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Abstract

We propose a theoretical argument for a new rational expectations equilibrium hypothesis in the intergenerational economy, where each generation is intergenerationally altruistic and rational. The intergenerationally-rational expectations equilibrium implies that deflation can continue under an extreme increase in money supply.

Keywords: Deflationary equilibrium, transversality condition, zero nominal interest rate policy.

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1. Transversality condition and the velocity of money

Observing the monetary policy in Japan for the last three decades, we have a question whether the velocity of money may be endogenous and responsive to the policy changes. If the velocity decreases endogenously in response to an additional monetary easing, it may be difficult to escape from deflation, even if the BOJ or the government of Japan firmly commits to the 2-percent inflation target by constitutionalize it. In what follows, we propose a theoretical argument of a new rational expectations equilibrium hypothesis in the intergenerational economy. The intergenerationally-rational expectations equilibrium implies that velocity is endogenous, and deflation can continue under an extreme increase in money supply.

We interpret the problem of endogeneity of money velocity as the violation of the transversality condition (TVC) in a standard dynamic general equilibrium model. The quantity theory of money is described as

$$PY = MV, \tag{1}$$

where P is the price level, Y is the real output (or Gross Domestic Product), M is the nominal amount of money, and V is the velocity of money.

Here, the TVC can be expressed as that the real value of money, $m = M/P$, should be finite in the infinite future. The above equation (1) implies that $m = Y/V$, which implies that the TVC (or the finite m) means that V is also finite. If m diverges to infinity as time passes, V must go to zero.

Why is the TVC relevant to the problem of deflation? The reason is that if TVC is violated, m can go to infinity as M goes to infinity. Then, P can stay at a low level, which means that the deflation continues. It is well known that the TVC must be satisfied in the rational expectations equilibrium, implying that the price level P should go to infinity as M goes to infinity. Thus, in the standard model, if the BoJ implements an extreme monetary easing, or increases M indefinitely, then the price level P should go up eventually. In other words, the TVC implies that the inflation is inevitable, if the BoJ implements an extreme monetary easing.

The reality that Japan experienced the coexistence of deflation and money growth seems inconsistent with the TVC with respect to money. Our objective in the next section is to propose a new concept of the rational expectations equilibrium, in which the TVC is not necessarily satisfied. In this new equilibrium, the coexistence of deflation and money growth

can be an equilibrium outcome.

2. Intergenerational rationality and deflationary equilibrium

The following argument is based on Kobayashi (2019).

In the usual macroeconomic models, the coexistence of deflation and money growth cannot be sustained for decades because the coexistence does not satisfy the TVC. The reason why deflation is impossible under an extreme monetary easing can be rephrased as follows: If deflation continues under the extreme monetary easing, the value of money increases indefinitely, which cannot happen in equilibrium because otherwise the money holders (households) can and will purchase the infinite amount of goods and services. As the total amount of goods and services is finite, this cannot happen. See Bernanke (2000) for an example of the similar reasoning. This logic can be broken if we consider a new concept of *intergenerational rationality*. We will explain how it is broken in what follows.

The textbook macroeconomic model is the infinite-horizon economy, in which the consumers or the households live for infinite future. But the reality is that all humans are mortal and the infinite-horizon model is just an approximation. Acemoglu (2009) argues that the following two assumptions are necessary for the economy to be approximated by the infinite-horizon model:

- 1) the individuals live for a finite period, while the household is succeeded by the descendants, and
- 2) the individuals have the intergenerational altruism in the form that the discounted value of the lifetime utility of their children enters their own lifetime utility.

Under these assumptions, the utility of individuals extends from generations to generations and the economy is described as the maximization problem of the utility for the infinitely-lived individuals. In the textbook macroeconomics, the economy of the finitely-lived individuals with intergenerational altruism is considered equivalent to the economy of the infinitely-lived individuals. We can show, however, that the former includes the latter, but not vice versa.

The optimality of the infinitely-lived individuals requires that the TVC must be satisfied, while the optimality of the finitely-lived individuals does not require the TVC to hold. The reason of this difference is summarized as follows.

- The infinitely-lived individuals can only have something they can experience as their expectations, because they will be alive when the expectations are realized.

- On the other hand, the finitely-lived individuals can have something they cannot experience as their intergenerational expectations, because they will be dead when the intergenerational expectations are realized.

This difference between the expectations of infinitely-lived individuals and the intergenerational expectations of finitely-lived individuals is completely neglected in the existing macroeconomics literature. This difference is meaningless when we analyze the business cycles or economic growth in the short-run or middle-run, such as four or five years. But, we argue, when we analyze economic dynamics of the intergenerational time horizon, this difference matters a lot.

Let us consider what the finitely-lived agents can hold as their expectations on the value of a piece of paper, which is called “money.” For simplicity of argument, let us assume that the “money” does not generate any utility. In the economy with the infinitely-lived individuals, the value of “money” is permanently zero, because the worthless paper today is worthless tomorrow.

However, in the economy with finitely-lived individuals, the people can hold the following expectations: “Although the ‘money’ is worthless for me, I believe that my descendants will become very happy if they hold ‘money’.” This expectation is not consistent with what the current generation can experience and therefore it looks an irrational expectation. But the current generation cannot experience what the next generation will experiences, meaning that there is no way for the current generation to confirm the truth of their expectation *ex post*. To confirm the expectations *ex post* is physically impossible, because they will be dead when their descendants live. In this situation, what guarantees the rationality of expectations? The only means to guarantee the rationality is the consistency of the value function: the value function, or the lifetime utility, for the current generation must be consistent with their expectation on the value function for the next generation, in equilibrium. The meaning of this consistency condition will be made clear in the following argument.

Let us consider again the example of the piece of paper, called “money.” When a finitely-lived agent believes “my descendants will be very happy with holding ‘money’,” what is the agent’s value function? He has the intergenerational altruism such that he feels happiness when he expects that his descendants will feel happiness. Then, he feels a desire for “money,” because he wants to obtain it to bequeath to his descendants. Now, because of this new desire, he feels that “money” is valuable for him, because he wants “money” to bequeath to his descendants, but not to increase his own consumption. In this way, a finitely-lived agent holds the

conviction that “money” is valuable for him. This conviction is consistent with his expectation on the utility of his descendants that “they will be happy with holding ‘money’”

Thus, the consistency of expectation is satisfied, and the expectation (“my descendant will be happy with holding ‘money’”) is justified as a rational expectation.

This logic is summarized as the following circular argument, which is the same as those typically adopted in the rational expectations hypothesis.

- “Money” is valuable for me, as I want it not because it increases my own utility, but because I am altruistic to my descendants and I want to bequeath “money” to them, because I believe that “money” will be valuable for my descendants.
- On the other hand, my expectation that “money” will be valuable for my descendants is consistent with the fact that “money” is valuable for me. This consistency supports the expectation as a rational expectation.
- In this way, the fact that “money” is valuable for me and the expectation that “money” is valuable for my descendants support each other as the grounds of justification. This is a circular argument.

This circular argument generates the value of “money” as a bubble. The same logic holds for the money in the real world. It is shown as follows that once the money has the value of the bubble, the deflation cannot be stopped even if the Bank of Japan increases the money supply extremely. As stated in the previous paragraph, the logic for the effectiveness of extreme monetary easing in fighting deflation is the following:

If deflation continues under the extreme monetary easing, the value of money increases indefinitely, which cannot happen in equilibrium because otherwise the money holders (households) can and will purchase the infinite amount of goods and services. As the total amount of goods and services is finite, this cannot happen.

This logic can be overturned in our model of the intergenerational economy, where people have non-satiated demand for money because they want to bequeath it as much as possible. In this economy, even when the total value of money supply is increasing indefinitely, the money holders (i.e., households) do not want to increase the purchase of the goods and services indefinitely, but they just store the additional money. Then, the demand for the goods and services stays finite, leading to the finite price level, while the indefinite amount of money is stored to be bequeathed to the next generation. This situation can continue as a long-term steady state.

This argument implies that there can emerge the deflationary equilibrium, where the people hoard money indefinitely, in the economy of finitely-lived individuals with the intergenerational altruism and rationality. It is also shown that the TVC is not satisfied. The TVC is not necessary to be satisfied in the intergenerational model, because the TVC is necessary for the optimality in the infinite-horizon model, not the intergenerational model. In our intergenerational model, the violation of the TVC is consistent with the optimality in the households' decision, because they have the bubbly demand for money, which makes them indifferent between hoarding money and increasing consumption.

3. Policy debate on the Japanese deflation redux

If the intergenerational model above is the true description of the Japanese economy, it gives us a new insight for the policy debate on the decade-long deflation in Japan. Our model implies that the deflationary equilibrium where deflation and money growth coexist can continue for a long period as a stable steady state. In this deflationary equilibrium, the TVC is violated. The existence of this deflationary equilibrium implies that the deflation cannot be stopped by the extraordinary monetary expansion by the central bank.

In the 1990s and 2000s, many economists argue that an extreme monetary easing can help the Japanese economy to escape from the deflation (see for example, among many others, Krugman [1998], Bernanke [2000], Eggertsson and Woodford [2003], Auerbach and Obstfeld [2005]). These arguments are based on the TVC without exception. They go as follows: the coexistence of deflation and monetary easing violates the TVC, while the TVC must be satisfied in equilibrium; thus, the deflation must stop eventually in equilibrium, as long as the central bank continues the extreme monetary easing.

However, our intergenerational theory claims that there exists a long-term equilibrium where the TVC is violated. Given that this theory is correct, the extreme monetary easing may not be able to stop deflation. Our theory implies that the popular opinion, which has been dominant for the last 20 years, that we need further monetary easing to fight deflation, may not be correct.

Then, what causes the persistent deflation in our intergenerational economy?

The deflationary equilibrium in our intergenerational economy is a steady state, which can

continue in the long-run, whereas in the standard Keynesian argument, deflation occurs when the economy deviates from the long-term steady state. In the long-term steady state, the following Fisher equation holds:

$$1+i = (1+\pi)(1+r), \quad (2)$$

where i is the steady-state value of the nominal interest rate, π is the inflation rate, and r is the real interest rate. In the long-term steady state, the real interest rate r is given by the market equilibrium and it cannot be affected by the monetary policy. Given that r is fixed, the decision by the central bank to set i decides the value of π . In the last 25 years in Japan, the nominal interest rate has been fixed at zero, i.e., $i = 0$. Then, the Fisher equation (2) implies that the value of π , the long-term inflation rate, becomes negative:

$$\pi = -r/(1+r) < 0$$

This argument shows that our model of the intergenerational economy implies that the zero interest rate policy generates the expectation of the long-term deflation. In the existing models, this conclusion from the Fisher equation is rejected because the long-term deflation under monetary easing violates the TVC. However, this conclusion cannot be rejected in the intergenerational model, because the TVC is not necessarily satisfied in equilibrium in our model.

In this case, the extraordinary monetary expansion, such as the quantitative easing, is not able to overturn the deflationary expectations. We may need a fundamentally different policy measures to fight the deflationary equilibrium.

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