AREC 815: Experimental and Behavioral Economics

Applications of Dynamic Inconsistency: Addiction

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Addiction in the Quasi-Hyperbolic Model

Characterizing Addictive Goods

- What does it mean to be addictive?
  - Dictionary defines addiction in terms of "physical dependency"
- Economic characterization of **addictive goods**:
  - **Negative internalities**: past consumption lowers current utility, regardless of current level of consumption
  - **Habit formation**: past consumption increases the utility of current consumption (for example, via withdrawal costs)

Is Addiction Rational?

- Economic definition of addictive emphasizes individual choice
  - Willingness to trade current-period benefit for future costs implies impatience, but not irrationality or lack of agency
- Standard model of "rational" addiction (Becker-Murphy 1988):
  - Agents recognize goods are addictive
  - Choose utility-maximizing consumption plan
  - Implication: addiction results from individual optimization

Is Addiction Rational?

- Extensions to rational model:
  - *Ex ante* uncertainty about consequences, addictiveness
  - Possibility of regret, *ex ante* vs. *ex post* optimality
- Evidence supporting rational addiction model:
  - Individuals *choose* whether to consume addictive goods
  - Responses to price changes $\Rightarrow$ forward-looking behavior

Is Addiction Rational?

- Evidence against rational addiction model:
  - Willingness to pay for commitment devices
  - Over-estimation of probability of exiting addiction
- Quasi-hyperbolic time preferences explain these phenomena

Utility from Addictive Substances

- Three types: time consistent (TC), naif, sophisticate
- In each period, agents decide whether to "take a hit" of an addictive substance ($a_t = 1$) or to refrain from hitting ($a_t = 0$)
- Consumption utility, u_t, in each period depends only on current and past consumption of addictive good
- An individual is addicted ($k_t = 1$) if she took a hit last period, and is otherwise unaddicted ($k_t = 0$): $k_t = a_{t-1}$

Utility from Addictive Substances

- Consumption utility within each period:

$$u_t(a_t, k_t) = \begin{cases} x_t - \rho k & \text{if } a = 1 \\ 0 - (\rho + \sigma) k & \text{if } a = 0 \end{cases}$$

- Interpretation:
  - $\rho =$ internality cost
  - $\sigma =$ withdrawal cost (due to habit-formation)
- Stationary utility model: $x_t = \bar{x}$ for $t = 1, 2, 3, \ldots$

Utility from Addictive Substances

- Special case of more general framework:

$$u_t\left(a_t, k_t\right) = \begin{cases} x_t + f(k_t) & \text{if } a = 1 \\ y_t + g(k_t) & \text{if } a = 0 \end{cases}$$

  where:

  - Negative internalities when $f'(k) < 0$ and $g'(k) < 0$
  - Habit forming when $f'(k) - g'(k) > 0$

- Results from simple model extend to general case (above), and to situations where addiction level is continuous function of past consumption

Utility from Addictive Substances

Consumption Utility

	Unaddicted ($k_t = 0$)	Addicted ($k_t = 1$)
Hitting ($a_t = 1$)	$\bar{x}$	$\bar{x} - \rho$
Refraining ($a_t = 0$)	0	$0 - (\rho + \sigma)$

- **Temptation to hit**: $u_t(1, k_t) - u_t(0, k_t)$
  - Temptation to hit when unaddicted: $\bar{x}$
  - Temptation to hit when addicted: $\bar{x} + \sigma$

Utility from Addictive Substances

- Future costs of hitting depend on beliefs about future behavior
- Three types of beliefs about future:
  - Future self will **start**: regardless of current behavior, expect to hit in period two and every subsequent period
  - Future self will **continue**: expect to hit in every future period if and only if one hits in period one
  - Future self will **quit**: expect to refrain in every future period regardless of current behavior
- Optimal current action depends on beliefs about future

Choosing to Hit: Three Period Example

- Preferences at time $t = 1$ represented by the utility function

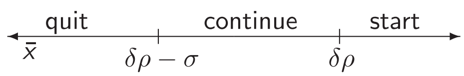
$$u_1 + \beta\delta u_2 + \beta\delta^2 u_3$$

- All types hit at $t = 3$
- When is it rational to become addicted?
  - When getting addicted yields higher lifetime utility than sobriety

When Will TCs Choose to Hit?

Claims about time consistent types:

- An unaddicted TC starts at $t = 1 \Leftrightarrow \bar{x} \geq \delta\rho$
- A TC type never starts hitting expecting to quit



When Will TCs Choose to Hit?

- The TC strategy for getting addicted is stationary
  - Starts $\Leftrightarrow \bar{x} \geq \delta\rho$
- TC behavior = long-run welfare maximizing behavior
- Cutoffs also characterize what a naif believes she will do at $t = 2$
  - Naif believes her future self is TC
- Given these beliefs about future actions, what will a naif do?

When Will a Naif Choose to Hit?

- Conclusion: an unaddicted naif will hit at $t = 1$

$$\bar{x} \geq \min \left\{ \beta\delta\left(\rho + \sigma\right), \left[\frac{\beta\delta\left(1+\delta\right)}{1+\beta\delta}\right]\rho \right\}$$

- Comments:
  - A naif is more likely to hit than a TC
  - Naifs may hit expecting to quit the following period
- What does a naif actually do at $t = 2$?
  - This is also what a sophisticate expects to do at $t = 2$

When Will a Sophisticate Choose to Hit?

- Claim: unaddicted sophisticates hist at $t = 1 \Leftrightarrow \bar{x} \geq \beta\delta\rho$
- Implication: unaddicted sophisticates more likely to hit than naifs
  - **Pessimism effect**
- Sophisticates are "worse off" than naifs in the stationary utility case?
  - More likely to *become* addicted
- Sophisticates likely to be better off in (more relevant?) case where tastes for addictive good or present bias fluctuate over lifetime

Addition: Empirical Evidence

- Levy (2010) extends the model to infinitely-lived consumers with preferences which depend on their age and addiction level
  - Cigarette smoking attractive when young, not when mature
- A rational consumer expects to:
  - Always smoke,
  - Never smoke, or
  - Smoke until maturity
- A present-biased consumer may also expect to smoke only today

Addiction: Empirical Evidence

Figure 1: Hazard Rates of Cigarette Smoking Initiation and Cessation

Source: 1987 National Health Interview Survey.

Addition: Empirical Evidence

- Because smoking is addictive, the probability of smoking (π) should be sensitive to both current and future cigarette prices
  - For young, time-consistent consumers, $\frac{\partial \pi / \partial p_{t+1}}{\partial \pi / \partial p_t} = \delta$
  - For young, present-biased consumers, $\frac{\partial \pi / \partial p_{t+1}}{\partial \pi / \partial p_t} \in \{0, \beta\delta, \delta\}$
- Only present-biased consumers ignore future prices

Addiction: Empirical Evidence

Table 2: Price Sensitivity Among Young Smokers

Panel A – Dependent Variable: $1(Smoker = 1)$, Linear Probability Model	(i) Age < 20	(ii) Age < 25	(iii) Age < 30	(iv) Age < 20	(v) Age < 25	(vi) Age < 30
$\ln(\text{price})_t$	-1.853***	-1.256***	-1.019***	-1.363***	-0.994***	-0.744**
	(0.226)	(0.135)	(0.104)	(0.525)	(0.334)	(0.294)
$\ln(\text{price})_{t+1}$	-0.118	-0.426***	-0.545***	-0.021	-0.389	-0.575**
	(0.161)	(0.096)	(0.075)	(0.471)	(0.289)	(0.251)
Ratio of coefficients[a]	0.064	0.340**	0.534***	0.016	0.392**	0.773***
	(0.093)	(0.110)	(0.124)	(0.339)	(0.162)	(0.051)
MSA Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
MSA-Specific Trends	Yes	Yes	Yes	Yes	Yes	Yes
N. obs	5,289	11,647	17,975	5,289	11,647	17,975
Panel B – First-stage Estimates of Prices						
$\ln(price)_t$						
$\ln(\text{taxes})_t$	–	–	–	0.527***	0.516***	0.511***
				(0.038)	(0.036)	(0.036)
Budget Gap[b]	–	–	–	0.194**	0.161**	0.151**
				(0.089)	(0.078)	(0.074)
$\ln(price)_{t+1}$						
$\ln(\text{taxes})_t$	–	–	–	0.551***	0.558***	0.565***
				(0.054)	(0.051)	(0.050)
Budget Gap[b]	–	–	–	0.478***	0.454***	0.428***
				(0.135)	(0.134)	(0.131)

Notes: Standard errors (in parentheses) are robust and clustered at the MSA level. All specifications control for age, age^2, race, and education and include both MSA dummies and MSA-specific time trends. * denotes significance at the 10% level; ** at the 5% level; and *** at the 1% level. Coefficients in Panel A are average marginal effects from a probit regression.

[a] The ratio of the coefficients on $\ln(\text{price}_{t+1})$ and $\ln(\text{price}_t)$ will equal the net discount factor $\beta\delta$ if consumers are fully rational, or may equal 0 if consumers are sufficiently present- or projection-biased. Standard errors are calculated by the delta method.

[b] Average percentage shortfall in state government budgets (general fund) within an MSA.

Addition: Empirical Evidence

- Older smokers seem aware that they will continue smoking
  - Only 5 percent of mature smokers expect to quit
  - Implication: $\frac{\partial \pi / \partial p_{t+1}}{\partial \pi / \partial p_t} \in \{\beta\delta, \delta\}$
- We can also decompose price shocks into permanent and transitory components, with the latter identified through agricultural conditions
  - For mature, time-consistent consumers, $\frac{\partial \pi_t / \partial p_t^P}{\pi_t / \partial p_t^T} = \frac{1}{1-\delta}$
  - For mature, present-biased consumers, $\frac{\partial \pi_t / \partial p_t^P}{\pi_t / \partial p_t^T} = \frac{1-(1-\beta)\delta}{1-\delta}$
- Present-biased consumers overreact to temporary price shocks

Addiction: Empirical Evidence

Table 3: Price Sensitivity Among Mature Smokers

Panel A – Dependent Variable: $1(Smoker = 1)$, Linear Probability Model	(i) Age > 30	(ii) Age > 35	(iii) Age > 30	(iv) Age > 35
$\ln(\text{price}_t)$	-0.824***	-0.879***	-0.725***	-0.787***
	(0.071)	(0.077)	(0.215)	(0.251)
$\ln(\text{price}_{t+1})$	-0.641***	-0.619***	-0.531***	-0.496**
	(0.052)	(0.057)	(0.183)	(0.213)
Ratio of Coefficients[a]	0.778***	0.704***	0.734***	0.630***
	(0.125)	(0.122)	(0.044)	(0.074)
MSA Fixed Effects	Yes	Yes	Yes	Yes
MSA-Specific Time Trends	Yes	Yes	Yes	Yes
N. obs	40,436	34,775	40,436	34,775
Panel B – First-stage Estimates of Prices				
$\ln(price)_t$				
$\ln(taxes_t)$	–	–	0.494***	0.498***
			(0.035)	(0.035)
Budget Gap[b]	–	–	0.146*	0.132*
			(0.074)	(0.072)
$\ln(price)_{t+1}$				
$\ln(taxes_t)$	–	–	0.550***	0.559***
			(0.048)	(0.048)
Budget Gap[b]	–	–	0.398***	0.384***
			(0.138)	(0.136)

Notes: Standard errors (in parentheses) are robust and clustered at the MSA level. All specifications control for age, age^2, race, and education and include both year dummies and MSA-specific time trends. * denotes significance at the 10% level; ** at the 5% level; and *** at the 1% level. Coefficients for in Panel A are average marginal effects from a probit regression.

[a] The ratio of the coefficients on $\ln(\text{price}_{t+1})$ and $\ln(\text{price}_t)$ will equal the net discount factor $\beta\delta$. Standard errors are calculated by the delta method.

[b] Average percentage shortfall in state government budgets (general fund) within an MSA.

Addiction: Empirical Evidence

Table 4: Permanent vs. Temporary Price Effects

Panel A – Dependent Variable: $1(Smoker = 1)$

	Age > 30		Age > 35		Age < 20
	(i)	(ii)	(iii)	(iv)	(v)
$\ln(p_t^P)$	-1.111***	-1.380***	-1.113***	-1.410***	-0.822***
	(0.118)	(0.181)	(0.118)	(0.177)	(0.166)
$\ln(p_t^T)$	-0.214***	-0.217***	-0.220***	-0.225***	-0.333***
	(0.044)	(0.068)	(0.045)	(0.068)	(0.112)
Ratio of Coefficients[a]	5.191***	6.359**	5.059***	6.267**	2.467
	(1.31)	(2.07)	(1.26)	(1.97)	(1.11)
MSA Fixed Effects	Yes	Yes	Yes	Yes	Yes
Trend	Yes	No	Yes	No	No
Trends by MSA	No	Yes	No	Yes	Yes
N obs.	37,651	37,651	32,322	32,322	5,289
R^2	0.497	0.505	0.495	0.503	0.457

Addition: Empirical Evidence

- Estimated β between 0.7 and 0.83, significantly less than 1
- Estimated δ between 0.88 and 0.90, not significantly less than 1
- Model suggests optimal sin tax on cigarettes: $2.20 to $5.30
  - This is not too far from NY's current tax on cigarettes
- Exacerbating biases would necessitate a higher sin tax
  - Paper also considers impact of **projection bias** in predicting future tastes; we won't discuss this until later in the semester