# Economy-Related Emotional Attitudes Towards Other People: How Can We Explain Them?

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## 1. Economy-related emotions are important

- Traditional economics considers people as:
  - rational decision makers,
  - that make all investment and other economic decisions based on the cold calculations of possible benefits and drawbacks.
- In reality, people often have strong economy-related emotions, and these emotions affect human decisions.
- It is therefore important to take these emotions into account when predicting how people will behave.
- Taking such emotions into account is an important part of behavioral economics, a branch of economics that got several Nobel prizes.

## 2. But where do these emotions come from?

- A natural next question is: where do these emotions come from?
- These emotions affect how people make economic decisions and thus, affect the country's economy; so:
  - if a person wants the country's economy to be going in a certain direction,
  - a natural hypothesis is that this person's economy-related emotions should help drive the country's economy in this direction.
- In this talk, we show that this hypothesis indeed explains – at least on the qualitative level – people's economy-related emotions.

## 3. But where do these emotions come from (cont-d)

- We show it on the example of a situation when a person is mostly interested in increasing the country's Gross Domestic Product (GDP).
- We show that in this case:
  - the analysis of the corresponding optimization problem
  - leads exactly to the economy-related emotional attitudes that people experience.

## 4. How decision theory describes individual and group decision making

- According to decision theory:
  - decisions of a rational person $i$, i.e., a person whose decisions are consistent,
  - are equivalent to optimizing an appropriate function $u_i(x)$ known as *utility function*.
- In other words, decisions of a rational person $i$ are equivalent to selecting an alternative $x$ for which the utility $u_i(x)$ is the largest possible.
- In general, utility is defined modulo linear transformations.
- Instead of the original function $u_i(x)$, we can use an alternative function $u'_i(x) = a \cdot u_i(x) + b_i$ for some constants $a_i > 0$ and $b_i$.
- This new function describes exactly the same preferences and thus, exactly the same economic behavior.

## 5. How decision theory describes individual and group decision making (cont-d)

- What if several people need to make a joint decision affecting all of them?
- In this talk, we consider a what is called a *win-win* situation, when:
  - we need to select between several decisions
  - each of which is potentially beneficial for everyone.
- In such cases, we start with what is called a *status quo* situation $x_0$.
- This is a situation in which the group is right now – and in which the group will remain if no group decision is selected.
- In this case, to make analysis easier, it makes sense:
  - to re-scale all individual utilities
  - so that each person utility $u_i(x_0)$ of the status quo situation $x_0$ becomes 0.

## 6. How decision theory describes individual and group decision making (cont-d)

- This can be done, e.g., by going from the original scale $u_i(x)$ to the new scale $u_i(x) + b_i$ with $b_i = -u_i(x_0)$.
- Because of this possibility, in the following, we will assume that all utility functions already have this property:

$$u_i(x_0) = 0 \text{ for all participants } i.$$

- Under this assumption, decision theory recommends to select a decision $x$ for which the product of the utilities $\prod_{i=1}^{n} u_i(x)$ is the largest.
- This idea is known as *Nash's bargaining solution.*

## 7. How emotional attitudes towards other people are taken into account

- Emotional attitude means that the person's preferences are affected:
  - not only by the objective conditions of this person,
  - but also by the conditions (i.e., utilities) of others.
- Thus, the person's utility function $u_i(x)$ that describes these preferences are also similarly affected.
- Let us denote the utility that only takes into account the objective conditions by $u_i^{(0)}(x)$.
- The actual utility $u_i(x)$ is affected not only by this value $u_i^{(0)}(x)$, but also by utilities $u_j(x)$ of others:

$$u_i(x) = f_i(u_i^{(0)}(x), u_j(x), u_{j'}(x), \ldots).$$

- The effect of others is usually smaller than the effect of the person's own objective conditions.

## 8. How emotional attitudes towards other people are taken into account (cont-d)

- Since the effect of the values $u_j(x)$ is small, we can follow the usual practice of physics and other applications:
  - expand the dependence on these values in Taylor series and
  - keep only linear terms in this expansion.
- So, we end up with the following formula:

$$u_i(x) = u_i^{(0)}(x) + \sum_{j \neq i} \alpha_{ij} \cdot u_j(x) \text{ for appropriate coefficients } \alpha_{ij}.$$

- These coefficients $\alpha_{ij}$, in effect, describe the emotions of the $i$-th person toward a person $j$.
- When the coefficient $\alpha_{ij}$ is positive, this means positive attitude.
- The person $i$ feels better when he/she knows that the person $j$ is better.

## 9. How emotional attitudes towards other people are taken into account (cont-d)

- When the coefficient $\alpha_{ij}$ is negative, this means negative attitude.
- The more person $j$ enjoys life, the worse person $i$ feels.
- This negative feeling may be well-justified.
- E.g., when the person $j$ gained his money in a still-legal but highly unethical way, by hurting others.

## 10. Resulting formulation of the problem

- Suppose that a person $i$ wants the community to achieve a certain objective.
- E.g., to increase the overall GDP which can be approximately described as sum

$$G \stackrel{\text{def}}{=} u_i^{(0)} + \sum_{j \neq i} u_j.$$

- The person $i$ can change the group behavior by using appropriate emotions toward other people; indeed:
  - once the person $i$ fixes his/her emotions, i.e., the coefficients $\alpha_{ij}$,
  - then, according to the Nash's bargaining solution, the group will select the alternative that maximizes the product

$$F \stackrel{\text{def}}{=} \left( u_i^{(0)} + \sum_{j \neq i} \alpha_{ij} \cdot u_j \right) \cdot \prod_{j \neq i} u_j.$$

## 11. Resulting formulation of the problem (cont-d)

- The question is:
  - what coefficients $\alpha_{ij}$ should the person $i$ select
  - so that the result of maximizing the expression (4) will also maximize $i$-th objective $G$.

## 12. Analysis of the problem

- Let us first formulate the above problem in general mathematical terms.
- We have two functions $F(v_1, \ldots, v_n)$ and $G(v_1, \ldots, v_n)$ of several variables.
- We want to make sure that:
  - at the point $m = (m_1, \ldots, m_n)$ at which the first function attains its maximum under some constraints,
  - the second function also attains its largest value under the same constraints.
- The fact that at the point $m$, the function $F(v_1, \ldots, v_n)$ attains its maximum under give constraints means that:
  - for any perturbation $m_i \mapsto m_i + \Delta m_i$ which is consistent with these constraints,
  - the value of this function cannot increase.

## 13. Analysis of the problem (cont-d)

- In particular, this must be true for small perturbations $\Delta m_i$.
- For small perturbations, terms quadratic (and of higher order) with respect to these perturbations are very small.
- They can, thus, be safely ignored.
- Thus, to find the modified value $F(m_1+\Delta m_1,\ldots,m_n+\Delta m_n)$ of this function, we can:
  - expand this expression in Taylor series in terms of $\Delta m_i$ and
  - keep only linear terms in this expansion.
- In this case, we get

$$F(m_1+\Delta m_1,\ldots,m_n+\Delta m_n)=F(m_1,\ldots,m_n)+\sum_{i=1}^{n}\frac{\partial F}{\partial m_i}\cdot \Delta m_i.$$

## 14. Analysis of the problem (cont-d)

- Thus, the requirement that the value of the function $F(v_1, \ldots, v_n)$ attains its maximum means that:
  - for all possible perturbations $\Delta m_i$,
  - the new value $F(m_1 + \Delta m_1, \ldots, m_n + \Delta m_n)$ of this function is smaller than or equal to the previous value $F(m_1, \ldots, m_n)$.
- Due to the above formula, this difference is equal to the sum in the right-hand side of this formula.
- Thus, the maximizing condition means that this sum should be non-positive: $\sum\limits_{i=1}^{n} \dfrac{\partial F}{\partial m_i} \cdot \Delta m_i \le 0$.
- This sum is the scalar ("dot") product $\nabla F \cdot \Delta m$ of two vectors:
  - the gradient vector $\nabla F = \left(\dfrac{\partial F}{\partial m_i}, \ldots, \dfrac{\partial F}{\partial m_n}\right)$,
  - and the perturbations vector $\Delta m = (\Delta m_1, \ldots, \Delta m_n)$.

## 15. Analysis of the problem (cont-d)

- Thus, the fact that the function $F(v_1, \ldots, v_n)$ attains its maximum at the point $m$ implies that:
  - for all possible perturbations $\Delta m$,
  - we have $\nabla F \cdot \Delta m \le 0$.
- At the same point $m$, the function $G$ should not increase.
- This means that $\nabla G \cdot \Delta m \le 0$.
- We do not exactly know a priori which perturbations $\Delta m$ will be possible and which not.
- We want to make sure that the maximum of $F$ also implies the maximum of $G$.
- So, it is reasonable to require that for *all* possible vectors $\Delta m$:
  - if we have $\nabla F \cdot \Delta m \le 0$,
  - then we should also have $\nabla G \cdot \Delta m \le 0$.

## 16. Analysis of the problem (cont-d)

- In particular, if $\nabla F \cdot \Delta m = 0$, this means that we have both

$$\nabla F \cdot \Delta m \le 0 \text{ and } \nabla F \cdot (-\Delta m) \le 0.$$

- Thus, we should have $\nabla G \cdot \Delta m \le 0$ and $\nabla G \cdot (-\Delta m) \le 0$ – i.e., $\nabla G \cdot \Delta m \ge 0$.
- So, we should have $\nabla G \cdot \Delta m = 0$.
- In geometric terms, the fact that the dot product of two vectors is 0 means that this vectors are orthogonal to each other.
- Thus, every vector $\Delta m$ which is orthogonal to $\nabla F$ should be orthogonal to $\nabla G$.
- All the vectors orthogonal to a given vector $\nabla F$ form a (hyper-)plane orthogonal to this vector.
- It is known that all the vectors which are orthogonal to all the vectors from this plane are collinear with $\nabla F$.

## 17. Analysis of the problem (cont-d)

- So, we must have $\nabla G = c \cdot \nabla F$ for some constant $c$ – or, equivalently, that $\nabla F = c' \cdot \nabla G$ for some constant $c' = 1/c$.
- Let us use this conclusion to analyze our case study, in which we unknowns $v_i$ are:
  - the "objective" utility value $u_i^{(0)}$ of person $i$, and
  - the utility values $u_j$ corresponding to all other persons $j$.

## 18. Analysis of the case study

- Let us consider the case, when the main objective of the person $i$ is increasing the GDP of his/her country:

$$G = u_i^{(0)} + \sum_{j \neq i} u_j.$$

- For the function $G$, its gradient is equal to $\nabla G = (1, \ldots, 1)$.
- So the above condition means that $\nabla F = c' \cdot \nabla G = (c', \ldots, c')$ for some constant $c'$.
- So, all partial derivatives of the function $F$ have the same value.
- It is convenient to describe $F$ as $F = \exp(H)$, where

$$H = \ln(F) = \ln\left(u_i^{(0)} + \sum_{j \neq i} \alpha_{ij} \cdot u_j\right) + \sum_{j \neq i} \ln(u_j).$$

- Here, by the chain rule formula, $\nabla F = \exp(H) \cdot \nabla H$.

# 19. Analysis of the case study (cont-d)

- So, all components of the vector $\nabla H$ differ from the corresponding components of the vector $\nabla F$ by the same factor $F = \exp(H)$.
- All the components of the gradient $\nabla F$ are equal to each other.
- This implies that all the components of the gradient $\nabla H$ are also equal to each other.
- Differentiating the expression for $H$ with respect to $u_i^{(0)}$, we conclude that
$$H_{,i} \stackrel{\text{def}}{=} \frac{\partial H}{\partial u_i^{(0)}} = \frac{1}{u_i^{(0)} + \sum\limits_{j \neq i} \alpha_{ij} \cdot u_j}.$$
- For each $k \neq i$, differentiating $H$ with respect to $u_k$, we get:
$$H_{,k} \stackrel{\text{def}}{=} \frac{\partial H}{\partial u_k} = \frac{\alpha_{ik}}{u_i^{(0)} + \sum\limits_{j \neq i} \alpha_{ij} \cdot u_j} + \frac{1}{u_k}.$$

# 20. Analysis of the case study (cont-d)

- These two derivative – i.e., these two components of the gradient – must be equal to each other, i.e., we must have

$$\frac{\alpha_{ik}}{u_i^{(0)} + \sum\limits_{j\ne i} \alpha_{ij} \cdot u_j} + \frac{1}{u_k} = \frac{1}{u_i^{(0)} + \sum\limits_{j\ne i} \alpha_{ij} \cdot u_j}.$$

- Multiplying both sides of this equation by $C \stackrel{\text{def}}{=} u_i^{(0)} + \sum\limits_{j\ne i} \alpha_{ij} \cdot u_j$, we conclude that $\alpha_{ik} + \dfrac{C}{u_k} = 1$.
- Thus, we arrive at the following formula for the coefficients $\alpha_{ik}$ describing the $i$-th person's emotions towards others.

## 21. Resulting formula and its interpretation

- We consider a person $i$ whose main objective is increasing the country's GDP.
- Then, he appropriate emotions towards others – namely, the emotions that best promote this objective – are described by the formula

$$\alpha_{ik} = 1 - \frac{C}{u_k}.$$

- Thus:
  - when a person $k$ works hard and contributes a lot to the GDP,
  - and thus, get a lot of compensation $u_k$ for his/her hard work,
  - we get $\alpha_{ik} \approx 1$ – i.e., the person $i$ has a very positive attitude towards this hard-working person $k$.

## 22. Resulting formula and its interpretation (cont-d)

- On the other hand:
  - if a person $k$ works as little as possible, so that $k$'s compensation is small,
  - the $i$'s attitude towards $k$ is much less positive, and it can be even negative if $u_k < C$.

## 23. Comments

- From the commonsense viewpoint, this negative attitude makes sense:
  - if $i$'s goal is to increase the country's GDP,
  - then $i$ naturally feels negative towards those who could help their country more but prefer not to work too hard.
- What we showed is that:
  - not only such motions are natural,
  - they actually help achieve such economic goals.
- For example, if many people think like that:
  - the country may try to force people to work more,
  - e.g., by imposing special taxes on those who do not pull their share of effort.
- It is important to take into account that we are dealing with an approximate model.

## 24. Comments (cont-d)

- Thus, our main conclusion – the above formula – should not be taken too literally.
- For example, it is necessary to take into account that:
  - this formula – and the resulting negative attitude,
  - only make sense towards people who could work more but prefer not to.
- It does not make any economic sense to have negative feelings towards people:
  - who try their best
  - but who cannot produce too much because of their health or age or disability.

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