ESTIMATING THE IMPACT OF MINIMUM WAGES ON PRICES

A study for the Low Pay Commission

30 September 2020

Confidential

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ACKNOWLEDGEMENTS

We would like to acknowledge the input of Professors Jonathan Wadsworth, Stephen Machin and Alex Bryson who provided comment on early versions of this study. We would also like to thank Tim Butcher, Emma Hill and Anthony Lord of the Low Pay Commission for providing feedback and facilitating opportunities to test our findings with a range of audiences.

EXECUTIVE SUMMARY

Abstract

We exploit variation in the extent to which sectors and regions in the United Kingdom are exposed to minimum wage labour costs to identify whether increases in the minimum wage are passed through to consumers in the form of higher prices. Using survey data on monthly inflation at the shop level for a highly disaggregated set of consumer products, we find a small but statistically significant price effect for the most exposed products. This is equivalent to a price elasticity with respect to minimum wages between 0.02 and 0.11, with larger effects since the introduction of the National Living Wage in 2016. This finding is robust to the choice of treatment definition and model specification, and is consistent with the findings of similar studies in the United States and Hungary.

Background and approach

As consensus emerged that the effect of minimum wages on employment was broadly neutral in the United Kingdom, the academic literature began exploring other channels through which the effect might be observed, including on consumer prices. This paper builds on the existing literature by exploiting sectoral and regional variation in firms' exposure to minimum wage increases.

We first construct a theoretical model of price setting by monopolistically competitive firms operating in perfectly competitive labour markets with identical, constant return-to-scale production functions. Under these assumptions, the elasticity of prices with respect to minimum wages should equal the share of minimum wage labour costs in total costs for the product market. This identity motivates our empirical strategy and provides a benchmark against which findings can be contextualised.

We use microdata from the Annual Survey of Hours and Earnings and the Annual Business Survey to identify sector and region combinations that are more or less likely to be exposed to increases in the minimum wage. The most exposed sectors are those related to cleaning services, the provision of care and the preparation and service of food and drink. The most exposed regions are North West and North East. We then map these to monthly consumer price data at the item and region level and Low Pay Commission data on the minimum wage rate applicable to adults aged 25 and over.

We use a panel model specification to test whether these 'exposed' firms raised consumer prices more in months where minimum wages increased than at other times of the year. We also test four alternative specifications to validate our findings: measuring anticipation and lagged effects; including a control group of less exposed item/regions; using a continuous measure of minimum wage exposure as the treatment variables; and testing the effect of introducing the National Living Wage (NLW) in April 2016.

Findings

Descriptively, we observe that inflation is higher in minimum wage uplift months than at other times of the year: 0.04 percentage points higher for the treatment group compared to 0.06 percentage points lower for the control group.

Using our panel model specification, which controls for a range of confounding factors, we find that inflation is **0.08 percentage points** higher in months where the minimum wage was uplifted, significant at the 1% level. Limiting the sample to the period after the introduction of the NLW in 2016, we find that inflation is **0.20 percentage points** higher in months where the minimum wage was uplifted, also significant at the 1% level.

This finding is not sensitive to the specification of standard errors or to the choice of control variables, although the effect is smaller in the absence of month fixed effects. The finding is somewhat sensitive to the choice of treatment definition but remains significant at the 5% level. Of note, the size of the effect doubles if a narrower definition of exposure is used to define treated item/regions, consistent with expectations.

The finding is not sensitive to including controls to capture anticipation and lagged effects. From 2016 onwards, inflation remains 0.20 percentage points higher in uplift months and is **0.59 percentage points** higher over the three-month period starting with the uplift month (significant at the 1% level).

The finding is not sensitive to including control item/regions in the specification. The effect of minimum wage uplift on treated item/regions over the full period is **0.11 percentage points** higher than it is for control item/regions (significant at the 5% level).

The finding is not sensitive to using a continuous measure of minimum wage uplift, rather than a binary measure. The elasticity of prices with respect to minimum wage uplift over the full period is **0.02**, consistent with the interpretation of the core specification.

Using a difference-in-differences approach with a synthetic control group, we find some evidence of a long-term effect of the introduction of the NLW on prices, but the finding is sensitive to the model specification.

Interpretation and conclusions

Overall, we find strong evidence of a statistically significant relationship between minimum wage uplift and the prices of exposed products. However, the effect is small relative to the size of the increase in minimum wages: equivalent to an elasticity of prices with respect to minimum wage of between **0.02** and **0.11**.[1] In other words, a 10% increase in the minimum wage would be expected to increase prices by 0.2% to 1.1%.

This is lower than the elasticity predicted by the theoretical framework of 0.2 to 0.4 but is similar to those studies elsewhere in the literature that identify a significant effect. Notably, Harasztosi and Lindner (2019) find an elasticity of prices with respect to minimum wages of **0.07 to 0.14** in Hungary, Aaronson (2001) finds an elasticity of **0.07** in North America and Aaronson et al. (2005) find an elasticity of **0.07 to 0.15** in the United States.

[1] The lower-bound reflect the elasticity for the period since 2010, ignoring any lagged effects. The upper-bound reflects the elasticity for the period since 2016, including the elevated inflation in the two months following uplift.

1 INTRODUCTION

Much of the early research into the unintended economic consequences of minimum wages focused on employment effects. However, as a consensus emerged that these were broadly neutral in the UK, the literature began exploring other channels through which the effect might be observed, including changes in hours, productivity, profitability and consumer prices.

There is a small body of literature testing the relationship between wage floors and consumer prices in the UK. Wadsworth (2010) studies the effects of introducing and increasing UK National Minimum Wage on the price of goods and services, comparing sectors where minimum wage workers account for a substantial share of total costs to those where they do not. He finds limited evidence that prices were higher in the months corresponding to the minimum wage uplift, but stronger evidence of a long-term effect in the years following the introduction of the minimum wage.

Draca et al. (2005) examine the impact that the 1999 introduction of the National Minimum Wage had in three 'exposed' sectors (restaurants, canteens and take-away food) but find no evidence of a price effect. Machin et al. (2003) consider the impact in the residential care sector and also find no effect, although they note that the sector was price regulated.

Elsewhere, there is stronger evidence of price effects; see Lemos (2008) or MaCurdy (2015) for a summary. Harasztosi and Lindner (2019) exploit a large increase in the minimum wage in Hungary and firm-level data, finding that the doubling of the minimum wage led to a 7% to 14% increase in prices over a four-year period. The authors also find strong evidence that prices of non-tradable products are more likely to rise than those of products that are exposed to international competition. Aaronson et al. (2005) use store-level data on restaurant prices in the USA to show an unambiguous price effect that is stronger where the store employs more minimum wage workers and when the minimum wage increase is larger.

Card and Krueger (1995) find that minimum wages led to a small price increase in their sample of affected New Jersey fast-food restaurants. Aaronson (2001), also examining fast-food prices, finds that a 10% increase in the minimum wage raises prices by <1%, particularly when overall inflation is high. MacDonald and Aaronson (2006) find most fast-food restaurants only raised prices on a subset of their product range in response to higher minimum wages, suggesting item-specific fixed costs.

This paper builds on the existing literature in two ways:

- We use monthly price data on a broad sample of over 700 'items'; and
- We measure prices and minimum wage exposure at the region level, rather than using national averages.

We use data from the Annual Survey of Hours and Earnings (ASHE) and the Annual Business Survey (ABS) to identify sectors and regions that are more or less likely to be exposed to increases in the minimum wage, mapping these to monthly consumer price data at the item and region level. We then test whether

these ‘exposed’ firms raised consumer prices more in months where minimum wages increased than in other months.

The remainder of this paper proceeds as follows. **Section 2** sets out the institutional context of minimum wage setting in the UK, and describes the theoretical framework underpinning our analysis. **Section 3** sets out the data sources we use to construct the variables for the analysis. **Section 4** describes the analytical approaches we employ to identify the empirical relationship, as well as the sensitivity and robustness checks conducted. **Section 5** presents the findings of the analysis, including descriptive statistics, robustness checks and alternative specifications. **Section 6** concludes.

2 INSTITUTIONAL CONTEXT AND THEORETICAL FRAMEWORK

Institutional context

In April 1999, the UK Government imposed a universal statutory minimum wage on employers. The Low Pay Commission (LPC), an independent public body, makes recommendations to government on the size of any minimum wage uplift, based on monitoring and evaluation evidence.

Since the introduction of the National Living Wage (NLW) in 2016, the minimum wage has been uplifted in April. The LPC typically makes its recommendation in October the previous year, with the government announcing its reaction to the recommendation in December.

There are now three minimum wage rates:

- the NLW for those aged 25 and over;
- age-specific minimum wages for those aged 21-24, 18-20 and 16-17; and
- an apprenticeship rate.

The minimum wage applicable to those aged 25 and over has increased substantially: from £3.60 in 1999 to £8.72 in 2020, equivalent to an average annual increase of 4.3% in nominal terms (see Figure 1).

The annual uplift was relatively high in the early part of the 21st century, but growth slowed to an average annual increase of 2.5% in the years following the financial crisis (2008 to 2015).

Figure 1 Minimum wage for those aged 25 and over

Source: *Low Pay Commission (2019), '20 years of the National Minimum Wage: A history of the UK minimum wage and its effects'.*

Note: *Nominal prices. Prior to April 2016, the applicable rate for those aged 25 years and over was known as the National Minimum Wage; from April 2016 it was known as the NLW.*

The introduction of the NLW in 2016 increased the applicable minimum wage by 10.8% above the previous April, and annual growth averaged 6.1% between 2015 and 2020. The minimum wage is now equivalent to 60% of median earnings.

The Low Pay Commission (2019) estimated that around 2 million jobs, 7% of the UK total, are directly affected by all minimum wages, not including spillover effects. However, this necessarily affects some sectors and regions of the economy more than others, variation which we exploit in this study.

Theoretical framework

Microeconomic theory suggests that a firm's ability to raise prices in response to an increase in input costs depends on a number of factors:

- the price elasticity of demand for the good;
- the degree of competition in the product market, and the extent to which competitors are subject to the price shock; and
- the firm's ability to substitute to alternative inputs or increase factor productivity.

We formalise this framework using a stylised version of the Hicks-Marshall style model described in Harasztosi and Lindner (2019). We consider a market of monopolistically competitive firms in a partial equilibrium framework, assuming that firms have identical, constant return-to-scale production functions and operate in perfectly competitive labour markets.

Consumer problem. Harasztosi and Lindner (2019) show that if consumers have a nested constant elasticity of substitution utility function, the demand response to a price increase (e_i) depends on the fraction of firms that raise prices.

If only one firm raises prices, then the demand response for that firm will be relatively high as consumers can readily substitute with similar products. The demand response is given by the following equation, where $-\kappa$ is the elasticity of substitution between different varieties within the product market:

$$e_i = \frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i} = -\kappa \quad (1)$$

We can show that if all firms in a product market raise their prices, the demand response for a given variety will be smaller, such that $e_i \in (-\kappa, 0)$, reflecting consumers' willingness to substitute for other goods outside the product market.

Firm problem. We know that if firms face a constant return-to-scale production function with three inputs (minimum wage labour l_m, high-wage labour l_h and capital k with costs w_m, w_h and r respectively), marginal cost is given by:

$$MC_i = l_m w_m + l_h w_h + kr \quad (2)$$

Also, in perfectly competitive markets, profit-maximising firms set marginal revenue to equal marginal cost:

$$MR_i = \frac{\partial R_i}{\partial \mathrm{q_i}} = \frac{\partial (p_i q_i)}{\partial \mathrm{q_i}} = p_i + q_i \frac{\partial p_i}{\partial \mathrm{q_i}} = p_i\left(1 + \frac{\partial p_i}{\partial \mathrm{q_i}}\frac{q}{\mathrm{p}}\right) = p_i\left(1 + \frac{1}{e_i}\right) \quad (3)$$

$$p_i\left(1 + \frac{1}{e_i}\right) = MC_i$$

$$p_i = \frac{MC_i}{1 + e_i^{-1}} = \frac{MC_i}{1 - \kappa^{-1}} \quad (4)$$

So, as κ is a constant, the relationship between prices and minimum wages can be defined as:

$$\frac{\partial \log p_i}{\partial w_m} = \frac{\partial \log MC_i}{\partial w_m} = \frac{\partial MC_i}{\partial w_m}\frac{1}{MC_i} = \frac{l_m}{MC_i} \quad (5)$$

Multiplying through by the minimum wage in order to express the left-hand side as the percentage change in price resulting from a percentage change in minimum wages, we see that this is equal to the share of minimum wage labour costs in total costs s_i:

$$\frac{\partial p_i}{\partial w_m}\frac{w_m}{p_i} = \frac{l_m w_m}{MC_i} = s_i \quad (6)$$

From this identity, we can draw two conclusions:

- First, the effect of a minimum wage increase on prices will be proportional to the importance of minimum wage labour costs in the production functions of firms in the product market.
- Second, the effect of a minimum wage increase on prices will be proportional to the share of firms in the product market that are affected by the minimum wage increase.

These two observations inform the identification strategy set out in Section 4: we exploit variation in the share of minimum wage labour in the production functions of firms, and variation in the degree to which products are tradable (which influences the share of firms affected by the minimum wage increase).

Price-adjustment mechanism. In our stylised model, firms do not incur price-adjustment costs, and therefore respond instantaneously to a minimum wage shock without lags or anticipation. However, empirical evidence suggests that firms adjust prices only once or twice per year with larger firms and firms operating in competitive markets likely to adjust prices more often, see e.g. Hall et al. (2000), Bils and Klenow (2004), Nakamura and Steinsson (2008). Alvarez et al. (2006) note that firms in the food service sector adjust their prices most often, with non-food service industry sectors adjusting prices least often.

These frictions may make it more difficult to empirically observe the effect of minimum wage uplift in the month that it occurs.

3 DATA SOURCES

This study draws on evidence from four datasets:

1. ONS Consumer Price Inflation price quotes by item, region and month, published on the ONS website;[2]
2. Annual Survey of Hours and Earnings (ASHE) microdata on a sample of hourly wages by sector and region, accessed from the ONS Secure Research Service;[3]
3. Annual Business Survey (ABS) aggregated data on turnover, gross value added (GVA) and employment costs by sector, published on the ONS website;[4] and
4. Low Pay Commission (LPC) data on the adult minimum wage over time, published in the 2019 report '20 years of the National Minimum Wage'.[5]

This section describes how these sources were used to construct the dependent and independent variables for the empirical analysis.

Dependent variables

First, we construct a measure of **monthly and year-on-year consumer price inflation**. The unit of analysis is item/region.

- **Items** are the product categories used by the ONS to construct the consumer price index, one level of granularity below sub-classes in the United Nations' Classification of Individual Consumption by Purpose (COICOP): for example, 'Minicab fare for 2 miles', 'Hair gel 150-200ml' and 'Electrician daytime rate per hour'. Items can be aggregated into sub-classes, classes, groups and divisions. Note that these are consumer goods and services only, and do not include intermediate goods and services purchased by businesses.
- **Regions** are the 12 UK NUTS1 regions: North East, North West, Yorkshire and the Humber, East Midlands, West Midlands, South West, East of England, London, South East, Wales, Scotland and Northern Ireland.[6]

We extract monthly price quotes from January 2010 to January 2020 inclusive for approximately 700 items and aggregate to the item/region level. There are approximately 140,000 quotes per month, but this translates to approximately 20

[2] ONS, 'Consumer price inflation item indices and price quotes', accessed 1 March 2020, https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/consumerpriceindicescpiandretailpricesindexrpiitemindicesandpricequotes

[3] Statistical data from ONS are Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. Research datasets may not exactly reproduce National Statistics aggregates.

[4] ONS (2019), 'Annual Business Survey: Non-financial business economy UK, 2018 provisional results', https://www.ons.gov.uk/releases/nonfinancialbusinesseconomyukannualbusinesssurvey2018provisionalresults

[5] Low Pay Commission (2019), '20 years of the National Minimum Wage: A history of the UK minimum wage and its effects'.

[6] This is a high level of regional aggregation, and there is likely to be substantial within-region variation in inflation (and minimum wage exposure) not captured at this level. However, the ONS does not publish more detailed geographic descriptions of price quotes, and sample sizes would anyway be too small for robust analysis.

quotes per month for each item/region. This small sample is a limitation of region-level analysis.

We chain link the monthly aggregates to construct a Jevons geometric price index for each item/region.

Independent variables

Next, we use data from **ASHE**, **ABS** and the **LPC** to identify sector and region combinations that are more or less likely to be exposed to increases in the minimum wage, informed by our theoretical model which suggests that the price response to a minimum wage increase should be proportional to the share of minimum wage labour costs in total costs (see Equation 6, Section 2).

- **Sectors** are the four-digit SIC sectors used by the ONS. For example: SIC 88.91 'Child day-care activities', SIC 58.13 'Publishing of newspapers' and SIC 93.11 'Operation of sports facilities'.
- **Regions** are the 12 UK NUTS1 regions, excluding Northern Ireland which is not included in ASHE.

First, sector/regions in which a large number of employees are paid at or just above the prevailing minimum wage are more likely to face an increase in input costs if the minimum wage is increased, and therefore more likely to increase prices.

To account for this, we extract employee-level data from ASHE and match this with the LPC's timeseries data on the minimum wages applicable to adults aged 25 years and over to construct a measure of **the share of workers earning less than or equal to the incoming minimum wage** in each sector/region. For example, an employee earning £7.00 per hour on January 2016 would be considered below the incoming minimum wage of £7.20. We pool over all observations between January 2015 and December 2018 to ensure a sufficient sample and exclude sector/regions for which there were fewer than 10 observations.[7] Of those remaining, the median sector/region has 50 observations, suggesting that the pooled sample size is sufficient to draw inferences about the share of minimum wage workers at the sector level.[8] Note that this approach implicitly assumes that the exposure of a sector/region to minimum wages is constant over time.

Second, sector/regions for which employment costs constitute a high share of total costs are also more likely to be affected by an increase in the minimum wage.

To account for this, we construct a measure of **employment costs as a share of total turnover** at the four-digit SIC level using published ABS aggregates.[9] For example, in 2016, SIC 45.20 (Maintenance and repair of motor vehicles) employment costs and turnover were £4.2 billion and £24.1 billion respectively,

[7] 3,500 of the 7,700 sector/regions were suppressed because they had fewer than 10 observations. We construct variants of the dataset with supressed sector/regions inferred from data aggregated to the sector and region levels and find no significant impact on the treatment assignment, suggesting that small samples are not common in sectors and regions that are highly exposed to minimum wage increases.

[8] Off the 100 most exposed sector/regions, the median number of observations is 269 observations, suggesting that sample sizes are substantially higher for exposed sector/regions.

[9] Where aggregates are not available at the four-digit level, we revert to three-digit or two-digit level aggregates accordingly.

implying an employment cost share of 17.6%. Again, we take the average cost share for 2015 through 2018.

Finally, we take the product of these two values to construct a measure of how 'exposed' each sector/region is to an increase in the minimum wage. This measure is a proxy for the share of minimum wage labour costs in total costs, the s_i term in Equation 6, Section 2:

$$\frac{L_m}{L_m+L_h} \times \frac{L_m w_m + L_h w_h}{Revenue} \approx \frac{l_m w_m}{MC_i} = s_i$$

where L_m and L_h are the total quantities of minimum wage and high wage labour employed at wages w_m and w_h respectively, and l_m is the quantity of minimum wage labour required to produce one product.

It is an imperfect proxy for three reasons:

- The first term is based on the share of workers earning less than or equal to the incoming minimum wage in a sector/region, rather than the share of the sector/region's wage bill attributable to workers earning less than or equal to the incoming minimum wage. We expect the ratio between the share of workers and the share of wages to be relatively consistent between sectors and leave this refinement for future work.
- The second term is calculated as a share of turnover, rather than as a share of total costs, because of limitations in published ABS data. Given mark-up is constant, assuming a constant returns to scale production function, turnover is proportional to marginal cost. The rationale for choosing turnover is discussed further in Box 1.
- The measure does not account for the share of the product market that is not required to pay UK minimum wages: notably overseas firms. This limitation is addressed by excluding tradable items from the sample, discussed in the following section.

BOX 1: TURNOVER OR GVA?

The theoretical model in Section 2 suggests that firms' response to a minimum wage increase is to raise prices by the product of the percentage increase in minimum wages and the share of minimum wage labour costs in total costs for that product market. The ideal denominator at the firm level is therefore total costs. ABS gives us a choice of two proxies: turnover or GVA.

If a firm's GVA accounts for most of its turnover, for example cleaning, care work and professional services, both $\frac{L_m w_m}{GVA}$ and $\frac{L_m w_m}{Revenue}$ are good predictors of a firm's price response to a minimum wage increase $\frac{\partial p_i}{\partial w_m}\frac{w_m}{p_i}$.

But if a firm's GVA is small relative to turnover, for example in wholesaling, both measures are flawed:

- Using $\frac{L_m w_m}{GVA}$ assumes that the share of minimum wage labour costs on GVA is identical for the producers of non-labour inputs.

- Using $\frac{L_m w_m}{Revenue}$ assumes that minimum wage labour is not required to produce any of the non-labour inputs to the product.

Without correspondence tables identifying the combination of sectors that are collectively responsible for producing, distributing and/or retailing a given item, we are unable to avoid these assumptions. However, for the set of sector/regions that are most exposed and have substantial non-employment costs (mostly food services), it is reasonable to assume that most of these inputs are tradable and therefore not particularly exposed to minimum wage increases. For this reason, we calculate exposure using minimum wage labour costs as a share of turnover in our core specification but test minimum wage labour costs as a share of GVA as a sensitivity.

By constructing an ordinal ranking of the exposure measure, we are able to identify sector/regions that are more likely to be affected by an increase in the minimum wage, and those that are less likely.

Figure 2 presents the 100 sector/regions with the highest exposure to a minimum wage increase, along with the exposure measure. Note that we remove all 'Libraries, archives, museums and other cultural activities' (SIC 91) where turnover is not a reliable proxy for total costs.

Figure 2 List of sector/regions highly exposed to increases in the minimum wage

	NW	NE	WA	EM	YH	WM	SC	EE	SW	SE	LN
General cleaning of buildings	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.3	0.3
Child day-care activities	0.3	0.4	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2	
Take-away food shops and mobile food stands	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	
Pre-primary education	0.3	0.3		0.3	0.3		0.3	0.2	0.2	0.3	
Other food services		0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	
Residential nursing care facilities	0.3	0.3	0.3	0.3	0.3	0.2		0.2			
Washing and cleaning of textile/fur products	0.2		0.2	0.2	0.2	0.3	0.2	0.3			0.2
Social work activities without accommodation	0.3	0.2	0.2	0.2	0.2	0.2					
Restaurants and mobile food service		0.2	0.2	0.2	0.2						
Other residential care activities n.e.c.	0.2	0.3			0.2						
Medical nursing home activities			0.2	0.2			0.3				
Hairdressing and other beauty treatment	0.2	0.2	0.2								
Activities of amusement/theme parks	0.2					0.2				0.2	
Window cleaning services	0.3	0.3									
Residential care activities		0.2	0.2								
Other cleaning services						0.2					0.2
Retail sale of bread, cakes etc. in sp. stores			0.2			0.2					
Other building and industrial cleaning activities	0.3										
Activities of call centres							0.2				
Temporary employment agency activities				0.2							
Human resources provision/management		0.2									
Private security activities	0.2										
Specialised cleaning services									0.2		

Sports and recreation education	0.2

Source: *Frontier Economics*

Notes: *Note that SIC 56.10 (Restaurants and mobile food service activities) is included alongside the more granular sector 56.10/3 (Take-away food shops and mobile food stands). This is to facilitate mapping from items that may be provided at licensed restaurants, unlicensed restaurants or take-away food shops.*

The most exposed sectors are those related to cleaning services, the provision of care, and the preparation and service of food and drink. This is broadly consistent with the sectors that Wadsworth (2010) found to be most exposed in 1998/99 and 2004/05, with one notable exception: we do not find that 'Taxi operation' appears in the 100 most exposed sector/regions.

The most exposed regions are North West and North East, which occur 13 times in the 100 most exposed sector/regions. By contrast, South West and South East only occur six times each in the top 100 and London only occurs three times.

For robustness, we construct two alternative measures of minimum wage exposure:

- First, using an alternative measure of labour-cost share, dividing employment costs by GVA rather than turnover.
- Second, limiting the ASHE sample to employees aged 25 and over. Younger employees face lower minimum wages (although age thresholds vary over time). Excluding young employees reduces the risk that the share of low-paid employees is overstated for certain sector/regions but also reduces sample sizes.

The ranking of the most exposed 100 sector/regions is not particularly sensitive to the choice of measure.

- Using GVA as the denominator for the labour cost share measures results in a number of retail and food services sector/regions moving into the top 100, at the expense of social care and cleaning sector/regions. This reflects the fact that, as GVA accounts for a smaller share of turnover in retail and food services sectors than in social care and cleaning, employment costs make up a relatively greater share of GVA.
- Using only data for employees aged 25 and over results in some sector/regions dropping out because there are too few observations in ASHE.

BOX 2: COMPARISON WITH MEASURING EXPOSURE AT THE SECTOR LEVEL

In Frontier Economics (forthcoming), we use similar data but measure exposure to minimum wages at the sector level, rather than the sector/region level. In theory, measuring exposure at the sector/region level should provide a treatment group that more effectively isolates the most exposed firms. This holds in practice:

- There are ten sector/regions more exposed to minimum wage increases than the most exposed aggregate sector (SIC 81.21 General cleaning of buildings), including eight SIC 81.21 sector/regions, SIC 88.91 (Childcare activities) in North East and SIC 85.10 (Pre-primary education) in Yorkshire and the Humber.
- There are 241 sector/regions more exposed to minimum wage increases than the 20th most exposed sector (SIC 86.10/2, Medical nursing home activities).

All of the 20 most exposed aggregate sectors appeared at least once in the 100 most exposed sector/regions. The exception was SIC 56.30 (Beverage servicing activity) where the most exposed sector/region was 114th.

We also use LPC data on the effective nominal minimum wage faced by 25-year-olds who are not apprentices to construct two additional independent variables:

- a binary variable capturing **whether the minimum wage increased** in a given month; and
- a continuous variable capturing the **percentage change in the minimum wage** in a given month.

Figure 1 shows the nominal minimum wage faced by adults aged 25 years and over from 1999 to 2020, along with the percentage change in the minimum wage in months where it was adjusted. Note that from 2016 (the introduction of the NLW), minimum wage increases took place in April rather than October, as they had in previous years.

Data linking

Finally, we link the dependent variables (measured by item/region) to the independent variables (measured by sector/region) in order to construct a consistent dataset for empirical analysis.

The objective of this linking is to assign each item/region a measure of exposure to changes in the minimum wage. Ideally, this would be done using published UK or international correspondence tables identifying the combination of sectors that are collectively responsible for producing, distributing and/or retailing a given item. However, in the absence of such tables, this process is completed manually with each item being linked to the sector judged to account for the highest share of gross value added at the point of consumption. For example:

- 'Dry cleaning-man's suit' is mapped to SIC 96.01 (Washing and (dry-)cleaning of textile and fur products).
- 'Washing machine repair' is mapped to SIC 95.22 (Repair of household appliances and home and garden equipment).
- 'Fish & chips takeaway' is mapped to SIC 56.10/3 (Take away food shops and mobile food stands).

Of the more than 700 items in the dataset, approximately 600 are considered tradable, in that a substantial share of the inputs to the finished product are subject to international competition, for example: 'Canned tomatoes 390-400g', 'Liquid soap 200-300ml' and 'Home office desk'. While the retail component of these items is largely non-tradable, we would expect firms producing the items to face competition from international firms, making it difficult for domestic firms to pass on the cost of a minimum wage increase to consumers (see Section 2). Harasztosi and Lindner (2019) demonstrate this empirically using evidence from a minimum wage shock in Hungary.

Moreover, the prices of tradable items are likely to be affected by a range of macroeconomic factors such as exchange rates and oil prices that render them an inappropriate control group for non-tradable items. For this reason, they are not mapped to a particular sector/region and are excluded from the core analysis. A full correspondence table from non-tradable items to sectors is presented as ANNEX A.

Figure 3 describes the structure of the dataset before and after the data linking.

Figure 3 Dataset structure before and after linking

Variable type	Variable	Aggregation	Aggregation after linking
Dependent	Monthly inflation	Item/Region/Month	Item/Region/Month
	Year-on-year inflation	Item/Region/Month	Item/Region/Month
Independent – treatment	Minimum wage exposed (binary)	Sector/Region →	Item/Region
Independent – time	Minimum wage uplift (binary)	Month	Month
	Minimum wage uplift (continuous)	Month	Month

Source: Frontier Economics

Importantly, constructing the dataset at the item level has implications for the interpretation of the findings. An item/region-level dataset may overweight some items with respect to their share of economic activity (the ONS over-samples some classes where the between-item price variability is high).[10] Conversely, a sector/region-level dataset might overweight sectors that account for a relatively smaller share of economic activity. This could be addressed in further research by applying weighting to each item or sector. In this paper, we test the sensitivity of the findings to excluding some sectors (such as food services) for which a disproportionately large number of items are surveyed.

In total:

- There are 172 non-tradable item/regions which map to the 50 most exposed sector/regions.
- There are a further 200 non-tradable item/regions which map to the next 50 most exposed sector/regions.
- There are a further 957 non-tradable item/regions which do not map to the 100 most exposed sector/regions.

[10] ONS (2019), 'Consumer Price Index Technical Manual'.

In our core treatment definition, treated items are those which map to the 100 most exposed sector/regions (sample=372) and control items are the set of non-tradable items which do not map to the 300 most exposed sectors (sample=543). Item/regions ranked 101 to 300 are excluded from the specification.

For robustness, we test two alternative treatment definitions.

- First, we consider only those tradable items which map to the 50 most exposed sector/regions as treated (sample=172). The control group is unchanged (sample=543).
- Second, we use a continuous measure of treatment, normalised such that items mapping to the most exposed sector/region (General cleaning of buildings in West Midlands) are coded as 1 and items mapping to the least exposed sector/regions (Funeral services in London) are coded as 0. Tradable items are excluded (total sample=1,268).

We add these definitions to the definitions of minimum wage exposure discussed above to construct five treatment definitions.

BOX 3: TREATMENT DEFINITIONS

1. Labour cost share is measured as employment costs over **turnover**; share of low-paid employees is measured for **all employees**; item/regions are listed as treated if they map to one of the **100 most exposed** sector/regions.
2. Labour cost share is measured as employment costs over **turnover**; share of low-paid employees is measured for **all employees**; item/regions are listed as treated if they map to one of the **50 most exposed** sector/regions.
3. Labour cost share is measured as employment costs over **gross value added**; share of low-paid employees is measured for **all employees**; item/regions are listed as treated if they map to one of the **100 most exposed** sector/regions.
4. Labour cost share is measured as employment costs over **turnover**; share of low-paid employees is measured for **employees aged 25 and over**; item/regions are listed as treated if they map to one of the **100 most exposed** sector/regions.
5. Labour cost share is measured as employment costs over **turnover**; share of low-paid employees is measured for **all employees**; item/regions are assigned a continuous measure of treatment $\in (0,1)$.

Notes: Treatment definition 5 is only used for identification strategies that include a control group.

4 ANALYTICAL APPROACH

To estimate the impact of minimum wages on prices, we employ a panel regression approach.

Limiting the sample to treated item/regions only, we test whether monthly inflation is higher in months during which the minimum wage was uplifted. The core specification is as follows:

$$inflation_{m,i} = \alpha + \beta_1 \times uplift_m + \gamma_i + \delta_m + inflation_{m-1,i} + \epsilon_{m,i}$$

Where:

- $inflation_{m,i}$ is the month-on-month percentage change in price index for each item/region *i* and month *m*;
- $uplift_m$ is a binary variable equal to one if the minimum wage increased in that month and zero if it did not;
- γ_i is an item/region fixed effect (to capture between-item/region variation in inflation);
- δ_m is a month fixed effect (to capture seasonality);
- $inflation_{m-1,i}$ is a lagged dependent variable (to account for autocorrelation in the inflation time series); and
- Clustered standard errors (region) are specified to account for the ONS sampling approach.

The coefficient β_1 can be interpreted as the difference between monthly inflation in minimum wage uplift months, and monthly inflation in months where there was no minimum wage uplift, in other words: the additional impact of minimum wage increases on prices for treated items.

In addition to testing the sensitivity of our findings to using different treatment definitions (see Box 3) and different control variables and error terms, we also test four alternative empirical specifications:

- a specification that controls for lags and leads before and after the uplift month, to account for potential anticipated or lagged responses to an increase in minimum wages;
- a specification that includes both treatment and control item/regions and tests the interaction of treatment and minimum wage uplift (rather than testing the uplift effect on treated item/regions);
- a specification where uplift is a continuous variable measuring the percentage change in minimum wage in each month (the coefficient on percentage change can be interpreted as the price elasticity of minimum wages); and
- a difference-in-differences specification to identify whether the substantial minimum wage increase in April 2016 had a different impact of treated item/region and a synthetic control group.

5 FINDINGS

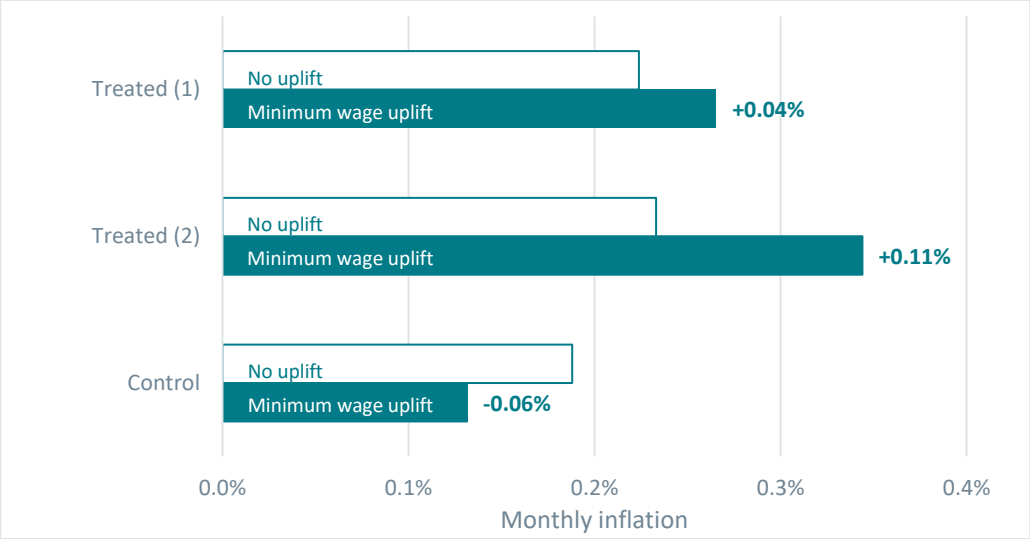
5.1 Core findings

Descriptive statistics

Descriptively, we observe that inflation is indeed higher in minimum wage uplift months than for months in which there is no uplift: 0.04 percentage points higher for the core treatment definition (1) compared to 0.06 percentage points lower for the control group. This finding is not sensitive to the choice of treatment definition, and the difference between uplift and non-uplift months is larger for a more narrowly defined treatment group (2) (see Figure 4).

If we overlay monthly inflation for treated item/regions on the months in which the minimum wage was uplifted, we observe some correlation, particularly from 2014 onwards (see Figure 5).

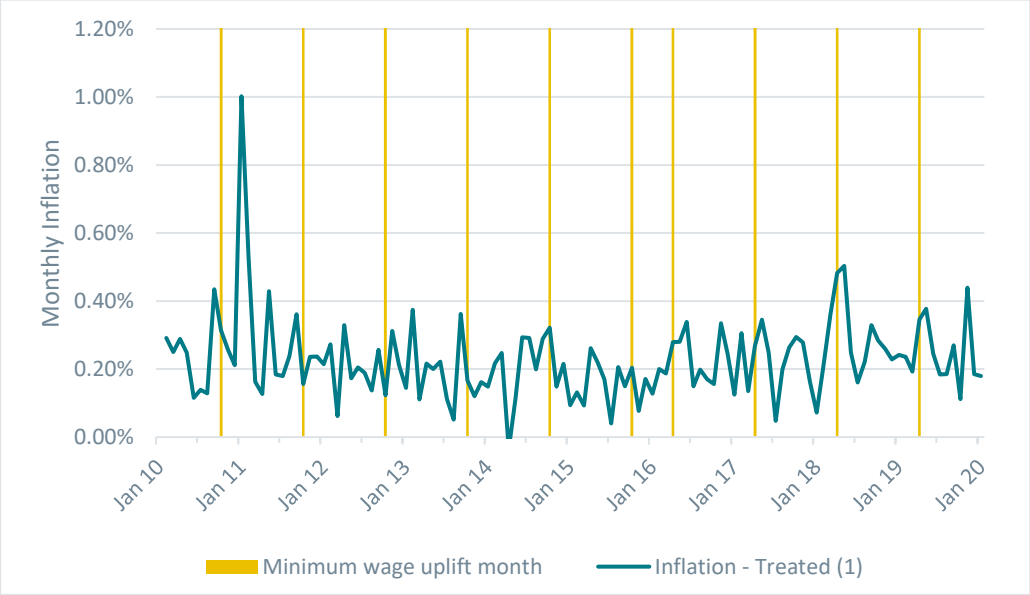
Figure 4 Monthly inflation in the minimum wage uplift months (compared to non-uplift months)



Source: *Frontier Economics*

Note: *Treated (1) refers to the core treatment definition. Treated (2) refers to those items that map to the 50 most exposed sector/regions.*

Figure 5 Monthly inflation over time – treated items



Source: Frontier Economics

Core specification

Using the core panel specification outlined in Section 4, we find that inflation is **0.081 percentage points** higher in months where the minimum wage was uplifted, significant at the 1% level (see Figure 6, column 1).

- The finding is not sensitive to the inclusion of lagged inflation in the specification.
- The finding is not sensitive to the specification of standard errors: the coefficient remains significant at the 1% level with regular standard errors, robust standard errors, or if errors are presumed to be clustered by item/region.[11]
- The finding is not sensitive to the inclusion of item/region fixed effects, but is sensitive to the inclusion of month fixed effects. Without month fixed effects, inflation was only 0.048 percentage points higher in uplift months, significant at the 5% level.

Figure 6 shows that the finding is somewhat sensitive to the treatment definition (see Box 3 for a definition of the four treatment definitions used in the panel analysis).

- Limiting the definition to only those items that map to the 50 most exposed sector/regions (specification 2) roughly doubles the effect of uplift month, which remains significant at the 1% level.
- Using gross value added as the denominator for labour cost share (specification 3) reduces the size and statistical significance of the effect marginally.
- Considering only employees aged 25 and over when calculating which sector/regions are exposed to minimum wage increases has a negligible effect.

[11] The coefficient is only significant at the 5% level if standard errors are assumed to be clustered by item.

Figure 6 Effect of minimum wage uplift on inflation

	Dependent variable: Percentage change in the item price index			
	(1)	**(2)**	**(3)**	**(4)**
MW uplift month	**0.081** (0.019)***	**0.171** (0.05)***	**0.066** (0.027)**	**0.076** (0.018)***
Sample	35,121	16,711	40,204	39,354
Adj. R^2	0.025	0.019	0.020	0.027

Source: *Frontier Economics*

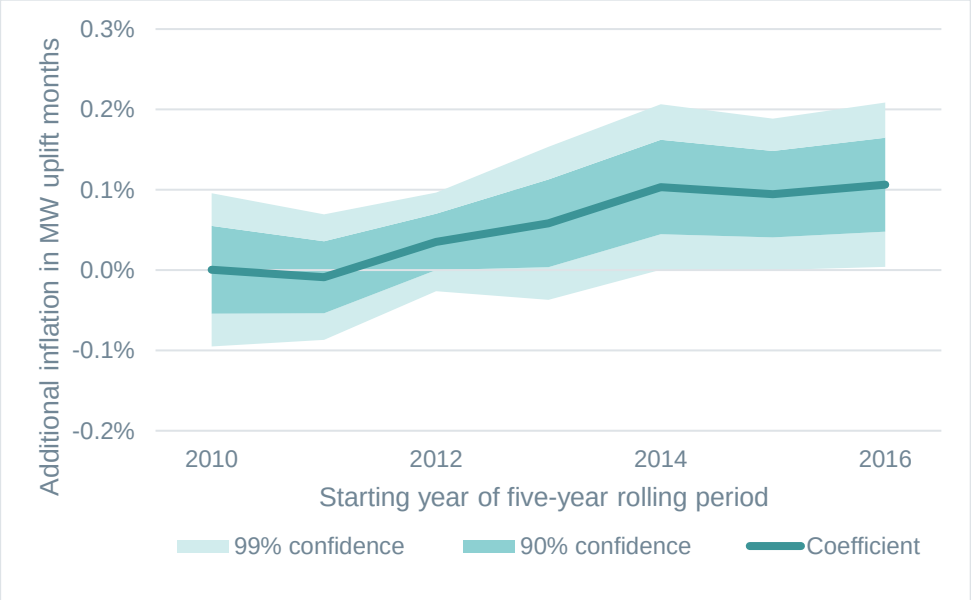
Note: *Clustered standard errors (by region) in parentheses; Significant at the 1% (***), 5% (**) and 10% (*) levels.*

To put these coefficients in context, the mean minimum wage increase over the period was 3.55%. So for the set of item/regions in the core specification, the elasticity of prices with respect to the minimum wage (the term defined in Equation 6, Section 2) is approximately 0.023. In other words, a 10% increase in the minimum wage could be expected to increase prices by 0.23%. This elasticity is significantly lower than the share of minimum wage labour costs in total costs for these firms, which is in the order of 0.2 to 0.4, implying that a 10% increase in the minimum wage should theoretically translate to a 2% to 4% increase in prices under the assumptions discussed in Section 2.

Core specification over time

The finding is somewhat sensitive to the time period of analysis. Figure 7 shows the effect of minimum wage uplift on inflation for a series of five-year rolling windows, starting with 2010-2014 and ending with 2016-2020, with 90% and 99% percentile confidence intervals shaded to show significance. The minimum wage effect increases over time and is significant at the 1% level from 2014-2018 onwards.

Figure 7 Effect of minimum wage uplift on inflation over time



Source: *Frontier Economics*

Note: Each point represents a five-year rolling window, starting from the year listed on the x axis. Shading shows the 90% and 99% percentile confidence interval. Month fixed effects are removed in this specification.

If we restrict the sample to the period starting from when the NLW was introduced (2016), we find that inflation is **0.197 percentage points** higher in months where the minimum wage was uplifted (significant at the 1% level).

As previously discussed, this may reflect two changes:

- that minimum wage increases were higher after the introduction of the NLW; and
- that the month in which wages were increased was changed from October to April in 2016.

To test whether the change in uplift month was relevant, we regress inflation on a binary variable equal to 1 if the month is April. We find that the effect of April is close to zero and not statistically significant. We also test whether minimum wage uplift predicts inflation for the control group of firms from 2016 onwards. Again, the effect of minimum wage uplift is not statistically significant. These findings suggest it is unlikely that the strong post-2016 effect is a result of the change in uplift month. The change in the effect over time is more likely to be attributable to the larger increases in minimum wages associated with the introduction of the NLW or that a higher share of jobs were impacted by the minimum wage in more recent years.

Robustness checks

We consider the robustness of these findings in four ways:

1. We test that the inflation panel is **stationary** using the Im-Pesaran-Shin and Fisher tests for unit roots in panel data, and reject the unit root null hypothesis at the 1% level. For completeness, we conduct Dickey-Fuller tests on each item/region in the panel, rejecting the null hypothesis of unit roots for each item/region time series at the 1% level.
2. We do not explicitly test for **autocorrelation** in the inflation error terms; the standard tests are frustrated by the dynamic panel structure of the data. While the inclusion of lagged dependent variables can lead to the underestimation of remaining coefficients, we do not expect this effect to be large enough to impact hypothesis tests (see e.g. Kelly and Keele, 2004).
3. We consider that the regression results might be **skewed because the ONS over-samples some product classes** (those for which the between-item price variability is high). This is the case for SIC 56 (Food and beverage service activities), which account for 23 of the 100 most exposed sector/regions, but 270 of the 372 most exposed item/regions. We find that inflation for non-food and drink items is 0.048 percentage points higher in minimum wage uplift months, significant at the 1% level, a third lower than the overall effect. This suggests that if the basket of items were reweighted to reflect their share of consumer spending, the average minimum wage effect would be smaller than the 0.081 percentage points estimated by the core specification.
4. We run **placebo tests** on each non-uplift month to help validate the identification strategy: for example, testing whether inflation for treated item/regions is higher in January or February than in other months. The

coefficient on the placebo month is negative and significant at the 10% level for July and August (for comparison, the coefficient on the true uplift month is significant at the 0.2% level). This is not inconsistent with a robust identification strategy, particularly as inflation tends to be relatively low in July and August for all item/regions regardless of minimum wage exposure. The coefficient on the placebo month is positive and significant at the 10% level for May. We explore this further in Section 5.2 when we discuss lagged and leading effects of uplift.

5.2 Alternative specifications

Panel with lags and leads

The effect of a minimum wage increase may be anticipated by some firms, while others may delay price increases until the following months. To account for this, we use an alternative specification which includes two lagged months and two leading months:

$$inflation_{m,i} = \alpha + \beta_1 \times uplift_m + uplift_{m+l} \times + \gamma_i + \delta_m + inflation_{m-1,i} + \epsilon_{m,i}$$

where l is a vector of lags and leads: $-2, -1, 1, 2$.

Figure 8 and Figure 9 show that inflation in minimum wage uplift months is higher than in other months, even when lags and leads are controlled for (statistically significant at the 1% level). This is very similar to the effect identified in the core specification, because the lagging/leading months are to a large extent substituting for the month fixed effects.

However, inflation in the leading and lagging months is not significantly different from zero, with the exception of a small decrease in inflation two months before uplift.

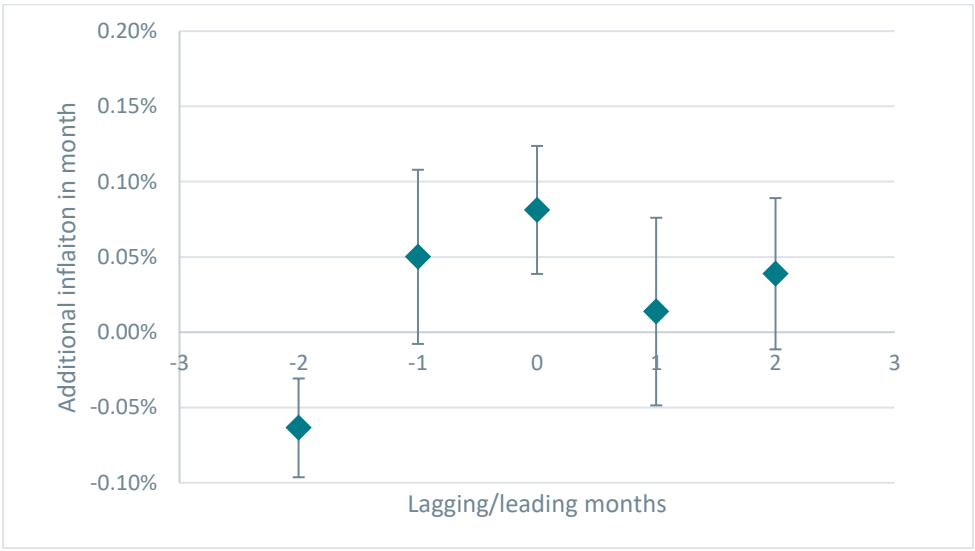
Figure 8 Effect of minimum wage uplift on inflation with lags and leads

	Dependent variable: Percentage change in the item price index			
	(1)	**(2)**	**(3)**	**(4)**
2 months before	-0.064 (0.014)***	-0.032 (0.031)	-0.073 (0.021)***	-0.071 (0.018)***
1 month before	0.050 (0.025)*	0.022 (0.031)	0.032 (0.025)	0.040 (0.019)*
MW uplift month	**0.081** (0.019)***	**0.171** (0.050)***	**0.065** (0.027)**	**0.076** (0.018)***
1 month after	0.013 (0.027)	-0.05 (0.053)	-0.00 (0.023)	0.021 (0.019)
2 months after	0.038 (0.022)	-0.04 (0.042)	0.032 (0.028)	0.043 (0.018)**
Sample	34,501	16,423	39,478	38,656
Adj. R^2	0.025	0.019	0.020	0.027

Source: *Frontier Economics*

Note: *Clustered standard errors (by region) in parentheses; Significant at the 1% (***), 5% (**) and 10% (*) levels.*

Figure 9 Effect of minimum wage uplift on inflation with lags and leads (core treatment definition)

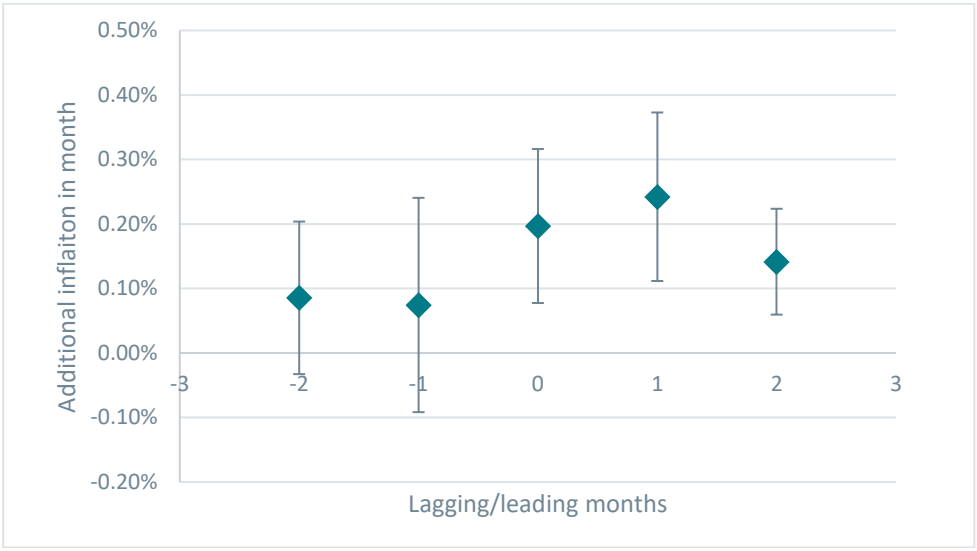


Source: Frontier Economics

Note: Error bars represent the 95% confidence interval of the coefficient.

If we restrict the sample to 2016 onwards, we observe large and significant lagged effects, with inflation increasing by 0.242 percentage points the month after the minimum wage uplift, and by 0.141 percentage points two months after uplift (see Figure 10), both significant at the 1% level.

Figure 10 Effect of minimum wage uplift on inflation with lags and leads (2016 onwards, core treatment definition)



Source: Frontier Economics

Note: Error bars represent the 95% confidence interval of the coefficient.

If we attribute these three effects (the uplift month and two lags) to the minimum wage, this suggests an overall effect of approximately **0.59 percentage points**

from 2016 onwards.[12] As the mean minimum wage increase from April 2016 onwards was 5.22%, this implies an elasticity of prices with respect to the minimum wage of 0.11. In other words, a 10% increase in the minimum wage could be expected to increase prices by 1.1%. This elasticity is still lower than the theoretical prediction but is similar to the long-run elasticity identified in Harasztosi and Lindner (2019).

Panel with control group

The preceding specifications consider only the treatment group of item/regions. To reject the hypothesis that minimum wages increase inflation for all item/regions regardless of exposure, we include both treated and control item/regions in the sample and test the interaction of treated item/region and minimum wage uplift month:

$$inflation_{m,i} = \alpha + \beta_1 \times uplift\_treated_{m,i} + \beta_2 \times uplift_m + \beta_3 \times treated_i + \gamma_i + \delta_m + inflation_{m-1,i} + \epsilon_{m,i}$$

Figure 11 Effect of minimum wage uplift on inflation

	Dependent variable: Percentage change in the item price index				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Specification without control group					
MW uplift month	**0.081** (0.019***)	**0.171** (0.05***)	**0.066** (0.027**)	**0.076** (0.018***)	N/A
Observations	35,121	16,711	40,204	39,354	
Adj. R^2	0.017	0.010	0.013	0.020	
Specification with control group					
MW uplift month & treatment	**0.105** (0.05**)	**0.169** (0.075**)	**0.106** (0.05*)	**0.098** (0.043**)	**0.245** (0.133*)
MW uplift month	-0.017 (0.042)	-0.008 (0.043)	0.008 (0.04)	-0.008 (0.039)	-0.058 (0.058)
Treatment	0.038 (0.008***)	0.049 (0.015***)	0.035 (0.01***)	0.039 (0.005***)	0.107 (0.021***)
Observations	85,451	67,041	100,503	88,412	117,633
Adj. R^2	0.006	0.005	0.010	0.005	0.017

Source: *Frontier Economics*

Note: *Clustered standard errors (by region) in parentheses; Significant at the 1% (***), 5% (**) and 10% (*) levels.*

The core specification without item/region fixed effects is included for comparison.

The interpretation of the treated and uplift treated coefficients is different from the other definitions; it shows the difference between the most exposed and least exposed item/regions, rather than the differences between treated and control item/regions.

[12] The causal interpretation is less clear in this case: post-2016 the first lag term always coincides with May and inflation appears to be higher in May for both treatment and control groups.

Figure **11**, column 1 shows that inflation is slightly higher for treated item/regions than control item/regions in non-uplift months (generally significant at the 1% level), and that there is no effect of minimum wage uplift on control item/regions. Importantly, it also shows that the effect of minimum wage uplift on treated item/regions is **0.105 percentage points** higher than it is for control item/regions (significant at the 5% level).

This finding is not sensitive to the choice of treatment definition (

Figure **11**, columns 2-5), although for treatment definition 3 the effect is significant only at the 10% level. Treatment definition 5, which uses a continuous measure of treatment $\in (0,1)$, shows that the effect of minimum wage uplift on the most exposed item/region is 0.245 percentage points higher than the least exposed item/region (significant at the 10% level).

Panel with continuous measure of minimum wage uplift

The previous specifications treat all increases in the minimum wage the same. However, Figure 1 shows that the magnitude of the minimum wage increase varies over the period, from 1.8% in October 2010 to 7.5% with the introduction of the NLW in April 2016. For this reason, we replace the binary uplift variable with a continuous uplift variable equal to the percentage change in minimum wages (set to zero in months where the minimum wage was not uplifted).

$$inflation_{m,i} = \alpha + \beta_1 \times \%\Delta mw \ + \gamma_i + \delta_m + inflation_{m-1,i} + \epsilon_{m,i}$$

An additional advantage of this approach is that the coefficient can be interpreted directly as the elasticity of prices with respect to minimum wages, the term defined in Equation 6, Section 2,.

Figure 12 shows that the effect of minimum wage uplift remains statistically significant at the 1% level (at the 5% level for treatment definitions 2 and 3). The coefficient implies that a 10% increase in the minimum wage increases prices in the uplift month by **0.22%**, consistent with the interpretation of the core specification. Note that month fixed effects cannot be used in this specification to ensure that the effect of minimum wages on inflation is captured by the coefficient on the minimum wage change variable.

Figure 12 Effect of minimum wage uplift on inflation

	Dependent variable: Percentage change in the item price index			
	(1)	**(2)**	**(3)**	**(4)**
% change in minimum wage	**0.022** (0.005***)	**0.038** (0.013**)	**0.015** (0.006**)	**0.021** (0.004***)
Observations	35,121	16,711	40,204	39,354
Adj. R^2	0.016	0.009	0.011	0.018

Source: *Frontier Economics*

Note: *Clustered standard errors (by region) in parentheses; Significant at the 1% (***), 5% (**) and 10% (*) levels.*

Difference-in-differences

Finally, we discard the panel model and test a difference-in-differences specification to identify whether the substantial minimum wage increase in April 2016 had a different impact on treated and control items.

$$inflation_{m,i} = \alpha + \beta_1 \times treated_i + \beta_2 \times after_m + \beta_3 \times treated\_after_{m,i} + \gamma\ time_m + \epsilon_{m,i}$$

Where:

- $inflation_{m,i}$ is the annual percentage change in the price index for an item/month;
- $treated_i$ is a binary variable equal to one if the item is in the treated group and zero if it is in the control group;
- $after_m$ is a binary variable equal to one if the month is April 2016 or later and zero otherwise,
- $treated\_after_{m,i}$ is a binary variable equal to one if the item is in the treated group and the month is April 2016 or later; and
- $time_m$ is a continuous time variable (to capture any long-run inflation trends).

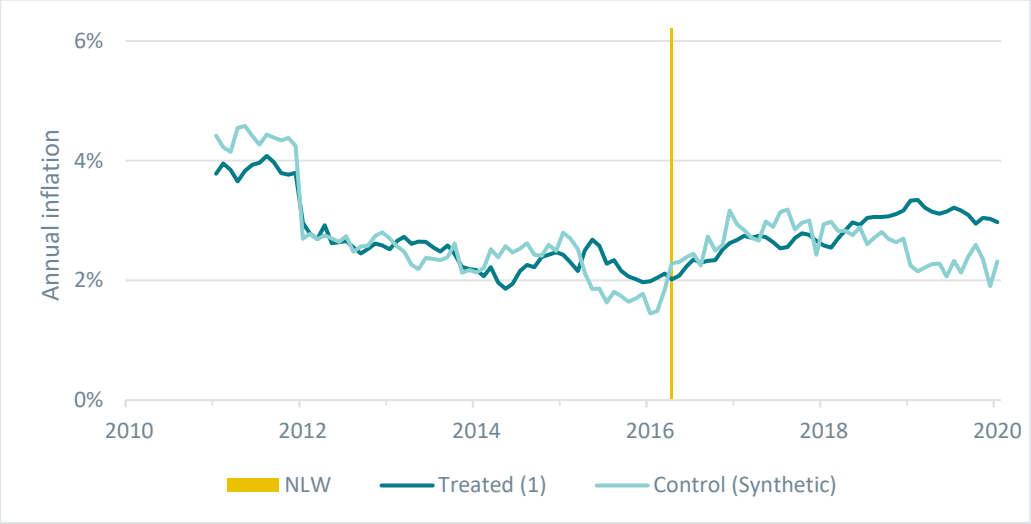
The coefficient β_3 can be interpreted as the additional impact of the April 2016 minimum wage increase on prices for the treatment group relative to the control group (assuming that the control group would otherwise have been expected to follow the same inflation trend as the treatment group).

We test whether the treatment and control groups specified in Section 3 fulfil the common trends assumption. However, there was no control group that tracked the inflation time series for the treatment group prior to 2016.

Instead, we construct a synthetic control group, sampled from item/regions that map to sector/regions ranked outside the 300 most exposed (see e.g. Abadie et al. (2010) for method). Figure 12 shows that inflation for the synthetic control group of item/regions maps the unweighted average inflation of the treated group reasonably well prior to April 2016.

After April 2016, both series follow a similar trend until April 2018 where they begin to diverge.

Figure 13 Annual inflation over time



Source: Frontier Economics

Using the difference-in-differences specification outlined above, applied to an eight-year window around April 2016, we find evidence that the introduction of the NLW was indeed associated with an increase in annual inflation of approximately **0.18%**, although this is only statistically significant at the 10% level.

The finding is not sensitive to the inclusion of the time control. However the finding is sensitive to the choice of the time window of the regression: limiting the sample to a four-year window suggests the effect is not significantly different from zero, and limiting the sample to a two-year window suggests the effect of the NLW was negative and significant.

6 CONCLUSIONS

We find consistent evidence that, for the item/region combinations that are most exposed to changes in the cost of minimum wage labour, inflation is higher in months when the minimum wage is increased than at other times of the year.

However, the effect is small relative to the size of the minimum wage increase: equivalent to an elasticity of prices with respect to minimum wage of **0.023**, and **0.038** since 2016. If we attribute the elevated inflation in the two months following uplift to the minimum wage, the elasticity could be as high as **0.11**. In other words, a 10% increase in the minimum wage would be expected to increase prices by 0.23% to 1.10%. This is lower than the increase predicted by the theoretical framework of 2% to 4%, but the framework ignores price-adjustment costs and makes a number of relatively strict assumptions about the level of competition in product and labour markets and the shape of firms' production functions.

These findings are similar to those studies elsewhere in the literature that identify a significant effect:[13]

- Wadsworth (2010) finds a long-term effect in the order of **0.2 to 0.9 percentage points** per year for the most exposed sectors using a difference-in-differences approach on the 1999 introduction of the UK minimum wage. Interpreting this as an elasticity is confounded by the fact that there was no UK-wide minimum wage prior to 1999. He finds no significant effect using the uplift month approach used in the core specification of this study.
- Harasztosi and Lindner (2019) find that the doubling of the minimum wage in Hungary led to a 7% to 14% increase in prices over a four-year period, equivalent to an elasticity of **0.07 to 0.14**.
- Aaronson (2001) finds an elasticity of prices with respect to minimum wages of **0.07** for restaurants in both Canada and the United States. Aaronson et al. (2005) find an elasticity of prices with respect to minimum wages of **0.07** for restaurants, increasing to **0.15** for those restaurants more exposed to minimum wages. Both sets of elasticities include leading and lagging periods in the core specification, meaning they are comparable to the upper bound of our elasticity estimates.

These findings are also similar to those identified using UK-wide item-level price aggregates (Frontier Economics, forthcoming). The key difference is that the region-level analysis finds positive and significant price effects for the whole period, while the national-level analysis only finds effects from 2016 onwards. This is likely a reflection of the more granular treatment definitions used in this study which more effectively isolate the products most exposed to minimum wage increases.

Future research could further refine the treatment assignment rule, notably by measuring the share of labour costs attributable to minimum wage workers (rather than the share of workers affected by minimum wage uplift) and by accounting for the share of minimum wage labour costs in respective supply chains (rather than assuming that all inputs are tradable). Future research might also investigate

[13] Neither Draca et al. (2005) nor Machin et al. (2003) find evidence that the introduction of the UK minimum wage had an effect on inflation in exposed sectors.

differences in prices adjustment frictions in different sectors to explore the time profile of price responses to minimum wages.

REFERENCES

Aaronson, D. (2001), 'Price Pass-Through and the Minimum Wage', *Review of Economics and Statistics*, 83.1, pp. 158-169.

Aaronson, D., French, E. and MacDonald, J., (2005), 'The Minimum Wage, Restaurant Prices and Labor Market Structure, *Journal of Human Resources*, 43.3, pp. 688-720.

Abadie, A., Diamond, A. and Hainmueller, J. (2010), 'Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program', *Journal of the American Statistical Association*, 105.490, pp.493-505.

Alvarez, L., Dhyne, E., Le Bihan, H., Veronese, G., Dias, D., Hoffman, J., Jonker, N., Lunnemann, P., Rumler, F. and Vilmunen, J. (2005), 'Sticky Prices in the Euro Area. A Summary of New Micro-Evidence', *Journal of the European Economic Association*. 4:2-3, pp. 575-584.

Bils, M. and Klenow, P. (2004), 'Some Evidence on the Importance of Sticky Prices', *Journal of Political Economy*, 112:5, pp. 947-985.

Card, D. and Krueger, A. (1995), *Myth and Measurement: The New Economics of the Minimum Wage*, Princeton, Princeton University Press.

Draca, M., Van Reenen, J and Machin, S. (2005), The Impact of the National Minimum Wage on Profits and Prices: Report for Low Pay Commission.

Hall, S., Walsh, M. and Yates, A. (2000), 'Are UK Companies' Prices Sticky?' *Oxford Economic Papers*, 52, pp. 425-446.

Harasztosi, P. and Lindner, P. (2019), 'Who Pays for the Minimum Wage?', *American Economic Review*, 109.8, pp. 2,693-2,727.

Kelly, N. and Keele, W. (2004), 'Dynamic Models for Dynamic Theories: The Ins and Outs of Lagged Dependent Variables', *Political Analysis,* 14.2, pp. 186-205.

Lemos, S. (2008), 'A Survey of the Effects of the Minimum Wage of Prices', *Journal of Economic Surveys*, 1.1, pp. 187-212.

Low Pay Commission (2019), '20 years of the National Minimum Wage: A history of the UK minimum wage and its effects', https://www.gov.uk/government/publications/20-years-of-the-national-minimum-wage

MacDonald, J. and Aaronson, D. (2006), 'How Firms Construct Price Changes: Evidence from Restaurant Responses to Increased Minimum Wages', *American Journal of Agricultural Economics*, 88.2, pp. 292-307.

Machin, S., Rahman, L. and Manning, A. (2003), 'Where the Minimum Wage Bites Hard: Introduction of Minimum Wages to a Low Wage Sector', *Journal of the European Economic Association,* 1.1, pp. 154-180.

MaCurdy, T. (2015), 'How Effective Is the Minimum Wage at Supporting the Poor?', *Journal of Political Economy*, 123.2, pp. 497-545.

Nakamura, E. and Steinsson, J. (2008), 'Five Facts About Prices: A Reevaluation of Menu Cost Models', *Quarterly Journal of Economics*, 123:4, pp. 1415-1464.

Wadsworth, J. (2010), 'Did the National Minimum Wage Affect UK Prices?', *Fiscal Studies*, 31.1, pp. 81-120.

ANNEX A ITEM TO SECTOR CORRESPONDENCE TABLE

Item ID	Item Description	SIC	SIC Description
220106	Pub: Cold Filled Roll/Sandwich	56.30	Beverage serving activities
220107	Pub - Hot Meal	56.30/1	Licensed clubs
220111	Burger In Bun-Eat In	56.10	Restaurants and mobile food service
220116	Lemonade/Cola Draught	56.10	Restaurants and mobile food service
220117	Bottled Mineral Water	56.10	Restaurants and mobile food service
220118	Restaurant Main Course 1	56.10	Restaurants and mobile food service
220119	Restaurant Main Course 1	56.10	Restaurants and mobile food service
220120	In Store Cafeteria Meal	56.10	Restaurants and mobile food service
220121	Restaurant Cup Of Coffee	56.10	Restaurants and mobile food service
220122	Restaurant - Sweet Course	56.10	Restaurants and mobile food service
220124	Muffin/Individual Cake	56.10	Restaurants and mobile food service
220125	Fruit Juice Bottle 250-350Ml	56.10	Restaurants and mobile food service
220126	Vegetarian Main Course	56.10	Restaurants and mobile food service
220127	Pub - Roll/Sandwich Hot Or Cold	56.30	Beverage serving activities
220128	Restaurant Evening Main Course	56.10	Restaurants and mobile food service
220205	Staff Restaurant Main Course	56.29	Other food services
220208	Staff Restaurnt Hot Snack Item	56.29	Other food services
220209	Primary School - Fixed Charge	56.29	Other food services
220210	Secondary School - Cafeteria	56.29	Other food services
220211	Staff Restaurant Fizzy Drink	56.29	Other food services
220212	Staff Restaurant Sandwich	56.29	Other food services
220213	Staff Restaurant Pudding	56.29	Other food services
220214	Staff Restaurant Main Course	56.29	Other food services
220301	Fish & Chips Takeaway	56.10/3	Take-away food shops and mobile food stands
220303	Sandwich -Take-Away (Cold)	56.10/3	Take-away food shops and mobile food stands
220304	Coffee -Take-Away	56.10/3	Take-away food shops and mobile food stands
220305	Tea - Take-Away	56.10/3	Take-away food shops and mobile food stands
220310	Potato Crisps - Individual Pack	56.10/3	Take-away food shops and mobile food stands
220316	Pizza Takeaway Or Delivered	56.10/3	Take-away food shops and mobile food stands
220317	Pasty/Savoury Pie - Takeaway	56.10/3	Take-away food shops and mobile food stands
220318	Indian Takeaway	56.10/3	Take-away food shops and mobile food stands
220319	Chinese Takeaway	56.10/3	Take-away food shops and mobile food stands
220320	Takeaway Soft Drink	56.10/3	Take-away food shops and mobile food stands
220321	Takeaway Coffee Latte	56.10/3	Take-away food shops and mobile food stands
220322	Burger In Bun - Takeaway	56.10/3	Take-away food shops and mobile food stands
220323	Kebab - Takeaway	56.10/3	Take-away food shops and mobile food stands
220324	Cinema Popcorn	59.14	Motion picture projection activities
220326	Takeaway Chicken & Chips	56.10/3	Take-away food shops and mobile food stands

Item ID	Item Description	SIC	SIC Description
220327	T'away Cooked Savoury Pastry	56.10/3	Take-away food shops and mobile food stands
310102	Draught Bitter (Per Pint)	56.30	Beverage serving activities
310104	Draught Stout Per Pint	56.30	Beverage serving activities
310109	Lager - Pint 3.4-4.2%	56.30	Beverage serving activities
310110	Premium Lager - Pint 4.3-7.5%	56.30	Beverage serving activities
310111	Bottled Premium Lager 4.3-7.5%	56.30	Beverage serving activities
310112	Bottle Of Lager In Nightclub	56.30	Beverage serving activities
310114	Cider 4.5%-5.5% Abv Pint/Bottl	56.30	Beverage serving activities
310301	Whisky (Per Nip) Specify Ml	56.30	Beverage serving activities
310302	Vodka (Per Nip) Specify Ml	56.30	Beverage serving activities
310309	Spirit Based Drink 275Ml	56.30	Beverage serving activities
310310	Wine, Per 175 - 250 Ml Serving	56.30	Beverage serving activities
310314	Bottle Of Champagne	56.30	Beverage serving activities
310315	Bottle Of Wine 70-75Cl	56.30	Beverage serving activities
410508	Plumber - Daytime Hourly Rate	43.22	Plumbing, heat and air-conditioning installation
410509	Electrician - Daytime Rate/Hour	43.21	Electrical installation
410516	Gas Service Charge Local	43.22	Plumbing, heat and air-conditioning installation
410517	Decorator - Daily Rate; Spec Hrs	74.10	Specialised design activities
410518	Carpenter Hourly Rate	43.32	Joinery installation
410632	Hire Of Domes Carpet Cleaner	77.29/9	Renting and leasing of other personal and household goods
430621	Annual Booster Injection	86.90	Other human health activities
430622	Dog Kennel Fees Daily Charge	93.19/9	Other sports activities
430623	Small Caged Mammal	47.76	Retail sale of flowers, plants, seeds, fertilizers, pet animals and pet food in specialised stores
440101	Domestic Cleaner Hourly Rate	81.21	General cleaning of buildings
440104	Dry Cleaning-Man's Suit	96.01	Washing and (dry-)cleaning of textile and fur products
440105	Driving Lesson 1 Hour	85.53	Driving school activities
440113	Window-Clean 3-Bed Semi	81.22/1	Window cleaning services
440116	Washing Machine Repair	95.22	Repair of household appliances and home and garden equipment
440118	PC Repair	95.11	Repair of computers and peripheral equipment
440120	Child Minder - Hourly Rate	88.91	Child day-care activities
440121	Catering-50 Set Menu Per Head	56.21	Event catering activities
440123	Home Removal - 1 Van	49.42	Removal services
440125	Gardener Hourly Rate	81.30	Landscape service activities
440126	Weekly Nanny Fees	88.91	Child day-care activities
440127	Monthly Self Storage Fee	68.20/9	Other letting and operating of own or leased real estate
440128	Home Care Assistant Hrly Rate	88.10	Social work activities without accommodation for the elderly and disabled
440129	Playgroup Fees - Per Session	88.91	Child day-care activities
440130	After School Club Charges	88.91	Child day-care activities

Item ID	Item Description	SIC	SIC Description
440132	Men's Clothing Hire - See Help	77.29/9	Renting and leasing of other personal and household goods
440227	Funeral-Cremation	96.03	Funeral and related activities
440232	Nursery Fees: Child 0-4	88.91	Child day-care activities
440233	Newspaper Ad Non-Trade 20 Word	58.13	Publishing of newspapers
440240	Basic Will For A Single Person	69.10/2	Solicitors
440254	Hourly Rate For Solicitor	69.10/2	Solicitors
520301	Man's Haircut	96.02	Hairdressing and other beauty treatment
520303	Women's Hrdressing - Cut/Blowdry	96.02	Hairdressing and other beauty treatment
520309	Women's Hrdressing - Cut/Blowdry	96.02	Hairdressing and other beauty treatment
520311	Womens Highlighting	96.02	Hairdressing and other beauty treatment
520313	Non-NHS Medicine - Physiotherapy	86.90	Other human health activities
520323	Full Leg Wax (Both Legs)	96.02	Hairdressing and other beauty treatment
520324	Residential Home	87.30	Residential care activities for the elderly and disabled
520325	Nursing Home	87.10	Residential nursing care facilities
520326	Private Dental Examination	86.23	Dental practice activities
520331	Basic Manicure	96.02	Hairdressing and other beauty treatment
520332	Non NHS Chiropractor	86.90	Other human health activities
610227	Car MOT Test Fee, Vat Exempt	45.20	Maintenance and repair of motor vehicles
610229	Auto Car Wash	45.20	Maintenance and repair of motor vehicles
610231	Car Service - Local Garage	45.20	Maintenance and repair of motor vehicles
610232	Car Service - Main Dealer	45.20	Maintenance and repair of motor vehicles
610233	Exhaust Fitting In Fast Fit	45.20	Maintenance and repair of motor vehicles
610234	Brake Fitting In Fast Fit	45.20	Maintenance and repair of motor vehicles
610235	Car Repairs Main Dealer	45.20	Maintenance and repair of motor vehicles
610236	Car Repairs Local Garage	45.20	Maintenance and repair of motor vehicles
610238	Car Wash Hand Or Automatic	45.20	Maintenance and repair of motor vehicles
610239	Exhaust Fitting Fast Fit Cent	45.20	Maintenance and repair of motor vehicles
610240	Brake Fitting Fast Fit Centre	45.20	Maintenance and repair of motor vehicles
610241	Wheel Alignment	45.20	Maintenance and repair of motor vehicles
620303	Self-Drive Van Hire	77.11	Renting and leasing of cars and light motor vehicles
620307	Self-Drive Car Hire Basic 24Hr	77.11	Renting and leasing of cars and light motor vehicles
620308	Minicab Fare For 2 Miles	49.32	Taxi operation
620315	Car Park Charges	52.21/9	Other service activities incidental to land transportation, n.e.c.
630359	Digital Development Per Print	74.20/3	Film processing
630361	Digital Development Per Print	74.20/3	Film processing

Item ID	Item Description	SIC	SIC Description
640207	Nightclub Entry - Saturday	56.30/1	Licensed clubs
640212	Theatre Adult Eves - Front Stlls	90.04	Operation of arts facilities
640219	Swimming Pool Adm Stnd Adult	93.11	Operation of sports facilities
640222	Exercise Class Up To 1Hr	93.11	Operation of sports facilities
640224	Ten-Pin Bowling Per Game	93.11	Operation of sports facilities
640226	Private Health Club Annual Fee	93.13	Fitness facilities
640232	Private Health Club Annual Fee	93.13	Fitness facilities
640233	Private Health Club Annual Fee	93.13	Fitness facilities
640240	Livery Charges Per Week	01.43	Raising of horses and other equines
640243	Soft Play Session Time Period	93.29	Other amusement and recreation activities n.e.c.
640406	Hotel 1 Night Price	55.10	Hotels and similar accommodation

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