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Inflation expectations of households and the upgrading channel☆

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ABSTRACT

Motivated by direct evidence that households tend to purchase higher quality goods over time (consumption upgrading), we use a survey experiment to study the relationship between consumption upgrading and households' beliefs about inflation. We find that providing price information on better-quality products will lead to higher inflation expectations. The effects on inflation expectations are smaller when price information on both higher- and lower-quality products is made available, suggesting that product replacement increases inflation expectations. Additional tests show that our results are not driven by mixing price with quality or numeracy. Our findings highlight the relationship between product replacement, product variety, and inflation expectations.

1. Introduction

The inflation expectations of households are crucial for the analysis of monetary policy and business cycles (Yellen, 2016; Bernanke, 2020). One key driver of inflation expectations is related to personal experiences (Coibion et al., 2020b). In recent years, there has been robust micro-level empirical evidence on how households form their inflation expectations based on the information they received in their daily lives (Malmendier and Nagel, 2015; Cavallo et al., 2017) and how households incorporate the price signals that they observed from their grocery consumption bundles into their inflation expectations (D'Acunto et al., 2021b). Nonetheless, there is a lack of causal evidence relating to the potential channels and mechanisms. In this paper, we seek to fill this gap by focusing on a specific channel that influences the beliefs of inflation: the upgrading channel. As households are exposed to products of higher quality in their daily lives, this could impact their beliefs about inflation.[1]

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[1] While existing literature has documented the effect of quality change on households' actual inflation rate (Argente and Lee, 2021; Bils and Klenow, 2001; Kaplan and Schulhofer-Wohl, 2017, our paper seeks to study the effect of quality change on a household's inflation expectations, rather than the actual inflation rate.

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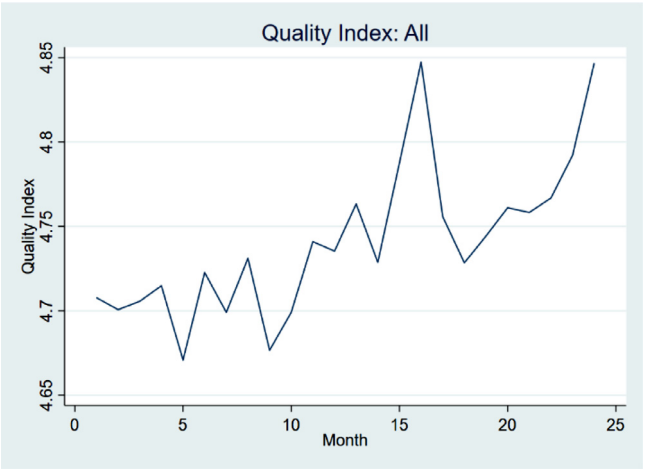

Fig. 1. Household Quality Index across Categories. Notes: This figure depicts the average monthly household quality index from 2016 to 2017 across all households in the Nielsen Homescan panel. For each household, we compute their individual quality index by determining the average quality of the goods that they consumed each month. Formally, we have $Q_{it} = \frac{1}{n_{it}} \sum_{j=1}^{n_{it}} X_{ijt}$ whereby Q_{it} refers to household i's quality index at time period t and X_{ijt} is the quality of good j that has been consumed by household i at time period t. For each category of goods available in the Nielsen Homescan panel, we group the brands into 10 bins based on the price per weight. Here, 1 refers to the lowest price per weight and 10 refers to the higher price per weight. This is an indication of the quality of the good. The average monthly household quality index plotted in Fig. 1 is based on the simple average of each individual household's quality index across time (i.e. $\frac{1}{m} Q_{it}$ where m is the total number of respondents).

To fix ideas in relation to consumption upgrading, we start by documenting how households in Singapore tend to purchase higher-quality goods in supermarkets over time. Using the Nielsen Homescan panel, which tracks the type of goods purchased by households in Singapore, we create a quality index that is based on the relative price per unit weight of a particular brand in each product category.[2] Consequently, upgrading occurs when households move towards products with relatively higher price per unit weight within each category.[3] Fig. 1 presents the changes in the households' monthly quality index between 2016 and 2017. We find that households have a strong inclination to upgrade to better quality goods in supermarkets as they shift from products with lower price per unit weight to higher price per unit weight in each product category.

Consumption upgrading could be driven by demand factors such as taste shocks, income shocks, peer effects in consumption (De Giorgi et al., 2020; Bertrand and Morse, 2016), or firms' decisions to vary product offerings (Jaravel, 2019; Goetz and Rodnyansky, 2021). In this paper, we focus on product replacement and quality change by designing a field experiment within our survey to demonstrate how consumption upgrading has a causal impact on inflation expectations. Product replacement and quality change occur when previously available goods are no longer made available, and new (and better-quality) products are introduced. Product replacement is prevalent in both domestic and international markets.[4] Through product replacement, we would be able to pin down a specific channel of upgrading and exclude other shocks, such as the income effect and other omitted variables that might be correlated with expected inflation.

We evaluate how households react to different information about price changes (for different goods) by conducting personal interview surveys with randomly selected individuals across Singapore in two settings (face-to-face and online). The former was conducted between March and June 2019 with 1072 individuals. The latter was conducted between February and May 2021 with 5000 respondents from the Rakuten Insight Online Panel. We follow the experimental setup used in studies such as Armantier et al., 2016; Cavallo et al., 2017 and Coibion et al., 2020a. In our benchmark survey experiment, we vary product replacement randomly in the information treatments based on price changes for two brands of ice-cream (Wall's and Häagen-Dazs) in 2009 and 2019. Although Häagen-Dazs is relatively more expensive (and arguably a better-quality good[5]) than Wall's, both prices increased by around 20%. In our survey experiment, we provide the price of Wall's in 2009 for all samples and vary the price information on higher- and lower-quality products in 2019. For Treatment 1 (T1), we only provide the price of the lower-quality product, Wall's, in 2019. For Treatment 2 (T2), we only provide the price of the higher-quality product, Häagen-Dazs, in 2019. For Treatment 3 (T3), we provide the price of both the lower- and higher-

[2] Online Appendix B presents a detailed discussion of the quality index based on the Nielsen Homescan Panel. While most studies (such as DellaVigna and Gentzkow, 2019) use the Nielsen Homescan Panel to study price changes of the same product over time, we use the brand of goods to understand changes in the quality of goods within each product category.

[3] Unit weight refers to the volume of the product (such as ounce or gram).

[4] For instance, Nakamura and Steinsson, 2012 found that 40% of products are replaced before one price change is reported in the microdata that underlie U.S. trade price indexes.

[5] See Jaimovich et al., 2019a for a detailed discussion on how relative prices are used to measure quality.

quality products, Wall's and Häagen-Dazs, in 2019. The main difference between the treatment groups is the availability of price information from higher- and lower-quality products in 2019.

The experimental design centres on how households react to price information on different types of goods. Our main findings are as follows. First, we find that product replacement increases inflation expectations. By comparing T2 with T1, we find evidence that exposure to higher-quality goods will lead to higher inflation expectations if the current price information on lower-quality goods is not available. Our comparison of T2 with T3 shows that if households are given current price information on both higher-quality and lower-quality goods, the effect on inflation expectations is significantly lower. This suggests that product replacement and quality change increase inflation expectations. Second, we find that an increase in product variety only leads to higher inflation expectations when the products are being replaced. By comparing T3 and T1, we do not find any statistically and economically significant differences in inflation expectations and perceptions when new products are being introduced without displacing the existing products. Moreover, as compared to T1, we find that the respondents with higher prior beliefs are more responsive in treatment groups T2 and T3. This could be attributed to confirmatory bias (Rabin and Schrag, 1999), as those with higher priors have experienced consumption upgrading and report higher posterior beliefs as a confirmation of their personal experiences.

What drives the increase in inflation expectations in our survey experiment? In addition to the product replacement and product variety channel, there are two other possible explanations. One is the possibility that respondents mix price and quality: Since prices and quality are highly correlated, households could respond to higher prices instead of quality. The other possibility is attributed to numeracy. Respondents may report a larger increase in inflation expectations due to larger price changes in absolute dollars and percentage units, as well as higher price levels. We design a series of tests through the online survey to distinguish between the three possible channels.

To examine whether price levels or quality can explain our main results, we vary the price information on different products of similar quality in two new treatment groups without product replacement. The first is the High-Price Quality Treatment, in which we provide price information on both Wall's and Häagen-Dazs in 2009 and 2019. The second is the Low-Price Quality Treatment, in which we vary the brand quality and price in opposite directions. In addition to the information in T1, we introduce the prices of another product: Fortune Premium Abalone Sauce in 2009 and 2019. In the sauce category, Fortune Premium Abalone Sauce is a high-quality product. Nonetheless, as compared to Walls', the price is lower in absolute terms, and it has a lower absolute dollar price increase. If the price effect matters, we should expect to see differences between the High-Price and Low-Price Quality Treatments. We did not see any statistically and economically significant differences between the two treatment groups, which suggests that prices alone do not play an important role without product replacement.

We then test whether numeracy can explain our main results by varying the price information with different absolute dollar price changes and percentage changes in two additional treatment arms. First, we design the Constant Percentage Change Treatment, in which the absolute dollar increase in prices is higher than that of T1, but the percentage change is the same as T1. In comparing the Constant Percentage Change Treatment and T1, we find that while there is a larger increase in inflation perceptions, there are no statistically and economically significant differences for inflation expectations. Consequently, we do not find consistent evidence supporting the claim that respondents focus primarily on absolute dollar price changes. Next, we introduce the Constant Dollar Change Treatment, in which the percentage change is lower than that of T1, but the absolute dollar price increase is the same as T1. For both inflation perceptions and expectations, there are no statistically and economically significant differences between Constant Dollar Change Treatment and T1. These additional tests show that exposure to high or low prices, as well as numeracy due to changes in price levels or percentage changes, do not change inflation expectations. However, upgrading due to product replacement and quality change does affect inflation expectations.

1.1. Related literature

Our research contributes to several strands of the literature. First, this paper contributes to the burgeoning literature on how economic agents form inflation expectations. Recent studies have identified several factors that could influence the inflation expectations of households. These include the priors and perceptions of inflation, shopping experience, and media as well as the understanding of economic policies (Coibion et al., 2020b). Our paper builds on the findings of D'Acunto et al., 2021b, who found that the inflation expectations of households in U.S. are shaped by the price signals that they observed in their grocery bundles. Nonetheless, most papers focus on how changes in the prices of the same good influence individuals' inflation expectations. Changing inflation expectations due to the changing composition of households' consumption basket is largely unexplored.

Second, our paper is related to the literature that studies the effect of product replacement and quality change on the economy. In measuring inflation, previous work has shown that the introduction of new goods could lead to biases in the Consumer Price index (Bils and Klenow, 2001; Hausman, 2003). To adjust for quality change, government agencies such as the US Bureau of Labor Statistics rely on methods such as hedonic adjustments to account for new and improved goods and services (Groshen et al., 2017). By adjusting prices based on the observable characteristics of different goods, this will allow a more consistent comparison (Silver and Heravi, 2007). Nonetheless, there is little evidence on how households will respond. We also build on the recent work that highlighted changes in the quality of goods and households' shopping behavior. It has been documented that the quality of the goods and services consumed by households has increased globally with

Table 1
Summary of Treatment Information

	2009	2009	2019	2019
Treatment 1	$5 Wall's Ice Cream		$6 Wall's Ice Cream	
Treatment 2	$5 Wall's Ice Cream		$14.45 Häagen - Dazs Ice Cream	
Treatment 3	$5 Wall's Ice Cream		$6 Wall's Ice Cream	$14.45 Häagen - Dazs Ice Cream
High-Price Quality Treatment	$5 Wall's Ice Cream	$12 Häagen-Dazs Ice Cream	$6 Wall's Ice Cream	$14.45 Häagen - Dazs Ice Cream
Low-Price Quality Treatment	$5 Wall's Ice Cream	$3 Fortune Premium Abalone Sauce	$6 Wall's Ice Cream	$3.60 Fortune Premium Abalone Sauce
Constant Percentage Change Treatment	$12 Häagen-Dazs Ice Cream		$14.45 Häagen - Dazs Ice Cream	
Constant Dollar Change Treatment	$10 Cock Brand Pure Groundnut Oil		$11 Cock Brand Pure Groundnut Oil	
Percentage information for Treatment 1	$5 Wall's Ice Cream		$6 Wall's Ice Cream	
	Comment: Wall's Ice Cream increased in price by **20%** from 2009 to 2019.			
Percentage information for Treatment 3	$5 Wall's Ice Cream		$6 Wall's Ice Cream	$14.45 Häagen - Dazs Ice Cream
	Comment: Wall's Ice Cream increased in price by **20%** from 2009 to 2019.			
Percentage information for Constant Dollar Change Treatment	$12 Häagen-Dazs Ice Cream		$14.45 Häagen - Dazs Ice Cream	
	Comment: Häagen-Daz Ice Cream increased in price by **20%** from 2009 to 2019.			
Percentage information for Constant Percentage Change Treatment	$10 Cock Brand Pure Groundnut Oil		$11 Cock Brand Pure Groundnut Oil	
	Comment: Cock Brand Pure Groundnut Oil increased in price by **10%** from 2009 to 2019.			

Notes: This table provides a summary of all the treatment information given to the respondents. Treatments 1, 2 and 3 are provided to the respondents in the benchmark experiment. High-Price Quality Treatment and Low-Price Quality Treatment are provided to the respondents in the quality experiment. Constant Percentage Change Treatment and Constant Dollar Change Treatment are provided to the respondents in the numeracy experiment. For the quality experiment and numeracy experiment, we compare the results with Treatment 1. Percentage information for Treatment 1, Treatment 3, Constant Dollar Change Treatment and Constant Percentage Change Treatment are provided to the respondents in the percentage information experiment. We compare the results with the treatment groups that are not provided with the relevant percentage information.

income (Jaimovich et al., 2019b), and that changes in the frequency of shopping trips have impacted consumption inequality (Coibion et al., 2021).

Understanding the relationship between the upgrading channel and inflation expectations has potential policy implications. In the face of low nominal interest rates, there have been proposals for central banks to use inflation expectations as policy tools (Coibion et al., 2020b). Changes in inflation expectations could influence consumption (D'Acunto et al., 2022), as well as how households rebalance their portfolio (Agarwal et al., 2022). Nonetheless, studies have shown that recent monetary policy tools that target households' expectations directly instead of those of financial markets were less effective than the predictions of macroeconomic models (Bachmann et al., 2015; McKay et al., 2016. In this paper, we provide another reason for the inattention and ineffectiveness of announcements: Inflation expectations are driven by product variety and product replacement. Consequently, neglecting consumers' choice of goods in designing expectations-based policies could lead to an ineffective outcome, which would have implications for how central banks should communicate to the public (Coibion et al., 2019).

The remainder of the paper is organized as follows. Section 2 presents the experimental design and survey data. Section 3 discusses our benchmark results. Section 4 studies potential mechanisms through additional tests. Section 5 concludes.

2. Experimental design and survey data

This section describes our survey experiment, which underpins the relationship between inflation expectations and the upgrading channel due to the introduction of better-quality products. We conducted our experiment in two settings: face-to-face and online. We used the same survey questions and experimental design in both settings.

2.1. Benchmark survey experiment

The experimental framework builds on recent literature that seeks to understand the formation of households' inflation expectations using survey experiments (Armantier et al., 2016; Cavallo et al., 2017; Coibion et al., 2020a). Before the experiment, we obtain information on the respondent's demographics and individual economic circumstances, as well as their beliefs of the economy. Specifically, we elicit subjects' inflation perceptions for the past 12 months and inflation expectations for the next 12 months. Households give a specific number, which constitutes their prior belief. We then provide respondents with information related to different treatment goods. Table 1 presents a summary of all the different treat-

ment information given to the households in this paper[6]. This includes both the benchmark survey experiment and the additional tests described in Section 4. After the treatment, we ask them the *same* question regarding their inflation expectations and perceptions. This is their posterior belief. Forecast revision is defined as the difference between the posterior and prior beliefs.

In our benchmark survey experiment, we create product replacement randomly in the information treatments and control for other variables, such as taste shocks and income shocks. Here, we randomly assign households to three treatment arms which introduce the prices of two well-known ice cream brands, Wall's and Häagen-Dazs in Singapore. While Wall's caters to the mass market, Häagen-Dazs positions itself as a "super premium brand" (and is regarded to be of higher quality than Wall's). In 2009, 1.5 liters of Wall's Neapolitan cost S$5, while 1 pint (0.473 liters) of Häagen-Dazs strawberry costs S$11.90. In 2019, both ice creams increased by 20%, to S$6 and S$14.45, respectively. Our experimental design focus on how respondents react to price changes for different types of goods. We provide the price of Wall's in 2009 for the entire sample and vary the price information as follows. For Treatment 1 (T1), households are given prices of the lower-quality product, Wall's, in 2019. For Treatment 2 (T2), we provide price information on the higher-quality product, Häagen-Dazs, in 2019 only. For Treatment 3 (T3), we provide price information on both Wall's and Häagen-Dazs in 2019.

By varying the availability of the price information in 2019, the purpose is to study the impact on inflation beliefs, given current price information on higher- and lower-quality products. In this paper, we do not have a pure control group, (i.e. one that does not receive any information treatment). Instead, we compare T2 and T3 with T1. This is because the objective of our experiment is to examine whether households change their beliefs about inflation when better-quality goods are being introduced in subsequent years. Since subjects in T2 are given the prices of Häagen-Dazs in 2019, an increase in inflation expectations vis-à-vis subjects in T1 suggests that exposure to price information on higher-quality goods will increase inflation expectations. Moreover, as subjects in T3 are given prices of both Häagen-Dazs and Wall's in 2019, an increase in inflation expectations vis-à-vis subjects in T1 implies that increasing product variety (by including better-quality goods) will increase inflation expectations. Finally, the difference between T2 and T3 will inform us about the importance of product replacement. An increase in inflation expectations for subjects in T2 vis-à-vis T3 suggests that product replacement results in higher inflation expectations.

The benchmark experiment is conducted in both face-to-face and online settings. For the face-to-face experiments, randomization is at the household level within each enumerator to ensure the balance of treatment and control for enumerator fixed effects. Each enumerator assigns subjects to different treatments based on their order. For example, the first subject is assigned to T1, the second to T2, and then to T3. The fourth subject will then repeat and be assigned to T1. For the online experiment, quota variables that are representative of Singapore's population are first created for all the treatment groups. Subsequently, randomization is conducted using the least-filled method, in which respondents are assigned to the treatment group that has the fewest respondents first. This continues until all quota variables have been met.

2.2. Experiment 1: face-to-face

The face-to-face personal interview survey was administered with surveyors interviewing individuals across Singapore. The survey was fielded between March and July 2019 and at different places, such as malls, food courts, and train stations. Each survey took around 15 min, and each respondent was given S$20 to complete the survey. Respondents were paid a fixed compensation; no part of the payment was contingent on the respondent's answers.

Table A1 in online Appendix A presents the descriptive statistics of the survey. In all, we have 1072 respondents across the three treatment groups. The average age across all samples is around 39; 48% of respondents are female; 45% are married; 80% live in public housing and have tertiary education; and the average household size is 3.92. The average monthly income is S$2680. We also check their understanding of inflation.[7] The inflation literacy question is answered correctly by 83% of households. Importantly, it is evident from the p-values across the different demographics and inflation beliefs that our random assignment of subjects creates balanced treatment and control groups. We also conduct pairwise balance of treatment comparisons between the three treatment groups and obtain similar results.

In this paper, we did not winsorize our sample and rely on Huber robust regression to take care of outliers in our analysis.[8] Huber robust regressions are used to control for outliers systematically and have been adopted in recent papers studying inflation expectations (Coibion et al., 2018 ;Coibion et al., 2020a). Table 2 presents the descriptive statistics of the pre- and post-treatment inflation expectations and perceptions based on the Huber robust moments and raw moments. For all the respondents in the face-to-face experiment, the pre-treatment Huber robust mean for inflation perceptions and expectations are 4.68 and 4.39, respectively. Post-treatment, the Huber robust mean for inflation perceptions and expectations are 3.89 and 3.56, respectively. In comparison, Singapore's inflation rate (as measured by percentage changes in the Consumer Price index for all items) in 2017 and 2018 was 0.6% and 0.4%, respectively. Consequently, we find that households in

[6] In online Appendix C, we show the actual presentation of the information that is being provided to the respondents.

[7] The inflation literacy question is as follows: "Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After one year, how much would you be able to buy with the money in this account?" The options are "More than today", "Exactly the same", "Less than today".

[8] For robustness, we also winsorize the (pre-treatment) inflation expectations and inflation perceptions at the 1% and 99% levels and used an Ordinary Least Square regression (See Section 3.2).

Table 2
Descriptive Statistics

	Huber Robust Moments		Raw Moments			Sample Size
	Mean (1)	St. Dev (2)	Mean (3)	Median (4)	St. Dev (5)	(6)
Panel A: Pre-treatment						
Face-to-Face						
Inflation Perceptions	4.68	0.126	9.32	5.0	14.15	1,072
Inflation Expectations	4.39	0.119	8.15	4.5	12.99	1,072
Online						
Inflation Perceptions	1.77	0.375	3.62	2.0	10.51	1,072
Inflation Expectations	2.15	0.381	4.57	2.0	10.90	1,072
Panel B: Post-treatment						
Face-to-Face						
Inflation Perceptions	3.89	0.104	6.10	3.0	10.18	2,334
Inflation Expectations	3.56	0.092	7.28	4.0	14.14	2,334
Online						
Inflation Perceptions	2.27	0.414	4.58	2.0	10.78	2,334
Inflation Expectations	1.87	0.045	4.97	2.0	11.10	2,334

Notes: This table reports the pre-treatment and post-treatment inflation perceptions and expectations for both face-to-face and online experiments. Moments in Columns (1) and (2) are computed using the Huber-robust method. Moments from Columns (3) to (5) relate to the raw moments.

Singapore have significantly higher inflation expectations and perceptions than the actual inflation rate. The high inflation expectations and perceptions vis-à-vis the actual inflation rate are consistent with findings from other surveys in Singapore (Clark et al., 2018) and other countries such as New Zealand and the United States (Coibion et al., 2018). We now turn to the online survey.

2.3. Experiment 2: online

The online survey was conducted from February to May 2021 and consisted of households from the Rakuten Insight Online Panel. Rakuten Insight is an international company that operates in more than 30 countries and has 12 proprietary panels across Asia. The panel size in Singapore is 80,000 across all demographics. Rakuten Insight provides participants with the link, and they complete the survey using their own electronic devices. Upon completion of the survey, respondents obtain points they can exchange for rewards such as vouchers. Similar to the face-to-face experiment, no part of the payment is contingent on the respondent's answers.

We use the online experiment to repeat the benchmark experiment in Experiment 1 and to run additional tests to unravel potential mechanisms. In all, we obtain 5000 respondents across 11 treatment groups. Like Experiment 1, we did not winsorize the sample and show that our overall results are unchanged if we winsorize the (pre-treatment) inflation expectations and inflation perceptions at 1% and 99%. We will focus on the results of the online benchmark experiment (Treatment Groups 1, 2, and 3) in this section and define this as Experiment 2. The remaining treatment groups will be discussed in Section 4.

Before we begin our discussion of the summary statistics for Experiment 2, we would like to highlight some key differences between the face-to-face experiment (Experiment 1) and the online experiment (Experiment 2). First, studies have shown that the survey method matters. Different survey methods could lead to different responses, even though the same questions were being asked (Kiesler and Sproull, 1986). Reasons include social desirability, whereby respondents are inclined to answer questions in ways that will be viewed positively by others. Another possible reason would be the amount of attention given. In this paper, the average time needed for the online survey (Experiment 2) was approximately 5 min, while the average time for Experiment 1 was 15 min. It is possible that respondents in the online experiment pay less attention or are more prone to make mistakes. We allay this concern by focusing on a subgroup: those who answered the inflation literacy question correctly.

Second, the experiments were conducted during different time periods. Experiment 1 was fielded between March and July 2019, while Experiment 2 was conducted from February to May 2021. A lot of things happened in between. In particular, the Covid-19 pandemic impacted consumption spending (Chetty et al., 2020); the consumption basket (Cavallo, 2020); and inflation beliefs (Armantier et al., 2020) globally. Since Singapore is a small and open economy that is highly dependent on trade, disruptions in global demand are expected to lead to a weak economic outlook and a consequent fall in inflation expectations. In Singapore, the actual inflation rate in 2019 and 2020 was 0.57% and -0.18%, respectively. Hence, we would expect households in Experiment 2 to report lower inflation expectations and perceptions pre-intervention. They could also be more pessimistic about the future. Nonetheless, this does not affect our survey experiment since we seek to exploit the changes in inflation expectations and perceptions *due* to the information treatment.

Table A2 in online Appendix A shows the summary statistics for the online benchmark survey we conducted. For Experiment 2, we have 2334 respondents across all three treatment groups; 48% are female and 74% live in public housing.

Compared with Experiment 1, respondents in Experiment 2 are older on average (46 years) and a larger proportion is married (67%). They have a higher average monthly income (S$7340). While a larger proportion of the respondents have tertiary education (83%), a lower proportion of them answered the inflation literacy question correctly (69%). As in Experiment 1, households in Singapore have significantly higher inflation expectations and perceptions than the actual inflation rate. Table 2 shows that pre-treatment, the Huber robust inflation perceptions and expectations are 1.77% and 2.15%, respectively. Post-treatment, the Huber robust inflation perceptions and expectations are 2.27% and 1.87%, respectively. While this is lower than the values reported in Experiment 1, it is still higher than Singapore's actual inflation rate 0.57% and -0.18%, in 2019 and 2020, respectively. It is important to point out that while the demographics and inflation expectations in Experiments 1 and 2 could differ, the *p*-values indicate that our random assignment of subjects creates balanced treatment and control groups for both experiments separately. Hence, this will not bias our results.

3. Benchmark experimental results

In this section, we investigate the relationship between quality change and inflation expectations based on the survey experiment described above.

We first pool the data from Experiments 1 and 2 to study drivers of inflation expectations and perceptions. Using an ordinary least square regression, we find that the pre-treatment inflation expectations and perceptions are shaped by common factors. (See Table A3 in online Appendix A). Respondents who are financially literate in inflation and with higher education reported lower inflation expectations. This is consistent with the recent literature that highlighted how respondents who are less educated (Armantier et al., 2015)) and have lower IQs (D'Acunto et al., 2019b) have less consistent inflation expectations. Married individuals also report higher inflation expectations. This could be attributed to gender roles and personal experiences, which has been demonstrated by studies in different countries (see Easaw et al., 2013 for a study on Italian households and D'Acunto et al., 2021a for a study on U.S. households). Moreover, we find that respondents' future expectations play an important role. Households who expect to increase their income and spending reported higher inflation expectations. While both indicators could be correlated, since an increase in income is correlated with an increase in spending due to the income effect, the percentage increase in spending could be influenced by other factors, such as nondiscretionary spending. Furthermore, there are other drivers for changes in spending. One possible reason is due to the upgrading channel. We now turn to our survey experiment.

3.1. Information treatment and inflation expectations

We present the post-treatment inflation expectations and perceptions of all treatment groups, alongside one standard deviation in Fig. 2. It is evident that the provision of information has different effects on the inflation expectations and perceptions of the subjects in different treatment groups. For both Experiments 1 and 2, we observe that respondents in T2 reported an increase in inflation expectations and perceptions compared with T1 and T3. This suggests that product replacement and quality change could potentially impact inflation beliefs. Figures A1 and A2 in online Appendix A further present the kernel density of the inflation expectations and perceptions (pre-treatment and post-treatment) by the treatment groups. Post-treatment, we find that respondents in T1 and T3 show lesser dispersion in terms of inflation expectations, as compared to T2. Consequently, we find that the respondents in T2 update their beliefs differently as compared to T1 and T3. More formally, we estimate the treatment effects through the following Huber robust regression:

$$\pi_{post,i} - \pi_{prior,i} = \alpha + \beta_1 T2 + \beta_2 T3 + \phi X_i + \gamma Z + \varepsilon_i \quad (1)$$

where $\pi_{post,i} - \pi_{prior,i}$ refers to the forecast revision in inflation expectations and perceptions of individual respondent *i due to* the information treatment. T2 is an indicator for Treatment 2 and T3 is an indicator for Treatment 3. X_i include controls for age, gender, inflation literacy, education levels, as well as fixed effects for the postal areas. In the pooled regression, we include Z as an indicator variable for Experiment 1. In all specifications, respondents in Treatment 1 serve as the control group.

Table 3 reports the results. Columns 1 and 2 presents the impact of the forecast revisions from the pooled sample. As compared to T1, we find that subjects in T2 reported higher inflation perceptions of 18 basis points (significant at 1 percent) and higher inflation expectations of 13 basis points (significant at 1 percent). In comparison, the impact of T3 in Columns 1 and 2 is not economically and statistically significant. For subjects in T3, there is a fall in inflation perceptions of 5 basis points (p-value = 0.42) and an increase in inflation expectations of 4 basis points (p-value = 0.44). We find similar results for the individual experiments. (See Columns 3 and 4 for results from the Face-to-Face experiment, as well as Columns 5 and 6 for the results from the online experiment).

The different outcomes between the subjects in T2 and T1 show that solely providing price information on higher-quality goods in 2019 (and not the lower-quality product) will lead to higher inflation expectations and perceptions. On the other hand, the comparison between T3 and T1 suggests that an increase in product variety through the introduction of a new product (without replacement) does not have a significant impact. Finally, from the Wald test, we find that the inflation expectations and perceptions of households in T2 and T3 are significantly different, which demonstrates that product replacement of goods will lead to higher inflation expectations and perceptions.

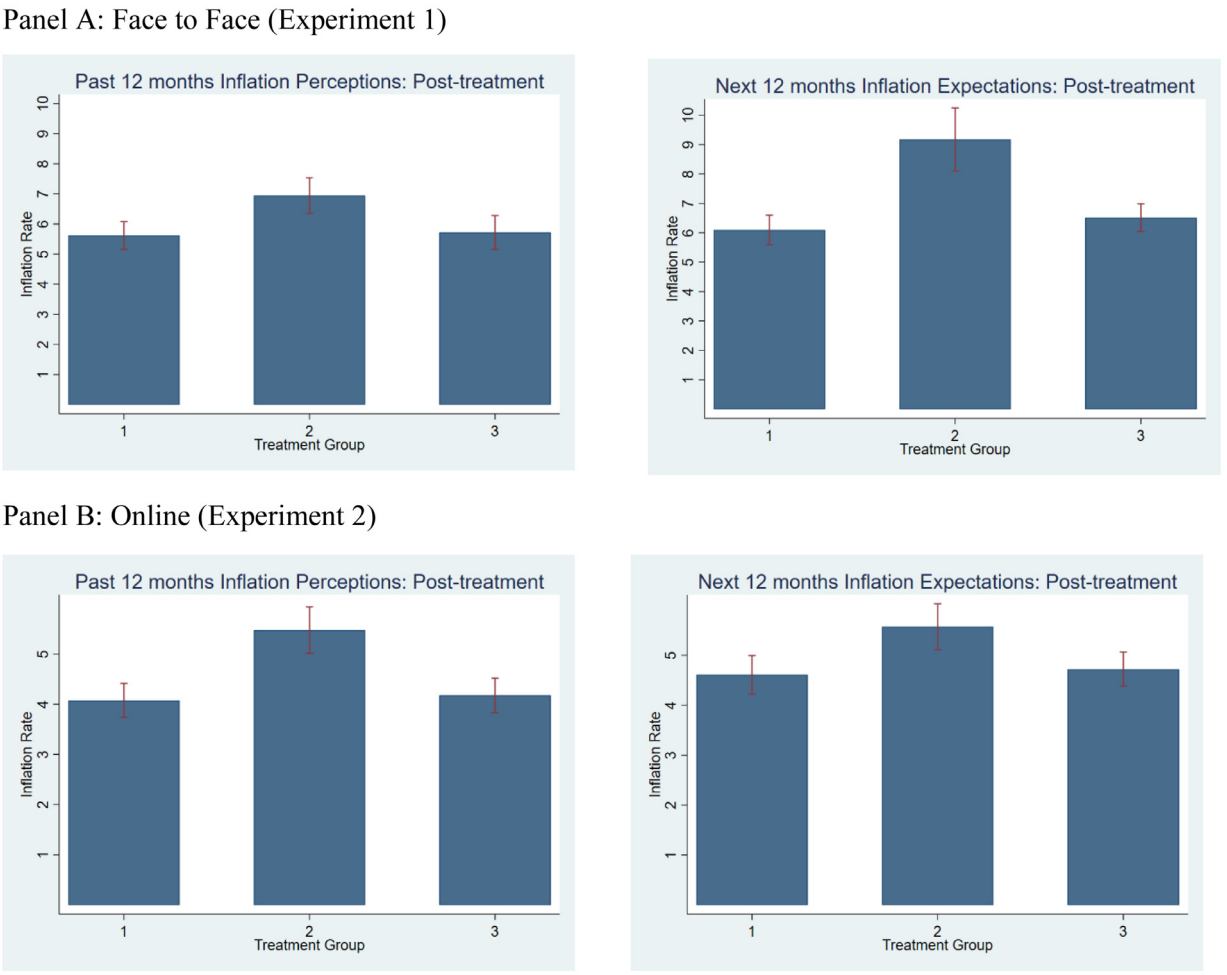

Fig. 2. Post-Treatment Inflation Expectations and Perceptions: Notes: This figure shows the level of households' inflation expectations and perceptions (post-treatment) by treatment groups, as well as the confidence interval based on one standard error. Panel A presents the results from the Face-to-Face sample (Experiment 1), while Panel B presents the results from the online sample (Experiment 2).

Table 3
Benchmark treatment effects

	Pooled Sample		Face-to-Face		Online	
Dependent Variable:Forecast Revision	Perceptions (1)	Expectations (2)	Perceptions (3)	Expectations (4)	Perceptions (5)	Expectations (6)
T2	0.175***	0.133**	0.399	0.866***	0.116**	0.089*
	(0.063)	(0.054)	(0.262)	(0.219)	(0.056)	(0.048)
T3	-0.051	0.042	-0.538**	0.097	-0.059	0.007
	(0.063)	(0.054)	(0.267)	(0.223)	(0.056)	(0.048)
Face-to-Face	-0.363***	-0.111**				
	(0.062)	(0.053)				
Wald test (T2=T3) *p*-Value	0.000	0.093	0.001	0.001	0.002	0.089
Observations	3,400	3,400	1,065	1,065	2,333	2,333
R-squared	0.072	0.171	0.196	0.192	0.078	0.464
Controls and Postal Codes Fixed Effects	Y	Y	Y	Y	Y	Y

Notes: This table presents the Huber-robust estimation based on Equation (1). Treatment 1 is the control group. The dependent variables are the forecast revision in inflation perceptions and expectations. Forecast revision is defined as the difference between the posterior beliefs and prior beliefs. Columns (1) and (2) report the results of the respondents from both Face-to-Face and the online sample. Face-to-Face is an indicator variable for the face-to-face experiment. Columns (3) and (4) report the results only from the Face-to-Face sample (Experiment 1), while Columns (5) and (6) report the results only from the online sample (Experiment 2). We include the following controls: Age, Gender, Inflation Literacy, Educational levels, as well as fixed effects for postal areas. Robust standard errors are reported in parentheses. *,**,*** denote statistically significant levels at 10%, 5% and 1%, respectively.

Table 4
Heterogeneity in posterior beliefs as a function of treatment and prior beliefs

Dependent Variable: Posterior Beliefs	Perceptions (1)	Expectations (2)
Prior	0.353***	0.510***
	(0.005)	(0.004)
Prior x T2	0.345***	0.474***
	(0.007)	(0.006)
Prior x T3	0.030***	0.299***
	(0.007)	(0.006)
T2	-0.474***	-0.888***
	(0.086)	(0.072)
T3	-0.075	-0.586***
	(0.086)	(0.072)
Face-to-Face	0.095	0.071
	(0.078)	(0.064)
Observations	3,400	3,400
R-squared	0.921	0.975
Controls and Postal Codes Fixed Effects	Y	Y

Notes: This table presents the Huber-robust estimation based on Equation (2). Treatment 1 is the control group. The dependent variables are the posterior (post-treatment) beliefs. We report the results of the respondents from both Face-to-Face and the online sample. Face-to-Face is an indicator variable for the face-to-face experiment. We include the following controls: Age, Gender, Inflation Literacy, Educational levels, as well as fixed effects for postal areas. Robust standard errors are reported in parentheses. *,**,*** denote statistically significant levels at 10%, 5% and 1%, respectively.

To further investigate households' differential response to different treatments, Figure A3 in online Appendix A plots households' priors against their posterior after receiving the information. Within each treatment group, the slopes of the regression lines are less than 1, showing that households with above average beliefs are inclined to reduce their forecasts, while those with below average beliefs increased their forecasts. Nonetheless, the slope differs. How will respondents with different priors update their beliefs when given different types of goods? We address this question by examining the heterogeneous treatment effects on the posterior beliefs through the following Huber robust regression:

$$\pi_{post,i} = \alpha + \beta_1 \pi_{prior,i} + \beta_2 T2 * \pi_{prior,i} + \beta_3 T3 * \pi_{prior,i} + \beta_4 T2 + \beta_5 T3 + \phi X_i + \gamma Z + \varepsilon_i \quad (2)$$

In this specification, we study posterior beliefs as a function of the treatment groups and prior beliefs. Here, $\pi_{post,i}$ and $\pi_{prior,i}$ refer to posterior and prior beliefs, while T2 and T3 are indicators for Treatment 2 and Treatment 3, respectively. X_i are the controls discussed earlier, and we include Z as an indicator variable for Experiment 1. Similar to Eq. (1), respondents in T1 serve as the control group. Hence, β_1 reflects the persistence of beliefs for the control group, T1. In comparison, β_2 and β_3 allow us to examine the heterogenous impact of prior beliefs when the respondents are given goods of different quality in T2 and T3 respectively.

Table 4 presents the results. For T1, the coefficients linking pre-treatment to post-treatment inflation perceptions and expectations are 0.35 and 0.51, respectively. As the slope is less than 1, it shows that the respondents with different prior beliefs are responding to the information treatment differently when they are given prices of the same product (Walls Ice-cream) across time. As compared to T1, respondents with higher prior beliefs are more responsive towards the treatment information in both T2 and T3. For each 100-basis point increase in the prior beliefs, we find that the effect of T2 is higher by 35 basis points for inflation perceptions and higher by 47 basis points for inflation expectations. At the same time, we find that the effect of T3 for each 100-basis point increase in the prior beliefs is larger by 3 basis points for inflation perceptions and larger by 30 basis points for inflation expectations. All the results are statistically significant at 1 percent. Hence, with the introduction of better- quality goods, respondents with higher prior beliefs are more responsive towards the information treatment. One possible reason could be attributed to confirmatory biases (Rabin and Schrag, 1999). As individuals overweight their personal experiences in the formation of inflation expectations (Malmendier and Nagel, 2016), respondents who have experienced consumption upgrading are likely to have higher prior beliefs. Confirmation bias suggests that the respondents with higher prior beliefs are more likely to focus on the price changes based on their own experiences. Hence, for respondents who received the information treatment of high-quality products, those with higher prior beliefs interpret the information as a confirmation of their initial beliefs and experiences, and hence report higher posterior beliefs as compared to T1.

In sum, we find that exposure to better-quality products will lead to higher inflation expectations and perceptions. Moreover, the impact is larger for those with higher prior beliefs. Our results suggest that product replacement and quality change could lead to higher inflation expectations and perceptions.

Table 5
Heterogeneous Effects on Changes in Inflation Expectations

Cognitive Indicator	Tertiary Education		Inflation Literate	
Dependent Variable: Forecast Revision	Perceptions (1)	Expectations (2)	Perceptions (3)	Expectations (4)
Treat2	0.326**	0.162	0.192	0.068
	(0.145)	(0.127)	(0.123)	(0.105)
Treat3	-0.006	0.090	-0.030	0.096
	(0.145)	(0.127)	(0.122)	(0.104)
Cognitive Indicator	0.038	0.195*	-0.363***	-0.111**
	(0.115)	(0.100)	(0.062)	(0.053)
Cognitive Indicator * T2	-0.175	-0.036	0.084	-0.045
	(0.161)	(0.140)	(0.103)	(0.088)
Cognitive Indicator * T3	-0.046	-0.051	-0.021	0.080
	(0.161)	(0.141)	(0.143)	(0.123)
Face-to-Face	-0.366***	-0.115**	-0.363***	-0.111**
	(0.061)	(0.053)	(0.062)	(0.053)
Observations	3,400	3,400	3,400	3,400
R-squared	0.069	0.165	0.071	0.173
Controls and Postal Codes Fixed Effects	Y	Y	Y	Y

Notes: This table presents the Huber-robust estimation based on the heterogeneous impact on the following cognitive indicators: Tertiary Education and Inflation Literate. Tertiary Education is an indicator for a respondent with post-secondary education. Inflation Literate is an indicator for a respondent who answered the inflation literacy question correctly. Treatment 1 is the omitted group. The dependent variables are the forecast revision in inflation perceptions and expectations. Forecast revision is defined as the difference between the post-treatment beliefs and pre-treatment beliefs. Columns (1) and (2) report the results for tertiary education as a cognitive indicator, while Columns (3) and (4) report the results for inflation as a cognitive indicator. Face-to-Face is an indicator variable for the face-to-face experiment. We include the following controls: Age, Gender, Inflation Literacy (for Columns 1 and 2), Educational levels (for Columns 3 and 4), as well as fixed effects for postal areas. Robust standard errors are reported in parentheses. *,**,*** denote statistically significant levels at 10%, 5% and 1%, respectively.

3.2. Robustness

We provide several pieces of evidence to assess the robustness of our results. First, our results are consistent for both inflation expectations and perceptions. As highlighted by Coibion et al., 2018, there is a tight correlation between inflation expectations and perceptions. In addition, we obtained similar findings for Experiment 1 and 2, which are conducted in different settings (face-to-face and online) in different time periods (2019 and 2021). Our results are also robust across different sub-samples. In Table A4, we winsorize the (pre-treatment) inflation expectations and perceptions at 1 percent and 99 percent and run the entire sample using OLS and Huber robust regression. In Table A5, we repeat our benchmark survey experiment with the sample who answered the inflation literacy question correctly. In these sub-samples, our key findings remain unchanged. This will allay concerns about the quality of the survey.

One of the common criticisms of survey experiments is the issue of spurious learning (Cavallo et al., 2017). That is, instead of inducing genuine learning, the information provision could result in respondents' reporting numbers for spurious reasons. We address this concern by examining cognitive abilities. The spurious effects are expected to be smaller for respondents who have higher cognitive ability (Agarwal and Mazumder, 2013). It is likely that households make mistakes when asked about inflation expectations due to lower quantitative reasoning (D'Acunto et al., 2019a)). To test this likelihood, we examine whether cognitive abilities play a role in influencing households to allocate more weight to the higher-quality product. In studying households' differential responses to different treatments based on their cognitive abilities, we study the following cognitive indicators: Tertiary Education and Inflation Literate. The former refers to respondents who have post-secondary education, while the latter indicates those who correctly answered the inflation literacy question. Consequently, we seek to study the heterogeneous treatment effects through the lens of educational levels and inflation literacy.

Table 5 presents the results. In Columns 1 and 2, we find that the effects of T2 on inflation perceptions (p-value = 0.28) and expectations (p-value = 0.80) are not significantly different between those with and without tertiary education. Similarly, in Columns 3 and 4, the effects of T2 on inflation perceptions (p-value = 0.42) and expectations (p-value = 0.61) are not significantly different between respondents who are financially literate and illiterate in inflation. As the results are economically and statistically insignificant, we find that our results for T2 are not driven by respondents with lower cognitive ability, thus allaying concerns about spurious results. We now turn to the potential mechanism of our results.

4. Potential mechanisms

In our benchmark survey experiment, we showed that the introduction of a higher-price, higher-quality product could increase inflation expectations. Nonetheless, there are several possible explanations for our results. First, we have the product replacement and product variety channel. When lower-quality products are replaced by better-quality goods, households

could report higher inflation expectations. In addition, inflation expectations could be influenced by changes in product variety. Second, it is possible that households mix up prices and quality. In our survey experiment, the higher-quality product is also the product with higher prices. Consequently, the results in our benchmark experiment could be driven simply by the exposure to higher prices (and not the quality of the products). Third, it could simply be a numbers game: Households report higher inflation expectations due to changes in prices (both in absolute dollar terms and percentage changes).

In this section, we discuss these possible mechanisms and design additional experiments to test them. All additional tests are performed via the online settings as a proof of concept during the same time period. Here, we introduce eight additional treatment groups across 2666 respondents.

4.1. Product replacement and product variety

One possible explanation from our survey experiment concerns product replacement and product variety. The former occurs when better-quality products are being introduced to replace older ones, while the latter refers to the introduction of new products (without replacement). Earlier studies have highlighted the role of product replacement bias (Nakamura and Steinsson, 2012) and quality change bias (Pakes, 2003; Bils, 2009) in impacting consumer price inflation. It is of interest, therefore, to examine how it would impact inflation expectations. Intuitively, changes in inflation expectations can have two causes: They can be due to changes in the prices of goods or shifts in the weights between different types of products. With the introduction of the new products, it is plausible that the subjects increased weights toward new products, which are of higher quality. To understand how product replacement and product variety could impact inflation expectations, consider a household's inflation expectations (π^e) as a weighted average of two types of goods (high quality and low quality) across time periods (period 0 and period 1):

$$\pi^e = \frac{w_1 P_{high1} + (1 - w_1) P_{low1}}{w_0 P_{high0} + (1 - w_0) P_{low0}} - 1 \tag{3}$$

The price of the high-quality good in period 0 and period 1 is defined as P_{high0} and P_{high1}, respectively. Analogously, the price of the low-quality good in period 0 and period 1 is P_{low0} and P_{low1}, respectively. We assume that the price of the high-quality good is always higher than that of the low-quality product and define w_0 and w_1 to be the weight of the high-quality good in period 0 and period 1, respectively. Therefore, an increase in inflation expectations can be due to an increase in weights toward better-quality goods—i.e., when w_1 increases from w_0. In this case, when better-quality goods are being introduced, respondents report higher inflation expectations when they shift to brands of higher quality (even though the prices of both types of goods have increased by the same proportion).

The design of our survey experiment allows us to hold alternative explanations, such as taste shock and income shock, constant and focus on product replacement and product variety. Based on the results in Table 3, we have two key findings. First, we find that product replacement increases inflation expectations and perceptions. By comparing T2 and T1, we find that exposure to higher-quality goods will lead to higher beliefs about inflation if current price information on the lower-quality goods is not available. By comparing T2 and T3, we find that exposure to higher-quality goods with replacement will also lead to higher beliefs about inflation relative to the case in which new products are being introduced without replacement. This is true for the entire sample and is robust across different cognitive levels. Second, we find that product variety does not increase beliefs about inflation when products are not being replaced. Our comparison between T3 and T1 suggests that there are no economically and statistically significant differences in inflation expectations and perceptions between the two treatment groups. This suggests that the introduction of new products will only lead to higher inflation beliefs when the products are being replaced.

Hence, we find evidence that product replacement can influence the inflation expectations of households. This builds on the literature of inflation expectations and personal experiences (D'Acunto et al., 2021b) and sheds light on the importance of product variety and price differences (Handbury and Weinstein, 2015). Here, we find that the quality of goods matters in influencing inflation beliefs.

4.2. Mixing prices and quality

Next, we discuss the possibility that respondents are influenced primarily by the prices of the goods and not the quality of the product. In our survey experiment, the higher-quality product is also the product with higher prices. Consequently, the results in our benchmark experiment could be driven by the exposure to higher prices (and not the quality of the products). To address this possibility, we vary the price information on different products of similar quality in two new treatment groups without product replacement. In particular, we introduced two treatment groups: the High-Price Quality Treatment and the Low-Price Quality Treatment.

For the High-Price Quality Treatment, we include complete information on both products (Häagen-Dazs and Wall's) in both time periods (2009 and 2019). This is to test whether the results in our benchmark experiment are driven primarily by higher prices. In all treatment groups in the benchmark experiment (T1, T2, and T3), we did not provide price information on the higher-quality product, Häagen-Dazs, in 2009. For the High-Price Quality Treatment, we provide price information on all products in both time periods. Consequently, the average price levels for 2009 and 2019 are higher in the High-Price Quality Treatment compared with those in the benchmark experiment. For the Low-Price Quality Treatment, we introduce

Table 6
Treatment Tests for Quality and Numeracy

Dependent Variable: Forecast Revision				
Panel A. Quality Experiment	Perceptions	Expectations		
	(1)	(2)		
High-Price Quality Treatment	0.135	-0.033		
	(0.085)	(0.069)		
Low-Price Quality Treatment	0.047	-0.002		
	(0.085)	(0.069)		
Wald Test (High-Price Quality = Low-Price Quality) P-Value	0.299	0.654		
Observations	1,531	1,531		
R-squared	0.232	0.473		
Controls and Postal Codes Fixed Effects	Y	Y		
Panel B. Numeracy Experiment	Perceptions	Expectations	Perceptions	Expectations
	(1)	(2)	(3)	(4)
Constant Percentage Change Treatment	0.454**	0.026		
	(0.178)	(0.119)		
Constant Dollar Change Treatment			-0.029	-0.069
			(0.158)	(0.124)
Observations	643	643	638	638
R-squared	0.461	0.883	0.387	0.592
Controls and Postal Codes Fixed Effects	Y	Y	Y	Y
Panel C. Percentage Information Experiment	Perceptions	Expectations		
	(1)	(2)		
With Percentage Information Treatment	0.440***	0.172**		
	(0.117)	(0.080)		
Observations	1,448	1,448		
R-squared	0.344	0.409		
Controls and Postal Codes Fixed Effects	Y	Y		

Notes: This table presents the Huber-robust estimation for the additional tests. The dependent variables are the forecast revision in inflation perceptions and expectations. Forecast revision is defined as the difference between the post-treatment beliefs and pre-treatment beliefs. Panel A and B present the findings of the Quality Experiment and Numeracy Experiment, respectively. In both panels, Treatment 1 is the omitted group. Panel C presents the findings of the Percentage Information Experiment. The omitted group is the group without percentage information for T1, T3, Constant Percentage Change and Constant Dollar Change Treatment. In all specifications, we include the following controls: Age, Gender, Inflation Literacy, Educational levels, as well as fixed effects for postal areas. Robust standard errors are reported in parentheses. *,**,*** denote statistically significant levels at 10%, 5% and 1%, respectively.

another information treatment that varies the brand quality and price level in opposite directions. Since prices and quality are highly correlated for goods in a particular product category, we focus on a product in another category that has a lower price but higher quality. This will allow us to disentangle the relationship between price and quality. Here, we introduce the price of a high-quality sauce: Fortune Premium Abalone Sauce. Abalone is a popular delicacy, and the premium sauce is a high-quality product in the sauce category. Just like the prices of Wall's ice cream in T1, the sauce increased its price by 20%. Nonetheless, it has a lower price of S$3 and S$3.60 in 2009 and 2019, respectively, compared with Wall's ice cream.

To test whether prices are the main factor driving inflation expectations, we compare the outcomes between the High-Price Quality Treatment and Low-Price Quality Treatment. If respondents' expectations are the result of them mixing up quality and prices, respondents in the High-Price Quality Treatment should report higher inflation beliefs when given a high-quality product with higher prices compared with the Low-Price Quality Treatment. Furthermore, the High-Price Quality Treatment should report higher inflation beliefs compared with T1, while the Low-Price Quality Treatment should report lower inflation beliefs compared with T1. Table A6 in Online Appendix A presents the summary statistics and balance of treatment for the sample used for the quality experiment.

Using Eq. (1), we compare the forecast revision of subjects in the High-Price Quality Treatment and Low-Price Quality Treatment with subjects in T1. This is based on the sample used when the additional tests are conducted concomitantly. Like the benchmark experiment, we use Huber robust regression and include the same controls. Table 6 Panel A presents the results. From the Wald test, we do not find respondents in the High-Price Quality Treatment behaving differently from those in the Low-Price Quality Treatment for the forecast revision for inflation expectations and perceptions. The p-value for the two treatment groups (High-Price Quality Treatment and Low-Price Quality Treatment) being equal for changes in inflation perceptions and inflation expectations are 0.299 and 0.654, respectively. These results suggest that the results from our benchmark experiment are not driven primarily by the distinction between quality and prices. We recognize that the results of our benchmark experiment could be driven by the joint effect of high quality and high prices simultaneously. Nonetheless, in the High-Price Quality Treatment and Low-Price Quality Treatment, we find that pure exposure to high or low price does not change inflation beliefs (after considering the quality of the goods). Together with the discussions in Table 3 and Section 4.1, we find that the replacement of different types of products affects the inflation beliefs.

4.3. Numeracy

Another alternative explanation for our benchmark experimental results is numeracy. First, respondents might focus on dollar changes, percentage changes and price levels (rather than the product replacement of the good). Moreover, the subjects might have low numeracy ability to calculate the price changes or do not pay attention to the price changes. In this subsection, we discuss these mechanisms and design additional experiments to test them.

One possible reason is that subjects could respond based on absolute dollar changes and not due to product replacement and quality change. Earlier research has documented that households do not understand the difference between levels and percentage increase in reporting their inflation expectations (de Bruin et al., 2012) and that investors do not think about changes in prices in percentage terms, but rather in dollar terms (Shue and Townsend, 2021). Such nonproportional thinking will suggest that goods that have a higher price could have a larger impact on households' inflation expectations, as they are larger in dollar changes, even though the percentage changes are kept constant. Since the higher-quality product in our benchmark survey experiment has higher dollar changes, it is possible that the results are driven primarily by an increase in absolute dollars. Another possible reason is related to percentage changes. When products are being replaced in T2, there is a larger increase in percentage changes (even though the product have changed). Finally, since final price levels are higher in T2, it is also possible that households focus on final price levels, but not on dollar changes or percentage changes.

To examine whether dollar changes and percentage changes could drive the results in our benchmark experiment, we introduce the following two treatment groups and compare them with respondents in T1. The first treatment group is the Constant Percentage Change Treatment. In T1, we show subjects that the prices of Wall's ice cream increased from S$5 to S$6. To keep the percentage change constant, we provided subjects in the Constant Percentage Change Treatment with the prices of Häagen-Dazs in 2009 (S$12) and 2019 (S$14.45). As highlighted earlier, both goods have increased their prices by 20%. The second treatment group is the Constant Dollar Change Treatment. In T1, we show respondents that the prices of Wall's ice cream increased by S$1. To keep the absolute dollar price change constant, we introduced another product, Cock Brand Pure Groundnut Oil, which increased its price from S$10 in 2009 to S$11 in 2019 for the Constant Dollar Change Treatment. Cock Brand Pure Groundnut Oil was chosen because it is in the median of the quality ladder for oil (just like Wall's is in the ice cream category) and experienced a similar increase in absolute dollar price change (S$1). Nonetheless, the percentage increase in price is smaller at 10%.

By pooling subjects in T1, the Constant Percentage Change Treatment, and the Constant Dollar Change Treatment, we would be able to test whether subjects focus on dollar price changes, percentage changes, or final price levels. First, since subjects in the Constant Percentage Change Treatment are provided with a higher absolute dollar price change (S$2.45) compared with T1 (S$1), they should report higher inflation expectations if the results are driven primarily by dollar price changes. Second, if the subjects focus on percentage changes, we expect subjects in the Constant Dollar Change Treatment (10% change) to report a smaller change in inflation expectations compared with T1 (20% change). Third, if the subjects primarily focus on the final price level, we expect subjects in the Constant Percentage Change Treatment and Constant Dollar Change Treatment to report higher changes in inflation expectations than subjects in T1, since the final price level in the Constant Percentage Change Treatment (S$14.45) and Constant Dollar Change Treatment (S$11) is higher than that of T1 (S$6).

Table A7 in online Appendix A shows the summary statistics and balance of treatment for the sample used for the Numeracy Experiment. We use the sample when the additional tests were conducted at the same time. Table 6 Panel B presents the results of the regression between the Constant Percentage Change Treatment and T1, as well as the Constant Dollar Change Treatment and T1. We follow the benchmark experiment in Eq. (1) and use Huber robust regression as well as the same controls and fixed effects. While Column 1 shows that respondents in the Constant Percentage Change Treatment report higher inflation perceptions of 45 basis points (significant at 5 percent) as compared to T1, the results for inflation expectations are economically and statistically insignificant. Column 2 shows respondents in the Constant Percentage Change Treatment report higher inflation expectations of 3 basis points (p-value = 0.83) as compared to T1. Hence, we are unable to find consistent evidence supporting the claim that households respond to changes in absolute dollars due to nonproportional thinking for inflation expectations. As highlighted earlier, we should expect to see subjects in the Constant Percentage Change Treatment report higher inflation expectations compared with T1 if there is evidence of nonproportional thinking. This is because there is a larger increase in dollar terms for the Constant Percentage Change Treatment ($2.45) compared with T1 ($1).

From Columns 3 and 4 in Table 6 Panel B, subjects in the Constant Dollar Change Treatment report lower inflation perceptions and expectations by 3 basis points (p-value = 0.86) and 7 basis points (p-value = 0.56) respectively. Both results are economically and statistically insignificant. Consequently, we are unable to find evidence to support the hypothesis that households focus primarily on percentage changes when forming their inflation beliefs. If our results are driven primarily by percentage changes, we should expect to see subjects in the Constant Dollar Change Treatment report smaller inflation expectations compared with T1. This is because there is a smaller increase in percentage terms for the Constant Dollar Change Treatment (10%) compared with T1 (20%). This also suggests that our results are not driven by final price levels. As the final price levels in the Constant Dollar Change Treatment (S$11) are higher than those in T1 (S$6), respondents should report higher inflation expectations if they are influenced by the final price level. Nonetheless, we do not find any evidence supporting this relationship. This seeks to allay concerns that our results are driven primarily by final price levels.

Why do the subjects not respond to percentage changes? One possibility is due to subjects' having low numeracy ability to calculate the price changes or not paying attention to the price changes. To study this likelihood, we repeated T1, T3, the Constant Percentage Change Treatment, and the Constant Dollar Change Treatment—but with a twist. On top of the information given previously, we also provided subjects with the corresponding percentage changes. By explicitly telling subjects the percentage changes, we seek to overcome the issue of low numeracy ability and increase the salience of price changes.

We introduce the following four treatment groups. First, the percentage information for Treatment 1 and the percentage information for Treatment 3 explicitly highlight the fact that the prices of Wall's ice cream have increased by 20%. Next, the percentage information for the Constant Percentage Change Treatment states explicitly that the prices of Häagen-Dazs ice cream have increased by 20%. Finally, the Constant Dollar Change Treatment explicitly states that the prices of Cock Brand Pure Coconut Oil have increased by 10%. We can compare the outcomes of these two groups (with and without information on percentage changes) to see whether information on percentage changes plays a role in influencing inflation expectations.

Table A8 in Online Appendix A presents the summary statistics and balance of treatment for the sample used for the percentage information experiment. This is based on the sample used when the additional tests were conducted at the same time. Following Eq. (1), Table 6 Panel C presents the results of the regression between the group who was given information on percentage changes and those who were not. Compared with subjects who were not given information on percentage changes, we find that subjects who were given information on percentage changes report higher inflation expectations of 17 basis points (significant at 5 percent) and higher inflation perceptions of 44 basis points (significant at 1 percent). The fact that households respond more when explicitly informed about percentage changes suggests that while numeracy matters, subjects might not have the cognitive ability to calculate or pay attention to the percentage changes in our benchmark experiment. While numeracy does impact inflation expectations, the level of numeracy is similar across treatment groups in the benchmark experiment due to randomization. Thus, numeracy cannot explain the difference between T2 and T1. Consequently, we find that product replacement and quality change, and not matters related to numeracy influence inflation expectations from our survey experiment.

5. Conclusion

In this paper, we first show that upgrading occurs by documenting changes in the quality of goods consumed by households in Singapore within categories of goods. Using a randomized experiment, we then find that exposure to prices of higher-quality goods over time—without retaining price information about lower-quality products—leads to higher inflation beliefs. This suggests that the replacement of lower-quality products by higher-quality products from the market will increase inflation expectations. We further conducted additional tests to show that our results are not driven by price changes, but rather by the type of goods.

Our findings have several implications for monetary policymakers who clearly communicate their views of future development and inflation targets (Blinder et al., 2001). Here we highlight another potential information friction in the form of product replacement and quality change. Unlike government agencies which relied on hedonic adjustments to update the Consumer Price Index, households fail to adjust for the quality change and prices. Hence, this could be a possible reason in explaining why households' inflation beliefs are consistently higher than the actual inflation rate. In a world with rapidly changing product menus and lifestyles, personal experiences could play an important role in driving inflation expectations and should not be neglected. An understanding of the role of product replacement will be useful for policymakers who aspire to use inflation expectations as a policy tool.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jmoneco.2022.04.003.

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