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Evaluating Limited Influence Estimators of Core Inflation in New Zealand

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Abstract

Core inflation is commonly understood as the component in headline inflation that is expected to persist over the medium term. This paper evaluates the recent performance of limited influence estimators of CPI inflation in New Zealand over the 2000 to 2022 period. We show that an asymmetric trimmed mean that removes 19% of the sample from the lower tail and 20% from the upper tail minimizes squared errors when a conventional ex-post smoothed measure of headline inflation is used as a proxy for core inflation. These weighst are very close to the 20% trimmed mean published by Statistics NZ, suggesting that this measure currently offers the most reliable measure of core inflation in the New Zealand context.

Keywords: Core Inflation, trimmed mean, median estimator, limited influence estimator.

JEL Classification: E31, E37, C33

1 Introduction

Inflation is a fundamental indicator of the state of the macroeconomy and changes in the cost of living. However, headline measures of inflation, such as the Consumer Price Index-Urban Cities (CPI-U) and the Personal Consumption Expenditure (PCE) price indexes in the US, or CPI inflation in New Zealand, typically exhibit substantial volatility, making it difficult to distinguish transitory fluctuations from more durable shifts in inflation. Policymakers and analysts consequently focus on less volatile measures that are based on excluding items that exhibit large changes in measured prices. Conventionally referred to as "core inflation," these measures are designed to be timely and to isolate the component of headline inflation that is expected to persist for several years.[1]

Core inflation measures are typically constructed using price measurements on the items comprising the consumption basket. The measures are essentially cross sectional filters, whereby price changes in some items are excluded before taking an average. For example, limited influence estimators, such as the median and trimmed mean, exclude items with price changes in the tails of the distribution, so that the items that are excluded items are permitted to change between different time periods. Examples of limited influence estimators can be found in Bryan and Pike (1991), Bryan and Cecchetti (1994), Bryan, Cecchetti and Wiggins (1997) and Dolmas (2005), amongst others. In contrast, a second set of core inflation measures simply exclude items that have historically exhibited high volatility. These include PCE and CPI inflation excluding energy and/or food items, and the measures proposed by Clark (2001). We refer to this second group as "excluded-item" measures of core inflation. While limited influence estimators typically out-perform excluded-item measures when evaluated by statistical criteria (see, amongst others, Bryan and Cecchetti, 1994; Smith 2004), excluded-item measures are favored because of their transparency and because they are communicable to the public (see, e.g., the discussion in Clark, 2001; and Wynne, 1999).

Bryan and Cecchetti (1994) first provided the theoretical foundation for the use of limited influence estimators using the Ball and Mankiw (1995) menu-cost model of firm-level pricing behavior. This model yields the following equation for observed price changes in the cross section of items (cf. eq.(3) in Bryan and Cecchetti, 1994):

$$\pi_{i,t} = m_t + \varepsilon_{i,t},\ i = 1, \ldots, n;\ t = 1, \ldots, T, \tag{1}$$

where $\pi_{i,t}$ is inflation in the ith item over some short-term interval (e.g., 1 month or 1 quarter) at time t, m_t is a common component across all items i, and $\varepsilon_{i,t}$ is an idiosyncratic inflation term for

[1] The emphasis on timeliness and accuracy rules out smoothing headline inflation as a measure of core inflation (see the discussion in Bryan and Cecchetti, 1994). However, smoothed headline inflation is frequently used as a measure of core inflation in ex-post evaluations of core inflation measures.

item i. Under the Ball-Mankiw model, for any given time period t, price changes in the tails of the distribution of $\{\pi_{i,t}\}_{i=1}^{n}$ are transitory, because only firms that receive sufficiently large shocks to their desired price level will pay the menu-cost and reset prices ahead of schedule. In fact the Ball-Mankiw model implies this transitory component is negatively autocorrelated,[2] which implies that large positive changes are likely to be transitory. If these shocks are asymmetrically distributed, then a conventional measure of the mean will be temporarily pulled in the direction of the skewness. Thus periodic and short-lived asymmetry in the distribution of $\{\varepsilon_{i,t}\}_{i=1}^{n}$ can lead to volatility in headline inflation measures. Limited influence estimators are, by construction, less sensitive to skewness, and therefore exhibit lower variance than headline inflation measures. Limited influence estimators are also more efficient than arithmetic averages under leptokurtoticity, and therefore will exhibit less volatility than headline inflation measures if the distribution of price changes is symmetric but fat-tailed (Bryan, Cecchetti and Wiggins, 1997).

While a single or preferred definition of core inflation is lacking, a measure of core inflation should be less volatile than headline inflation, and it should provide a an accurate approximation of durable changes in headline inflation over some "near" or "medium" term horizon (Bryan and Cecchetti, 1994; also see Blinder 1997). In practice this near-to-medium-term horizon equates to anything between one to five years (see, e.g., Bryan and Cecchetti, 1994; Cogley, 2002; Smith, 2004). Rich and Steindel (2007) extend the set of quantitative criteria to include qualitative criteria. Their criteria are: (i) transparency; (ii) similarity of means; (iii) tracking the trend rate of inflation; and (iv) explanatory content. While limited influence estimators typically out-perform excluded-item measures when evaluated by statistical criteria (see, amongst others, Bryan and Cecchetti, 1994; Smith 2004), excluded-item measures are favored because of their transparency and because they are communicable to the public (see, e.g., the discussion in Clark, 2001; and Wynne, 1999).

In this paper we evaluate the performance of limited influence estimators of core inflation in New Zealand, restricting our analysis to quantitative metrics of performance. Statistics New Zealand currently publishes 5, 10, 15, 20, 25 and 30% trimmed means, and a weighted percentile median. To evaluate estimator performance, we define a family of limited influence estimators that nests the measures published by Statistics New Zealand, as well as asymmetric trimmed means. We then evaluate the accuracy of the measures using quadratic measure of loss between the various measures and a smoothed headline inflation time series that serves as an ex-post measure of core inflation. Our preferred smoothing filter is a centered three-year moving average, which is similar to the ex-post measure of core inflation used by Bryan, Cecchetti and Wiggins (1997) for monthly inflation measures. We show that an asymmetric trimmed mean that removes 19% from the lower tail of the distribution and 20% from the upper tail minimizes quadratic loss over the 2000 to 2022

[2] See the discussion in section III C in Ball and Mankiw (1995).

evaluation period. This optimized asymmetric trimmed mean is very close to the 20% symmetric trimmed mean published by Statistics New Zealand, and suggests the latter as a preferred measure of the durable component in headline inflation. The 20% trimmed mean also performs well when shorter windows are used to smooth headline inflation, including five- and nine- quarter centered moving averages.

In the following section we describe our data and methods. Section three exhibits evaluations of performance. We then offer some concluding remarks.

2 Data and Methods

Core inflation measures are constructed using price measurements on the items comprising the consumption basket. We use the finest level of disaggregate price data published by Statistics New Zealand, which is 'group 3'. In the Appendix we list the 108 items comprising the basket as of the June 2020 re-basing of the CPI consumption basket. These price indexes are quarterly and are not seasonally adjusted. The data are obtained from the March 2022 release of the CPI.[3] Approximately half of the constituent time series begin in Q1 1999. We therefore begin our sample at this point.

The histogram in Figure 1 depicts the empirical distribution of quarterly inflation rates for the March 2022 quarter. This quarter is notable for having a rather high quarterly inflation rate of 6.9%. There is a long right tail, with 'Other Fuels' exhibiting a near 50% increase over the quarter. 'Petrol' experienced a 38% increase over the same period.

2.1 Weighted Percentile Trimmed Means

In this subsection we detail the construction of weighted percentile trimmed means. Let $\{(w_{i,t}, \pi_{i,t})\,;\ i = 1, \ldots, n\}$ denote the joint distribution of individual item inflation rates and CPI weights in a given time period t, and assume the n components are ordered such that $\pi_{1,t} \leq \pi_{2,t} \leq \ldots \leq \pi_{n,t}$. For $\alpha \in [0, 1]$, define $i_t(\alpha) = \min\left\{I : \sum_{i=1}^{I} w_{i,t} \geq \alpha\right\}$. Note that for the Statistics NZ CPI, the weights change only every three years. The weighted trimmed mean that removes $100 \times \alpha\%$ from the lower tail of the distribution, and $\beta \times 100\%$ from the upper tail, is given by

$$\hat{\pi}_t^{(\alpha,\beta)} := \frac{1}{1-\alpha-\beta} \sum_{i=i_t(\alpha)}^{i_t(1-\beta)} w_{i,t}\pi_{i,t} \tag{2}$$

Symmetric trimmed means set $\alpha = \beta \in (0, 0.5)$, while weighted percentile medians have $\alpha = \beta = 0.5$. Figure 2.1 presents time series of various core inflation measures, including the asymmetric

[3] https://www.stats.govt.nz/information-releases/consumers-price-index-march-2022-quarter/

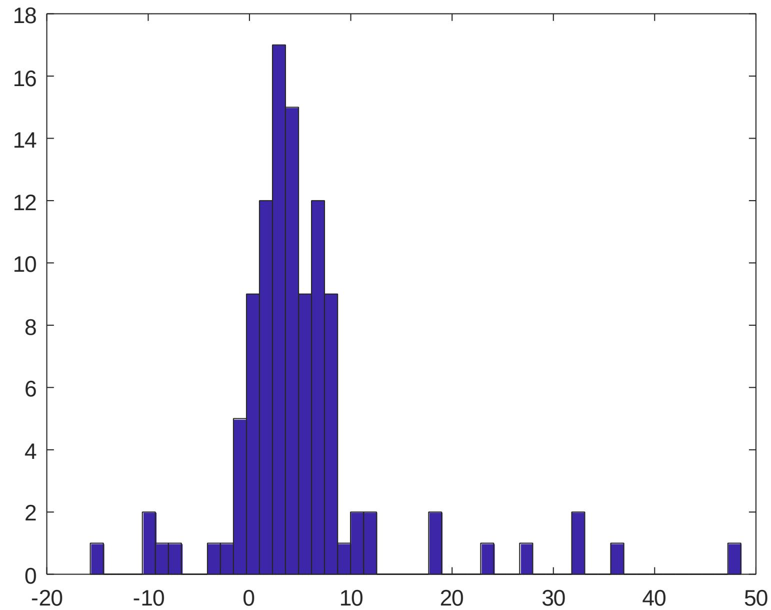
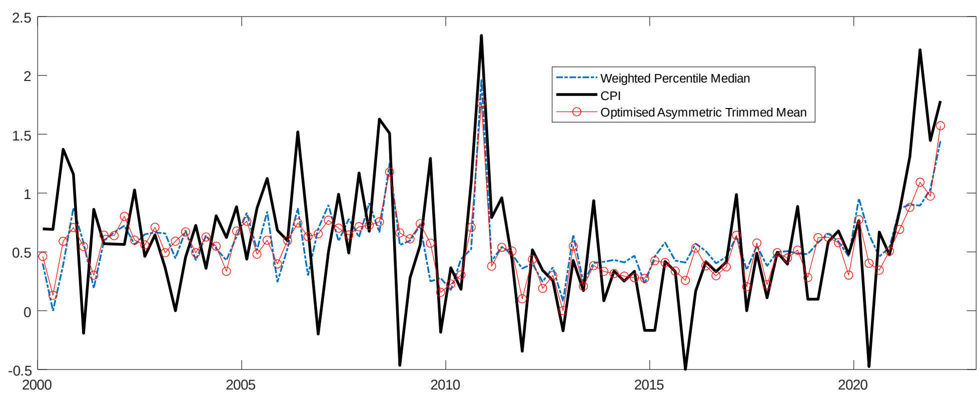


Figure 1: Quarterly Inflation (%) of CPI items, Q1 2022.

trimmed mean optimized to minimize the MSE with the 13 quarter centered moving average of headline CPI inflation (see the following section for the optimization method).



Quarterly Inflation Rates, 2000-2022. The optimized asymmetric trimmed mean removes 19% from the lower tail and 20% from the upper tail of the distribution.

3 Evaluating Core Inflation Measures

A reliable measure of core inflation should provide an accurate estimate of the underlying rate of inflation in prices that is expected to persist over a medium-term horizon (Bryan and Cecchetti,1994; Blinder, 1997). Thus a commonly adopted method for evaluating different core inflation measures is to assess which measure can best predict low frequency movements in headline inflation in practice (see, e.g., Bryan, Cecchetti and Wiggins, 1997; Smith, 2004; Dolmas, 2005). We provide three sets of evaluations, each corresponding to a different window length for smoothing headline inflation: a 5 quarter centered moving average; a 9 quarter centered moving average; and the 13 quarter centered moving average. These correspond to approximately one, two and three years.

We evaluate the trimmed mean measures for various α and β using mean square error (MSE) between the weighted trimmed mean and an ex-post measure of core inflation:

$$MSE\left(\alpha,\beta,h\right)=\tfrac{1}{T}\textstyle\sum_{t=1}^{T}\left(\hat{\pi}_t^{(\alpha,\beta)}-\hat{m}_t\left(h\right)\right)^2,$$

where

$$\hat{m}_t\left(h\right)=\tfrac{1}{2h+1}\textstyle\sum_{s=-h}^{h}\pi_{t+s}$$

for some $h\geq 1$, such that $\hat{m}_t\left(h\right)$ is a $2h+1$ centered moving average of headline inflation π_t.

Our preferred measure is a 13 quarter centered moving average, i.e. $\hat{m}_t\left(6\right)$. This corresponds to the 36 month centered window advocated by Bryan, Cecchetti and Wiggins (1997) for monthly measures of price inflation. The surface in Figure 2 exhibits the MSEs for various values of $(\alpha,\beta)\in(0,0.5]$ for $\hat{m}_t\left(6\right)$ over the 2000 to 2022 period.

Evidently asymmetry in the cutoffs leads to rather large increases in MSE. Symmetric and near-symmetric filters ten to perform best.

Following Dolmas (2005) we consider choosing α and β to minimize the mean square error (MSE) between the weighted trimmed mean and an ex-post measure of core inflation $\hat{m}_t\left(h\right)$. That is

$$\left(\hat{\alpha},\hat{\beta}\right)=\arg\min_{\alpha,\beta}\textstyle\sum_{t=1}^{T}\left(\hat{\pi}_t^{(\alpha,\beta)}-\hat{m}_t\left(h\right)\right)^2 \tag{3}$$

This minimum corresponds to the lowest point on the surface. When $h=6$, the surface is minimized at $\hat{\alpha}=0.19$ and $\hat{\beta}=0.2$. This is very close to the twenty percent trimmed mean already published by Statistics New Zealand.

Finally, we also consider mean absolute error as a secondary measure of estimator loss

$$MAE\left(\alpha,\beta,h\right)=\tfrac{1}{T}\textstyle\sum_{t=1}^{T}\left|\hat{\pi}_t^{(\alpha,\beta)}-\hat{m}_t\right|$$

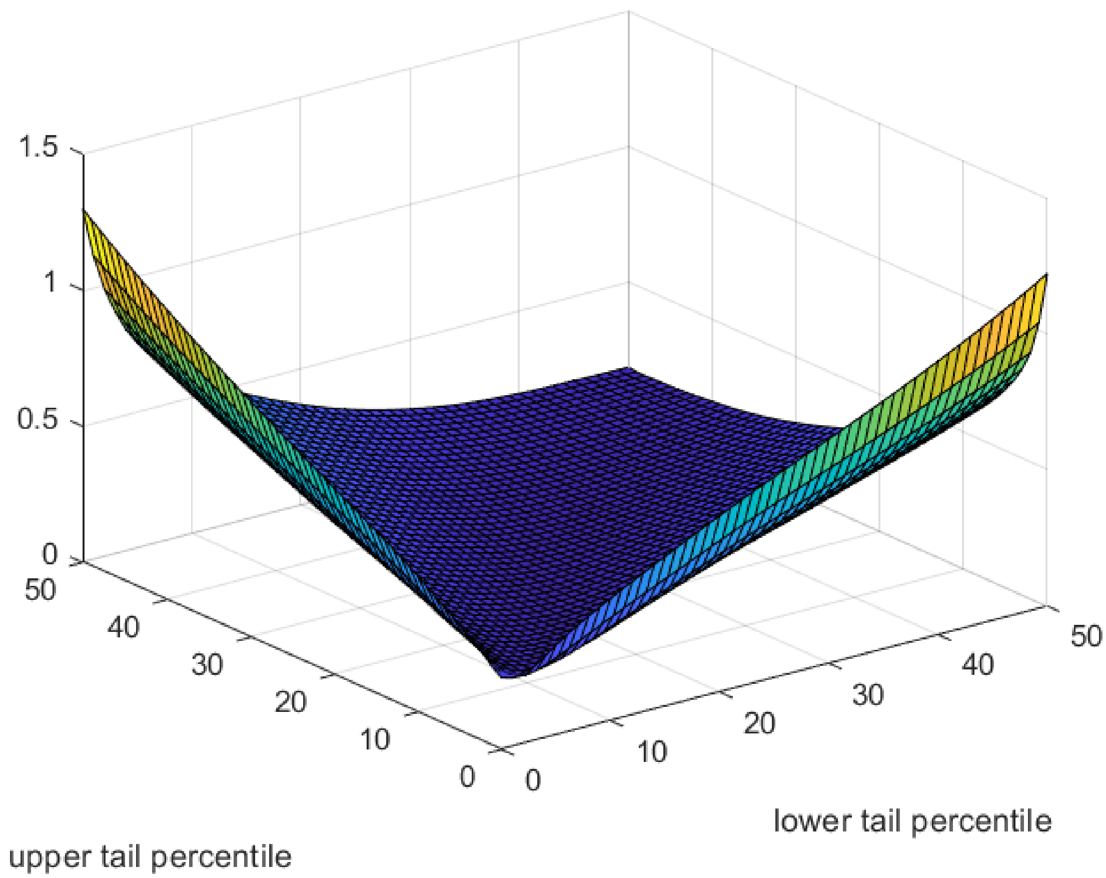


Figure 2: MSEs of asymmetric trimmed means with various lower and upper tail cutoffs

Table 1 presents the mean, variance, MSE and MAE of the quarterly core inflation measures over the 2000-2022 period. We exhibit 5, 10, 15, 20, 25, 30, 35 and 40% trimmed means since these are reported by Statistics New Zealand. We also report a weighted percentile median. Smith (2004) argues that a weighted median is the "best" core inflation measure in the sense that it provides the best forecast of CPI-U inflation in the US.

The results show that the 20% trimmed mean performs best for all three smoothing filters when loss is evaluated by MAE, and for two out of three smoothing filters when evaluated by MSE. Interestingly, it is not the measure with the lowest volatility, which is the 40% trimmed mean. It exhibits a mean that is 0.007 less than that of headline CPI over period. Based on this we conclude that the 20% trimmed mean provides the most accurate measure of smoothed headline inflation among the measures of inflation considered.

The symmetric trimmed means all have a lower MSE than the weighted median. Thus the median measure is not terribly accurate.

Table 1: In-sample summary of limited influence core inflation measures, 2000Q1–2022Q1

	CPI	Median	Trimmed Means							
			5%	10%	15%	20%	25%	30%	35%	40%
mean	0.5813	0.5696	0.6117	0.5859	0.5771	0.5736	0.5715	0.5666	0.5599	0.5536
st dev.	0.5435	0.2778	0.3628	0.3454	0.3284	0.3129	0.2996	0.2888	0.2811	0.2765
MSE (5)	0.1746	0.0848	0.0827	0.0688	**0.0636**	0.0641	0.0660	0.0690	0.0720	0.0756
MAE (5)	0.3147	0.2171	0.2164	0.2011	0.1965	**0.1965**	0.1972	0.1997	0.2027	0.2069
MSE (9)	0.2047	0.0719	0.0849	0.0668	0.0599	**0.0587**	0.0595	0.0612	0.0630	0.0645
MAE (9)	0.3236	0.2004	0.2200	0.1944	0.1781	**0.1733**	0.1743	0.1756	0.1805	0.1861
MSE (13)	0.2145	0.0704	0.0823	0.0642	0.0573	**0.0557**	0.0558	0.0574	0.0596	0.0622
MAE (13)	0.3302	0.1877	0.2109	0.1798	0.1658	**0.1620**	0.1622	0.1643	0.1695	0.1767

Notes: Bold font denotes the measure that performs best according the metrics of lowest MSE or lowest MAE.

Table 2 exhibits the performance of the optimized asymmetric trimmed means across the three different smoothing filters considered. Generally speaking the size of the filter increases as the smoothing filter lengthens. For the 5Q moving average, the optimal trimmed mean removes 16% from each tail of the distribution. For the 13Q moving average, this increases to 19% for the lower tail and 20% for the upper tail.

The improvement offered by the asymmetric mean over the 20% trimmed mean is generally insubstantial. For example, it has an MSE that is 1.1%, 0.07%, and 0.18% less than that of the 20% symmetric trimmed mean for the 5Q, 9Q and 13Q smoothing filters, respectively. Thus the improvement from adopting a more complicated optimized trimmed mean would not have resulted in a vast improvement over the 20% trimmed mean over the 2000 to 2022 period.

Table 2: Optimized Asymmetric Trimmed Means, 2000Q1–2022Q1

	5Q moving average	9Q moving average	13Q moving average
lower tail (α)	0.16	0.18	0.19
upper tail (β)	0.16	0.18	0.20
mean	0.5574	0.5521	0.5340
st dev.	0.2862	0.2808	0.2763
MSE	0.0634	0.0587	0.0556
MAE	0.1965	0.1737	0.1618

Notes: Asymmetric trimmed means are optimized to minimize MSE relative to either a five-, nine- or thirteen- quarter moving average of headline CPI inflation.

4 Concluding Remarks

In this paper we evaluate limited influence estimators of core inflation in the New Zealand context. Our primary measure of accuracy is the MSE between the trimmed mean and a smoothed measure of headline CPI inflation that is commonly used as an ex-post proxy of core inflation. We show that among the trimmed mean inflation measures published by Statistics New Zealand, the 20% trimmed mean performs best over the 2000 to 2022 period in terms of MSE and MAE for three different smoothing filters. Further reductions in MSE offered by asymmetric trimmed means that are optimized to minimize MSE are small. Our findings suggest that a 20% symmetric trimmed mean has been the most reliable measure of persistent changes in inflation over the past twenty years. It may therefore also be the most reliable measure of core inflation in the near term.

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5 Appendix

5.1 CPI components

Actual rentals for housing; Audio-visual equipment; Beer; Books; Bread and cereals; Carpets and other floor coverings;Children's and infants' clothing; Children's and infants' footwear; Cigarettes and tobacco; Cleaning products and other household supplies; Clothing accessories; Clothing services; Coffee, tea, and other hot drinks; Computing equipment; Confectionery, nuts, and snacks; Contents insurance; Cultural services; Dental services; Direct credit service charges; Domestic accommodation services; Domestic air transport; Dwelling insurance; Early childhood education; Electrical appliances for personal care; Electricity; Equipment for sport, camping, and outdoor recreation; Fish and other seafood; Food additives and condiments; Fruit; Furniture and furnishings; Games, toys, and hobbies; Gas; Glassware, tableware, and household utensils; Hairdressing and personal grooming services; Health insurance; Hospital services; Household textiles; International air transport; Jewelry and watches; Knitting and sewing supplies; Life insurance; Local authority rates and payments; Major household appliances; Major recreational and cultural equipment; Major tools and equipment for the house and garden; Meat and poultry; Medical services; Men's clothing; Men's footwear; Milk, cheese, and eggs; Newspapers and magazines; Oils and fats; Other appliances, articles, and products for personal care; Other education; Other grocery food; Other household services; Other medical products; Other miscellaneous services not elsewhere classified; Other personal effects; Other private transport services; Other property related services; Other vehicle fuels and lubricants; Overseas accommodation costs prepaid in New Zealand; Paramedical services; Pet-related products; Petrol; Pharmaceutical products; Plants, flowers, and gardening supplies; Postal services; Primary and secondary education; Professional services; Property maintenance materials; Property maintenance services; Purchase of bicycles; Purchase of housing; Purchase of motorcycles; Purchase of new motor cars; Purchase of second-hand motor cars; Rail passenger transport; Ready-to-eat food; Real estate services; Recording media; Recreational and sporting services; Refuse disposal and recycling; Repair and hire of household appliances; Restaurant meals; Road passenger transport; Sea passenger transport; Small electrical household appliances; Small tools and accessories for the house and garden; Soft drinks, waters, and juices; Solid fuels; Spirits and liqueurs; Stationery and drawing materials; Telecommunication equipment; Telecommunication services; Tertiary and other post-school education; Therapeutic appliances and equipment; Vegetables; Vehicle insurance; Vehicle parts and accessories; Vehicle servicing and repairs; Veterinary services; Vocational services; Water supply; Wine; Women's clothing; Women's footwear.