

The elasticity of demand for gambling: How much should the machine give me back to make me lose all my money?

Thomas Breda

Groupe de Travail Risques, Paris School of Economics

October 22, 2015

Motivation

- Unique dataset on slot machines: “price” and aggregate demand both observed.
- 3 goals:
 - See if people play more when the machine gives back more.
 - Try to define a price of gambling and see if gambling can be rationalized.
 - More broadly, try to understand why people play (not done here...).

Motivation

- Unique dataset on slot machines: “price” and aggregate demand both observed.
- 3 goals:
 - See if people play more when the machine gives back more.
 - Try to define a price of gambling and see if gambling can be rationalized.
 - More broadly, try to understand why people play (not done here...).
- But a limitation: no individual data.
 - inferring gambling behavior from aggregate data might rely on heroic assumptions

“Context”

- The market grew rapidly since 1987: More than 40 Billions bet and 2 Billions spent in 2006. It does not grow anymore.
- 40 billions is 2% of France GDP. Gambling represents a higher share in the household budget than books and newspapers.
- 15 euros per minute are bet in average on each machine when casinos are open.
- The profits are made over a small number of players who play a lot (often on 2 or 3 machines) and often with low socio-professional background.

Difference with other games

- Different from National Lottery which offers very high prizes.
- Different from sports or horse races betting and from poker which require skills
- But close from Scratch cards
- Considered by psychologists as very addictive
 - possible to play again immediately
 - high payout rate
 - human bias: overoptimism. belief that you can win, that gains can actually exceed losses
 - neurologic explanation: thrill to experience a jackpot
 - rational economic explanation: cheap leisure

Data description

- 1020 slot machines (for a total of 22000 in France)
- in 6 casinos (for a total of 197 in France)
- monthly data during 2 years (2004, 2005, while casinos exist since 1987)
- Available information:
 - Machine identifying number and place
 - Date (month)
 - Minimum bet on the machine (mise minimale): m
 - Expected Payout rate (Taux de Retour Joueur): t_e = expected gain for a bet equal to 1 (or ratio between expected gains and amount bet)
 - Realized Payout rate (Taux de Retour Joueur): t_r = average realized gain for a bet equal to 1.
 - Number of units bet: n = number of time the minimum bet has been bet.
 - Turn over or sales (Chiffre d’Affaire): $s = n * m$ = total money bet (including “re-bet” of gains).
 - Gross profit (Produit Brut des Jeux): $\Pi = s(1 - t_r)$ with t_r = realized payout rate.

Original data: Modèle 35 des feuillets de la comptabilité publique

CASINO: CASINO LE PHARAON

SAS Grand Casino de Lyon
70 Quai Charles de Gaulle
69006 Lyon
Tel: 04 78 17 53 53

Etat mensuel de détermination des produits, théorique et réel, des jeux des machines à sous

Modèle n° 35

Article 74-2 de l'arrêté

du 25 Décembre 1989

modifié

Période du 01/11/2005 Au 31/10/2006

Devise : EUR

Machine	Socle	PRODUIT THEORIQUE DES JEUX DE LA PERIODE						Produit réel de la période
		Compteur électronique n°1 Nombre de pièces ou de jetons enregistrés durant le mois	Compteur mécanique n°2 Nombre de pièces ou de jetons enregistrés durant le mois	Cptr électronique des entrées cartes nb d'unités	Valeur unitaire des mises	Complément à 100 du taux de redistribution de la machine	produit théorique des jeux (2) $S = (1 \text{ ou } 2) \times 4 \times 5$	
1	153	5 850 652	5 850 652	0	20 Cents	11,54 %	135 033,05	156 081,20
2	152	6 479 776	6 479 776	0	20 Cents	11,54 %	149 553,23	161 669,40
3	343	6 634 997	6 634 997	0	20 Cents	11,54 %	153 135,73	171 876,00
4	344	6 916 359	6 916 359	0	20 Cents	11,31 %	156 448,04	145 881,20
5	345	6 310 407	6 310 407	0	20 Cents	11,54 %	145 644,19	171 960,00
6	151	9 293 360	9 293 360	0	20 Cents	11,88 %	220 810,23	223 808,40
7	150	6 479 029	6 479 029	0	20 Cents	12,99 %	168 325,17	191 712,40
8	340	7 311 688	7 311 688	0	20 Cents	12,79 %	187 032,98	186 280,40
9	341	6 820 638	6 820 638	0	20 Cents	12,99 %	177 200,18	200 657,40
10	342	1 550 996	1 550 996	0	20 Cents	12,99 %	40 294,88	47 008,80
10	342	5 215 232	5 215 229	0	20 Cents	7,96 %	83 235,10	92 825,40
11	811	7 856 468	7 826 068	0	20 Cents	12,49 %	196 254,57	208 718,80
12	812	10 374 558	9 474 428	0	20 Cents	12,47 %	258 741,48	291 114,60
13	813	9 923 443	9 923 255	0	20 Cents	12,50 %	248 086,08	242 068,60
14	814	8 488 561	8 488 454	0	20 Cents	12,44 %	211 195,40	217 627,80
15	815	8 999 270	8 999 059	0	20 Cents	12,50 %	224 581,75	225 078,60
16	553	4 901 664	4 901 664	0	50 Cents	8,83 %	216 408,47	225 825,50
17	131	1 374 824	1 374 824	0	50 Cents	9,06 %	62 279,53	72 043,50
18	554	4 460 280	4 460 280	0	50 Cents	7,96 %	177 519,14	189 265,00
19	128	2 664 596	2 664 596	0	50 Cents	7,18 %	95 659,00	96 619,50
20	541	1 568 533	1 568 533	0	1 Euro	9,21 %	144 461,89	105 279,00
21	542	2 267 586	2 267 585	0	1 Euro	7,18 %	162 812,67	189 712,00
22	555	3 555 636	3 555 636	0	50 Cents	7,97 %	141 692,09	145 160,50
23	543	1 983 145	1 983 140	0	1 Euro	5,03 %	99 752,19	103 525,00
24	124	1 266 268	1 266 264	0	1 Euro	7,16 %	90 664,79	96 265,00

Original data: zoom

Machine	Socle	PRODUIT THEORIQUE DES JEUX DE LA PERIODE						Produit réel de la période
		Compteur électronique n°1 Nombre de pièces ou de jetons enregistrés durant le mois	Compteur mécanique n°2 Nombre de pièces ou de jetons enregistrés durant le mois	Cptr électronique des entrées cartes nb d'unités	Valeur unitaire des mises	Complément à 100 du taux de redistribution de la machine	produit théorique des jeux (2) $5 = (1 \text{ ou } 2) \times 4 \times 5$	
1	153	5 850 652	5 850 652	0	20 Cents	11,54 %	135 033,05	156 081,20
2	152	6 479 776	6 479 776	0	20 Cents	11,54 %	149 553,23	161 669,40
3	343	6 634 997	6 634 997	0	20 Cents	11,54 %	153 135,73	171 876,00
4	344	6 916 359	6 916 359	0	20 Cents	11,31 %	156 448,04	145 881,20
5	345	6 310 407	6 310 407	0	20 Cents	11,54 %	145 644,19	171 950,00
6	151	9 293 360	9 293 360	0	20 Cents	11,88 %	220 810,23	223 808,40
7	150	6 479 029	6 479 029	0	20 Cents	12,99 %	168 325,17	191 712,40
8	340	7 311 688	7 311 688	0	20 Cents	12,79 %	187 032,98	186 280,40
9	341	6 820 638	6 820 638	0	20 Cents	12,99 %	177 200,18	200 657,40

Legal Requirements

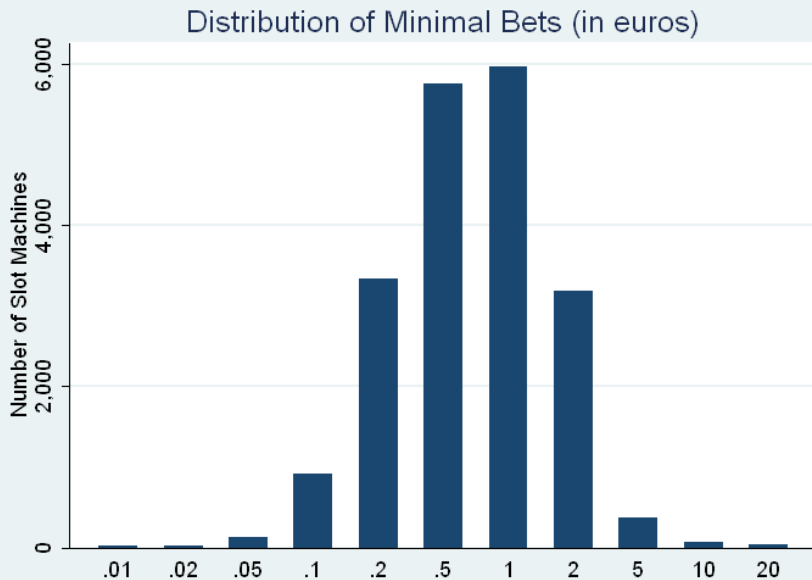
- The Pre-programmed (Expected) Payout Rate t_e must be higher than 86%.
 - Anti-addiction policy should actually impose a ceiling, not a floor.
- Machines have many payout rates pre-programmed.
- Casinos can change the pre-programmed payout rate.
(This must be done by an external firm which visits every casino in principle every 3 months)
- Changes in payout rates induce a double declaration a given month. I have deleted the observations with double declaration.
- Minimal bets and slot machine places can also be changed by the casino.

Number of changes

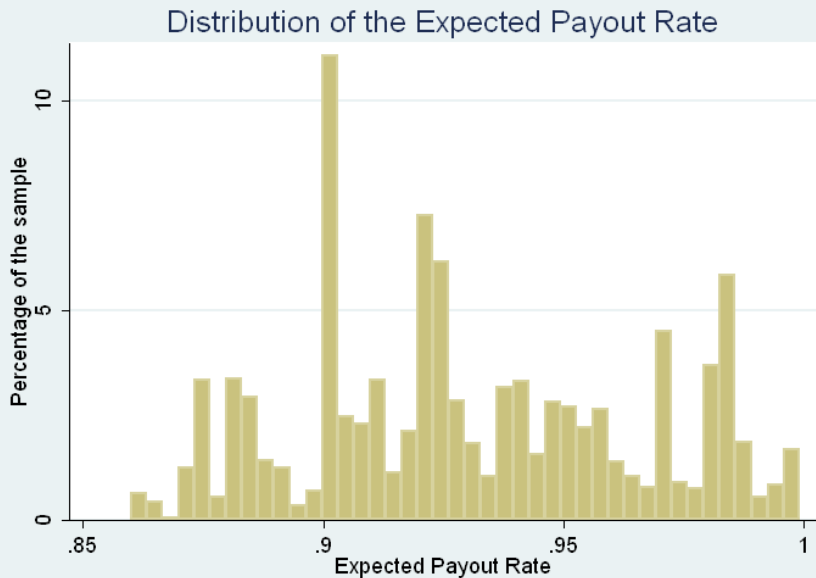
Table: Number and proportion of structural changes done by the casinos

	Nb. of obs	Proportion
t_e changed	430	2.2%
Minimum bet changed	231	1.2%
Place changed	1064	5.4%
Only t_e changed	173	0.9%

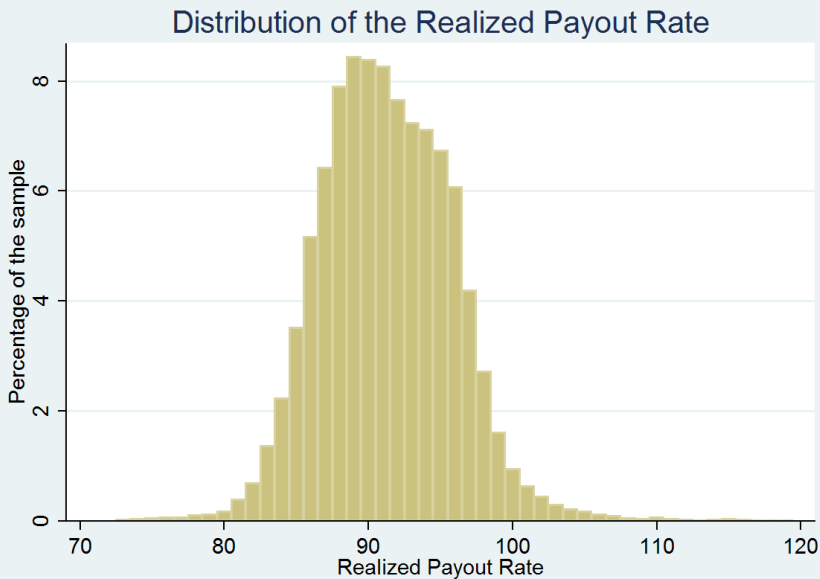
Distribution of Minimal Bets



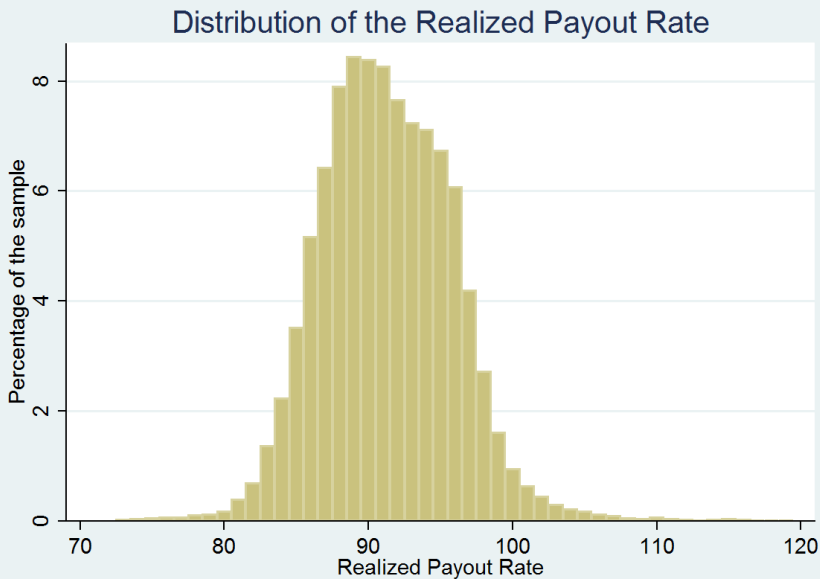
Distribution of Expected Payout Rates



Distribution of Realized Payout Rates

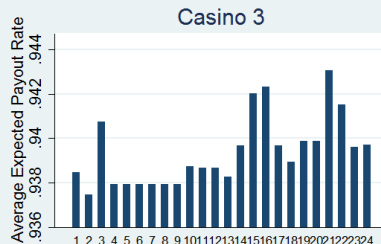
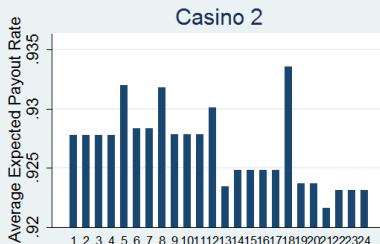
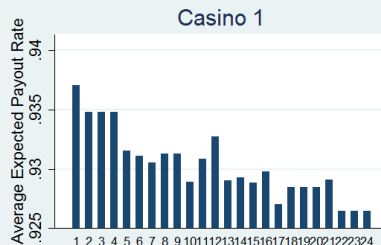
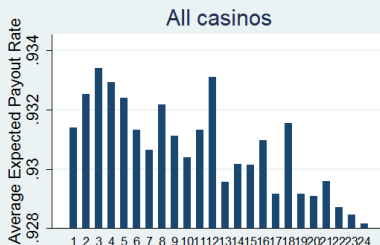


Distribution of Realized Payout Rates

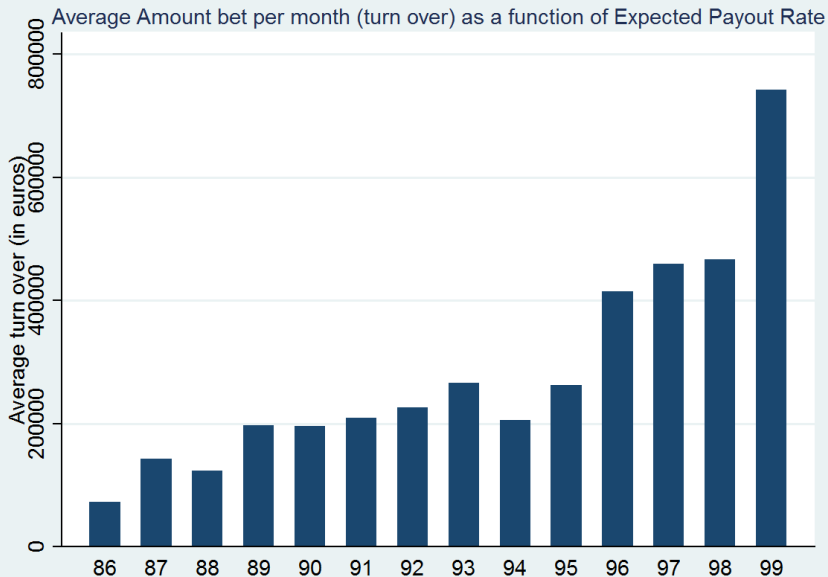


Evolution of Realized Payout Rates with time

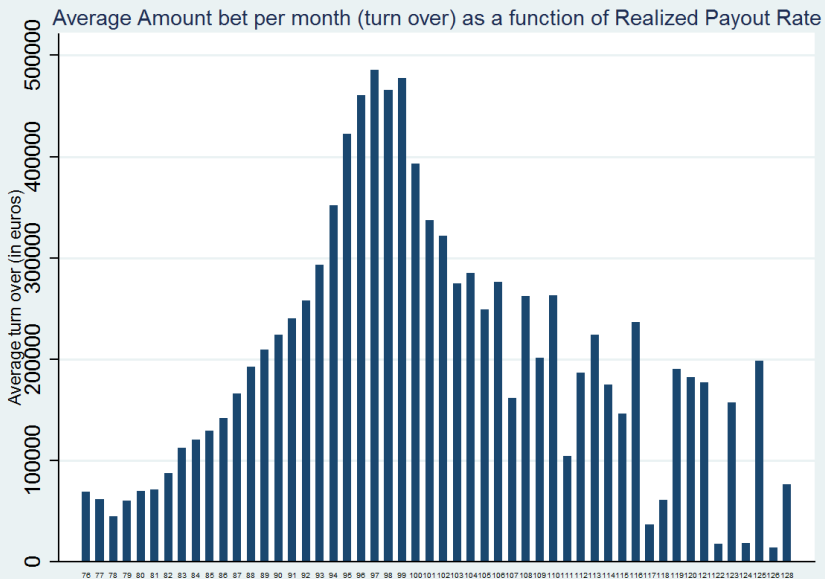
Evolution of the Expected Payout Rate with time



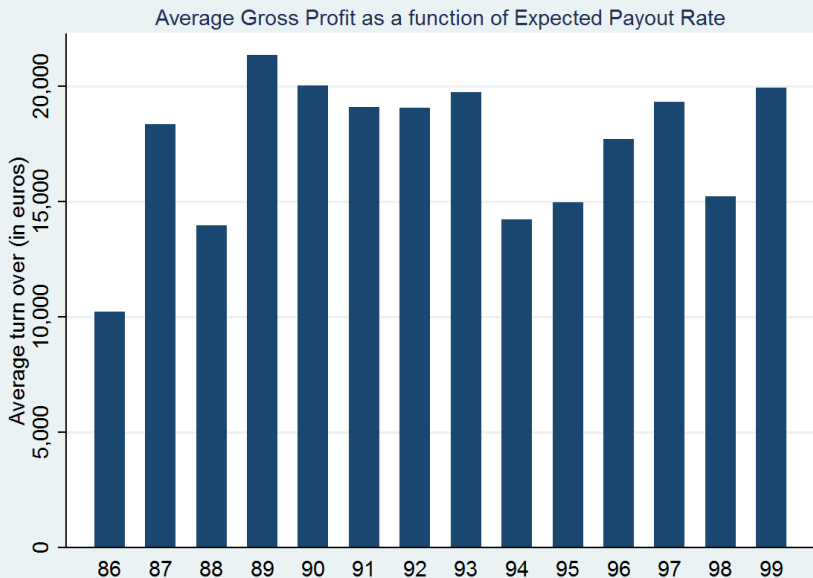
Turn Over as a function of Expected Payout Rates



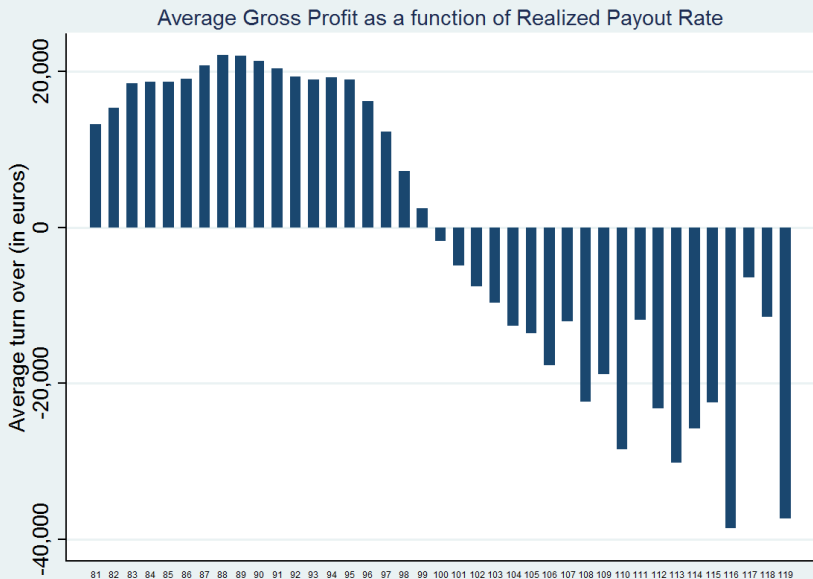
Turn Over as a function of Realized Payout Rates



Turn Over as a function of Expected Payout Rates

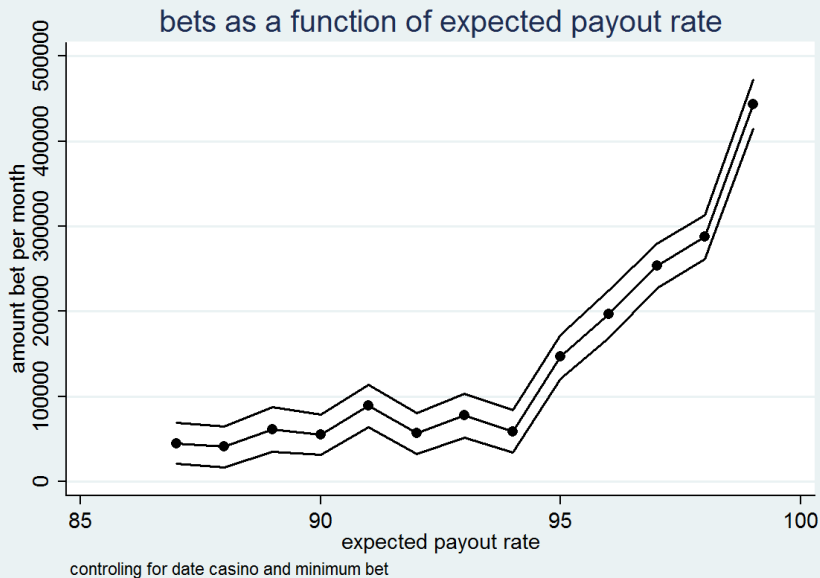


Turn Over as a function of Realized Payout Rates

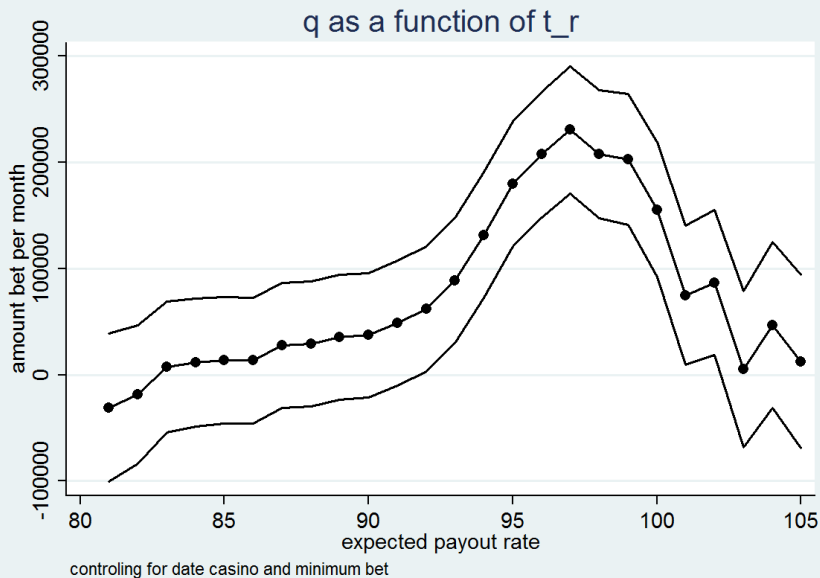


- Contemporary analysis: the link between payout rate in date t and turn over in date t .
 - ① Cross-section analysis
 - ② Panel analysis
 - ③ Reaction to exogenous shocks (Instrumentation)
- Analysis of long term effects could also be done (but not today...).

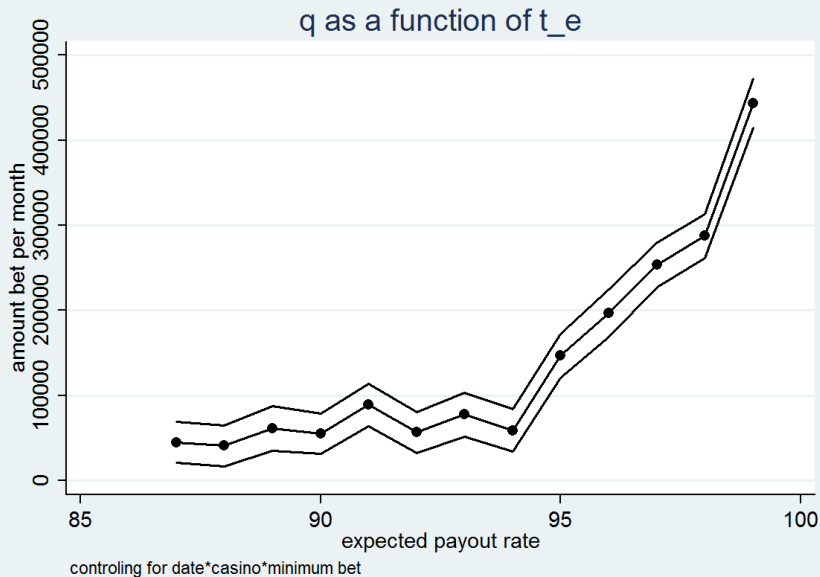
Cross-section



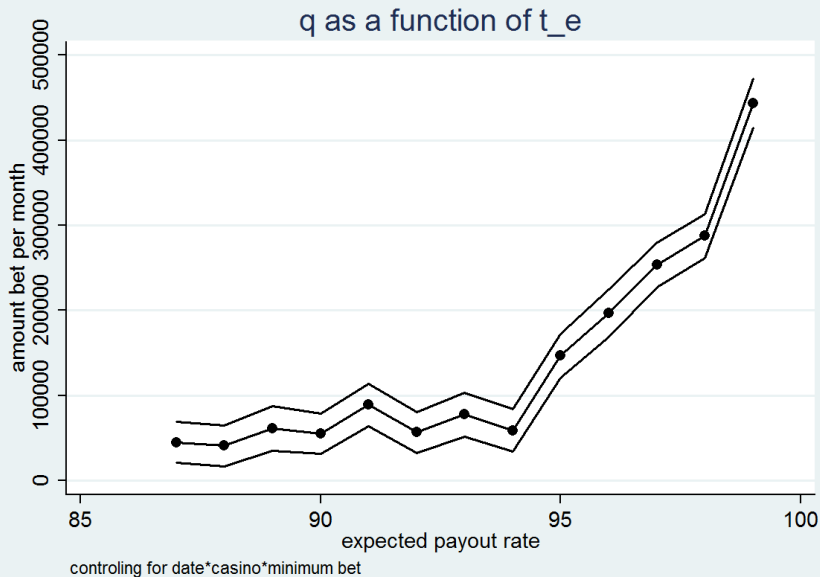
Cross-section



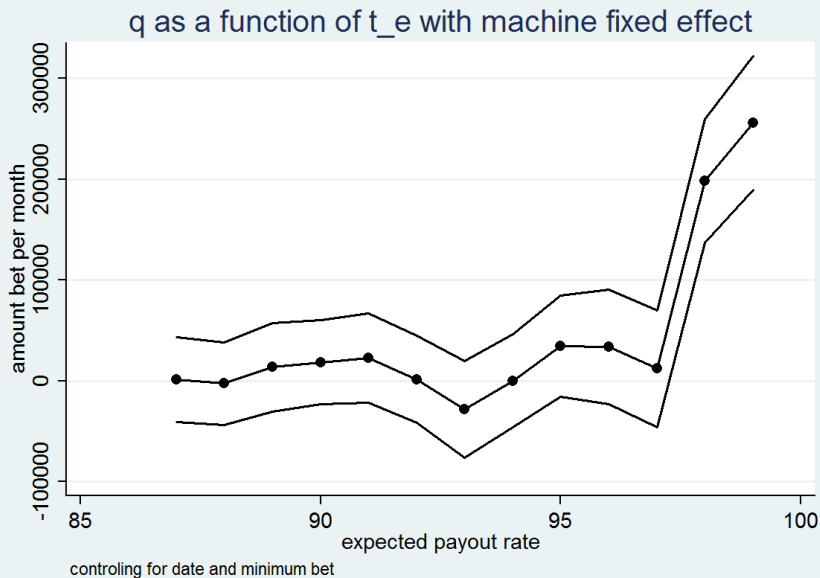
Cross-section



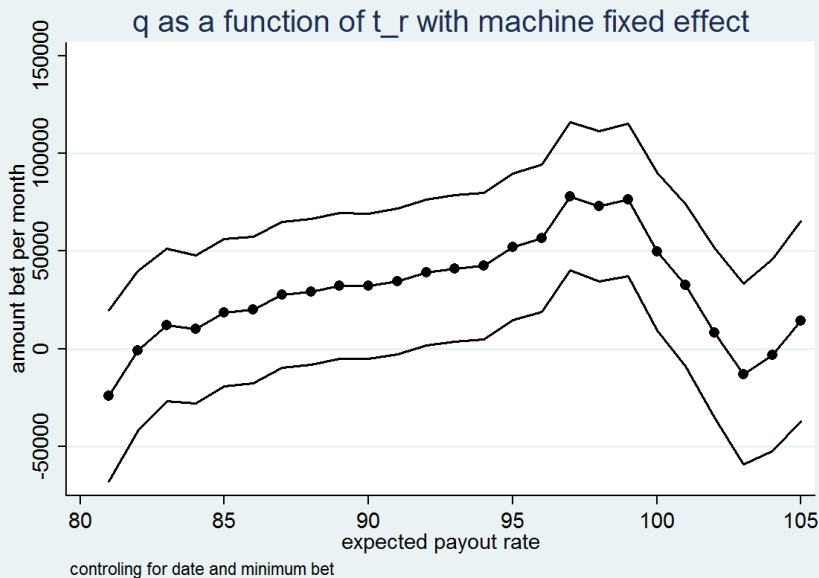
Cross-section



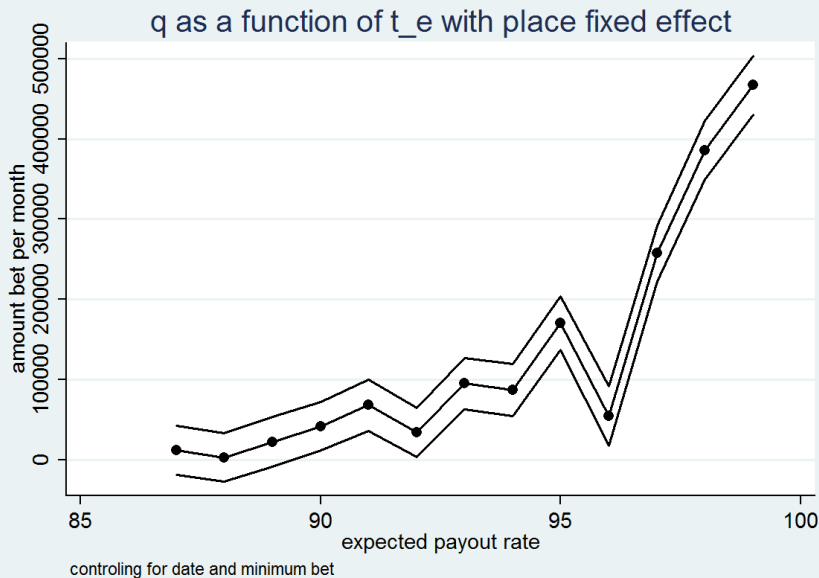
Panel



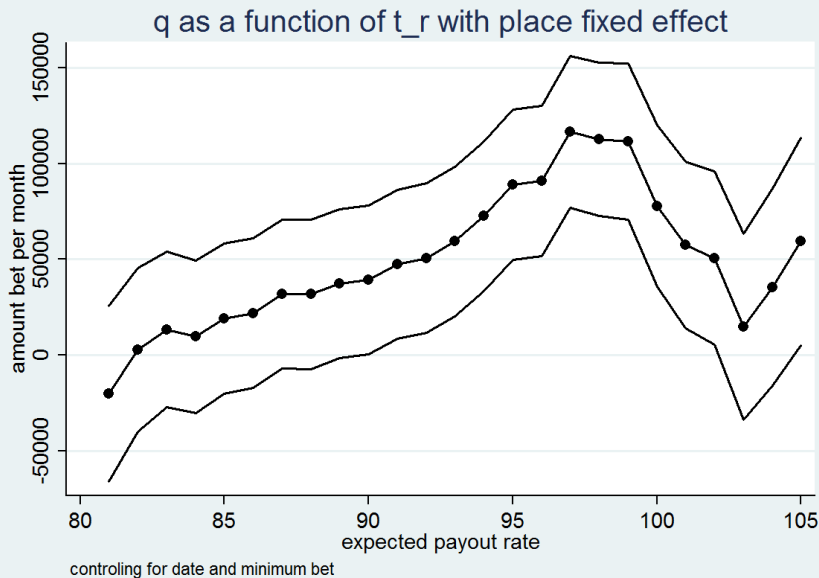
Panel



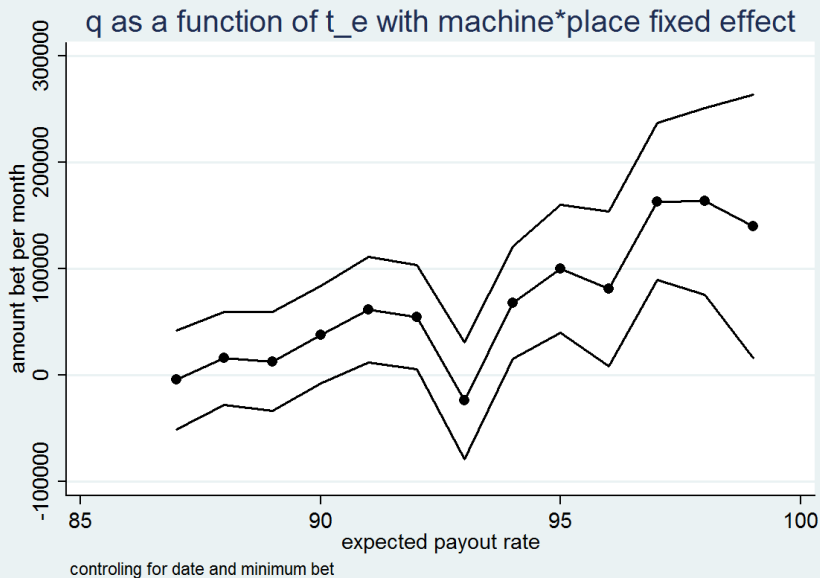
Panel



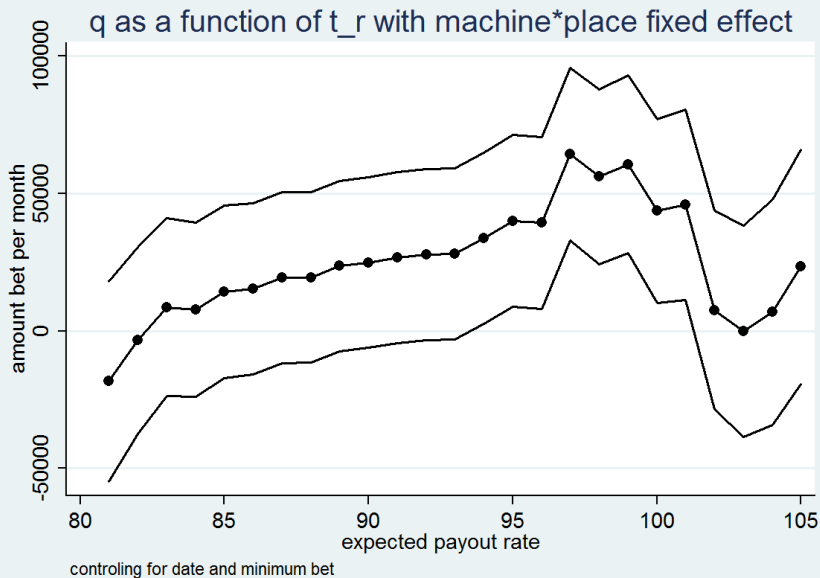
Panel



Panel



Panel



Partial Conclusion/Discussion

- The demand reacts strongly to the payout rate, especially the expected payout rate even though the price is never observed.
- Cross-section analysis subject to endogeneity because machines with a high payout rates are different from those with a low payout rate (video poker versus one-armed bandit ("bandit manchot")).
- Panel analysis might be biased too because the casino chose to change the payout rate of specific machines (who performed badly for example).
 - Possible to do falsification tests to check this.
- Other idea: Find a purely exogenous shock.

Exogenous shock

- We can write: $t_r = t_e + d$
- d is the difference between what the machine is supposed to give back in the long run and what it actually paid back a given month.
- This is purely exogenous! (since the machine works with a random number generator...)
- Idea:
 - Run few simple regressions to check if d influence s (sales).
 - Estimate: $\ln(s) = \alpha \ln(t_r) + \beta X + \epsilon$ where t_r is instrumented by d .

Really Exogenous?

- To be a valid instrument, d should not have any direct link with s .
- From the law of large numbers: $\mathbb{E}[t_r] = t_e$.
- From the central limit theorem:

$$\sqrt{N} \left(\frac{\sum t_i}{N} - t_e \right) \xrightarrow{N \rightarrow \infty} \mathcal{N}(0, \sigma^2)$$

with t_i the gains at each bet i ($t_i = 0$ if the player loses and $t_i \geq 1$ if he win)

- But $\frac{\sum t_i}{N} = t_r$ and $s = N * m$.
- This implies that $d = t_r - t_e$ converges to 0 like $1/\sqrt{N}$
- However $d * \sqrt{N}$ has no direct link with s ...
- I will use both d and $d * \sqrt{q}$ as instruments.

Table: Estimation of demand elasticities: various methods

Dependent variable: Log s						
specification	(1) OLS	(2) 2sls	(3) 2sls	(4) 2sls	(5) 2sls	(6) 2sls
$\log(t_r)$	1.512*** (0.062)	0.605*** (0.082)	0.205** (0.092)	0.336*** (0.075)	0.851*** (0.051)	1.331*** (0.116)
Sample	All	All	All	$N > 10^5$	$N > 5 \times 10^5$	$N > 10^6$
Observations	19810	19810	19810	17729	5386	586
R-squared	0.684	0.681	0.677	0.748	0.927	0.943
Instrument:	None	d	$d\sqrt{N}$	$d\sqrt{N}$	$d\sqrt{N}$	$d\sqrt{N}$
Controls:						
Date	yes	yes	yes	yes	yes	yes
Casino	yes	yes	yes	yes	yes	yes
Min. bet	yes	yes	yes	yes	yes	yes

Sales and corrected payout rate

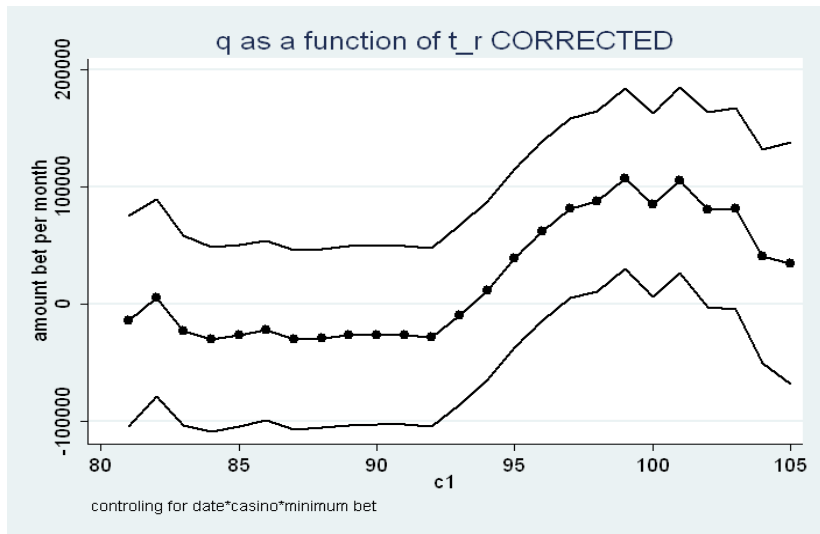


Figure: Correcting for Central Limit Theorem Convergence does not affect the results when t_r greater than 1.

Gambler's fallacy

- This phenomenon is likely to reflect gambler's fallacy
 - i.e. the belief that an event that has happened more frequently than usually will not occur in the future
- How to show it?
 - without jackpots, central limit theorem applies and $D = \sqrt{N} * (t_r - t_e)$ will be too low but normally distributed, for say $N > 100000$.
 - if D exhibits a large positive deviation from 0, this suggests there has been a jackpot
 - arbitrary consider top .5% of D distribution as jackpots.
 - then jackpot in month m lowers play by 30 % in month $m + 1$.
 - without biased behavior, such a correlation should not exist.

Economic price (1)

- Which good should we consider?
 - we use the good: gamble once.
 - since a single bet takes a fairly fixed amount of time (2 seconds), this is equivalent to a good defined in term of “time spent playing”.
 - if gamblers maximize their playing time, they should favor low-bet high-payout-rate machines
 - might not always be possible because of congestion
 - but same reaction to price variations in terms of minimal bets and payout rate should be expected

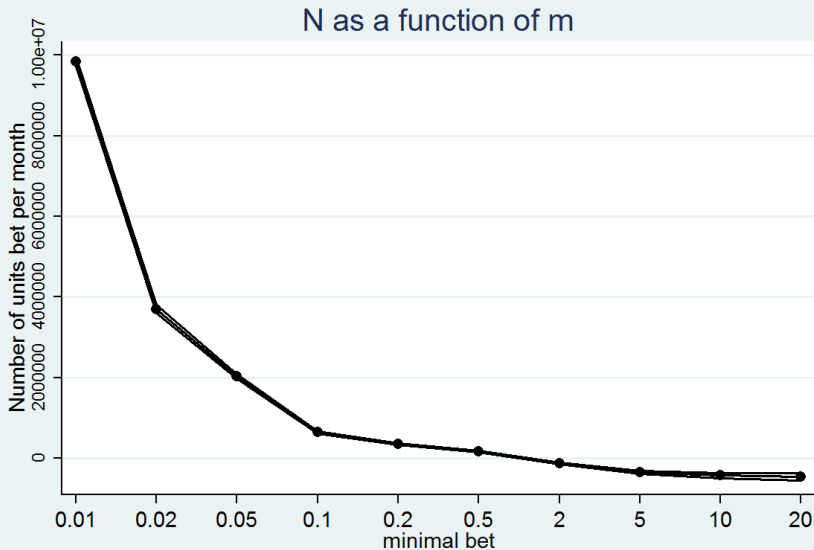
Economic price

- We can define:
 - the expected price of a gamble $p_e = m(1 - t_e)$
 - the realized price of a gamble $p_r = m(1 - t_r)$
- The expected price is chosen by the casino.
- The realized price is the expected price plus a purely random shock.
- We then have that the demand $q = n$ and as usual, realized gross profits are $\Pi_r = q * p_r$.
- This price is the more natural definition.

Price and rationality

- Gambling cannot be rationalized as an investment (negative payoff!).
- It could be rational as leisure.
- In this case, if players are rational, they should react in the same way to price variations induced by shifts in m or in t .
- Since t is not observed directly whereas m is, they should react more to shifts in m .
- We test: $\ln(q) = \alpha \ln(p_e) + \beta X + \epsilon = \alpha \ln(m) + \alpha \ln(1 - t_e) + \beta X + \epsilon$

Sales and minimum bets



controlling for date casino and payout rate

Sales and minimum bets

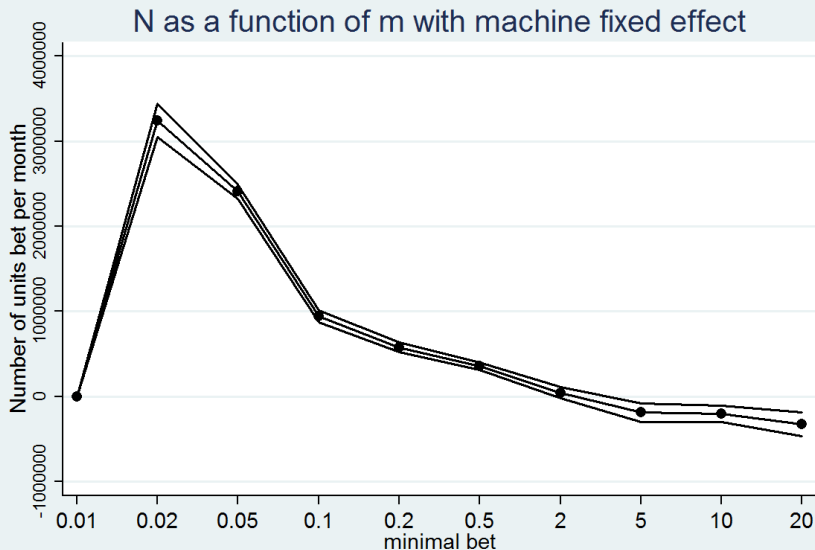


Table: Demand elasticity: comparing price shifts induced by minimum bets and payout rates

VARIABLES	(1) Log q	(2) Log q	(3) Log q	(4) Log q
logPE1	-0.244*** (0.00594)	-0.256*** (0.0194)		
logPR1			-0.294*** (0.00653)	-0.0836*** (0.00533)
logM	-0.710*** (0.00585)	-1.081*** (0.0139)	-0.675*** (0.00526)	-0.993*** (0.0112)
Observations	19811	19811	19126	19126
R-squared	0.649	0.824	0.647	0.830
Control	cas*mois	cas*mas	cas*mois	cas*mas

- We have seen that demand reacts strongly to unobserved payout rates.
- This explains why casinos chose so high pay out rates.
- More broadly, it shows that gambling reacts to price incentives as any other good.
- But reaction differs depending on the type of change (minimal bet versus payout rate).
- This might indicate unrational behavior.
- There is also indication of gambler's fallacy: jackpot previous month lowers by 30% turn over

⇒ Policy implication of all this: put a ceiling on payout rates?

- But can we say more?
- Can we provide from the data any clever argument explaining why people keep playing a game with negative expected payoff?