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

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Abstract. Research has shown that to properly understand people's economic behavior, it is important to take into account their emotional attitudes towards each other. Behavioral economics shows that different attitudes results in different economy-related behavior. A natural question is: where do these emotional attitudes come from? We show that, in principle, such emotions can be explained by people's objective functions. Specifically, we show it on the example of a person whose main objective is to increase his/her country's GDP: in this case, the corresponding optimization problem leads exactly to natural emotions towards people who contribute a lot or a little towards this objective.

1 Formulation of the Problem

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 of different options. 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 recently got several Nobel prizes.

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 paper, we show that this hypothesis indeed explains – at least on the qualitative level – people's economy-related emotions. We show it on the example of a situation when a person is mostly interested in increasing the country's Gross Domestic Product (GDP) as much as possible. We show that in this case, the analysis of the corresponding optimization problem leads exactly to the economy-related emotional attitudes that people experience.

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2 Towards Formulating the Problem in Precise Terms

How Decision Theory Describes Individual and Group Decision Making. According to decision theory (see, e.g., [2–5, 8–10]), 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.

What if several people need to make a joint decision affecting all of them? In this paper, 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 – the 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. 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 text, we will assume that all utility functions already have this property, i.e., that $u_i(x_0) = 0$ 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 possible. This idea is known as *Nash's bargaining solution*; see, e.g., [5–7].

How Emotional Attitudes Towards other People are Taken into Account. Emotional attitude means that the person's preferences – and thus, the person's utility function $u_i(x)$ that describes these preferences – are affected not only by the objective conditions of this person, but also by the conditions (i.e., utilities) of others. 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. Since the effect of the values $u_j(x)$ is small, we can follow the usual practice of physics and other applications (see, e.g., [1, 11]): 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:

$$u_i(x) = u_i^{(0)}(x) + \sum_{j \neq i} \alpha_{ij} \cdot u_j(x), \tag{1}$$

for appropriate coefficients α_{ij}. These coefficients α_{ij}, in effect, describe the emotions of the i-th person toward a person j:

- When the coefficient α_{ij} is positive, this means positive attitude: the person i feels better when he/she knows that the person j is better.

- When the coefficient α_{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.

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 the sum

$$G \stackrel{\text{def}}{=} u_i^{(0)} + \sum_{j \neq i} u_j. \tag{2}$$

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 α_{ij}, then, according to the Nash's bargaining solution, the group will select the alternative that maximizes the product

$$F \stackrel{\text{def}}{=} \left(u_i^{(0)} + \sum_{j \neq i} \alpha_{ij} \cdot u_j \right) \cdot \prod_{j \neq i} u_j. \tag{3}$$

The question is: what coefficients α_{ij} should the person i select so that the result of maximizing the expression (4) will also maximize i-th objective G – e.g., in our example, the expression (2).

3 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. In particular, this must be true for small perturbations Δm_i. For small perturbations, terms quadratic (and of higher order) with respect to these perturbations are very small and 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 Δm_i and keep only linear terms in this expansion. In this case, we get

$$F(m_1 + \Delta m_1,\ldots,m_n + \Delta m_n) = F(m_1,\ldots,m_n) + \sum_{i=1}^{n} \frac{\partial F}{\partial m_i} \cdot \Delta m_i. \tag{4}$$

Thus, the requirement that the value of the function $F(v_1,\ldots,v_n)$ attains its maximum means that for all possible perturbations Δm_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 formula (4), 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:

$$\sum_{i=1}^{n} \frac{\partial F}{\partial m_i} \cdot \Delta m_i \le 0. \tag{5}$$

This sum is the scalar ("dot") product $\nabla F \cdot \Delta m$ of two vectors: the gradient vector

$$\nabla F = \left(\frac{\partial F}{\partial m_i}, \ldots, \frac{\partial F}{\partial m_n} \right) \tag{6}$$

and the perturbations vector

$$\Delta m = (\Delta m_1, \ldots, \Delta m_n). \tag{7}$$

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 Δm, we have $\nabla F \cdot \Delta m \le 0$.

The fact that at the same point m, the function G should not increase means that $\Delta G \cdot \Delta m \le 0$. We do not exactly know a priori which perturbations Δm will be possible and which not. So, to make sure that the maximum of F also implies the maximum of G, it is reasonable to require that for *all* possible vectors Δm, if we have $\nabla F \cdot \Delta m \le 0$, then we should also have $\nabla G \cdot \Delta m \le 0$.

In particular, if $\nabla F \cdot \Delta m = 0$, this means that we have both $\nabla F \cdot \Delta m \le 0$ 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 these vectors are orthogonal to each other. Thus, every vector Δm which is orthogonal to ∇F should be orthogonal to ∇G. All the vectors orthogonal to a given vector ∇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 ∇F, i.e., 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.

4 Case Study

Description of the Case: Reminder. We consider the case when the main objective of the person i is increasing the GDP of his/her country.

In this case, the function G has the form (2).

Analysis of the Case. For the function G, its gradient is equal to $\nabla G = (1,\ldots,1)$, so the above condition means that

$$\nabla F = c' \cdot \nabla G = (c', \ldots, c') \tag{8}$$

for some constant c', i.e., that all partial derivatives of the function F have the same value. It is convenient to describe F as $F = \exp(H)$, where

$$H = \ln(F) = \ln\left(u_i^{(0)} + \sum_{j \neq i} \alpha_{ij} \cdot u_j\right) + \sum_{j \neq i} \ln(u_j). \tag{9}$$

Here, by the chain rule formula, $\nabla F = \exp(H) \cdot \nabla H$. So, all components of the vector ∇H differ from the corresponding components of the vector ∇F by the same factor $F = \exp(H)$. Since all the components of the gradient ∇F are equal to each other, this implies that all the components of the gradient ∇H are also equal to each other.

Differentiating the expression (9) with respect to $u_i^{(0)}$, we conclude that

$$H_{,i} \stackrel{\text{def}}{=} \frac{\partial H}{\partial u_i^{(0)}} = \frac{1}{u_i^{(0)} + \sum\limits_{j \neq i} \alpha_{ij} \cdot u_j}. \tag{10}$$

For each $k \neq i$, differentiating the expression (9) with respect to u_k, we get:

$$H_{,k} \stackrel{\text{def}}{=} \frac{\partial H}{\partial u_k} = \frac{\alpha_{ik}}{u_i^{(0)} + \sum\limits_{j \neq i} \alpha_{ij} \cdot u_j} + \frac{1}{u_k}. \tag{11}$$

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

$$\frac{\alpha_{ik}}{u_i^{(0)} + \sum\limits_{j \neq i} \alpha_{ij} \cdot u_j} + \frac{1}{u_k} = \frac{1}{u_i^{(0)} + \sum\limits_{j \neq i} \alpha_{ij} \cdot u_j}. \tag{12}$$

Multiplying both sides of this equation by

$$C \stackrel{\text{def}}{=} u_i^{(0)} + \sum_{j \neq i} \alpha_{ij} \cdot u_j, \tag{13}$$

we conclude that

$$\alpha_{ik} + \frac{C}{u_k} = 1. \tag{14}$$

Thus, we arrive at the following formula for the coefficients α_{ik} describing the i-th person's emotions towards others.

Resulting Formula and Its Interpretation. For a person i whose main objective is increasing the country's GDP, the appropriate emotions towards others – namely, the emotions that best promote this objective – are described by the formula

$$\alpha_{ik} = 1 - \frac{C}{u_k}. \tag{15}$$

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.
- 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 $u_k < C$.

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 and thus, our main conclusion – the formula (15) – should not be taken too literally. For example, it is necessary to take into account that the formula (15) – 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 cannot produce too much because of their health or age or disability.

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References

1. Feynman, R., Leighton, R., Sands, M.: The Feynman Lectures on Physics. Addison Wesley, Boston, Massachusetts (2005)
2. Fishburn, P.C.: Utility Theory for Decision Making. Wiley, New York (1969)
3. Fishburn, P.C.: Nonlinear Preference and Utility Theory. The John Hopkins Press, Baltimore, Maryland (1988)
4. Kreinovich, V.: Decision making under interval uncertainty (and beyond). In: Guo, P., Pedrycz, W. (eds.) Human-Centric Decision-Making Models for Social Sciences. SCI, vol. 502, pp. 163–193. Springer, Heidelberg (2014). https://doi.org/10.1007/978-3-642-39307-5_8
5. Luce, R.D., Raiffa, R.: Games and Decisions: Introduction and Critical Survey. Dover, New York (1989)
6. Nash, J.: The bargaining problem. Econometrica **18**(2), 155–162 (1950)

7. Nguyen, H.P., Bokati, L., Kreinovich, V.: New (simplified) derivation of Nash's bargaining solution. J. Adv. Comput. Intell. Intell. Inform. (JACIII) **24**(5), 589–592 (2020)
8. Nguyen, H.T., Kosheleva, O., Kreinovich, V.: Decision making beyond Arrow's 'impossibility theorem', with the analysis of effects of collusion and mutual attraction. Int. J. Intell. Syst. **24**(1), 27–47 (2009)
9. Nguyen, H.T., Kreinovich, V., Wu, B., Xiang, G.: Computing Statistics under Interval and Fuzzy Uncertainty. Springer Verlag, Berlin, Heidelberg (2012)
10. Raiffa, H.: Decision Analysis. McGraw-Hill, Columbus, Ohio (1997)
11. Thorne, K.S., Blandford, R.D.: Modern Classical Physics: Optics, Fluids, Plasmas, Elasticity, Relativity, and Statistical Physics. Princeton University Press, Princeton, New Jersey (2017)