APPLICATION OF COURNOT'S MODEL ON A COUPLE'S BUDGET ALLOCATION

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ABSTRACT

Budget allocation of the couples belongs to the field of family finance management, but also represents a source of dispute among them, which directed the research of this topic towards family therapy and psychology. This paper will offer quantitative approach, implementing Cournot's duopoly model to a situation of a couple's budget allocation. That will emphasis the underlying economic principles, as well as show that there exists an equilibrium solution or an equilibrium set of possible solutions.

Keywords:
applied game theory, couple decision-making, family finance management

1. INTRODUCTION

This paper will consider a newly wedded couple deciding on the amount of money they should save or invest. They both understand that it is useful to save money, but the deviation tendency for spending money is high. However, for the purpose of this paper this couple will aim for a rational answer. We will assume that one person prefers to spend the money, while the other prefers to save the money. The two players compete over the dominance of the budget. That provides the situation framework which requires game theory as a methodology. Therefore, this situation will be modeled using game theory framework, precisely Cournot's model. Game theory is mathematical discipline dedicated to analysis and anticipating human behavior in strategic situations. Requirements of the game theory also have to be satisfied: there has to be at least two players, players have to interact strategically, feasible strategies have to be described, as well as available information, pay offs and players' preferences regarding the pay offs. That will result in formalization of bargaining stage on personal budget allocation.

The application of the Cournot's model to a situation where a couple has to decide on saving and spending of their limited budget will show that (1) division of the limited budget by a couple follows same economic principles as duopoly market division; (2) there is an equilibrium solution or an equilibrium set of possible solutions. In addition, offered equilibrium solution can be adjusted/ extended and compared to existing models questioning the deviations from the equilibrium, such as deviation towards non reporting income, expenses for child from previous marriage, transfers given the amount of caring and deviations due to personality characteristics. The model results can relate to existing model's results providing a simulation with empirical data as confirmation for each.

Secondary data will be implemented in the model using compilation method. The aim of this model is to answer what is the optimal behavior of participants in observed game from a new, different perspective, such that it can be applicable both in everyday life and can serve for further scientific research and model development. Moreover, this Cournot's model implementation can serve as a basis for future empirical research of this topic.

2. LITERATURE REVIEW

Financial arguments are common part of couples' interaction, and has been previously documented and studied by numerous authors. Family financial management requires decision-making of many situations, such as spending, savings, retirement plan, buying choices, plan for children and their expenses, residence choice, and so on. Godwin (1990) noticed that at the time, there was many literatures on what couples should do, but very few research on how couples actually behave in

this situations. Since then, a numerous researches have been conducted and most of them found that financial problems and financial argument influence marital satisfaction (Kerkmann et al., 2000). Lawrence et at (1993), found that savings and pursuing goals were negatively correlated with arguing, and cost-cutting strategies, delaying and do-it-yourself are positively correlated to arguments. The same author relays of the research of Goodman, 1986, Mitchell and Zalenski, 1985, Yankelovich, Skelly, & White, 1975, which found that from one-third to over one-half of their respondents argue about finances.

Guiso and Sodini (2013) use the term household finance, and state related issues such as financial mistakes, financial literacy, portfolio allocation, debt decision and consumer financial regulation. According to these authors, "household finance is the normative and positive study of how households use financial markets to achieve their objectives". Even though they pointed out to required interdisciplinarity when dealing to this topic, they do not engage deeply into decision-making process.

Further literature review shows that the research of this topic has been transferred from personal finance to the field of family therapy and self-help psychology (Post, 2005, Wilson, 2012). Almost forty years after first significant studies in this field, Queen at al., (2013) state that research on decision making in couples is yet at an early stage of development. The same authors develop framework for decision making process in couples regarding to decision context, individual characteristics, other social partners and how it effects on the quality of the process. However, authors insist on collaborative decision making.

Modeling cooperative decision making enables forming a descriptive framework, which can be loosely defined for each situation, and in best case shows direction of the decision. The lack of this approach is that enables achieving uniquely defined outcome or a set of possible outcomes. If one wants to do that, should use non cooperative decision making. In combination with other parameters which can be observed in this situation, such as two persons who strategically interact, have different preferences over outcomes and have to agree on making a financial decision, form a framework which requires game theory methodology.

Game theory deals with situations of conflict between two or more participants. The aim is to determine the behavior of participants that best for them, assuming they are rational. Conflict is regulated by strict rules, and the solution of conflicts is determined by the actions of all parties to the conflict. The rules specify the behavior of players. Strategy is a comprehensive plan of action, the rules of the decision or set of instructions that players must abide by taking into account all available prior information about the game (Brkić, 2003). Also, it is important to make distinction between the use of terms of cooperation, as in terms of possibility of making an agreement and as cooperative game theory model which implies that the rules can be changed during the game. Non cooperative, formal models can also allow possibility of making an agreement, moreover the equilibrium solution can be observed

as a rational point of an agreement. The distinction is noted by Malapit (2012: 2), "cooperation implies that couples pool their resources and then jointly decide how these resources are allocated, be it through consensus, Nash bargaining, or some other collective decision making. *** Noncooperation implies that individuals allocate their own resources according to their personal preferences". After clarification of the terms, authors use formal model in order to determine situations in which spouses have motivation to hide their income. They find that in patriarchal or matriarchal systems, a non-deciding person has a tendency to hide their income. Conrad and Lommerud (2000) offer Cornout - Nash equilibrium model of non-cooperative marriage. Ashraf (2009) shows that in jointly made decisions over budget allocation partners report less money, or keep a secret stash of money. Regarding the bargaining power, influences of threat points such as divorce or departure (Lundberg, Pollak, 1993; McElroy, Horney, 1981). Beside the bargaining power, there are additional influence factors included in modelling budget allocation that can reflect on newlywed couple budget allocation decision, such as expenditure on children from previous marriages (Del Bocca, Flinn, 1994). Chen and Woolley (1999) formed a Cournot-Nash model for a family decision making and examined the transfers within the household given the amount of caring between the spouses. According to Carter and Katz (1997), only transfers within the household are subjective to cooperative decision making.

Decision making and interaction in real life are usually not susceptible to simple rules. Especially at individual level, where personal characteristics take place. The clear connection of personal characteristics to decision-making in game theory has been shown by Tay et al. (2006), Nassiri - Mofakham (2007, 2009), Roozmand (2011), and Škare and Kostelić (2015). Therefore, it is advisable to include behavioral characteristics, as a part of the model, or at least as an orienting parameter. Different kind of behavioral characteristics which represent the boundaries for rational decision making, systematized by Kahneman and Tversky (2003) are called heuristics, biases and cognitive illusions. For the purpose of this paper, personal characteristic will be noted as an orienting factor regarding the preference of outcome.

Influences such as domestic violence (Tauchen et al., 1991), division of housework (Lundberg, Pollak,1993; Konrad, Lommerud, 1995), and long-term repeated interaction (Chiappori, 1992), investment in mutual children (Ott, 1995) will be disregarded due to the nature of the observed situation. This paper will not discuss sequential interaction, or question consumer or savings choices such as buying preferences or choice of financial products or financial literacy.

This regards to a loosely defined correction parameter of the existential spending. There is a part of the budget required for existential expenses which is usually formed at the national level for four-member monthly necessary expenses (average consumer basket). So, this part of the budget must not be part of the division on the spending and the savings amongst the partners. The average consumer basket has to

be corrected for the number of family members, additional income in family, preferences, personality and life style.

3. METHODOLOGY

Game description. In following game two persons have to define amounts for savings and spending from the mutual budget. We assume that the players have done the market research regarding the products and interest rates. Also, we assume that savings is the first person's preference, while second person prefers spending.

Cournot's model will be used because, in its emphasized features, situation reminds of a duopoly, two companies of approximately same market power compete for the share of the limited market. Each person of the couple is an agent choosing an amount of the limited budget. Applying the Cournot's model (Gibbons, 1992: 14-21; Mas Coleil, Whinston, Green, 1995: 389 - 394, Rasmusen, 2006: 84-86), to the informal declaration of the personal budget allocation is translated into static game of complete information.

The model will be enriched with secondary data. The data source is Croatian bureau of statistics. The Statistical report "Revision of data on basic characteristics of household consumption" provides the data necessary to determine the monthly life expenses. The Statistical report "Statistical Yearbook of the Republic of Croatia" and the data is obtained from Croatian Employment Service regarding every employed person in Croatia. The personal characteristics for implementation in the model will be used from the paper Škare and Kostelić (2015).

Assumptions. First assumption is that static model of complete information can explain the personal budget allocation game. Let the m_1 and m_2 denote the amount of the money, at the disposal of the first and second player, respectively.

Let the

$$u(M) = b - M$$

denotes the possible utility from the savings, where

$$M = m_1 + m_2 \quad .$$

$u(M)$ denotes savings utility, b denotes the amount of joint budget diminished for average cost of life expenses, M is total amount of available joint budget, m_1 denotes the chosen savings amount of the first player, and m_2 denotes the chosen spending amount of the second player.

This leads to utility functions, where $f(U_1)$, utility function of the first player is defined by the preference for investment, while $f(U_2)$ the second player's utility function is defined by the investment diminished by discounting factor revealing his preference for spending. Respectively,

$$f(U_1) = m_1\left[r^n - 1\right] + m_2,$$

$$f(U_2) = m_1 \frac{1}{(1+r)^n} + m_2,$$

and

where r is interest rate.

As it can be noticed, the preferences shape the perception of the gain, which is implemented in the utility function. While first utility function shows preference of $m_1 > m_2$, the second utility function shows preference of $m_1 < m_2$.

There can be derived also a payoff function, π

$$\pi = (U - c) \cdot m,$$

where U denotes utility (result of utility function), c is investment cost, and m is chosen amount of savings.

From this it can be noticed that in observed situation is true $m_{,1} = m_2 \Rightarrow U_1 \neq U_2 \Rightarrow \pi_1 \neq \pi_2$. The utility functions are different, hence payoff functions are different, so the perceived benefit from the equal amount of savings is different for each player.

Furthermore, a condition $M < b$ has to be satisfied. Parameter *b* denotes a part of the budget which remains after subtracting average cost of living corrected for factors (number of family members, additional income in family, preferences, life style...) from the total income. Therefore, the amount that remains for spending and for the investment must not exceed *b*. Otherwise, the situation becomes unsustainable and the family existence is violated, and payoffs tend to ○.

If $M \geq b$, then $u(M) = 0$. Let's assume that the total cost of obtaining savings product is $cm_1 = 0$, hence marginal cost is denoted with constant c, $c = 0, c < b$.

Strategies available for each player regard to the choice of the different amount of budget to obtain. Negative quantities are not feasible strategies. Given that, the set of feasible strategies is $S_1 = [0, b)$, where strategy s_1 denotes chosen amount of money $m_1, m_1 > 0$.

The payoff function for the first player is defined with the payoff functions and the choice of the other player, $u_1(s_1, s_2)$. Let the payoff functions are defined with utility which both players gain, which is rewritten:

$$\pi_1(m_1, m_2) = m_1(u(m_1 + m_2) - c) = m_1\left[b - m_1 - m_2 - c\right].$$

Lemma. If a strategy pair $(s^*_{,1}, s^*_2)$ is Nash equilibrium, for each player has to be true $u(s^*_1, s^*_2) > u(s_1, s_2)$, for each feasible strategy $s \in S$. In addition, it has to

solve the optimization problem $\max_{s_1 \in S_1} u(s_1, s_2^*)$.

Respectively, in provided framework is valid

$$\max_{0 \le m_1 \le b} \pi_1(m_1, m_2^*) = \max_{0 \le m_1 \le b} m_1 \left[b - m_1 - m_2 - c \right]$$

It is assumed that $m_2^* < b - c$ is necessary and sufficient condition for optimization of the first player strategy and leads to

$$m_1 = \frac{1}{2}(b - m_2^* - c)$$

If the strategy pair of chosen amounts of money, $(m_{,1}^*, m_2^*)$ is Nash equilibrium, then for the players rational choices must be true:

$$m_1^* = \frac{1}{2}(b - m_2^* - c)$$

$$m_2^* = \frac{1}{2}(b - m_1^* - c)$$

and .

Proof. If, for example, first player would choose to regard to the available budget amount monopolistically, he would choose $m_1 = M$, which leads to maximization of his pay off function, $f(U_1) = M\left[r^n - 1_{-,} \pi_1(M,0), \pi_1(M,0)\right.$. Given that there are two players, they would maximize their benefits only if aggregated amounts are equal to monopolistic quantity, which leads to $m_1 = m_2 = \frac{M}{2}$. According to previous derivation it can be seen that $m_1 = \frac{M}{2} = \frac{b-c}{2}$ is not the best answer of the first player to the choice of the second player, because it leads to violating condition that *M* must not exceed *b*. That leads to unsustainability of the family existence, and payoffs tend to 0. Hence, $m_1^* = \frac{1}{2}(b - m_2^* - c)$ is the best answer to any chosen amount by second player.

4. RESULTS

When solving the set of equations, it results in

$$m_1^* = m_2^* = \frac{1}{3}(b - c)$$

,

which satisfies presumed conditions.

This provides the framework form implementation of empirical data.

Average consumption expenditures (existential) per household in 2014 for a four-member family is 81315 Kuna/ yearly or 6776,25 Kuna monthly (Revision of

data on basic characteristics of household consumption[1], 2014: 2), average monthly earnings in Croatia was 5533 Kuna in 2014 (Statistical Yearbook of the Republic of Croatia[2] 2015: 174).

If we assume that observed newlywed couple has average consumption expenditures and both spouses earn average paycheck, we get that joint budget amount is 11 066,00 Kuna, and monthly consumption expenditures is 3 388,13 Kuna. That means that after covering basic expenses couple has to decide how much to save and spend of the amount of 7 677,87 Kuna. If we implement the data to the previously described situation, we get $m_1^* = m_2^* = \frac{b-c}{3} = 2559,29$ Kuna. Given that the amount of the living cost is corrected only for number of family members, but not for the other factors, it is possible to define that $0 \leq (m_1^*, m_2^*) \leq 2559,29$ Kuna, where couple is indifferent to their allocation, as long as it is within the interval.

Furthermore, tendency for deviation has to be explained.

Deviation towards non-reporting income.

If one of the players would choose to treat the available budget amount monopolistically, and would choose m_1, he would maximize own profit of $\pi_1(m_1,0)$, using the amount of money $m_1 = \frac{b-c}{2}$, and gaining $\pi_1(m_1,0) = \frac{(b-c)^2}{4}$. Given that there are two players, they can only maximize profit if the aggregated amounts of budget are equal to the monopolistic amount. Deviation towards the monopolistic amount of each player would lead to family survival violation.

So, it can be assumed that the decision maker will choose equilibrium solution, but the non - decision maker will tend to hide money and create a secret stash regardless to the second person preferences.

Let the tendency for deviation is arbitrary quantified to, *d = 1000 Kuna.* The joint budget amount is now 10 066,00 Kuna, and monthly consumption expenditures remain 3 388,13 Kuna. That means that after covering basic expenses couple has to decide how much to save and spend of the amount of 6 677,87 Kuna. If we implement the data to the previously described situation, we get $m_1^* = m_2^* = \frac{b-c}{3} = 2225,96$ Kuna.

The received amount enables non - decision maker to retain control over the budget and generate individual benefit, but diminishes benefit pay offs for both players within the game framework.

1 "The selected sample for 2014 included 4160 dwellings occupied by private households, out of which 2029 private households were successfully interviewed. The response rate at the household level was 54%" (2014:1)

2 "The Labour Cost Survey includes all persons employed in legal entities selected into the sample who signed a work contract with an employer for a fixed or specified period of time, irrespective of whether they worked full time or less than full time and who received wage. Persons who worked on the basis of work agreements or author's contracts, contracts with juveniles' and students' employment services, pupils and students in training and employees who did not receive salaries are excluded." (2015:173)

Deviation because of expenditure on children from previous marriages.

Expenditure on children from previous marriage is a court-ordered obligation, hence increases the amount of monthly consumption expenditures. According to the Croatian Law (314.,4.; NN75/14), the obligatory expenditure on children from previous marriages for a parent who earns from 5501 - 6500 Kuna is 1190 Kuna for a child up to 6 years old; 1392 Kuna for a child of 7 - 12 years; 1525 Kuna for a child of 13 - 18 years. Hence, average obligatory expenditure on children is 1369 Kuna.

So, applying this deviation, we get joint budget amount is 11 066.00 Kuna, and monthly consumption expenditures is 4 757.13 Kuna (assuming that there is only one child support payed monthly). That means that after covering basic expenses couple has to decide how much to save and spend of the amount of 6308,87 Kuna. If we implement the data to the previously described situation, we get $m_1^* = m_2^* = \frac{d-c}{3} = 2102{,}95$ Kuna.

Given that the received amount diminishes benefit pay offs for both players is caused by only one player, the other person has a reason for applying tit for tat strategy which causes deviation from equilibrium solution. The person can do that by keeping the same amount for self or keeping a secret stash. That would diminish the joint budget amount to 9 697 Kuna, leading to choosing amounts of spending and saving of $m_1^* = m_2^* = \frac{d-c}{3} = 1646.62$ Kuna.

It is obvious that this behavior, even though justified, leads only to further diminishing benefit pay offs for both players from mutual budget allocation within the game framework.

Deviation due to transfers within the household given the amount of caring.

For the purpose of examination of the influence of the amount of caring to the household transfers to the equilibrium solution, it is necessary to implement a caring parameter as a preference in the equations.

It is assumed that "caring parameter" contributes to the utility function of one player by increase the utility function of other player. If first player prefers savings over spending and cares for the other player $\mu = 0.5, \mu \in [0.1]$, then his payoff function is defined as $f(U_1) = m_1\left[r^n - 1\right] + \mu m_2$. That leads to $m_1^* = \frac{1}{2}(b - 1.5m_2^* - c)$, while for the purpose of this example, second player remains with his equilibrium choice, $m_2 = \frac{1}{3}(b-c)$. That leads to $m_1^* = \frac{1}{4}(b-c)$, respectively allowing the second player choice $m_2^* = \frac{5}{12}(b-c)$.

This deviation can explain money transfer among the partners where are no expectations in return. In this situation, the amount chosen for savings will be 1919.46 Kuna, while amount chosen for spending will be 3199.11 Kuna. In this case, there is a transfer of 639,83 Kuna from savings to spending due to 0.5 factor of first player

caring for second player. If the second player responds in reciprocity, the observed amount (or a part of it, depending on caring parameter) will be transferred back to the first player.

It can be noticed that the chosen amount of spending violates the first equilibrium outcome set $0 \leq (m_1^*, m_2^*) \leq$ 2559,29 Kuna. However, achieved amounts do not violate presumption $m_1^* + m_2^* < b$, hence they are feasible choices - just not the optimal ones.

Deviation due to personal characteristics.

If we assume that observed newlywed couple has some differences over the personality characteristics, and/or general attitudes, we can expect deviation from the equilibrium solution regarding the differences over choosing amount of saving and spending, consumer choices, general preferences, interests, as well as differences over negotiation tactics, communication style, strategies and perception of rational choices.

The differences over negotiation tactics and communication style can be examined in an iterated communication model, namely dynamic model, which exceeds the scope of this paper. The similar situation occurs with discussion of consumer choices and interests.

For the purpose of the discussion of deviation due to personal characteristics, perception of rational choice will be examined. Thinking - Feeling is a personality trait from MBTI personality trait indicator used in modeling a negotiation situation by Škare and Kostelić (2015). It is a personality trait which distinguishes people who generally tend to make rational choices and people who tend to make emotional choices. Let the first player to be rational and second player emotional. It can be assumed that rational player will strive for equilibrium solution, which is rational choice. On the other side, emotional decision makers tend to make impulsive decisions without giving much thought about it. Therefore, sudden expenses can occur.

Emotional decision maker, if aware of own habits, could decide to keep a part of the income for him/ her-self in order to ensure enough resources for impulsive choices. That leads to the same outcome as in already observed example with hiding income. The rational player should anticipate such behavior and suggest this strategy if the emotional player does not come up with that option (in order to forestall possible future disputes).

For the purpose of this example, let the emotional player chooses to keep for himself 500 Kuna. Joint budget amount is 10 566,00 Kuna, and after covering basic expenses couple has to decide how much to save and spend of the amount of 7177,87 Kuna. If we implement the data to the previously described situation, we get $m_1^* = m_2^* = \frac{b-c}{3} =$ 2392,62 Kuna. This result fits the assumed set of possible outcomes $0 \leq (m_1^*, m_2^*) \leq$ 2559,29 Kuna, where couple is indifferent to their allocation, as long as it is within the interval.

However, the rational player should decide over keeping his part of the budget at disposal for allocation for mutual savings or spending or to keep the same amount of his budget for him/ her-self. Rational choice would be to keep the same amount of his budget for him/her-self, as a tit for tat strategy, which leads to the same outcome as in the example of expenditure on child from previous marriage. In that case, joint budget amount is 10 066,00 Kuna, and after covering basic expenses couple has to decide how much to save and spend of the amount of 6 677,87 Kuna. When we implement the, we get $m_1^* = m_2^* = \frac{b-c}{3} = 2225{,}96$ Kuna.

Nevertheless, the rational player could have a caring parameter due to which could decide to leave his part of the budget for allocation to mutual savings and spending as a form of transfer given the amount of caring. This does not necessary question his rationality. The caring parameter is implemented in his payoff function, so a following transfer is rational choice for that player, given the presumption of caring. However, it can be discussed in terms of subjective rationality, given that the outcome does not follow simple optimization problem providing objectively rational solution. Subjective rationality can be modeled within the game using both endogenous and exogenous parameters providing a solution which better explains individual choices, but deviates from the classic equilibrium solution. In this case, implementation of caring parameter means that player's choices will be guided by specific personal characteristic, but the outcome will still have an underlining rationality (transfer is rational choice given the player payoff function).

This situation could be modeled in two ways. If we start from the complete budget situation, the caring parameter ascribed to the other player's choice amount would lead to the similar situation as in the example of deviation due to transfers within the household given the amount of caring. The difference is that in this situation transfer among the players enables that emotional player keeps an amount for impulsive spending (not receiving an amount from the partner, but keeping his own, while partner's money remains in joint budget and is used for allocation on spending and savings). Second option is to start from the situation after emotional player has retained the amount and the rational player has played tit for tat. If the transfer occurs in this situation, then the caring parameter should not be assigned to emotional player's chosen amount, but to utility from mutual savings and spending.

5. DISCUSSION

This model describes a glimpse of reality, but it can be used as an example of rational choice in interpersonal bargaining over budget allocation. Although many financial decisions relay on emotions, practice showed that rational choice is preferable in this situation. The presumption of rationality in decision-making process can be critique for this model. The counter argument is that biases and heuristics related to decision-making regarding financial decisions tend to lead to poorer decisions, respectively smaller payoff. Models are often used as an assistance in decision-making. This can be a simple solution manual for this sort of situations, given that it is stated that financial decisions tend to lead to a dispute. Moreover, given that the model can easily be adjusted for each situation it can serve as a simple application.

Each model represents a sort of caricature or abstraction of the situation. The emphasized features of the situation of budget division among spender and saver in the family, look much alike the situation of the duopoly. That was the motivation for the Cournot's model application. The application of the model itself, shows that assumptions and calculations follow both original model and logical flow. Therefore, follows that division of the limited budget by a couple follows same economic principles as duopoly market division.

Given that it was possible to satisfy the required assumptions, the game model provided necessary calculations to achieve the equilibrium outcome. There is a unique solution if we assume player's rationality and disregard behavioral parameter, and decision interval if behavioral parameter is considered. However, that shows that there is an equilibrium solution or an equilibrium set of possible solutions for the application of the Cournot's model to a situation where a couple has to decide on saving and spending of their limited budget. In addition, specific situations have been discussed, such as deviation towards non reporting income, expenses for child from previous marriage, transfers given the amount of caring and deviations due to personality characteristics have been examined and shown that the model results can relate to existing models providing an empirical simulation confirmation for each.

6. CONCLUSION

This paper provides an insight on decision-making process in personal budget allocation. If there are two parties with different preferences, decision may be harder to achieve, but nevertheless it is possible and shown by applying Cournot's model to observed situation. Moreover, it proves that (1) division of the limited budget by a couple follows same economic principles as duopoly market division; and following (2) there is an equilibrium solution or an equilibrium set of possible solutions.

Given that financial decision-making provokes the argument amongst the couples, the conclusions from the game can provide a simple solution manual for this sort of situations. Moreover, the model could easily be adjusted for each situation with specific parameter implementation and it can serve as a simple application. Hence, there is possible use of the findings in everyday life.

This paper represents a framework which can be further developed in future research. Possible future research is regarding the communication iteration, development of behavioral parameter in the model, as well as inclusion of heuristics, biases and cognitive illusions in decision-making process.

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