Nutrition, Labor Supply, and Productivity: Evidence from Ramadan in Indonesia

Zihan Hu and Zhiwen Wang*

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Abstract

This paper studies the short-term effects of nutrition deficiency on labor supply and productivity. Using high-frequency administrative data from a retail chain in Indonesia, we exploit the nutrition shock induced by Ramadan fasting among Muslim salespersons, a non-physically demanding occupation. Based on an event study approach, we find a 30% decrease in productivity for them during the two hours before sunset, when they experience the most energy deficiency. Their productivity recovers immediately after sunset, when they can break their fast. They leave work 32 minutes earlier during the hours of greatest energy deficiency. The effects are in line with the nutrition mechanism and are not likely driven by major competing explanations such as demand shocks, fast-breaking events, dehydration, and sleep deprivation.

Keywords: Nutrition deficiency, Labor supply, Productivity, Ramadan fasting

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1 Introduction

Whether nutritional status affects labor market outcomes is a long-standing question. The relationship between current nutrition and labor supply and productivity is the crucial assumption behind the nutrition efficiency wage hypothesis. Based on this assumption, the hypothesis suggests that improving nutrition and, therefore, productivity is a main factor explaining why employers pay higher than market-clearing wage in developing countries (Leibenstein, 1957; Mirrlees, 1975; Stiglitz, 1976). This hypothesis has been widely applied to explain various phenomena in developing countries, such as involuntary unemployment, household savings, intra-household distribution, and the poverty trap (see Strauss (1986) and Dasgupta (1997) for a summary). Despite its theoretical importance, few papers provide empirical evidence to support this crucial assumption behind the nutrition efficiency wage hypothesis. Therefore, this paper examines the effects of nutrition deficiency on labor market outcomes among salespersons, a non-physically demanding occupation.

This question is also important to understand the consequences of nutrition deficiency, given that approximately 124 million people across 51 countries still faced "crisis" levels of acute food insecurity or worse in 2017 (FAO et al., 2018). Moreover, the relationship between nutrition and labor market outcomes may be more obvious for physically demanding occupations. Whether the nutrition-productivity relationship still exists for non-physically demanding occupations is an important unanswered question, especially given the global shift toward cognitive rather than physical labor. To the best of our knowledge, our paper is the first to examine the nutrition-productivity relationship for a non-physically demanding occupation.

There are two main barriers to investigating the effects of nutrition deficiency on labor market outcomes. First, high-frequency data with daily and hourly measurements of labor supply and productivity are crucial for understanding the short-term and immediate effects of nutrition deficiency. Given that cognitive performance changes with nutritional status even over just a few hours (Gailliot et al., 2007; Danziger, Levav and Avnaim-Pesso, 2011), measurements at daily or lower frequency levels may fail to detect the latent relationship between nutrition and productivity for non-physically demanding occupations.

We use unique high-frequency administrative data from a cosmetic retail chain in Indonesia to investigate this question among salespersons, a non-physically demanding occupation. The data include detailed information about each transaction and daily clock-in/clock-out data for salespersons. Clock-in/clock-out data provide us labor supply measurements not only at the extensive margin, i.e., absence from work, but also at the intensive margin, i.e., working hours. We match each transaction to the corresponding salesperson and calculate the salespersons' daily and hourly sales as a measurement of incentivized productivity. The unique high-frequency measures of productivity at the hourly level enable us to link productivity change to nutritional status within a day, which provides us with a unique opportunity to investigate the immediate effects of nutrition deficiency on productivity over a few hours.

The second barrier comes from the endogeneity of nutritional intake that hampers causal interpretations. Following Almond and Mazumder (2011), we use Ramadan fasting as an exogenous nutrition shock to enable a causal interpretation. As introduced in detail in Section II, adult Muslims are obligated to fast during daylight hours during Ramadan. Fasting during the Ramadan month is associated with a decrease in blood glucose (Kul et al., 2014), which is the primary energy source for human cognitive function. Basically, we use an event-study approach to estimate the effects of nutrition deficits on productivity and labor supply by comparing the affected and unaffected salespersons, that is Muslim and non-Muslim salespersons, during Ramadan with pre-Ramadan periods as the baseline.

High-frequency administrative data and event-study estimates based on Ramadan fasting let us overcome the challenges in the literature to date. However, using Ramadan fasting as a natural experiment leads us to another empirical challenge. Along with fasting, other changes occur simultaneously during Ramadan, such as fast-breaking events, dehydration, and sleep deprivation. Therefore, we first examine the "reduced form" effects of Ramadan on the labor market outcomes of the affected salespersons using an event study approach. We then perform extensive supplemental analyses showing patterns consistent with the nutrition mechanism, our preferred interpretation, and exclude these major competing explanations.

First, we investigate productivity changes during Ramadan. We calculate the total sales for each employee in each working hour as the measurement of productivity. To interpret total sales as a productivity measurement, we must rule out a key competing hypothesis, namely, that the change in total sales is driven by demand-side changes instead of productivity changes. Although our event-study approach can address demand shocks that are common to Muslim and non-Muslim salespersons, these salespersons may face different demand since customers might be more likely to approach salespersons who share their religion. In contrast to this hypothesis, we find that Muslim salespersons do not benefit more from increased demand in a city with a higher female Muslim ratio, based on a triple-differences approach.

Controlling for demand-side changes and comparing with the non-Muslim salespersons, we find a statistically significant drop in productivity by 30% for the Muslim salespersons only during the two hours before sunset, the period when they have fasted for around 12 hours and in which they might experience the most energy deficiency in a fasting day. Productivity then recovers back to the normal level immediately after sunset when they can break their fast. This pattern is unique to the Ramadan period and does not coincide with the trend of total demand.

We find that these productivity patterns within a day align closely with the nutritional status of the affected salespersons within a day. These findings provide strong support for the nutrition mechanism as the main driving force behind our finding.[1] Meanwhile,

[1] Another remaining concern is fluid restriction during Ramadan. Although we cannot cleanly separate nutrition deficiency and dehydration, we provide detailed arguments in the discussion section about why dehydration during daytime might have sufficiently large effects to drive our results, based on the medical and physiological literature.

we find no significant negative effects on productivity at the daily level, possibly due to income targeting behaviors. This finding suggests the cruciality of having hourly data to detect the productivity changes for a non-physically demanding occupation such as salespersons.

We then investigate the change of labor supply at both the extensive and intensive margins. Although the affected salespersons are not more likely to be absent from work, the day-shift affected salespersons work 35 minutes less on average each working day during Ramadan. The effects on hours worked begin immediately at the start of Ramadan and disappear almost immediately after the end of Ramadan. In contrast, the hours worked by night-shift workers remain nearly unchanged during Ramadan. This finding is consistent with the fact that day-shift workers are more affected by fasting than night-shift workers in terms of total fasting hours at work and that the night-shift workers can rest at home before they clock in and have food before they clock out.

To better understand the observed effects of Ramadan on working hours, we break down the decreases in working hours into coming to work late and leaving work early. On average, the day-shift (9 a.m. to 5 p.m.) Muslim salespersons leave work 32 minutes earlier during Ramadan. In contrast, there are no significant effects on the clock-out time among night-shift (2 p.m. to 10 p.m.) salespersons. This contrast is consistent with the nutrition mechanism, as the day-shift affected salespersons may be most energy deficient at their clock-out time around 4-6 p.m. due to fasting, while night-shift salespersons can eat after sunset before 10 p.m.

The time after sunset might also be accompanied by some fast-breaking events. If these events were the driving force behind leaving work early, the affected salespersons would leave work earlier when the sunset time is earlier. In contrast to this prediction, we find that a later sunset time is associated with leaving work earlier. This finding is consistent with the nutrition mechanism in the sense that extra fasting time during work decreases labor supply.

Our paper contributes to an extensive body of literature that investigates the effects of nutritional status on labor market outcomes. An important strand of this literature focuses on examining the effects of malnutrition during the *in utero* period or during childhood on adult labor market outcomes. To answer this important question, researchers exploit different types of nutrition shocks, such as Ramadan (Almond and Mazumder, 2011; Majid, 2015), famine (Chen and Zhou, 2007; Neelsen and Stratmann, 2011; Ampaabeng and Tan, 2013; Dercon and Porter, 2014), food crisis (Jürges, 2013), experimental intervention (Maluccio et al., 2009), and welfare programs (Hoynes, Schanzenbach and Almond, 2016; Aizer et al., 2016; Bütikofer, Mølland and Salvanes, 2018).

Despite the well-documented long-term effects of malnutrition, few papers investigate the short-term effects of nutrition deficiency on labor market outcomes. Some pioneering works rely on small samples or strong identification assumptions, and they report conflicting resutls. For example, Immink and Viteri (1981) and Deolalikar (1988) find no significant impact of nutrition on labor productivity. Strauss (1986) finds a significant positive impact of nutrition improvement.[2]

The paper most close to ours is the working paper by Schofield (2015). Based on a well-designed field experiment, she finds that additional nutrition increased the labor supply and income of cycle-rickshaw drivers by approximately 10 percent by the final week of the experiment. She also implements another distinctive research design and finds that longer overlap between Ramadan and the labor-intensive portions of cropping cycles results in a greater decline in annual agricultural outputs.

Along with Schofield (2015), we examine the effects of nutrition deficiency on labor market outcomes by using a quasi-experimental approach to address the endogeneity of caloric intake. This paper also makes several additional contributions, relative to Schofield (2015), and further extends the literature in the following ways.

First, to the best of our knowledge, we are the first to investigate the nutrition-productivity relationship in the context of a non-physically demanding occupation. All previous related

[2]Some recent research finds positive effects of school breakfast program or free lunch program on student achievement and health (Frisvold, 2015; Gundersen, Kreider and Pepper, 2012).

research focuses on physically demanding occupations, such as farming, construction work, and cycle-rickshaw driving. It is important to know whether there is still a calorie-productivity relationship in non-physically demanding occupations given the increasing portion of cognitive workers.

Second, we are among the first to use high-frequency data, including hourly productivity and exact clock-in/clock-out times, to investigate the immediate effects of nutrition deficiency. Investigating immediate effects is crucial for cognitive workers, given that cognitive performance responds to nutritional status within just a few hours (Gailliot et al., 2007; Danziger, Levav and Avnaim-Pesso, 2011). Therefore, productivity change might not be detectable when using lower-frequency daily measurements. To the best of our knowledge, our paper is the first to investigate the immediate effects of nutrition deficiency on labor supply and productivity in a real-world setting.

Third, we can investigate how labor market outcomes recover from nutrition deficiency by exploiting the recovery pattern after Ramadan and after sunset during Ramadan. The length of the recovery time can shed light on the mechanisms behind the effects of nutrition. Cognitive impairments can be eliminated rapidly after caloric intake (Gailliot et al., 2007), whereas nutrition-impaired physical conditions often require weeks to fully regain normal conditions (Keys et al., 1950). The immediate recovery of productivity suggests that cognitive status drives productivity changes in a fasting day for non-physically demanding occupations.

Our paper is also associated with an increasing corpus of literature that investigates the relationship between religion and economic performance (see Iyer (2016) for a comprehensive review). Campante and Yanagizawa-Drott (2015) are the first to estimate a causal effect of the strictness of religious practice on economic performance. They find that longer daylight hours during Ramadan have robust negative effects on output growth and positive effects on subjective well-being in Muslim countries. Our results on labor supply and productivity provide a potential mechanism for their effects on economic growth.

Beyond widespread transitory food insecurity in developing countries, our paper is also relevant to developed countries by contributing to a growing number of literature on dieting and voluntary fasting. There is an increasing prevalence in excessive dieting including fasting for losing weight (Chao et al., 2008; Da Luz et al., 2017). In the U.S at any time, approximately one-third of its adult population are dieting, and around 7 million dieters are fasting (Kruger et al., 2004). Related studies focus on the health impacts of dieting and fasting (Tomiyama, Ahlstrom and Mann, 2013; Patterson et al., 2015), we present evidence suggesting that such behaviors can affect performance in the workplace.[3]

More broadly, our findings about the immediate changes of productivity before and after fast breaking during Ramadan are consistent with the literature that studies the effects of the immediate decision environment on cognitive behaviors and decision makings. For example, the seminal work of Danziger, Levav and Avnaim-Pesso (2011) finds a substantial jump of the probability of a favorable judicial ruling for a prisoner after a food break. Most recently, Schilbach (2019) suggests that shifting critical decisions away from drinking times could alter individuals savings behavior for given net income and alcohol expenditure.

The remainder of the paper is organized as follows. Section 2 describes the background information about Ramadan fasting and store operation. Section 3 describes our data. Section 4 introduces the econometric model. Section 5 presents our results for labor supply and productivity, and Section 6 discusses the competing explanations and the underlying mechanism. Section 7 concludes the paper.

2 Background

Fasting during Ramadan We utilize the event of fasting during the month of Ramadan in Indonesia, which can serve as a natural experiment of zero energy intake during the

[3]The effects we document can be an upper bound estimation of the immediate causal impacts of dieting. During Ramadan fasting, adult Muslim can have breakfast before the dawn prayer and supper after sunset. They skip their meals at noon. Similarly, majority of dieters who are fasting are skipping a meal (Kruger et al., 2004).

daytime. According to Islamic law, all healthy, adult Muslims are obliged to fast, which means that they refrain from eating and drinking from dawn to sunset during Ramadan. In reality, Muslims begin fasting at the time of the dawn prayer (Fajr), which is approximately 1 hour and 20 minutes ahead of sunrise.

In Indonesia, the most populous Muslim country,[4] most Muslims strictly observe fasting. According to a survey by the Pew Research Center (2012), 99% of Muslims in Indonesia fast during the daytime over Ramadan. This percentage is one of the highest among Islamic countries.[5] In a Ramadan day, fasting people can have a pre-dawn breakfast called Suhur and a post-sunset meal called Iftar. At the end of Ramadan, there is the fast-breaking festival of Lebaran (Eid al-Fitr) which lasts for five days.[6]

Most studies document a significant decrease in caloric intake during Ramadan. Both Husain et al. (1987) and Mafauzy et al. (1990) find a significant drop, around 18%, in caloric intake during Ramadan in Malaysia, which is geographically and culturally close to Indonesia.[7] In India, the energy intake among Muslims even declines by 32%, which is a 700-calorie decrease (Schofield, 2015).[8] A meta-analysis documents that the daily caloric intake decreases by 10% on average among Islamic countries in West Asia, and a significant increase in daily energy intake is found only in North Africa countries

[4]Approximately 87.2% of the 261 million population in Indonesia are Muslim.

[5] According to the Pew Research Center (2012), practicing fasting during Ramadan is nearly universal among Muslims in Southeast Asia, with Indonesia at 99%, Malaysia at 99%, and Thailand at nearly 100%. This number among six survey countries from the Middle East-North Africa region (Jordan, Lebanon, Iraq, Palestine, Egypt, Tunisia, and Morocco) ranges from 86% to 98%. In contrast, the annual fast is not universal among all Muslims. In six countries in Central Asia (Kazakhstan, Azerbaijan, Uzbekistan, Kyrgyzstan, Turkey, and Tajikistan), 30% to 88% (with an average number of 58%) of Muslims practice fasting during Ramadan.

[6] Lebaran is the popular name for Eid al-Fitr in Indonesia. The Lebaran holiday officially lasts for two days, but during our sample years, the government declared a three-day joint leave called Cuti bersama before and after the Lebaran. Therefore, the Lebaran holiday is five days long in reality.

[7] To our knowledge, we do not find studies that calculate the changes in caloric intake during Ramadan in Indonesia.

[8] By utilizing survey data, Schofield (2015) estimates a decrease of 700 calories per person per day, which is a substantial decrease compared with the average consumption of 2200 calories.

(Sadeghirad et al., 2014).[9] Furthermore, even if the overall daily caloric intake is unaffected, zero nutritional intake during the daytime can impact cognitive function, especially in the period when a person has fasted for more than 10 hours (Iraki et al., 1997; Waterhouse, 2010).

In line with a nutrition deficiency, there is consistent evidence of a decrease in blood glucose levels during Ramadan fasting. Kul et al. (2014) document in a meta-analysis of 16 studies that blood glucose levels significantly decrease during Ramadan fasting compared with the level prior to Ramadan. Blood glucose serves as the primary energy source for human cognitive function (Alberts et al., 2002; Gailliot et al., 2007). The decline in blood glucose can impair cognitive function, e.g., working memory (Martin and Benton, 1999), vigilance (Benton, 1990), and facial recognition (Metzger, 2000).

Store operations To study the effects of energy deficits induced by fasting on a non-physically demanding occupation, we investigate the performance of salespersons who work at a retailer chain which focuses on the market of exclusive cosmetics in Indonesia. A salesperson's role in the company is a cognitively demanding occupation rather than a physically demanding one. It requires sound knowledge about selling skills, makeup tips, skin care, and the features and instructions of a large number of various, high-end products. The company trains its new employees for three months to qualify them.

After this training, salespersons commence their job in stores. Their primary work is selling cosmetic products to on-site customers, and they earn a commission on their sales amount. In general, the commission accounts for a significant proportion of their salary.[10] The store is open for business 12 hours a day, from 10 a.m. to 10 p.m. As a result, store

[9] The loss of weight during Ramadan further indicates that fat and lean tissue are used for fuel by the body because of insufficient energy intake (Rodriguez, Di and Langley, 2009). Dewanti et al. (2006) find that the body weight of fasting Muslims in Indonesia decreases by 1.5 kilograms during Ramadan. In a meta-analysis, nearly all of the 34 studies included find a decrease in body weight, with an average loss of 1.24 kilograms (Sadeghirad et al., 2014).

[10] The salary comprises a base pay and a commission. The company did not provide us the compensation data due to confidentiality. However, the company informs us that the commission accounts for, on average, approximately one-third of the salespersons' total salary, with considerable variation among salespersons.

managers schedule salespersons into two work shifts: the day shift and the night shift.[11] Day-shift salespersons work from 9 a.m., one hour before the opening hour, to 5 p.m., and the night-shift salespersons work from 2 p.m. to 10 p.m.[12] To record their working time, salespersons are required to clock in and clock out when they come to work and leave.

Here, we show the daily routine of a Muslim salesperson who fasts for Ramadan (see Figure 1). She has breakfast before the time for Fajr, the dawn prayer (4:45 a.m. on average). Then, she starts fasting. If she is on the day shift, she has to work without any nutritional intake during her official working hours from 9 a.m. to 5 p.m., the time before the average time of sunset (5:54 p.m.).If she works the night shift, she can have a rest at home but not eat before she leaves for work which starts at 2 p.m. After working several hours, after sunset, she can break her fast and continue to work until 10 p.m. with replenished energy. Moreover, she may adjust her labor supply by asking for a day off, coming to work late, or leaving early based on her discretion.[13]

3 Data

Workplace data Our workplace data come from a retail chain in the cosmetics market in Indonesia. The company sells products in more than one hundred stores in over 40 cities nationwide. In our sample period from 2013 to 2016, over one thousand salespersons worked in these stores, and they realized millions of sales transactions.[14] Specifically, our workplace data include a transaction dataset, a clock-in/clock-out dataset, and

[11] In general, there are two to six non-managerial salespersons in a store. Approximately half of them work the day shift, and the other half work the night shift. Moreover, salespersons rotate their shifts regularly. Only approximately 1% of salespersons do not switch their work shifts during Ramadan in our sample period.

[12] A day-shift worker needs to come in 9 a.m., one hour ahead of the store opening time at 10 a.m. In this one hour, they usually perform some preparatory tasks such as cleaning, stocktaking, and stocking shelves.

[13] If anything, our estimates of the effects on labor supply should be a lower bound, given employees' possible concerns about a penalty for their absence during official working hours. If full flexibility were guaranteed, the estimates should be magnified.

[14] We do not reveal the exact number to protect the identity of the company and for confidentiality. We exclude the managers who works in stores and their sales transactions since their primary duties are managing the store and being the cashier instead of selling.

the demographic information of salespersons.

First, the transaction data include the sales amount, the transaction time in a date-hour-minute format, and the corresponding salesperson for the transaction. Thus, these data enable us to measure the productivity of a salesperson by her sales amount precisely and at a high-frequency level, i.e., the hourly level and the daily level. At the company, a salesperson earns a commission as a percentage of her sales amount. As a result, the salespersons have an incentive to sell more, which makes the sales amount a relatively reliable measurement of salesperson productivity. Accordingly, the company has to accurately match each sales transaction to the corresponding salesperson.[15]

Second, the clock-in and clock-out data provide us labor supply measurements not only at the extensive margin, i.e., a working day dummy, but also at the intensive margin, i.e., the hours worked on a working day. We define a given day as the working day of a salesperson if there is a clock-in or clock-out record under her employee number. Otherwise, she is absent on this day. We measure the hours worked on a working day by the difference between a salesperson's clock-out time and clock-in time. Salespersons can earn overtime pay if they work more than the regular eight hours.[16] Therefore, salespersons have an incentive to increase their labor supply, and the company has to accurately measure their working time.

Third, the demographic data of salespersons include religion, age, gender, and the time with the company. We match together the demographic data, the transaction data, and the clock-in/out data via the employee number. After matching, there are 877 salespersons in our analysis sample. For each salesperson, we can find several years of transaction records, which leaves us with 2,203 salesperson-years. These salespersons are aged 22.6

[15] The cashier records the salesperson who realizes the deal. The salesperson usually accompanies the customer to pay the cashier. If a customer walks in and takes the products to the cashier directly, the sales will be recorded under the cashier, who is generally the store manager.

[16] Overtime pay is two times the regular basis. Salespeople can also earn commissions on sales realized in the additional working hours. On average, they work for 9.5 hours per day, which is 1.5 hours longer than the official eight hours.

years on average,[17] and most of them (88.9%) are female. Muslim salespersons account for 89.5%, which is close to 87.2%, the ratio of the Muslim population in Indonesia. We have no information on education, but we control for individual fixed effects in all our regressions.

Sunrise and sunset data Muslims are obligated to fast from the dawn prayer (Fajr), which is approximately 1 hour and 20 minutes before sunrise, to sunset. We obtain the time of sunrise and sunset at the daily level of each city in our sample between 2013 and 2016 from the United States Naval Observatory (USNO).[18] Based on the data, we calculate the time relative to sunset, the time for dawn prayer, and the hours fasted. During Ramadan in our sample years, the average sunrise time and sunset time are 6:05 a.m. and 5:54 p.m., respectively. The average time for the dawn prayer is 4:45 a.m. Muslim workers fast for an average of 13.1 hours per day during Ramadan in our sample period.[19]

4 Empirical Framework

Our event study approach compares the affected and unaffected salespersons, that is Muslim and non-Muslim salespersons. Equation (1) estimates the impacts on the daily level labor supply and productivity measurements, such as absences, hours worked on a working day, clock-in and clock-out times, and daily sales amount. Our main specification is as follows:

$$Y_{ist} = \sum_{w=-6}^{w=11} \beta_w Muslim_i \times RelativeWeek_w + \eta_i \times year_t + \gamma_t + store_s \times year_t + \epsilon_{ist} \quad (1)$$

[17] In total, 95% of the salespersons were aged between 19 and 28 years old.

[18] The data can be found on the website of the United States Naval Observatory (`https://aa.usno.navy.mil/data/docs/RS_OneYear.php`, last accessed on March 19, 2019).

[19] The 95% range of the average sunrise time and sunset time are from 5:41 a.m. to 6:29 a.m. and from 5:21 p.m. to 6:28 p.m., respectively. The daylight time is 11.8 hours averagely. The 95% range of the daylight hours is from 11.5 hours to 12.2 hours. The fasting time is the time period of 1 hour and 20 minutes for the dawn prayer plus daylight hours.

where Y_{ist} is the daily labor market outcome measurement for individual i in store s on date t. The key coefficients of interest are the pattern of β_ws, and the coefficients before the interaction terms $Muslim_i \times RelativeWeek_w$. Here $Muslim_i$ is the indicator of whether individual i is a Muslim. $RelativeWeek_w$ indicates a set a dummy variables indicating the relative weeks of date t compared with the start of Ramadan in this year. Specifically, a value between -1 and -6 means the first to the sixth week before Ramadan. $RelativeWeek_w$ equals 1 to 4 if it is the first to the fourth week during Ramadan.[20] We use $RelativeWeek_w = 5$ as an indicator of Lebaran, the approximately five-day holiday right after Ramadan. Days with a $RelativeWeek_w$ value between 6 and 11 are approximately the sixth to the eleventh weeks after the beginning of Ramadan, that is, the first (6 minus 5) to the sixth (11 minus 5) week after Lebaran (the 5th week). Including six weeks after Lebaran allows us to investigate effects after Ramadan.

β_w estimates the differences between the affected and unaffected salespersons at a given week relative to the omitted category, which includes the seventh to the fourteenth weeks before Ramadan, another two months before the pre-trend period. Our results are robust to different lengths of the omitted group, such as six weeks, one month, and two weeks. We do not use a more commonly applied omitted group, the week before Ramadan, due to the concern of people preparing for Ramadan.[21]

We include individual-year fixed effects $\eta_i \times year_t$ to capture individual characteristics, such as gender, religion, age, and unobserved personal characteristics, e.g., work-leisure preferences. We also include a set of dummies for each day of each year γ_t.[22] It

[20]Since Ramadan lasts 29-30 days, week 4 includes 8 or 9 days.

[21] Muslims might decrease their caloric intake before Ramadan to be more adaptive to fasting during Ramadan. Additionally, the month before Ramadan, "Shaban", is a month when some Muslims begin fasting for a few days as documented by Buitelaar (1991). The first motivation is to make amends for missed fasting days. For people who were unable to fast for all of Ramadan in the previous year, Shaban offers the last chance to make up for these missed days. This type of fasting concerns people who were ill during the last Ramadan, but the vast majority of people who owe fasting days are women who interrupted their fast during their menstruation. The second motivation is voluntary fasting in this month. During Shaban, the Prophet himself practiced voluntary fasting more often than during any other month of the year, and some Muslims follow his example.

[22] For example, July 1, 2014 is one dummy variable

not only captures the effects of the relative time compared to Ramadan, but also controls for daily variations, such as holidays and days of the week. Given the possible rotations of employees across different stores, individual fixed effects cannot fully capture all region or store characteristics. Therefore, we also include year specific store fixed effects, $store_s \times year_t$.

Equation (1) is applied only to the analysis of the daily level measurements. To investigate the productivity changes within a day, we slightly change the specification. We first calculate the hourly total sales for each salesperson in each hour relative to the sunset time.[23] We then run hour-by-hour regressions for each relative hour to sunset h based on equation (2):

$$\begin{aligned} Y^h_{ist} = \beta^h_b Muslim_i \times BeforeRamadan_t + \beta^h_r Muslim_i \times Ramadan_t \\ + \beta^h_a Muslim_i \times AfterRamadan_t + \eta^h_i \times year_t + \gamma^h_t + store^h_s \times year_t \\ + CitySale^h_{st} + CitySale^h_{st} \times Muslim_i + \epsilon^h_{ist} \end{aligned} \quad (2)$$

where Y^h_{ist} is the total sales of employee i in store s during relative hour to sunset h on date t. For example, relative hour to sunset equals -1 means the first hour before sunset, which is the period from 5 p.m. to 6 p.m. if the sunset time is 6 p.m., and relative hour to sunset equals 1 means the first hour after sunset. Since our main focus here is the productivity change within a day instead of productivity changes across different weeks, we combine relative weeks before, during, and after Ramadan in equation (1) into three dummy variables. β^h_r is our main coefficient of interest. By comparing β^h_rs across different relative hours h, we can examine the productivity change of the affected salespersons for each hour within a Ramadan day. We include the same sets of fixed effects as equation (1).

In addition to the fixed effects, we include the total sales from all stores in a city

[23] For example, if the sunset time on this day in this city is 6:30 p.m., a relative hour that equals minus one indicates one hour before sunset, that is, 5:30 p.m. to 6:30 p.m.

during relative hour h on date t as an index of total demand. By further including $CitySale^h_{st} \times Muslim_i$, we allow for differentiated responses to the total demand changes between the Muslim and non-Muslim salespersons. Our results are robust to whether we include demand-side controls. This finding provides support that our event-study approach has already captured the effects from the demand-side change that is common to the affected and unaffected salespersons. However, there is another important concern that salespersons of different religious beliefs face different demand shocks. That is, consumers might be more likely to approach salespersons who share their religion. We provide proof and detailed discussions in Section 6.1.1 to show that this is not likely to be the case in this retail chain.

Finally, all of our specifications report standard errors clustered at the individual level to allow for the possibility that the error terms might be correlated for an individual across times. Our results are robust to the standard errors clustered at the store level.

5 Main Results

This section presents our main results. First, we analyze the reduced-form effects on productivity at the hourly and daily levels. The hourly results indicate that the changes in the productivity of affected workers align closely with their nutrition status within a Ramadan day. Second, we explore the effects on labor supply at the extensive margin, i.e., the probability of coming to work, and at the intensive margin, i.e., the hours worked on a working day. Third, we closely examine the labor supply within a working day by investigating the salespersons' clock-in and clock-out times for both the day-shift and night-shift workers. We indicate that the effects on labor supply in terms of hours worked are also consistent with the nutrition mechanism.

5.1 Worker productivity

Hourly productivity We first investigate the productivity in each hour relative to the sunset during Ramadan. We show how the hourly productivity of the affected workers, i.e., Muslim salespersons, responds to the changes in their energy status before and after the sunset. Figure 2 presents the estimated coefficients from the hour-by-hour regressions in equation (2) on hourly productivity during Ramadan, and before and after Ramadan shown in Figure 3 as a comparison.[24] Here, we focus on the changes in productivity of day-shift workers who work mainly during fasting hours.[25]

First, Figure 2 shows that during Ramadan, the productivity of the affected day-shift workers is the lowest in the two hours right before sunset. In this period, they experience the most energy-deficiency in a Ramadan day based on the hours fasted. On average, Muslim workers have fasted for 12 hours at this time.[26] During these two hours before sunset, they sell 7.1 dollars per hour less than their unaffected colleagues.[27] This estimate implies a 30% decrease in productivity as measured by sales, given that the average sales per hour in these two hours is approximately 23.6 dollars. The effects are also statistically significant with a p-value < 0.01.

Second, the productivity of Muslim salespersons recovers to the normal level right after sunset, when they can break their fast (see also Figure 2). The estimate of the productivity difference between the affected and unaffected salespersons during the first hour after sunset is statistically indistinguishable from zero. Such an immediate recovery of

[24] See the regression results in Appendix Table A.IV

[25] The official working time of day-shift workers is from 9 a.m. to 5 p.m., which falls within fasting hours. For the night-shift workers, they can rest at home before coming to work around 2 p.m. In this way, they can save energy in most (around nine hours) of the approximately 13 fasting hours. They can also break their fast after working for approximately three to four hours when sunset arrives. Thus, fasting during daylight hours should affect day-shift workers rather than night-shift workers. The results in Panels (a) and (b) of Figure 5 agree with our hypothesis and indicate that the hours worked of day-shift workers are significantly affected, whereas the hours worked of night-shift workers do not change during Ramadan.

[26] In these two hours before sunset, Muslim workers have fasted for an average of 12 hours. After these two hours, they can break their fast as the arrival of sunset.

[27] All sales have been converted into U.S. dollars. The exchange rate between Indonesian Rupiah and U.S. dollars was one to 0.000068 on November 11, 2018.

productivity after sunset when they can eat is consistent with an instant rehabilitation of cognitive function. When facing energy deficiency, human cognitive function can recover immediately after caloric intake (Gailliot et al., 2007). Moreover, it is worthwhile to mention that these workers know the arrival time of sunset and can break their fast accordingly.[28] For example, in shopping malls, where the majority of the stores are located, loudspeakers broadcast the arrival of sunset during Ramadan.

Third, the pattern in Figure 2 is unique in the Ramadan period. As shown in Figure 3, there is no significant change before and after sunset during the pre- and post-Ramadan periods, when fasting is not required. There are also no significant differences between the sales of Muslim and non-Muslim workers in each hour during these non-Ramadan periods. We also do not find a similar trend during Ramadan for night-shift Muslim workers (see Panel (a) of Appendix Figure A.3).[29]

Finally, there are some marginal increases in the sales by Muslim workers relative to the sales by non-Muslim workers during the working hours other than the two hours right before sunset. This phenomenon may indicate a possible income-targeting behavior, as documented in literature (Camerer et al., 1997; Crawford and Meng, 2011). To maintain their total commissions from sales in a day, Muslim workers may choose to work harder before feeling hungry and after having their supper as indicated in Figure 2.

Robustness of the hourly patterns There are several concerns about the patterns of hourly productivity. One important concern is that the sales pattern may result from a change in demand instead of workers' productivity. First, our event-study approach can

[28] As indicated by the company manager, Muslim employees usually bring meals or snacks and consume them after sunset during Ramadan.

[29] These night-shift workers can rest at home before coming to work at 2 p.m. They can save energy during most fasting hours (around nine out of 13 hours). Thus, fasting during daylight hours should mainly affect day-shift workers rather than night-shift workers. If anything, there is a significant decrease in the first hour after sunset. This is probably driven by the working schedule where night-shift workers can have a one-hour rest around 5 p.m. to 7 p.m. During Ramadan, the night-shift Muslim workers tend to concentrate their resting time in the first hour after sunset when they can enjoy a fast-breaking meal at the same time.

address the demand shocks that are common to Muslim and non-Muslim salespersons.[30] Second, we show in Section 6.1.1 that our results are not driven by plausible differences in the demand changes among Muslim and non-Muslim workers during Ramadan.

As a reassurance, we show that the variation in total demand is inconsistent with the changes in the hourly productivity of the affected salespersons. Appendix Figure A.1 summarizes the total sales of all stores in each hour during the Ramadan and non-Ramadan periods. During Ramadan, the total demand drops significantly only in the hour right after sunset. In contrast, the productivity of the affected salespersons drops significantly in these two hours before sunset.

Another concern is that such an hourly pattern during Ramadan in Figure 2 may result from selection bias instead of nutrition effects. First, the significant decrease that begins in the second hour before sunset can be due to sample attrition when some affected workers leave earlier in this hour. As a robustness check, we restrict our regression sample to these workers who works until the first hour before sunset and later. The results are quite similar to our main results (see Panel (a) of Appendix Figure A.2).

Second, sample bias might also result in the recovery of productivity in the first hour after sunset since people who experience a productivity decrease are more likely to leave the sample after sunset. We restrict our regression sample to the salespersons who continue working until the second hour after sunset and later. We find a similar and significant pattern, although it is smaller in magnitude (see Panel (b) of Appendix Figure A.2). The decreased magnitude is expected given that Muslim salespersons who overwork during Ramadan may be those less sensitive to nutrition deficiency.

Accordingly, we indicate that the productivity patterns are robust and aligns closely with the nutritional status of salespersons within a Ramadan day. This result provides strong support for the nutrition mechanism. In section 6.1, we also show that these unique

[30] Moreover, we directly include the hourly total sales in each city as a proxy of the demand change. In Appendix Table A.V, we show that our results are robust to not including the demand-side controls. This result further validates that our specification has already captured the change in the total demand.

patterns cannot be explained by other behavioral changes during Ramadan, such as sleep deprivation and dehydration. These findings together suggest that the nutrition mechanism should be the main driving force behind our findings on hourly productivity.

Daily productivity We now investigate whether the daily data can reflect the changes in hourly productivity. Figure 4 shows the results from equation (1) in which the daily productivity is the sales amount on a working day.[31] We find that in contrast to the notable variation in hourly productivity, there is only a significant decrease in daily productivity in the first week of Ramadan for the day-shift affected workers. They sell 21.2 dollars per day less than their unaffected colleagues, which transfers to a 11.5% drop in productivity. However, there is no significant change in daily productivity in the following three weeks during Ramadan.[32] On average, their productivity is largely unchanged during Ramadan.

Actually, the differences in daily productivity between Muslim salespersons and their non-Muslim colleagues gradually increase and the sign turns from negative to positive. This upward trend indicates a possible adaptation mechanism during Ramadan, which is documented by related studies (Sweileh et al., 1992; Farooq et al., 2006). As suggested by El Ati, Beji and Danguir (1995), during Ramadan, the body can adapt to a prolonged alteration of the normal feeding behavior to maintain the body composition in a physiological range.[33] Our results indicate that cognitive workers might be able to adapt to a regular fasting behavior, and as a result, the short-term nutritional deficiency may affect their productivity in a less degree after a adaptation period.

This result further emphasizes the importance of high-frequency hourly data that enable the detection of the instant effects of energy deficits on non-physical occupations over a few hours. The relatively unchanged daily productivity may also result from the increased sales during the less energy-deficient period, as shown in Figure 2.

[31] See the regression results in Appendix Table A.III.

[32] We also do not find any significant changes before and after the start of Ramadan for night-shift Muslim workers (see Panel (b) of Appendix Figure A.3).

[33] Farooq et al. (2006) show a tremendous adaptation capacity of both liver and intestinal metabolic activities in a Ramadan-type fasting.

Such increases neutralize the adverse, instant impact of energy deficits during the caloric-deficient period and indicate possible income targeting behaviors as discussed previously.

In summary, during the most energy-deficient period – the two hours before sunset during Ramadan – the productivity of the affected workers declines significantly by 30%. Their productivity recovers immediately after sunset, when they can have food. The productivity pattern within a day aligns closely with the nutritional status of these fasting salespersons. This fact provides strong support for the nutrition mechanism as the main driving force behind our findings. Moreover, the average daily productivity in a working day during Ramadan does not change much. This result can be driven by possible income targeting behaviors and implies the importance of high-frequency hourly data to make the instant effects detectable. The increasing trend of daily productivity during Ramadan further indicates an adaptation mechanism.

In addition to the evidence on productivity that supports the nutrition mechanism, we further provide detailed analyses in the next two subsections. We show that the effect on the intense margin – labor supply in a working day – also aligns closely with nutrition status within a Ramadan day.

5.2 Labor supply

We now turn to the analysis of the changes in the labor supply of the affected workers during Ramadan compared with their unaffected colleagues. We explore the effects on labor supply both at the extensive margin, i.e., the probability of coming to work, and at the intensive margin, i.e., hours worked on a working day. Figure 5 presents the results from equation (1) in the event-study plots.[34]

[34] See the regression results in Appendix Table A.I.

Extensive margin of labor supply - Absence In Panel (a) of Figure 5, we start with an investigation of whether a salesperson comes to work on a given day.[35] We find that the the likelihood of affected workers to come to work does not change significantly during Ramadan relative to their unaffected colleagues and relative to the pre-Ramadan period. This result indicates that Ramadan fasting does not affect the extensive margin of labor supply of the affected workers.

We suggest that this finding can be reasonable for several reasons. First, an absence decision may not be fully flexible and feasible in the workplace. Specifically, permission to leave during a selling season such as Ramadan might be less favorable for store managers. Second, the short-term caloric deficits may only affect labor supply decisions over a few hours and do not impact the extensive margin of labor supply, i.e., absence. As suggested in the results of hourly productivity, the caloric deficits only take effects in the two-hour period before sunset when the salespersons have fasted for around 12 hours, and there is no such impact on other periods.

However, we identify that the most noticeable decrease occurs during Lebaran, the holiday following the end of Ramadan. Although Lebaran is a national holiday, it is an Islamic festival mainly celebrated by Muslims. Therefore, we can observe a significant difference in the probability of coming to work between Muslim workers and their non-Muslim colleagues.[36]

Intensive margin of labor supply - Hours worked We now turn to the intensive margin of labor supply, namely, the hours worked on a working day. Panel (b) of Figure 5 repeats the analysis with a focus on the hours worked of the affected workers relative to

[35] We cannot distinguish a sick day from regular leave. However, we notice that the company does not provide an additional holiday to Muslim salespersons, relative to their non-Muslim colleagues, during Ramadan.

[36] We further find that there are significant decreases in the working probability for Muslim workers in the first and second weeks after the Lebaran holidays, i.e., the sixth and seventh weeks after the beginning of Ramadan. As suggested by the company manager, Lebaran and the one to two weeks after it are periods when Muslim workers return to their hometowns for family reunions, and it takes them time to return to the workplace.

their unaffected colleagues. The event-time analysis indicates that the impacts on hours worked are significant immediately after the start of Ramadan. During the entire Ramadan period, the hours worked by the affected workers decrease significantly with p-values $<$ 0.01. The drops range from 0.26 hours (16 minutes) in the third week to 0.48 hours (29 minutes) in the second week, with an average decrease of 0.33 hours (20 minutes) per working day.

Before Ramadan, there are no statistically or economically significant differences between the affected and unaffected workers. The only exception is a marginal decrease in the fourth week before Ramadan, which is the first week of Shaban, the period that offers Muslims the last chance to make up for the fasts that they missed during previous Ramadan (Buitelaar, 1991). As a result, the decrease in this particular week might result from possible fasting days to compensate for their missed fasts. This situation can be significant in our case when the vast majority of the people who owe fasting days are women who are allowed to interrupt their fast during their menstruation (Buitelaar, 1991), and 89% of the salespersons in our sample are women.

After Ramadan (except Lebaran), when the Muslim workers can break fast, the hours worked by them return directly to the regular level. We also notice that the most significant drop occurs during Lebaran. As we argued above, this drop is mostly because Lebaran is an important holiday for Muslim workers, not because of nutrition deficiency.

Hours worked in the day shift and night shift The above results show the average effects on the hours worked by both the day-shift and the night-shift salespersons. However, the two shifts might be affected to different degrees (see Figure 1). Day-shift workers are obligated to fast for the duration of their entire official working hours, from 9 a.m. to 5 p.m. In contrast, the night-shift workers can rest at home before 2 p.m. and break their fast after working for approximately three to four hours, when sun sets. We investigate the impacts of Ramadan on day-shift and night-shift salespersons separately and report the results in Panels (c) and (d) of Figure 5.

We find that although the hours worked by day-shift workers fall significantly during Ramadan (see Panel (c) of Figure 5), the hours worked by night-shift workers remain nearly unchanged (see Panel (d) of Figure 5). During Ramadan, on average, day-shift workers decrease their working hours by 0.59 hours (35 minutes) per working day.

This result shows that the labor supply in a working day is affected more for day-shift workers than for night-shift workers. This finding is consistent with the fact that day-shift workers are affected by fasting more than night-shift workers in terms of total fasting hours at work and that the night-shift workers can rest at home before they clock in and have food before they clock out. Thus, we suggest that the changes in hours worked are consistent with the condition of the caloric intake of the workers who work on different shifts during Ramadan.

5.3 Clock-in and clock-out times

We closely examine the clock-in and clock-out times of both the day-shift and night-shift workers to further show that the patterns of hours worked are consistent with the nutrition mechanism. Hours worked are defined as the difference between salespersons' clock-in and clock-out times. If the decrease in hours worked is driven by energy deficiency, we should expect that the clock-in and clock-out times of the affected workers will change more significantly in the period when they are more energy-deficient. On the contrary, their clock-in and clock-out times should not vary much in periods of less calorie deficits. We verify our prediction by applying the event-study specification (1) on the clock-in and clock-out times of both day-shift and night-shift workers. We plot these estimates in Figure 6.[37]

These results are generally consistent with the nutrition status of the fasting workers. First, around 5 p.m., the day-shift affected workers clock out 32 minutes earlier, on average, during Ramadan (Panel (b) of Figure 6). The effects are statistically highly

[37] See the regression results in Appendix Table A.II.

significant, with p-values < 0.01 in all four weeks of Ramadan.[38] Around 5 p.m., the day-shift affected workers might experience the greatest caloric deficiency in a fasting day. They have fasted for on average 12 hours around this time. In addition, they have worked for approximately 8 hours out of this 12-hour fasting period.

However, one alternative argument is that day-shift affected workers leave early because they are attending a post-sunset feast or other fast-breaking events at home or in a mosque and not because of nutrition deprivation. We rule out this explanation by utilizing the variation of sunset times (see Section 6.1.2 for details).

Second, on the contrary, the clock-in time, 8:38 a.m. on average, of the day-shift affected workers does not change significantly, relative to the clock-in time of their unaffected colleagues, except for a marginally significant delay by 5 minutes in the last week of Ramadan (Panel (a) of Figure 6). On average, the salespersons come late to work by just 3 minutes during Ramadan. Around their clock-in time, they had a rich breakfast approximately 4 hours before. As a result, they should experience much less caloric deficiency compared with their circumstances around 5 p.m.

Third, the clock-in and clock-out times of the night-shift affected workers generally do not change much (Panel (c) and (d) of Figure 6). If anything, we find a marginal significant delay, by 6.7 minutes on average, in the clock-in time of the night-shift affected workers in the first and second weeks of Ramadan.[39] The clock-in time of night-shift workers, around 2 p.m., should be affected by fasting to a much lesser degree than the clock-out time of day-shift workers, around 5 p..m. Around 2 p.m., although the night-shift affected workers have fasted for approximately 9 hours, they can rest at home and save energy during this fasting period. Additionally, the fasting should not influence their

[38] We note that the range of 95% confidence intervals for the clock-out time of day-shift workers in Panel (b) is relatively more substantial than that in the other three panels. We suggest that this may result from the relatively large standard deviation of the clock-out time among day-shift workers. During our sample period, the standard deviation of the clock-out time among day-shift workers is 2.5 hours, and the standard deviation of their clock-in time and the clock-in and clock-out times of night-shift workers is merely 0.8 hours, 1.2 hours, and 0.9 hours, respectively.

[39] The effect is statistically significant with a p-value < 0.1 and 0.05 in the first and second weeks, respectively. However, this significance vanishes in the third and fourth weeks of Ramadan.

clock-out time, around 10 p.m., since they can break their fast and replenish their energy reserves after sunset and before 10 p.m.

Accordingly, the results in Figure 6 are generally consistent with the nutritional status of the fasting workers. The labor supply of the affected workers decreases most significantly in the period when they experience the most energy deficiency, i.e., the clock-out time of day-shift workers around 5 p.m. After sunset, when they can break their fast, the effect almost disappears, with no significant change of the clock-out time around 10 p.m. The effects on the labor supply in terms of the clock-in and clock-out times of the affected workers align closely with their energy status on a fasting day.

In addition, the patterns of both the labor supply and hourly productivity within a fasting day are consistent with the energy status of the affected workers. Both labor supply and hourly productivity decrease the most during the most nutrition deficient period before sunset and recovers after sunset when the fasting workers can eat. These two parallel patterns provide strong support for the nutrition deficiency as our main underlying mechanism. Moreover, the effect on labor supply in terms of the clock-out time vanishes after sunset during Ramadan, when the fasting workers can break their fast. In Panel (b) of Figure 5, the adverse impact on labor supply in terms of the hours worked also disappears after Ramadan when fasting is not required. This consistency emphasizes the robustness of the effects on labor supply in term of hours worked.

6 Discussion

6.1 Competing explanations

Using Ramadan fasting as an exogenous nutrition shock leads us to another empirical challenge. Other behavioral changes occur simultaneously during the Ramadan period, such as consumer demand change, fast-breaking events after sunset, sleep deprivation, and dehydration effects. In this subsection, we provide detailed evidence to show that these competing explanations are not likely to drive our results.

6.1.1 Demand side effects

One important concern regarding using the sales amount as a measurement of productivity is that the sales amount also reflects changes from the demand side. As indicated in Section 4, the event study approach can address the total demand shocks that are common to both Muslim and non-Muslim salespersons. As discussed in Section 5, our results are robust to the inclusion or exclusion of the city hourly total sales as a control variable which further validates that our specification has already captured the change in total demand.

However, our estimates might still be biased if customers intend to ask for help from salespersons of the same religion. This is especially a problem for our identification strategy if the demand changes during Ramadan are mainly driven by Muslim customers. For example, Muslim customers might buy more cosmetic products during Ramadan as Lebaran gifts. If so, our estimates may be driven by the changing behavior of customers instead of the nutrition deficiency of salespersons.

We next want to directly test whether Muslim and non-Muslim salespersons face different demands (later referred to as "religion proximity"). If they do, we should expect Muslim salespersons to benefit more from increasing demands in cities with higher Muslim ratios. Corresponding to this prediction, we regress the hourly sales amount with a triple-differences specification by including another factor, the Muslim ratio among females in each city.[40] Religion proximity should result in a significantly positive coefficient before the triple interaction of the "Muslim X City Sales X Muslim Ratio".[41]

The regression results are summarized in Table I.[42] The first column shows the results

[40]The Muslim ratio in each city is calculated from the 2010 Indonesia census data, which were accessed from IPUMS. We restrict the sample to urban females when calculating the Muslim ratio.

[41]Here, the three-way interaction represents the one-to-one correspondence with the prediction of Muslim salespersons benefiting more from increasing demands in cities with higher Muslim ratios.

[42]We include the same set of fixed effects as our main specification. We further control the shift dummy and the relative hour fixed effects. All two-way interactions necessary for the triple-differences are included in the regressions.

based on the sample from all periods. Inconsistent with religion proximity, the coefficient of the triple interaction is negative and statistically insignificant. It might also be likely that religious identity is more salient during Ramadan and Lebaran, an important Muslim holiday in Indonesia. Therefore, we restrict the sample period to the Ramadan period and the Lebaran period in columns (2) and (3), respectively. The results are also not significantly different from zero.[43]

Furthermore, Appendix Figure A.1 shows the demand increase during Ramadan. Since more than 86% of the population is Muslims in Indonesia, this increase of demand might be mostly driven by Muslims. Therefore, even if matching with the same religion is still a concern, it will cause our coefficients to bias toward positive values. This means that our estimates are lower-bound estimates.

6.1.2 Fast-breaking events

In Section 5.3, we find that day-shift Muslim salespersons are more likely to leave work earlier. We argue that this may be due to their energy deficits around 4-6 p.m. However, the time after sunset might be accompanied by fast-breaking events, such as religious rituals and family reunion meals. If these event were the driving force behind leaving work early, Muslim salespersons would leave work earlier as the sunset time arrives earlier.

To test this prediction, we regress the time of leaving work based on a triple-differences specification by including another factor, namely, the sunset times measured in minutes. The coefficient before the triple interaction of "Sunset X Muslim X Ramadan" indicates how Muslim salespersons respond to the change of sunset times during Ramadan. The results are summarized in Table II. The dependent variables of columns (1) and (2) are the

[43]This test raises another concern that the company may match the ratio of Muslim salespersons to the ratio of potential Muslim customers. For example, if the company expects that nine out of ten customers are Muslims, and he also set Muslim salespersons ratio at 90 percent. If so, our test cannot find statistically significant results even if Muslim and non-Muslim salespersons face different demands. However,the matched ratio of salespersons cannot explain the insignificant results that we find in both the Ramadan and non-Ramadan periods. Compared with the non-Ramadan period, there are fewer Muslim salespersons and more Muslim customers during Ramadan. This means that at most, only one of the Ramadan and non-Ramadan periods can have the matched ratio of Muslim salespersons.

clock-out time of day-shift workers and night-shift workers as a comparison, respectively.

Inconsistent with fast-breaking events as driving forces behind leaving work earlier, we find that a later sunset time is associated with leaving work earlier for the day-shift Muslim salespersons during Ramadan. The effects of the sunset time are highly statistically significant with a p-value < 0.01. As a placebo test, we run the same regressions for night-shift salespersons whose decisions about the time to leave work are not supposed to be affected by the sunset time. The coefficient is not statistically significant and much smaller in magnitude.

Such results provide evidence against the concerns that leaving work early for day-shift salespersons is driven by fast-breaking events. Moreover, this finding is consistent with the nutritional mechanism in the sense that extra fasting time during work decreases the labor supply of day-shift salespersons.

6.1.3 Sleep deprivation

Another behavioral change during Ramadan is sleep deprivation. Roky et al. (2001) reports that during Ramadan, the sleep time of Muslims decreases by 40 minutes on average. Therefore, the decreased sleep time could be associated with the declined performance, which could drive our results. However, our evidence indicates that sleep deprivation is not likely to result in our findings.

First, our results regarding hours worked and productivity do not agree with the pattern of sleepiness during Ramadan. BaHammam (2003) reports that Muslims feel more sleepy in the morning and less sleepy in the afternoon during Ramadan than they do before Ramadan.[44] If the sleepiness pattern were the main factor, we should expect that Muslim workers would be affected more in the morning instead of in the afternoon. However, we find the opposite results. First, they leave earlier in the afternoon, but they do not come

[44] Regarding the changes in sleeping patterns during Ramadan, the percentage of Muslims who feel sleepy increases most significantly in the morning, from 8 a.m. to 10 a.m., during Ramadan relative to pre-Ramadan period. In contrast, the percentage of Muslims who feel sleepy declines by three to eight percentage points in the afternoon, from 4 p.m. to 6 p.m., during Ramadan.

late to work in the morning (see Panel (a) and (b) of Figure 6). Second, their productivity decreases the most in the afternoon, but it does not change much in the morning (see Figure 2).

Second, the sleepiness mechanism is not consistent with the recovery pattern of hourly productivity. In Figure 2, we find that the productivity of the affected workers recovers immediately right after sunset, when they can eat. Sleepiness is insufficient to explain this immediate recovery after sunset. As documented by Orr et al. (1997), sleepiness increases following food ingestion, especially for a meal rich in carbohydrates. If anything, the affected workers should feel drowsier after sunset, when they have some food usually rich in carbohydrates. This notion is supported by BaHammam (2003), who finds that the proportion of Muslims feeling sleepy during one to two hours after sunset almost doubled during Ramadan relative to the pre-Ramadan period. However, in contrast to a decrease predicted by the increased sleepiness after the post-fast meal, we find that an immediate rise in the productivity of Muslim workers. Accordingly, the effects of sleep deprivation and the resulting sleepiness are not consistent with and cannot explain our findings; therefore, sleep deprivation is not likely to drive our results.

6.1.4 Dehydration effects

Along with food restrictions, adult Muslims should refrain from drinking water in the daytime during Ramadan. Given the complete overlap of food and fluid restrictions, we cannot cleanly separate the effects of nutrition deficiency and the effects of dehydration. Therefore, our results may be cautiously interpreted as capturing the combined effects of fasting and fluid restriction. However, we argue that dehydration during daytime is not likely to be sufficiently large to be the primary driver of our results.

Researchers have documented a 2% threshold for water loss to elicit discernible effects. Wittbrodt and Millard-Stafford (2018) conclude based on a summary of 33 articles on physiological research that cognitive performance declined when the water deficit exceeds approximately 2% of body mass loss. A similar 2% threshold is documented for the effects of dehydration on physical performance (see Sawka et al. (2007) and Casa, Clarkson and Roberts (2005) for a review).

We cannot find direct evidence of the body water loss rates among salespersons in an air-conditioned environment in Indonesia. Nevertheless, Maughan and Shirreffs (2012) document that for resting individuals in a temperate environment, the water loss that occurs during a day without food or fluid typically amounts to approximately 1% of body mass by sunset during Ramadan, which is far below the two-percent threshold. As they conclude, "this small loss of body water is unlikely to have a major adverse effect on any aspect of physical or cognitive performance".[45]

6.2 Nutritional mechanism - Cognitive impact

As shown in Section 2, during Ramadan fasting, there is a decrease in blood glucose levels because of insufficient caloric intake relative to energy expenditure (Kul et al., 2014). The low level of blood glucose can impair cognitive function immediately (Fairclough and Houston, 2004). Our evidence implies that the changes in the productivity and labor supply of Muslim workers are driven by the impacts of fasting on cognitive function.

Fasting can influence cognitive function. Refraining from food ingestion, including carbohydrates, in the daytime during Ramadan leads to a decline in blood glucose (Kul et al., 2014). A number of studies find that fluctuations of blood glucose within a normative range can exert a significant impact on the cognitive performance of the brain (Fairclough and Houston, 2004).[46] They find a significant causal relationship between blood glucose level and working memory (Martin and Benton, 1999), vigilance (Benton,

[45] It is a concern that salespersons may lose more water than resting individuals. As another benchmark, Schofield (2015) documents around a two-percent body mass loss in the daytime for Indian farmers based on a calibration calculation. Salespersons are highly likely to have lower water loss due to the non-physically demanding nature of their job and the temperate indoor working environment.

[46] The brain is consistently consuming approximately 20-30% of the body's calories (Benton, Parker and Donohoe, 1996). However, the brain has no storage capacity for energy, and it is completely dependent on a constant supply of glucose from blood (Scholey, 2001).

1990), facial recognition (Metzger, 2000), and multi-tasking (Sünram-Lea et al., 2002). In addition, Gailliot et al. (2007) find that a drop in blood glucose level leads to a decreased ability in self-control related to thought, attention, and emotion. Notably, after intaking glucose, these impairments are eliminated rapidly.

The hourly productivity patterns of Muslim workers align closely with the glucose level and cognitive status of fasting people during Ramadan. Our results show that in the two hours before sunset, when these cognitive workers experience the most energy-deficiency, their productivity declines significantly, by 30%. Right after sunset, when they can break their fast,[47] their productivity recovers immediately (see Figure 2). These patterns align closely with both the glucose level and cognitive status of fasting people during Ramadan. Iraki et al. (1997) find that the blood glucose of fasting people during Ramadan drops more significantly in the hours before sunset relative to the pre-Ramadan period, and it increases after sunset. Waterhouse (2010) shows that the mental performance of fasting people during Ramadan decreases before sunset and increases once they break fasting after sunset.

The effects of fasting on the hours worked is also consistent with the patterns of cognitive impact induced by nutritional deficiency. During Ramadan, the hours worked decrease only for day-shift fasting salespersons, who experience the most energy-deficiency around their clock-out time (5 p.m.) and leave earlier by 32 minutes (see Panel (b) of Figure 6). In contrast, night-shift fasting salespersons do not clock out earlier around 10 p.m. (see Panel (d) of Figure 6), when they already have supper after sunset. This recovery is consistent with the fact that the cognitive impairment induced by caloric deficiency can be cleared quickly when their energy supply recovers (Gailliot et al., 2007). Consistent with this phenomenon, we further observe that the impact of nutritional deficiency on hours worked disappears immediately after Ramadan when Muslim workers break their

[47] Muslim workers can break their fast with some food or snacks usually rich in carbohydrates. Carbohydrates are the primary source of glucose. When people eat food containing carbohydrates, the digestive system breaks down the digestible carbohydrates into sugar, which enters the blood and increases the blood glucose level (Alberts et al., 2002).

fast (see Panel (b) of Figure 5).

6.3 Policy relevance and generalizability

The specific setting of Ramadan fasting provides us with a solid causal interpretation of our estimates. Especially, the clear pattern of nutritional status within a Ramadan day provides us with a unique opportunity to show the productivity response to nutritional status over just a few hours. However, the short-term nature of Ramadan fasting might raise another concern of the policy relevance and the generalizability to other types of nutrition deficiency.

First, the short-term effects that we investigate speak directly to acute food insecurity. Acute food insecurity is also known as transitory food insecurity and stands in contrast to chronic food insecurity.[48] Despite its short-term nature, acute food insecurity has become an increasing issue worldwide in addition to chronic hunger. The number of people facing "crisis" levels of *acute* food insecurity or worse increased from 80 million in 2015 to 124 million in 2017, mainly due to increasing climate variability (FAO et al., 2018). Therefore, estimating the short-term effects of nutrition deficiency becomes increasingly important and policy-relevant.

Although our findings cannot be directly applied to chronic hunger, nutrition deficiency over a longer time period may have larger and more persistent effects. This means that the sizable short-term effects that we document may be a lower-bound estimation of the effects of long-term nutritional problems.

In addition to food insecurity, our findings can provide a better understanding of the labor market effects of fasting or dieting that is practiced to lose weight and for religious reasons. In the U.S., 36% of the population report that they have fasted to lose weight (French, Jeffery and Murray, 1999), and at any time in the U.S., around 7 million people

[48] Chronic food insecurity reflects a long-term lack of access to adequate food, and is typically associated with structural problems of availability, access or utilization. Transitory food insecurity, by contrast, is associated with sudden and temporary disruptions in availability, access or, less commonly, utilization. (Barrett and Lentz, 2010)

are fasting for body weight control (Kruger et al., 2004).[49] The fact that over one billion Muslim will fast for a month each year implies that understanding the short-term impacts of fasting is an important question per se. Moreover, fasting is not uncommon across different religions, such as the Christian season of Lent, the Jewish holy day of Yom Kippur, and Tuesday/Thursday fasting among some Hindus.

7 Conclusion

Diet and work are two of the most important things in our daily life. However, we only have a limited understanding about whether and to what extent insufficient nutrient intake affects our work performance. The causal evidence is also unclear, especially in the short-term daily and hourly levels and among cognitive workers. The shortage of both high frequency data at workplace and credible exogenous nutrition shocks for workers prevent researchers from further examining the possible effects of nutrition deficiency on work performance.

In this paper, we utilize Ramadan fasting as an exogenous nutrition shock to enable a causal interpretation. We further obtain administrative data at a high-frequency level from a large retailer in Indonesia. Specifically, we compare Muslim salespersons with their non-Muslim colleagues during Ramadan, with the pre-Ramadan period as the baseline, and estimate the short-term effects of Ramadan fasting on their productivity and labor supply. As noted, the jobs of salespersons in this high-end cosmetics retailer are characterized as more cognitively demanding than physically demanding.

We find evidence that nutritional deficiency can significantly decrease both workers' productivity and labor supply in the short term. For productivity, we find significant adverse effects on productivity before sunset when the fasting workers experience the most energy deficiency. We further find that their labor supply also declines significantly

[49] We refer to fasting as short-term fast, such as skipping a meal for losing weight. Majority of dieters who are fasting are skipping a meal (Kruger et al., 2004). During Ramadan fasting, adult Muslim can have breakfast before the dawn prayer and supper after sunset. They skip their meals at noon.

during the hours of greatest energy deficiency compared with the insignificant changes in other periods. The patterns of the changes in both their productivity and labor supply are consistent with their nutrition status during a fasting day. We further indicate that these results are not likely driven by other competing explanations during Ramadan, such as demand shocks, fast-breaking events, dehydration, and sleep deprivation.

Our findings point out the short-term or even immediate causal impact of nutrition deficiency on productivity and labor supply. The results suggest that current nutrition intake itself can directly impact labor performance, which can close the gap between nutrition and labor outcomes. Particularly, the results provide direct support for the nutrition-productivity hypothesis, which has been less substantiated by empirical casual evidence.

Moreover, our findings concerning a cognitive occupation are also meaningful, given the global shift toward cognitive rather than physical labor. The nutrition-productivity relationship may be more evident for physically demanding occupations. However, whether this relationship still exists for non-physically demanding occupations is an important unanswered question. Our results suggest that the nutrition-productivity effect on cognitive workers can be substantial.

Finally, our findings are important bacause there is a significant number of people in the world who suffer from nutritional deficiency and even crisis levels of acute food insecurity.[50] However the potential adverse effects of insufficient food on their productivity and labor supply are not well studied. Our results indicate food deprivation can exert a significant impact on both labor productivity and labor supply, which suggests that ensuring food security can be viewed as an investment in human capital. The direct links of food security productivity and labor supply and probably economic growth should be incorporated in the calculus of policymakers concerning the food security.

[50] Over 800 million people consume insufficient calories FAO (2010). Approximately 124 million people faced even crisis levels of acute food insecurity (FAO et al., 2018).

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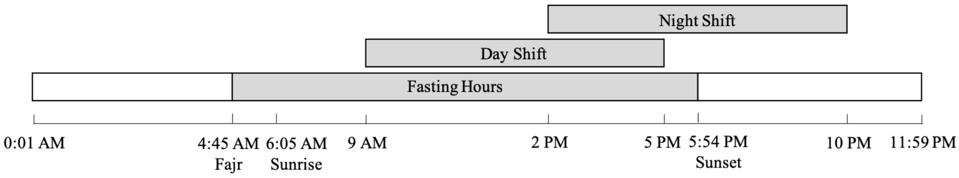
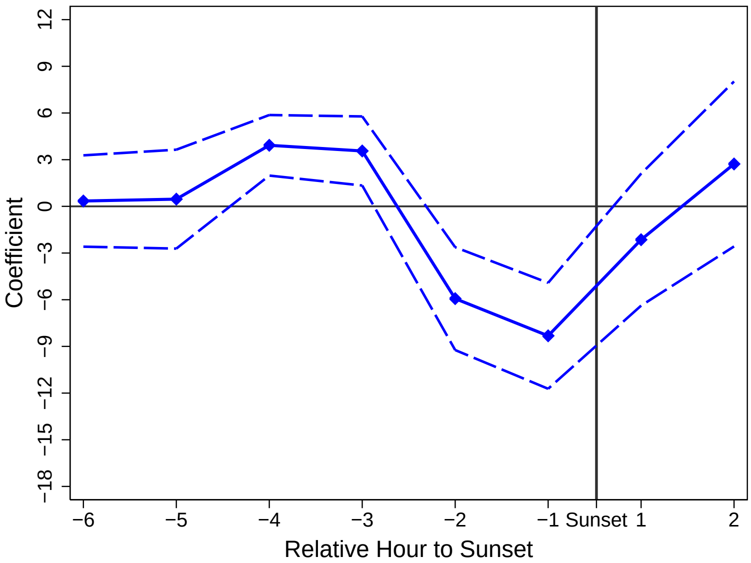
Figure 1: Fasting Hours and Official Working Hours of Day Shift and Night Shift



Note: Fasting hours begin at the time for the dawn prayer (Fajr) and end at sunset. During Ramadan in our sample period, the average Fajr time is 4:45 a.m., and the average sunset time is 5:54 p.m. The official working hours of day-shift and night-shift workers are from 9 a.m. to 5 p.m. and from 2 p.m. to 10 p.m., respectively.

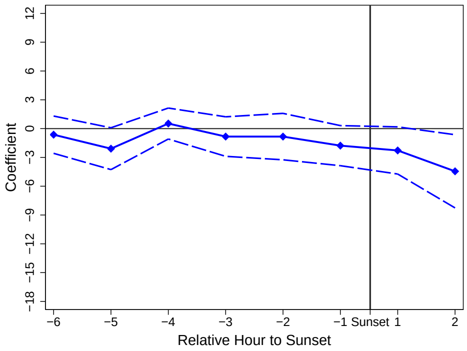
Figure 2: Hourly Productivity During Ramadan



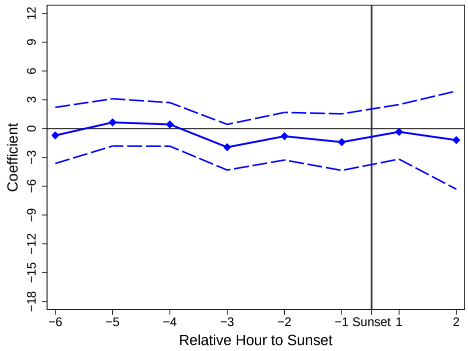
Note: The graph plots event-study estimates of the effects on hourly productivity, i.e., the sales amount in each hour relative to sunset, during Ramadan for day-shift Muslim workers, along with the corresponding 95% confidence intervals. The sales in *Relative Hour to Sunset* -X and X are the sales in U.S. dollars within the X-th hour before and after the sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The vertical line indicates the sunset time. The average sunset time is 5:54 p.m. with a 95% range [5:21 p.m., 6:28 p.m.] in our sample period.

Figure 3: Hourly Productivity Before and After Ramadan

(a) Before Ramadan

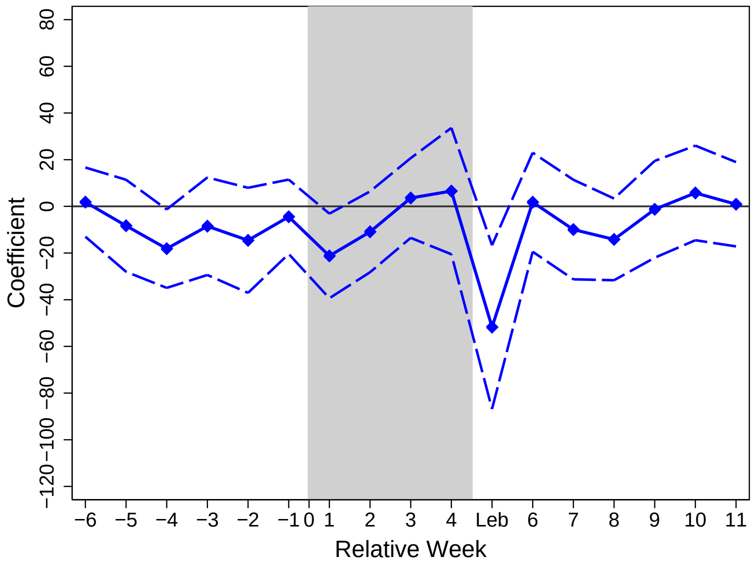


(b) After Ramadan



Note: The graphs plot event-study estimates of the effects on hourly productivity, i.e., the sales amount in each hour relative to sunset, before Ramadan (Panel (a)) and after Ramadan (Panel (b)) for day-shift Muslim workers, along with the corresponding 95% confidence intervals. The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The vertical line indicates the sunset time.

Figure 4: Daily Productivity



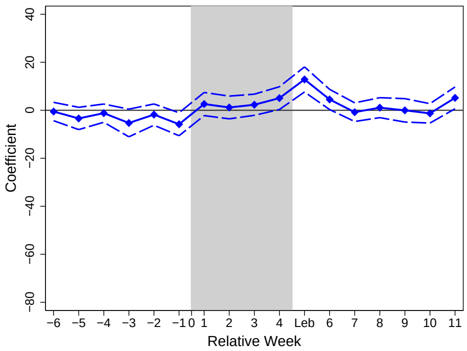
Note: The graph plots event-study estimates of the effects on daily productivity, i.e., the sales amount in U.S. dollars on a working day, in each week before, during, and after Ramadan for day-shift Muslim workers, along with the corresponding 95% confidence intervals. Relative week -X and X mean the X-th week before and after the starting date of Ramadan, i.e., relative week 0. "Leb" is the Lebaran holiday, which lasts five days right after Ramadan. The vertical gray area is the Ramadan period.

Figure 5: Labor Supply

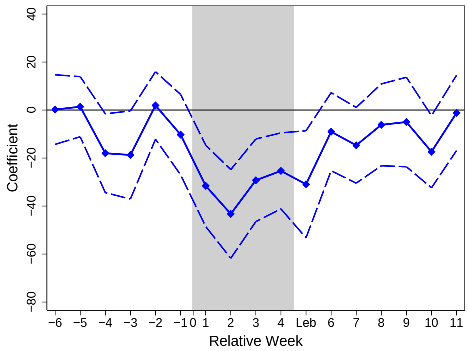
Note: The graphs plot event-study estimates and the corresponding 95% confidence intervals. *Working Day* is a dummy variable for whether a salesperson comes to work on a given day. *Hours Worked* is the number of hours worked on a working day. The official working time of day-shift and night-shift workers is from 9 a.m. to 5 p.m. and 2 p.m. to 10 p.m., respectively. Relative week -X and X mean the X-th week before and after the starting date of Ramadan, i.e., relative week 0. “Leb” is the Lebaran holiday, which lasts five days right after Ramadan. The vertical gray area is the Ramadan period.

Figure 6: Time of Clock in and Clock out (in Minutes)

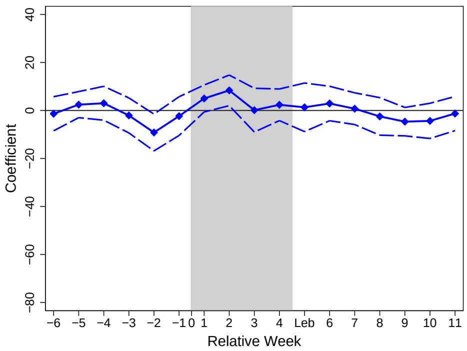
(a) Clock-in Time of Day Shift (around 9 a.m.)



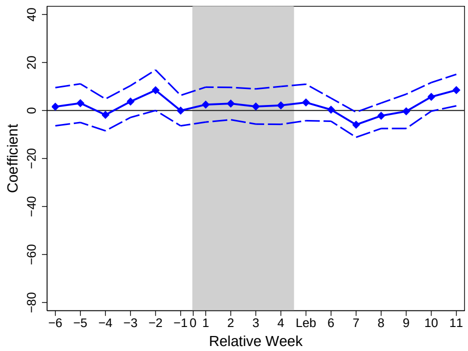
(b) Clock-out Time of Day Shift (around 5 p.m.)



(c) Clock-in Time of Night Shift (around 2 p.m.)



(d) Clock-out Time of Night Shift (around 10 p.m.)



Note: The graphs plot event-study estimates and corresponding 95% confidence intervals. The official working time of day-shift and night-shift workers is from 9 a.m. to 5 p.m. and 2 p.m. to 10 p.m., respectively. *Clock-in Time* is a salesperson's clock-in time measured in minutes. *Clock-out Time* is a salesperson's clock-out time measured in minutes. Relative week -X and X mean the X-th week before and after the starting date of Ramadan, i.e., relative week 0. "Leb" is the Lebaran holiday, which lasts five days right after Ramadan. The vertical gray area is the Ramadan period.

Table I: Test for Religion Proximity

Total Sales	Full	Ramadan Period	Lebaran Period
Muslim X City Sales X Muslim Ratio	-0.000	0.001	0.005
	(0.006)	(0.008)	(0.013)
City Sales X Muslim	0.001	0.000	-0.003
	(0.001)	(0.002)	(0.002)
City Sales	0.014***	0.014***	0.018***
	(0.001)	(0.002)	(0.002)
Other DDD Controls	Yes	Yes	Yes
Store-Year FE	Yes	Yes	Yes
Date	Yes	Yes	Yes
Individual-Year FE	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes
Observations	2214280	362960	44501
R-Squared	0.227	0.269	0.299

Notes: The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. All two-way interactions necessary for triple-differences are included in regressions. ***Significant at 1%, **significant at 5%, *significant at 10%.

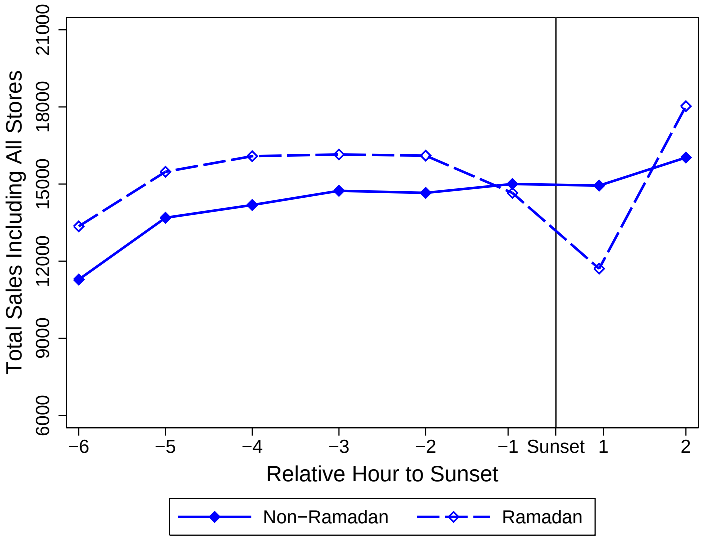
Table II: Test for Fast Breaking Events

	(1)	(2)
Dependent Variable:	Clock-out Time (Day Shift)	Clock-out Time (Night Shift)
Sunset X Muslim X Ramadan	-0.831***	-0.220
	(0.235)	(0.256)
Other DDD Controls	Yes	Yes
Store-Year FE	Yes	Yes
Date FE	Yes	Yes
Individua-Year FE	Yes	Yes
Observations	120535	112015
R-Squared	0.186	0.309

Notes: *Clock-out* is the clock-out time measured in minutes of a salesperson. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.

A Appendix

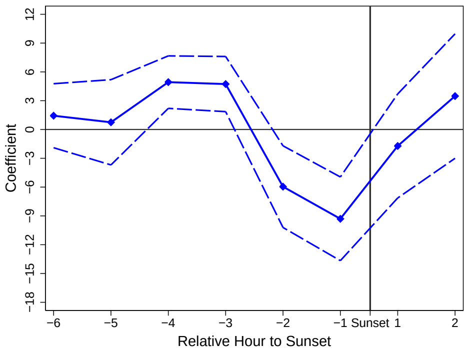
Figure A.1: Total Sales during Ramadan and Non-Ramadan



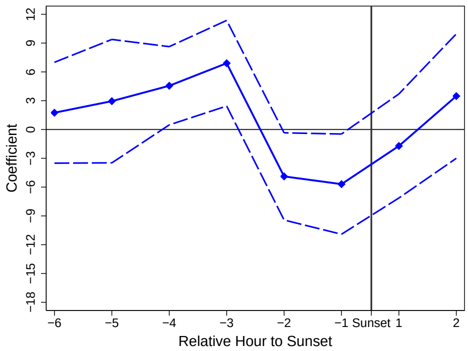
Note: The graph summarizes the total sales of all stores in each hour during the non-Ramadan period (solid line) and Ramadan period (dashed line). The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The vertical line indicates the sunset time. The average sunset time is 5:54 p.m. with a 95% range [5:21 p.m., 6:28 p.m.] in our sample period.

Figure A.2: Worker Productivity at Hourly Level (Balance Sample)

(a) Works until the first hour before sunset and later



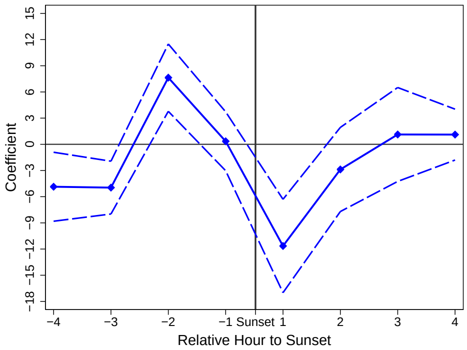
(b) Works until the second hour after sunset and later



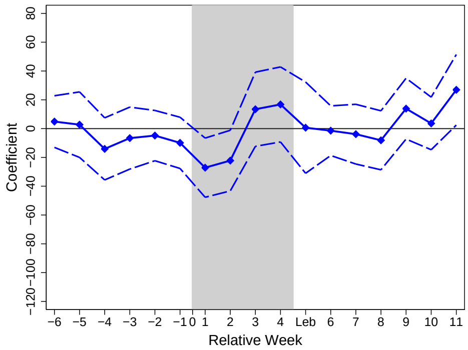
Note: The graph plots event-study estimates of the effects on hourly productivity, i.e., the sales amount in each hour relative to sunset, during Ramadan for day-shift Muslim workers, along with the corresponding 95% confidence intervals. Panel (a), the sample of day-shift salespersons who works until the first hour before sunset and later. Panel (b), the sample of day-shift salespersons who works until the second hour after sunset and later. The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The vertical line indicates the sunset time. The average sunset time is 5:54 p.m. with a 95% range [5:21 p.m., 6:28 p.m.] in our sample period.

Figure A.3: Hourly Productivity During Ramadan and Daily Productivity (Night Shift)

(a) Hourly Productivity during Ramadan



(b) Daily Productivity



Note: The graphs plot estimates of the effects on the productivity at both the hourly level and daily levels of night-shift Muslim workers. Panel (a) plots event-study estimates of the effects on hourly productivity, i.e., the sales amount in each hour relative to sunset, during Ramadan, along with the corresponding 95% confidence intervals. The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The vertical line indicates the sunset time. The average sunset time is 5:54 p.m. with a 95% range [5:21 p.m., 6:28 p.m.] in our sample period. Panel (b) plots event-study estimates of the effects on daily productivity, i.e., the sales amount in U.S. dollars on a working day, in each week before, during, and after Ramadan, along with the corresponding 95% confidence intervals. Relative week -X and X mean the X-th week before and after the starting date of Ramadan, i.e., relative week 0. "Leb" is the Lebaran holiday, which lasts five days right after Ramadan. The vertical gray area is the Ramadan period.

Table A.I: The Impacts on Labor Supply

	(1)	(2)	(3)	(4)
Dependent Variable:	Working Day (All Shifts)	Hours Worked (All Shifts)	Hours Worked (Day Shift)	Hours Worked (Night Shift)
Muslim X Before Ramadan (Week 6)	0.005	0.005	0.012	0.049
	(0.012)	(0.081)	(0.120)	(0.085)
Muslim X Before Ramadan (Week 5)	-0.014	0.034	0.080	0.010
	(0.013)	(0.068)	(0.107)	(0.076)
Muslim X Before Ramadan (Week 4)	-0.028**	-0.208**	-0.280**	-0.081
	(0.012)	(0.090)	(0.138)	(0.068)
Muslim X Before Ramadan (Week 3)	0.000	-0.075	-0.224	0.096
	(0.016)	(0.087)	(0.148)	(0.078)
Muslim X Before Ramadan (Week 2)	-0.012	0.108	0.062	0.294***
	(0.016)	(0.084)	(0.119)	(0.100)
Muslim X Before Ramadan (Week 1)	-0.025	0.004	-0.074	0.038
	(0.020)	(0.080)	(0.137)	(0.078)
Muslim X Ramadan (Week 1)	0.002	-0.314***	-0.569***	-0.043
	(0.022)	(0.097)	(0.138)	(0.082)
Muslim X Ramadan (Week 2)	-0.013	-0.475***	-0.741***	-0.092
	(0.021)	(0.096)	(0.147)	(0.078)
Muslim X Ramadan (Week 3)	-0.016	-0.264***	-0.526***	0.025
	(0.024)	(0.094)	(0.154)	(0.081)
Muslim X Ramadan (Week 4)	-0.028	-0.269***	-0.507***	-0.004
	(0.020)	(0.087)	(0.142)	(0.083)
Muslim X Lebaran	-0.163***	-0.683***	-0.730***	0.034
	(0.029)	(0.148)	(0.198)	(0.090)
Muslim X After Lebaran (Week 1)	-0.058***	-0.151*	-0.226*	-0.043
	(0.014)	(0.081)	(0.135)	(0.071)
Muslim X After Lebaran (Week 2)	-0.054***	-0.176**	-0.232*	-0.111*
	(0.019)	(0.076)	(0.136)	(0.067)
Muslim X After Lebaran (Week 3)	-0.019	-0.091	-0.121	0.004
	(0.020)	(0.093)	(0.154)	(0.079)
Muslim X After Lebaran (Week 4)	-0.013	-0.063	-0.083	0.072
	(0.024)	(0.093)	(0.158)	(0.078)
Muslim X After Lebaran (Week 5)	-0.019	-0.117	-0.268**	0.167**
	(0.023)	(0.083)	(0.125)	(0.075)
Muslim X After Lebaran (Week 6)	0.021	0.027	-0.106	0.163**
	(0.021)	(0.075)	(0.131)	(0.080)
Branch-Year FE	Yes	Yes	Yes	Yes
Year-Date FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	331214	249724	129459	120265
R-Squared	0.092	0.155	0.203	0.268

Notes:

Working Day is a dummy variable for whether a salesperson comes to work on a given day. *Hours Worked* is the number of hours worked on a working day. *Lebaran* is a holiday, which lasts five days right after Ramadan. The official working time of day-shift and night-shift workers is from 9 a.m. to 5 p.m. and 2 p.m. to 10 p.m., respectively. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.II: The Impacts on the Time of Clock in and Clock out (in Minutes)

	(1)	(2)	(3)	(4)
Dependent Variable:	Clock-in Time (Day Shift)	Clock-in Time (Night Shift)	Clock-out Time (Day Shift)	Clock-out Time (Night Shift)
Muslim X Before Ramadan (Week 6)	-0.513	-1.358	0.201	1.587
	(1.949)	(3.625)	(7.395)	(4.057)
Muslim X Before Ramadan (Week 5)	-3.394	2.445	1.395	3.059
	(2.368)	(2.771)	(6.386)	(4.107)
Muslim X Before Ramadan (Week 4)	-1.185	3.019	-17.991**	-1.819
	(1.938)	(3.604)	(8.375)	(3.386)
Muslim X Before Ramadan (Week 3)	-5.287*	-2.053	-18.721**	3.728
	(2.938)	(3.718)	(9.372)	(3.377)
Muslim X Before Ramadan (Week 2)	-1.788	-9.160**	1.916	8.458**
	(2.260)	(3.918)	(7.181)	(4.308)
Muslim X Before Ramadan (Week 1)	-5.809**	-2.337	-10.230	-0.037
	(2.441)	(4.113)	(8.548)	(3.239)
Muslim X Ramadan (Week 1)	2.612	5.011*	-31.557***	2.459
	(2.457)	(2.865)	(8.645)	(3.710)
Muslim X Ramadan (Week 2)	1.178	8.391**	-43.284***	2.893
	(2.413)	(3.254)	(9.427)	(3.437)
Muslim X Ramadan (Week 3)	2.314	0.147	-29.263***	1.672
	(2.246)	(4.650)	(8.779)	(3.742)
Muslim X Ramadan (Week 4)	5.071**	2.380	-25.355***	2.129
	(2.421)	(3.361)	(8.081)	(4.024)
Muslim X Lebaran	12.858***	1.327	-30.927***	3.353
	(2.663)	(5.159)	(11.380)	(3.877)
Muslim X After Lebaran (Week 1)	4.522**	2.925	-9.026	0.340
	(2.147)	(3.665)	(8.295)	(2.452)
Muslim X After Lebaran (Week 2)	-0.784	0.753	-14.695*	-5.916**
	(1.985)	(3.372)	(8.050)	(2.674)
Muslim X After Lebaran (Week 3)	1.103	-2.463	-6.159	-2.198
	(2.120)	(3.989)	(8.696)	(2.707)
Muslim X After Lebaran (Week 4)	-0.019	-4.645	-4.986	-0.337
	(2.488)	(3.016)	(9.508)	(3.649)
Muslim X After Lebaran (Week 5)	-1.276	-4.325	-17.363**	5.690*
	(2.064)	(3.743)	(7.670)	(3.038)
Muslim X After Lebaran (Week 6)	5.182**	-1.274	-1.172	8.504**
	(2.311)	(3.631)	(8.007)	(3.350)
Branch-Year FE	Yes	Yes	Yes	Yes
Year-Date FE	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes
Observations	129459	120265	129459	120265
R-Squared	0.319	0.224	0.188	0.309

Notes:

Clock-in Time is a salesperson's clock-in time measured in minutes. *Clock-out Time* is a salesperson's clock-out time measured in minutes. *Lebaran* is a holiday, which lasts five days right after Ramadan. The official working time of day-shift and night-shift workers is from 9 a.m. to 5 p.m. and 2 p.m. to 10 p.m., respectively. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.III: The Impacts on Daily Productivity

	(1)	(2)	(3)
Dependent Variable:	Daily Sales (Day Shift)	Daily Sales (Night Shift)	Daily Sales (All Shifts)
Muslim X Before Ramadan (Week 6)	1.824	4.890	2.779
	(7.561)	(9.149)	(6.450)
Muslim X Before Ramadan (Week 5)	-8.296	2.744	-3.729
	(10.053)	(11.607)	(7.729)
Muslim X Before Ramadan (Week 4)	-18.126**	-14.079	-15.268*
	(8.573)	(11.000)	(7.981)
Muslim X Before Ramadan (Week 3)	-8.498	-6.593	-7.198
	(10.660)	(10.985)	(8.662)
Muslim X Before Ramadan (Week 2)	-14.554	-4.834	-10.931
	(11.485)	(8.907)	(8.020)
Muslim X Before Ramadan (Week 1)	-4.454	-9.883	-6.208
	(8.125)	(9.075)	(7.342)
Muslim X Ramadan (Week 1)	-21.231**	-27.125***	-21.279***
	(9.246)	(10.485)	(7.883)
Muslim X Ramadan (Week 2)	-10.906	-22.207**	-14.726**
	(8.835)	(10.739)	(7.081)
Muslim X Ramadan (Week 3)	3.592	13.452	9.322
	(8.715)	(13.144)	(9.097)
Muslim X Ramadan (Week 4)	6.551	16.788	11.908
	(13.807)	(13.290)	(9.685)
Muslim X Lebaran	-51.728***	0.648	-37.632***
	(17.891)	(16.159)	(13.388)
Muslim X After Lebaran (Week 1)	1.780	-1.435	1.840
	(10.821)	(8.792)	(8.383)
Muslim X After Lebaran (Week 2)	-9.929	-3.853	-7.326
	(10.882)	(10.583)	(8.258)
Muslim X After Lebaran (Week 3)	-14.150	-8.117	-11.607
	(8.926)	(10.455)	(7.882)
Muslim X After Lebaran (Week 4)	-1.266	13.875	6.097
	(10.583)	(10.777)	(7.942)
Muslim X After Lebaran (Week 5)	5.755	3.596	5.351
	(10.336)	(9.311)	(8.148)
Muslim X After Lebaran (Week 6)	0.908	26.952**	12.361
	(9.216)	(12.500)	(7.763)
Branch-Year FE	Yes	Yes	Yes
Year-Date FE	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Observations	133962	126241	260203
R-Squared	0.520	0.543	0.511

Notes:

Daily Sales is the sales amount in U.S. dollars on a working day. *Lebaran* is a holiday, which lasts five days right after Ramadan. The official working time of day-shift and night-shift workers is from 9 a.m. to 5 p.m. and 2 p.m. to 10 p.m., respectively. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.IV: The Impacts on Hourly Productivity

Hourly Sales	-6	-5	-4	-3	-2	-1	1	2
Muslim X Before Ramadan (1-6 weeks)	-0.632	-2.091*	0.529	-0.829	-0.831	-1.774*	-2.276*	-4.448**
	(0.991)	(1.112)	(0.823)	(1.051)	(1.234)	(1.065)	(1.253)	(1.945)
Muslim X Ramadan	0.344	0.464	3.925***	3.560***	-5.929***	-8.318***	-2.142	2.725
	(1.497)	(1.622)	(0.992)	(1.132)	(1.686)	(1.737)	(2.163)	(2.705)
Muslim X After Ramadan (1-6 weeks)	-0.707	0.649	0.436	-1.937	-0.793	-1.405	-0.337	-1.199
	(1.491)	(1.256)	(1.158)	(1.213)	(1.265)	(1.503)	(1.450)	(2.609)
City Hourly Total Sales X Muslim	-0.003	-0.003	-0.003**	-0.002	-0.003	-0.003*	-0.004*	-0.006***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
City Hourly Total Sales (Value)	0.025***	0.023***	0.013***	0.009***	0.015***	0.014***	0.015***	0.018***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Branch-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	127798	127582	127032	123150	116209	103861	66132	42219
R-Squared	0.321	0.334	0.256	0.237	0.312	0.264	0.220	0.264

Notes: The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.V: The Impacts on Hourly Productivity without Demand-Side Controls

Hourly Sales	-6	-5	-4	-3	-2	-1	1	2
Muslim X Before Ramadan (1-6 weeks)	0.690	-1.474	-0.334	0.147	-0.163	-0.983	-1.212	-2.785
	(1.045)	(1.330)	(1.012)	(1.031)	(1.356)	(1.216)	(1.477)	(1.900)
Muslim X Ramadan	2.042	1.551	3.032**	1.804	-4.437**	-4.092***	-0.315	3.926*
	(1.456)	(1.624)	(1.224)	(1.271)	(1.719)	(1.543)	(1.986)	(2.229)
Muslim X After Ramadan (1-6 weeks)	-1.350	-0.985	-0.182	-1.499	-0.124	-1.467	0.489	-2.703
	(1.490)	(1.364)	(1.094)	(1.245)	(1.379)	(1.303)	(1.590)	(2.363)
Branch-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	80737	80589	80232	77811	73568	66137	44491	30844
R-Squared	0.281	0.306	0.246	0.226	0.288	0.245	0.215	0.267

Notes: The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.VI: The Impacts on Hourly Productivity (Sample works until the first hour before sunset and later)

Hourly Sales	-6	-5	-4	-3	-2	-1	1	2
Muslim X Before Ramadan (1-6 weeks)	0.419	-2.203	1.571	-1.220	0.084	-1.760	-2.294*	-6.114**
	(1.342)	(1.371)	(1.122)	(1.370)	(1.673)	(1.321)	(1.392)	(2.460)
Muslim X Ramadan	1.437	0.750	4.934***	4.733***	-5.955***	-9.303***	-1.717	3.479
	(1.701)	(2.265)	(1.395)	(1.466)	(2.170)	(2.224)	(2.765)	(3.307)
Muslim X After Ramadan (1-6 weeks)	-1.205	-0.672	0.719	-2.671	-1.459	-0.568	-0.153	-1.778
	(1.842)	(1.467)	(1.737)	(1.696)	(1.606)	(1.866)	(1.627)	(3.169)
City Hourly Total Sales X Muslim	-0.004	-0.004*	-0.005***	-0.004*	-0.006**	-0.007***	-0.009**	-0.008***
	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
City Hourly Total Sales (Value)	0.027***	0.026***	0.016***	0.013***	0.019***	0.019***	0.020***	0.021***
	(0.003)	(0.002)	(0.001)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
Branch-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	78887	78887	78887	78887	78887	70742	45425	29109
R-Squared	0.332	0.345	0.265	0.245	0.318	0.270	0.223	0.271

Notes: The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.

Table A.VII: The Impacts on Hourly Productivity (Sample works until the second hour after sunset and later)

Hourly Sales	-6	-5	-4	-3	-2	-1	1	2
Muslim X Before Ramadan (1-6 weeks)	0.229	-1.628	0.602	-2.414	0.520	-2.225	-2.294*	-6.114**
	(1.758)	(1.567)	(1.660)	(1.892)	(2.056)	(1.959)	(1.392)	(2.460)
Muslim X Ramadan	1.747	2.953	4.555**	6.903***	-4.887**	-5.692**	-1.717	3.479
	(2.680)	(3.280)	(2.079)	(2.275)	(2.317)	(2.663)	(2.765)	(3.307)
Muslim X After Ramadan (1-6 weeks)	-1.650	0.022	0.005	-3.347	-4.052*	0.125	-0.153	-1.778
	(2.519)	(2.424)	(2.339)	(2.322)	(2.205)	(2.738)	(1.627)	(3.169)
City Hourly Total Sales X Muslim	-0.001	-0.003	-0.003	-0.004	-0.007***	-0.006**	-0.009**	-0.008***
	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
City Hourly Total Sales (Value)	0.025***	0.025***	0.015***	0.013***	0.020***	0.021***	0.020***	0.021***
	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
Branch-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-Date FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	45425	45425	45425	45425	45425	45425	45425	29109
R-Squared	0.350	0.363	0.285	0.264	0.351	0.316	0.223	0.271

Notes: The sales in *Relative Hour to Sunset* -X and X mean the sales in U.S. dollars within the X-th hour before and after sunset. For example, Relative Hour to Sunset -1 means the sales amount within the first hour right before sunset, which is the sales from 5 p.m. to 6 p.m. if the sunset time is 6 p.m. The sample consists of employee-day observations. Ordinary least squares estimates for all columns. Standard errors in parentheses, clustered by individual. ***Significant at 1%, **significant at 5%, *significant at 10%.