Economics of innate rewards

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Context

- In an economy, there are:
  - **Vice goods** that consumers consume "too much" (sodas, fatty food, drugs...) and
  - **Virtue goods** that they consume "too little" (virtue products: vegetables, health insurance...)
- In the literature, typically:
  - they are studied separately
  - using **intertemporal models** or **dual-self models** to explain the non-optimality of the consumer's decision
- Public policies to deal with:
  - Vice goods: sin taxes, tools to help consumers preplan consumption (e.g. commitment devices)...
  - Virtue goods: nudges...

Aim of the paper

- The paper aims to:
  - discuss how an economy naturally produces the two types of goods (i.e. how firms choose their products' design) and the associated purchase environments (e.g. more or less exciting music, fidelity programs...)
  - discuss how the non-optimality of consumers' decisions can be mitigated by public policies

Contributions of the paper

1. I propose a **dual-self model** in which ***decision utility*** depends on 2 distinct kinds of "fundamentals" of valuations:
   - ***innate rewards*** (also called ***primary rewards***): naturally rewarding stimuli inherited from human evolution (e.g. sugary food, positive social interactions, soft touch...) and early-life experiences (pre- and post-natal)
   - ***constructed values*** (i.e. the usual utility) built based on a cognitive model of the likely outcomes of actions and of their desirability (i.e. the "classical" rational utility).
2. The model discusses **two sources of economic inefficiency** and how they interact:
   - **Product design:** Fallacious *innate rewards* (not reflecting the usefulness of an action to maintain the individual alive / in a good state)
   - **Product marketing:** Too high weight of *innate rewards* VS *constructed values* in decisions
3. I compare the efficiency of several **public policies** in progress

Literature

- Behavioral Economics: **dual-process models of behavior** (Loewenstein, O'Donoghue and Bhatia, 2015; Benhabib and Bisin, 2005)
- Psychology and neuroscience: relative importance of ***model-free* and *model-based reinforcement learning*** (Daw et al., 2011)
- Psychology and medicine: **"evolutionary mismatches"** (Li, van Vugt and Colarelli, 2018)
- Marketing: **Construal Level Theory** and purchasing behaviors, **product design for vice goods** (Jain and Li, 2018)
- Behavioral economics: policy tools (**nudges**) (Chetty, 2015)
- Optimal taxation: **sin taxes** (O'Donoghue and Rabin, 2006)

Summary

General formulation of the dual-self

- A typical individual:
  - Experiences ***innate rewards*** associated with his actions
  - Has built his own ***constructed values*** of actions based on his ***personal goals*** (i.e. everything he wants to value in life and how much) and on a cognitive map of how his actions can help him reach them
- In an ***environment*** $\boldsymbol{s} \in \mathbb{R}^L$ (both internal, e.g. stress, hunger..., and external, e.g. required speed of decision, number of choices...), an individual must choose a combination of N possible actions $\boldsymbol{a} = (a_1, ..., a_N) \in \mathbb{R}^N$.
- His ***decision utility*** is a weighted average of the ***innate rewards*** $\mathcal{R}_{\boldsymbol{s}}(\boldsymbol{a})$ and of the ***constructed values*** $V_{\boldsymbol{s}}^{cons}(\boldsymbol{a})$ corresponding to the combination of actions, with a weight $\alpha(\boldsymbol{s}) \in [0; 1]$:

$$U_{\boldsymbol{s}}^{dec}(\boldsymbol{a}) = \alpha(\boldsymbol{s})\mathcal{R}_{\boldsymbol{s}}(\boldsymbol{a}) + (1 - \alpha(\boldsymbol{s}))V_{\boldsymbol{s}}^{cons}(\boldsymbol{a})$$

- His ***underlying utility*** corresponds to his ***constructed values***:

$$U_{\boldsymbol{s}}^{und}(\boldsymbol{a}) = V_{\boldsymbol{s}}^{cons}(\boldsymbol{a})$$

General formulation of the dual-self (2)

- Remark 1: Think of it as a continuum in the complexity of valuations
- Remark 2: Everything depends on the individual
- Remark 3: *Constructed values* can be thought of as complex cognitive constructs based on *innate rewards*, which are assumed to be complex enough to allow for the building of any arbitrary set of *constructed values*
- Remark 4: The *constructed values* also affect *innate rewards* through positive interactions.

General formulation of the dual-self (3)

- Remark 5: Considering (just for the remark) that the *innate rewards* associated with an action are linear in the quantity of action performed (for example the quantity of the purchased good), we have:

$$\mathcal{R}_{\boldsymbol{s}}(\boldsymbol{a}) = \mathbf{1}^t.\boldsymbol{R}_{\boldsymbol{s}}.\boldsymbol{a} = (1,...,1).\begin{pmatrix} r^{\boldsymbol{s}}_{11} & r^{\boldsymbol{s}}_{12} & \dots & r^{\boldsymbol{s}}_{1N} \\ r^{\boldsymbol{s}}_{21} & r^{\boldsymbol{s}}_{22} & \dots & r^{\boldsymbol{s}}_{2N} \\ \dots & \dots & \dots & \dots \\ r^{\boldsymbol{s}}_{M1} & r^{\boldsymbol{s}}_{M2} & \dots & r^{\boldsymbol{s}}_{MN} \end{pmatrix} . \begin{pmatrix} a_1 \\ a_2 \\ \dots \\ a_N \end{pmatrix}$$

This matrix:

- was much sparser for hunter-gatherers than nowadays (discounts, fidelity programs, smiling figures on packaging...).
- now contains some excessive rewards (i.e. those that can easily be manipulated) $\rightarrow$ from "safety net" to "black hole"

General formulation of the dual-self (4)

- In the ***decision utility*** $U_s^{dec}(\boldsymbol{a}) = \alpha(\boldsymbol{s})\mathcal{R}_{\boldsymbol{s}}(\boldsymbol{a}) + (1 - \alpha(\boldsymbol{s}))V_{\boldsymbol{s}}^{cons}(\boldsymbol{a})$, individuals make **two kinds of errors**, respectively on:
  - *Innate rewards* $\mathcal{R}_{\boldsymbol{s}}(\boldsymbol{a})$ that imperfectly reflect $U_{\boldsymbol{s}}^{und}(\boldsymbol{a})$
  - The weight of *innate rewards* versus *constructed values*: $\alpha(\boldsymbol{s})$
- Remark 6: From an evolutionary point of view, this *decision utility* can make sense if one set of values is more quickly available than the other (or if there are errors on both *constructed values* and *innate rewards* and they are not perfectly correlated)
- Remark 7: *Constructed values* are assumed to perfectly reflect the *underlying utility* $\rightarrow$ *innate rewards* cannot "correct" erroneous *constructed values*: not always true $\rightarrow$ focus on "modern" economics decisions

Summary

Application 1: Product design

- A firm selling a good of (exogenous) price p, constructed value net of price v, baseline innate reward content r.
- Decision of the firm: boosting the innate reward content of the good by k for a unit cost k
- Mass 1 of consumers with a uniform distribution of innate reward weight $\alpha \sim \mathcal{U}([0, \bar{\alpha}])$
- **Decision utility** of an individual with weight α depending on his action A (purchase $A = P$, or no purchase $A = NP$):

$$U_\alpha^{dec}(A) = [\alpha(r + k) + (1 - \alpha)(v - p)]\, \mathbf{1}_{A=P}$$

- **Underlying utility**:

$$U_\alpha^{und}(A) = v - p$$

Application 1: Product design (2)

- **Profit of the firm:**

$$\Pi(k) = (p - k)D(k)$$

where $D(k)$ is the demand for the product depending on the innate reward content boost k.

- An individual chooses to buy the good iff:

$$\alpha(r + k) + (1 - \alpha)(v - p) > 0$$

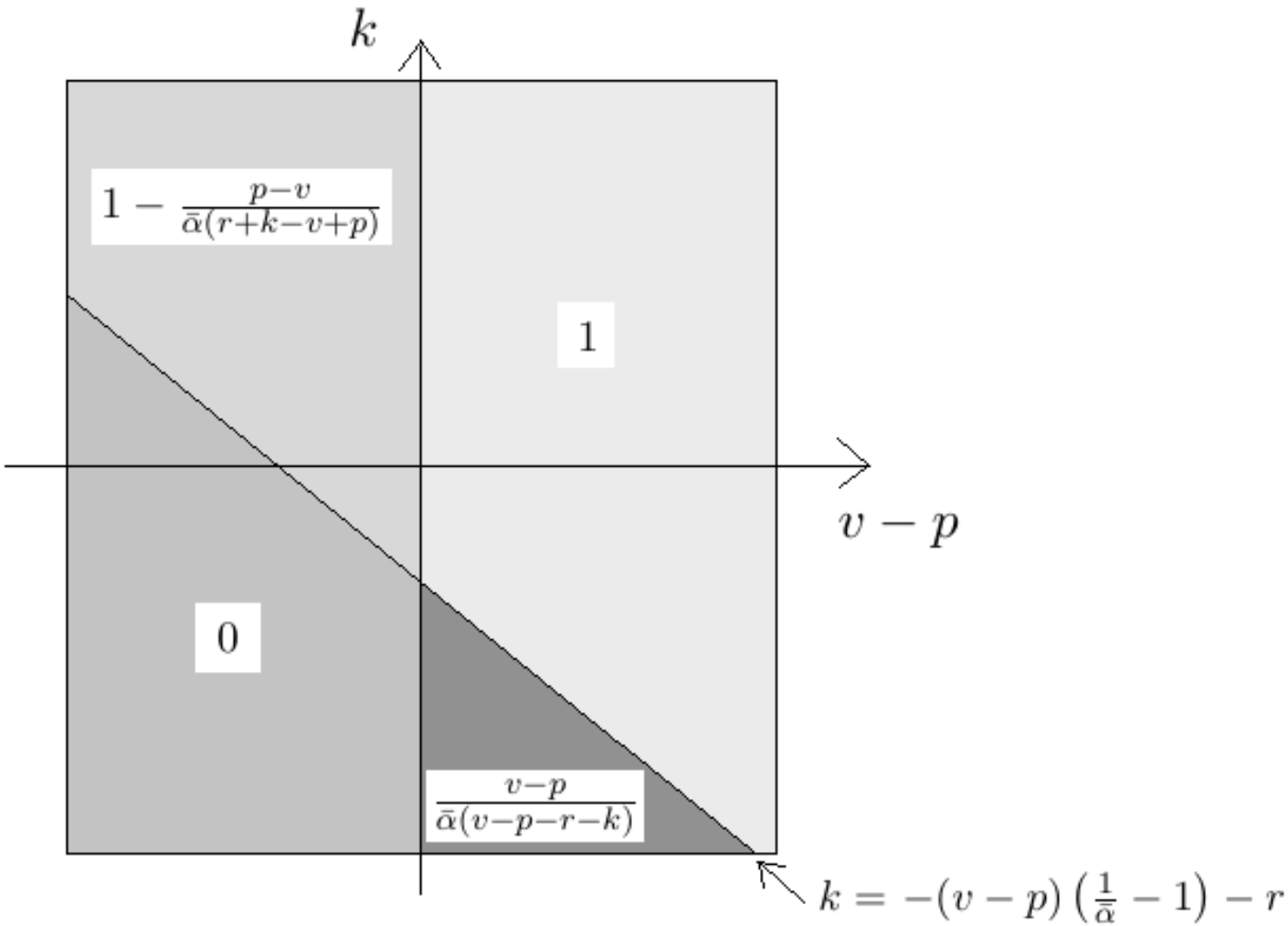
$$\text{i.e.:} \begin{cases} \alpha > \frac{p-v}{r+k-v+p} & \text{if } r + k - v + p > 0 \\ \alpha < \frac{p-v}{r+k-v+p} & \text{if } r + k - v + p < 0 \end{cases} \quad (1)$$

- **Demand** is thus:

$$D(k) = \begin{cases} 1 - \frac{p-v}{\bar{\alpha}(r+k-v+p)} & \text{if } k > -(v-p)\left(\frac{1}{\bar{\alpha}} - 1\right) - r \text{ and } v - p < 0 \\ 0 & \text{if } k < -(v-p)\left(\frac{1}{\bar{\alpha}} - 1\right) - r \text{ and } v - p < 0 \\ \frac{v-p}{\bar{\alpha}(v-p-r-k)} & \text{if } k < -(v-p)\left(\frac{1}{\bar{\alpha}} - 1\right) - r \text{ and } v - p > 0 \\ 1 & \text{if } k > -(v-p)\left(\frac{1}{\bar{\alpha}} - 1\right) - r \text{ and } v - p > 0 \end{cases}$$

Application 1: Product design (3)

- Graph of demand $D(k)$:



Application 1: Product design (4)

- **Examples:** Very sugary drink with few vitamins, very violent or exciting movie with little informational content, very beautiful new shirt of low quality and high environmental impact... VS purchase of a house, health insurance...

- **Remark:** The average consumer's underlying utility is maximized when: $r + k = v - p$.

Application 1: Product design (5)

Proposition 1: Market equilibrium:

- If $v - p > 0$, then:
  - if the baseline innate reward content of the good is low (i.e. $r < v - 2p$), the firm does not invest to increase it ($k^* = 0$).
  - if the baseline innate reward content of the good is high (i.e. $r > v - 2p$), the firm invests in increasing this innate reward content ($k^* = \tilde{k}(p, v, r) \equiv \min\left(p, -(v-p)\left(\frac{1}{\bar{\alpha}} - 1\right) - r\right)$).
- If $0 > v - p > \tilde{V} \equiv -\frac{\bar{\alpha}(r+p)}{1-\bar{\alpha}}$ (case only possible if $r > -p$), then the firm invests in increasing the innate reward content ($\Pi'(k^*) = 0$).
- If $\tilde{V} > v - p$, then the firm does not invest in increasing the innate reward content ($k^* = 0$).

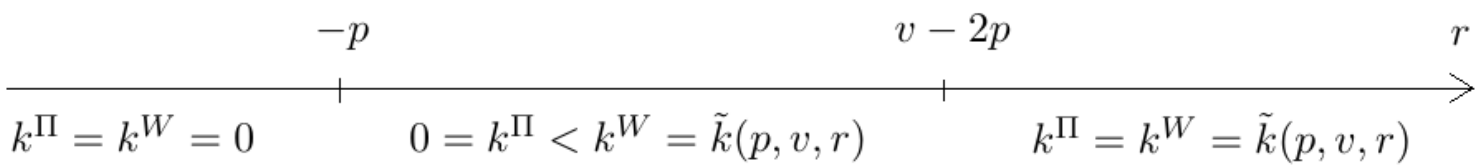
Application 1: Product design (6)

- Social Welfare:

$$W(k) = (v - p)D(k) + (p - k)D(k) = (v - k)D(k)$$

Proposition 2: Comparison market equilibrium / welfare-maximization:

- If $v - p > 0$, then the firm often invests **too little** in increasing the *innate reward* content of the product:



- If $0 > v - p > \tilde{V}$, then the firm invests **too much** in increasing the innate reward content ($k^{opt} < k^*$ where $W'(k^{opt}) = 0$).
- If $\tilde{V} > v - p$, then the firm does not invest in increasing the innate reward content and it is optimal ($k^{opt} = k^* = 0$).

Application 1: Product design (7)

- **Impact of a unit tax on the price of the product:**

$$\Pi(k) = (p(1-t) - k)D(k)$$

Tax $\Rightarrow$ k^* decreases so that:

  - When $v - p > 0$: the discrepancy between k^* and k^{opt} increases
  - When $v - p < 0$: the discrepancy between k^* and k^{opt} decreases

- **New public policy to be introduced in the model**: generalization of sin taxes: for all goods, taxing depending on the discrepancy between behaviors when people are "in control" vs. "not in control".

Application 2: Product marketing

- Same model, but the firm can also manipulate the weight of innate rewards by changing the distribution of α to $\mathcal{U}([0, \bar{\alpha} + \sigma])$
- Decision utility of an individual with α:

$$U_{\alpha}^{dec}(A) = [\alpha(r + k) + (1 - \alpha)(v - p)]\, \mathbf{1}_{A=P}$$

- The firm's profit writes: $\Pi(k, \sigma) = (p - k - \sigma)D(k, \sigma)$

Application 2: Product marketing (2)

Proposition 3: Market equilibrium:

- For goods with positive *constructed values*: no investment to increase the weight of *innate rewards*
- For goods with negative *constructed values*: investment to increase the *innate reward* content and the weight of *innate rewards* go hand in hand, with $r + k - v + p = \bar{\alpha} + \sigma$

- Examples: Supermarkets and souvenir shops VS housing agencies or banks

Proposition 4: Market equilibrium vs. Welfare maximization:

- For goods with negative *constructed values*, the possibility for the firm to manipulate the weight of *innate rewards* widens the gap between the equilibrium welfare and the optimal welfare.

Application 2: Product marketing (3)

- A simple unit tax on price becomes even more inefficient.

- **Public policies to be introduced in the model**:
  - Taxing depending on the discrepancy between behaviors when people are "in control" vs. "not in control".
  - Regulation on purchase environments?

Summary

Public policies

- **To align *innate rewards* with the *underlying utility* (i.e. the *constructed value*)**
  - **Food**: align *innate rewards* (e.g. sugar, fat...) with the nutritional benefits
  - **Entertainment**: align *innate rewards* (linked with the imitation of positive social interaction...) with the informational/educational content
  - **Marketing**: suppress *innate rewards* of purchasing (linked with discounts, fidelity programs, free shipping...)
- **To reduce the weight of *innate rewards*:**
  - In stores or commercial websites: suppress all exciting or stressing stimuli (e.g. music, pop-ups, ads...)
  - In day-to-day life: reduce the level of stress and uncertainty

$\neq$ Most nudges because modification of the goods per se

In practice

Recursive approach to calibrate *innate rewards*, in several steps:

1. **Quantifying *innate rewards* and *constructed values* (or at least the direction of the gap between the two):**
   - In the lab: comparing choices in the presence / absence of cognitive load (or high emotion irrelevant to the decision)
   - Outside of the lab: measuring the modification of behaviors after an exogenous shock on their mood, tiredness or else, irrelevant to the economic decision
2. **Then, modify the *innate rewards*' content of one good to reduce the gap between estimated *innate rewards* and estimated *constructed values***
3. Start again at step 1.

Summary

Conclusion

- **Large effect of *innate rewards* on human decisions**
- *Innate rewards*'s role of **"safety net" has been turned into a "black hole"**
  $\rightarrow$ Nowadays: Large discrepancy between *innate rewards* and the usefulness of actions to enhance survival chances
- At the same time: **reliance on *innate rewards* is permanently exacerbated**

$\Rightarrow$ Taxes and even nudges can only get us so far to deal with this...

$\Rightarrow$ *Innate rewards* should be harnessed by policy makers instead of being freely manipulated by firms

$\Rightarrow$ They could **powerfully bend human behaviors toward more sustainable-development-compatible activities** and **significantly contribute to the mitigation of global warming**

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