

The Tipping Point: Analysis of Conditions

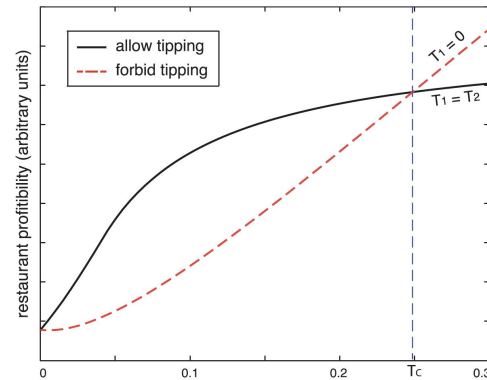
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Introduction

Reference Paper: *The Tipping Point A Mathematical Model for Profit Driven Abandonment of Restaurant Tipping*, Sarah M. Clifton et al (2018)

- Restaurants will abandon tipping after reaching a critical threshold. (25%)
- Employee Dynamics: Waiters Decrease
- Diners value increase
 - Decrease menu value and quality



Model

Fraction of Diners

$$\frac{dD}{dt} = (1 - D) \frac{v_1}{v_1 + v_2} - D \frac{v_2}{v_1 + v_2}$$

$$v_1(W, C) = \frac{W + r_{cw} C}{m_1(1 - T_1)}$$

$$v_2(W, C) = \frac{(1 - W) + r_{cw}(1 - C)}{m_2(1 - T_2)}$$

Fraction of Waiters

$$\frac{dW}{dt} = (1 - W) \frac{b_{w1} + g_1}{b_{w1} + g_1 + b_{w2} + g_2} - W \frac{b_{w2} + g_2}{b_{w1} + g_1 + b_{w2} + g_2}$$

$$g_1(D, W) = \frac{m_1 r_{DW} D T_1}{W}$$

$$g_2(D, W) = \frac{m_2 r_{DW} (1 - D) T_2}{1 - W}$$

Fraction of Cooks

$$\frac{dC}{dt} = (1 - C) \frac{b_{c1}}{b_{c1} + b_{c2}} - C \frac{b_{c2}}{b_{c1} + b_{c2}}$$

Hourly Profit

$$P(D, W, C) = m_1 r_{DW} D - b_{w1} W - b_{c1} r_{cw} C$$

Goals

Condition: No Tip and Equal Wage (\$18.53)

- Explore the impact of R value
- Explore changes in restaurant operations when number of diners, number of cooks, and number of waiters change

Numerical Results

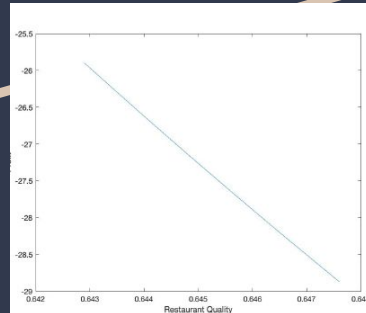


Figure 6: Restaurant Quality and Profit

Constant Conditions: No Tips, Equal Wage, and Equal N_D, N_W, N_C

Refer below for the ODE modeled with the conditions listed above.

Fraction of Diners

$$\frac{dD}{dt} = \frac{1}{3} - \frac{2}{3}D \quad (11)$$

Fraction of Waiters

$$\frac{dW}{dt} = -W + \frac{1}{2} \quad (12)$$

Fraction of Cooks

$$\frac{dC}{dt} = -C + \frac{1}{2} \quad (13)$$

- Negative profit
 - Constant expenses
 - Equal number of diners, waiters, and cooks (10)

No Tips, Equal Wage, and $N_D = 2, N_W = 5, N_C = 3$

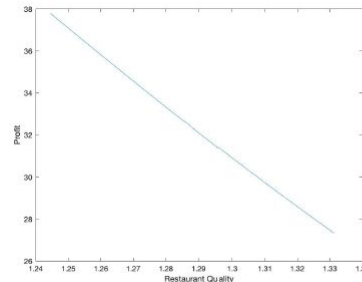
- Negative profit
- More expenses than incoming cash flow.

MATLAB Code

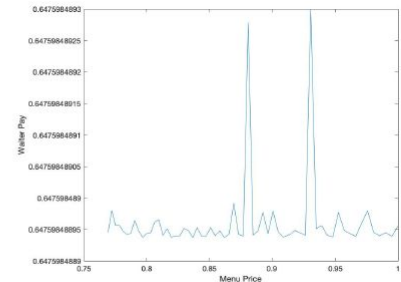
- Utilized optimization code provided. Created additional code to generate plots with different variables.

No Tips, Equal Wage, and $ND = 10, NW = 5, NC = 3$

- R value range: [4,20]
- Restaurant operations depend heavily on diners needs.
 - Cooks become more important in restaurant operations.
- 2 Reasons for Decreased Profit
 - Increased expenses (Cooks pay increases)
 - Change in restaurant dining style: Fine Dining



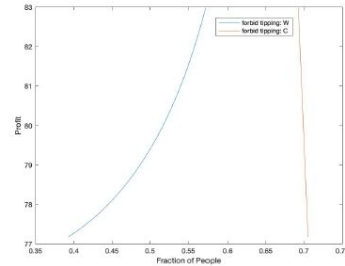
(a) Restaurant Quality and Profit



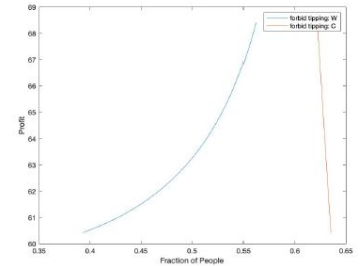
(b) Waiter Pay and Menu Price

No Tips, Equal Wage, $N_D = 10$, $N_W = 3$, $N_C = 1$

- Optimization of employees
 - One waiter for five tables and four cooks for 50 customers per hour
- Max profit compared to past simulations
 - $N_D = 10$, $N_W = 2$, and $N_C = 2$.



(a) Fraction of People and Profit Using Optimization



(b) Fraction of People ($N_D = 10, N_W = 2 = N_C$) and Profit

Discussion/Key Points

Restaurant Operations

- Diners needs (R value)
- Employee optimization
- Business model importance
 - Unique marketing for increase in diner demand

Current Model Problems

- Limited modeling variables and accuracy
 - Expenses do not include other variables (utilities, raw material expenses).
 - Decreased accuracy in profit modeling
- Models limited styles of restaurant dining
 - Might not be able to model fine dining or other styles

Next Steps

- Improve model accuracy by considering diverse variables when calculating profit.
- Create models for different styles of dining
 - Difference between fine dining and fast food

References

(1) Clifton SM, Herbers E, Chen J, Abrams DM. The tipping point: A mathematical model for the profit-driven abandonment of restaurant tipping. Chaos. 2018 Feb;28(2):023109. doi:10.1063/1.5004711. PMID: 29495672.

(2) Glasmeier, Amy K. "LivingWage Calculator." LivingWage Calculator - LivingWage Calculation for Boulder County, Colorado, <https://livingwage.mit.edu/counties/08013>.

(3) Edmonds, Kadence. "How Many Members of Staff Do I Need in My Restaurant?" Epos Now, Epos Now, 31 Mar. 2021, <https://www.eposnow.com/us/resources/how-many-members-of-staff-do-i-need-in-my-restaurant/>.