Appendix

A.1 A model of consumers' strategic responses to the policy

With model-free evidence in hand, we introduce a simplified model to explore how households' different incentives to minimize the shock from demonetization generate such observed increases in returns and purchases. Although we do not observe consumer information for each transaction, we treat each transaction record as a shopping behavior of a single household and analyze the data through the lens of a household-level utility model.[1] We do not sketch any strategic responses of retailers in this model as the abruptness of the policy enactment allows us to assume that there is no overnight response by the retail chain, which we also confirm reviewing news articles. Future work may extend the framework and incorporate the supply side decisions to understand an equilibrium outcome when both households and firms are expected to react simultaneously.

Before the currency reform policy, household i has the following utility function attached to their cash income:

$$\begin{aligned} u_i &= U(z_i - T(z_i')) \\ &= U(z_i - T(z_i - b_i)), \quad 0 \leq b_i \leq z_i \end{aligned} \tag{A.0.1}$$

where z_i is before-tax earnings in cash that is saved in soon-to-be demonetized notes (500 and 1000 INR notes), $z_i' = z_i - b_i$ is *reported* taxable income in cash, and $T(\cdot)$ is a tax function which is monotonically increasing. For simplicity, we define the tax function T to be the following:

$$T(z) = (1-t)(z - z^*)\mathbb{1}\{z > z^*\} \tag{A.0.2}$$

where z^* is the earning threshold above which a marginal tax rate t is applied. Under this tax system, households whose earnings in cash are greater than z^* can reduce the amount of tax paid by reporting their income to be smaller. We assume that $U(\cdot)$ is linear in after-tax income $z_i - T(z_i')$.

The demonetization policy changes the utility function in several ways. First, it puts a restriction on how much households can shade their income in cash by forcing them to deposit or exchange the demonetized cash notes at the banks. In the utility function, this is reflected as $b_i = 0$ after demonetization. Second, it penalizes those households that have been evading taxes, i.e., whose b_i has been greater than 0. This introduces a new term $P(\cdot)$ in the utility function after demonetization, which is the tax penalty as a function of the size of avoided tax $(T(z_i) - T(z_i - b_i))$. We

[1] Although our data set does not specify any individual-level information, we can safely assume that each transaction record on the day of policy announcement is made by a unique individual, as the data set records all the items purchased on the same trip as a single transaction. Given the four-hour window between the announcement and the effective date, it is unlikely that a single household made multiple shopping trips to the same store after the announcement.

assume the following functional form for the tax penalty:

$$\begin{aligned} P_i &= (\pi_o + \pi_1(T(z_i) - T(z_i - b_i))) \cdot \mathbb{1}\{b_i > 0\} \\ &= (\pi_o + \pi_1 t b_i) \cdot \mathbb{1}\{b_i > 0\} \qquad (\because \text{Equation (A.0.2)}) \end{aligned} \tag{A.0.3}$$

where π_0 denotes a flat fee that anyone has to pay if their amount of tax evasion (tb_i) is greater than 0. Third, due to the imminent cash shortage and the increased traffic at the banks, the policy creates a cost related to exchanging or depositing the cash notes at the banks (e.g., waiting in line for hours). We assume that this cost has to be paid once for any household who has positive amount of demonetized cash. We specify the depositing cost D to be

$$D_i = \begin{cases} D & \text{if holdings of cash to be demonetized} > 0 \\ 0 & \text{if holdings of cash to be demonetized} = 0 \end{cases} \tag{A.0.4}$$

Combining these components, the new utility function is

$$\begin{aligned} u_i^{Post} &= U\left(z_i - T(z_i) - P(tb_i) - D(z_i)\right) \\ &= U\left(\underbrace{z_i - T(z_i) - (\pi_0 + \pi_1 t b_i) \cdot \mathbb{1}\{b_i > 0\}}_{\text{New budget set}} - \underbrace{D \cdot \mathbb{1}\{z_i > 0\}}_{\text{Depositing cost}}\right) \end{aligned} \tag{A.0.5}$$

where tb_i is the total amount of avoided tax (following Equation (A.0.2)).

1) Strategic returns Households can save on tax penalty by making purchases with soon-to-be demonetized cash notes and returning the items to receive legal notes from the retailer. For some households whose before-tax income in demonetized cash (z_i) is not large, such strategic returns can even save the depositing cost by converting all z_i to legal notes.

Suppose that R_i is the amount of purchases household i makes with old notes that are later returned for legal notes. Then, i's utility function with strategic returns becomes

$$u_i^{Return} = U\left(z_i \underbrace{-R_i + R_i}_{\substack{\text{Purchases followed} \\ \text{by returns}}} - \underbrace{T(z_i - R_i)}_{\text{Savings in tax}} - \underbrace{(\pi_0 + \pi_1 t(b_i - R_i)) \cdot \mathbb{1}\{b_i - R_i > 0\}}_{\text{Savings in penalty}} - \underbrace{D \cdot \mathbb{1}\{z_i - R_i > 0\}}_{\text{Savings in depositing cost}}\right) \tag{A.0.6}$$

$$\geq u_i^{Post} = U\left(z_i - T(z_i) - (\pi_0 + \pi_1 t b_i) \cdot \mathbb{1}\{b_i > 0\} - D \cdot \mathbb{1}\{z_i > 0\}\right).$$

R_i, the amount of money that is converted to legal notes via strategic returns, does not have to be deposited to bank accounts and thus can stay outside the formal tax network. As illustrated in

Equation (A.0.6), this saves household income in three different ways: 1) by reducing the amount of tax to be collected, 2) by reducing the penalty attached to former tax evasion, and 3) by removing the depositing cost if all demonetized cash can be converted to legal notes this way. Here, we do not assume any frictions or cost associated with the return activity itself, including the cost of multiple store visits.

Although strategic returns would give the highest utility to households given the policy, a strict return policy does not always guarantee that such returns can take place. Although any purchased items can be returned in 7 days if there are any issues with the products according to the store managers we contacted, anecdotal evidence suggests that the refund option for simple change of mind is rarely available. Also, even the most generous refund policy in the market still requires certain conditions to be met like intact packaging. This implies that, among people who made purchases on the day of announcement before the policy information became public, only those who did not open the package could attempt to return the purchased items which was not always successful. Even those people who made purchases after the policy announcement before the effective date purely for strategic purposes had to go through the stringent return process that not everyone could complete.

2) Incremental final purchases For households who have evaded a large amount of tax before the policy, it can still be beneficial to convert soon-to-be demonetized notes to physical products even if the option of return is not available, since such purchases lower post-policy tax and tax penalty. Household i's utility with these strategic final purchases is

$$u_i^{IncPurchase} = U\left(z_i - C_i - \underbrace{T(z_i - C_i)}_{\text{Savings in tax}} - \underbrace{(\pi_0 + \pi_1 t(b_i - C_i)) \cdot \mathbb{1}\{b_i - C_i > 0\}}_{\text{Savings in penalty}} - \underbrace{D \cdot \mathbb{1}\{z_i - C_i > 0\}}_{\text{Savings in depositing cost}}\right) \tag{A.0.7}$$

$$\geq u_i^{Post} = U\left(z_i - T(z_i) - (\pi_0 + \pi_1 t b_i) \cdot \mathbb{1}\{b_i > 0\} - D \cdot \mathbb{1}\{z_i > 0\}\right)$$

$$\text{if } C_i \leq T(z_i) - T(z_i - C_i) + \pi_1 C_i \mathbb{1}\{b_i > 0\} + D_i \mathbb{1}\{z_i - C_i \leq 0\}$$

where C_i is the amount of strategic purchases made with demonetized cash notes. The inequalities imply that it is beneficial for i to discard C_i as long as C_i is less than the savings i gets from a lower tax penalty and zero depositing cost. This is consistent with households' abandonment of demonetized cash without depositing it, which is documented in press reports:

> "Some have thrown in the towel, rather than risking an investigation into their taxes, filling pillowcases and paper bags with the old currency and dumping them in the trash. Notes of 1,000 rupees, the equivalent of about $15, have been spotted floating down the Ganges River."

"Indians Rush Frantically to Launder Their 'Black Money,'" The New York Times, Nov. 20, 2016.

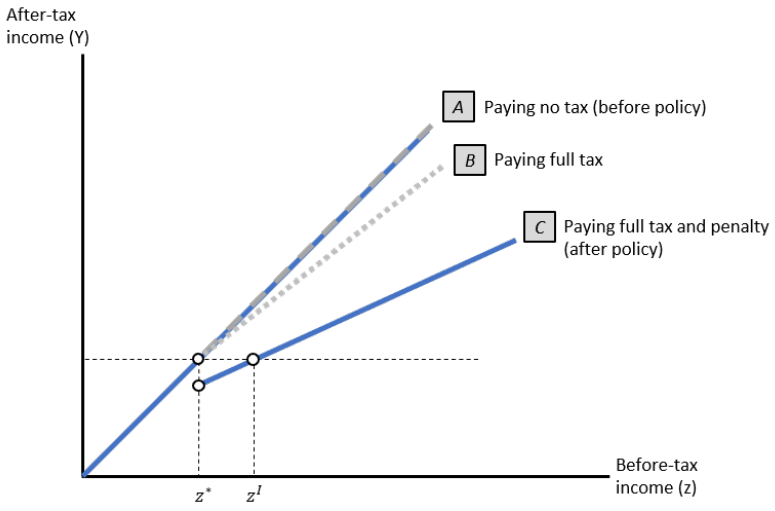
Figure 1 illustrates graphically how the policy can trigger such strategic purchases or cash disposal.[2] Before the policy, after-tax income of households whose before-tax earnings are greater than z^* should follow the tax schedule represented as line B in the graph ($Y = z^* + (1-t)(z - z^*)\mathbb{1}\{z > z^*\}$). Conditional on tax evasion behavior, the actual after-tax income stays along the line A ($Y = z$) as households under-report their income to be $z' = z^*$. After the policy enactment, the new budget set becomes $Y = z^* + (1-t)(z - z^*)\mathbb{1}\{z > z^*\} - (\pi_o + \pi_1 t b_i) \cdot \mathbb{1}\{b_i > 0\}$ (Equation (A.0.5)), which is represented as line C. The policy introduces a discrete shift in the budget set at z^* for tax-evading households due to the flat fee component of the tax penalty (π_0 in Equation (A.0.3)). The slope of the after-policy budget above the threshold z^* (line C) is flatter than the slope of the full tax schedule (line B) because of the tax penalty proportional to the avoided tax amount (π_1 in Equation (A.0.3)).

These shifts in the income schedule introduced by the policy explain why some households are willing to make extra purchases with cash or to even dispose cash as news articles report. After the policy is enforced, because of the higher full tax as well as the penalty associated with previous tax evasion, there is a region of before-tax income $[z^*, z^I)$ that is strictly dominated by z^*. In other words, within $[z^*, z^I)$, pre-tax income greater than z^* gives a lower after-tax income than z^* does. This results in behavioral responses among certain households to lower the income to be z^* via strategic purchases (Figure 1(b)). The region of before-tax income that is dominated by z^* increases as the flat fee component and the linear rate of tax evasion penalty becomes higher (i.e., as line C in Figure 1(a) shifts down and becomes flatter with higher π_0 and π_1).

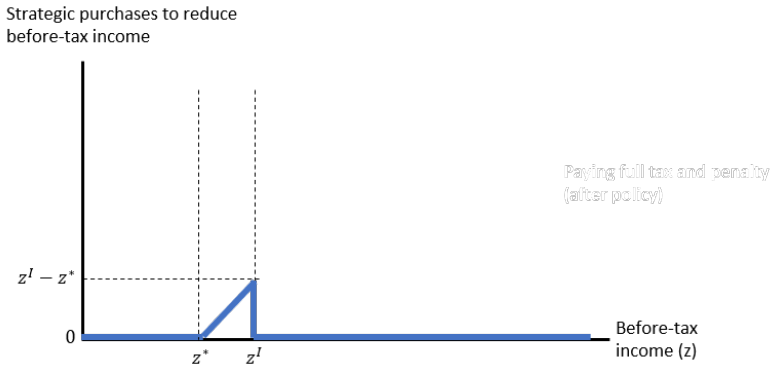
Note that $u_i^{IncPurchase}$ in Equation (A.0.7) assumes that that 1) the products purchased do not provide any consumption utility, and 2) they cannot be resold in the second-hand market. These assumptions make purchase activities similar to cash discarding, which provides the lower bound of the utility from strategic purchases.

Incremental purchases in response to the policy can be larger when reselling purchased items is allowed. Suppose that households can resell the purchased items C_i in the second-hand market at a discounted price, θC_i, where $0 < \theta < 1$. Then, household i's utility from strategic purchases and

[2] We closely follow an illustrative graph in Kleven & Waseem (2013) to demonstrate our context.



(a) Budget sets



(b) Strategic purchases as a function of earnings in cash

Figure 1: Strategic incremental purchases to the demonetization policy, when reselling in the second-hand market is not allowed

reselling becomes

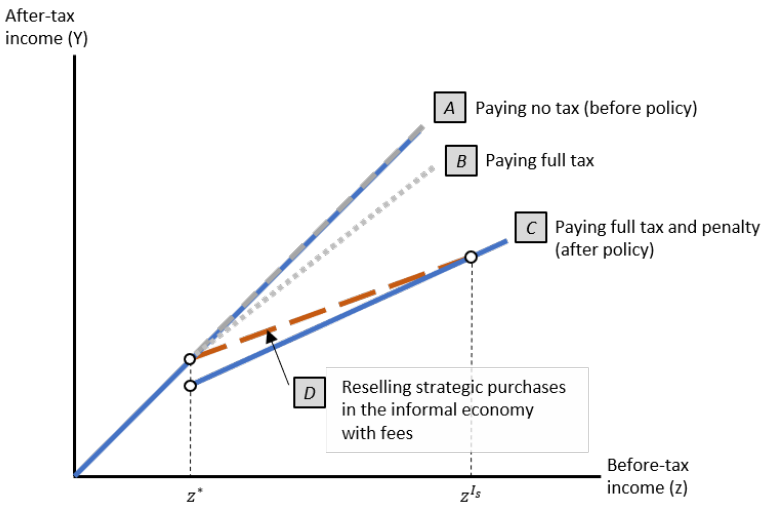
$$u_i^{IncPurchase'} = U\left(z_i \underbrace{-C_i + \theta C_i}_{\substack{\text{Part of value} \\ \text{recouped} \\ \text{via reselling}}} + \underbrace{T(z_i - C_i)}_{\text{Savings in tax}} - \underbrace{(\pi_0 + \pi_1 t(b_i - C_i)) \cdot \mathbb{1}\{b_i - C_i > 0\}}_{\text{Savings in penalty}} - \underbrace{D \cdot \mathbb{1}\{z_i - C_i > 0\}}_{\text{Savings in depositing cost}} \right) \tag{A.0.8}$$

$$\geq u_i^{Post} = U\left(z_i - T(z_i) - (\pi_0 + \pi_1 t b_i) \cdot \mathbb{1}\{b_i > 0\} - D \cdot \mathbb{1}\{z_i > 0\}\right)$$
$$\text{if} \quad (1-\theta)C_i \leq T(z_i) - T(z_i - C_i) + \pi_1 C_i \mathbb{1}\{b_i > 0\} + D_i \mathbb{1}\{z_i - C_i \leq 0\}.$$

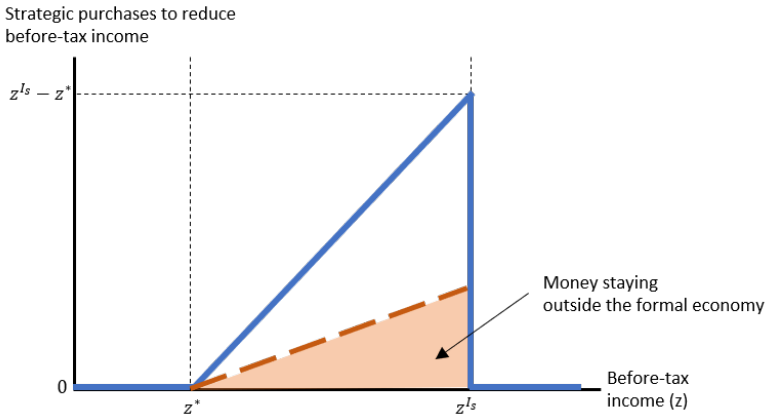
The model predicts that the amount of strategic purchases would be larger with the second-hand market, as C_i that equates the last inequality in Equation (A.0.8) is larger than C_i that makes the last inequality in Equation (A.0.7) binding. Also, the amount of money saved from reselling (θC_i) still avoids the tax network, given that most transactions in the second-hand market are not recorded in any taxable accounts.

Figure 2 shows how reselling can promote more behavioral responses to the policy. An option of reselling a purchased item at a lower price introduces a new segment of budget set, which is represented as line D in Figure 2(a). It allows households to replace the tax and penalty with the costs associated with reselling the products. If we assume that the reselling cost θC_i outweighs the savings in tax and penalty above certain income level (z^{I_s} in Figure 2(a)), then any household that belongs to $[z^*, z^{I_s})$ would be willing to make strategic purchases and resell the items to recoup part of the money (Figure 2(b)). Furthermore, as illustrated above, money used in such transactions remains still off the official tax radar as reselling occurs in the informal economy. Therefore, strategic purchase expansion conflicts with one of the major goals of the demonetization policy.

3) Accelerated final purchases Households without any tax evasion still have incentives to make intertemporal substitution and save on the costs of visiting banks to deposit cash. Suppose that household i plans to purchase a good that costs c_i in the near future. If the household has cash in the notes that are to be demonetized, they can accelerate their purchase to be on the day of announcement, pay with the soon-to-be-demonetized notes, and save on the cost of depositing them:



(a) Budget sets



(b) Strategic purchases as a function of earnings in cash

Figure 2: Strategic incremental purchases in response to the demonetization policy, when reselling in the second-hand market is allowed

$$u_i^{AccPurchase} = U\left(z_i - c_i - T(z_i - c_i) - \underbrace{D \cdot \mathbb{1}\{z_i - c_i > 0\}}_{\text{Savings in depositing cost}}\right) \tag{A.0.9}$$

$$\geq u_i^{Post} = U\left(z_i - \underbrace{(1-\delta_i)c_i}_{\substack{\text{Discounted} \\ \text{future planned purchases}}} - T(z_i - c_i) - D \cdot \mathbb{1}\{z_i > 0\}\right)$$

$$\text{if} \quad b_i = 0 \quad \text{and} \quad \delta_i c_i \leq D \cdot \mathbb{1}\{z_i - c_i \leq 0\}.$$

δ_i is a discount factor, which is an increasing function of how far in the future the original planned purchase is.[3] This case deviates from the case of purchase expansion (Inequalites (A.0.6), (A.0.7), and (A.0.8)) in two ways. First, the tax penalty is zero because the case applies to a set of households whose tax evasion is zero. Second, the only difference between the utility with and without accelerated purchases is the savings in depositing cost. Other components remain the same because c_i is planned to be purchased regardless of the policy enactment.

The inequalities imply that households are willing to accelerate their purchases as long as the cost of intertemporal substitution ($\delta_i c_i$) is smaller than the savings from the depositing cost (D_i). For the condition to be met, households should be able to use up the entire cash holdings via accelerated purchases ($z_i - c_i = 0$), as the depositing cost becomes zero only when there is no cash holdings left to be deposited. Also, the discount factor should be small enough to be outweighed by the benefit from not depositing the banned bills, which limits the degree of purchase acceleration.

4) Strategic choices of payment method (switching to cash) Finally, households originally planning to make purchases on the day of announcement can switch to cash from other payment methods to use the cash notes that are about to be demonetized. Here, there is no intertemporal substitution as the purchase is originally planned to take place on the day of announcement, which removes the discount factor δ_i from the post-utility function (u_i^{Post} in Equation (A.0.9)).

$$u_i^{Switching} = U\left(z_i - c_i - T(z_i - c_i) - \underbrace{D \cdot \mathbb{1}\{z_i - c_i > 0\}}_{\text{Savings in depositing cost}}\right) \tag{A.0.10}$$

$$\geq u_i^{Post} = U\left(z_i - c_i - T(z_i - c_i) - D \cdot \mathbb{1}\{z_i > 0\}\right)$$

$$\text{if} \quad b_i = 0 \quad \text{and} \quad c_i \leq D \cdot \mathbb{1}\{z_i - c_i \leq 0\}.$$

[3] We do not put the discount factor in the tax function as we assume that the tax is collected on a regular basis at a fixed time schedule for all individuals. In other words, we assume that the tax function incorporates a fixed discount factor that is the same for every household.

Given these types of households responses to the policy, the retailer's profit can be expressed as follows:

$$\Pi_s = \Pi_s^0 + \underbrace{q(\sum_i C_i) - r(\sum_i R_i) - a(\sum_i c_i)}_{=\Delta\Pi_s} \tag{A.0.11}$$

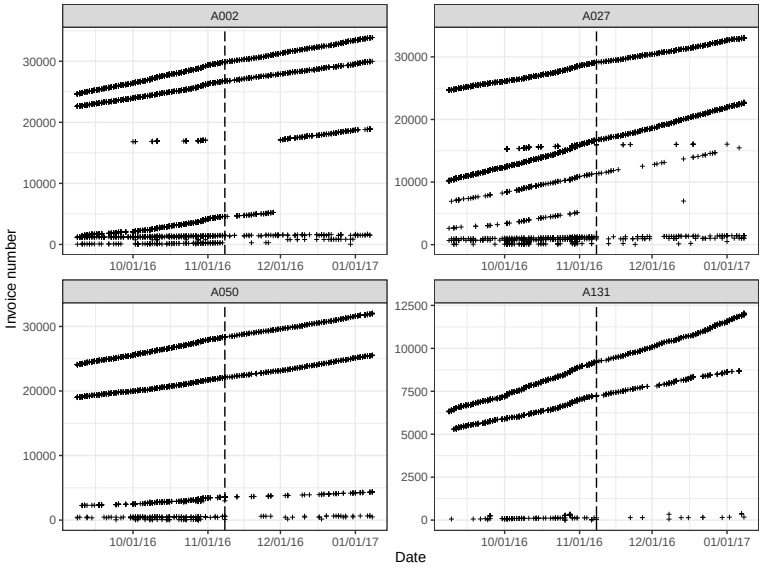
where Π_s is the profit of store s under the policy, Π_s^0 is the counterfactual profit when there is no policy, and $\Delta\Pi_s$ is the change in profit due to the policy. $q(\cdot)$ is a function that maps total incremental final purchases ($\sum_i C_i$) to profit. $r(\cdot)$ is the cost function associated with total incremental returns ($\sum_i R_i$), and $a(\cdot)$ captures any potential costs due to high volume of purchase acceleration (e.g., stockouts, customer management). Throughout our analysis, we assume that $a(\cdot)$ is zero.

A.2 Evidence against significant measurement errors

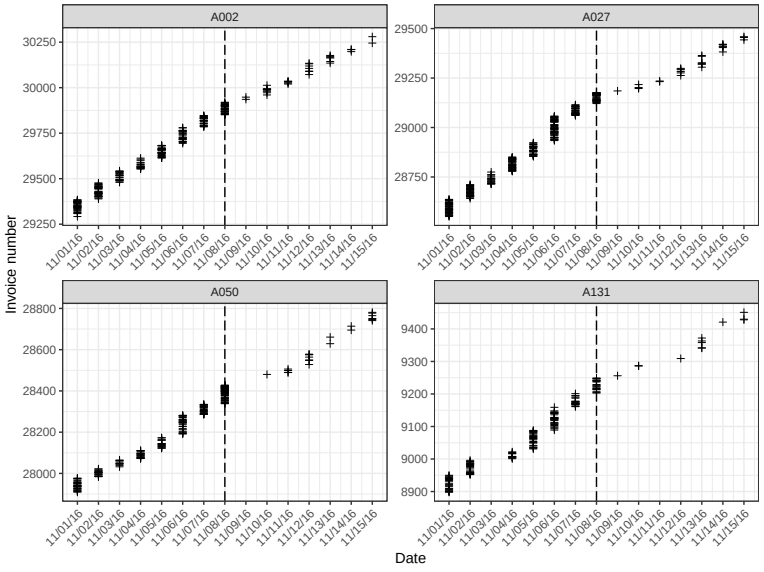
A.2.1 Minimal impact of back-dated invoices

We provide evidence from the data that back-dated receipts did not take a major portion of the observed transactions on the date of announcement in this particular empirical context. The data provider is one of the largest national retail chains for durable goods in India, and each store has minimal room for flexible changes in customer policies. In particular, unlike the owners of small retail shops, cashiers or managers of the chain's store branches do not have access to manipulate or change the transaction records in the system, which makes the issuance of back-dated receipts extremely challenging. To further confirm this anecdotal evidence, we check the receipt numbers recorded for all the transactions and see if the *sequence* of the invoice numbers changes in a non-ascending way after the policy announcement. Our hypothesis is that, if there were a significant number of back-dated receipts issued by the stores, we should see the receipt numbers out of order around the time of demonetization, as the receipt numbers are automatically generated by the system based on time stamps. Figure 3 shows sequences of system-generated invoice numbers for a sample set of stores. We confirm that all stores do have ascending receipt numbers before and after the policy announcement including the selected sample stores, which are reported to have a significant amount of strategic transactions in our empirical results. As seen in Figure 3, there exist multiple sequences of invoice numbers that start with different alphabets and/or serial numbers for each store, and one might raise concerns that a separate series was created for backdated purchases. To rule out this hypothetical scenario, we analyze all series numbers and we find no such series number which started on the day of announcement. News article search also reveals that the data provider was not accused of any backdating practices while media extensively covered those

incidences whenever they happened at a large scale or at a single national chain. [4]



(a) All invoice sequences



(b) Zoom-in to a one particular sequence

Figure 3: Sequences of system-generated invoice numbers for cash purchases, by sample stores

[4] "Lens on jewellers who sold gold bars and showed back-dated entry," The Times of India, December 16, 2016
"ED files charge sheet in demonetisation case against Hyderabad dealer," Business Standard, June 1, 2021
"Demonetisation: Old money can still buy you hairdos and spa sessions," The Economic Times, November 16, 2016.

A.2.2 Substantial increase in cash purchases at grocery stores immediately after the announcement

First, we check whether we find similar spikes in strategic purchases in other categories, namely grocery items. Given the nature of the category, we do not expect to see much strategic returns in this supplementary data set. However, we hypothesize that, if a significant amount of strategic purchases indeed happened before midnight after the announcement, a drastic increase in cash purchases would be observed after the announcement in grocery stores as well. The supplementary data set is from one of the five largest supermarket chains in India, which records transactions in six stores spread over four major cities of India — Bangalore, Delhi, Hyderabad and Indore - from August 2016 to December 2016. Unlike the main data set, it has a more detailed time stamp on every transaction, which allows us to see purchase patterns on an hourly basis.

Figure 4 shows hourly cash purchases of grocery items in different stores on the day of announcement. Red lines denote hourly cash purchases on the day of announcement in those cities with high estimated strategic transactions in our main analysis (see Figure 5 for comparison with the results from the main data set). Black solid lines represent the same for those cities with low estimated strategic transactions. Dashed vertical line marks 8:00 PM when the announcement was made. As the announcement took place on Tuesday, we also plot hourly transaction data in other Tuesdays from August to December as benchmarks (plotted in gray). Confirming our hypothesis, cash purchases in grocery stores do increase after the announcement in those cities with high estimated strategic transactions according to the main data set.[5] This further supports our findings that many consumers reacted immediately after the announcement to use their soon-to-be-demonetized cash notes.

A.2.3 Institutional details

Several institutional details make rush transactions within 4-hour window more plausible. Most large cities in India are small enough so that anyone can reach from one end to the other end within an hour.[6] Also, like in stores in the U.S., stores cannot force customers to leave at the closing hour if customers succeed in stepping into the store before it closes. Figure 4 gives suggestive evidence of this behavior; 4 stores out of 6 - Delhi 1, Delhi 2, Hyderabad 2, and Indore - record positive amount of transactions even after their usual closing hours (10:00 pm).

[5] An observed spike between 3 PM and 4 PM in Delhi 1 store is because of local farmers market happening regularly, which is implied by multiple gray lines that have similar peaks.

[6] Travel Time Report Q1 2019 vs Q1 2018, MoveInSync.

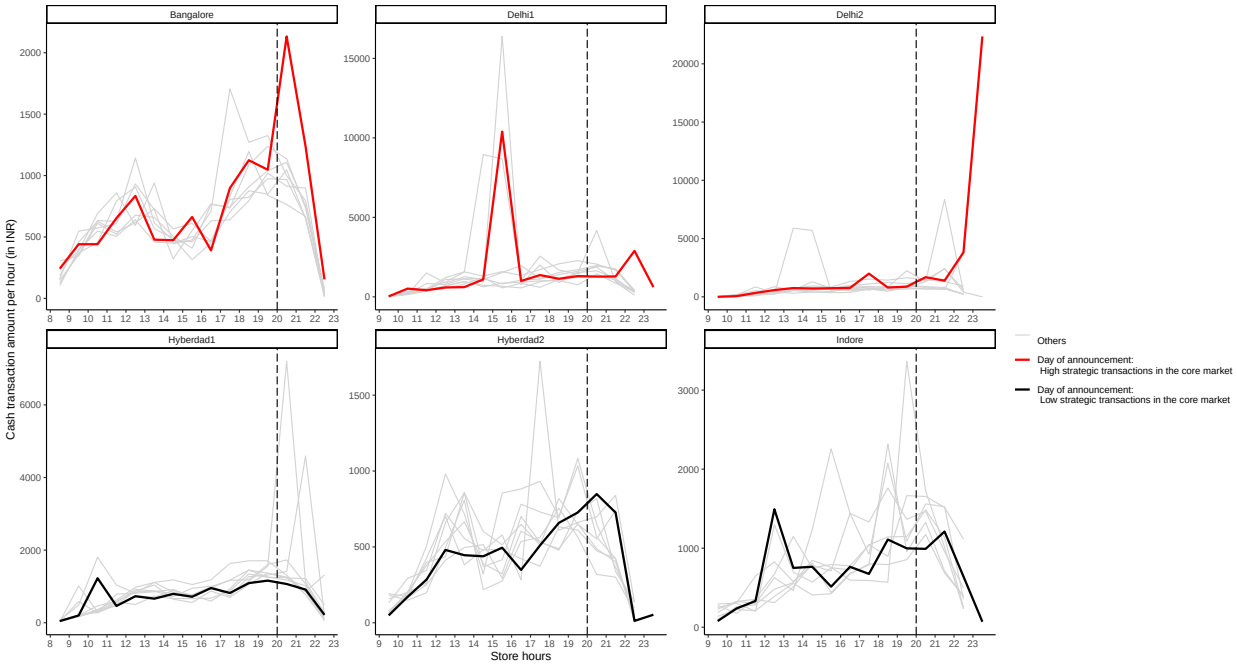


Figure 4: Supplementary data analysis: Cash purchases in grocery stores

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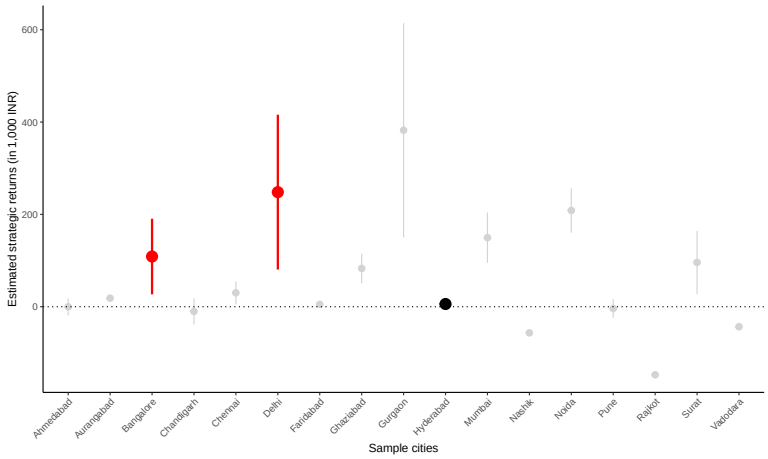
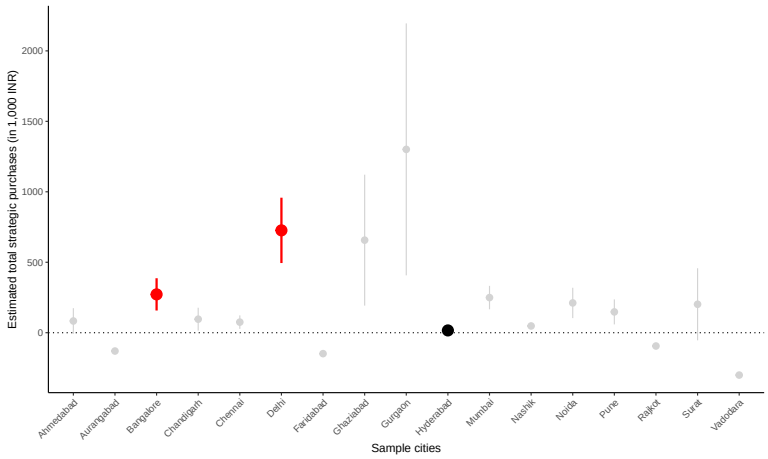


(a) Estimated strategic returns in the main data set, by cities



(b) Estimated strategic purchases in the main data set, by cities

Figure 5: Main data analysis: Estimated strategic transactions by cities

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