The Implication of Subsistence Consumption for Economic Welfare*

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Abstract

Using a subsistence consumption-augmented real business cycle model, we show that, for any given exogenous growth rates or parameter values, high initial subsistence levels increase the welfare cost of business cycles. This happens because subsistence consumption increases consumption volatility. Our finding suggests that eliminating economic fluctuations can be more beneficial to less-developed economies in which subsistence consumption is a high fraction of aggregate consumption. However, fast-growing economies exhibit a lower discrepancy of welfare costs between rich and poor countries, a result that also highlights the importance of growth-enhancing policies.

JEL classification: E20, E32, I31

Keywords: Subsistence consumption-augmented RBC model, Business cycles in less-developed countries, Economic welfare

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1 Introduction

Subsistence consumption, which refers to a minimum level of consumption required to sustain life, is usually determined by the poverty line. In particular, lower and upper bounds of the international poverty lines employed by the World Bank are \$694 and \$1,132 (in 2011 PPP prices).[1] This implies that the poverty line over GNI per capita ranges from 2% for high income economies to 44% for low income economies, as reported in Table 1.1.

Table 1.1: Poverty Line over Per Capita Income

Group of countries[a] (number of countries)	GNI per capita[b]	Ratio I[c]	Ratio II[d]
Low income economies (31)	1,571	0.44	0.72
Lower middle income economies (51)	6,002	0.12	0.19
Upper middle income economies (53)	14,225	0.05	0.08
High income economies: OECD (32)	43,588	0.02	0.03

Note: Data are taken from the Word Bank.
[a]Country grouping according to the World Bank.
[b]In 2014 dollars.
[c]Ratio between the lower poverty line (\$694) and GNI per capita.
[d]Ratio between the upper poverty line (\$1,132) and GNI per capita.

Incorporation of subsistence consumption into macroeconomic models is crucial to study the performance of less-developed countries. While the effects of subsistence consumption on growth have been extensively studied in the growth/development literature[2], the attempts to analyze implications of subsistence consumption for business cycles are rare (Ravn, Schmitt-Grohe, and Uribe (2008) and Achury, Hubar, and Koulovatianos (2012)). Our paper adds to the literature by studying the effects of subsistence consumption on the welfare cost of business cycles.

In doing so, we incorporate subsistence consumption in an otherwise standard real business cycle (RBC, henceforth) model and compute the welfare cost of business cycles à-la Lucas (1987). Our main finding is that the welfare cost is increasing in the initial subsistence consumption, and the result is is robust to a wide range of parameter values and exogenous growth rates. A positive relationship between consumption volatility and subsistence consumption attributes to the consequence. The model's prediction is consistent with findings on less-developed economies (Aguiar and Gopinath (2007) and Bick, Fuchs-Schndeln, and Lagakos (2016)), which suggests that eliminating business cycles can be

[1]This corresponds to \$1.90 and \$3.1 a day, respectively.
[2]Steger (2000); and Herrendorf, Rogerson, and Valentinyi (2014) provides an extensive of the literature.

more beneficial in such economies.

2 The Model

A standard RBC model is extended in the simplest way to make our analysis comparable with that in the existing literature.[3]

2.1 Setup A social planner solves the following utility maximization problem in which the preference of a representative household takes Stone-Geary form[4]:

$$\max_{c_t, k_{t+1}, h_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\ln(c_t - \bar{c}_t) - \psi \frac{h_t^{1+\phi}}{1+\phi} \right], \tag{2.1}$$

subject to

$$c_t + k_{t+1} = Z_t k_t^{1-\alpha} h_t^{\alpha} + (1-\delta) k_t \tag{2.2}$$

where $\beta \in (0,1)$ is the discount factor, h_t represents hours worked at period t, c_t is period t consumption[5], and $\bar{c}_t \equiv \frac{\bar{c}}{X_t}$ denotes period t subsistence consumption, with $\bar{c} \geq 0$ and $X_t = (1+g_x)X_{t-1}$ being a growing variable. This setup captures the fact that the relevance of a subsistence consumption to an aggregate economy becomes lower as the economy grows (see Table 1.1). In addition, $\phi > 0$ is the inverse of Frisch labor elasticity[6], $\psi > 0$ is the preference parameter, $\delta \in (0,1)$ is the rate of depreciation, $\alpha \in (0,1)$ is the labor share, k_t denotes period t capital stock, and Z_t denotes a total factor productivity, following an AR (1) process:

$$\ln Z_t = \rho \ln Z_{t-1} + \varepsilon_t, \tag{2.3}$$

where $\rho \in (0,1)$ and $\varepsilon_t \sim N(-\frac{\sigma_z^2}{2}, \sigma_z^2)$.[7]

We compute the equilibrium transition path by backward solving the policy functions and forward simulating the economy (see Appendix for details).

[3] Our finding is also robust to introduction of population growth. See Online Appendix A.2.

[4] Stone-Geary form is in the class of Gorman polar form so that aggregation is available as in the standard models. See Acemoglu (2009) for related discussions.

[5] One can interpret variables introduced in our exercise measured as efficiency units, by assuming that X_t is the labor-augmenting technology progress.

[6] We consider log utility in order for the model to exhibit balanced growth property (King, Plosser, and Rebelo (2002)).

[7] This ensures $\mathbb{E}(Z_t) = 1$.

2.2 Welfare Cost The welfare cost can be computed by comparing the value of living in a non-fluctuating economy with value of living in an economy that fluctuates around the non-fluctuating economy.

We first define the value of the non-fluctuating economy as V^{NF}:

$$V^{NF} = \sum_{t=0}^{\infty} \beta^t U(c_t^{NF} - \bar{c}_t, h_t^{NF}), \tag{2.4}$$

where superscript NF denotes non-fluctuating economy and U denotes a utility function in a general form.

Similarly the value of the fluctuating economy, V^F, is given by

$$V^F = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t^F - \bar{c}_t, h_t^F) \tag{2.5}$$

where superscript F denotes fluctuating economy.

In addition, we define

$$V^{F,\lambda} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U((1+\lambda)(c_t^F - \bar{c}_t), h_t^F), \tag{2.6}$$

where λ is the compensating variation of consumption, measuring the fraction of consumption a consumer is willing to pay to live in a stable economy.

$$V^{NF} = V^{F,\lambda}. \tag{2.7}$$

By equating V^{NF} to $V^{F,\lambda}$, using the utility specification in equation (2.1), we obtain

$$\lambda = \exp\big((1-\beta)(V^{NF} - V^F)\big) - 1 \tag{2.8}$$

2.3 Parameterization We calibrate the parameters to match long-run moments of the U.S. economy: β is set as 0.995 to match an annualized real risk-free rate of return of 2%. α is 0.67 in line with the labor income share in the post-war U.S. data and δ is 0.02 to match the investment–capital ratio observed in the data. We further set $\rho = 0.95$ and $\sigma_z = 0.01$. While we calibrate parameters to be consistent with the U.S. data, the results are robust to different parameter values (see Supplementary

Online Appendix A.3).

One can interpret the economy with $\bar{c} = 0$ to be a developed economy since the subsistence consumption level is very small in the data in such an economy (Table 1.1) and the scaling parameter, ψ, is set to ensure that hours worked in the developed economy is one third at the steady-state for given values of ϕ.

3 Implications for Economic Welfare

3.1 Results As a benchmark we set $\phi = 1$ and consider the following initial values for the subsistence consumption: $\bar{c}_0 = (0, 0.1, 0.2, \cdots, 1.2)$. These values imply that the initial subsistence consumption–output ratios vary from zero to about 50%.

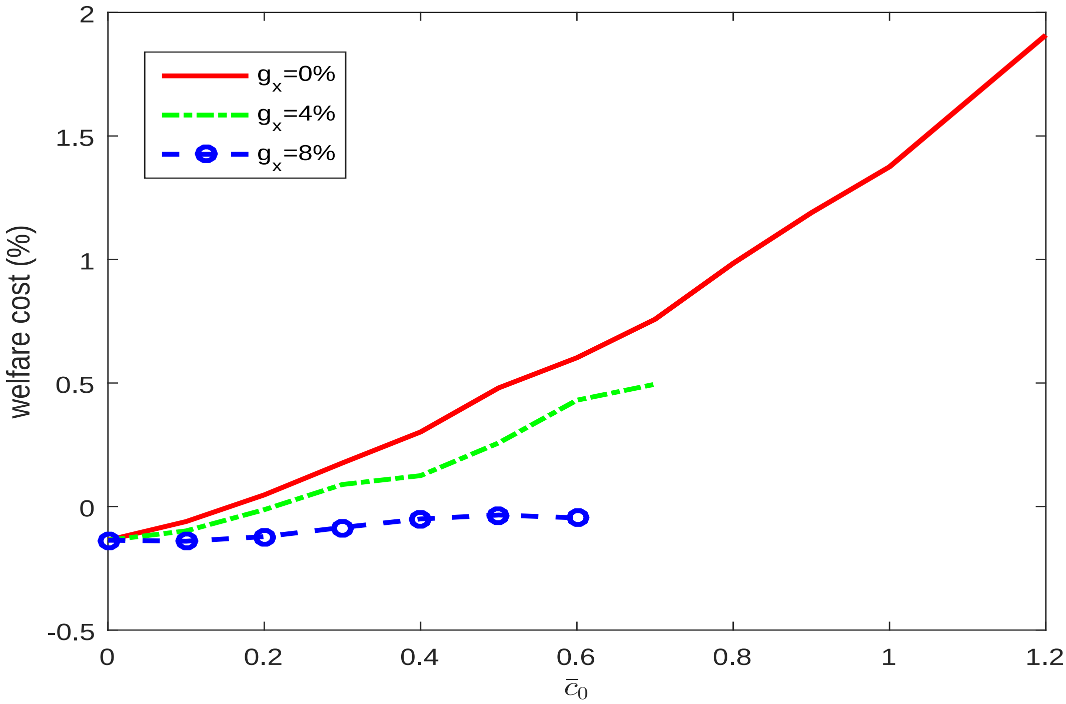

Figure 3.1: Welfare Cost of Business Cycles (%): Benchmark Economy

Figure 3.1 plots the welfare cost of business cycles in the model economy; we compute the welfare costs for different $\bar{c}_0$ and g_x while keeping other parameters fixed.[8] A positive (resp. negative) value

[8] We do not experiment on the combinations with $g_x > 0$ and $\bar{c}_0$ exceeding 0.7. The reason is that $\bar{c}/y$ at these points are too high, above 50%, which is unlikely to happen in a country with reasonable growth rate.

for the welfare cost means that a consumer prefers to live in a less (resp. more) volatile economy. For a low enough $\bar{c}_0$, the welfare cost is actually negative, and this observation is consistent with Lester, Pries, and Sims (2014) and Cho, Cooley, and Kim (2015): agents prefer a volatile economy to a stable one.[9] However, the welfare cost becomes greater and positive as the level of initial subsistence consumption increases, and this result is the most important finding. It implies that the previous finding that business cycles are welfare-improving within the class of RBC model is not robust to the introduction of subsistence consumption. Moreover, if we compare two economies who differ only in the levels of initial subsistence consumption, the welfare cost is greater in the economy with a high subsistence consumption. Because a high detrended subsistence consumption is more likely to appear in a less-developed economy, stabilization policies may be more beneficial to such an economy.

Another interesting observation is that business cycles become less costly as the exogenous growth rate (g_x) increases. We note that an economy with a high g_x converges to the standard RBC economy faster than the economy with a low g_x; hence, the welfare gain from the fluctuations becomes greater since the transition period is much shorter for such an economy. This further implies that welfare loss from the economic fluctuations might become substantially higher when the less-developed economy experiences the slow growth: Poor but fast-growing economies exhibit much lower welfare costs compared with poor stagnant countries. This suggests that if policymakers in a poor country could choose between growth-enhancing policies and stabilization policies, then growth-enhancing policies should be a priority.

Since our main finding, a positive relationship between subsistence consumption and the welfare cost, does not change with respect to the growth rate of X_t ($g_x = 0$), we focus on the economy without growth in what follows.

3.2 Economic Intuition This section discusses the reason why $\bar{c}_0$ and the welfare cost are positively related. As the welfare cost is closely related to both consumption volatility and hours volatility, the key to understand our finding is to study behavior of variability of consumption (and labor) alongside the subsistence consumption. The left panel of Figure 3.2 plots the standard deviation of the detrended life-time value of living in the volatile economy ($\sigma(V)$) and the right panel plots the standard deviation of detrended consumption relative to that of labor ($\sigma(c)/\sigma(h)$). Both standard deviations are increasing in the level of subsistence consumption.

[9]This is a natural consequence since their models are nested by our model ($\bar{c}_0 = 0$).

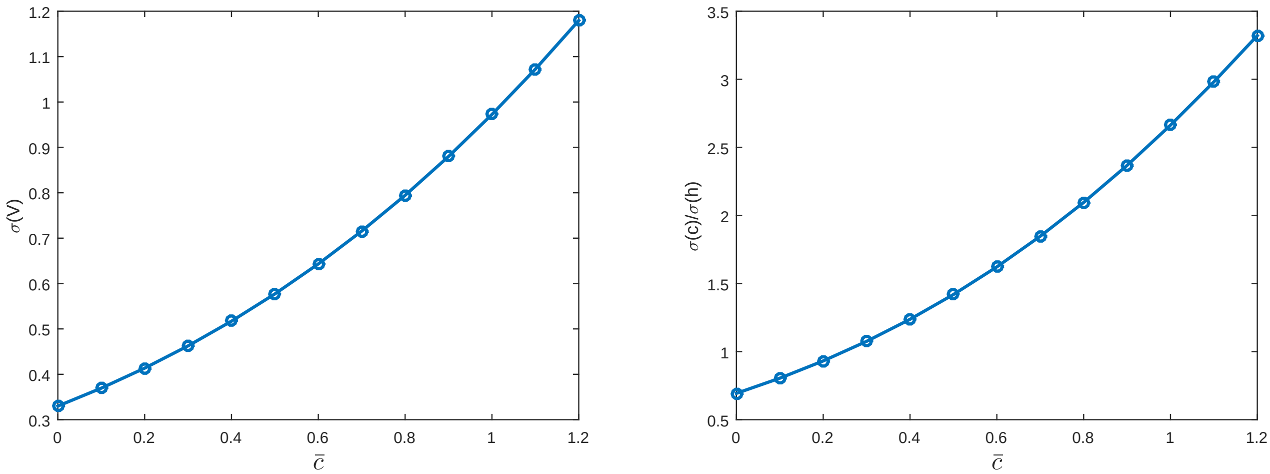

Figure 3.2a: $\sigma(V)$ Figure 3.2b: $\sigma(c)/\sigma(h)$

Figure 3.2: Volatility of Key Variables

In fact, when there is a technology shock, consumption responses more vigorously as the subsistence consumption becomes higher, whereas the response of labor is declining in the subsistence consumption. Figure 3.3 shows the impulse response of consumption and labor to a positive technology shock. The response of labor is lower with a higher subsistence consumption because the higher labor supply at the steady state aggravate the disutility from working. (Figure 3.4). On the flipside, given a negative shock, the consumer cannot substantially lower the labor supply in order to keep the subsistence consumption. As the marginal rate of substitution between consumption and labor is equated to the wage, the restricted response of labor requires consumption to adjust more.

4 Conclusion

This paper is the first one to extend the literature on the welfare cost of business cycles by studying the implications of subsistence consumption for the welfare cost. In doing so, considerations regarding subsistence consumption are introduced into an otherwise standard RBC model. We find that the welfare cost is increasing in the initial level of subsistence consumption. The result can be explained by the fact that consumption volatility is also increasing in the subsistence consumption. Given that our model can match several key properties of less-developed countries such as high working hours and high consumption volatility, our findings justify more active stabilization policies for those countries.

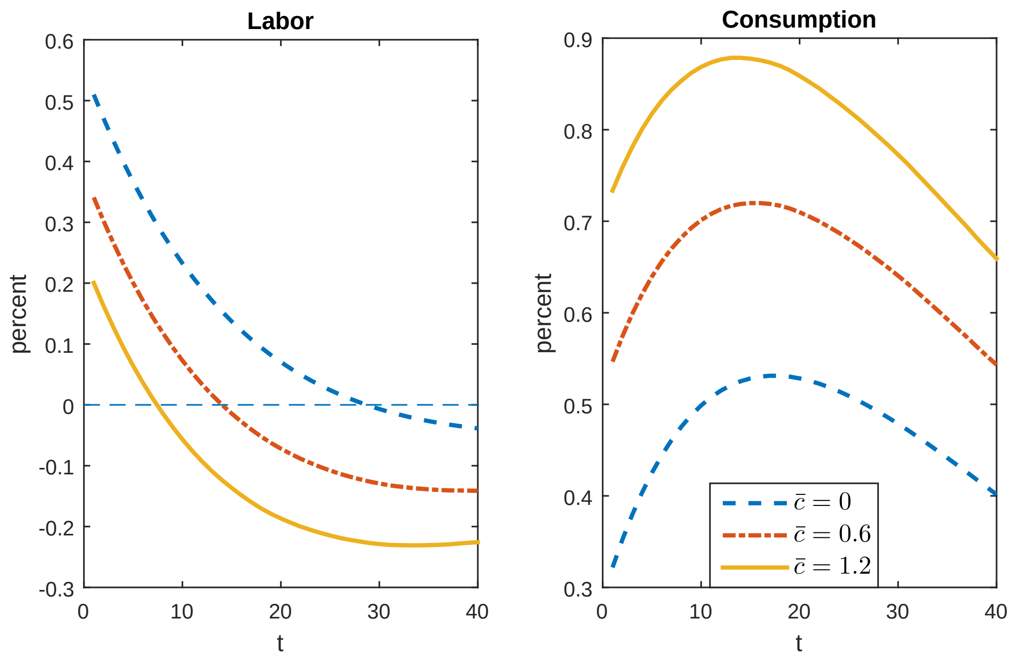

Figure 3.3: Impulse Response of Labor and Consumption

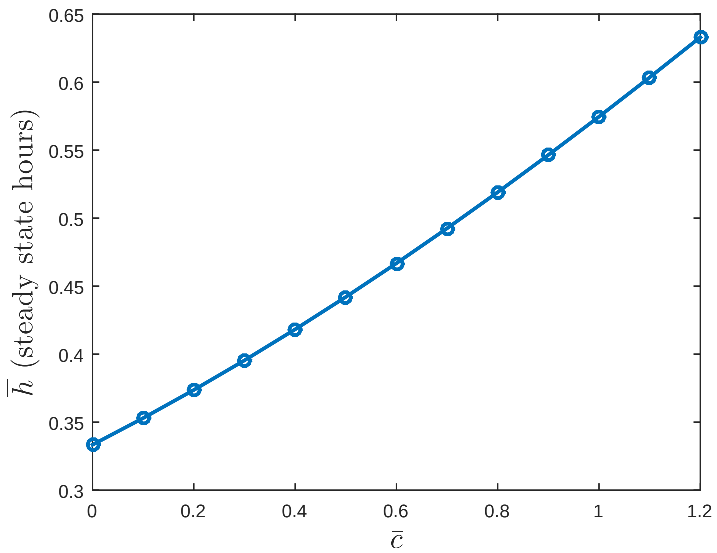

Figure 3.4: Steady-State Labor

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Appendix. Computation Algorithm

Following procedure is taken to compute the equilibrium along the transition path (see online appendix for details):

Step 1: Use value function iteration to solve for the final steady state. Because $\bar{c}_t \equiv \frac{\bar{c}}{(1+g_x)^t x_0}$ converges toward zero, final steady state exists.

Step 2: Take results from *Step 1* as the last period to backward solve policy functions along the transition path. At each period, adjust $\frac{\bar{c}}{(1+g_x)^t x_0}$. The length of the transition depends on g_x, $\bar{c}$ and x_0. In principle, the path should be long enough such that $\frac{\bar{c}}{(1+g_x)^t x_0}$ is small enough, and we choose the threshold to be $1e-10$.

Step 3: Forward simulating N times, where N is sufficiently large. In particular, we simulate 100,000 times.

A Supplementary Online Appendix (Not for Publication)

A.1 Details of Computation Algorithm

Step 1: Because $\frac{\bar{c}}{(1+g_x)^t x_0}$ converges toward zero, there exists a final steady state. We first solve the final steady state using value function iteration. More specifically, the Bellman equation is

$$V(k,Z) = \max_{k',h} \left\{ u\left(Zk^{\alpha}h^{1-\alpha} + (1-\delta)k - k', h \right) + \beta \mathbb{E}[V(k',Z')] \right\}. \tag{A.1}$$

where we use the general form of the utility function.

We need to guess an initial value for $V(k',Z')$ and choose k' and h to obtain $V(k,Z)$. If $V(k',Z')$ and $V(k,Z)$ is close enough, then denote $V(k',Z')$ by V^{∞} as the final steady sate value; otherwise replace $V(k,Z)$ by $V(k',Z')$ and redo the above procedure until $V(k,Z)$ converges.

Step 2: Take the value function V^{∞} from *Step 1* as the last period, we follow the same procedure in *Step 1* to backward solve the policy functions for c, h, k', and V along the transition path. At each period, $\frac{\bar{c}}{(1+g_x)^t x_0}$ is adjusted. More specifically, the Bellman equation along the transition path becomes:

$$V(k,Z) = \max_{k',h} \left\{ u\left(Zk^{\alpha}h^{1-\alpha} + (1-\delta)k - k' - \frac{\bar{c}}{(1+g_x)^t x_0}, h \right) + \beta \mathbb{E}[V(k',Z')] \right\}. \tag{A.2}$$

The length of the transition depends on g_x, $\bar{c}$ and x_0. In principle, the path should be long enough such that $\frac{\bar{c}}{(1+g_x)^T x_0}$ is small enough, where T is the total length. We choose this threshold to be 10^{-10}.

Step 3: Having the policy function for c, h, k' along the transition and the transition rule of Z, we forward simulate the economy N times for the stable economy and the fluctuating economy respectively, where N is sufficiently large. In these exercises, we chose N to be 100,000. Then we calculate the average to be the transitional path for c, k', and h. Take the first period value

$V^{NF}(k_1, Z_1)$ and $V^F(k_1, Z_1)$ are taken to be the value for the stable and the fluctuating economy respectively.

Step 4: Compute the welfare cost using the following formula (equation (2.8)):

$$\lambda = \exp\left((1-\beta)(V^{NF} - V^F)\right) - 1 \tag{A.3}$$

A.2 Model with Population Growth

In this section, we study the extent to which introducing exogenous population growth can affect our findings. In the exercise, it is assumed that there is no exogenous technology progress in order to focus on the role of population growth.

A.2.1 Setup

There is no distortion hence we again consider the social planner's problem.

Preference. Preference of the representative household takes the following form:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \hat{\beta}^t N_t \left[\ln\left(c_t - \overline{c}\right) - \psi \frac{h_t^{1+\phi}}{1+\phi}\right], \tag{A.4}$$

where $\hat{\beta} \in (0,1)$ is the discount factor, c_t is period t consumption, $\overline{c} \geq 0$ denotes subsistence consumption, h_t represents hours worked at period t, and all variables are measured at the individual level. N_t is the population size that grows at a net rate $g_N \geq 0$ and $N_0 \equiv 1$. In addition, $\phi > 0$ is the inverse Frisch labor elasticity and $\psi > 0$ is the preference parameter.

We can recast the problem:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\ln\left(c_t - \overline{c}\right) - \psi \frac{h_t^{1+\phi}}{1+\phi}\right], \tag{A.5}$$

where $\beta = \hat{\beta}(1+g_N)$.[10]

Technology. Aggregate production function takes the usual Cobb-Douglass form:

$$Y_t = Z_t K_t^{1-\alpha} \left(h_t N_t\right)^{\alpha}, \tag{A.6}$$

where $\alpha \in (0,1)$, Y_t is an aggregate output, K_t denotes an aggregate capital stock, and Z_t denotes a total factor productivity of the economy, which follows AR (1) process:

[10] The condition $\hat{\beta} \in (0,1)$ is sufficient for existence of the equilibrium.

$$\ln Z_t = \rho \ln Z_{t-1} + \varepsilon_t, \tag{A.7}$$

where $\rho \in (0,1)$ and $\varepsilon_t \sim N(-\frac{\sigma_z^2}{2}, \sigma_z^2)$.

Feasibility condition of the transformed economy is

$$c_t + (1 + g_N)k_{t+1} = Z_t k_t^{1-\alpha} h_t^{\alpha} + (1-\delta)k_t, \tag{A.8}$$

where $\delta \in (0,1)$ is the rate of depreciation, $k_t = K_t/N_t$, and $c_t = C_t/N_t$.

Social Planner Problem. The social planner solves the following problem:

$$V(Z_t, k_t) = \max_{\tilde{c}_t, h_t, k_{t+1}} \left\{ \ln \tilde{c}_t - \psi \frac{h_t^{1+\phi}}{1+\phi} + \beta \mathbb{E}_t V(Z_{t+1}, k_{t+1}) \right\} \tag{A.9}$$

subject to

$$\tilde{c}_t + (1 + g_N)k_{t+1} = Z_t k_t^{1-\alpha} h_t^{\alpha} + (1-\delta)k_t - \overline{c}, \tag{A.10}$$

where $\tilde{c}_t \equiv c_t - \overline{c}$.

A.2.2 Findings

Figure A.1 plots the welfare cost of business cycles, by computing for λ that solves equation (2.8) with different rate of population growth.

It is easy to observe that the welfare cost increases in g_N, the rate of population growth. Importantly, our main finding that subsistence level is positively correlated with the welfare cost is unaffected. On average, population growth is greater in the less-developed economies[11] so that considering population growth enhances our argument that stabilizing economic fluctuations are more important for such countries.

A.3 Robustness Checks

This section reports the robustness checks.

Labor Supply Elasticity. We vary Frisch labor elasticity, as this is one of the key parameters in determining the welfare cost (Lester, Pries, and Sims (2014)). In particular, we consider $\phi = (0, 1, 10)$ while g_x is kept as 0% in Figure A.2, which confirms robustness of our main finding.

[11] Annualized population growth rate is above 2% for most poor countries and is around zero for developed countries (http://data.worldbank.org/indicator/SP.POP.GROW).

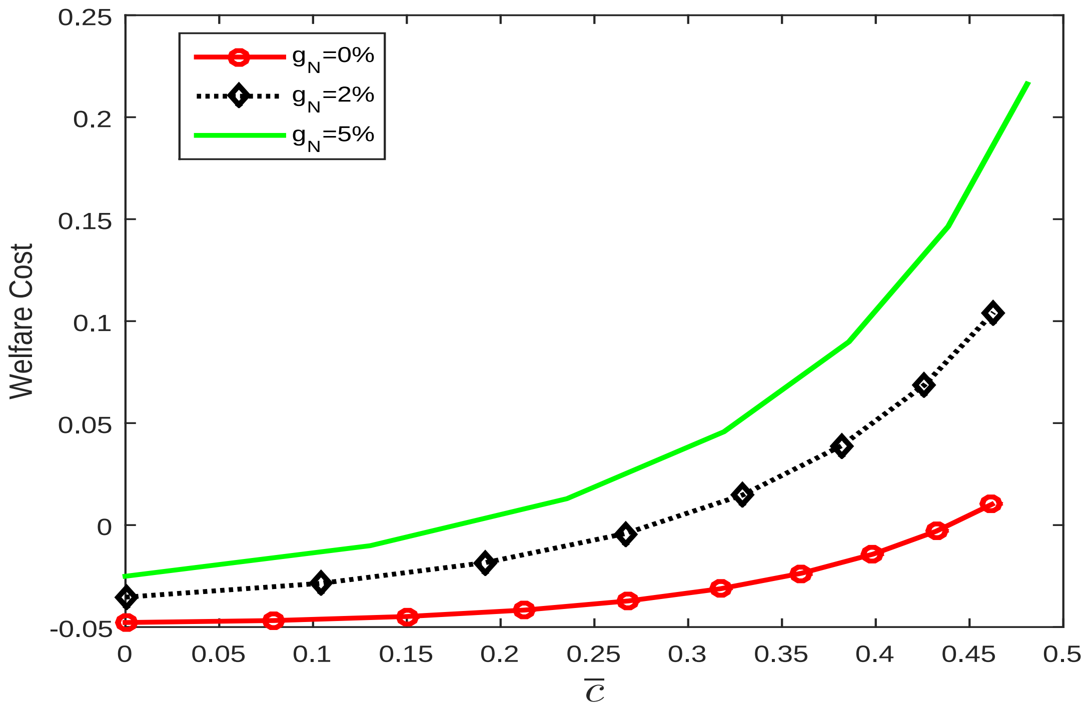

Figure A.1: Welfare Cost of Business Cycles (%): Benchmark Economy

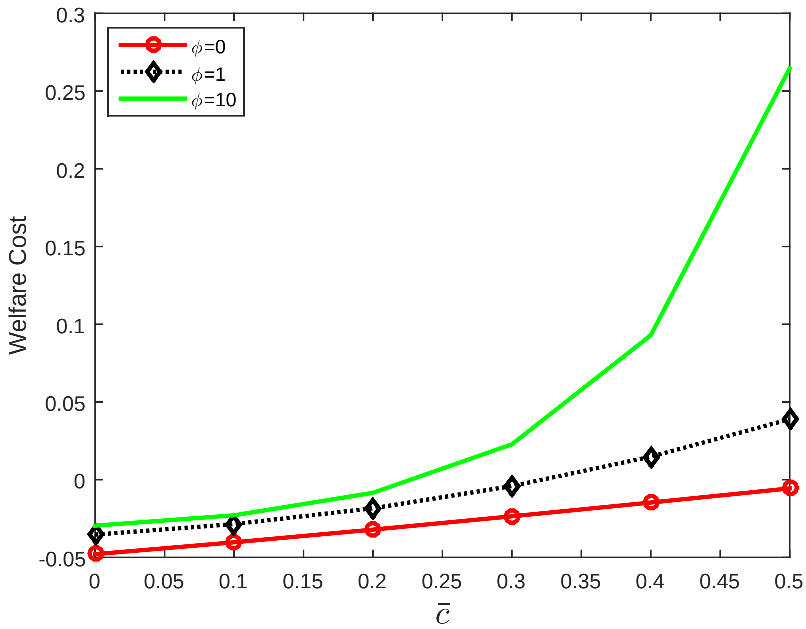

Figure A.2: Welfare Cost of Business Cycles (%): varying ϕ

Concavity of Utility. As is pointed out by Lester, Pries, and Sims (2014), concavity of a utility function may play an important role in determining the welfare cost of business cycles. In this section, we further check robustness of our findings in this regard. In doing so, we consider the following utility specification:

$$U(c_t - \overline{c}, h_t) = \frac{(c_t - \overline{c})^{1-\gamma} - 1}{1-\gamma} - \psi \frac{h_t^{1+\phi}}{1+\phi} \quad \text{(A.11)}$$

where $\gamma \geq 0$ measures relative risk aversion.

As the above utility function does not allow the model to exhibit a balanced growth path, we normalize population size as one and assume no exogenous growth ($g_x = 0$). The result is drawn in Figure A.3, which confirms robustness of our finding.

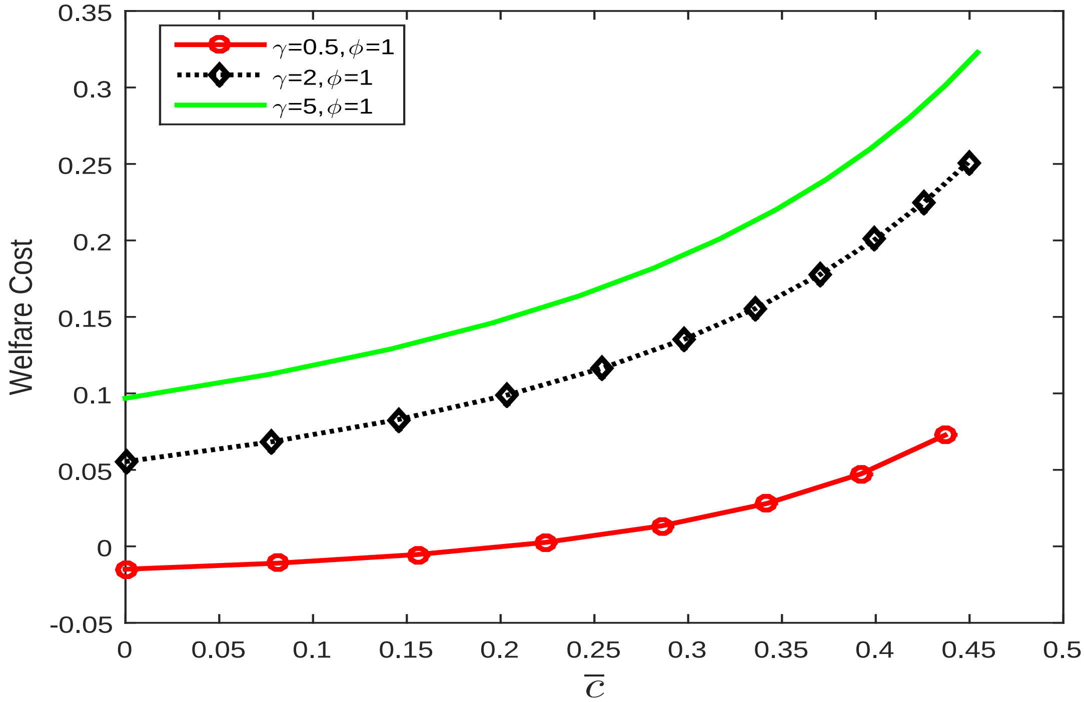

Figure A.3: Welfare Cost of Business Cycles: Effects of Risk Aversion