Quota Dynamics and the Intertemporal Allocation of Salesforce Effort

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  - The literature on quotas (theory and empirical) is relatively sparse

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- Salespeople choose effort based on achievement relative to quota

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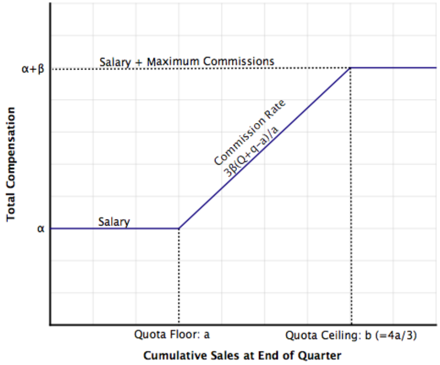
Agenda

- Introduction
- Model Framework
- Data and Model-Free Evidence
- Econometric Implementation
- Results
- Counterfactuals
- Conclusions



- Compensation = Salary + Commission × **I**(Quota<Sales<Ceiling)
  - No bonus, Ceiling is a fixed fraction of quota
  - Quota is reset on a quarterly basis and is adjusted based on current performance ("ratcheting")

- Compensation Scheme

$$w_t = \alpha + \beta \mathbf{I}\left(I_t = N\right)\left[\begin{array}{c} \left(\frac{Q_t + q_t - a_t}{b_t - a_t}\right)\mathbf{I}\left(a_t \leq Q_t + q_t \leq b_t\right) \\ +\mathbf{I}\left(Q_t + q_t > b_t\right) \end{array}\right]$$

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- Current Payoff

$$u_t = E[w_t] - r \operatorname{var}[w_t] - C(e_t; d)$$

- Cumulative Sales

$$Q_{t+1} = \begin{cases} Q_t + q_t & \text{if} \quad I_t < N \\ 0 & \text{if} \quad I_t = N \end{cases}$$

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$$a_{t+1} = \begin{cases} a_t & \text{if} \quad I_t < N \\ \sum_{k=1}^{K} \theta_k \Gamma\left(a_t, Q_t + q_t\right) + v_{t+1} & \text{if} \quad I_t = N \end{cases}$$

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- Months of the quarter

$$I_{t+1} = \begin{cases} I_t + 1 & \textit{if} \quad I_t < N \\ 1 & \textit{if} \quad I_t = N \end{cases}$$

Value Function
Early in the quota cycle

$$V\left(Q_t, a_t, I_t; \Omega, \Psi\right) =$$

$$\max_{e>0}\left\{\begin{array}{l} u\left(Q_t, a_t, I_t, e; \Omega, \Psi\right) \\ \quad +\rho \int_{\varepsilon} V\left(Q_{t+1} = Q\left(Q_t, q\left(\varepsilon_t, e\right)\right), a_{t+1} = a_t, I_t + 1; \Omega, \Psi\right) \\ \qquad \qquad \qquad \times f\left(\varepsilon_t\right) d\varepsilon_t \end{array}\right\}$$

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End of the quota cycle

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- Empirical Approch
  - Estimate $\widehat{\Omega}$ given Ψ and current DGP
  - Simulate $e\left(\mathbf{s}_t; \widehat{\Omega}, \Psi = \Psi_{new}\right)$ under counterfactual

Our Data are Unusually Rich

Cross-sectional and Temporal Variation for Each Agent

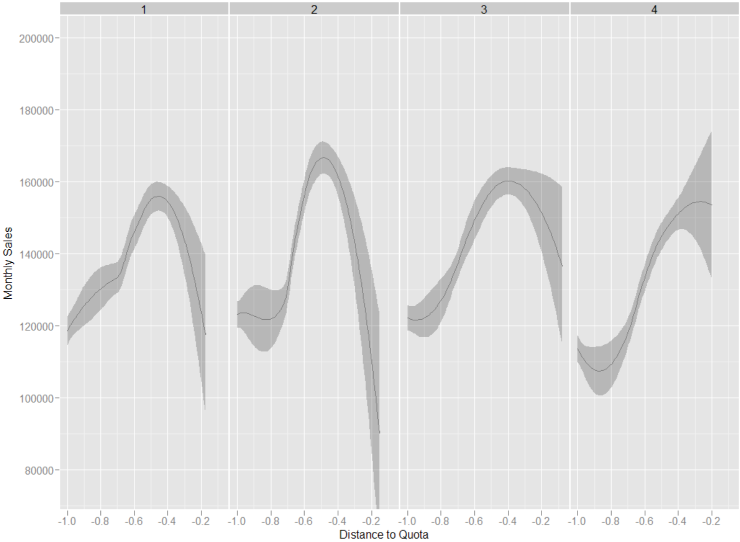
- Data come from a salesforce/division of a Fortune 500 firm
- Medical product (non-pharma) prescribed by physician
- Spans four years (2004-2007)
- Sales and detailing calls for each salesperson at month/client level
  - Salesforce has about 90 salespeople
  - on average ~150 clients per salesperson!
  - Gives us ~3600 obs **per salesperson** and ~324,000 obs total.
- Complete compensation details for each salesperson
  - Quotas for each quarter
  - Commissions and salaries paid.

Descriptive Statistics of Data

Variable	Mean	SD
Salary	$67,632	$8,585
Incentive Proportion at Quota	0.23	0.02
Age	43.23	10.03
Tenure	9.08	8.42
Num_Clients	162.20	19.09
Quota	$397,020	$95,680
Cum:Sales (end of quarter)	$374,755	$89,947
%ΔQuota (when +)	10.01%	12.48%
%ΔQuota (when -)	-5.53%	10.15%
Monthly Sales	$138,149	$38,319
Cum:Sales (beg: of month)	$114,344	$98,594
Distance to Quota (beg: of month)	$278,858	$121,594

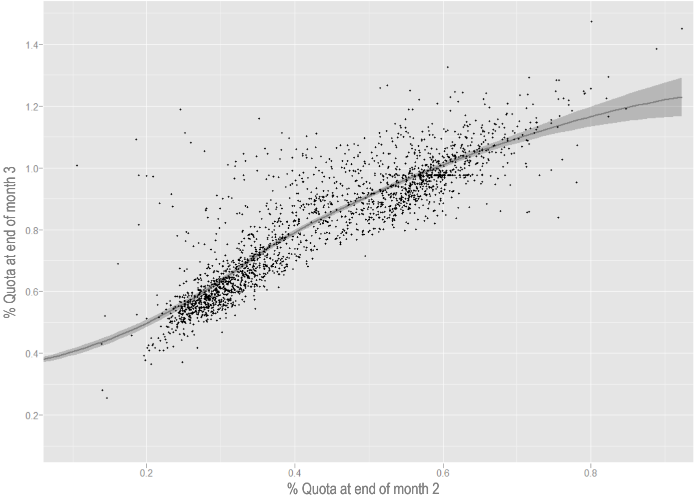
Effort Timing by Agents

Model free evidence - Sales as a function of distance to quota



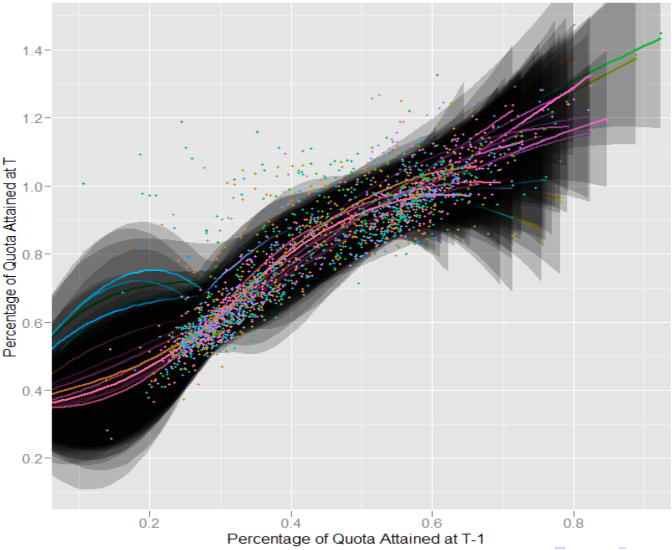
Effort Timing by Agents

Model Free Evidence - Near Quota Effort



Effort Timing by Agents

Model Free Evidence - Individual Salespeople



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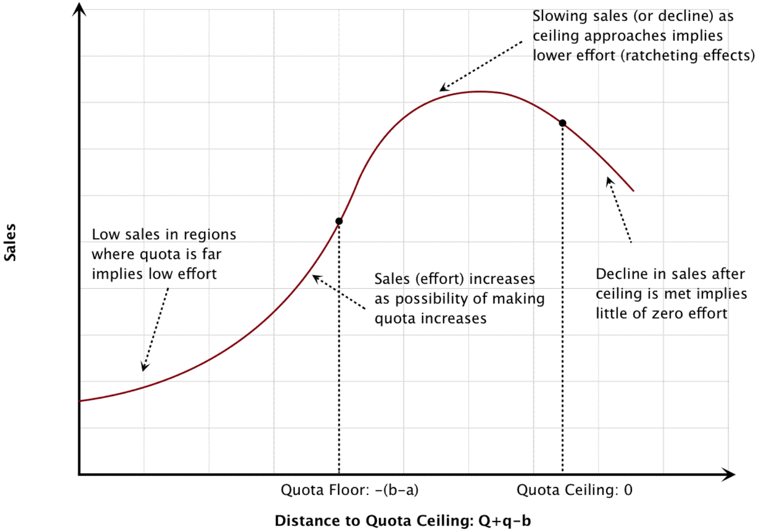
  - Unobservability of effort (pervasive in principal-agent settings)

Identification of Effort Policy



Econometric Implementation

Nonparametric Estimation of the Effort Policy Function

- Control Variable

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  - Empirical distribution of month-specific errors, $\hat{\varepsilon}_t = \sum_j \left(q_{jt} - \left(\hat{\delta}' \mathbf{z}_j + \hat{e}\left(\mathbf{s}_t\right) D_{jt}\right)\right)$

Intuition for identification of effort

Two steps

- Step 1: Estimate period specific productivity of sales-calls

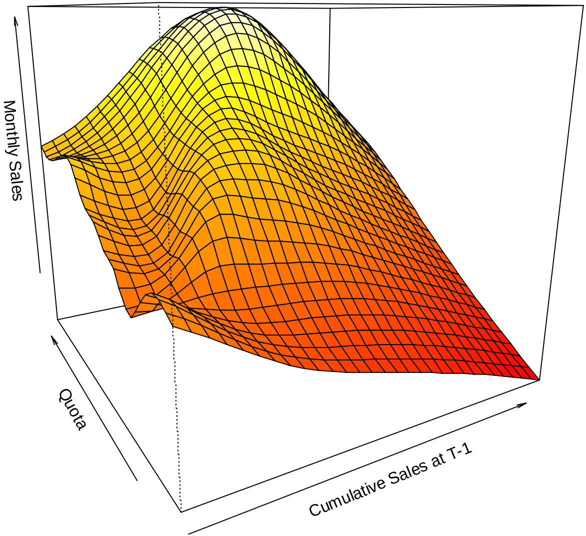
$$q_{jt} = \delta' \mathbf{z}_j + \gamma_t D_{jt} + \varepsilon_{jt}$$

- Step 2: Project productivitiy on flexible function of the state

$$\widehat{\gamma}_t = \lambda' \boldsymbol{\vartheta} (\mathbf{s}_t)$$

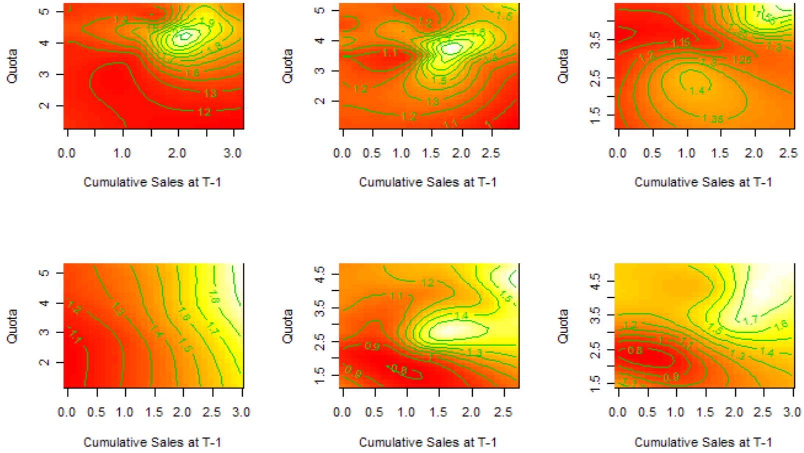
Estimation Results

Estimated Effort Policy ("average" agent)



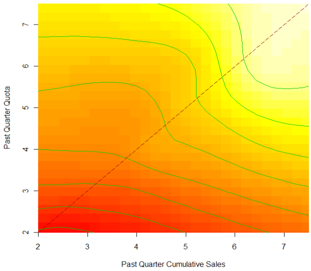
Estimation Results

Examples of Individual Effort Policy Estimates



Econometric Implementation

Estimating the Quota policy function



- Above quota policy was estimated using bivariate splines. (Preliminary)
- For now we use,

$$a_{t+1} = \underset{(0.056)}{1.25}\, a_t + \underset{(0.021)}{0.539}\, Q_t$$

$$\left(R^2 = 0.48\right)$$

Solving for Optimal Effort

DP Implementation details

- Recall that optimal effort solves

$$e\left(\mathbf{s}_t;\Omega,\Psi\right)=\arg\max_{e>0}\left\{V\left(\mathbf{s}_t;\Omega,\Psi\right)\right\}$$

- This requires solving for the fixed point in V and maximizing to obtain e_t.
- The optimal effort policy was solved using modified policy iteration (Rust 1996).
  - Policy approximated over the two continuous states using 10 points in each state dimension.
  - Expectations over the distribution of the demand shocks (ε_t) implemented using Monte Carlo integration using 1000 draws
  - Quota ratcheting error, (v_{t+1}) was integrated out using Gauss Hermite quadrature
  - Maximization involved in computing optimal policy was implemented using the highly efficient SNOPT solver

Optimal Effort-Policy

Distortions from Quota

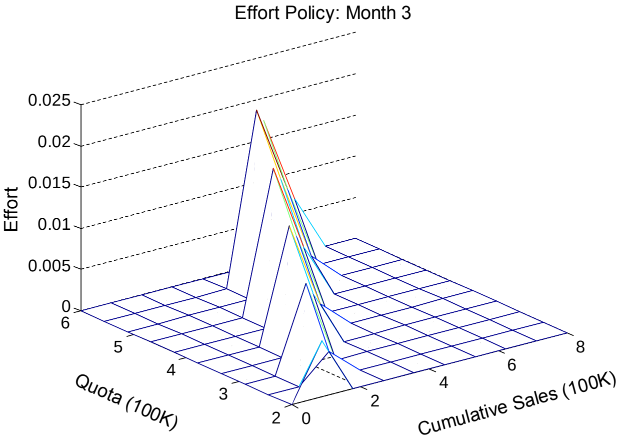
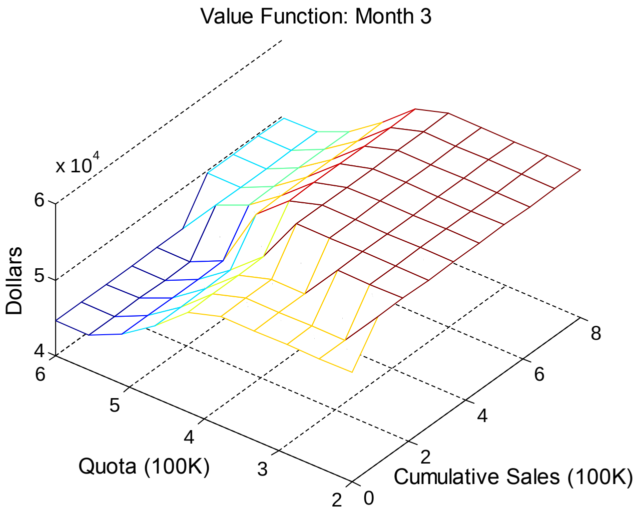


Figure:

Value Function

End of quarter value function



Predicted Sales from Model

Recovering the "Scalloped" Sales Patterns

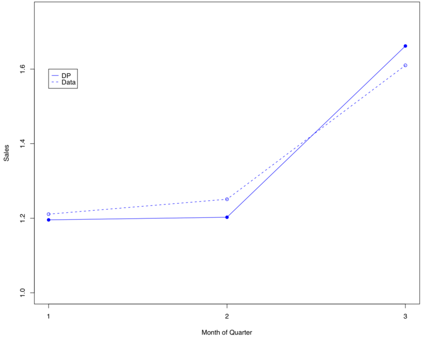


Figure:

- DP recovers the sales pattern in the data "remarkably" well
- Under predicts sales in months 1 and 2 and overpredicts in 3.

Evaluating the compensation scheme

Comparisons with counterfactual schemes

- First-best (firm can observe effort)

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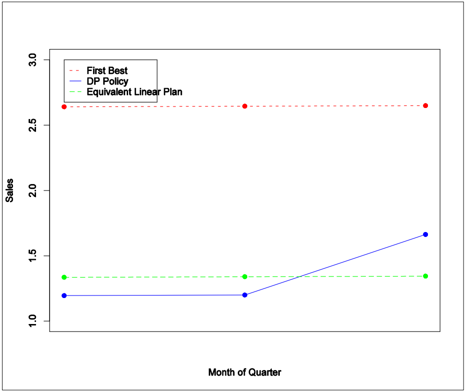
- No intertemporal reallocation under either plan
- Approach will be to simulate effort and sales, under the two plans



- First best achieves quarterly sales of about $800,000
- Compared to average sales of $370,000 under the current plan
- A linear compensation plan with a 9% commission would achieve similar sales.

Conclusions

- Developed a realistic framework to understand the net effects of quota based schemes in real-wrold business settings

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    - Your comments are welcome!

Thank you!

APPENDIX

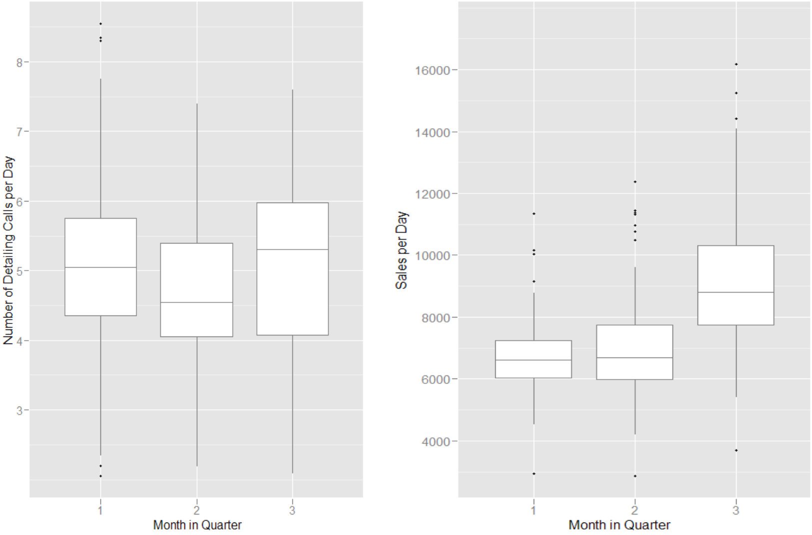
Analysis of Sales-Calls

Sales-Calls are not a decision variable for the agent

- Neither number nor allocation of calls across clients is under control of the agent.
- Management pre-specifies number and distribution of calls across client types
- Agents adhere closely to this top-down management specification
- Though sales-calls are observed, the firm specifies compensation based on sales, not calls.

Analysis of Sales-Calls

Agents adhere closely to specifications



Analysis of Sales-Calls

Sales-Calls do not explain sales, and are unrelated to quota attainment

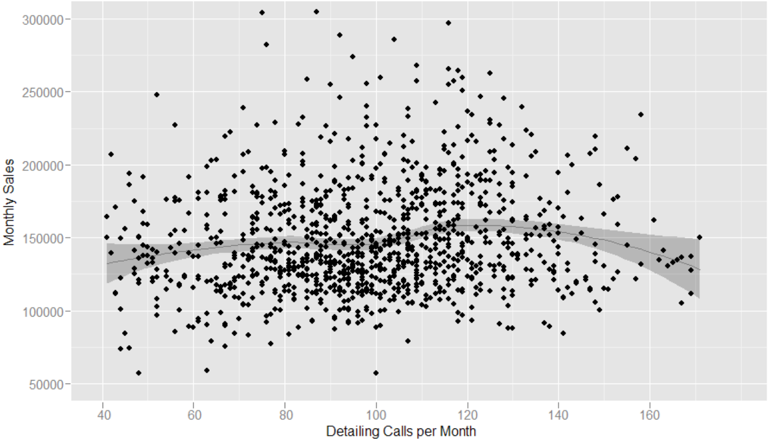


Figure: Number of sales-calls and Realized Sales

Analysis of Sales-Calls

Sales-Calls Distribution across clients do not vary by month-of-the-quarter

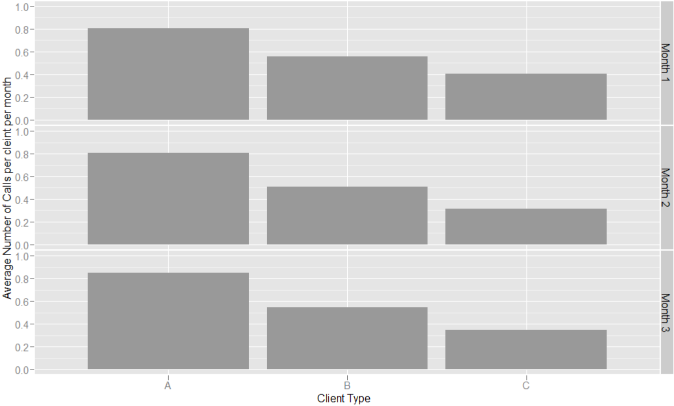


Figure: Sales-Calls by Client Type

Analysis of Sales-Calls

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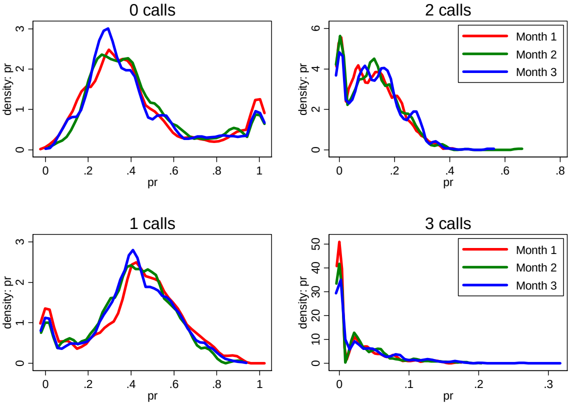

Figure: Proportion of calls made by month-of-quarter to type 'A' clients

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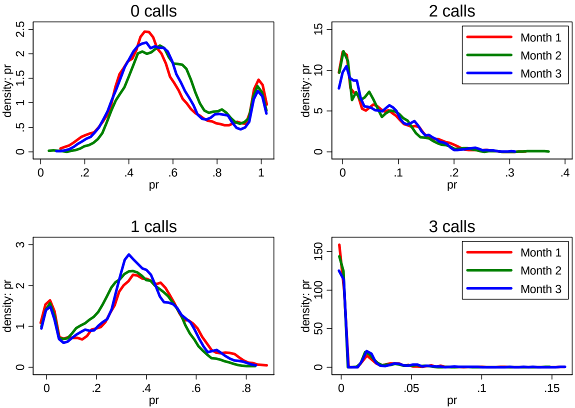

Figure: Proportion of calls made by month-of-quarter to type ‘B’ clients

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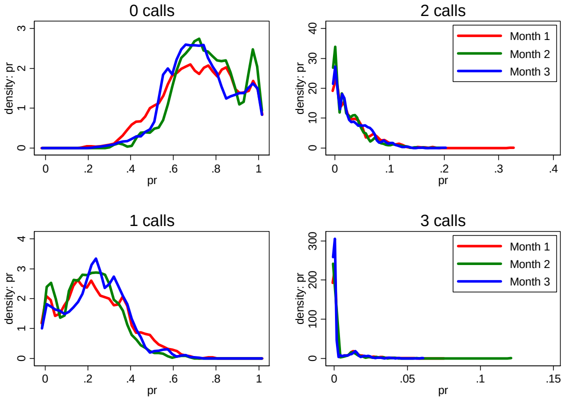

Figure: Proportion of calls made by month-of-quarter to type ‘C’ clients