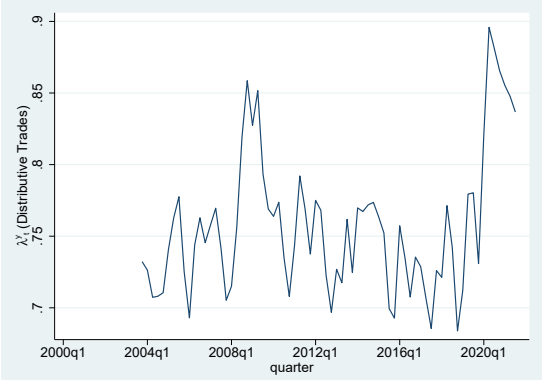
Figure 3: Proportion of Firms Altering Output Each Quarter (λ_t^y)



(a) Manufacturing Sector



(b) Services Sector

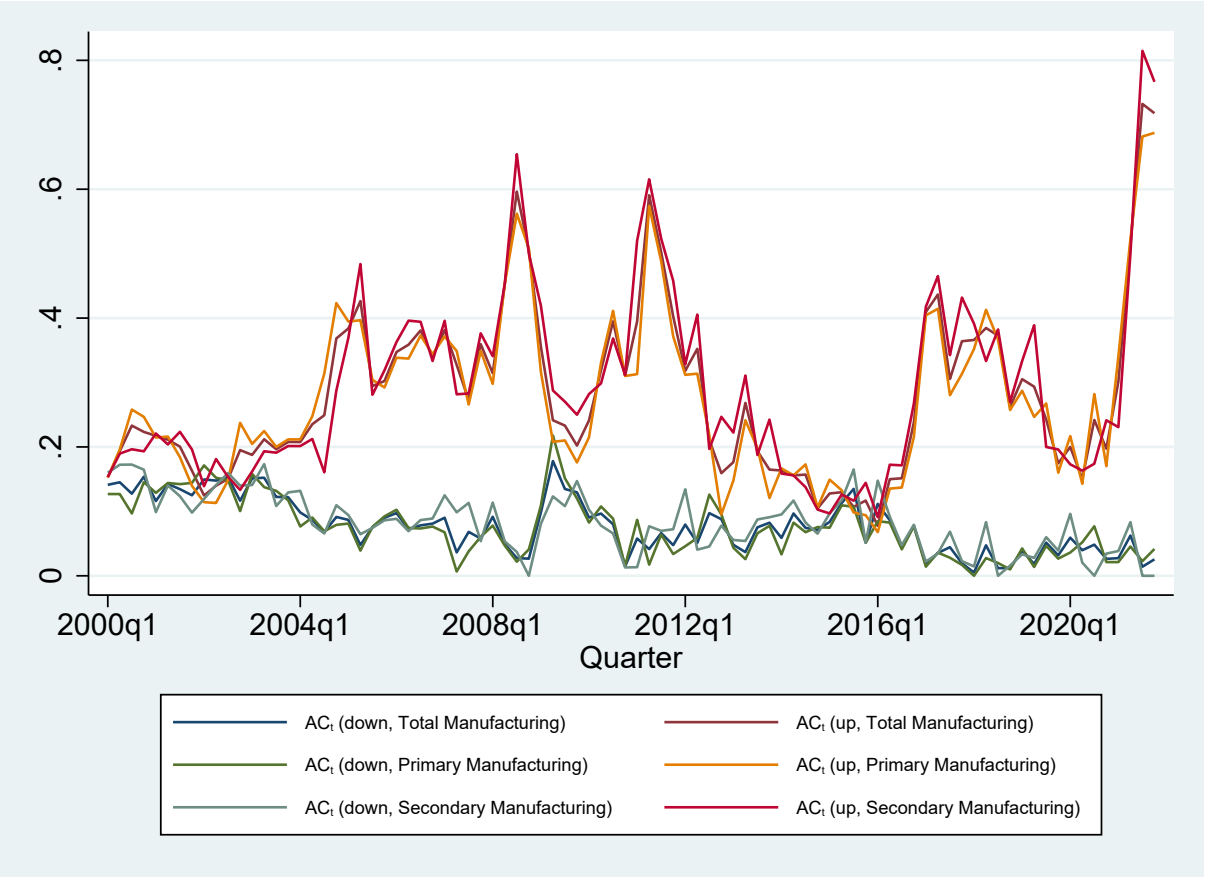


(c) Distributive Trades Sector

Note: λ_t^y (Total Manufacturing) is the time-varying proportion of total manufacturing firms changing output each quarter. λ_t^y (Primary Manufacturing) is the time-varying proportion of primary manufacturing firms changing output each quarter. λ_t^y (Secondary Manufacturing) is the time-varying proportion of secondary manufacturing firms changing output each quarter. λ_t^y (Services) is the time-varying proportion of services firms changing output each quarter. λ_t^y (Distributive Trades) is the time-varying proportion of distributive trades firms changing output each quarter. Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM). and secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Total manufacturing is the sum of primary and secondary manufacturing. Data measuring when manufacturing firms change prices is taken from the enhanced Industrial Trends Survey (ITS), where question 8 asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to volume of output (i.e. production)". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. Services is grouped SIC07 H to S. Data measuring when services firms change prices is taken from the enhanced Services Sector Survey (SSS), where question 3a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months with regard to volume of business". Note the enhanced SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96. Distributive trades is grouped SIC07 G. Data measuring when distributive trades firms change prices is taken from the enhanced Distributive Trades Survey (DTS), where question 2a asks "how have your volume of sales for the past three months changed and what do you expect to occur in the next three months". Firm survey responses are available from 2000Q1, 2005Q4 and 2003Q4 for the ITS, SSS and DTS (respectively).

Manufacturing) and *AC* (up, Primary Manufacturing), and a correlation of 0.89 between *AC* (up, Total Manufacturing) with *AC* (up, Secondary Manufacturing).

Figure 4: Timepath of Average Cost per unit of Output



Note: AC_t (down, Total Manufacturing) is the proportion of total manufacturing firms whose average costs per unit of output went "down" in quarter t. AC_t (up, Total Manufacturing) is the proportion of total manufacturing firms whose average costs per unit of output went "up" in quarter t. AC_t (down, Primary Manufacturing) is the proportion of primary manufacturing firms whose average costs per unit of output went "down" in quarter t. AC_t (up, Primary Manufacturing) is the proportion of primary manufacturing firms whose average costs per unit of output went "up" in quarter t. AC_t (down, Secondary Manufacturing) is the proportion of secondary manufacturing firms whose average costs per unit of output went "down" in quarter t. AC_t (up, Secondary Manufacturing) is the proportion of secondary manufacturing firms whose average costs per unit of output went "up" in quarter t. Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM). and secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Total manufacturing is the sum of primary and secondary manufacturing. Data measuring when manufacturing firms change prices is taken from the enhanced Industrial Trends Survey (ITS), where question 8 asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to volume of output (i.e. production)". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. Firm survey responses are available from 2000Q1.

4.2 The Office of National Statistics (ONS) Data

The total, primary and secondary manufacturing and services aggregate price levels are constructed by weighting the contributing two-digit SIC07 level price levels[25]. This is

[25]Note since the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33, these sectors are excluded in the weighted manufacturing aggregates. Similarly, since the enhanced SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96, only these sectors are included in the weighted services aggregate price level.

implemented using series taken from the ONS Producer Price Inflation (PPI)[26] and Services Producer Price Inflation (SPPI)[27] datasets for the manufacturing aggregates and services (respectively). Weighting is implemented using the same chain-linked (S)PPI weights[28] used by the ONS. Chain-linked (S)PPI weights are unavailable pre-2009, and remain unchanged between 2009 and 2013. Thus, the 2009 to 2013 chain-linked (S)PPI weight values are used pre-2009. ONS series HPSW is used as the aggregate price level for the distributive trades sector - taken from the SPPI dataset.

The same weighting process is used regarding the aggregate output levels[29] - now using the Index of Production (IoP) for the manufacturing aggregates[30], and the Index of Services (IoS) for the services[31] and distributive trades sectors[32]. Weighting is implemented using the same IoP(S) weights used by the ONS. All ONS aggregate price and output levels have base year 2016Q1.

Note that total manufacturing is the sum of primary and secondary manufacturing. Thus changes in the total manufacturing aggregate price or output level is a weighted average of changes in both the primary and secondary manufacturing aggregate price or output levels - where the weights are the relative PPI or IOP weight of primary and secondary manufacturing to total manufacturing (respectively). These relative PPI and IoP weights are depicted in Figure 5a and Figure 5b. With respect to both aggregate price and output, secondary manufacturing has a greater relative weight that primary manufacturing. Thus, movements in secondary manufacturing price or output have a greater contribution to total manufacturing price or output than primary manufacturing price or output - with the relative importance of secondary manufacturing increasing after 2012. Thus, large movements in primary manufacturing price or output make a relatively small contribution to total manufacturing price or output.

[26]Specifically, ONS series GB9U, GBA6, G6SI, G6SJ, G6SN, G6SO, G6SP, G6SQ, G6SR, G6SS, G6ST, G6SV, G6SW, G6SX, G6SY, G6SZ, G6T3, G6T5, G6VF, G6VG, G6WH, G72N, G75I, G776 and G777 are used.

[27]Specifically, ONS series HPZZ, HQGY, HQPZ, HQRA, HQSR, HQUF, HR6L, HSFH, HSHG, HZJ6 and I435 are used.

[28]Available upon request from the ONS and based on sales data.

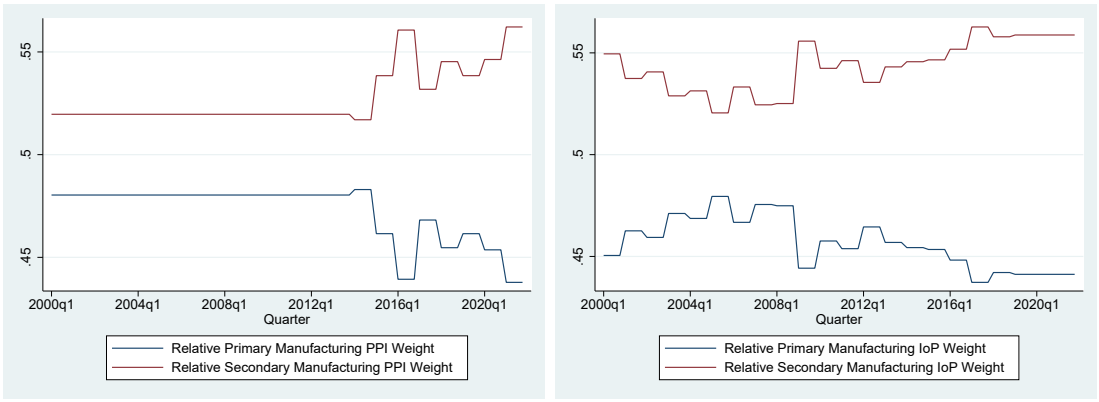
[29]Note since the SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96, only these sectors are included in the weighted services aggregate output level.

[30]Specifically, ONS series L2EM, K256, K25L, K25M, K25N, K25P, K25Q, K25R, K25T, K25V, K265, K267, K268, K26C, K26F, K26J, K26L, K26N, K26P, K26Q and K26W are used.

[31]Specifically, ONS series KFV6, S2L4, S2L5, S2L6, S2L7, S2LA, S2LF, KFW4, S2LT, S2M2, S2MD, S2MH and S2MO are used.

[32]Specifically, ONS series S2KV is used.

Figure 5: Relative Importance of Primary and Secondary Manufacturing to Total Manufacturing



(a) Using PPI Weights (b) Using IoP Weights

Note: Relative Primary Manufacturing PPI Weight is the relative PPI primary manufacturing to total manufacturing. Relative Secondary Manufacturing PPI Weight is the relative PPI secondary manufacturing to total manufacturing. Relative Primary Manufacturing IoP Weight is the relative IoP primary manufacturing to total manufacturing. Relative Secondary Manufacturing PPI Weight is the relative PPI secondary manufacturing to total manufacturing. PPI weight data available from the ONS upon request. IoP weight data taken from the IoP dataset. Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM). Secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Total manufacturing is the sum of primary and secondary manufacturing. Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33.

5 New Measures of Prices, Output and Costs

5.1 The Flexible Price Level

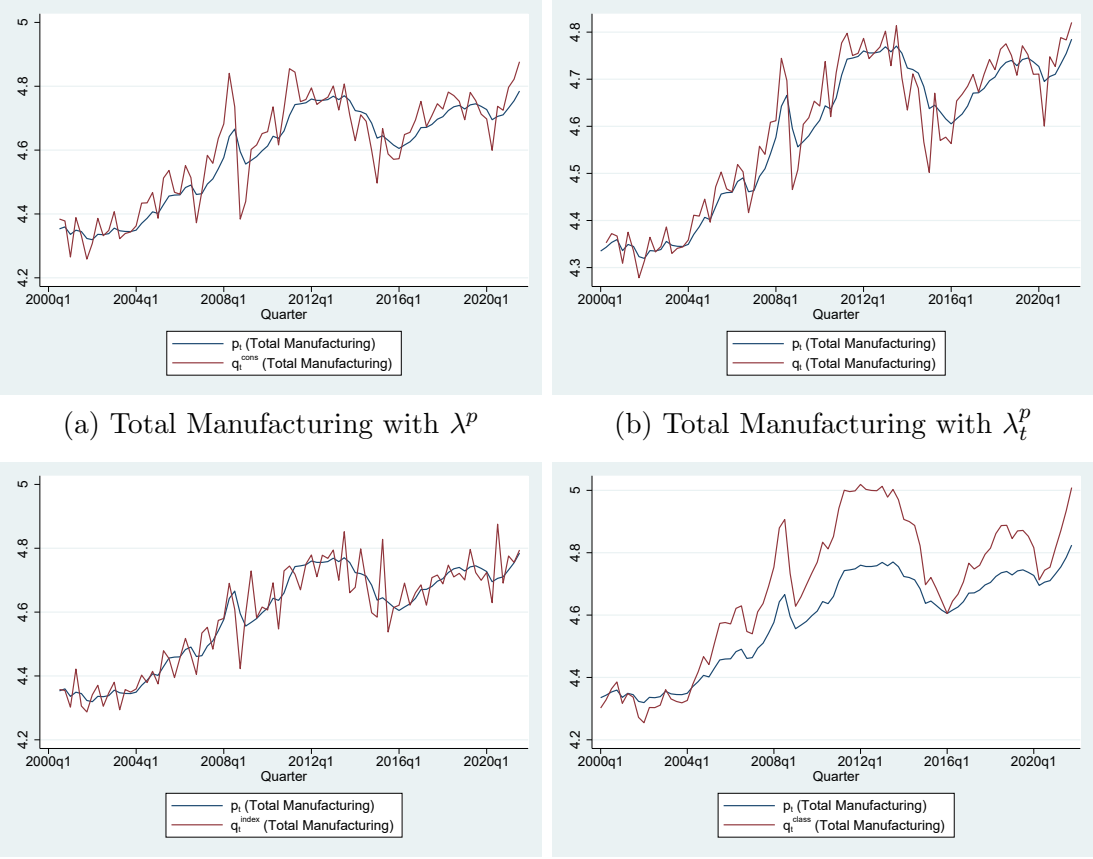
As Section 2.1 demonstrated, there are three possible iterations for flexible price. It can be constructed using q_t (Equation 4 which is based on λ_t^p, a time-varying proportion of firms change prices each quarter), q_t^{index} (Equation 8 which assumes that non-adjusting firms index their prices to lagged inflation) or q_t^{class} (Equation 12 which is based on the classification of industries into flexible and sticky categories). A fourth possibility, following the time-dependent pricing literature, is to define q_t^{cons} using λ^p (i.e. a constant proportion of firms change prices each quarter), set at 0.25 on the assumption that firms change prices once a year[33]. Figure 6a to Figure 10c plots q_t, q_t^{index}, q_t^{class} and q^{cons}, along with the aggregate price level (p_t) for the total manufacturing, primary manufacturing, secondary manufacturing, services and distributive trades sectors[34].

First note that q_t, q_t^{index}, q_t^{class} and q_t^{cons} are each more volatile than p_t - amplifying

[33]Specifically, $q_t^{cons} = \frac{1}{\lambda^p}(p_t - (1-\lambda^p)p_{t-1}$.

[34]Due to sample size, Equation 12 is not constructed for distributive trades.

Figure 6: Flexible Price Indices for Total Manufacturing



(a) Total Manufacturing with λ^p

(b) Total Manufacturing with λ_t^p

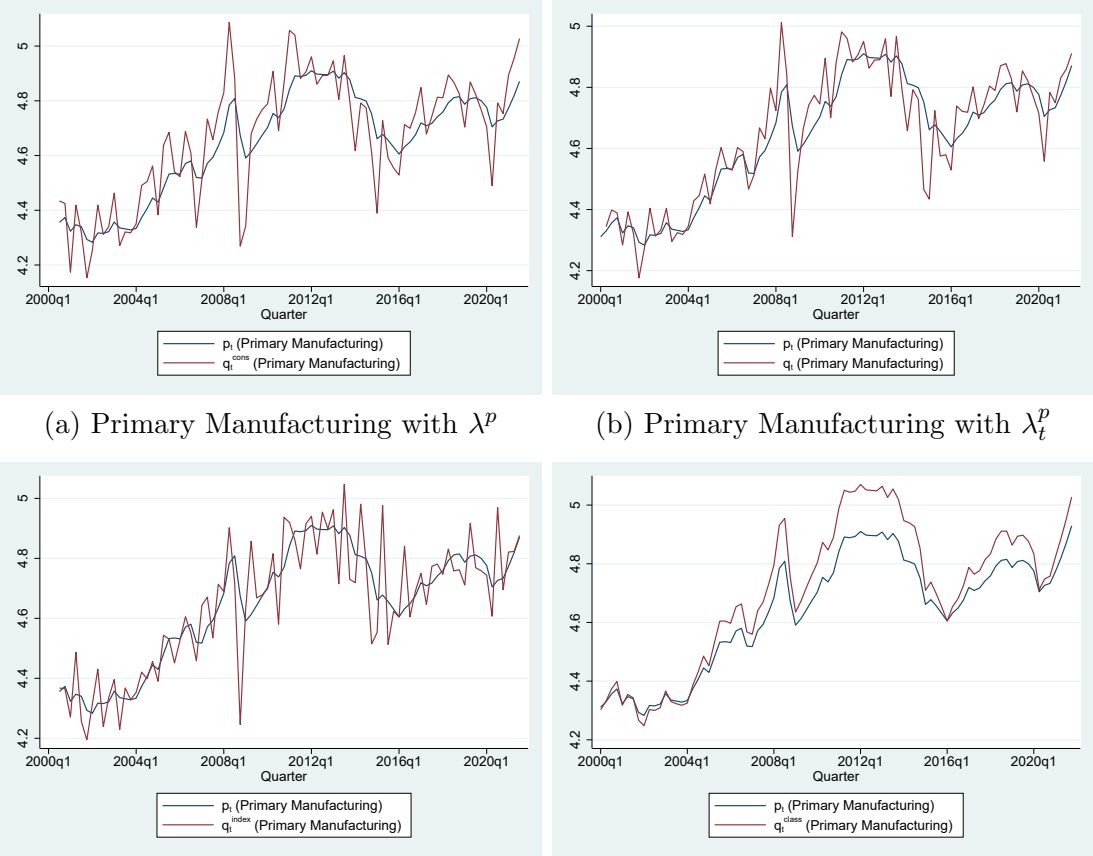
(c) Total Manufacturing with Indexation

(d) Total Manufacturing with Classification of Industries

Note: p_t (Total Manufacturing) is the aggregate price level for total manufacturing. q_t^{cons} (Total Manufacturing) is the flexible price index for total manufacturing calculated using a constant proportion of firms adjusting their prices each period ($\lambda^p = 0.25$). q_t (Total Manufacturing) is the flexible price index for total manufacturing calculated using Equation 4 (i.e. using λ_t^p taken from the ITS). q_t^{index} (Total Manufacturing) is the flexible price index for total manufacturing calculated using Equation 9 (i.e. using λ_t^p and assuming non-adjusting firms index their prices to lagged inflation). q_t^{class} (Total Manufacturing) is the flexible price index for total manufacturing calculated using Equation 12 (i.e. classifying industries into sticky and flexible subgroups). Total manufacturing is SIC07 7 to 33 (i.e. the sum of primary and secondary manufacturing). Data measuring when manufacturing firms change prices is taken from the enhanced Industrial Trends Survey (ITS), where question 12a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to average selling prices at which domestic orders (sales) are booked". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. ITS data is available from 2000Q1. p_t is constructed using ONS series GB9U, GBA6, G6SI, G6SJ, G6SN, G6SO, G6SP, G6SQ, G6SR, G6SS, G6ST, G6SV, G6SW, G6SX, G6SY, G6SZ, G6T3, G6T5, G6VF, G6VG, G6WH, G72N, G75I, G776 and G777. Base is 2016Q1.

the underlying volatility in p_t. Note that the flexible price indices based on observed price changes (q_t and q_t^{index}) exhibit less volatility than q_t^{cons}, which is based on the arbitrary assumption that $\lambda^p = 0.25$ (although not in services, where q_t^{index} is the most volatile). Second, despite (sometimes substantial) differences in value between λ^p and λ_t^p, the resulting q_t are quite similar. The only sector this is not true for is distributive trades - although as Figure 2c demonstrated, the assumption of $\lambda^p = 0.25$ was not realistic. However, using λ^p instead of λ_t^p overestimates the change in q_t around sharp

Figure 7: Flexible Price Indices for Primary Manufacturing



(a) Primary Manufacturing with λ^p

(b) Primary Manufacturing with λ_t^p

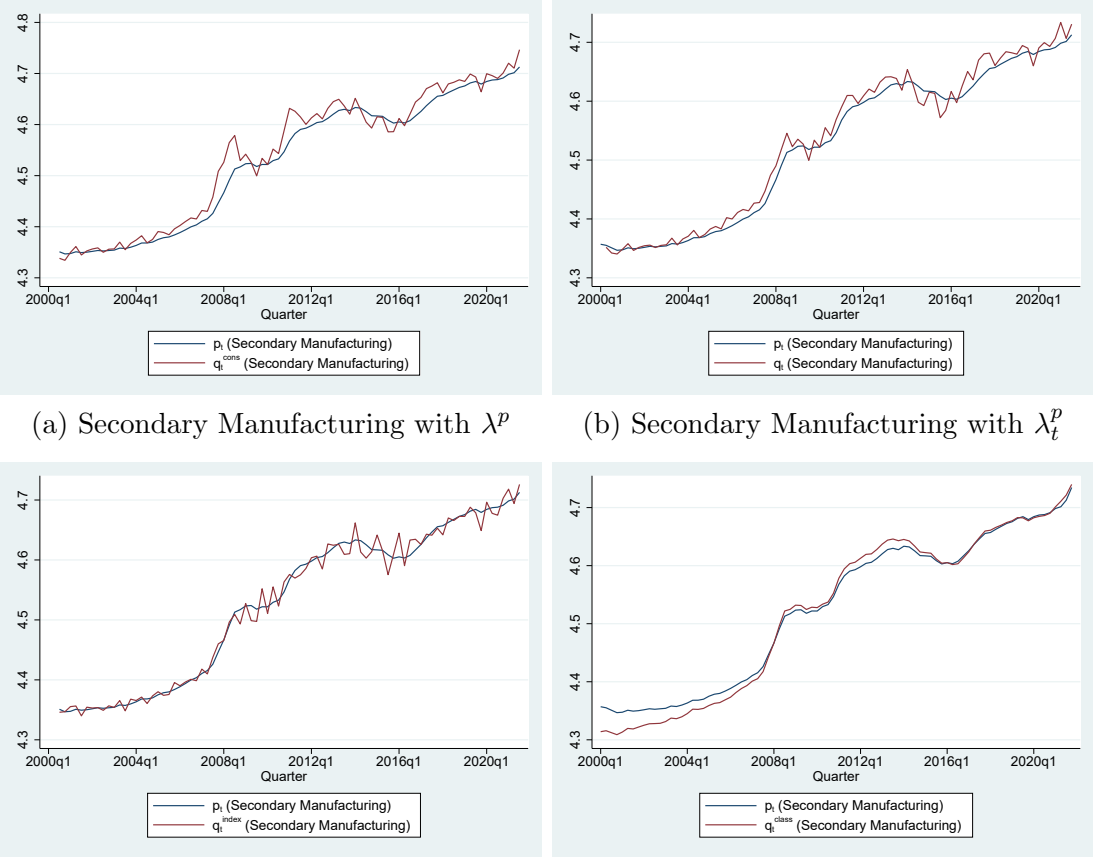
(c) Primary Manufacturing with Indexation

(d) Primary Manufacturing with Classification of Industries

Note: p_t (Primary Manufacturing) is the aggregate price level for primary manufacturing. q_t^{cons} (Primary Manufacturing) is the flexible price index for primary manufacturing calculated using a constant proportion of firms adjusting their prices each period ($\lambda^p = 0.25$). q_t (Primary Manufacturing) is the flexible price index for primary manufacturing calculated using Equation 4 (i.e. using λ_t^p taken from the ITS). q_t^{index} (Primary Manufacturing) is the flexible price index for primary manufacturing calculated using Equation 9 (i.e. using λ_t^p and assuming non-adjusting firms index their prices to lagged inflation). q_t^{class} (Primary Manufacturing) is the flexible price index for primary manufacturing calculated using Equation 12 (i.e. classifying industries into sticky and flexible subgroups). Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM). Data measuring when manufacturing firms change prices is taken from the enhanced Industrial Trends Survey (ITS), where question 12a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to average selling prices at which domestic orders (sales) are booked". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. ITS data is available from 2000Q1. p_t is constructed using ONS series GB9U, GBA6, G6SI, G6SJ, G6SN, G6SO, G6SP, G6SQ, G6SR, G6SS, G6ST, G6SV, G6SW, G6SX, G6SY, G6SZ, G6T3, G6T5, G6VF, G6VG, G6WH, G72N, G75I, G776 and G777. Base in 2016Q1.

increases or decreases in p_t. Third, allowing non-adjusting firms to index their prices results in q_t^{index} being closer to p_t around stable periods and more volatile around sharp changes in p_t, than the scenario where non-adjusting firms do not index their prices (and the flexible price is given by q_t). Finally, while q_t^{class} closely mirrors the other flexible price indices (except for total manufacturing post-2005), it tends not to be as volatile

Figure 8: Flexible Price Indices for Secondary Manufacturing



(a) Secondary Manufacturing with λ^p

(b) Secondary Manufacturing with λ_t^p

(c) Secondary Manufacturing with Indexation

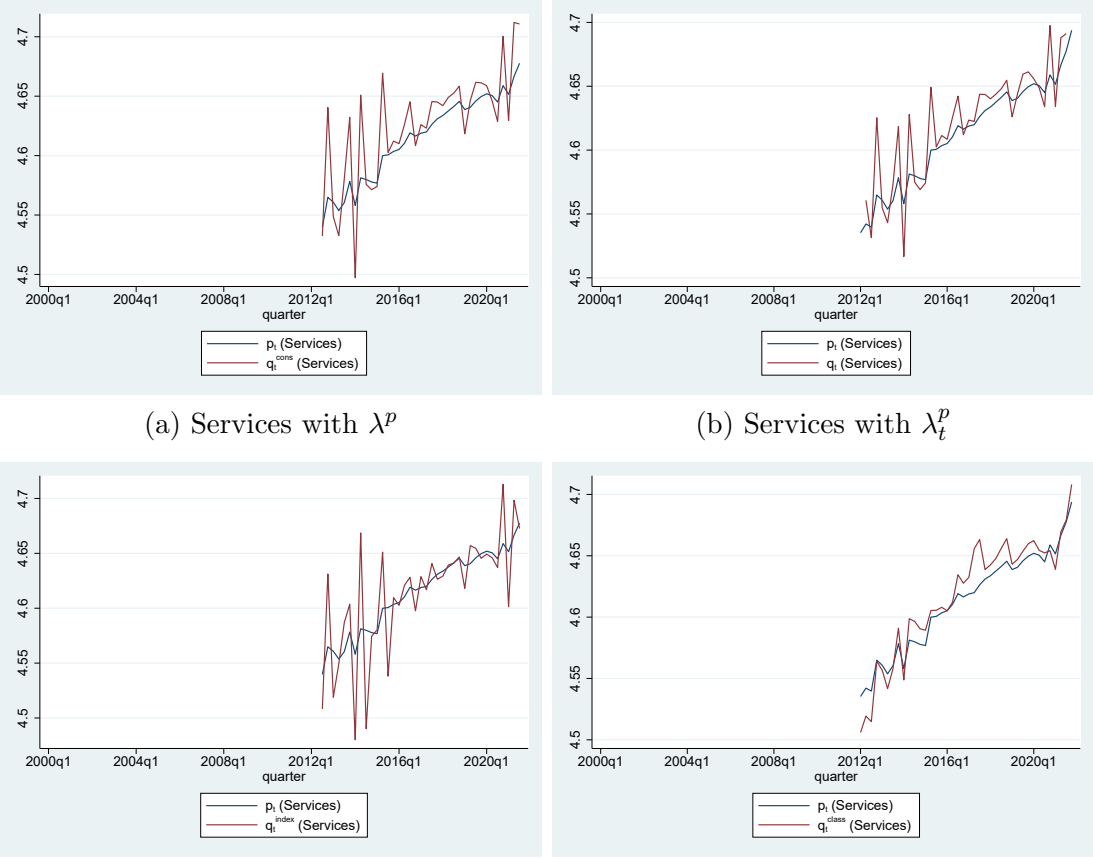
(d) Secondary Manufacturing with Classification of Industries

Note: p_t (Secondary Manufacturing) is the aggregate price level for secondary manufacturing. q_t^{cons} (Secondary Manufacturing) is the flexible price index for secondary manufacturing calculated using a constant proportion of firms adjusting their prices each period ($\lambda^p = 0.25$). q_t (Secondary Manufacturing) is the flexible price index for secondary manufacturing calculated using Equation 4 (i.e. using λ_t^p taken from the ITS). q_t^{index} (Secondary Manufacturing) is the flexible price index for secondary manufacturing calculated using Equation 9 (i.e. using λ_t^p and assuming non-adjusting firms index their prices to lagged inflation). q_t^{class} (Secondary Manufacturing) is the flexible price index for secondary manufacturing calculated using Equation 12 (i.e. classifying industries into sticky and flexible subgroups). Secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Data measuring when manufacturing firms change prices is taken from the enhanced Industrial Trends Survey (ITS), where question 12a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to average selling prices at which domestic orders (sales) are booked". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. ITS data is available from 2000Q1. p_t is constructed using ONS series GB9U, GBA6, G6SI, G6SJ, G6SN, G6SO, G6SP, G6SQ, G6SR, G6SS, G6ST, G6SV, G6SW, G6SX, G6SY, G6SZ, G6T3, G6T5, G6VF, G6VG, G6WH, G72N, G75I, G776 and G777. Base is 2016Q1.

as q_t, q_t^{index}, or q_t^{cons}[35]. This is clear for secondary manufacturing and services, while

[35]Flexible industries are classed as $\lambda_t^p > 0.33, 0.36, 0.3$ and 0.32 for total manufacturing, primary manufacturing, secondary manufacturing and services (respectively), with sticky industries the reverse. This is based on the practice of the Federal Reserve Bank of Atlanta in their construction of a flexible and sticky price index. Total manufacturing flexible industries include two-digit SIC07 levels 7 to 9, 14, 16, 17, 18, 19, 20, 23 and 24. Primary manufacturing flexible industries include two-digit SIC07 levels 7 to 9, 16, 17, 18, 19, 23 and 24. Secondary manufacturing flexible industries include two-digit SIC07 levels 10 to 12, 14, 20, 27 and 29. Services flexible industries include two-digit SIC07 levels 49, 51, 52, 53 and 56.

Figure 9: Flexible Price Indices for Services



(a) Services with λ^p

(b) Services with λ_t^p

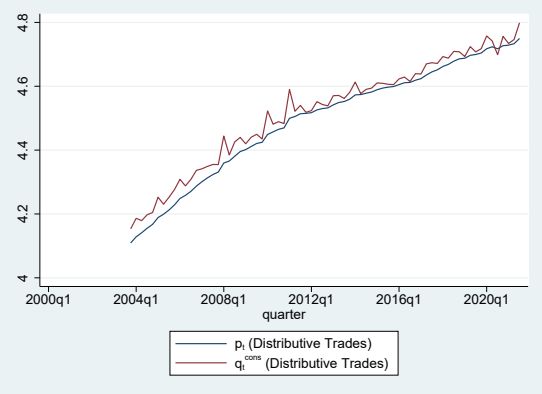
(c) Services with Indexation

(d) Services with Classification of Industries

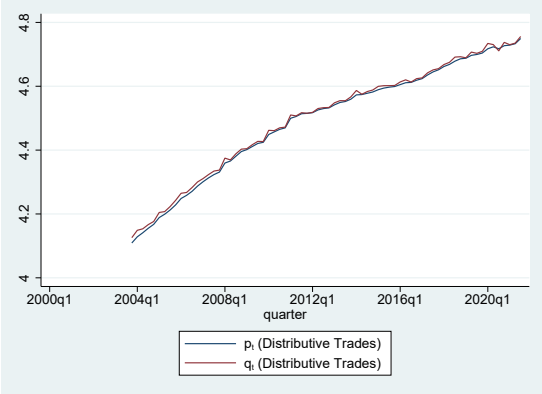
Note: p_t (Services) is the weighted aggregate price level for services. Note since the SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96, only these sectors are included in the weighted services aggregate price level. q_t^{cons} (Services) is the flexible price index for services calculated using a constant proportion of firms adjusting their prices each period ($\lambda^p = 0.25$). q_t (Services) is the flexible price index for services calculated using Equation 4 (i.e. using λ_t^p taken from the ITS). q_t^{index} (Services) is the flexible price index for services calculated using Equation 9 (i.e. using λ_t^p and assuming non-adjusting firms index their prices to lagged inflation). q_t^{class} (Services) is the flexible price index for services calculated using Equation 12 (i.e. classifying industries into sticky and flexible subgroups). Data measuring when manufacturing firms change prices is taken from the enhanced Services Sector Survey (SSS), where question 5a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months with regard to average selling prices". SSS data is available from 2005Q4. p_t is constructed using ONS series HPZZ, HQGY, HQPZ, HQRA, HQSR, HQUF, HR6L, HSFH, HSHG, HZJ6 and I435. Base is 2016Q1.

for total and primary manufacturing q_t^{class} does not witness the substantial decreases or oscillations of q_t, q_t^{index}, or q_t^{cons}. However, q_t and q_t^{index} are constructed based on quarterly firm-level data price changes - whereas q_t^{class} is constructed using a once-off classification of industries into flexible and sticky subgroups. This ignores the possibility of industries switching classifications. In addition, both q_t and q_t^{index} are grounded in the microfoundations of the New Keynesian model.

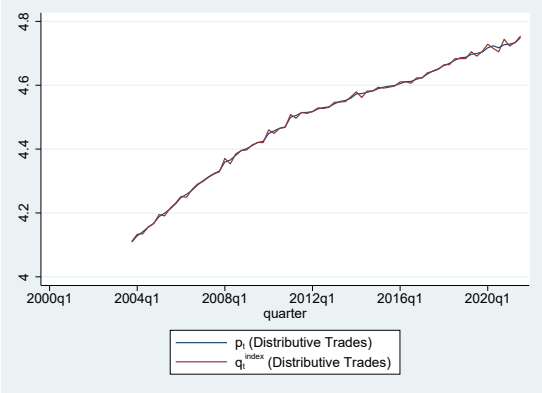
Figure 10: Flexible Price Indices for Distributive Trades



(a) Distributive Trades with λ^p



(b) Distributive Trades with λ_t^p



(c) Distributive Trades with Indexation

Note:

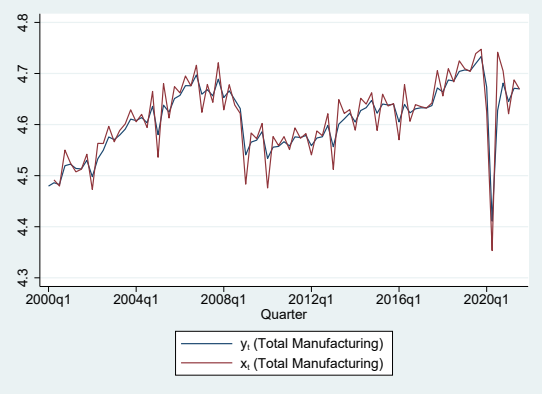
Note: p_t (Distributive Trades) is the aggregate price level for distributive trades. q_t^{cons} (Distributive Trades) is the flexible price index for distributive trades calculated using a constant proportion of firms adjusting their prices each period ($\lambda^p = 0.25$). q_t (Distributive Trades) is the flexible price index for distributive trades calculated using Equation 4 (i.e. using λ_t^p taken from the ITS). q_t^{index} (Distributive Trades) is the flexible price index for distributive trades calculated using Equation 9 (i.e. using λ_t^p and assuming non-adjusting firms index their prices to lagged inflation). Distributive trades is grouped SIC07 level G. Data measuring when manufacturing firms change prices is taken from the enhanced Distributive Trades Survey (DTS), where question 6a asks "how have your average selling prices for the past three months changed and what do you expect to occur in the next three months". DTS data is available from 2003Q4. p_t is constructed using ONS series HPSW. Base is 2016Q1.

5.2 The Flexible Output Level and Marginal Cost

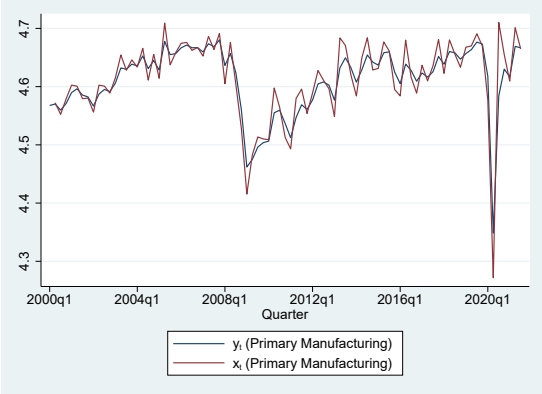
Figure 11a to Figure 12b depicts the flexible output level (x_t), as defined in Equation 15, for each industrial aggregate (along with the aggregate output level, y_t). As with the flexible price indices, x_t amplifies the volatility in y_t. However, while the volatility is amplified, x_t closely aligns with y_t - more so than q_t does with p_t. This trend is more noticeable in the services sector and distributive trades sector - in the latter case, divergence between x_t and y_t are minimal.

Figure 13a to Figure 13c depicts (for the $(1 - \lambda_t^y)$ of firms that do not alter their produc-

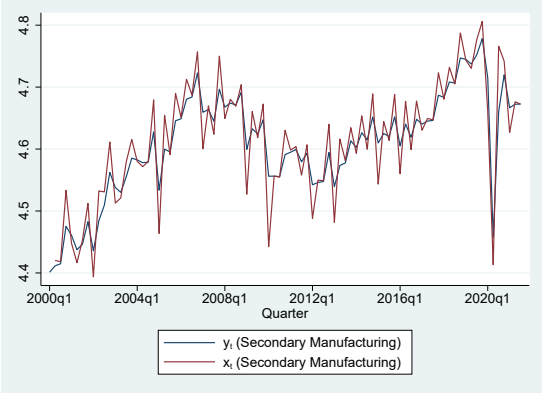
Figure 11: The Flexible Output Index x_t (Manufacturing)



(a) Total Manufacturing



(b) Primary Manufacturing

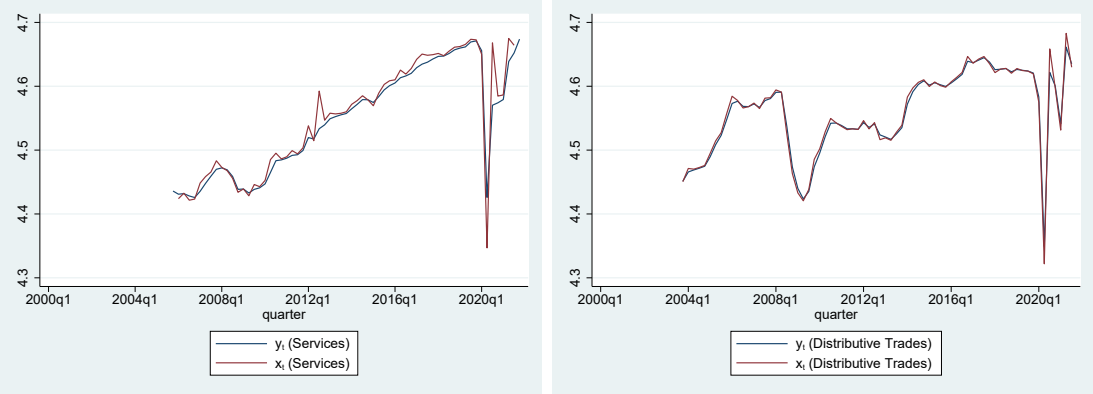


(c) Secondary Manufacturing

Note: y_t (Total Manufacturing), y_t (Primary Manufacturing) and y_t (Secondary Manufacturing) is the aggregate output level for total manufacturing, primary manufacturing and secondary manufacturing (respectively). x_t (Total Manufacturing), x_t (Primary Manufacturing) and x_t (Secondary Manufacturing) is the flexible output index for total manufacturing, primary manufacturing and secondary manufacturing (respectively) calculated using Equation 14 (i.e. using λ_t^y taken from the ITS). Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM). and secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Total manufacturing is the sum of primary and secondary manufacturing. Data measuring when manufacturing firms change output is taken from the enhanced Industrial Trends Survey (ITS), where question 8 asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to volume of output (i.e. production)". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. Firm survey responses are available from 2000Q1 for the ITS. y_t is constructed using L2EM, K256, K25L, K25M, K25N, K25P, K25Q, K25R, K25T, K25V, K265, K267, K268, K26C, K26F, K26J, K26L, K26N, K26P, K26Q and K26W for the manufacturing aggregates. Base is 2016Q1.

tion plans) marginal costs for the total, primary and secondary manufacturing sectors (using Equation 18 and Equation 19), along with π_t. For each manufacturing aggregate, marginal costs closely tracks π_t. Specifically, ϕ_t (Total Manufacturing) has a correlation of 0.4 with π_t (Total Manufacturing); ϕ_t (Primary Manufacturing) has a correlation of 0.35 with π_t (Primary Manufacturing) and ϕ_t (Secondary Manufacturing) has a correlation of 0.64 with π_t (Secondary Manufacturing). This positive correlation is expected given that (for example) the New Keynesian Philips Curve states that current inflation

Figure 12: The Flexible Output Index x_t (Services and Distributive Trades)



(a) Services (b) Distributive Trades

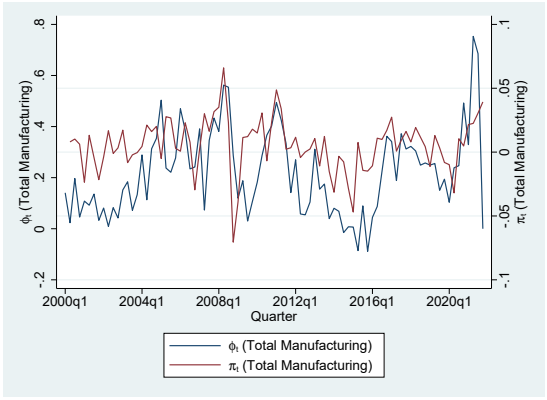
Note: y_t (Services) and y_t (Distributive Trades) is the aggregate output level for services and distributive trades (respectively). x_t (Services) and x_t (Distributive Trades) is the flexible output index for services and distributive trades (respectively) calculated using Equation 14 (i.e. using λ_t^y taken from the SSS and DTS). Note since the SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96, only these sectors are included in the weighted services aggregate price level. Distributive trades is grouped SIC07 G. Data measuring when services firms change output is taken from the enhanced Services Sector Survey (SSS), where question 3a asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months with regard to volume of business". Data measuring when distributive trades firms change output is taken from the enhanced Distributive Trades Survey (DTS), where question 2a asks "how have your volume of sales for the past three months changed and what do you expect to occur in the next three months". Firm survey responses are available from 2005Q4 and 2003Q4 for the SSS and DTS (respectively). y_t is constructed using KFV6, S2L4, S2L5, S2L6, S2L7, S2LA, S2LF, KFW4, S2LT, S2M2, S2MD, S2MH and S2MO for services and S2KV for distributive trades. Base is 2016Q1.

is a function of expected future inflation and current marginal costs.

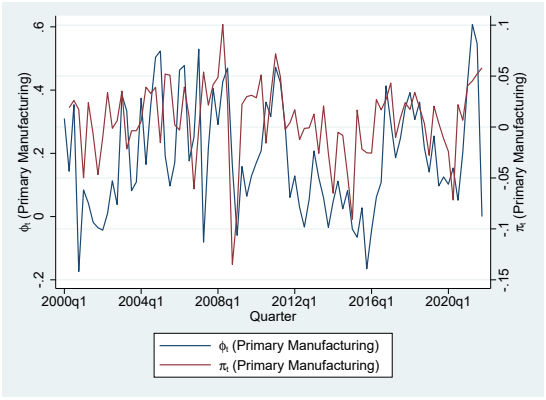
6 Conclusion

This technical note has demonstrated how reliable measures of the flexible price level, the flexible output level and marginal costs indicator can be derived using firm-level survey responses to the CBI dataset and official statistics from the ONS. Thus, important economic variables which have typically gone unmeasured have now been provided for a large section of the UK economy. Furthermore, while the functional form of these variables seems intuitively obvious - they are in fact derivable from the underlying microfoundations of the New Keynesian Model. This not only provides a solid foundation for the intuitive specification of these variables, but is also important for future research. Examination of these variables is indeed of interest, but it is not the end goal. Rather it is the first step in estimating a New Keynesian Philips Curve that does not assume a constant proportion of firms adjust their price each period, that can be estimated in terms of the flexible price level instead of the inflation rate and that does not have to rely on noisy and/or poor

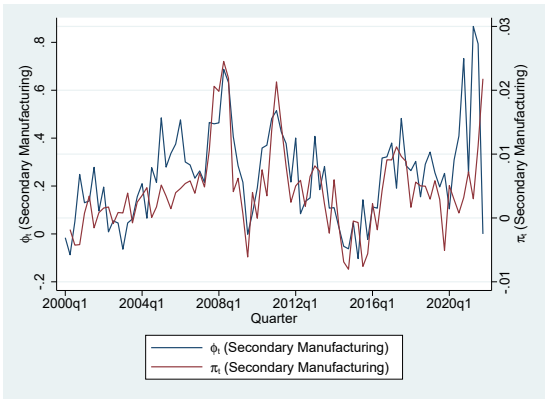
Figure 13: Marginal Costs ϕ_t



(a) Total Manufacturing



(b) Primary Manufacturing



(c) Secondary Manufacturing

Note: ϕ_t (Total Manufacturing), ϕ_t (Primary Manufacturing) and ϕ_t (Secondary Manufacturing) are marginal costs for total manufacturing, primary manufacturing and secondary manufacturing (respectively) calculated using Equation 19. π_t (Total Manufacturing), π_t (Primary Manufacturing) and π_t (Secondary Manufacturing) is the inflation rate for total manufacturing, primary manufacturing and secondary manufacturing (respectively). Primary manufacturing is mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors (i.e.Grouped SIC07 levels B, CC, CD, CG, CH CK and CM). and secondary manufacturing is food, clothing, chemicals, computers, electrical equipment and transport equipment (i.e. Grouped SIC07 levels CA, CB, CE, CF , CI, CJ and CL). Total manufacturing is the sum of primary and secondary manufacturing. Data measuring when manufacturing firms change output is taken from the enhanced Industrial Trends Survey (ITS), where question 11 asks "excluding seasonal variations, what has been the trend over the past three months and what are the expected trends for the next three months, with regard to average costs per unit of output". Note the enhanced ITS is missing firm responses from two-digit SIC07 levels 5, 6, 11, 21, 31 and 33. ITS data is available from 2000Q1. π_t is constructed using ONS series GB9U, GBA6, G6SI, G6SJ, G6SN, G6SO, G6SP, G6SQ, G6SR, G6SS, G6ST, G6SV, G6SW, G6SX, G6SY, G6SZ, G6T3, G6T5, G6VF, G6VG, G6WH, G72N, G75I, G776 and G777. Base is 2016Q1.

proxies for marginal costs. By providing reliable (and plausible) estimates of the flexible price level, optimal output level and marginal costs this technical note has shown this avenue of research is both justified and promising.

References

Aoki, K. (2001). Optimal monetary policy responses to relative-price changes. *Journal of Monetary Economics*, 48(1):55–80.

Bachmann, R. and Elstner, S. (2015). Firm optimism and pessimism. *European Economic Review*, 79(C):297–325.

Bakhshi, H., Khan, H., Burriel-Llombart, P., and Rudolf, B. (2007). The new keynesian phillips curve under trend inflation and strategic complementarity. *Journal of Macroeconomics*, 29(1):37–59.

Blanchard, O. and Kiyotaki, N. (1987). Monopolistic competition and the effects of aggregate demand. *American Economic Review*, 77(4):647–666.

Caballero, R. and Engel, E. (1993). Microeconomic rigidities and aggregate price dynamics. *European Economic Review*, 37(4):697–711.

Calvo, G. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary Economics*, 12(3):383–398.

Caplin, A. and Spulber, D. (1987). Menu costs and the neutrality of money. *Quarterly Journal of Economics*, 102(4):703–725.

Chari, V., Kehoe, P., and McGrattan, E. (2000). Sticky price models of the business cycle: Can the contract multiplier solve the persistence problem? *Econometrica*, 68(5):1151–1179.

Christiano, L., Eichenbaum, M., and Evans, C. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Clarida, R., Galı, J., and Gertler, M. (1999). The science of monetary policy: A new keynesian perspective. *Journal of Economic Literature*, 37(4):1661–1707.

Coibion, O., Gorodnichenko, Y., and Kamdar, R. (2018). The formation of expectations, inflation, and the phillips curve. *Journal of Economic Literature*, 56(4):1447–91.

Dixit, A. and Stiglitz, J. (1977). Monopolistic competition and optimum product diversity. *American Economic Review*, 67(3):297–308.

Dupor, B., Kitamura, T., and Tsuruga, T. (2010). Integrating sticky prices and sticky information. *Review of Economics and Statistics*, 92(3):657–669.

Erceg, C., Henderson, D., and Levin, A. (2000). Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics*, 46(2):281–313.

Fischer, S. (1977). Long-term contracts, rational expectations, and the optimal money supply rule. *Journal of monetary Economics*, 85(1):485–512.

Galı, J. and Gertler, M. (1999). Inflation dynamics: A structural econometric analysis. *Journal of Monetary Economics*, 44(2):195–222.

Golosov, M. and Lucas, R. (2007). Menu costs and phillips curves. *Journal of Political Economy*, 115(2):171–199.

Kimball, M. (1995). The quantitative analytics of the basic neomonetarist model. *Journal of Money, Credit and Banking*, 27(4):1241–1277.

Klenow, P. and Kryvtsov, O. (2008). State-dependent or time-dependent pricing: Does it matter for recent u.s. inflation? *Quarterly Journal of Economics*, 123(3):863–904.

Klenow, P. and Malin, B. (2010). Microeconomic evidence on price-setting. In Friedman, B. M. and Woodford, M., editors, *Handbook of Monetary Economics*, volume 3, chapter 6, pages 231–284. Elsevier, 1 edition.

Lee, K., Mahony, M., and Mizen, P. (2020). The cbi suite of business surveys. ESCoE Technical Report 08, Economic Statistics Centre of Excellence (ESCoE).

Mankiw, N. and Reis, R. (2002). Sticky information versus sticky prices: A proposal to replace the new keynesian phillips curve. *Quarterly Journal of Economics*, 117(4):1295–1328.

Mark Bils, M. and Klenow, P. (2004). Some evidence on the importance of sticky prices. *Journal of Political Economy*, 112(5):947–985.

Nakamura, E. and Steinsson, J. (2008). Five facts about prices: A reevaluation of menu cost models. *Quarterly Journal of Economics*, 123(4):1415–1464.

Roberts, J. (1995). New keynesian economics and the phillips curve. *Journal of Money, Credit and Banking*, 27(4):975–984.

Rotemberg, J. and Woodford, M. (1997). An optimization-based econometric framework for the evaluation of monetary policy. *NBER Macroeconomics Annual 1997*, 12:297–361.

Taylor, J. (1979). Staggered wage setting in a macro model. *The American Economic Review*, 69(2):108–113.

Woodford, M. (1996). Control of the public debt: A requirement for price stability? Working Paper 5684, National Bureau of Economic Research.

Yun, T. (1996). Nominal price rigidity, money supply endogeneity, and business cycles. *Journal of Monetary Economics*, 37(2):345–370.

A Converting Old Classifications into SIC07

A.1 Conversion in the ITS

SIC80 is the primary means of recording industrial classification in the ITS. Using Stata code provided by Jennifer Smith (University of Warwick)[36], the 4 digit SIC80 is converted to 2 digit SIC92 - which in turn is converted to 2 digit SIC07[37].

There are a number of instances where the 4 digit SIC80 has not been correctly recorded - these need correcting before conversion to 2 digit SIC92. Some corrections are solved by examining the database directly. For example, firms which have SIC80 recorded as 1.1 are also recorded as having industrial classification 4196 (bread and flour confectionery). Thus, instances where SIC80 is recorded as 1.1 is corrected to 4196. Some corrections are solved thanks to the conversion process. For example, some firms are recorded with industrial classification 247 - which could be 2471, 2478 or 2479 in the 4 digit SIC80. However, each of these 4 digit classifications is converted to the same 2 digit SIC92 (26 manufacture of other non-metallic mineral products). Unfortunately, some corrections cannot be solved. For example, some firms are recorded with industrial classification 223 - which could be 2234 or 2235 in the 4 digit SIC80, both of which have different conversions to 2 digit SIC92. However, only 0.67% of survey responses cannot be corrected to allow an accurate conversion to 2 digit SIC92.

Thus, the 4 digit SIC80 in the ITS is converted to 2 digit SIC92 which is then converted to 2 digit SIC07. The 2 digit SIC07 levels in the ITS are:

- 7 Mining of metal ores
- 8 Other mining and quarrying
- 9 Mining support service activities
- 10 Manufacture of food products
- 12 Manufacture of tobacco products

[36] Available from: https://warwick.ac.uk/fac/soc/economics/staff/jcsmith/sicmapping/

[37] Converting the 2 digit SIC92 to 2 digit SIC07 relies on the fact that SIC03 is essentially identical to SIC92 at the 3-digit aggregation level and above. I have used SIC03 as a proxy for SIC92.

- 13 Manufacture of textiles
- 14 Manufacture of wearing apparel
- 15 Manufacture of leather and related products
- 16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
- 17 Manufacture of paper and paper products
- 18 Printing and reproduction of recorded media
- 19 Manufacture of coke and refined petroleum products
- 20 Manufacture of chemicals and chemical products
- 22 Manufacture of rubber and plastic products
- 23 Manufacture of other non-metallic mineral products
- 24 Manufacture of basic metals
- 25 Manufacture of fabricated metal products, except machinery and equipment
- 26 Manufacture of computer, electronic and optical products
- 27 Manufacture of electrical equipment
- 28 Manufacture of machinery and equipment (not elsewhere classified)
- 29 Manufacture of motor vehicles, trailers and semi-trailers
- 30 Manufacture of other transport equipment
- 32 Other manufacturing
- 43 Specialised construction activities
- 46 Wholesale trade, except of motor vehicles and motorcycles
- 70 Activities of head offices; management consultancy activities
- 86 Human health activities

Alternatively, the grouped SIC07 levels in the ITS are:

- B Mining and quarrying[38]
- CA Manufacture of food products, beverages and tobacco[39]
- CB Manufacture of textiles, wearing apparel and leather products[40]
- CC Manufacture of wood and paper products, and printing[41]
- CD Manufacture of coke, and refined petroleum products[42]
- CE Manufacture of chemicals and chemical products[43]
- CG Manufacture of rubber and plastic products, and other non-metallic mineral products[44]
- CH Manufacture of basic metals and metal products[45]
- CI Manufacture of computer, electronic and optical products[46]
- CJ Manufacture of electrical equipment[47]
- CK Manufacture of machinery and equipment not elsewhere classified[48]
- CL Manufacture of transport equipment[49]

[38]Consists of 7 (mining of metal ores), 8 (other mining and quarrying) and 9 (mining support service activities).

[39]Consists of 10 (manufacture of food products), 11 (manufacture of beverages) and 12 (manufacture of tobacco products). Note there are no firms with SIC07 11 in the ITS.

[40]Consists of 13 (manufacture of textiles), 14 (manufacture of wearing apparel) and 15 (manufacture of leather and related products).

[41]Consists of 16 (manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials), 17 (manufacture of paper and paper products) and 18 (printing and reproduction of recorded media).

[42]Consists of 19 (manufacture of coke and refined petroleum products).

[43]Consists of 20 (manufacture of chemicals and chemical products).

[44]Consists of 22 (manufacture of rubber and plastic products) and 23 (manufacture of other non-metallic mineral products).

[45]Consists of 24 (manufacture of basic metals) and 25 (manufacture of fabricated metal products, except machinery and equipment).

[46]Consists of 26 (manufacture of computer, electronic and optical products).

[47]Consists of 27 (manufacture of electrical equipment).

[48]Consists of 28 (manufacture of machinery and equipment (not elsewhere classified)).

[49]Consists of 29 (manufacture of motor vehicles, trailers and semi-trailers) and 30 (manufacture of other transport equipment).

- CM Other manufacturing[50]
- F Construction[51]
- G Wholesale and retail trade and repair of motor vehicles and motorcycles[52]
- MA Legal, accounting, management, architecture, engineering, technical testing activities[53]
- QA Human health activities[54]

A.2 Conversion in the SSS

SIC92 is the primary means of recording industrial classification in the SSS. As with the ITS, the SIC92 is converted to 2 digit SIC07. In contrast to the SIC80 in the ITS there are no inconsistencies in the recording of SIC92 in the SSS which need correcting. Thus, the 4 digit SIC92 in the SSS are converted to 2 digit SIC07. The 2 digit SIC07 levels in the SSS are:

- 49 Land transport and transport via pipelines
- 50 Water transport
- 51 Air transport
- 52 Warehousing and support activities for transportation
- 53 Postal and courier activities
- 56 Food and beverage service activities
- 62 Computer programming, consultancy and related activities
- 68 Real estate activities

[50]Consists of 31 (manufacture of furniture), 32 (other manufacturing) and 33 (repair and installation of machinery and equipment). Note there are no firms with SIC07 31 or 33 in the ITS.

[51]Consists of 41 (construction of buildings), 42 (civil engineering) and 43 (specialised construction activities). Note there are no firms with SIC07 41 or 42 in the ITS.

[52]In this instance corresponds with 46 (wholesale trade, except of motor vehicles and motorcycles).

[53]In this instance corresponds with 70 (activities of head offices; management consultancy activities).

[54]In this instance corresponds with 86 (human health activities).

- 70 Activities of head offices; management consultancy activities
- 77 Rental and leasing activities
- 86 Human health activities
- 90 Creative, arts and entertainment activities
- 96 Other personal service activities

Alternatively, the grouped SIC07 levels in the SSS are:

- H Transportation and storage[55]
- I Accommodation and food service activities[56]
- JC IT and other information service activities[57]
- L Real estate activities[58]
- MA Legal, accounting, management, architecture, engineering, technical testing activities[59]
- N Administrative and support service activities[60]
- QA Human health activities[61]
- R Arts, entrainment and recreation[62]

[55]Consists of 49 (land transport and transport via pipelines), 50 (water transport), 51 (air transport), 52 (warehousing and support activities for transportation) and 53 (postal and courier activities).

[56]Consists of 55 (accommodation) and 56 (food and beverage service activities). Note there are no firms with SIC07 55 in the SSS.

[57]Consists of 62 (computer programming, consultancy and related activities) and 63 (information service activities). Note there are no firms with SIC07 63 in the SSS.

[58]Consists of 68 (real estate activities).

[59]Consists of 69 (legal and accounting activities), 70 (activities of head offices; management consultancy activities) and 71 (architectural and engineering activities; technical testing and analysis). Note there are no firms with SIC07 69 or 71 in the SSS.

[60]Consists of 77 (rental and leasing activities), 78 (employment activities), 79 (travel agency, tour operator and other reservation service and related activities), 80 (security and investigation activities), 81 (services to buildings and landscape activities) and 82 (office administrative, office support and other business support activities). Note there are no firms with SIC07 78, 79, 80, 81 or 82 in the SSS.

[61]Consists of 86 (human health activities).

[62]Consists of 90 (creative, arts and entertainment activities), 91 (libraries, archives, museums and other cultural activities), 92 (gambling and betting activities) and 93 (sports activities and amusement and recreation activities). Note there are no firms with SIC07 91, 92 or 93 in the SSS.

- S Other service activities[63]

A.3 Conversion in the DTS

SIC07 is the primary means of recording industrial classification in the DTS. Thus, no conversion is needed. The 2 digit SIC07 levels in the DTS are:

- 45 Wholesale and retail trade and repair of motor vehicles and motorcycles
- 46 Wholesale trade, except of motor vehicles and motorcycles
- 47 Retail trade, except of motor vehicles and motorcycles

Alternatively, the grouped SIC07 level in the DTS is:

- G Wholesale and retail trade and repair of motor vehicles and motorcycles

B Minor Cleaning of CBI Dataset

Before utilising the CBI dataset, some cleaning techniques are employed. First, firms without a unique identification number are dropped from the sample. For reasons of anonymity, each firm that participates in at least one survey is provided with a unique identification number by the CBI so their responses can be tracked through subsequent survey waves. However, within the dataset a number of survey responses are not paired with a unique identification number. While it could be the case that these survey responses are all generated by one firm there is no guarantee this is true. Therefore, in order to ensure the highest level of accuracy possible all survey responses without a corresponding unique identification number are dropped.

Second, firm responses recorded as N/A are designated as missing responses. For the trichotomous style question regarding what happened to prices/output/average costs in the previous quarter firms can reply up, same, down or N/A. Recording these N/A answers as missing ensures calculating the percentages of firm responses to the survey questions are more accurate.

[63]Consists of 94 (activities of membership organisations), 95 (repair of computers and personal and household goods) and 96 (other personal service activities). Note there are no firms with SIC07 94 or 95 in the SSS.

C Potential Price Indices to be Constructed using CBI Survey Data

The CBI dataset provides (qualitative) price movement data for manufacturing (SIC07 group C), services (SIC07 group H to S) and distributive trades (SIC07 G). Since the CBI also provides industrial classification data, multiple price indices can be constructed based on different aggregations of industrial subtypes. Existing empirical literature, provides an insight into possible classifications. For example, according to Klenow and Malin (2010) service firms changes prices less frequently than manufacturing firms. What follows primarily applies to manufacturing firms (i.e. firms which complete the ITS)

According to Bils and Klenow (2004) and Klenow and Malin (2010) firms which face greater competition should (in theory) display greater flexibility in their prices[64]. The Herfindahl–Hirschman index (HHI) is a measure of market concentration used to assess market competitiveness. A HHI less than 1,500 indicates an unconcentrated industry, a HHI between 1,500 and 2,500 indicates the industry is moderately concentrated, while industries with a HHI above 2,500 are highly concentrated. The Department for Business, Innovation and Skills analysis of key sectors (by SIC2007) measures the HHI at the 5 digit SIC07 level for 2006 to 2015. However, due to the necessary conversion of SIC80 and SIC92 to SIC07 for the ITS and SSS (respectively), the CBI dataset only contains 2 digit SIC07 data. Therefore, an aggregated 2 digit HHI using weights based on 5 digit total employment level (available from the ONS Business Register and Employment Survey dataset)[65] [66]. Unconcentrated 2-digit SIC07 levels in the manufacturing sector include 10, 13, 14, 16, 17, 18, 19, 20, 22, 25, 27 and 32. Moderately concentrated 2-digit SIC07 levels in the manufacturing sector include 15, 23, 26, 28 and 29. Heavily concentrated 2-digit SIC07 levels in the manufacturing sector include 12, 24 and 30.

Durable goods are more flexible with respect to prices than non-durables (Klenow and Malin, 2010). The United States Census Bureau Manufacturers' Shipments, Inventories and Orders lists a set of industries which produce durable goods. At the 2 digit SIC07

[64]Conversely, firms facing lesser competition have stickier prices.

[65]While data is available for SIC07 47, SIC07 49 and SIC07 70 this isn't sufficient to yield significant insights into constructing price indices from the SSS or DTS.

[66]Note the aggregate HHI is constructed using the 2015 5-digit HHI and 2015 5-digit total employment level

level these are 16, 23, 24, 25, 26, 27, 28, 29, 30 and 32.

Cyclical goods change prices more frequently than non-cyclical goods (Klenow and Malin, 2010). Following Klenow and Malin (2010), the cyclical nature of each industrial subsector in the ITS is based on the coefficient obtained from regressing the grouped SIC07 level GVA growth on the industrial sector GVA growth. The results are presented in Table 3 for the ITS. In the manufacturing sector there is evidence of cyclicality for SIC07 level 13, 14, 15, 16, 18, 22, 23, 27, 28 and 29.

Table 3: Cyclicality (Index of Production)

2-Digit SIC07 Level	Coefficient
10	0.326***
13	2.842***
14	2.067***
15	2.038***
16	2.252***
17	0.339***
18	1.149***
19	0.519***
20	0.278***
22	1.339***
23	2.027***
24	0.657***
25	0.973***
26	0.968***
27	1.056***
28	1.449***
29	5.718***
30	0.903***
32	0.837***

Note: 10 Manufacture of food products; 12 Manufacture of tobacco products; 13 Manufacture of textiles; 14 Manufacture of wearing apparel; 15 Manufacture of leather and related products; 16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; 17 Manufacture of paper and paper products; 18 Printing and reproduction of recorded media; 19 Manufacture of coke and refined petroleum products; 20 Manufacture of chemicals and chemical products; 22 Manufacture of rubber and plastic products; 23 Manufacture of other non-metallic mineral products; 24 Manufacture of basic metals; 25 Manufacture of fabricated metal products, except machinery and equipment; 26 Manufacture of computer, electronic and optical products; 27 Manufacture of electrical equipment; 28 Manufacture of machinery and equipment (not elsewhere classified); 29 Manufacture of motor vehicles, trailers and semi-trailers; 30 Manufacture of other transport equipment; 32 Other manufacturing.

Small firms exhibit stickier prices than large firms (Klenow and Malin, 2010). The ONS activity, size and location dataset provides the number of firms in the Inter-Departmental Business Register (IDBR) by SIC07 and the standard employment sizebands[67]. Using the ONS 2021 returns[68] 2 digit SIC07 level industries in the manufacturing sector which are populated primarily by large firms are 19 and 23. Conversely, 2-digit SIC07 level industries in the manufacturing sector which are populated primarily by micro, small and medium firms are 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30 and 32.

Another potential classification is provided by the ONS, which aggregates grouped SIC07 levels B, CC, CD, CG, CH CK and CM into one classification called primary manufacturing[69]. In other words, primary manufacturing consists of mining and the wood, coke, rubber, base metals, machinery and other manufacturing subsectors. Conversely, secondary manufacturing aggregated grouped SIC07 levels are CA, CB, CE, CF , CI, CJ and CL[70]. In other words, secondary manufacturing consists of food, clothing, chemicals, computers, electrical equipment and transport equipment.

In order to examine this further and to provide an empirical justification for any aggregation of the manufacturing sector, a set of binary variables ($Z_{j,t}$) are created taking a value of 1 if industry j is concentrated, durable goods industry, cyclical, large or primary and zero otherwise[71]. Table 4 provides the Spearman correlation for these binary variables.

Denote $\lambda^{p}_{j,t}$ as the proportion of firms in each 2-digit SIC07 level (j) which update their price each quarter (t). Table 5 presents the results of regressing $\lambda_{j,t}$ on the binary classification variables. Results from Table 5 indicate that only the binary variable for primary manufacturing is statistically significant.

Accordingly, based on the results from Table 5 five price indices (including the corresponding flexible price indices) are created: total manufacturing price index, primary manufacturing price index, secondary manufacturing price index, service price index and

[67]The standard employment sizebands are: micro 0-9 employees, small 10-49 employees, medium 50-249 employees and large 250 or more employees.

[68]Which are effectively the same as 2017 - the first year of this ONS dataset.

[69]In terms of 2-digit SIC07 levels this is 7, 8, 9, 16, 17, 18, 19, 22, 23, 24, 25, 28 and 32.

[70]In terms of 2-digit SIC07 levels this is 10, 12, 13, 14, 15, 20, 26, 27, 29 and 30.

[71]For example, concentration is 1 if the 2-digit SIC07 level is moderately or heavily concentrated and 0 if unconcentrated.

Table 4: Spearman Correlation Coefficient

	Concentration	Durability	Cyclical	Large	Primary
Concentration	1				
Durability	0.535	1			
Cyclical	0.162	0.126	1		
Large	0.498	0.187	0.011	1	
Primary	-0.096	0.206	0.033	0.307	1

Note: Concentrated is 1 if industry j is concentrated (0 otherwise), Durability is 1 if industry j is in a durable goods industry (0 otherwise), Cyclical is 1 if industry j is cyclical (0 otherwise), Large is 1 if industry j is large (0 otherwise) and Primary is 1 if industry j is primary manufacturing (0 otherwise).

Table 5: $\lambda_{j,t}$ and Industrial Classifications

	(1)	(2)	(3)	(4)	(5)
	Coeff./SE	Coeff./SE	Coeff./SE	Coeff./SE	Coeff./SE
$\lambda_{j,t}$					
Concentration	-0.045		-0.037		-0.039
	(0.04)		(0.02)		(0.03)
Durable	0.007				
	(0.03)				
Cyclical	0.029			0.026	0.028
	(0.03)			(0.03)	(0.03)
Large	0.028	0.016		0.016	
	(0.03)	(0.03)		(0.03)	
Primary	0.045	0.053	0.051**	0.055*	0.052**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Constant	0.298***	0.297***	0.313***	0.283***	0.298***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Observations	1661	1661	1661	1661	1661
Industries	19	19	19	19	19

Concentrated is 1 if industry j is concentrated (0 otherwise), Durability is 1 if industry j is in a durable goods industry (0 otherwise), Cyclical is 1 if industry j is cyclical (0 otherwise), Large is 1 if industry j is large (0 otherwise) and Primary is 1 if industry j is primary manufacturing (0 otherwise). *p<0.1 **p<0.05 ***p<0.01

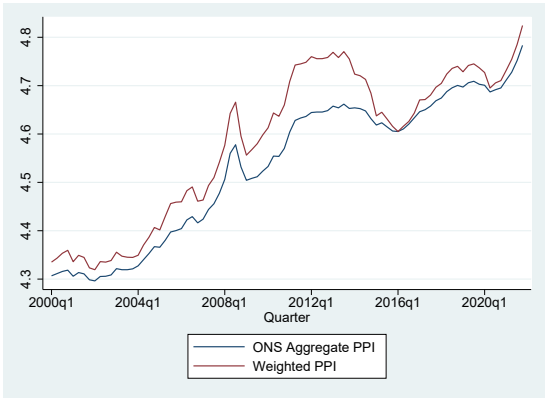
distributive trades price index.

D Comparing Weighted and Unweighted Price Indices

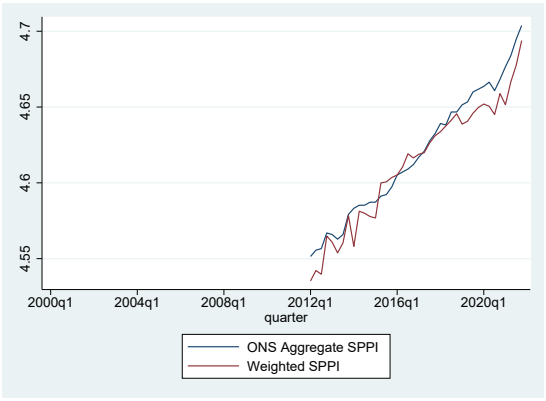
Figure 14a and Figure 14b compares the ONS aggregate price index for manufacturing and services with the weighted versions used in this technical note (respectively). Note since the SSS only has firm responses from two-digit SIC07 levels 49, 50, 51, 52, 53, 56, 62, 68, 70, 77, 86, 90 and 96, only these sectors are included in the weighted services aggregate price level. Figure 14c and Figure 14d present the corresponding output index graphs. In each case, the weighted index (consisting only of industries recorded in the

CBI dataset) corresponds closely with the ONS aggregate series.

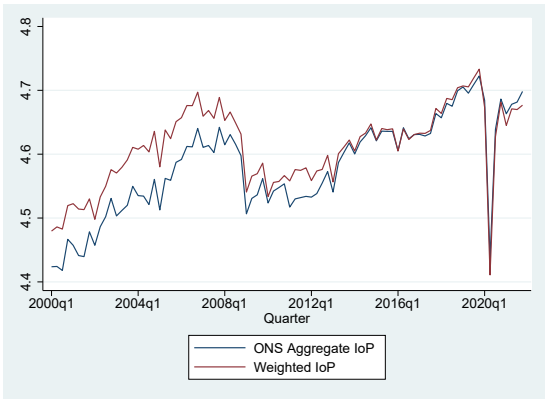
Figure 14: Comparing Weighted and Unweighted Indices



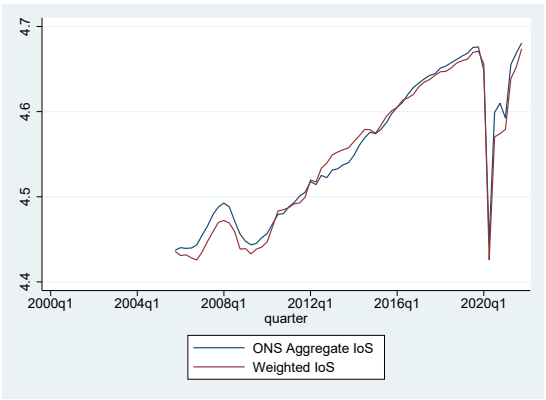
(a) Manufacturing PPI Comparison



(b) Services SPPI Comparison



(c) Manufacturing IoP Comparison



(d) Services IoS Comparison

Note: Base is 2016Q1.