Consumption in Digital Twin model

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Abstract

test

1. Introduction

1.1 Economics for Digital Twin

Digital Twins is a virtual representation of a physical object or system that leverages real-time data, advanced analytics, and simulation techniques to provide insights, support decision-making, and optimize performance throughout the lifecycle of the object or system. Based on the Digital Twin, various technologies such as Internet of Things (IoT), sensors, data analytics, artificial intelligence (AI), and virtual reality (VR) are used. They enable the collection of real-time data from the physical object or system, which is then used to create a virtual counterpart that mimics its behavior and responds to changes in real-time.

Economics for Digital Twin is the measure with Digital Twin technologies to analyze the real economy through the virtual economy. With the difference from the most economic model, the goal not is to give the good explanation for the economy through the abstracted and simple model but to copies the real and complex world in the virtual machine. The start point of this measure is completely different from canonical economic models.

The reason of the difference with the canonical economic model is from mainly three sides. The first one is that Digital Twin model has the geographical limitation. In the most canonical economic model, they often focuses on the market that give a price to good from the quantity of the demand and the supply, and the other factors, such as the geographical setting up, in the canonical model is simplified too much. So we cannot identify why a same kind of a good has different costs and need longer time to be supplied to a market. The geographical limitation also produce the difference in the resources and environments of nature for each areas and so it can bring us to expand the possibility of more precise analysis to weight on the resources that can produce industries for nations and the relation between economic and nature for the sustainability.

The second aspects is to focuses on the time limitation. In the canonical model, the time is often dealt with a term from the starts to the end. For example, the time t in the DSGE model is considered as the quarterly of the year because the data set for the GDP is releases by each quarterly of the year. This is the completely correct approach and does not have any problems to analyze if people always be in the centralized market. However, in the real world, human need to do something to take a time, including join in the centralized market. For example, please imagine a daily life of the normal workers. They have a breakfast at their home, go to their workplace to work, head to the market to buy some foods, and go back to their home to have them and go sleep at their home. Their action needs a time. So they think required time to do in their decision, not only asset allocation. Of course, if you want to weigh the result of the activity in the market, you still do not have to weigh the time limitation. However, as I will explain later in this paper, sometimes human's utility will be met outside the market and even if they do not pay money, such as walk around good places. In the canonical model, these activities in the human is not focused on.

The third aspect is to focuses on the human limitation. Human beings cannot get full information to the world where they live, and memorize all of them. Also, they cannot move from a place to another faraway place in the blink of eye, and fly to the sky and spaces without a airplane and a rocket. These limits a menu of their actions and decisions in the real world. As a matter of course, there is no superman in the real world.

These three limitations, a geographical limitation, a time limitation and human limitation, is the major limitation in the Digital Twin economic model and improve analysis for economics. Also, they can bring us other benefits because these limitation make economic model more realistic.

The first one is the counter-factual simulation. that most economics papers tackle is easy to be executed and we can get more sophisticated results.

The second one is that Economics for Digital Twin are expected to be a platform for the sociological areas, such as sociology, education etc. In the most economic models, they have focused on the analysis of the economy, including macro economic model. However, in the present time, the analysis of economics will be wider and it is difficult to analyze the activity of the economy in the only knowledge for the economics. So we need to model that integrates with various sociological models.

2 Utility for Digital Twin

2.1.1 current consumption model

In the canonical model, the demand function is derived by the maximized utility subjected to the budget constraint, such as the simple case;

$$\max_{C_t, B_{t-1}} \sum_{t \in T} U(C_t)$$
$$s.t. \quad C_t + B_t = Y_t + (1 + r_t) B_{t-1}$$

where C_t is the consumption, B_t is the risk-free rate bond and Y_t is the production at the time of t. And we are going to get the dynamics in the consumption "Permanent income hypothesis";

$$C_t = \frac{r}{1+r} \left(B_0 + \sum_{t=0}^{\infty} \left(\frac{1}{1+r} \right)^t Y_t \right)$$

From the equation, we can get what the current consumption depends on the sum of the future income/products. In this model, the change in the income will make the consumption change, which means this model focuses on the production. So we can consider this model as the supply-side economic model.

This concept will be able to apply for the ideal economy that has always the quantity of the demand and supply or people will consume however much quantities production are there. That means over supply and demand does not happen essentially in this model.

This optimal allocation problem mainly imply the following three interpretations.

Points

1. The amount of the consumption depend on the budget and collateral constraints
2. The amount of the consumption depend on the interest rate
3. The amount of the consumption depend on the wage

Implications

- The amount of the consumption will increase if the interest rate goes down
- The amount of the consumption will increase if the wage goes up

Philosophy

Human beings thinks about the optimal allocation for their asset within each periods. Specifically, under the rational expectations, they think about the amount of the optimal consumption.

Cons

- You need to solve more complex optimal problem fi you want to add variety constraints to your model.

- Coherently, the supply decides the demand. (If the supply goes up over times, then the consumption will goes up as well)

1.2.2 new consumption model for Digital Twin

The approach of the optimal allocation for the maximization of the utility is required to solve the asset allocation model for every time. So this way does not fit the Digital Twin model that I will create in the following reason.

First, it needs a lot of time to get the solution from the complex utility function. This approach is required to get the rigor equilibrium in the economic model and so we need solve the multiple equation every time. However, in the Digital Twin model, human beings need to make their decision on consumption or something because the time limitation is crucial for their decision. So I consider that the optimal allocation is the ideal result of the optimal decision, but the model of the human activities do not need to lean to it. Instead of that, we propose another approach to replicate their decision making.

3. Proposition

3.1 Desire-based utility

I assumed that human beings have some desires that push them to do action for something. For example, the reason why human beings get and have a food is for their appetite. Also, the reason why they completely stop their activities and take a rest at the night is the desire for their sleep. Like this, the action of human begins is ruled by their desire.

Besides, their desire determined their consumption activities. If they faces the situation that they get a bread and a vegetable and they can eat only either one, they will choose to have a bread because it make their hungry get away from them much more than they have a vegetable.

Also, in the case of the multiple desire, we can see the activity of the more complex consumption. If there are three desire such as the appetite, the desire of the sweet and the desire of the sour. When a person who want to meet the desire of the sour now because today is the hottest day is there and he get sweets and lemons, which food he will have at first? Yes. He will have a lemon at first. However, after he have a lemon, if he is still hungry, which food he will have at the next? If his desire of the sour is not enough, he will have lemon as well. However, If his desire of the sour is enough, he will have sweet. Of course, he is not hungry, there does not happen anymore.

This complex consumption cannot be explained with the dynamic preference because it focus on the result of the consumption with revealed preference. However, in the reality, the dynamic preference are existed, and it depends on the desire of human beings.

[Definition] A desire is a measure that animals, including human beings, decide to prefer one to another in the demand of goods and services at a time. Therefore, a desire itself cannot show someone's preference. However, if those get a menu list of goods and services that they can get, the order of their preference is decided based on a menu.

This means that we can know someone's preference from the observation, so-called "revealed preference", but we cannot get inner preference in their mind. Therefore, I think we cannot decide them to prefer something to another thing before they know there are things. This also can say that the demand is decided by the original desire of animals, not by something in the world, "Demand-centered" utility.

This can get a explanation why a good and another one is substituted. For example,

[For simulation] For the Digital Twin simulation, we need to decide which kind of desires we need to include in the model. You should ask antholopologist and nutrician.

[Model] First of all, Desire for a factor $x \in X$ at time t has the lower and upper threshold.

$$Desire_{\{x,t\}} \in [0, 100]$$

Next, Desire will be decreasing over time automatically without any events.

$$Desire_{\{x,t\}} = \alpha_{\{x\}} Desire_{\{x,t-1\}} + \varepsilon_t$$

where ε_t is the exogenous variable that depends on some events.

And, the level of the utility for a person is determined by the combination of desires. So, the level of the utility of a person $n \in N$ is

$$u_t^n = U\Big(\bigcup_{x \in X} Desire_t \Big)$$

where a function of $U(\cdot)$ is a utility function.

Note that the time t for this setting means the **delta time** like one second in the real world, and so, for example, the yearly amount of the consumption is represented as

$$u_{Year} = \sum_{t=0}^{31{,}536{,}000} U\Big(\bigcup_{x \in X} Desire_t \Big)$$

because

$$1(sec) \times 60(minutes) \times 60(hours) \times 24(days) \times 365(Year) = 31,536,000.$$

Also, ε means something to meet desires. It does not matter whether they are goods or services such as a food, electronics, entertainment or something like that. However, each person have the priority which desire he/she should meet at first. Especially, the desire of sleeping and desire of the eating (appetite) is need to be met to live a life for all of human beings.

3.2 The revealed preference and consumption to meet the desire

In the previous, I discussed the origin of a preference and set them as a desire. In this section, I proposed the system to decide preference and consumption to desire.

At the demand centered model, those who have a combination of a desire do not have any specific an order of a preference for goods. However, when they see a menu of goods, their preference will be revealed. This system is an revealed preference system in the deman centered model.

When they meet an menu of goods, they choose one based on their priority of desire to meet. At the background on it, their desire matching mechanism will work. For example, a menu has a sweet, an orange and a chair. If those who want to meet an appetite at the first of their priority see this menu, they does not choose a chair. And then, those who want to meet an sour at their second priority, they will pick an orange out of menu. In this case, the order of their preference will be

$$orange \succ sweet \succ chair$$

In this case, if an orange is run out, will they choose sweet out of the menu? To answer this problem, we need to discuss the cost of the time to get an orange. If they have a time to go to another shop which have some orange, they will go there. However, If not, they will not.

Let us another example, there are people who have the same priority order of desires, and then there are also orange, apple, and lemon. As you recognize, orange, apple and lemon are foods and have tastes of the sour. In this case, how will people decide to choose one out of them?

Fortunately, at the progress of the modern science, we can get the specific level of the nutritious of the food. Which means that we can identify which one have the most sour food among them. So we can give calories and the level of sours and sweet to these foods. So we also have those have an appetite, the desire of sours and sweet.

From these information, we can assume how people will decide to chose, such as two measures. The first one is their priority centered measure. In this way, they will meet their desire in their prioritized order of desire.

For example, In the case of what their most prioritized desire is the appetite and there are an orange which has 100cal, an apple which has 150cal and lemon which has 50cal, they will choose an apple because it has the most energy.

Another way is matching-mechanism-centered measure. In this way, they will meet their desire in the way of matching. For example, Assume that their desire of sour and that of sweet are indifferent. And their level of the desire of the sour is 50 and that of sweet is 80 and there are an orange which has +75 sour and +20 sweet, an apple which has +50 sour + 40 sweet, and lemon which has +100 sour and +0 sweet, they will choose some food based on the maching mechanism.

3.3 Goods which acceralate consumption to meet desire

Out of goods, there are some goods which are useful for us to make our lives better and change our lives, such as transportation goods like a car, machines like a refrigerator.

In the DSGE model, all goods that people consume are final goods. However, these goods, especially industries provide are not hold for these final goods. For example, if you buy a car, the DSGE and statistic in GDP will include the data of the transaction with an price on it. However, in the DSGE model, the effect of what they buy a car is all of that. Anything does not happen more. However, in the reality, if they buy a car, they can go anywhere speedily, which mean that will bring us changing consumption speed, efficient consumption, and sometimes new consumption to meet new desire, such as an sightseeing and the opportunity to get local goods. This also can expand the amount of the consumption.

These goods are almost durable goods, but is not always one, such as an eraser which cannot affect human utility at all but it is consumed if you will use it. So we should use the idea of the depreciation for these goods.

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IF (Desire <= Threshold) THEN
  epsilon_t >0
ELSE
  epsilon_t =0
END
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1. Meet the desire according to the order of their priorities
2. Deposit residual something
3. Borrowing something if there are some lacks
4. Checking the account whether it is deficit or not at each quartely period
5. Cannot borrow something if someone pay back their borrowing in a year.

Implication

- Priotize the desire or the demand. If there is no desire, human will not consume something
- Under the setting, The amount of the consumption will increase if the interest rate goes down
- Under the setting, The amount of the consumption will increase if the wage goes up

3.3 How to coincidence with the supply and the demand

In this setup, we do not get the demand function from the optimal problem that we generally derive in a standard model. So, we need to find another way to get the coincidence with supply and the demand.

$$Price_t = \frac{Q_{S,t}}{Q_{D,t}}$$

where the amount of the demand Q_D by the demand, the are of the amount of the supply Q_S by the supplier.

Current Approach

$A \succcurlyeq_t B \cap B \succcurlyeq_t C$ ⟶ A — The good A will be selected but we could not know its reason except for individual's preference.

$A \succcurlyeq_t B \cap C \succcurlyeq_t A$ ⟶ ? — We could not know which kind of goods will be selected.

*$A, B, C \in X$ are goods

Desire based Approach

Desire

The list of desires and priority		
Priority	Desire	Status
1	Appetite	30
2	Taste of the sour	50
3	Taste of the sweet	10
	Etc.	

Matching between desire and menu by the order of the priority

⟶ A

Menu

The menu of goods to be able to get			
Desire	Appetite	Taste of the sour	Taste of the sweet
Apple	+40	+80	+10
Bread	+80	0	+10
Chocolate	+20	0	+80
Etc.			

* As a result of the matching, we may get the order of the preference to goods, but it does not matter for the consumption.

Figure 1: test

3.3.1 Decentralized Trading

In Decentralized trading, the amount of the demand depends on the preference from someone you meet.

$$The\ quantity\ of\ the\ demand = \frac{100 - current\ desire}{preference_i}$$

where $alpha_i$ is the individual preference to meet desire. For example, there is an apple that only affect only one desire. Also, current desire is 20. So he want to meet 80 desire to make up to full desire from now on. Also, there are diverse preference for apple by each person, such as person A feel like 25 desire for each apple when he have an apple, also person B feel like 15 desire for each apple. This preference may be curve such as a utility function but for simplicity, I assume they are an linear increment desire.

Also, there is a multiple case desire. For example, when you have an apple, it might make increase your two desire, such as your appetite and your desire for taste of sweetness. In this model, you can make the activity for consumption more complex, such as you will have apple not curry because you need to meet both of the appetite and taste of sweet. This model for the complex consumption activities also leads to integrate with the Input-Output Table analysis that deal with diverse goods and services in Digital Twin model.

Note that in the multiple case desire, if you can make one of your desire up to 100 at least, you are satisfied with your consumption. Therefore,

$$The\ quantity\ of\ the\ demand_{\{a\}} = \min\left[\frac{100 - current\ desire_{\{a,i\}}}{preference_{\{a,i\}}}\right]$$

3.3.2 Centralized Trading

Centralized Trading

4. Further Discussion

4-1. Fiat money

5. Conclusion

6. Appendix

6-1 Data of the consumption for the food

Then,m, we propose the new approach of the utility for the Digital Twin economic model.

The optimized utility make model supply sides intrinstically because. Therefore, the RBC model is the supply sided model and New Keynesian Economic model is the supply sided model with price flactuation by the ad-hock sticky price.

This

Human beings act is not the optimal allocation for their working time and assets because they do not know all of things tasks and assets that they have or will have. They prioritize their tasks and act by the order of their priority every time.

Aim:

- Build the model like DSGE
- Build the utility based on the desire not maximized utility to use Digital Twin analysis