Gift Exchange Experiment Pre-Registration
Model and Estimation

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This document describes the experimental design for the proposed gift exchange field experiment, lays out the theoretical model, and specifies the benchmark structural estimation models and the reduced form analysis.

Section 1) Describes experimental design

Section 2) Describes the general model and lays out the special cases of altruism and warm glow, as well as a model of combined altruism and warm glow.

Section 3) Describes the simple reduced form analysis

Section 4) Describes functional form and parametric assumptions which will be made for the structural estimation, which leads to the exact estimating equations.

Section 5) Planned computational procedures.

Section 6) APPENDIX: Reference for notation in this document

NOTE: This experiment registration, including the full specification of the model and planned structural estimation, was written on 21 Nov 2014. This was after one full phase of data collection, with data on 131 subjects collected and two full rounds of treatment orders completed. We plan to gather data on approximately 200 more subjects, although exact sample sizes will depend on (unpredictable) show-up of the invited workers.

1 Experimental Design

We hire temporary workers for a single day's employment (about 5 hours of work) through posted ads on Craigslist.com. Workers prepare mailers – i.e. fold and place materials in envelopes, working their way through a mailing list – for fundraising and advertising campaigns. They work in ten sessions of 20 minutes each over the course of the day, for 4 different employers (three charities and one firm). The ten sessions include two training sessions where the prepared envelopes are not used, although the workers are paid for each envelope correctly prepared. Workers receive a single lunch break after the fourth work session of the day.

The different sessions vary the following aspects of the work:

1. The fixed amount ($0, $3.5 or $7) and piece rate per envelope ($0.20, $0.10 or $0 per envelope) paid to the workers

2. The return to the employer of the work ($0 in training session, $0.6 per envelope or $0.3 per envelope before wage costs), implemented in some sessions with a (truthfully implemented) "match" to the funds raised from the mailings.

3. The type of the employer (charity or firm)

4. An unanticipated "gift" in the final two sessions: Either a higher fixed pay ($14) than received previously (positive monetary gift), the same fixed pay ($7), a lower fixed pay ($3, negative monetary gift) or else an in-kind gift (a thermos with the logo of the employing charity) in addition to the basic fixed pay of $7 (in-kind positive gift).

In each case, we observe the effort exerted by the worker. The response to variation in piece rates helps us identify the cost of effort function. The response of workers' effort to variation in the return to the employer helps identify and distinguish warm glow and pure altruism. The response to the gift treatments identifies the reciprocity parameters. Putting all the estimates together, we intend to determine the importance of worker altruism towards employers, and help interpret the magnitude of employees' positive or negative reciprocity to gifts.

1.1 Within Subject Variation

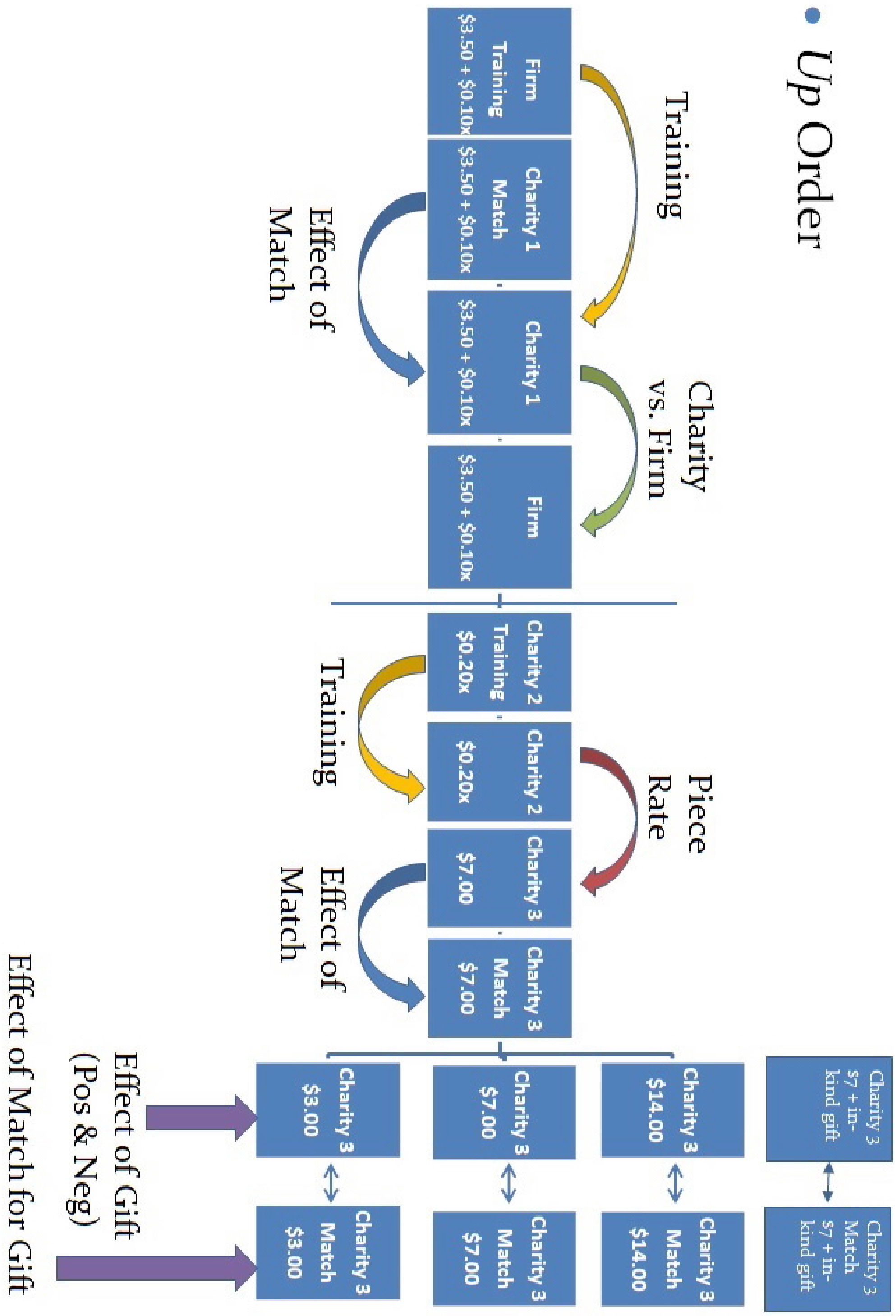
Each worker works for 10 work sessions in day, during which they face varying incentives. This provides a rich source of within subject variation.

The first of the ten work sessions for each subject is a training session, where the worker is paid to stuff practice envelopes, but the envelopes are discarded and not mailed by the employer (as always, there is no deception in the experiment, and the envelopes are truly discarded as announced to the workers). The fifth session, which is immediately after lunch, is a second training session. The last two sessions – 9 and 10 – are always the gift sessions, where workers receive unanticipated positive, negative, in-kind gifts or no gift. The remaining six sessions (other than the two training and two gift sessions) vary in order in one of two ways. Each subject is assigned to either UP or DOWN order, each of which specifies a particular sequence of the work sessions. Importantly, the two orders are reversed or mirror images of each other (excluding the position of the training and gift sessions, which are fixed). Particular pay scheme + employer combinations are thus observed (in different subjects) in two different positions – once early and once late in the day. By averaging across these two occurrences, we can partially deal with issues of learning and tiredness over the course of the day.

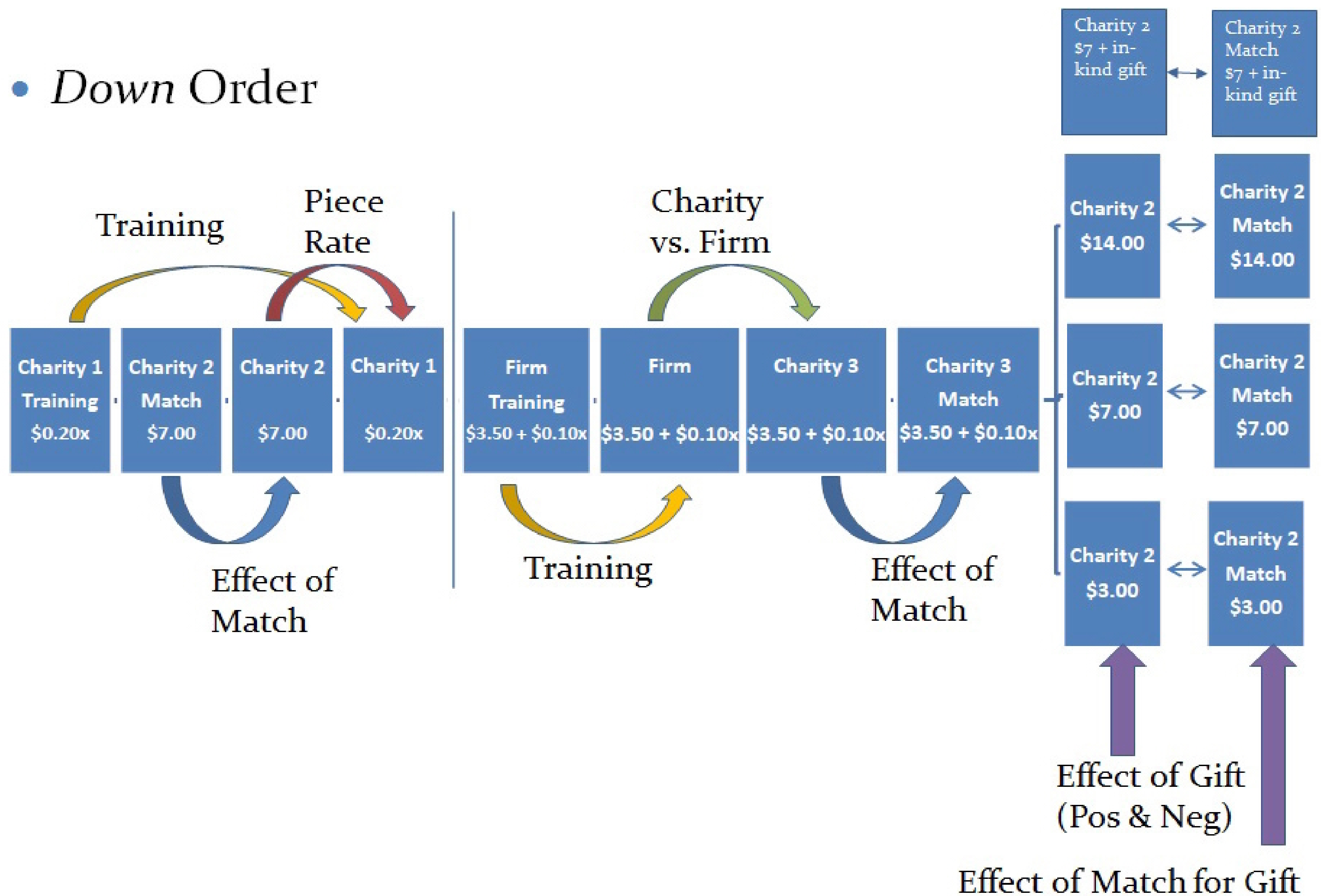
1.2 Between Subject Variation

The experiment uses two types of between-subject variation:

1. First, the order of the experimental sessions is randomized. There are 12 types of sessions, which vary (a) the session order (UP or DOWN), (b) the charity order (CHARITY ORDER 1, 2 or 3) in which one of the charities (B, RN or RIC) corresponds to Charity No 1 in the experimental design, and (c) the match order in the final two sessions (MATCH FIRST or MATCH LAST). This produces 2x3x2=12 treatment session types. The order of the 12 treatments was randomly drawn at the beginning of the study. We plan to hold at least 48 experimental sessions (of which 24 have already been completed as of the time of this posting) and ideally 72 total sessions if we can find enough subjects to recruit. In



Up Order
Firm Training $3.50 + $0.10x
Charity 1 Match $3.50 + $0.10x
Charity 1 $3.50 + $0.10x
Firm $3.50 + $0.10x
Training
Charity vs. Firm
Effect of Match
Charity 2 Training $0.20x
Charity 2 $0.20x
Charity 3 $7.00
Charity 3 Match $7.00
Training
Piece Rate
Effect of Match
Charity 3 $7 + in-kind gift
Charity 3 Match $7 + in-kind gift
Charity 3 $14.00
Charity 3 Match $14.00
Charity 3 $7.00
Charity 3 Match $7.00
Charity 3 $3.00
Charity 3 Match $3.00
Effect of Gift (Pos & Neg)
Effect of Match for Gift


Down Order
Training
Piece Rate
Charity 1 Training $0.20x
Charity 2 Match $7.00
Charity 2 $7.00
Charity 1 $0.20x
Effect of Match
Charity vs. Firm
Firm Training $3.50 + $0.10x
Firm $3.50 + $0.10x
Charity 3 $3.50 + $0.10x
Charity 3 Match $3.50 + $0.10x
Training
Effect of Match
Charity 2 $7 + in-kind gift
Charity 2 Match $7 + in-kind gift
Charity 2 $14.00
Charity 2 Match $14.00
Charity 2 $7.00
Charity 2 Match $7.00
Charity 2 $3.00
Charity 2 Match $3.00
Effect of Gift (Pos & Neg)
Effect of Match for Gift

Comparison of Up vs Down Orders
Firm Training $3.50 + $0.10x
Charity 1 Match $3.50 + $0.10x
Charity 1 $3.50 + $0.10x
Firm $3.50 + $0.10x
Charity 2 Training $0.20x
Charity 2 $0.20x
Charity 3 $7.00
Charity 3 Match $7.00
Charity 3 $7 + in-kind gift
Charity 3 Match $7 + in-kind gift
Charity 3 $14.00
Charity 3 Match $14.00
Charity 3 $7.00
Charity 3 Match $7.00
Charity 3 $3.00
Charity 3 Match $3.00
Charity 1 Training $0.20x
Charity 2 Match $7.00
Charity 2 $7.00
Charity 1 $0.20x
Firm Training $3.50 + $0.10x
Firm $3.50 + $0.10x
Charity 3 $3.50 + $0.10x
Charity 3 Match $3.50 + $0.10x
Charity 2 $7 + in-kind gift
Charity 2 Match $7 + in-kind gift
Charity 2 $14.00
Charity 2 Match $14.00
Charity 2 $7.00
Charity 2 Match $7.00
Charity 2 $3.00
Charity 2 Match $3.00

total, there will be at least 4 full loops through the complete set of 12 treatment sessions, and ideally 6 full loops. In any case, we will aim to run a completed loop though all the 12 sessions constituting one full run. On each day that the experiment is run, either one or sometimes two experimental sessions will be run (depending on how many individuals respond to the posted advertisement and show up).

2. The second randomization is at the individual level, within a given experimental session. Randomization occurs during lunch within an experiment session and is used to determine whether a subject is put into the positive gift, in-kind gift, negative gift, or control (neutral) gift treatment. The total number of envelopes each subject created in the previous sessions is totaled and their rank determined. The highest and lowest rank were put into one treatment, the second highest and second lowest were put into another treatment, and the middle two were put into the third treatment. In the very first experimental session, the highest and lowest rank were randomly placed in the negative gift. Following this, in the second group, the highest and lowest rank were place in the the neutral gift. In the third session, they were placed in the positive gift. This pattern was then repeated. Thus, the randomization was one-time and affected which treatment the first pair of "highest and lowest" workers were assigned to. After that, assignment was deterministic, although of course it depended on worker performance on a given day. The goal was the have ability be balanced over time in the different gift treatments combining over all the sessions, and as similar as possible on average even within a session.

NOTE: This experiment registration, including the full specification of the model and planned structural estimation, was written on 21 Nov 2014. This was after one full phase of data collection, with data on 131 subjects collected and two full rounds of treatment orders (that is, 24 sessions) completed. We plan to gather data on approximately 200 more subjects, making for a total of about 330 workers. But note that exact sample sizes will depend on (unpredictable) show-up of the invited workers. This will require collecting at least another two full rounds of treatment order sessions (T1-T12 twice over, in randomized order) and ideally four more full rounds (pending enough subjects to recruit). Notice that the only difference between the sessions run after Nov. 21, 2014 is the addition of an "in-kind gift" treatment, where workers are provided with an unanticipated gift (a thermos with the logo of the employing charity) in the gift periods, so the subjects are split four-ways in rounds 9-10. This treatment was not included in the first 24 sessions, since we thought of including this treatment after the initial 24 sessions.

2 Model

We model the effort choices of workers as depending upon both their own private incentives and effort costs, and possibly also the payoffs to their employers. In particular, we assume workers choose effort e (=to solve the following utility maximization problem:

$$\begin{aligned} \max_e u(e) &= W + p_W e - C(e) + A\left(Gift, p_F, p_W\right) e \\ s.t.\ e &\geq 0 \end{aligned} \tag{1}$$

The first piece of the utility function, $W + p_W e$, captures the private monetary payoff from participating in the experiment and putting effort e for risk-neutral subjects. The payment is the sum of a show-up fee $W \geq 0$ and a piece rate $p_W \geq 0$ (where W stands for worker). In the experiment, effort e will correspond to the number of envelopes prepared for mailing in a given 20 minute work session.

The second piece of the utility function, $C(e)$, captures the cost of effort from doing the task. We assume the regularity conditions $C'() > 0$, $C''() > 0$, $C'(0) = 0$ and $\lim_{e\to\infty} C'(e) = \infty$ to guarantee existence and uniqueness of the solution. Importantly, we will allow the cost of effort function to change over the course of the work day, as workers gain experience with the task, possibly begin to feel tired, etc.

The third piece captures how the worker internalizes the benefits that his effort provides to the employing firm. We assume that the firm earns a piece rate p_F (where F stands for firm) from effort e. In the context of the experiment, p_F corresponds to the average amount of donations raised per envelope mailed when the employer is a charity, and the average additional revenue raised from the solicitation and coupons mailed when the employer is a grocery store. The net returns to the firm would then also subtract out the piece-rate payment to the worker p_W, if any. The worker cares about the payoff to the firm with a social preference coefficient A, which may depend upon whether or not the worker received an unexpected gift $Gift$ from the employer. Importantly, we will consider two special cases of social preference below: (i) *altruism,* where the worker takes into account the exact payoffs $(p_F - p_W)e$ of the employer and thus $A = \alpha(p_F - p_W)$, and (ii) *warm glow*, where the worker simply places a weight on per unit of effort e he expends "for the employer", regardless of exactly how that effort translates into payoff for the employer; this, $A = a$.

The maximization problem (1) yields the first-order condition

$$p_W + A(Gift, p_F, p_W) - C'(e^*) = 0 \tag{2}$$

or

$$e^*(Gift, p_F, p_W) = C'^{-1}(p_W + A(Gift, p_F, p_W)) \tag{3}$$

where $C'^{-1}()$ is the inverse function of $C'()$, which exists and is monotonically increasing by the assumptions above. The second order conditions are trivially satisfied since $-C''(e^*) < 0$ by assumption, and the existence of a positive, finite solution is guaranteed by the assumptions $C'(0) = 0$ and $\lim_{e\to\infty} C'(e) = \infty$ as long as α is non-negative. The comparative statics are that the optimal effort is increasing in the social preference parameter A, and the piece rate p_W (provided A does not decrease enough in p_W) . Effort also increases in the return to the firm p_F as long as altruism A increases in p_F and is positive. Finally, the show-up fee W does not affect the productivity except for its possible effect on the altruism parameter through an unexpected gift.

2.1 Altruism

The first case we consider is that of pure altruism by the worker towards the employing firm. With altruism, the worker's utility depends on own payoff $(W + P_w e)$ and on the employer's exact payoff $(p_F - p_W)e$, where $(p_F - p_W)$ is the employer's net payoff per envelope prepared by the worker.

The level of altruism α may also be modified by whether the worker has received an unanticipated gift (positive monetary, positive in-kind, negative or neutral / no gift) from the firm. The effect of a gift on altruism is modeled as an additive term α_{gift}. We expect $\alpha_{gift} > 0$ for positive gifts, $\alpha_{gift} < 0$

for negative gifts, and $\alpha_{gift} = 0$ for the no gift condition. We also assume the effect of a gift, if any, decays in the next period by a multiplicative factor δ.

Thus, in the case of altruism, the social preference terms is:

$$A\left(Gift, p_F, p_W\right) = \left(\alpha + \alpha_{gift}\delta_t\right) * \left(p_F - P_w\right) * e \tag{4}$$

The entire utility maximization problem for the altruism model, then, for an individual i in session t given an experimental treatment order o, is then:

$$\begin{aligned} Max\ U_{ito} &= W_{to} + p_{W_{to}} * e_{ito} + (\alpha_{to} + \alpha_{gift_{to}}\delta_{to}) * (p_{Fto} - p_{W_{to}}) * e_{ito} - C_{ito}(e_{ito}) \\ s.t.\ e &\geq 0 \end{aligned}$$

2.2 Warm Glow Model

The warm glow model differs from the altruism model in that workers with warm glow do not take into account or "care" about the actual utility or payoffs of the employer, but instead derive utility only from the effort they themselves put in towards their employer's goals. This can be interpreted as individuals getting utility from the process of giving rather than the actual utility of the receiver.We consider this case to be closely related to the idea of warm glow proposed by Andreoni (1990), where donors derive utility from giving, but not necessarily from the public good itself. But this specification could also capture some social norm for putting in effort for an employer. As before, we allow for worker's warm glow to change as a result of receiving an unanticipated gift.

Thus, in the case of altruism, the social preference terms is:

$$A\left(Gift, p_F, p_W\right) = \left(a + a_{gift}d_t\right) * e \tag{5}$$

where a is the warm glow parameter, a_{gift} is the change due to receiving an unanticipated gift, d is the decay in the gift by the next period, and e is effort, as before. The entire utility maximization problem for the warm glow model, then, for an individual i in session t given an experimental treatment order o, is then:

$$\begin{aligned} Max\ U_{ito} &= W_{to} + p_{W_{to}} * e_{ito} + (a_{to} + a_{gift_{to}}d_{to}) * 0.3 * e_{ito} - C_{ito}(e_{ito}) \\ s.t.\ e &\geq 0 \end{aligned}$$

Note that the warm glow parameter, a, is scaled by multiplying by 0.3, the average net payoff to the firm per envelope in the experiment. This is simply a matter of convenience in comparing the estimated altruism and warm glow parameters, and leads to no less of generality.

2.3 Altruism and Warm Glow Model

This model combines the features of altruism and warm glow models, and includes parameters for both altruism and warm glow. We expect this to be at best an anciliary specification for estimation, since we are not well powered in simulations to separately estimate both warm glow and altruism jointly (and especially the differential effect of the gift on both altruism and warm glow).

In the altruism and warm glow model, an individual i in session t order o maximizes:

$$Max\ U_{ito} = W_{to} + p_{W_{to}} * e_{ito} + (\alpha_{to} + \alpha_{gift_{to}} \delta_{to}) * (p_F - p_{W_{to}}) * e_{ito} + (a_{to} + a_{gift_{to}} d_{to}) * 0.3 * e_{ito} - C_{ito}(e_{ito})$$

3 Reduced Form Analysis

The reduced form analysis will primarily consist of graphical plots making certain key comparisons of average effort levels across treatments and work periods, separately by UP and DOWN order, and also averaged across the two orders. The key comparisons are the following:

1. **Piece Rate Comparison**: Comparing average effort across real output (i.e. not training) sessions with no match and with the three possible levels of piece rate payment: \$0, \$0.10 and \$0.20 per envelope. This comparison shows the responsiveness of effort to own pay, and helps as a measuring rod to interpret the effect of the return to employer, training vs. non-training and gifts described below. We control for changes in worker productivity over time by making such comparisons over the orders UP and DOWN, which reverse the order of such comparisons.

2. **Training versus Real Work**: Comparing (i) the first training session with the real work session immediately following it, and (ii) the second training session with the real work session immediately following it. In each case, the training and real work sessions have the same private payoffs to the worker, but the real work session is meant to also activate the worker's social preferences towards the employer. This comparison reflects the strength of the social preferences towards the employer, although it does not distinguish altruism from warm glow utility. (Notice that in this reduced-form comparison it is hard to control for the fact that workers productivity changes over time)

3. **Match vs. No Match**: Comparing effort in the matched (i.e. high firm return) session with the unmatched (i.e. low firm return) session for the same charity with the same pay incentives. This will reflect the existence of pure altruism towards the employer. If workers social preferences are purely warm glow, effort should be the same between the match and no match conditions. Same as in (1), we use the change in order between UP and DOWN to control for changes in productivity over the workday.

4. **Comparison of Different Charities**: Comparing effort across the three different charities, pooled across the various pay schemes. This will reveal whether the social preferences towards the employer differs by employing charity. Same as in (1), we use the change in order between UP and DOWN to control for changes in productivity over the workday.

5. **Comparison of Charities and Firm**: Comparing effort when working for the firm versus working for the same pay scheme ($W = \$3.5, p_W = \$0.1$) for a charity, pooled across the three different charities. this comparison will reveal whether social preferences differ between the firm and charities. Same as in (1), we use the change in order between UP and DOWN to control for changes in productivity over the workday.

6. **Gift Treatments**: Comparing effort in the positive monetary gift, positive in-kind gift, control / neutral gift and negative gift treatments, separately by whether the gift treatment was match or no match (i.e. high versus low p_F). Unlike the other graphs, this will not be different in the UP and DOWN order.

7. **Gift Decay**: Comparing effort in the 9th and 10th periods, which correspond to the first and second gift sessions, pooling across match and no match sessions. This will provide evidence on how much the gift effect decays in one session of about 20 minutes.

   In each case, we will perform simple tests of significance of the difference in means across these groups.

4 Assumptions for Structural Estimation

We will estimate the model by non-linear least squares. This requires us to make functional form assumptions about the cost of effort function (including how it evolves over time as workers learn and possibly get tired over the course of the day), and distributional assumptions about the error term in the estimating equation. Below, we specify the benchmark estimating equations for the structural analysis.

4.1 Effort Cost Function

We will consider two main functional forms for the cost of effort function - a power cost function and an exponential cost function.

4.1.1 Power Effort Cost Function

The power cost function takes the form:

$$C_{ito}(e_{ito}) = exp(k_i) * (timetrend_t)\frac{e_{ito}^{1+s}}{(1+s)} * exp(-s * \epsilon_{ito})$$

The components of the cost function are

1. k_i: captures the worker fixed effect in ability.
2. $timetrend_t$: a function of time t intended to capture learning and tiredness effects, described below in a separate sub-section.
3. e: effort.
4. s: the curvature of the cost function.
5. $exp(-s * \epsilon_{ito})$: error term, with $\epsilon_{ito} \sim N(0, \sigma_\epsilon^2)$

Note the following properties of the power cost function, assuming curvature parameter $s > 0$ and $timetrend \geq 0$ for all time periods:

1. $lim_{e \to +\infty} = \infty$
   This follows directly

2. $C'() > 0$
   $C_{ito}(e_{ito}) = exp(k_i) * (timetrend) * \frac{e_{ito}^{1+s}}{(1+s)} * exp(-s * \epsilon_{ito})$
   $\Rightarrow C'() = e_{ito}^s * exp(k_i) * (timetrend) * exp(-s * \epsilon_{ito}) > 0$, given $timetrend > 0$ for all t

3. $C'(0) = 0$
   Follows from above

4. $C''() > 0$
   $C'() = e_{ito}^s * exp(k_i) * (timetrend) * exp(-s * \epsilon_{ito}) > 0$
   $\Rightarrow C''() = s * (e_{ito}^{s-1} * exp(k_i) * (timetrend) * exp(-s * \epsilon_{ito})) > 0$, given $s > 0$ and $timetrend > 0$

Altruism with Power Cost Function:

With the power cost function and considering the case of pure altruism, the first order conditions with respect to effort, e_{ito}, gives us the following equation:

$p_{W_{to}} + (\alpha_{to} + \alpha_{gift_{to}} \delta_{to}) * (p_F - p_{W_{to}}) = exp(\bar{k}) * (timetrend) * e_{ito}^s * exp(-s * \epsilon_{ito}) \quad (\#)$

$\Rightarrow e_{ito}^s = \frac{p_{W_{to}} + (\alpha_{to} + \alpha_{gift_{to}} \delta_{to}) * (p_F - p_{W_{to}})}{exp(k_i) * (timetrend) * exp(-s * \epsilon_{ito})}$

$\Rightarrow -s * \epsilon_{ito} = log(LHS(\#)) - k_i - log(timetrend) - s * log(e_{ito})$

$log(LHS(\#))$ denotes the expression in the left hand side of equation (#). The model then gives an equation for the log of effort which can directly be estimated via non-linear least squares.

$$\log(e_{ito}) = \frac{1}{s} * (log(LHS(\#)) - k_i - log(timetrend)) + \epsilon_{ito} \quad (6)$$

Warm Glow with Power Cost Function:

Similar to the altruism model, the first order conditions of the warm glow model are:

$p_{W_{to}} + (a_{to} + a_{gift_{to}} d_{to}) * 0.3 = exp(k_i) * (timetrend) * e_{ito}^s * exp(-s * \epsilon_{ito}) \quad (\# \#)$

which gives the following equation to estimate:

$$log(e_{ito}) = \frac{1}{s} * (log(LHS(\#\#)) - k_i - log(timetrend_t)) + \epsilon_{ito} \quad (7)$$

4.2 Exponential Effort Cost Function

We will also consider an alternative specification of effort, which assumes that cost is increasing exponentially in effort:

$$C_{ito}(e_{ito}) = exp(k_i) * (timetrend_t) * \frac{1}{s} * exp(s * e_{ito}) * exp(-s * \epsilon_{ito}) \quad (8)$$

Conveniently, the first order conditions for the model with exponential cost function is the log of the first order conditions with the power cost function. For example, for the altruism model the first order condition with exponential cost functions is:

$$p_{W_{to}} + (\alpha_{to} + \alpha_{gift_{to}}\delta_{to}) * (p_F - p_{W_{to}}) = exp(k_i) * (timetrend) * exp(s * e_{ito}) * exp(-s * \epsilon_{ito}) \quad (\#^*)$$

$$=> -s * \epsilon_{ito} = log(LHS(\#*)) - k_i - log(timetrend) - s * e_{ito}$$

$$=> e_{ito} = \frac{1}{s} * (log(LHS(\#*)) - k_i - log(timetrend) + \epsilon_{ito}$$

4.3 Time Effects - Learning, Tiredness etc.

An important potential confound in the experiment is the existence of learning and tiredness effects, or other changes over the course of the day which could end up correlated with the changes in pay schemes. These effects will not confound the reduced form estimate of the gift effects, since the variation in gift is randomized between subjects. However, it could potentially interfere with the within subject comparisons of effort in different pay schemes (e.g. fixed wage versus low piece rate versus high piece rate). We deal with this in the experimental design by having two orders of the treatment - UP and DOWN, which large reverse the order of the different pay schemes. But, especially for the structural estimation, we also explicitly model these time effects in two ways: a parametric approach assuming polynomial time trends in the cost of effort function, and an approach using dummy variables for different time periods. In each case, the time effect is modeled as multiplying the cost of effort function, through the $timetrend_t$ term in the cost of effort function described above. We describe both approaches below, with justifications:

4.3.1 Polynomial Time Trends:

Let t=time period (with $t = 1...10$ representing the 10 different twnty-minute work sessions each worker participates in over the course of a day). Then, we will estimate models with the following polynomial specifications for the $timetrend_t$ term:

1. Cubic function of time: $timetrend_t = 1 + \eta_1(t-1) + \eta_2(t-1)^2 + \eta_3(t-1)^3$
2. Quartic function of time $timetrend_t = 1 + \eta_1(t-1) + \eta_2(t-1)^2 + \eta_3(t-1)^3 + \eta_4(t-1)^4$
3. Robustness: Quintic function of time $timetrend_t = 1+\eta_1(t-1)+\eta_2(t-1)^2+\eta_3(t-1)^3+\eta_4(t-1)^4$

Justification: We want a sufficiently flexible learning function to allow for the sharp learning and

subsequent flattening out we observe in the pilot data. A quadratic specification would likely force a downward slope towards the final periods, which we do not want to impose. And our simulations suggest we do not have enough time periods or data to estimate precisely a sixth order specification, and limited power for a fifth-order quintic specification. Therefore, we will estimate cubic and quartic specifications as benchmarks, and a quintic as a robustness exercise.

4.3.2 Time Dummies:

Let d_t a dummy for time period t, and d_{t-k} a dummy taking a single value for all the time periods from t to k, including k. We will estimate models including the following list of dummies (where the absence of, say, d_2 would mean that there is no dummy for period 2 – the cost function is assumed to be same for all periods with missing dummies).

1. List of dummies: $d_3, d_4, d_5, d_6, d_{7-10}$: This is the most flexible dummy specification we will consider. Note that it does not include a dummy d_2 for period 2, since this dummies out the comparison of the first period (training) with the second period, which has the same worker incentives but with an actual payoff for the employer, and thus plays an important role in estimating altruism. We impose the same dummy from periods 7-19 since the pilot data suggest a flat trajectory in those periods. And dummying out the gift treatments substantially reduces power to estimate the gift effects, although we are still identified from the between subject comparison of positive, negative and neutral gifts.

2. List of dummies: d_3, d_4, d_{5-10}: This imposes more structure on the learning trajectory by requiring the same cost function in each period from 5 to 10. This is consistent with the observed trajectory of the pilot data, and the preliminary estimates of the dummies from the first phase of data collection (ending in mid 2014, and comprising about 1/3 of the total planned data).

3. List of dummies: $d_2 = 0.5 * d_3, d_3, d_4, d_{5-10}$: This now allows for learning from period 1 to 2, but not fully flexibly. Instead, it requires the dummy for period 2 to be halfway between the dummies for period 1 and 3. In other words, it requires a linear $timetrend_t$ term in the structural model from periods 1 to 3. We will also explore for robustness, $d_2 = 0.25d_3$ and $d_2 = 0.75d_3$.

5 Computational procedures

5.1 Non-Linear Least Squares

Non-linear least squares is used to estimate the parameters in equations 6, 7, 8 etc. We will use Stata's `nl` program for estimation, which uses the iterative Gauss-Newton method to converge to a solution. The `nl` command's option `delta` will be increased to $4e^{-10}$ from its default $4e^{-7}$. This value specifies the change in the tolerance parameter to be used when calculating the numeric derivatives, and the chosen value provides good convergence in simulations and with pilot data. Finally, the parameter estimates are calculated with robust standard errors and clustered by time session.

5.2 Starting Values

Starting values for each parameter to initialize the non-linear least squares estimation are picked randomly from a normal distribution to ensure the estimates are not sensitive to any particular starting value. Each starting value for each parameter is drawn from a uniform distribution over a range of plausible parameter values. Once a set of parameter starting values is chosen, the non-linear least squares model is estimated. The best (lowest least squares) estimate is selected as the overall result. Multiple estimations over different sets of parameter starting values are compared to ensure the parameter final estimates have converged.

6 APPENDIX: Notation

t: session number (excluding lunch session).
o: order number. In pilot, $o = 1$ means Order 1 (four sessions before lunch).

U_{ito}: utility of individual i in (session t and order o).
W_{to}: show up fee in (...).
$p_{W_{to}}$: piece rate wage for participants in (...).
$p_{F_{to}}$: piece rate revenue for firm in (...).
e_{ito}: effort level for individual i in (...).
α_{to}: altruism parameter in (...), which takes α_j for charity j ($j = 1, 2, 3$), α_f for firm and 0 for Becker center in training sessions.
$\alpha_{pos_{to}}$: the effect of positive gift on altruism parameter in (...).
$\alpha_{neg_{to}}$: the effect of positive gift on altruism parameter in (...).
δ_{to}: gift decay effect on altruism in (...), which takes value 1 when the gift first presents (in the second last session), and takes value δ when it presents again (in the last session).
$C_{ito}(e_{ito})$: individual i's cost in (...), when he exerts effort e_{ito}.
k_{io}: individual i's ability in order o.
η_{t-1}: time trend that captures learning, physical and mental fatigue overtime. $\eta_0 = 0$.
s: curvature of the cost function. $1/s$ is the piece rate elasticity of the cost function.
lunch: a lunch dummy to capture the lunch fixed effect.
a_{to}: warm glow parameter in (...), which takes a_j for charity j ($j = 1, 2, 3$), a_f for firm and 0 for Becker center in training sessions.
$a_{pos_{to}}$: the effect of positive gift on warm glow parameter in (...).
$a_{neg_{to}}$: the effect of negative gift on warm glow parameter in (...).
d_{to}: gift decay effect on warm glow in (...), which takes value 1 when the gift first presents (in the second last session), and takes value d_{num} when it presents again (in the last session).