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Difference or Ratio: Implication of Status Preference on Stagnation

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Difference or Ratio:

Implications of Status Preference on Stagnation*

by

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Abstract

We consider a dynamic macroeconomic model of households that regard relative affluence as social status. The measure of relative affluence can be the ratio to, or the difference from, the social average. The two specifications lead to quite different equilibrium consequences: under the ratio specification full employment is necessarily realized, whereas under the difference specification there is a case where a persistent shortage of aggregate demand arises. Furthermore, using data of an affluence comparison experiment we empirically find that the difference specification fits the data better than the ratio specification. Therefore, affluence comparison can be a cause of persistent stagnation.

JEL classification: C91, E12, E24

Keywords: status, stagnation, unemployment.

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1. Introduction

Recently many countries suffer from serious long-run recessions. One is the Great Recession that spreads worldwide in the wake of the 2008 international financial crisis. Another is Japan's 'lost decades' that started when its asset bubble burst in 1990. Facing such serious economic circumstances, economists now more than ever need an analytical framework that can treat inefficient macroeconomic outcomes and valid policy options for recovery from chronic stagnation.

The currently dominant research agenda for dealing with stagnation is the New Keynesian approach promoted by researchers such as Christiano et al. (2005) and Blanchard and Galí (2007). They considered microeconomic foundations of price sluggishness and analyzed macroeconomic fluctuations. This type of analysis is quite successful in examining short-run recessions that fade out as prices adjust. However, because it treats perturbations around the full-employment steady state, in order to analyze chronic and serious stagnation with unemployment we need a different theoretical framework. Along this line, in the recent IMF annual conference Summers (2013) criticized too much reliance on the DSGE approach in solving economic crises and emphasized the need for researchers to work on long-run recessions rather than short-run business fluctuations. This paper shares the same view and adopts a long-run stagnation model.

A long-run stagnation model in a dynamic optimization framework was first explored by Ono (1994, 2001), following the spirit of Chapter 17 of Keynes's *General Theory*. Households in this model have an insatiable preference for money, which causes a liquidity trap to appear. Prices continue to adjust, but nevertheless shortages of aggregate demand and employment persist in the steady state. Murota and Ono (2011) also presented a model of persistent stagnation in which status preference plays the same role in creating persistent

stagnation as does the insatiable preference for money. They considered three objects of status preference—consumption, physical capital holding, and money holding—and found that an economy grows or stagnates depending on which is the primary measure of status. If it is money (an unproducible asset), persistent stagnation with unemployment occurs.

The above-mentioned insatiable desires for absolute and relative money holdings were discussed by Keynes (1972, p. 326). He wrote: “Now it is true that the needs of human beings may seem to be insatiable. But they fall into two classes—those needs which are absolute in the sense that we feel them whatever the situation of our fellow human beings may be, and those which are relative in the sense that we feel them only if their satisfaction lifts us above, makes us feel superior to, our fellows.” It may, however, be ambiguous whether the target of people’s desire is to hold money or wealth. In the literature of status preferences, such as Corneo and Jeanne (1997) and Futagami and Shibata (1998), status concerns are often defined with respect to wealth holdings.

Following this convention, we present a model with status preference for wealth, instead of money holdings, and explore the possibility of persistent stagnation. In this analysis there are two specifications of relative affluence. One is that people care about the difference of their wealth holdings from the social average. The other is that people care about the ratio of those to the social average.¹ Murota and Ono assumed that people care about the difference of money holdings because this specification was necessary for persistent stagnation to occur. Corneo and Jeanne (1995) and Futagami and Shibata (1998) took the ratio as the measure of status because that specification was required for endogenous growth to occur in

¹ Clark and Oswald (1998) considered both the difference and ratio specifications of social status and explored tax policy implications for both cases in a static setting.

their models.² We examine both cases and find that persistent stagnation with unemployment occurs under the difference specification but not under the ratio specification. Thus, if the difference specification reflects the real world, our disequilibrium model offers a potential to provide adequate policy implications for long-run stagnation.

We then empirically examine the two specifications to see which is more plausible. Data are borrowed from the hypothetical discrete choice experiment of Yamada and Sato (2013). They conducted a large-scale socially representative survey and estimated the effects of income comparisons by applying the data to the random utility model framework of Train (2009). While the framework is mostly used for parameter estimations of utility functions, as in Viscusi et al. (2008), we instead conduct a horse race between the two specifications of status preference and apply the Akaike Information Criteria (AIC) and R-squared to the comparison. We find that the difference specification fits the data much better than the ratio specification does, and hence the model that accommodates persistent stagnation is supported.

Previous macroeconomic studies of the status preference, such as Cole et al. (1992), Konrad (1992), Zou (1994), Corneo and Jeanne (1997) and Futagami and Shibata (1998), investigated the effects of status preference on the economic growth rate. There are also quantitative approaches that tested the validity of status preference, e.g. Abel (1990), Gali (1994) and Bakshi and Chen (1996). They argued that observed asset price volatility can be explained by the motivation to keep up with the Joneses. Our purpose is to relate status preference to the possibility of persistent demand deficiency and long-run stagnation.

² Under the difference specification and decreasing returns to real capital, Murota and Ono (2011) showed that endogenous growth occurs when households regard real capital as status.

2. Two Specifications of Status Concern

We consider a representative household that cares about relative affluence, whose utility is

$$\int_0^{\infty} [u(c) + v(m) + \sigma(a, \bar{a})] \exp(-\rho t) dt, \quad (1)$$

where $u(c)$ is the utility of consumption c , $v(m)$ is the utility of money m for transactions, $\sigma(a, \bar{a})$ represents status preference, a is total asset holdings, and \bar{a} is the social average of a . Functions $u(c)$ and $v(m)$ satisfy

$$\begin{aligned} u'(c) > 0, u''(c) < 0, u'(0) = \infty; \\ v'(m) > 0, v''(m) < 0, v'(0) = \infty, v'(\infty) = 0. \end{aligned} \quad (2)$$

Two types of status preference $\sigma(a, \bar{a})$ are considered. One is that the household cares about the difference (case D), and the other is that it cares about the ratio (case R).³

$$\begin{aligned} \text{Case D:} \quad \sigma(a, \bar{a}) &= \sigma_D(a - \bar{a}), \quad \sigma'_D > 0; \\ \text{Case R:} \quad \sigma(a, \bar{a}) &= \sigma_R\left(\frac{a}{\bar{a}}\right), \quad \sigma'_R > 0. \end{aligned} \quad (3)$$

The flow budget equation and the asset budget constraint are respectively

$$\begin{aligned} \dot{a} &= ra + wx - Rm - c - \tau, \\ a &= m + b, \end{aligned} \quad (4)$$

where r is the real interest rate, w is the real wage, x is the amount of employment, b is interest-bearing assets, R is the nominal interest rate, and τ is a lump-sum tax. Obviously R satisfies

$$R = r + \pi,$$

³ Quite different theoretical implications obtained from the ratio and difference specifications documented below have nothing to do with so called the Keeping Up with the Joneses (KUJ) and the Running Away from the Joneses (RAJ) effects. While the utility function with the difference specification is always a KUJ type, the utility function with the ratio specification can be KUJ and RAJ, depending on the marginal rate of substitution.

where π is the inflation rate. The number of representative households is normalized to unity and each representative household owns one unit of labor endowment. Therefore, the amount of employment x straightforwardly represents the employment rate.

Maximizing (1) subject to (4) gives a Ramsey equation and portfolio choice summarized as

$$\rho + \eta \frac{\dot{c}}{c} + \pi = R + \frac{\sigma_a(a, \bar{a})}{u'(c)} = \frac{v'(m) + \sigma_a(a, \bar{a})}{u'(c)}, \quad (5)$$

where

$$\eta = -u''(c)c/u'(c), \quad \sigma_a(a, \bar{a}) = \frac{\partial \sigma(a, \bar{a})}{\partial a}.$$

The transversality condition is

$$\lim_{m \rightarrow \infty} u'(c) (m + b) e^{-\rho t} = 0. \quad (6)$$

The firm sector is competitive and uses only labor with linear technology θx , where θ is the labor productivity and is assumed to be constant. In this case, the firm sector infinitely expands production if nominal commodity price P is higher than W/θ , but produces nothing if P is lower than W/θ . Thus, with perfect flexibility of P , P takes the value that satisfies

$$\frac{W}{P} = w = \theta, \quad (7)$$

as long as a finite and positive amount of the commodity is traded. Since the profits in this case are zero, the firm value equals zero. Therefore, interest-bearing assets b consist of only government bonds.

In the money market,

$$\frac{M}{P} = m,$$

where M is the nominal money stock. The monetary authority is assumed to keep M constant, for simplicity, and thus

$$\frac{\dot{m}}{m} = -\pi. \quad (8)$$

The fiscal authority finances interest payments rb by collecting lump-sum tax τ and issuing new bonds.⁴ Formally,

$$\dot{b} + \tau = rb.$$

The fiscal authority adjusts \dot{b} and τ so that the no-Ponzi-game condition is satisfied. In the neighborhood of the steady state, in particular, it adjusts tax τ so that b equal \bar{b} :

$$b = \bar{b}, \quad (9)$$

where \bar{b} is the long-run debt level that the government targets.

Due to the perfect flexibility of P in the commodity market,

$$c = \theta x. \quad (10)$$

If W is also perfectly flexible,

$$x = 1. \quad (11)$$

Substituting (8), (10) and (11) into (5) yields

$$\dot{m} = \left(\rho - \frac{v'(m) + \sigma_a(a, \bar{a})}{u'(\theta)} \right) m. \quad (12)$$

Since $a = \bar{a} = m + b$, from (3) $\sigma_a(a, \bar{a})$ satisfies

$$\text{Case D: } \sigma_a(a, \bar{a}) = \sigma'_D(0),$$

$$\text{Case R: } \sigma_a(a, \bar{a}) = \frac{\sigma'_R(1)}{m+b}. \quad (13)$$

Equation (12) has the same structure as the dynamics of the standard money-in-the-utility-function model (Blanchard and Fischer, 1989, pp. 239-243), and thus P initially jumps to the level that makes m satisfy

$$\text{Case D: } c = \theta, \quad \frac{v'(m) + \sigma'_D(0)}{u'(\theta)} = \rho,$$

⁴ We ignore government purchases, for simplicity, but even when government purchases are considered the arguments presented are essentially the same.

$$\text{Case R: } c = \theta, \quad \frac{v'(m) + \frac{\sigma'_R(1)}{m+b}}{u'(\theta)} = \rho, \quad (14)$$

and the steady state is immediately reached. However, the steady state, and hence, the equilibrium path, may not exist in case D as shown below.

In case R, the value of m that satisfies (14) definitely exists, since from (2)

$$\lim_{m \rightarrow 0} \frac{v'(m) + \frac{\sigma'_R(1)}{m+b}}{u'(\theta)} (= \infty) > \rho > \lim_{m \rightarrow \infty} \frac{v'(m) + \frac{\sigma'_R(1)}{m+b}}{u'(\theta)} (= 0).$$

Thus, the full-employment steady state is indeed realized. In case D, however, there is no m that satisfies (14) if

$$\frac{\sigma'_D(0)}{u'(\theta)} > \rho. \quad (15)$$

This happens because for any m

$$\frac{v'(m) + \sigma'_D(0)}{u'(\theta)} > \rho,$$

which is inconsistent with the first equation in (14). Note that both θ and $\sigma'_D(0)$ can be independently set and hence we can innocuously consider the case where the condition of (15) is satisfied. In particular, if productivity θ is high or if the status preference $\sigma'_D(0)$ is strong, (15) is likely to hold. Then \dot{m} given by (12) is negative for any positive m . Moreover, if

$$\lim_{m \rightarrow 0} v'(m)m > 0,$$

it is strictly negative even when $m = 0$, implying that m becomes negative within a finite time.⁵ Thus, there is no feasible path for case D if the condition (15) is satisfied.

⁵ This condition is required to avoid hyperinflationary paths in the standard money-in-the-utility-function model. See Obstfeld and Rogoff (1983) for this property.

3. Persistent Stagnation under the Difference Specification

In the previous section, we find that under the difference specification (case D) and flexible adjustments of P and W there is no dynamic equilibrium path if (15) holds. This is because preference for money holding always dominates preference for consumption. This would naturally suggest a shortage of aggregate demand although it is not allowed to exist due to the assumption of perfect flexibilities of prices and wages. Therefore, we introduce sluggish wage adjustments to the model so as to allow for a shortage of aggregate demand. Consequently, we find that the dynamic equilibrium path exists and that shortages of aggregate demand and employment remain even in the steady state.⁶

Recent dominant settings of wage adjustments are the New Classical, the New Keynesian, and the hybrid Phillips curves. They well fit to analyze short-run fluctuations around the full-employment steady state, but not to examine persistent stagnation because they are set up so that the inflation-deflation rate cumulatively expands as long as market disequilibrium exists.⁷ Thus, the possibility of unemployment in a steady state, which we focus on, is intrinsically eliminated. In order for the unemployment steady state to be possible, we adopt the conventional Walrasian wage adjustment process:

$$\frac{\dot{w}}{w} = \alpha(x - 1), \quad (16)$$

where α is the adjustment speed. Obviously, this is a simplified form of wage adjustment without a microeconomic foundation but we can provide a microeconomic foundation for this type of adjustment. In the appendix we indeed apply the wage adjustment mechanism with a microeconomic foundation proposed by Ono and Ishida (2013) to the present model

⁶ Obviously, nominal wage sluggishness does not exclude the case where full employment is reached in the steady state.

⁷ See Woodford (2003) for properties of those Phillips curves.

and show that the same steady state with the same stability property as presented below obtains.

Because P always moves in proportion to W , as shown by (7), the wage adjustment mechanism (16) leads to

$$\pi = \alpha(x - 1).$$

From (4), (5), (8), (9), (10) and the above equation, we obtain an autonomous dynamic system:

$$\begin{aligned}\eta \frac{\dot{c}}{c} &= \frac{v'(m) + \sigma_a(a, \bar{a})}{u'(c)} - \rho - \alpha \left(\frac{c}{\theta} - 1 \right), \\ \frac{\dot{m}}{m} &= -\pi = -\alpha \left(\frac{c}{\theta} - 1 \right), \\ b &= \bar{b}.\end{aligned}\tag{17}$$

where $\sigma_a(a, \bar{a})$ is given by (13). The full-employment steady state given by (14) is eventually reached as long as it exists.⁸ It always is the case in case R, and also in case D with (15) being invalid.

However, if (15) holds in case D, a steady state with full employment given by (14) does not exist. Then, the first and second equations of (17) form a two-dimensional autonomous dynamic system with respect to c and m :

$$\begin{aligned}\eta \frac{\dot{c}}{c} &= \frac{v'(m) + \sigma'_D(0)}{u'(c)} - \rho - \alpha \left(\frac{c}{\theta} - 1 \right), \\ \frac{\dot{m}}{m} &= -\pi = -\alpha \left(\frac{c}{\theta} - 1 \right).\end{aligned}\tag{18}$$

Because W is sluggish, P initially takes the value that satisfies (7) for the initial W . Then P determines the initial level of m , while c jumps to the amount that is on the saddle path.⁹

Along this path, a demand shortage remains and deflation continues.

⁸ The uniqueness and the stability of the present dynamics are proved in the same way as in Ono (1994, 2001), who treats the case where $b = 0$.

In the steady state of the present dynamics, from (18) c satisfies

$$\Phi(c) \equiv \frac{\sigma'_D(0)}{u'(c)} - \left(\rho + \alpha \left(\frac{c}{\theta} - 1 \right) \right) = 0. \quad (19)$$

From (15), one has

$$\Phi(\theta) = \frac{\sigma'_D(0)}{u'(\theta)} - \rho > 0. \quad (20)$$

Therefore, for (19) to have a positive solution, it must be valid that

$$\Phi(0) = -(\rho - \alpha) < 0, \quad (21)$$

and then c satisfies

$$0 < c < \theta,$$

which implies a persistent demand shortage. Deflation continues, making m diverge to infinity. Nevertheless, the transversality condition (6) is valid since

$$\lim_{m \rightarrow \infty} \frac{\dot{m}}{m} = \rho - \frac{\sigma'_D(0)}{u'(c)} < \rho,$$

and $b = \bar{b}$. Note that in this state $v'(m) = 0$ and thus the second equation of (5) yields

$$R = 0,$$

i.e., the zero interest rate holds.

Let us mention the economic implication of the difference between the two relative affluence specifications. In case R, in which households care about the ratio of their asset holdings to the social average, the marginal utility of real money balances, represented by $v'(m) + \sigma'_R(1)/(m + b)$, converges to zero as m approaches infinity. Thus, there is a level of m that equalizes the desire to accumulate real money balances to the desire to consume sufficient commodities to realize full employment, and then the steady state with full

⁹ The dynamic equations given in (18) are mathematically the same as those in the case where there is a strictly positive upper bound on the marginal utility of money, as analyzed by Ono (2001). He showed that there is a unique dynamic path and that it converges to the stagnation steady state if (15) is valid.

employment obtains. In case D, in which households care about the difference, the desire to accumulate assets $\sigma_D'(0)$ remains strictly positive. Thus, if (15) holds, no matter how much assets the households accumulate, the desire to accumulate money as an asset stays to be higher than the desire to consume sufficient commodities to realize full employment. A demand shortage remains despite continued declining prices and expanding real balances.

4. Experimental Evidence of the Two Specifications of Status

In the previous section we showed that persistent stagnation arises as an equilibrium outcome when households care about not the ratio of their asset holdings to, but the difference from, the social average. To see relevance to the real world, we investigate which of the two specifications of relative affluence is more plausible.

We use the data set created by the hypothetical discrete choice experiment of Yamada and Sato (2013), which includes 48,172 observations from 10,203 respondents. They conducted an original Internet-based survey in February 2010 with Japanese subjects, and investigated the intensity and sign of income comparisons against the social average.¹⁰ By applying the data to a random utility model framework, they estimated the following utility function with relative affluence:¹¹

$$V = V(y, \bar{y}) = V\left(\frac{(y\bar{y}^\gamma)^{1-\rho}}{1-\rho}\right), \quad (22)$$

where y is the subject's income and \bar{y} is the social average of income. We replace (22) by the two utility specifications with a single composite variable given in (3), so that we can focus

¹⁰ By setting up an experiment such that parameters were fully randomized and choice situations were orthogonal, they exploited full potential of the discrete choice experiment framework to find if the subjects had altruism or jealousy. See section 3 of Yamada and Sato (2013) for details of the experimental setting. Experimental details are provided in a supplemental material of this paper.

¹¹ This setting was first presented by Dupor and Liu (2003) and Liu and Turnovsky (2005).

on a comparison of the two. We then apply the conditional logit model framework and compare their AICs to see which specification better fits the data.

Note that there is a gap between the theoretical structure in the previous sections and the experimental setting given below. In the choice experiment of Yamada and Sato (2013), the relative affluence is associated with income, whereas in our model it is with asset holdings. That said, income is a predictor of asset holdings under the permanent income hypothesis. Moreover, Headey and Wooden (2004) found that income and asset holdings are both important determinants of subjective well-being, and that the positive effect of asset holdings on subjective well-being is taken away when adding an income term as an additional control. This evidence suggests that income is a good proxy for asset holdings in the happiness analyses. Therefore, we take income y as a proxy for assets a and replace $\sigma(a, \bar{a})$ given in (3) by $\sigma(y, \bar{y})$.

To facilitate the experimental data of Yamada and Sato (2013) to conduct a horse race of the ratio and difference specifications, let us reformulate the model to the following random utility model:

$$\sigma(y_i, \bar{y}_i) = \beta X_i + C + \epsilon_i,$$

where i represents each income scenario, X_i is

$$\text{Case D: } X_i = y_i - \bar{y}_i,$$

$$\text{Case R: } X_i = \frac{y_i}{\bar{y}_i},$$

β is the marginal utility from the status, C is the constant term, and ϵ is the error term that follows an independent and identical distribution of extreme value type 1 (IIDEV1). The probability p_{ij} that respondents prefer income situation i to income situation j is given by

$$p_{ij} = \text{Prob}\left(\sigma(y_i, \bar{y}_i) > \sigma(y_j, \bar{y}_j)\right), \text{ for all } i \neq j.$$

By assuming IIDEV1 for the error term we consider a conditional logit model (McFadden, 1974) and estimate the parameter β of the random utility function using the maximized likelihood method. We also assume that irrelevant alternatives are independent (IIA), and that the random components of each alternative and those within each subject are respectively uncorrelated.

Table 1: Estimation results from the conditional logit model

Dep var: Utility	Relative income		Pseudo R2	AIC	N
	Sign	robust s.e.			
Ratio	0.4430***	(0.1059)	0.0053	63261.28	48172
Difference	0.0337***	(0.0004)	0.2255	51721.87	48172

Robust standard errors clustered by subjects, *** $p < 0.01$.

Table 1 reports the results of the conditional logit model estimations. The first row is for the ratio specification, and the second for the difference specification. In both cases, the relative income terms, $y_i - \bar{y}_i$ and y_i/\bar{y}_i , have a positive and significant effect. The striking finding here is a significant difference in the AIC between the two specifications. The AIC under the difference specification is smaller than that under the ratio specification. Also, the pseudo R-squared for the difference specification (which is 0.22) is much higher than that for the ratio specification (which is 0.0053). Therefore, the difference specification fits the data better than the ratio specification.¹²

¹² After we finished this project, we have learned a study by Mujcic and Frijters (2013). Using their own experimental data on ranking comparisons, they also found that the difference specification fitted the data better than the ratio specification.

In section 3 we have found that with the difference specification persistent stagnation can occur while with the ratio specification full employment is always reached in the steady state. Because the present experimental result supports the former, we may conclude that our model accommodates persistent stagnation and unemployment.

5. Conclusion

When relative affluence compared to the social average is taken as status, the measure can be the ratio to, or the difference from, the social average. The two specifications lead to mutually quite different scenarios of business activity. If it is the ratio, full employment is necessarily reached in the steady state. If it is the difference, there is a case where unemployment and stagnation due to shortage of aggregate demand appear in the steady state. This case arises particularly if the output capacity is high or if the desire for the relative affluence is strong.

Using the experimental data on income comparison carried out by Yamada and Sato (2013), we find that the difference specification fits the data better than the ratio specification does. Therefore, relative affluence can be a cause of persistent stagnation, and our model can be a good platform to analyze persistent stagnation. Furthermore, since the mathematical structure of the present model is essentially the same as that of Ono (1994, 2001), the same policy implications as those of Ono hold. They are quite different from those under the conventional models and are more in conformity with classical wisdom of Keynes (1936): an increase in government purchases expands private consumption, while improvements in productivity and wage adjustments reduce private consumption and worsen stagnation.

Appendix: Stability with a microeconomic foundation of sluggish wage adjustment

In the text we assume the conventional Walrasian wage adjustment process that lacks a microeconomic foundation, represented by (16). Ono and Ishida (2013) extended the fair-wage hypothesis a la Akerlof (1982) and Akerlof and Yellen (1990) to a dynamic setting and proposed a microeconomic foundation of wage adjustment that converges to the conventional Walrasian one. Furthermore, they applied it to a money-in-the-utility-function model and obtained the condition that makes the stability and uniqueness of the steady state hold. This appendix introduces that wage adjustment mechanism, instead of (16), to the present model and shows that under conditions (20) and (21) the unemployment steady state given by (19) is reached.

Let us start the analysis by summarizing the dynamics of fair wages presented by Ono and Ishida (2013). Employed workers randomly separate from the current job at the Poison rate α , and therefore total employment x , which also represents the employment rate because the population is normalized to unity, changes in the following way:

$$\dot{x} = -\alpha x + \chi, \tag{A1}$$

where χ is the number of workers that are newly hired. While workers are employed, they form fair wage W_F in mind by referring to their past wages, their fellow workers' fair wages (which equal their own) and the unemployment situation of the society. More precisely, they first consider the rightful wage v , which is the wage that they believe fair if everybody is employed. Therefore, $v(t - \Delta t)$, implying the rightful wage that is ex post conceived at time $t - \Delta t$, is calculated so that the current fair wage equals the average of $v(t - \Delta t)$ and the zero income of the unemployed. Because the number of the employed is $x(t - \Delta t)$, it satisfies

$$v(t - \Delta t)x(t - \Delta t) = W(t - \Delta t). \tag{A2}$$

Newly hired workers, in contrast, do not have any preconception about the fair wage and simply follow the incumbent workers' conceptions.

At time t the number of new comers is $\chi(t)\Delta t$. Therefore, when the incumbent workers calculate the fair wage $W(t)$, the total number of workers that they care is $1 - \chi(t)\Delta t$. Because the rightful wage that they have in mind is the one that was ex post conceived at time $t - \Delta t$, which is $v(t - \Delta t)$ in (A2), and the number of the incumbent workers is $x(t - \Delta t)(1 - \alpha\Delta t)$, $W(t)$ is formed as follows:

$$W(t) = \frac{v(t-\Delta t)x(t-\Delta t)(1-\alpha\Delta t)}{1-\chi(t)\Delta t}.$$

Substituting (A2) into the above equation and rearranging the result leads to

$$\frac{W(t)-W(t-\Delta t)}{\Delta t} = \chi(t)W(t) - \alpha W(t - \Delta t).$$

Therefore, by reducing Δt to zero we obtain

$$\frac{\dot{W}}{W} = \chi - \alpha. \quad (\text{A3})$$

The representative firm is competitive and takes commodity price P as given. In the presence of unemployment, it will set the wage equal to the fair wage because the fair wage is the lowest wage under which the employees properly work. The commodity price adjusts to W/θ since there is no commodity supply if $P < W/\theta$ and excess commodity supply if $P > W/\theta$. Under full employment the firm tries to pick out workers from rival firms to expand the market share by raising the wage so long as the marginal profits are positive, making W equal to θP .

Note that P follows the movement of the fair wage in the presence of unemployment and that W follows the movement of P in the absence of unemployment. Thus, anyway we have

$$\theta P = W,$$

which yields

$$\pi = \frac{\dot{W}}{W}. \quad (\text{A4})$$

From (5), the time differentiation of (10), (A1), (A3) and (A4), in the presence of unemployment we obtain an autonomous dynamic system of c and P .

$$\begin{aligned} \dot{c} &= F(c, P) \equiv \left(\frac{c\theta}{c+\theta\eta} \right) \left[\frac{v'(M/P)+\sigma_a(a,\bar{a})}{u'(c)} - \rho - \alpha \left(\frac{c}{\theta} - 1 \right) \right], \\ \dot{P} &= \pi P = H(c, P) \equiv \left(\frac{Pc}{c+\theta\eta} \right) \left[\frac{v'(M/P)+\sigma_a(a,\bar{a})}{u'(c)} - \rho + \alpha \left(\frac{\theta\eta}{c} \right) \left(\frac{c}{\theta} - 1 \right) \right], \end{aligned} \quad (\text{A5})$$

instead of (17). Note that in the neighborhood of the steady state, where $\dot{c} = 0$, π in (A5) equals

$$\pi = \alpha \left(\frac{c}{\theta} - 1 \right),$$

as is the case in the dynamics given by (17). This is the Walrasian adjustment in which adjustment speed α is the Poisson rate of job separation or equivalently $1/\alpha$ is the average duration of employment. The steady state condition of the first dynamic equation of (A5) is equivalent to (19) and then a shortage of aggregate demand persists. In this steady state, from (5) and (8) we find

$$\frac{\dot{m}}{m} - \rho = -\frac{\sigma_a(a,\bar{a})}{u'(c)} < 0.$$

Therefore,

$$\lim_{t \rightarrow \infty} (\bar{b} + m_t) \exp(-\rho t) = 0,$$

i.e., deflation continues and nevertheless the transversality condition is valid.

Let us next examine the dynamic stability. The characteristic equation of the dynamics given by (A5) is

$$\begin{vmatrix} F_c - \lambda & F_P \\ H_c & H_P - \lambda \end{vmatrix} = \lambda^2 - (F_c + H_P)\lambda + (F_c H_P - H_c F_P) = 0. \quad (\text{A6})$$

The partial derivatives of F and H are obtained from (A5) as follows:

$$F_c = \left(\frac{c\theta}{c+\theta\eta} \right) \left[\eta \left(\frac{v'(M/P)+\sigma_a}{u'(c)c} \right) - \frac{\alpha}{\theta} \right],$$

$$\begin{aligned}
F_P &= \left(\frac{c\theta}{c+\theta\eta} \right) \left(\frac{-(M/P^2)v''\left(\frac{M}{P}\right) + \frac{\partial\sigma_a}{\partial P}}{u'(c)} \right), \\
H_c &= \left(\frac{P}{c+\theta\eta} \right) \left[\frac{\theta\eta}{c} (\pi + \alpha) + \eta \left(\frac{v'(M/P) + \sigma_a}{u'(c)} \right) + \alpha(c - \theta)\eta' \right], \\
H_P &= \pi + \left(\frac{cP}{c+\theta\eta} \right) \left(\frac{-(M/P^2)v''\left(\frac{M}{P}\right) + \frac{\partial\sigma_a}{\partial P}}{u'(c)} \right).
\end{aligned}$$

in the neighborhood of the state in which $\dot{c} = 0$. Therefore,

$$\begin{aligned}
F_c H_P - H_c F_P &= \left(\frac{c\theta\pi}{c+\theta\eta} \right) \left[\eta \left(\frac{v'(M/P) + \sigma_a}{u'(c)c} \right) - \frac{\alpha}{\theta} \right] \\
&- \left(\frac{c\theta}{(c+\theta\eta)^2} \right) \left(\frac{-(M/P)v''\left(\frac{M}{P}\right) + P\frac{\partial\sigma_a}{\partial P}}{u'(c)} \right) \left[\frac{\alpha c}{\theta} + \frac{\theta\eta(\alpha + \pi)}{c} + \alpha(c - \theta)\eta' \right], \tag{A7}
\end{aligned}$$

where

$$\begin{aligned}
\frac{\partial\sigma_a}{\partial P} &= 0 \text{ in case D,} \\
\frac{P\partial\sigma_a}{\partial P} &= -\frac{M\sigma'_R(1)}{(m+\bar{b})^2} \text{ in case R.} \tag{A8}
\end{aligned}$$

If full employment is achieved in the steady state, $c = \theta$ and $\pi = 0$ and then from (A7) and (A8),

$$F_c H_P - H_c F_P = -\alpha(1 + \eta) \left(\frac{-(M/P)v''\left(\frac{M}{P}\right) + P\frac{\partial\sigma_a}{\partial P}}{u'(c)} \right) < 0. \tag{A9}$$

If unemployment continues in the steady state, which occurs only in case D, from (13) we find

$$\pi < 0. \tag{A10}$$

From (20) and (21) $\Phi(c)$ satisfies

$$\Phi'(c) = \frac{\eta\sigma'_D(0)}{u'(c)c} - \frac{\alpha}{\theta} > 0. \tag{A11}$$

Therefore, if

$$\lim_{m \rightarrow \infty} m v''(m) = 0,$$

which holds e.g. when the elasticity of $v(m)$ is constant, from (A7), the first equation of (A8), (A10) and (A11) we obtain

$$F_c H_P - H_c F_P = \left(\frac{c\theta\pi}{c+\theta\eta} \right) \left[\frac{\eta\sigma'_D(0)}{u'(c)c} - \frac{\alpha}{\theta} \right] < 0. \tag{A12}$$

From (A9) and (A12), in either case one of the two solutions of (A6) is positive and the other is negative. Note that in the presence of unemployment P follows the movement of W , which cannot jump, as mentioned below equation (A3). Because c is jumpable while P is not, the dynamics is saddle-path stable.

Having shown the validity of the saddle stability in the case where the steady state is reached from the region with unemployment, we next turn to the case where full employment has already been realized. In this case W flexibly follows the movement of P , as mentioned below equation (A3). Then the firm produces θ and c always equals it.

$$c = \theta \tag{A13}$$

Substituting (A13) into (5) and (8) and rearranging the result gives

$$\dot{m} = -\pi m = -m \left[\frac{v'(m) + \sigma_a(a, \bar{a})}{u'(\theta)} - \rho \right].$$

Therefore, it has the same property as the standard money-in-the-utility-function model, as discussed in Blanchard and Fischer (1989). P jumps to the steady-state level given by (14) and the steady state is immediately reached.

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