Nudging Consumers towards Card Payments:
A Field Experiment

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PRELIMINARY RESULTS, PLEASE DO NOT CITE WITHOUT CONTACTING AUTHORS

ABSTRACT

We investigate the impact of soft interventions – so-called nudges – on the way consumers pay at the point of sale. In particular, we set up an experiment in a university canteen frequented by both students and university personnel. In an attempt to steer consumers towards card payments, we administered two temporary interventions. In a first stage, posters with pro-card slogans appealing on customers' sense of loyalty and connection with their alma mater were mounted on the cash registers. After five weeks cashiers were instructed to also explicitly point out that payment by card would be appreciated. As hypothesized, Chow tests reveal a very significant break in payment patterns at the start of the experiment, for both students and personnel. However, on closer scrutiny the results for students are inconclusive because of the spring break (when fewer students are on campus). Employees, for their part, appear to have increased their use of cards by 6.07 percent because of the posters. The effect of the oral prompts is uncertain, as the combined effect of posters and prompts is smaller than the effect of the posters alone. Finally, our interventions apparently did not generate a lasting impact. For students post-experiment card usage is never significantly different from the forecast. For employees, card usage is still significantly higher in the first week after the removal of the posters, but this effect disappears in the second week.

JEL classification: D12, E41; C51

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1. INTRODUCTION

In recent years, interest in behavioral economics has been growing. Studying the influence of feelings, motives and attitudes on economic decisions is an increasingly popular topic among behavioral economists and economic psychologists (Kirchler and Hoelzl, 2011). Angner and Loewenstein (2012, p. 642) define behavioral economics as *"the attempt to increase the explanatory and predictive power of economic theory by providing it with more psychologically plausible foundations"*. One field of economics that would stand to benefit from such foundations is payments economics, the study of payment systems, and in particular those studies that look into the determinants of the adoption and usage of payment instruments. A better understanding of these determinants would help social planners, payment system providers as well as merchants in their attempts to steer consumers in the direction of more efficient payment instruments.

A potentially promising tool for such steering are so-called nudges, as popularized by Thaler and Sunstein (2008). Nudges, also called soft interventions, do not radically change the pecuniary incentives or the choice architecture – the context in which people make decisions – but rather harness unobtrusive influences on their choice behavior. As documented by Thaler and Sunstein, 'choice architects' are present in many decisions in our life: decisions about medical treatments, health care plans, education programs and even the meals we order in a restaurant. Rearranging the dessert bar in a school canteen by putting the healthy desserts at eye level is an example of trying to nudge people towards a healthier diet. By contrast, hard interventions alter people's pecuniary incentives or even simply block certain choices. In a payments context, examples of hard interventions are the surcharges that merchants sometimes apply when customers want to pay small amounts by card (Jonker, 2011) or card-only lanes in supermarkets.

In this paper we analyze payment behavior in a university canteen frequented by both students and personnel. In the canteen we set up an experiment to test two soft interventions. With our nudges we wanted to influence customers' payment choice at the checkout and, in particular, steer them away from cash, towards payment cards. In a first step we used small posters containing a pro-card slogan that was meant to harness social norms in general and appeal to customers' connection with the university in particular. Specifically, the message stated that for security reasons the university preferred card payments. The posters were placed in a

visible spot at all cash registers. In a second step, cashiers were asked to also explicitly point out to customers that payment by card would be appreciated.

We evaluated the impact of our interventions by means of a post-experiment survey but also, and primarily, by means of time series analysis. Specifically, based on pre-experiment data we estimated ARIMA forecasts and compared the forecasted level of card usage – that is, without the interventions – with observed payment behavior during as well as after the experiment.

Overall, we find that, at least for university personnel, the experiment initially effectively accelerated the structural decline in cash payments that was already present, but that this effect did not last. During phase 1 – the phase with only the posters – employees' card usage increased by 6.07 percent. Whether the second intervention, the oral prompts by the cashiers, generated a separate, additional effect could not be substantiated with our data. Finally, our interventions unfortunately did not have a sustained impact. For students there is apparently no post-experiment effect at all. Employees, for their part, still used cards more often during the first week of the post-experiment period but this effect vanished during the second week.

The structure of the remainder of this paper is as follows: in the next section we present a literature review on payment behavior in general and interventions in particular. In section 3 we explain the experiment setup. In section 4 we present the data and our evaluation methods. Section 5 presents and discusses the results. Section 6 concludes.

2. LITERATURE REVIEW

What is it that determines consumers' choice of payment instruments? Can we influence this behavior? And, if so, how can we steer consumers towards cost-efficient instruments? Researchers in various countries have already investigated (some of) these questions, and have done so in several ways. We distinguish two main groups of contributions, but the reader should be aware that some fall in both categories[2]. The first group of papers either describes and analyzes the use of one specific payment instrument or studies the influence of certain characteristics on consumers' payment choice. These characteristics are typically of two types: characteristics of the transaction itself and consumers' socio-demographic identities. The second group of contributions attempts to

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[2] For alternative classifications, see Bounie and François (2006) or Bolt, Jonker and van Renselaar (2008).

analyze the effects of price and cost mechanisms on the adoption or use of payment instruments, typically in combination with socio-demographic characteristics.

To start with the first group, the use of cash as a means of payment has of old been the subject of many a study. The rise of payment cards and their impact on cash usage has kept studies on payment patterns popular. Recent examples, mainly based on household survey data, are Bagnall and Flood (2011) for Australia, Jacobsen and Nielsen (2011) for Denmark, Segendorf and Jansson (2012a) for Sweden, Jonker, Kosse and Hernández (2012) for the Netherlands, and Arango, Hogg and Lee (2012) for Canada[3]. The main conclusion of these studies is that there is a negative correlation between average transaction value and the incidence of cash payments. Indeed, for low-value payments consumers still prefer cash. As a result, in most countries mentioned earlier – with the exception of Denmark and Sweden – cash still dominates when it comes to the number of transactions. In terms of value, debit card payments account for the largest share. Also, in all countries the average amount paid by debit card exceeds the average amount of cash transactions, again illustrating consumers' preference to pay low-value amounts in cash (Jacobsen and Nielsen, 2011; Jonker et al., 2012). This is not to say that there are no inter-country differences. In the Netherlands, for example, the share of cash payments for transactions below 5 EUR is much lower compared to Canada, France and Germany, suggesting more card-oriented payment behavior in the Netherlands, even for low-value transactions (Arango et al., 2014).

Still in the first group of contributions, other empirical studies show that both transaction characteristics and socio-demographic attributes affect consumer payment behavior. To start with the latter, age consistently has a significant impact on the choice between cash and card payments. Using Swedish data for 2006, Bergman, Guibourg and Segendorf (2007) find that card usage increases with age. However, evidence for other countries indicates that this effect is not necessarily linear. Bagnall and Flood (2011) ascertain that in Australia not only older but also younger age groups use cash more often than the age group between 30 and 50 years. In the same line, Dutch data show that younger consumers between the age of 15 and 24 are the heaviest cash users, even more so than those over 65 (Jonker, 2007). For Canada, Arango et al. (2012) find no significant difference in cash usage between individuals in the 35-55 age group and those younger than 35. Besides age, other demographic factors that almost

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[3] For an overview and an international comparison of the findings of these country-specific studies, see Jonker et al. (2012) and Arango et al. (2014).

consistently prove to significantly correlate with payment choice are income, marital status, education, gender and degree of urbanization (Arango et al., 2012; Bergman et al., 2007; Jonker et al., 2012; Jonker, 2007; Klee, 2008).

Continuing our overview of the first group of contributions, other transaction characteristics than size matter too. Hayashi and Klee (2003) find, in a study for the US, that cashier presence and self-service are also significant factors in consumers' payment choice. Bounie and François (2006) study, with French data, the effect of type of good, spending place, type of contact, day of the week and constraints at the supply side (acceptance by merchants). With the exception of day of the week, all other characteristics have a significant influence on payment choice.

Apart from socio-demographic factors and transaction characteristics, consumers' perceptions or attitudes also help to understand their payment behavior. Not all consumers perceive and value a given characteristic of a payment instrument similarly, and perceptions can be very subjective, emotional even (Schuh and Stavins, 2010). Jonker (2007) studies, for the Netherlands, the effect of perceived safety, perceived speed, perceived cost and perceived ease of use. In a study on Canada, Arango and Taylor (2009) focus on convenience and risk, but also acknowledge other factors such as acceptance, speed, security, access to funds, fees and rewards, record keeping and budgeting control. Schuh and Stavins (2010) use US data and investigate a selection of seven payment characteristics: cost, convenience, safety, privacy, accuracy, timing and record keeping. Kosse (2013) studies the impact of perceived safety on cash and debit card usage in the Netherlands. Finally, Teoh et al. (2013) concentrate on the effect of self-efficacy, trust, security, benefits and ease of use on Malaysian consumers' perception towards electronic payment means.

The second group of contributions in the field of consumer payment behavior seeks to analyze the effect of price and cost mechanisms on the adoption or use of payment instruments. One way to measure the efficiency of a payment system is in terms of social costs[4]. Schmiedel et al. (2012, p. 6) define social costs as "*the costs to society, reflecting the use of resources in the production of payment services; that is, the total cost of production excluding payments made to other participants in the payment chain*". The ratio between the social cost of a given payment instrument and GDP exhibits country- and sector-specific

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[4] For further reading on costs of payment methods, see Garcia-Swartz, Hahn and Layne-Farrar (2006a, 2006b) and Shampine (2007, 2012).

differences, see Brits and Winder (2005); NBB (2005), Bergman et al. (2007); Bolt, Jonker and van Renselaar (2008); Jacobsen and Pedersen (2012); Segendorf and Jansson (2012b) and Schmiedel et al. (2012). Obviously, in practice, merchants' and consumers' choice for a payment means is determined not by social costs but the private costs of alternative payment instruments (Bergman et al., 2007).

Besides cost calculations, the literature has also examined the impact of pricing. The paper by Bolt, Humphrey and Uittenbogaard (2008) is a major contribution. It compares, in a two-country model, pricing and non-price effects on the usage of electronic means of payment over the period 1990-2004. The paper focuses on Norway and the Netherlands because in Norway consumers face direct, per-transaction fees, whereas this is not the case in the Netherlands. Bolt et al. find that transaction-based pricing clearly accelerated the shift towards electronic payment instruments in Norway: the relative rise of debit card use from price and non-price effects is estimated at 10.4 percentage points, with one fifth of this rise reportedly caused by pricing. In the US, Borzekowski, Kiser and Ahmed (2008) study the effect of fees charged for PIN-based debit card transactions. Predictably, the fees steered consumers towards signature debit cards or even dissuaded them from using debit cards at all. Bolt, Jonker and van Renselaar (2010) conduct a similar study with Dutch data and conclude that retailers who surcharge can expect a significantly lower share of debit card payments than those who do not surcharge. They also estimate, with an ordered probit model, that removing debit card surcharges would lead to more debit card payments and reduce the use of cash. Briglevics and Shy (2012), for their part, study not so much card surcharges but rather price discounts for paying by debit card instead of credit card, and for paying in cash instead of by debit card. They find that price discounts steer consumers' payment choice towards the merchant's preferred - least costly - payment means, which results in profit enhancements. However, Briglevics and Shy cannot ascertain whether the latter outweigh the cost of administering the price discounts. Finally, papers that deal specifically with loyalty rewards confirm that participation in loyalty programs increases credit card use at the expense of other payment instruments (Ching and Hayashi, 2010; Simon, Smith and West, 2010).

Somewhere in between these two main groups of studies, we place the papers by Leenheer, Elsen and Pieters (2012) and van der Horst and Matthijsen (2013). Leenheer et al. address the questions which factors influence consumers' payment choice and which interventions could

alter it. In terms of methodology, they mainly use the LISS panel[5] to conduct both a survey and experiments, next to controlled lab experiments with students. Overall, Leenheer et al. conclude that payment behavior is influenced by three factors: perception and attitudes, wallet content, and habits. In their research set-up, several hard and soft interventions prove effective, but the impact varies depending on the user segment. For instance, prompts (small messages at the checkout with variants of the slogan "use cards please") are effective for users who chose their payment instrument based on the sector and the value of the transaction, but not for persistent cash users. Van der Horst and Matthijsen (2013) conjecture that payment choice is fundamentally based on habits and therefore cannot easily be manipulated. They opt for a virtual-reality and a neuroscientific study with a representative Dutch panel and find that actively promoting card usage by means of posters increases the likelihood that respondents pay by card, while surcharges steer them towards cash payments.

Transaction-based pricing, price discounts, and loyalty rewards are all examples of interventions. Since the goal of these interventions is to directly affect consumers' payment decisions, we call them hard interventions – as explained in the introduction. Unlike hard interventions, soft interventions – nudges – rule out any price or cost influence. The original definition of nudging in fact excludes the use of choice constraints as well as alterations to agents' economic incentives (Marteau et al., 2011). Nudges 'simply' try to affect the choice architecture, the context in which decisions are made, without limiting the choices or directly inducing changes.

Thaler and Sunstein (2008) provide examples of several nudging mechanisms, such as group conformity, the spotlight effect, and social influence. We only elaborate on social influence because it was the inspiration for our interventions in the university canteen; see section 3. Thaler and Sunstein identify three categories of social influence. The first category of nudging by social influence is through providing information. Knowing what other people do, what other people decide or think has an impact on our own decisions. Second, this information effect can be combined with peer pressure. Such nudges have already been used in environmental, societal and health matters. Examples are smart energy meters, consumption data sharing at community level, posters with sales figures of condom packages in Zambia, and manipulations of shelf layout and adjustments of the default fries portion in canteens

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[5] The Longitudinal Internet Studies for the Social sciences (LISS) is a large panel, representative for Dutch society.

(Abdukadirov and Marlow, 2012; Allcott and Mullainathan, 2010; Allcott, 2011; Ashraf, 2013; Giesen et al., 2013; Rice, 2013; Torriti, 2012; van Kleef, Otten and van Trijp, 2012). A third way of nudging people's behavior is via priming. Priming involves a triggering signal in our brain that gives us impulses towards a certain outcome without even consciously experiencing the nudge. For example, participants in a survey concerning their consumption of a specific food product tend to shift their consumption upwards (Kahneman, 2011; Thaler and Sunstein, 2008).

With the nudge theory in mind, several techniques for behavioral change can be applied. Seymour and Vlaev (2012) distinguish six types: incentives, mapping choices, defaults, feedback, error expectation, and structuring complex choices. Van Oorschot et al. (2013) add anchors, framing, required choosing and reminders to the list. Leenheer et al. (2012) divide their interventions based on the timing (antecedent or consequent interventions) and subtleness (structural or information interventions).

To sum up, payment patterns and in particular the shift from cash to card payments have been the subject of many a study. Yet, empirical papers that study the effect of nudges on payment patterns are rare. The contributions of Leenheer et al. (2012) and van der Horst and Matthijsen (2013) come close to what we do, but are not based on real-life data, only on experimental and survey data. With our paper we intend to contribute to filling this gap in the literature with data retrieved from a real-life field experiment.

3. EXPERIMENTAL DESIGN

Our experiment took place between March and May 2013 in the canteen on campus Etterbeek of the Vrije Universiteit Brussel (VUB)[6]. On an average day, the canteen has some 1,700 customers. While there are some external visitors among the clientele, the canteen is mainly frequented by students and university staff (see section 5). As explained in the Introduction, the purpose of the experiment was to steer customers towards card payments – the management of the canteen being of the opinion that this would lower their back office costs.

The canteen is designed as a 'free flow' restaurant. A customer takes a tray, selects his own menu from different 'bars' and then goes to the checkout. A complete menu consists of soup, a main dish, a dessert and an additional plate of either rice, frites, or (mashed) potatoes. The

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[6] The VUB has two student campuses: one is campus Etterbeek (for Human Sciences and Exact Sciences), the second is campus Jette (for Medical, Pharmaceutical and Biomedical Sciences).

restaurant has several main dishes: pasta, wok, vegetarian, grill, two menus of the day and a light menu. The menus vary depending on the season, but each type of menu has a fixed place. For a full ground plan of the canteen, see appendix 1. There are six counters, which are placed in parallel two by two. One couple is immediately adjacent to the dessert bar; the four other counters are across. Counter 6 is only open at peak times and accounts for less than 1% of total turnover. We therefore excluded it from the experiment.

The particular design of the canteen limited the possible interventions and their implementation. Customers will typically not go to the same bar every day and can also switch between the five checkouts, so working with control groups (for example, vegetarians or users of specific checkouts) was impossible. We therefore decided to opt for a different approach and implement the interventions in such a way that they were clearly visible to all patrons. We thus looked for spots where all customers have to pass, and since the objective of the experiment was to influence the choice of payment means, the checkouts seemed an obvious choice.

The payment instruments accepted in the restaurant are cash, meal vouchers, the Proton e-purse, and the Belgian debit card, which is called Bancontact/Mister Cash[7]. The restaurant does not accept Maestro or credit cards. Also, debit cards are only accepted since June 2012. At the time of our analysis – and in particular in the pre-experiment period – they were thus still a relatively new phenomenon and, as we will show in section 4, their relative importance gradually increased over time.

Figure 1
Timeline of experiment

| pre-experiment *18 weeks* | phase 1 *5 weeks* | phase 2 *2 weeks* | phase 3 *1 week* | post-experiment *2 weeks* |
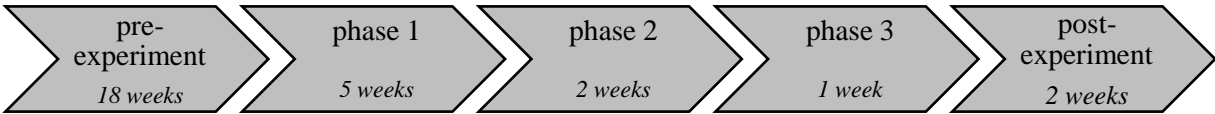
Source: own figure

As for timing, we decided to gradually build up the experiment, in five stages spread over 28 weeks; see Figure 1. We obviously first needed to observe the patterns in payment behavior without any interventions. The pre-experiment period consisted of the first semester

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[7] The canteen also accepts payments by PingPing. PingPing is a mobile payment instrument for payments up to 25 EUR. More information about PingPing is available on their website http://www.pingping.be/wp/. The use of PingPing in the canteen is nearly zero and not even considered in the dataset. It is therefore not included in any of our calculations.

of the academic year 2012-2013 – the first semester after the introduction of debit card terminal – and lasted 18 weeks. The experiment itself consisted of three phases spread over 8 weeks. After the discontinuation of the interventions, we continued to observe the payment patterns for another two weeks (post-experiment). This is a relatively short period but the end of the academic year was approaching, and once classes are over the number of students on campus drops dramatically, thus altering the composition of the clientele of the canteen.

For the actual experiment we decided to try out two interventions, following the example of Leenheer et al. (2012). In phase 1, we attached small posters with a pro-card slogan on the cash registers of all five checkouts. In phase 2, we added an intervention: cashiers of checkouts 1 and 2 were asked to also explicitly point out to customers that card payments would be appreciated. In phase 3, cashiers did not intervene any longer but the posters remained in place.

Figure 2
Five messages evaluated in the pre-experiment survey

A	Paying by card is faster. The canteen of the university prefers card payment. You too?
B	Less cash = safer for the VUB[8]. Payment by card preferred.
C	Cash is expensive. Pay by card and help us save money at the university.
D	The people behind you don't like waiting. Card payments are faster.
E	Looking for coins? Follow the trend. Pull out your card!

In order to select the exact content of the message on the posters, we set up a pre-experiment survey. Specifically, we wanted to select a clear, informative message that was perceived as steering but that also appealed to customers' connection to the university. In order not to run the risk of influencing the results of the experiment itself, we did not conduct the survey on the Etterbeek campus. Rather we distributed questionnaires among students and employees at the University of Antwerp (90 respondents) and at the campus Jette of the VUB (48 respondents). The respondents were presented with five potential nudge messages, all containing at least one category of social influence as described by Thaler and Sunstein (2008); see Figure 2. The idea was also to try to reinforce the informative component of the message by peer pressure. Specifically, the messages highlighted a number of advantages of

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[8] For the respondents at the University of Antwerp (UA), VUB was replaced by UA.

card payments: speed, safety, costs, and convenience. In addition, most slogans attempted to evoke a sense of loyalty or connection of the reader towards his or her university.

In the survey, respondents were asked, among other things, if the messages were clear, understandable, and 'steering', and whether they had seen similar messages in real life. At the end of the survey, respondents also had to express their general preference by ranking the messages and were also asked to rank the messages according to the level of connection they felt after reading them. The idea was then that the message that scored highest in the rankings would be selected for the experiment, on condition that it obtained a score of 90% or more for clarity and comprehension[9].

In both universities message B had the highest score in both rankings (thus obliterating the need to weight them)[10]. In addition, the scores for clarity and comprehension exceeded our self-imposed threshold, and 81% of the respondents perceived the message as steering or very steering. Message B was therefore selected for the experiment. Another interesting finding of the pre-experiment survey is that, on average, only one fifth of the respondents had already seen similar messages in real life. The use of posters at the cash register is not very established in Belgium, certainly not compared to the Netherlands, where the SBEB[11] actively campaigns for debit card payments with a variety of slogans.

To conclude the description of the set-up of our experiment, let us explain how our interventions fit into the typologies of nudges listed in the literature review. The use of posters relies on the mapping technique as described by Seymour and Vlaev (2012). The slogan that we selected emphasizes a specific characteristic of card payments, namely their safety for merchants and for society in general. By providing this information, the posters try to map customers' choice towards the preferred payment means of the canteen management: cards. The second intervention – the oral prompts – could be pigeonholed in van Oorschot et al.'s (2013) category of reminders: the cashiers restate the preference for card payments already signaled by the posters. Crucially, both interventions also try to harness social norms. The

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[9] All respondents had to answer the same questions but in order to avoid answering biases we shuffled the order of the options and used five different versions of the survey. We conducted a Kruskal-Wallis one-way ANOVA test to test for group dependency by survey version and university. The results showed that the version of the survey did not significantly influence the results.

[10] For the complete sample, Kendall's tau-b rank correlation coefficient between general preference and level of connection amounted to 0.44.

[11] SBEB stands for Stichting Bevorderen Efficiënt Betalen - translated literally: Foundation for the Promotion of Efficiency in Payments. For information on SBEB, see http://www.efficientbetalen.nl/.

first part of the slogan (*"Less cash = safer for the VUB."*) states that cards are safer. It embodies a descriptive norm – how things are, rather than how things ought to be. The second part of the slogan (*"Payment by card preferred."*) and the oral prompts both explicitly encourage customers to pay by card. Here the focus is on how customers *should* pay, which is a normative norm (Cialdini, Reno and Kallgren, 1990; Dolan et al., 2012).

4. DATA AND METHODOLOGY

In order to assess the impact of our interventions, we obviously needed both pre-experiment and later data. Importantly, our unit of analysis is not individual transactions. Rather we have data on the daily turnover of the canteen per accepted payment instrument (and per check-out), with each day representing one observation. Overall, we have 133 observations: 87 in the pre-experiment period, 37 during the experiment, and 9 after the experiment. Unfortunately, we do not know the volume of transactions per instrument nor can we derive it with the data in our possession. As a result, we cannot determine whether the size of the transaction matters in the choice of payment instrument as the extant literature suggests (see the literature review in section 2).

On the positive side, for each customer, the cashiers do record whether she is a student, a VUB employee or an external visitor.[12] This is because the prices charged at the canteen are based on two criteria: the type of menu and the customer's relation to the university. Cold dishes are always the cheapest and grill dishes the most expensive. For students and external visitors each type of menu has a fixed price, with visitors paying more than students. For VUB employees, prices for a given menu increase with rank. During the pre-experiment period an employee of the highest rank paid 4.60 EUR for a cold dish, compared to 2.65 EUR for an employee of the lowest rank. The VUB canteen is thus an environment with almost exclusively low-value payments[13]. On March 1st, all prices increased slightly as a result of the annual price adjustment[14], but since we work with percentage shares per payment instrument this does not cause problems for our analysis.

Importantly, the canteen applies a surcharge of 10 euro cents for debit card payments that are smaller than the lowest price of a full menu for the relevant customer segment. Specifically,

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[12] This information is not available for the first 8 weeks of the pre-experiment period.
[13] This makes it less of a problem that we cannot analyze the impact of transaction size; cf. supra.
[14] The price rise was on average 2.02%.

this means that employees who spend less than 2.65 EUR, students who spend less than 4.60 EUR, and visitors who spend less than 8.30 EUR are affected. For payments in cash, e-purse or meal vouchers there is never a surcharge. As it is unlikely that soft interventions overrule hard interventions, for our experiment the implication is that where very small payments are concerned we should not expect to be able to nudge patrons of the canteen in the direction of debit cards, given that the pecuniary incentives go in the other direction. There is obviously the alternative of the e-purse, but although everyone who has a Bancontact/Mister Cash card by definition also has a Proton e-purse – the two applications reside on the same card – the vast bulk of the cardholders never use the e-purse application. Our post-experiment survey confirms this: while 96% of the respondents have a debit card only 45% report to merely *have* the e-purse application too. Figures for the number of active e-purse users are undoubtedly dramatically lower (Van Hove, 2004).

Figure 3
Weekly average share per payment instrument during pre-experiment period
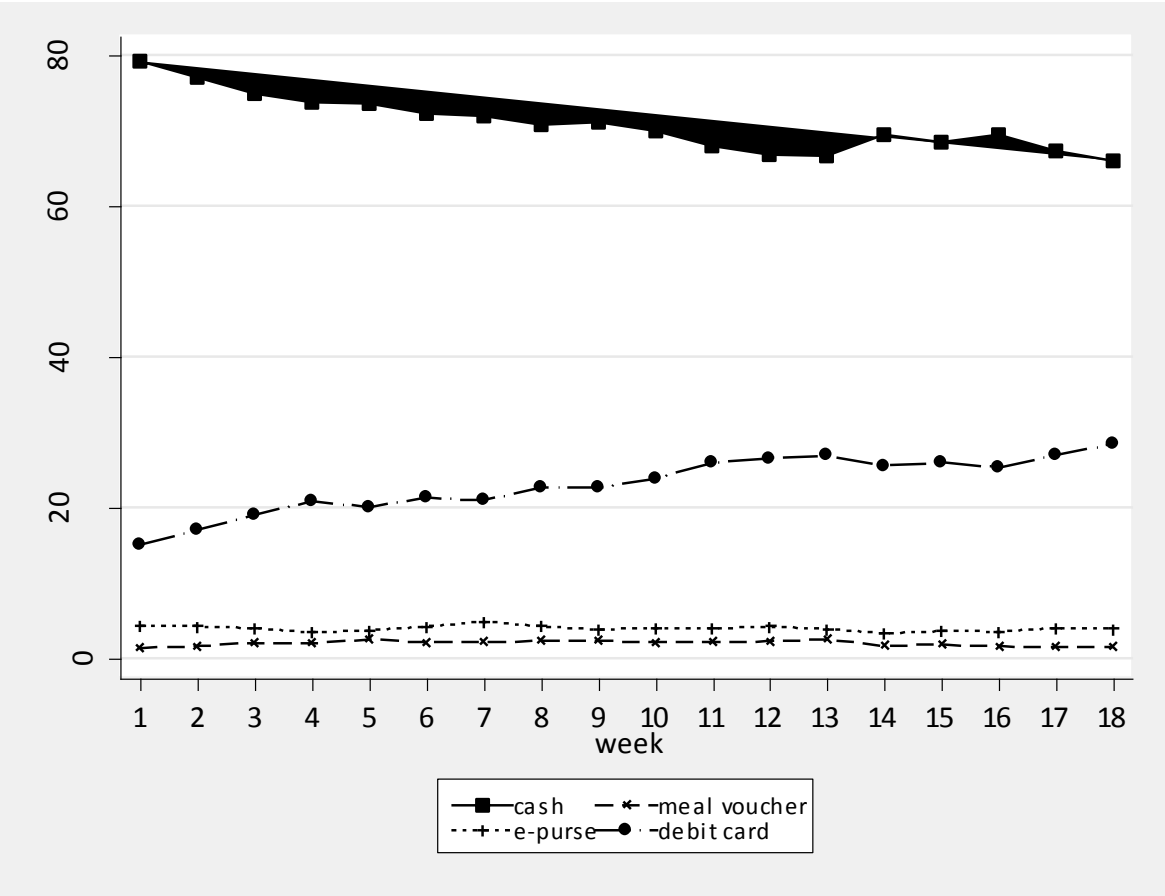
Source: own calculations

Figure 3 shows[15], for the pre-experiment period, the percentage shares in turnover of all (important) payment instruments. On average, cash represented 70.85%, followed by debit cards with 23.11%, e-purse with 4.01%, and meal vouchers with 2.02%. Crucially, Figure 3 shows a slight structural increase in debit card use, at the expense of cash. This is clearly something that we will need to take into account. For our analysis, we decided not to work with the four individual payment instruments shown in Figure 3, but to regroup them in 'paper' (that is, cash and meal vouchers) versus 'cards' (debit and e-purse). There are three reasons for this decision. First, the poster we prepared did not specify which type of card - debit or e-purse – the canteen preferred. Second, there is the fact that, as mentioned earlier, meal vouchers and e-purse account for a very small share of turnover. Their shares also remained stable during the pre-experiment period[16]. Third, the regroupment enabled us to focus on the share of inefficient (paper) versus efficient payment instruments (cards).

As mentioned, we have daily data. As a result, weekends, public holidays and other closing days of the university canteen cause gaps in the time series. In order to have a continuous series, we created a calendar with only the opening days of the canteen and built the time series based on that calendar. As explained in Section 3 on the design of the experiment, the data was collected over a period of 28 weeks in total: the first 18 weeks represent the pre-experiment period, the next 8 weeks cover the experiment itself, and the remaining 2 weeks the situation after the experiment.

After the transformation, the data are suitable for time series analysis and forecasts – the goal obviously being to generate reliable out-of-sample forecasts of the share of card payments *without* interventions; forecasts that can, in a second step, be compared with the observed data. Since the dataset only captures the choice of payment means, it is a univariate time series that can be modeled by an autoregressive moving-average (ARMA) model.

A general ARMA (*p*, *q*) is modeled as:

$$y_t = \rho_1 y_{t-1} + \cdots + \rho_p y_{t-p} + \epsilon_t - \theta_1 \epsilon_{t-1} - \ldots - \theta_q \epsilon_{t-q}$$

or rewritten

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[15] To eliminate day of the week effects, we used weekly average shares.

[16] Note also that the Proton e-purse will be discontinued at the end of 2014. An official announcement can be found on the website of the Bancontact/Mister Cash company: http://www.bancontact.com/en/about-bancontact-mistercash-company/news /.

$$\boldsymbol{\rho}(L^p)y_t = \boldsymbol{\theta}(L^q)\,\epsilon_t$$

where

$$\boldsymbol{\rho}(L^p) = 1 - \rho_1 L - \rho_2 L^2 - \cdots - \rho_p L^p$$

$$\boldsymbol{\theta}(L^q) = 1 + \theta_1 L + \rho_2 L^2 + \cdots + \theta_q L^q$$

and with lag operator $L^j y_t = y_{t-j}$

The parameters p and q give the order of the AR and MA components, ρ and θ respectively. ϵ_t is a white-noise disturbance term.

Let the dth difference of y_t be denoted by $\Delta^d\, y_t$, where Δ denotes the difference operator $\Delta = 1 - L$

A replacement of y_t by $\Delta^d\, y_t$ yields the general autoregressive integrated moving-average (ARIMA) model:

$$\boldsymbol{\rho}(L^p)\, \Delta^d y_t = \boldsymbol{\theta}(L^q)\epsilon_t$$

with parameters (*p, d, q*).

Many time series exhibit a periodic seasonal component, implying the need for a seasonal ARIMA model, abbreviated as SARIMA. As default, multiplicative SARIMA models are applied where nonseasonal and seasonal factors work multiplicatively on the time series. A general multiplicative SARIMA model with parameters *(p, d, q) (P, D, Q)$_s$* is modeled as:

$$\boldsymbol{\rho}(L^p)\boldsymbol{\rho}_s(L^P)\Delta^d\Delta_s^D y_t = \boldsymbol{\theta}(L^q)\boldsymbol{\theta}_s(L^Q)\epsilon_t$$

where

$$\boldsymbol{\rho}(L^P) = 1 - \rho_{s,1}L^s - \rho_{s,2}L^{2s} - \cdots - \rho_{s,P}L^{Ps}$$

$$\boldsymbol{\theta}(L^{qS}) = 1 + \theta_{s,1}L^s + \rho_{s,2}L^{2s} + \cdots + \theta_{s,Q}L^{Qs}$$

s is the seasonal period, Δ_s denotes the lag-s seasonal difference operator $\Delta_s\, y_t = y_t - y_{t-s}$, Δ^d means that the difference operator is applied d times, and similarly for Δ_s^D . P and Q represent the order of the multiplicative autoregressive and multiplicative moving-average component, respectively.

To select the ARIMA model, we follow the Box-Jenkins methodology as described by Becketti (2013); Box, Jenkins and Reinsel (1994, 2008); Enders (2004); Gujarati (2003); Mélard (2007) and Suhartono (2011). The Box-Jenkins methodology consists of three iterative steps: model identification, model estimation and diagnostic checking. Once the model was selected, we predicted the share of paper and card payments based on the fitted model. For the determination of the model and the forecasts we used Stata.

Figure 4a
Share of paper payments on a daily basis[17]
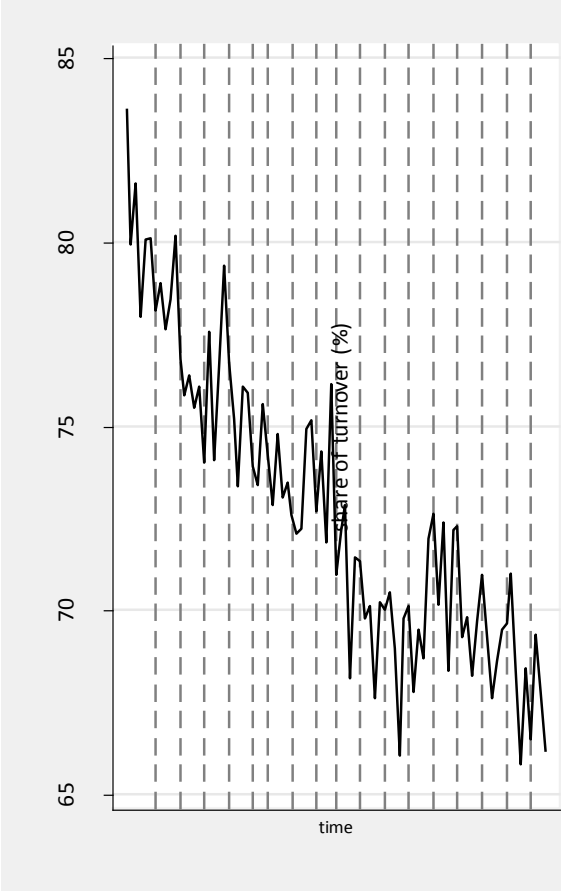
Figure 4b
Box plots of share of paper payments per day
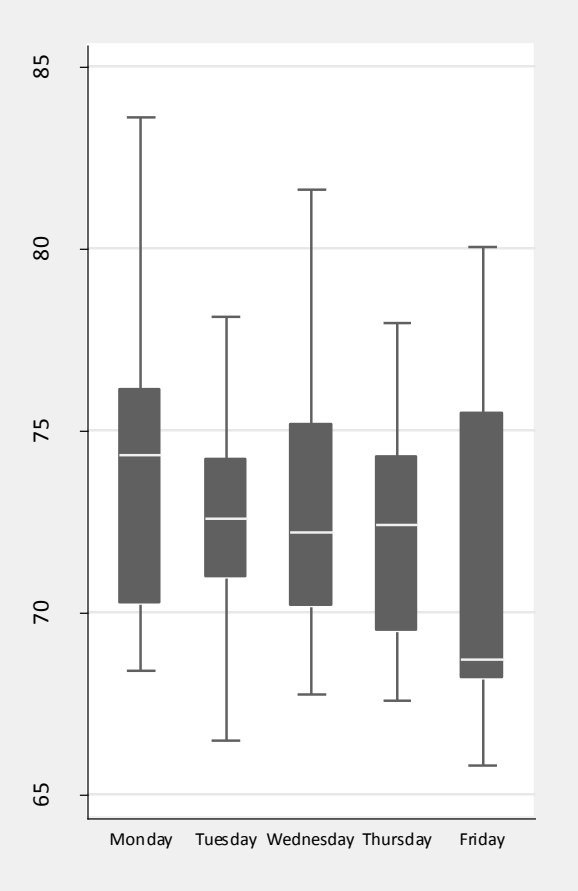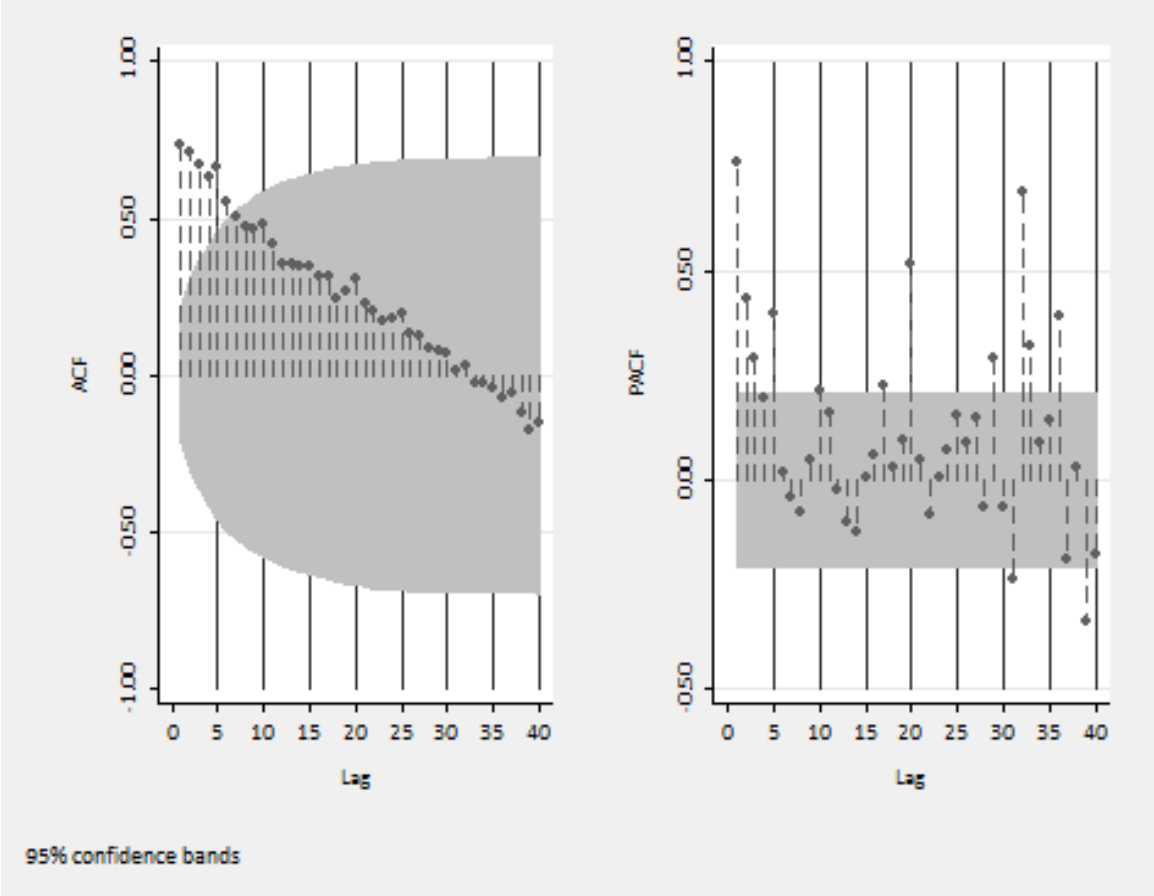

Source: own calculations

We started the identification of the model by questioning the stationarity of the series. As Figure 3 showed, the share of paper payments decreased over time and *vice versa* for card payments, suggesting a unit root in the series. Figure 4a represents the shares on a daily basis, with the dashed vertical lines indicating the first day of every week. As can be seen, in the course of a week the share increases and decreases, indicating an effect of the day of the week. Phillips-Perron (PP) and Dickey Fuller (ADF) unit roots show that the series contains a unit root if each day of the week is considered separately. Taking the first difference of the

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[17] Due to holidays not all weeks have 5 days.

data makes the series stationary. Box plots for the share of paper payments in Figure 4b show that there is a difference between data collected on Mondays and Fridays. On Fridays, the share of card payments is higher than on Mondays. T-tests show that the difference is significant on the 10% level[18].

For the selection of the parameters of the ARIMA model, we applied the autocorrelation function (ACF) and partial autocorrelation function (PACF). In Figure 5, we see the ACF and PACF of the share of paper payments. The ACF shows the non-stationarity of the data since the function only decays gradually. The PACF of the data has an oscillating course with a very significant spike at lag 1 and spikes at lags 5, 10, 15, 20, etc. The shape of the ACF and the spikes at lags s-points are remainders of the seasonality in the data. In order to deal with this seasonal persistence we take the seasonal difference at order 1 of the initial data. Here, s=5 since our data cover five weekdays.

Figure 5
Autocorrelation and partial autocorrelation function of the share of paper payments

95% confidence bands

Source: own calculations

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[18] We tested the data for normality: both the data for Mondays and Fridays are normally distributed.

For the selection of the AR and MA components, we follow the approach suggested by Mélard (2007). We explore the AC and PAC function of the series, fit simple models and investigate the residuals. When the ACF and PACF show statistically significant (partial) autocorrelation in the residuals and the residuals are white noise, we may add AR or MA components to the fitted model.

We show the ACF and PACF of the differenced data in Figure 6. The ACF now has an oscillating course with spikes at lags of seasonal periods and has a significant spike at lag 1. The PACF of the differenced data has an oscillating course with spikes at lags 1, 2, 3, and 4. The spike at lag 1 of the AC requires a MA component, while the PACF suggests an AR component.

Figure 6
Autocorrelation and partial autocorrelation function of first difference of share of paper payments

95% confidence bands
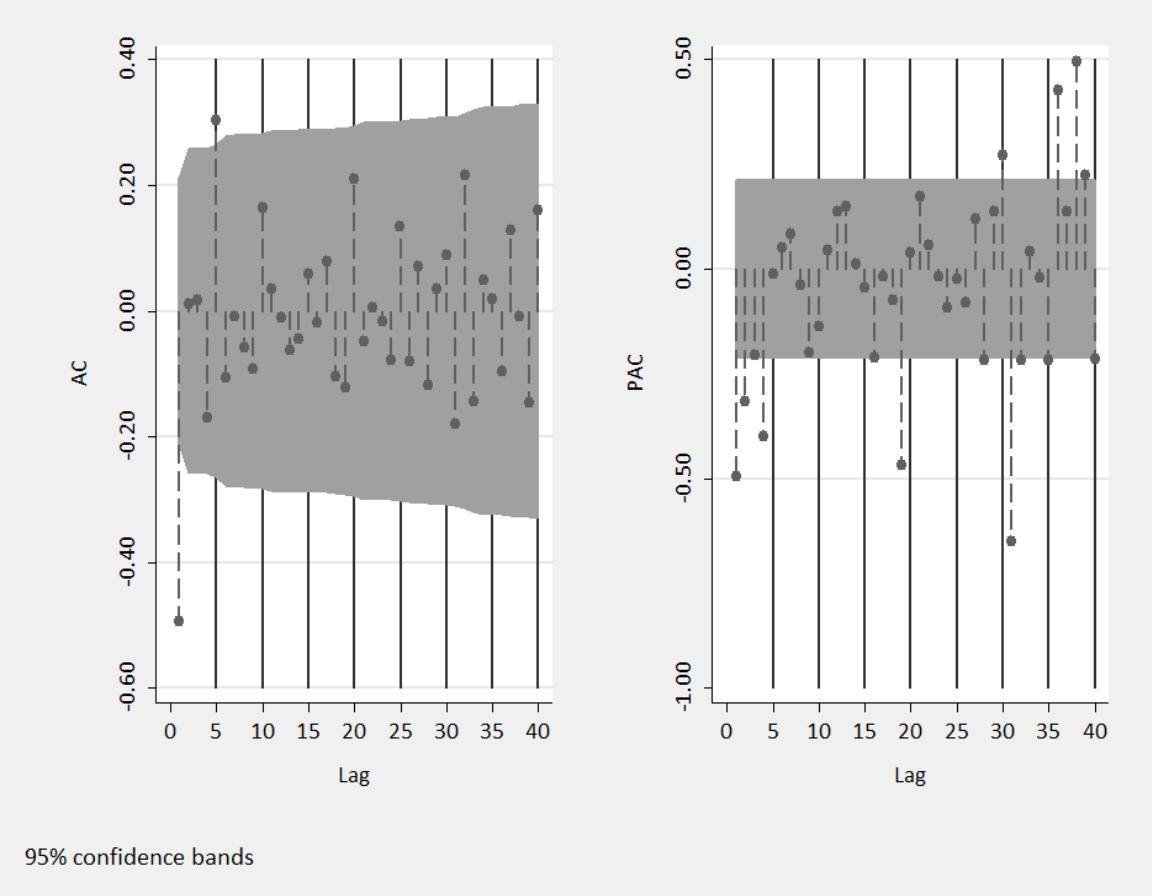
Source: own calculations

Two models survive the first round: a model with a seasonal difference of order 1 and a model with white noise residuals:

Model 1: SARIMA $(0,1,1)(0,1,1)_5$

Model 2: SARIMA $(1,1,1)(0,1,1)_5$.

The residuals are tested for serial correlation with the Portmanteau test for white noise and show no serial correlation $(\boldsymbol{\alpha = 5\%})$.

The second step of the Box-Jenkins methodology is the estimation of the model coefficients. The estimation in Stata gives:

Model 1: $\quad \Delta \Delta_5 y_t = \epsilon_t + 1.35\, \epsilon_{t-1} + 0.75\, \epsilon_{t-5} + 1.015\, \epsilon_{t-6}$

Standard error	0.1303297	0.1321382
t	-10.37	-5.69

Model 2: $\quad \Delta \Delta_5 y_t - 0.10\, y_{t-1} = \epsilon_t + 1.46\, \epsilon_{t-1} + 0.74\, \epsilon_{t-5} + 1.087\, \epsilon_{t-6}$

Standard error	0.1734003	0.3513607	0.1318277
t	-0.59	-4.15	-5.65

The final step of the Box-Jenkins methodology is the diagnostic checks of the estimated models. We start with the significance of the model coefficients. All coefficients of model 1 are significant on the 5% level. The MA coefficients of model 1 and 2 do not differ to a great extent; the AR term of model 2 is insignificant $(\alpha = 5\%)$, which emphasizes the importance of the MA components.

We continue to check the adequacy of these models by performing tests of the residuals of the models. As already calculated, the Q statistics in the Portmanteau test show no evidence that the residuals of model 1 and 2 deviate from white noise. Data that is inadequately seasonally adjusted or models that do not include appropriate seasonal differencing can exhibit nonrandom periodicity that we cannot detect with the Q statistic. We examine the cumulative periodogram of the residuals to highlight nonrandom periodicity in the data. For a white noise series, the cumulative periodogram should be a straight line between the cumulative

periodogram value of 0 at a frequency of 0 and 1 at a frequency of 0.5. Marked deviations from this straight line indicate nonrandom periodicity. The residuals of model 1 and 2 do not exhibit any signs of nonrandom periodicity: the cumulative periodograms remain close to the 45-degree line and well within the confidence bands (appendix 2).

A final check consists in overfitting the models. The Box-Jenkins approach gives preference to the model with the fewest parameters: the most parsimonious model. We add parameters to the existing models and test the significance of the added coefficients. In case the additional parameters are insignificant, this suggests that the more parsimonious specifications are adequate. We add parameters to the AR and MA components of model 1 and model 2 simultaneously because of the risk of parameter redundancy. The results for both models show that the added parameters are insignificant, so we maintain the initial fitted models. Between the two models, we prefer model 1 since all coefficients are significant and model 2 can be seen as an overfitting of model 1 with an insignificant AR(1) parameter.

Finally, we used the selected model to forecast the share of paper payments during as well as after the experiment. We compared the actual data with the forecasts and tested for breaks in the series caused by the interventions. The results are presented and discussed in the following section.

In addition to the time series analysis, we also assessed the impact of our interventions with an online survey conducted after the experiment, in June 2013 (N = 527). Among other things, we asked whether the respondents had noticed the slogans and if they had been asked to pay by card at checkout 1 and 2. Respondents who answered affirmatively were also asked about the impact on their payment behavior.

5. RESULTS

In this section we evaluate the success of our experiment. Did the posters have any effect at all in steering customers towards cards? If so, how strong was the effect? Did the prompts by the cashiers have an additional effect and how strong was that? And, crucially, are the effects lasting? To answer these questions, we first used Chow tests to check for breaks in the data series at the points in time when we introduced the interventions. To determine whether the interventions had a lasting effect, we also tested for a break at the end of the experiment. In a second step, we calculated the magnitude of the effects. We compared the actual data with the

forecasts and also used paired t-tests to assess the significance of the differences. The post-experiment survey is used to double-check selected results.

In the next subsection we first discuss the aggregate results. Our conclusion from this analysis will be that the payment behavior of students and employees needs to be examined separately. We do this in section 5.2.

5.1 Aggregate results

For a first impression, we plotted the forecasts of model 1 and the actual aggregate data in one and the same graph; see Figure 8. The dashed vertical lines mark the start of, respectively, phases 1, 2, and 3, and the post-experiment period. What immediately catches the eye is the sharp decline of the observed share of paper payments between the 29th of March and the 12th of April. This sharp decline has clearly something to do with the spring break (when classes are interrupted but university staff is present). In 2013, the spring break was between the 2nd and 12th of April as marked by the solid vertical lines in Figures 8 and 9.

Figure 8
Share of paper payments between February 11 and May 24, 2013

Source: own calculations

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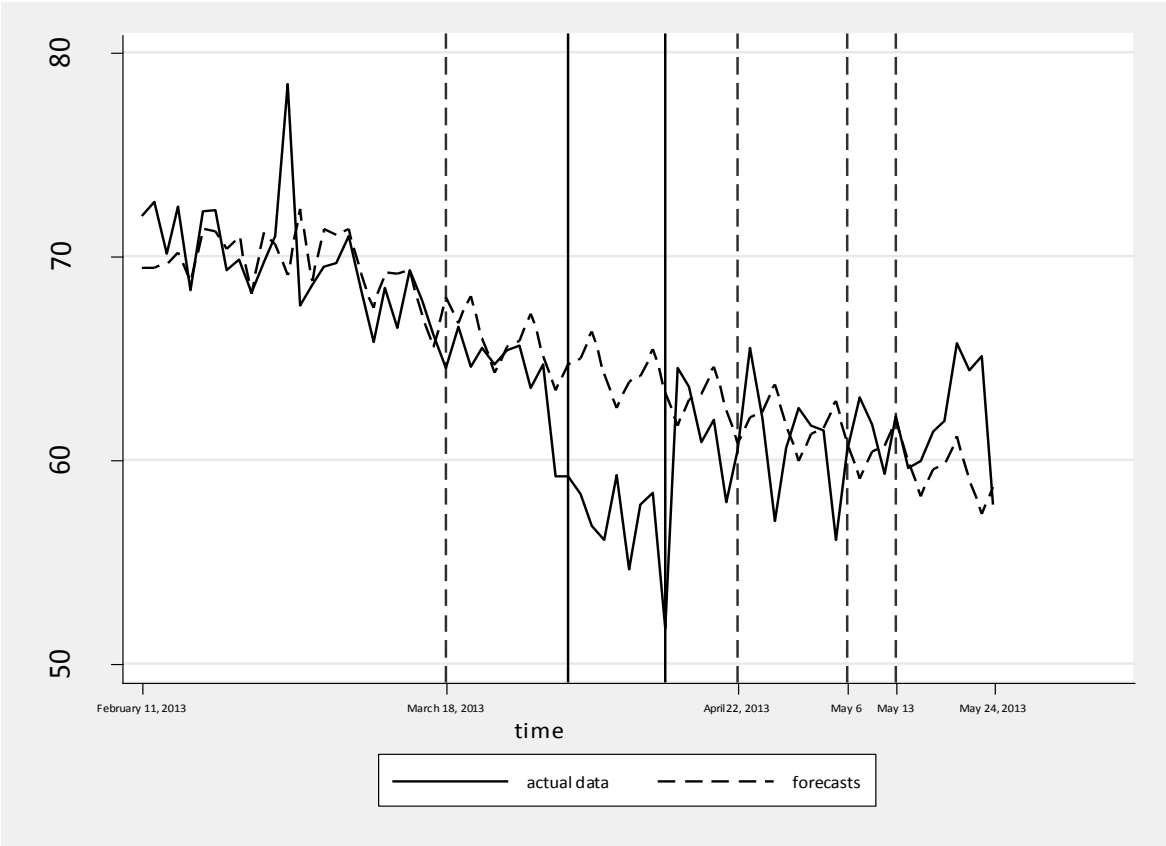
Figure 9
Share of segments in daily total turnover over time
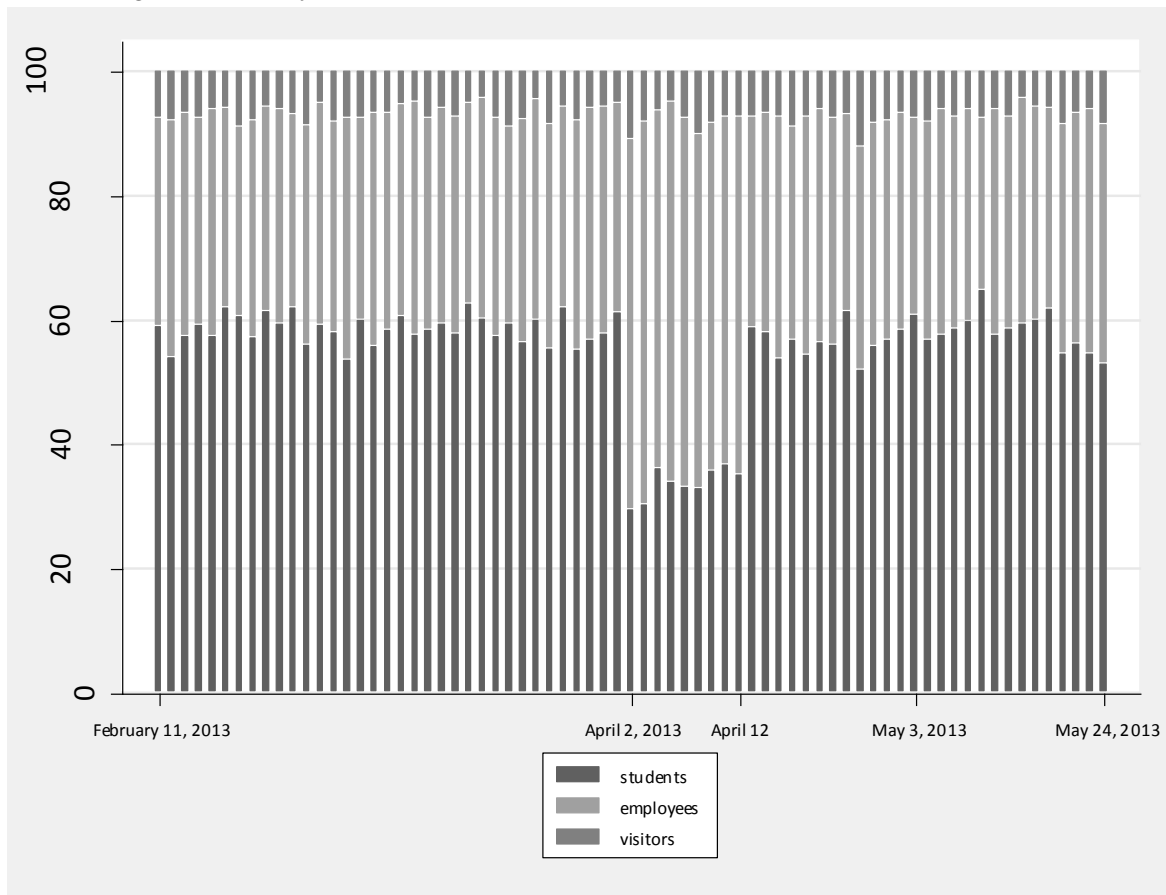
Source: own calculations

The t-tests in Table 1 effectively show significant differences ($\alpha = 1$) [19]. Employees consistently pay more often by card than students. The lower number of students who were on campus during the spring break thus effectively explains a (probably large) part of the sharp decline in card payments in that period. Also, in a first indication that the impact of our interventions might be different across customer groups, it can be seen in Table 1 that the difference in payment behavior between students and employees by and large increases over time, and reaches almost 15 percentage points after the experiment. Simplifying somewhat, for both groups the share of paper payments systematically declines from one phase of the experiment to the next, with the exception of phase 3 for employees. For students this decline is slower and, crucially, after the experiment the share of paper payments goes up again. This

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[19] Before conducting t-tests, we tested if the share of paper payments is normally distributed. This turned out not to be the case for the employee data of the pre-experiment period. The other phases do contain normally distributed data.

would seem to indicate that for this customer group the impact of our interventions, if any, did not last. We analyze this in more depth in the next subsection.

Table 1
Mean values of share of paper payments

phase	students (%)	employees (%)	Δ
pre-experiment[20]	72.65	62.95	-9.70***
1	64.92	54.36	-10.56***
2	64.67	52.06	-12.61***
3	64.50	52.77	-11.73***
post-experiment	66.64	51.89	-14.75***
phase 1:			
before spring break	67.76	56.45	-11.31***
spring break	61.02	52.99	-8.03***
after spring break	66.24	52.64	-13.60***

***   significant at the 1% level

5.2 Results per user segment

We now evaluate the effect of our interventions for students and employees separately. We leave external visitors out of our analysis because they represent only a small proportion of turnover. Moreover, they were not the target group of our interventions, as we did not expect visitors to feel connected with the VUB.

To estimate separate models for the student and employee segments we followed the same method as described in the Data and Methodology section[21]. For students the estimation yields a SARIMA $(1,1,0)(0,1,0)_5$ model:

Model 3: $\Delta \Delta_5 y_t - 0.57 y_{t-1} = \epsilon_t$

Standard error   0.1663886
t   -3.41

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[20] Based on 25 pre-experiment observations.

[21] The estimations are based on 25 observations of the pre-experiment period. We have only 25 observations because the distinction between student and employee is only available for the last 5 weeks of the pre-experiment period, as mentioned in footnote 20. The lower number of observations results in higher RMSFEs compared to the aggregated model.

For employees the estimation gives a SARIMA $(0,1,1)(0,1,1)_5$ model:

Model 4: $\Delta \Delta_5 y_t = \epsilon_t + 0.58\, \epsilon_{t-1} + 0.99\, \epsilon_{t-5} + 0.58\, \epsilon_{t-6}$

Standard error	0.1987084	0.2647811
t	-2.92	-3.78

As mentioned earlier, we tested the data for breaks by means of Chow tests. We obviously expected breaks at the points in time when we introduced the interventions. To check for a lasting effect, we also tested for a break at the end of the experiment. We applied simple regression models with one lag term and carried out regressions of the actual share of paper payments for the three phases of the experiment and for the post-experiment stage. In a second step, we calculated the magnitude of the effects. By means of paired t-tests, we compared the actual data with the forecasts. In order to test for sustained effects of the interventions, we compared the pre- and post-experiment period for both the observed payment patterns and the forecasts.

Figure 10
Share of paper payments for students
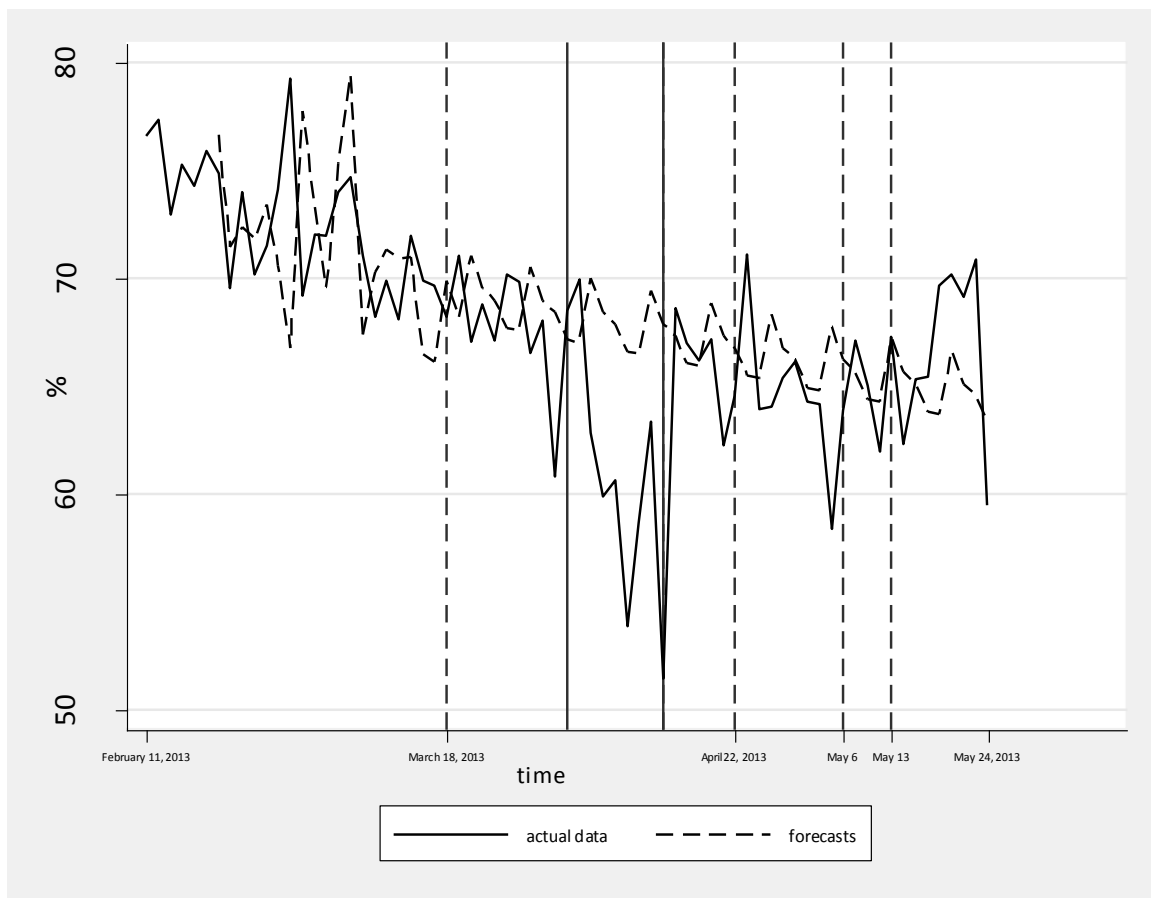
Source: own calculations

For students, the Chow test revealed a very significant break ($\alpha = 1\%$) at the start of the experiment, which indicates that their payment behavior changed compared to the pre-experiment situation. In figure 10, the dashed vertical lines again mark the start of a phase while the solid vertical lines demarcate the spring break. We clearly see the stronger than predicted decline of the share of paper payments in phase 1, especially during the spring break. The forecasts of model 3 do not predict a decrease of this magnitude: the residuals show peaks during phase 1. The root mean squared forecast error (RMSFE), a measure for the magnitude of a forecast error, is 4.25 for the observation period but rises to 6.00 by phase 1. Because the drop in the share of paper payments is particularly pronounced during the spring break, we conducted our test a second time, now only considering the observation of phase 1 prior to the spring break. In this set-up we no longer detect a break[22]. This means that the spring break itself explains at least part of the decline in paper payments and that we cannot isolate the effect of the intervention, if any[23].

For employees, the Chow test also detected a very significant break at the start of the experiment. As shown in Figure 11, here the spring break is less disruptive and thus less of a problem for our analysis. These findings seem to imply that the slogan effectively had an impact for employees during phase 1, while for students the effect is doubtful.

Table 2 shows the results of the paired t-tests, with 'AS' and 'AE' standing for Actual share of paper payments for, respectively, Students and Employees. Similarly, 'FS' and 'FE' represent the Forecasts. The payment behavior of both segments clearly changed in phase 1: they both pay more often by card than predicted by their respective forecasts. However, for students the increase in the use of cards is only significant during the spring break, while for employees the effect is observed for the full 5 weeks. Over this period, employees' card usage was on average 3.30 percentage points (or 6.07 per cent) higher than forecasted. The results of the survey support these findings. For one, there is a statistically significant relation between the status of the respondent – student or employee – and noticing the posters ($\alpha = 1\%$). Only 34% of the students reported to have noticed the slogan at the checkouts, compared to 62% of

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[22] This is also true when we additionaly exclude the last Friday before the spring break.
[23] Apparently the students who are still on or near campus during the spring break – foreign students who did not return home, doctoral students who continued working, … – exhibit a different payment behavior compared to the total student population. We can only speculate as to why this is the case.

Figure 11
Share of paper payments for employees
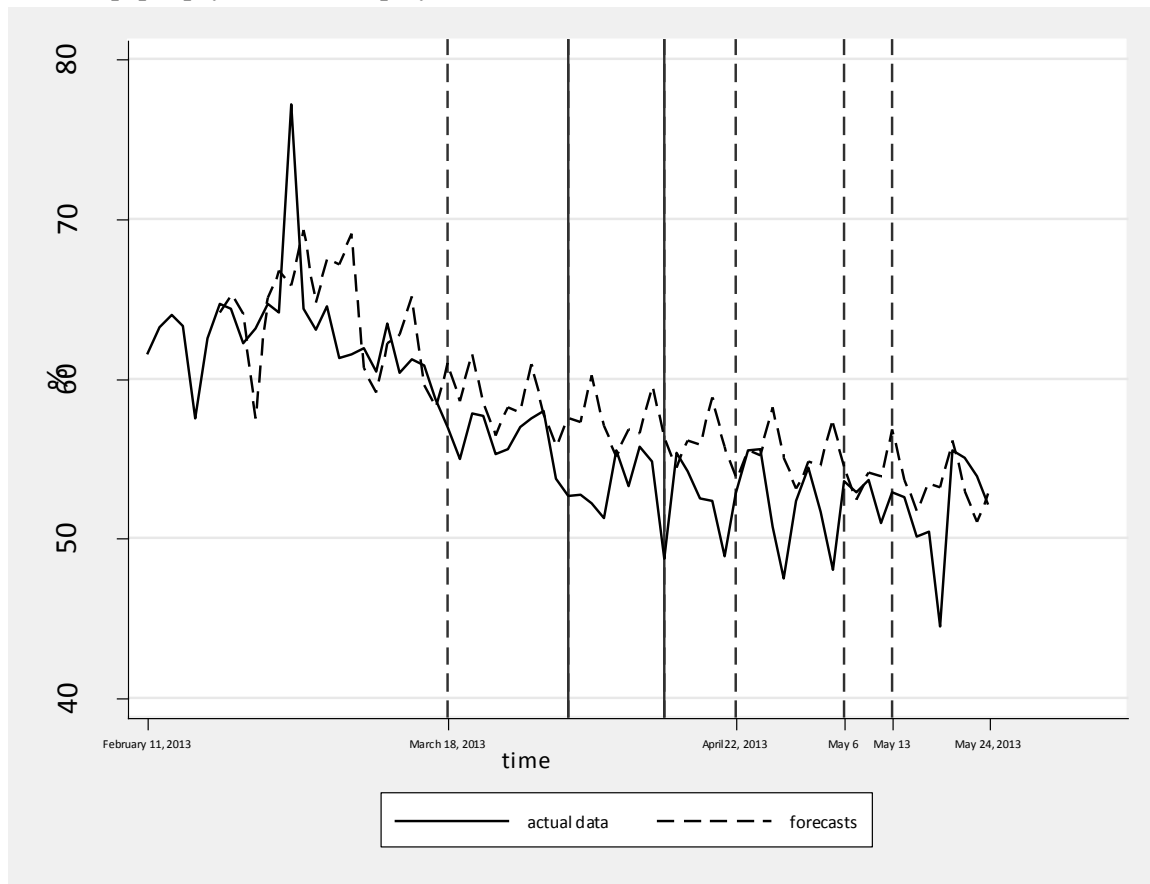
Source: own calculations

Table 2
Mean values of share of paper payments in phase 1

	AS	FS	Δ	AE	FE	Δ
phase 1	64.92	68.22	-3.30***	54.36	57.66	-3.30***
before spring break	67.76	69.09	-1.33	56.45	58.64	-2.19***
spring break[24]	61.02	67.87	-6.85***	52.98	57.37	-4.39***
after spring break	66.24	67.10	-0.86	52.64	56.20	-3.56*

***	significant at the 1% level
*	significant at the 10% level

employees. Second, of the students who had noticed the posters, 21% indicated to pay "more often" by card after having seen the poster, 40% kept on paying in cash (while 39% already

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[24] The absolute value of the difference is higher, namely 6.93, when we include Friday 29th of March in the spring break. This does not, however, affect the significance of the differences for either the spring break or for the periods before and after.

paid by card). Among the employees who had noticed the posters, newly converted card payers represented 25%, diehard cash-payers 32%, and 43% already paid by card. Expressed as a percentage of the total number of respondents, these figures imply that, according to the survey, 7 per cent of the students and 15.5 per cent of the employees would have started paying more often by card because of our intervention. A comparison with the figures in Table 2 highlights that "more often" clearly does not mean "all the time", as the impact in terms of number of payments is substantially lower.

As mentioned in the literature review, the effect of slogans on payment choice has already been studied by Leenheer et al. (2012) and van der Horst and Matthijsen (2013). Unfortunately, an in-depth comparison with their results is not possible because neither paper presents figures as to the magnitude of the effects. Hence, the only thing we can conclude is that our results for employees appear to be in line with earlier research, but that the same van not be said for students.

The second intervention, the oral prompts by the cashiers at cash desks 1 and 2, again did not produce a significant break in students' payment patterns. By contrast, for employees there is again a significant break, albeit this time only at the 5% level. Specifically, in phase 2 the difference between the forecasted and actual share of paper payments amounts to -3.22 percentage points. However, this actually means that the combined effect of the posters and the oral prompts is smaller than the effect of the posters alone in phase 1. The fact that there is nevertheless a break in the series is suggestive of a scenario in which the impact of the posters gradually waned and the oral prompts rekindled the attention. But this is speculative and it is not possible to isolate the effect, if any, of the prompts [25]. It is also possible that (not all of) the cashiers followed our instructions conscientiously. Only 7% of the respondents of the survey indicated that they had received an oral request to pay by card. If we assume that the cashiers only prompted those customers who wanted to pay cash, we estimate that some 33% of the respondents should have received an oral request[26].

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[25] An analysis on the level of individual cash desks also provides no decisive answer: there is a (marginally) significant difference at cash desk 2 (of -3.74 percentage points) but not at cash desk 1.

[26] This figure is computed as follows. We assume, first, that the survey is representative for the customers of the canteen and, second, that cashiers, understandably, saw no reason to prompt customers who already had their card ready. In other words, we need to know the percentage of non-card payers at cash desks 1 and 2. If we multiply the share of cash payments at cash desks 1 and 2 with the share that these desks represent of the total turnover, we obtain 66.31 * 57.70 = 38.26%. In addition, it is not realistic to expect cashiers to promote card payments to customers who spend less than the price of a full menu price as such card payments would be

Finally, there is the question whether the interventions had a lasting effect. We find that for both customer segments there is a break at the end of the experiment ($\alpha = 5\%$). This does not bode well, as it indicates a change in payment behavior after the experiment.

Table 3
Differences in mean values between actual data and forecasts, post-experiment

	AS	FS	Δ	AE	FE	Δ
post-experiment	66.64	65.01	1.63	51.89	53.53	-1.64
first week	66.02	65.11	0.91	50.10	53.77	-3.66[*]
second week	67.41	64.90	2.51	54.12	53.24	0.88

[*]   significant at the 10% level

As shown in table 3, when we consider the whole two weeks of the post-experiment stage, we do not detect a significant difference between the forecasts and the actual data, neither for students nor for employees. If we treat the two weeks separately, we again detect no significant differences for students. By contrast, for employees there is a significant difference during the first week (of 3.66 percentage points), but the difference becomes insignificant by the second week. In short, the interventions had no lasting effect at all for students and only a temporary post-experiment effect for employees.

6. CONCLUSION

In this paper we examine the effect of soft interventions on consumers' choice of payment instrument at the point of sale. In particular, we conducted an experiment in a university canteen by, firstly, displaying pro-card slogans at the counters and, secondly, instructing cashiers to explicitly request patrons to pay by card.

We find that our nudges had a different impact on the two largest segments of the clientele of the canteen: students and university personnel. For students, the effect of the interventions is doubtful. Employees, for their part, did increase their use of cards because of the posters, by an estimated 3.30 percentage points (or 8.59 per cent). Unfortunately, where the oral prompts

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subject to a surcharge (see Section 4). Based on data that we have on the number of menus sold, we estimate that roughly 5% of the turnover consists of such low-value transactions, thus lowering the expected target group for the prompt to 38.26 - 5 = 33.26 per cent of the customers.

are concerned, (some of) the cashiers probably did not follow up our instructions correctly. Hence, no hard conclusions can be made about the impact of the prompts: in phase 2 of our experiment, the share of card payments among employees was 3.22 percentage points higher than forecasted, but this actually implies that the combined effect of both nudges (in phase 2) was smaller than the impact of the posters alone in phase 1. Finally, our interventions did not have a sustained effect: once the posters were removed, the development of card usage resumed its normal trend.

When we compare our results with the Dutch studies of Leenheer et al. (2012) and van der Horst and Matthijsen (2013) – who apparently only test the immediate impact of their interventions – we find that our results for employees dovetail with their findings but that our results for students contradict them. However, one has to realize that the VUB canteen is an environment with almost exclusively low-value payments. As documented in the literature review, for low-value amounts many consumers' preference for cash is still particularly pronounced. In other words, compared to the Dutch experiments – which do not focus on low-value payments – our testing ground would appear to be a particularly tough one. An added complication was the existence of surcharges for the very small payments.

Interestingly, however, the different impact of our slogan on students and employees might also be an indication of an altogether different phenomenon. As explained, our slogan was specifically selected to appeal on customers' sense of loyalty and connection with their university. Although we cannot underpin this assertion, because we have not tested for it, it would seem reasonable to assume that employees, many of which have been at the university for a long time, feel more of a connection with the university than students. Hence, our findings might indicate that nudging consumers by harnessing social norms is simply more effective when consumers really feel part of the relevant society [27].

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[27] Note that there are competing explanations: for one, students are younger and, as the literature review documents, younger people have a stronger preference for cash; second, students might receive their pocket money in cash or might be paid cash when doing student jobs; and finally, because for employees the surcharges kick in at a higher threshold they are less of a problem for employees than for students. However, with the data that we have we cannot discriminate between these explanations. For this, further research would be needed.

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APPENDICES

Appendix 1: Ground plan university canteen VUB
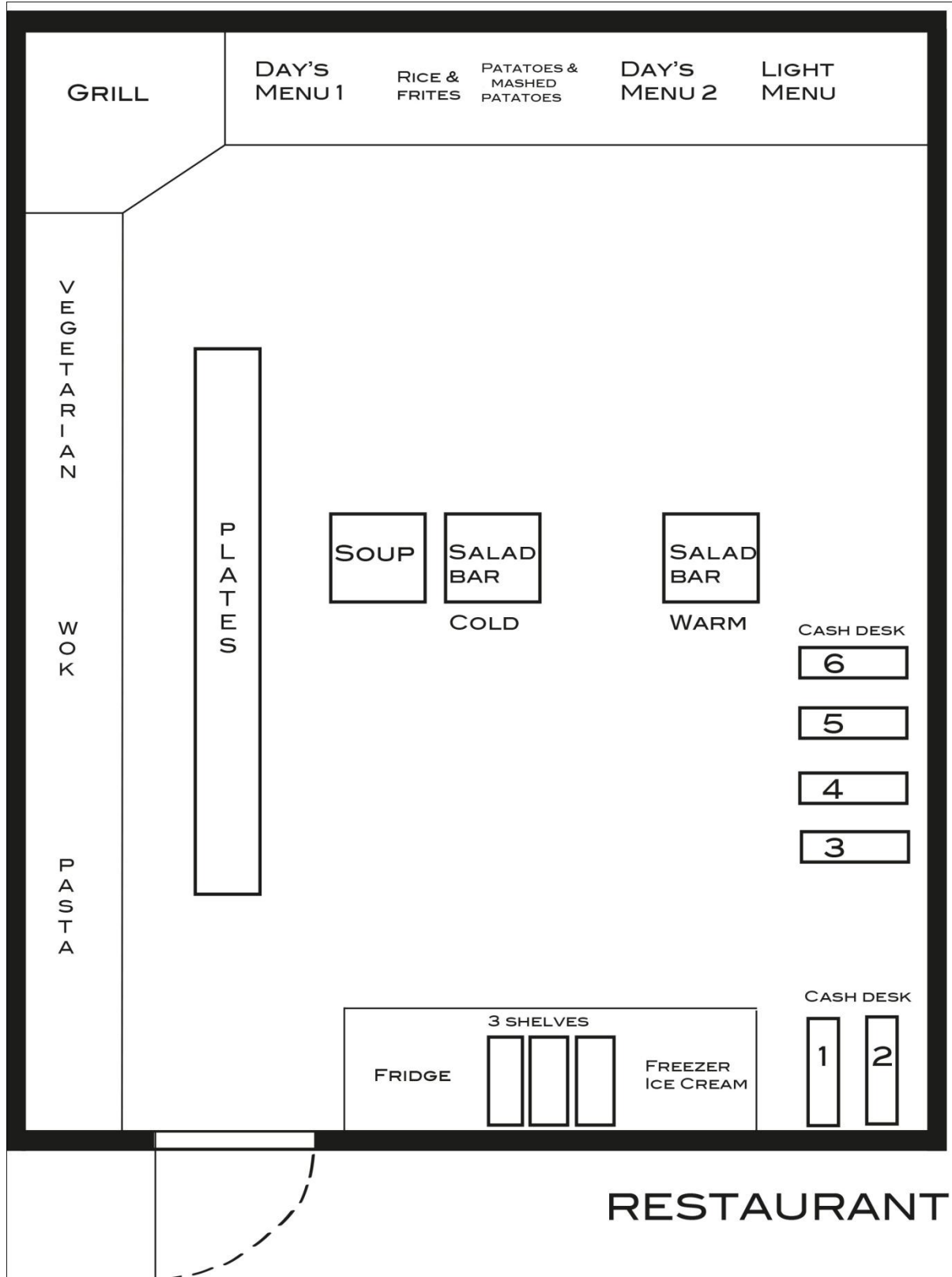
Appendix 2: Cumulative periodograms
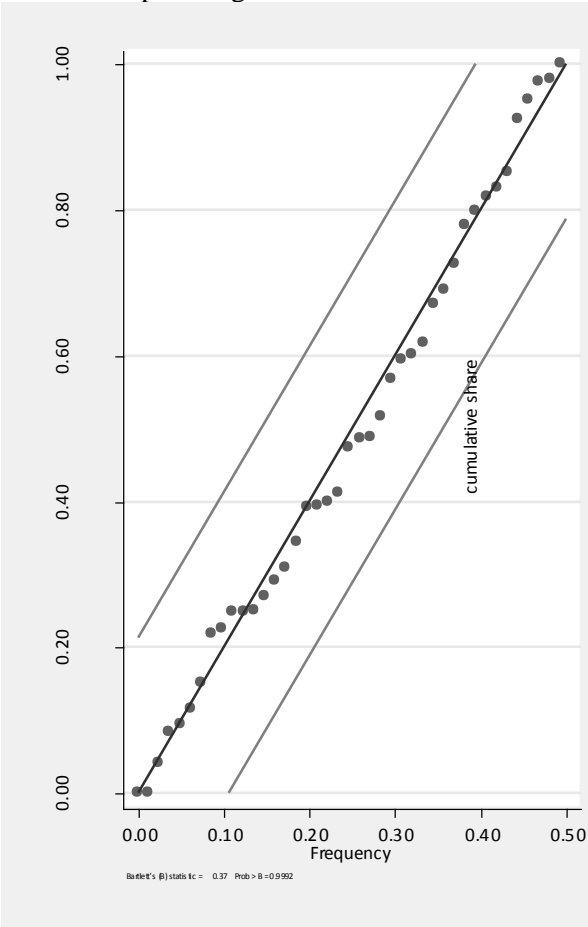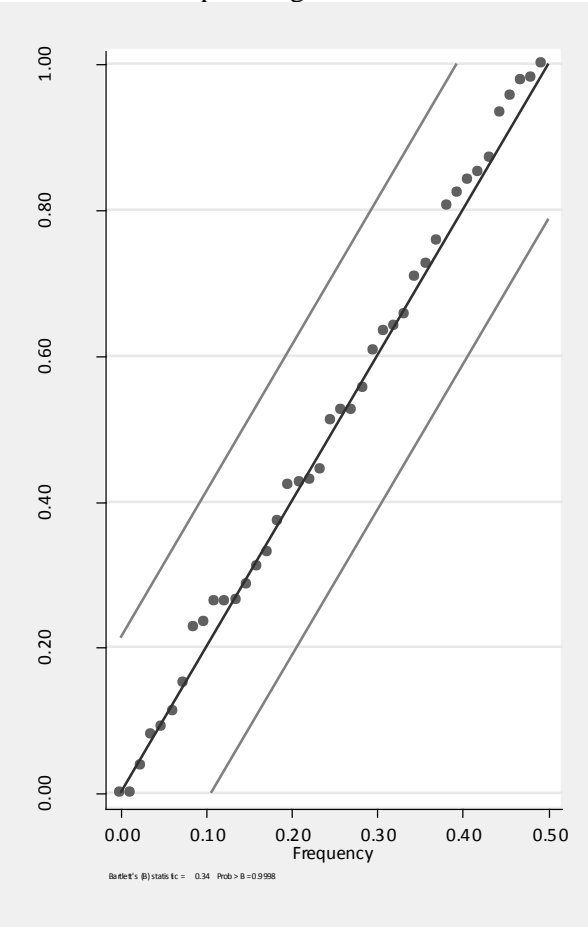
Figure 7a
Cumulative periodogram residuals model 1

Figure 7b
Cumulative periodogram residuals model 2

Source: own calculations