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The Welfare Cost of Business Cycles for Heterogeneous Consumers: A State-Space Decomposition

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Abstract

The main objective of this paper is to measure the welfare costs related to permanent and transitory shocks for heterogeneous consumers. We use data from the Consumer Expenditure Survey (CEX) and compute the average consumption in three different income groups: low, middle and high income. We sort consumers from the poorest to the richest and we create these three groups using income as a reference. Then, we consider a model where consumers in different groups face different shocks. Our findings indicate that the welfare costs of economic fluctuations are higher than previous works that explore heterogeneous agents argue. Moreover, our estimations indicate that high-income consumers are more sensitive to both transitory and permanent shocks than other classes of consumers.

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1 Introduction

Lucas (1987) argues that the welfare cost due to business cycles is small, about 0.04% of personal consumption per-capita. Lucas made three basic assumption: (i) there is a representative consumer, (iii) the welfare function is time-separable and iso-elastic (iii) the log of annual per capita consumption is serially uncorrelated and normally distributed around a linear trend. Subsequent work measured the cost of business cycles with different methods and data bases. In general, these works have either changed the environment of the problem or relaxed Lucas assumptions. Some authors changed the preference utility and achieve high welfare cost, as example we have Van Wincoop (1994), Dolmas (1998) and Tallarini (2000). Although they found great welfare costs, these papers are criticized by Otrok (2001) who says that it is trivial to find big number for the welfare cost when we can choose preferences. Our approach is to relax the assumption of representative consumer keeping CRRA preferences. In our model, consumers are heterogeneous with respect to income. Then, we measure how different class of consumers are willing to pay (in terms of consumption) to eliminate consumption uncertainty.

There are some works that relax the hypothesis of representative consumer and compute the welfare cost of business cycles. Imrohoroglu (1989), Krusell and Smith (1999), De Santis (2007), Krebs (2003, 2007), and others measured the costs of fluctuations in economies where agents are heterogeneous and markets are incomplete. Although one can expect that the costs of fluctuations would be higher, as bad income shocks hurt a few households severely, the typical finding from these studies is that the costs of fluctuations are only slightly higher or even lower than the Lucas benchmark. It is also common in all works of this group the use of calibration techniques on some well design economic models, which implies that the individual consumption series is derived from simulations.

The literature that uses econometric tools to estimate the welfare cost of business cycles have important results relaxing some of the assumption of Lucas. Obstfeld (1994) points that, for reasonable calibrations, the costs of fluctuations are small even if consumption is infinitely persistent. Exploring serial correlation in consumption series, Reis (2009) finds that a high persistence of consumption in the data severely distorts conventional measures of welfare cost of cycles and estimates a cost of fluctuations between 0.5% and 5% of per capita consumption. Issler et al. (2008) and Issler et al. (2014) split off the cost in welfare costs due to permanent and transitory shocks and finds even negative numbers for the costs of fluctuations. We notice that all those works build on the assumption of a representative consumer.

Our contribution to the literature is to measure the welfare costs related to permanent and transitory shocks in heterogeneous class of consumers using microdata. For the best of our knowledge, we are the first work to use data from individual consumers to estimate the welfare cost of business cycles.[1] Our approach is similar to Issler et al. (2014) estimation of a structural time-series models with long-run constraints. We assume a structural time-series model, where the unobserved components are assumed to be normal and uncorrelated, as in Harvey (1985) and Koopman et al. (2009). We put our problem in a state-space form and

[1]Although our primary data is extracted from individuals, we agreggate consumers within income groups to execute our estimations.

use Kalman Filter to estimate the transitory and permanent components of our model.

We find evidence that consumers have a higher costs due to permanent shocks than the costs due to transitory shocks. A intuitive result, since permanent shock affects current and future consumption, while transitory shocks can only direct change current consumption. Also, high-income consumers have higher costs due to economic fluctuations than other income-classes of consumers. Finally, our results indicates that the total costs of economic fluctuations are higher than the related literature suggests. In general, works that keeps the representative consumer hypothesis use aggregate consumption data, which may hide part of the variation in the consumption of individual (or groups of) consumers. Also, it is possible that the literature that explore heterogeneous consumers with incomplete markets can not identify all the variation in consumption series, or they can not account the persistence of consumption, which is a important component of the welfare costs as Reis (2009) shows.

2 Model

We consider a economy where there is a large number of individual indexed by $i = 1, 2, \ldots N$. All individuals have the same utility function:

$$u(c_{t,i}) = \frac{c_{t,i}^{(1-\phi)} - 1}{1-\phi}.$$

where t represents the period of consumption and ϕ is the relative risk aversion coefficient of an agent. Each person lives forever and discount future utility at the rate $\beta \in (0,1)$. Individuals maximize the following objective function:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(c_{t,i}) \right\} \tag{1}$$

Following Issler et al. (2014), we decompose $ln(c_{t,i})$ as the sum of a deterministic term, a martingale trend and a stationary and ergodic cycle:

$$ln(c_{t,i}) = ln(\alpha_{0,i}) + ln(1+\alpha_{1,i})t - \frac{\omega_{t,i}^2}{2} + \sum_{j=1}^{t} \epsilon_{j,i} + \sum_{k=0}^{t-1} \psi_k \mu_{t-k,i} \tag{2}$$

where, $\ln\left(\alpha_{0,i}(1+\alpha_{1,i})^t \cdot \exp(-\frac{\omega_{t,i}^2}{2})\right)$ is the deterministic term of log-consumption, $\epsilon_{t,i}$ represents an permanent shock and $\mu_{t,i}$ is a stationary shock for individual i. Here, we make an assumption to allow us to use the Kalman filter to estimate properties of those shocks: we suppose that shocks are uncorrelated and have a bivariate Normal distribution:

$$\begin{pmatrix} \epsilon_{t,i} \\ \mu_{t,i} \end{pmatrix} \sim i.i.d.\mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{11,i} & 0 \\ 0 & \sigma_{22,i} \end{pmatrix} \right) \tag{3}$$

Considering the uncorrelated shocks hypothesis, the unconditional variance of $\ln(c_{i,t})$ is $\omega_{t,i}^2 = \sigma_{11,i}t + \sigma_{22,i}\sum_{k=0}^{t-1}\psi_k^2$. Giving that the marginal distribution of a multivariate normal distribution is also normal distributed, we have that

$$\begin{aligned} \epsilon_{t,i} &\sim \mathcal{N}(0, \sigma_{11,i}); \quad (4) \\ \mu_{t,i} &\sim \mathcal{N}(0, \sigma_{22,i}). \quad (5) \end{aligned}$$

Then, we can turn off either permanent or transitory shock and calculate counterfactual log-consumption exposed to only one kind of those shocks.

In order to find a consumption sequence only exposed to permanent shock, $c^P_{t,i}$, we tun off transitory shock and obtain the following sequence of log-consumption:

$$ln(c^P_{t,i}) = ln(\alpha_{0,i}) + ln(1 + \alpha_{1,i})t - \frac{\sigma_{11,i}}{2}t + \sum_{j-1}^{t} \epsilon_j. \quad (6)$$

With $c^P_{t,i}$, we can measure welfare cost associated to transitory shocks. Similar to Lucas (1987), we find $\lambda_{P,i}$ comparing the conditional expected utility from the sequence of consumption exposed only to permanent shock and the consumption exposed to all macroeconomic uncertainty, i.e, solves the following equality

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u((1 + \lambda_{P,i})c_{t,i} \right] = \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u(c^P_{t,i}) \right]. \quad (7)$$

Then, $\lambda_{P,i}$ represents *the welfare cost of cycles* for consumer i in terms of consumption. Following the algebra in Issler et al. (2014), we get the following expression:

$$\lambda_{P,i} = \begin{cases} exp\left(\frac{\phi\tilde{\sigma}_{22,i}}{2}\right) - 1 & \text{for } \phi \neq 1 \\ exp\left(\frac{\tilde{\sigma}_{22,i}}{2}\right) - 1 & \text{for } \phi = 1 \end{cases}, \quad (8)$$

where $\tilde{\sigma}_{22,i} = \sigma_{22,i} \sum_{k=0}^{\infty} \psi_k^2$ represents the unconditional counterpart of $\sigma_{22,i} \sum_{k=0}^{t-1} \psi_k^2$. We implicit assume that a convergence condition

$$\beta(1 + \alpha_{1,i})^{(1-\phi)} exp\left(-\phi(1 - \phi)\frac{\sigma_{11,i}}{2}\right) < 1$$

holds.

Now, turning off the transitory shock, we found consumption exposed only to transitory shock with the following sequence

$$ln(c^T_{t,i}) = ln(\alpha_{0,i}) + ln(1 + \alpha_{1,i})t - \frac{\sigma_{22,i} \sum_{k=0}^{t-1} \psi_k^2}{2} + \sum_{k=0}^{t-1} \psi_k \mu_{t-k,i}. \quad (9)$$

Thus, we can measure *the welfare cost of growth variation* by finding $\lambda_{T,i}$ that solves the following equality

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u((1 + \lambda_{T,i})c_{t,i} \right] = \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u(c^T_{t,i}) \right]. \quad (10)$$

Assuming the convergence condition $\beta(1+\alpha_{1,i})^{(1-\phi)} < 1$, we have

$$\lambda_{T,i} = \begin{cases} \left[\frac{(1-\beta(1+\alpha_{1,i})^{1-\phi} exp(-\phi(1-\phi)\frac{\sigma_{11,i}}{2})}{1-\beta(1+\alpha_{1,i})^{(1-\phi)}}\right]^{\frac{1}{(1-\phi)}} - 1 & \text{for } \phi \neq 1 \\ exp\left(\frac{\beta\sigma_{11,i}}{2(1-\beta)}\right) - 1 & \text{for } \phi = 1 \end{cases}. \tag{11}$$

Finally, we can measure the combined effect of both shocks. In this case we turn off ϵ_t and $\mu_{t,i}$ and find that $ln(c_{t,i}^D) = ln(\alpha_{0,i}) + ln(1+\alpha_{1,i})t$. The *welfare cost of all macroeconomic uncertainty*, $\lambda_{D,i}$, solves:

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t u((1+\lambda_{D,i})c_{t,i}\right] = \mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t u(c_{t,i}^D)\right], \tag{12}$$

which give us

$$\lambda_{D,i} = \begin{cases} \left[\frac{(exp(\phi(1-\phi)\frac{\sigma_{22,i}}{2})(1-\beta(1+\alpha_{1,i})^{1-\phi} exp(-\phi(1-\phi)\frac{\sigma_{11,i}}{2}))}{(1-\beta(1+\alpha_{1,i})^{(1-\phi)}}\right]^{\frac{1}{(1-\phi)}} - 1 & \text{for } \phi \neq 1 \\ exp\left(\frac{\beta\sigma_{11,i}+(1-\beta)\tilde{\sigma_{22,i}}}{2(1-\beta)}\right) - 1 & \text{for } \phi = 1 \end{cases}, \tag{13}$$

assuming that the convergence condition $\beta(1+\alpha_{1,i})^{(1-\phi)} < 1$ holds.

Following Alvarez and Jermann (2004), we can calculate marginal welfare cost of trend and business cycle. The idea is take a convex combination of cycle free consumption,$c_{t,i}^*$ and consumption $c_{t,i}$: $(1-\alpha)c_{t,i} + \alpha c_{t,i}^*$, and then differentiate in α the equivalent variation in consumption. We obtain the marginal welfare costs as exposed below.

$$\lambda'_{P,i}(0) = \begin{cases} exp\left(\phi\tilde{\sigma}_{22,i}\right) - 1 & \text{for } \phi \neq 1 \\ exp\left(\tilde{\sigma}_{22,i}\right) - 1 & \text{for } \phi = 1 \end{cases}, \tag{14}$$

$$\lambda'_{T,i}(0) = \begin{cases} \frac{(1-\beta(1+\alpha_{1,i})^{1-\phi} exp(-\phi(1-\phi)\frac{\sigma_{11,i}}{2})}{(1-\beta(1+\alpha_{1,i})^{1-\phi} exp(\phi(1+\phi)\frac{\sigma_{11,i}}{2})} - 1 & \text{for } \phi \neq 1 \\ \frac{1-\beta}{1-\beta exp(\sigma_{11,i})} - 1 & \text{for } \phi = 1 \end{cases}, \tag{15}$$

$$\lambda'_{D,i}(0) = \begin{cases} \frac{(exp(\phi\tilde{\sigma}_{22,i})(1-\beta(1+\alpha_{1,i})^{1-\phi} exp(-\phi(1-\phi)\frac{\sigma_{11,i}}{2}))}{(1-\beta(1+\alpha_{1,i})^{(1-\phi)} exp(\phi(1+\phi)\frac{\sigma_{11,i}}{2})} - 1 & \text{for } \phi \neq 1 \\ \frac{exp(\tilde{\sigma_{22,i}}(1-\beta))}{1-\beta exp(\sigma_{11,i})} - 1 & \text{for } \phi = 1 \end{cases}. \tag{16}$$

3 Estimation and data

We use the Consumer Expenditure Survey (CEX) to gather income and expenditure data at household-level. CEX program consists of two different surveys, the Quarterly Interview Survey and the Diary Survey, providing data of American consumers, expenditures, income, and consumer unit (families and single consumers) characteristics. We only look at the Quarterly Interview Survey, which tracks consumer units large expenditures, such as major appliances and cars, and is conducted quarterly with each consumer unit. A consumer unit appears up to four interviews, spaced three months apart. After its final interview, a new randomly selected household replaces this consumer unit. There are six types of data files organized by quarter. However, we focus only at the FMLI file, also referred to as the Consumer Unit (CU) characteristics and income file, contains consumer unit characteristics, consumer unit income, and characteristics and earnings of the reference person and of the spouse. The file includes weights needed to calculate population estimates and variances.[2]

Our sample is drawn from CEX data files corresponding to the period 1996:Q1 through 2014:Q4 (the latest quarter available at the time that the paper was written). We use three variables from CEX data files: (i) Expenditure: total expenditures last quarter; (ii) Income: amount of wage and salary income, before deductions, received by all CU members in past 12 months; and, (iii) CU replicate weight. To adjust for inflation, we deflate income using implicit price deflators for gross domestic product, and expenditures using implicit price deflators for personal consumption expenditures from the Bureau of Economic Analysis of the U.S. Department of Commerce. The base-year for the deflated variables is 2009.

After some exclusions, we obtain a sample with 331,974 observations.[3] For each period we sort the data by income from the lowest to the highest income, respectively, $I_{\ell t}$ and I_{ht} . After that, we aggregate consumers in three income groups. Let I_t^i be income of consumer i in period t. Then we create the following groups: Group 1 - consumers with $I_t^i \in [I_{\ell t}, I_{ht}/3)$; Group 2 - consumers with $I_t^i \in [I_{ht}/3, 2I_{ht}/3)$; and Group 3 - consumers with $I_t^i \in [2I_{ht}/3, I_{ht}]$. Finally, we compute the average of the log-consumption of each groups for each period. As a result of this aggregation, we have three consumption time series with 76 observations.[4] As a last treatment, we remove seasonal quarter effects from our data using dummy variables.

Figure 1 presents our consumption time series for different income levels and also the mean consumption time series.

Before we describe the technique used in the empirical work, we briefly describe an additional assumption. It would be difficult to report the λ's for a big panel of consumers, because it would require a long time series to estimate all of those parameters. Then, we make the following assumption: individuals from the same income group receive the same shocks and share a equal trend. Therefore, for a group with $K < N$ individuals, we calculate the average of the log-consumption:

$$\frac{1}{K}\sum_{\ell=1}^{K}[ln(c_{t,\ell})] = \frac{1}{K}\sum_{\ell=1}^{K}ln(\alpha_{0,\ell}) + \frac{1}{K}\sum_{\ell=1}^{K}\left[ln(1+\alpha_{1,\ell})t - \frac{\omega_{t,\ell}^2}{2}\right] + \sum_{j=1}^{t}\epsilon_j + \sum_{k=0}^{t-1}\psi_k\mu_{t-k,g} \qquad (17)$$

where g represents an income group. With that assumption, the average of $\ln(c_{t,i})$ keeps the same permanent and transitory shocks that individuals receive. Then, we can calculate the λ's described in the last section for groups of individual. It is essential to our empirical approach.

We estimate our model in a state-space form with normal disturbances using the Kalman Filter. Following Drukker and Gates (2011) we apply the *sspace* to estimate a local-level

[2]There is no full form for the file name FMLI. In accord to the Bureau of Labor Statistics FMLI is a file with characteristics, income, weights, and summary level expenditures for the Consumer Unit.

[3]We drop individuals in the bottom and top 1% of the income distribution. We do this to avoid consumers with extremely low income (including zero income) and because without this exclusion our time series of group 3 was composed only by one observation in many periods.

[4]For our estimation of welfare costs of economic fluctuations, we have the implicit assumption that consumers do not jump from one income group to another.

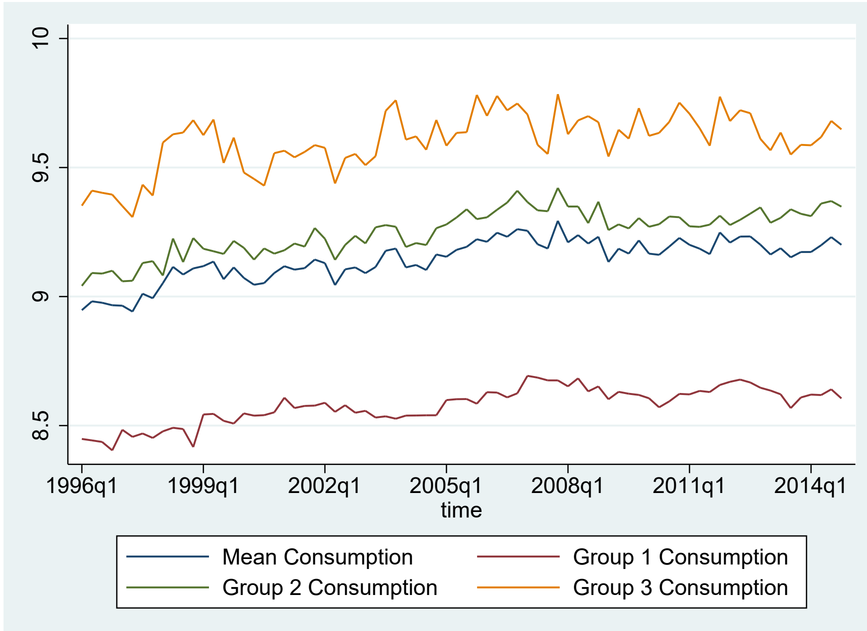

Figure 1: Consumption per income level

model. The observation and state equations are, respectively:

$$\begin{aligned} y_t &= \mu_t + \epsilon_t \\ \mu_t &= \mu_{t-1} + \xi_t \end{aligned} \tag{18}$$

Where, $\epsilon_t \sim N(0, \sigma_\epsilon^2)$ and $\xi_t \sim N(0, \sigma_\xi^2)$ and both are independent. The parameters in this model are σ_ϵ^2, σ_ξ^2, and μ_0.

Following Issler et al. (2014), we impose that permanent and transitory shocks on consumption are independent, relying on the structural time-series model of Harvey (1985) and Koopman et al. (2009). The idea is to decompose a single integrated series in a trend and a cycle by maximum likelihood, guaranteeing consistent and asymptotically Normal parameter estimates. Applying the local-level model to our trend-cycle decomposition of consumption for different income levels consists in:

$$\begin{aligned} c_{it} &= \bar{c}_t + \epsilon_{it} \\ \bar{c}_t &= \bar{c}_{t-1} + \delta_i + \xi_{it} \end{aligned} \tag{19}$$

Where, c_i is consumption for different income (i) level: low, middle and high; $\bar{c}$ is mean consumption; $\epsilon_{it} \sim N(0, \sigma_{\epsilon_i}^2)$ and $\xi_{it} \sim N(0, \sigma_{\xi_i}^2)$ and both are independent. Note that we constrained our state variable to have a unit root, and c_i and $\bar{c}$ parameter to be equal one.

Using Kalman Filter in this state-space model we can estimate our key parameters for each income (i) level: ; $\sigma_{\epsilon_i}^2$ is our variance related to cycle ($\sigma_{22,i}$ in the model) and $\sigma_{\xi_i}^2$ variance related to trend ($\sigma_{11,i}$ in the model, invariant to adition of a constant), and we also will estimate a different constant for each i. Where $ln(1+\alpha_1)$ is equal $\mathbb{E}(\Delta\bar{c}_t)$.

4 Empirical results

Table 1 presents the estimated parameters for our model employing the state-space approach using Kalman Filter. Figure 2 plots the (log) consumption and the estimated trends for all the income groups.

Table 1: Estimated parameters (1996-2014)

Class	$ln(1+\alpha_1)$	σ_{11}	σ_{22}
Group 1	0.0023293	0.0002672	0.0003397
Group 2	0.0038581	0.0002668	0.0009009
Group 3	0.0036965	0.0017165	0.0028653

In figure 2 we can see that there is a higher shift in the consumption of a group if the group has a higher income. Also, in accord to table 1, we notice that the volatility of permanent and transitory shocks are increasing in the income group. There are two facts that can explain it. First, we take averages of consumers using income groups and since the income distribution is asymmetric, the amount of people is decreasing in the income terciles. Therefore, the average is a bigger smoother of consumption series in groups 1 and 2 than in group 3. Second, there is a higher heterogeneity among the richest consumers than among the poorest consumers. Thus, when we group more heterogeneous agents it is natural to find a more volatile time series.

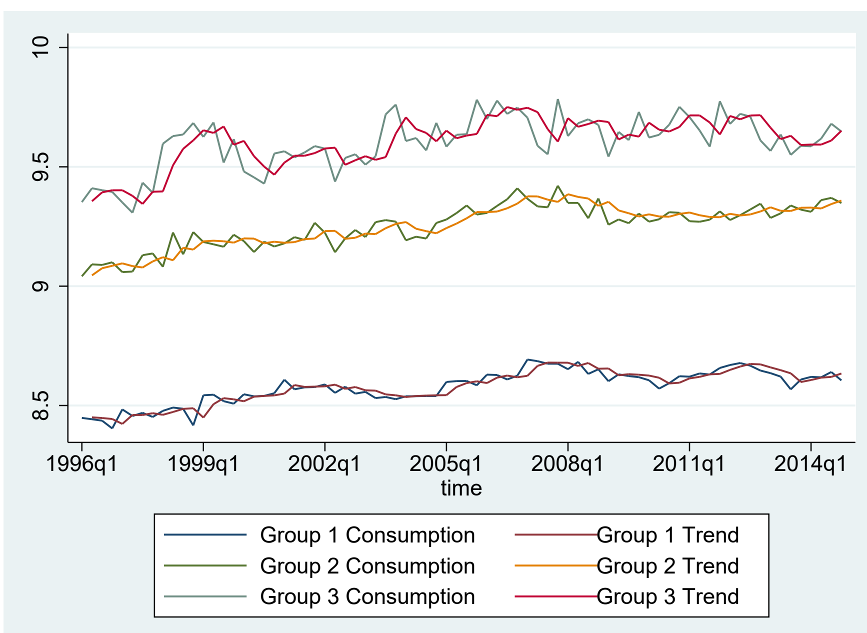

Figure 2: Consumption per income level profile (deseasonalized logs)

High-income consumers have the biggest welfare cost due to cycles (see table 2) in our estimations.[5] This result is robust to changes in risk aversion coefficient, because both the cost and the marginal cost are incresing on ϕ.[6] The results are in percent of consumption, therefore, to avoid business cycle a high-income individual would give up a fraction of his consumption between 0.14% and 1.44%, while low-income individuals would give up something between 0.02% and 0.17% of his consumption to avoid cycles. Those numbers are higher than the findings in Issler et al. (2014). This give us some evidence that if we consider consumer heterogeneity, the costs of cycles can be higher than previous results. The marginal welfare cost of cycles presents the same interpretation we give to the welfare cost of cycles.

Table 2: Welfare Cost of Business Cycle (1996-2014) - % consumption.

	Welfare cost				**Marginal welfare cost**			
ϕ	1	3	5	10	1	3	5	10
Group 1	0.02	0.05	0.08	0.17	0.03	0.10	0.17	0.34
Group 2	0.05	0.14	0.23	0.45	0.09	0.27	0.45	0.90
Group 3	0.14	0.43	0.72	1.44	0.29	0.86	1.44	2.91

Our estimations indicate that consumers are willing to pay a higher fraction of their consumption to avoid variations due to economic growth (permanent shocks) than they are willing to pay to attenuate cycles. To see that, one can contrast the number in tables 2 and 3.

We find a non-linear relation between the welfare cost associated to economic growth variation and our groups of income. People in group 2 are less sensitive to variations in the permanent shocks on consumption. We interpret this result as an evidence that consumers with intermediary income have a better adaptation when shocks are permanent than people in the other income groups. However, we should note that in absolute values even this group are more sensitive to permanent shocks in comparison to transitory.

When we analyze the cost associated to all macroeconomic uncertainty, we observe that the cost due to economic growth predominates over cost associate with transitory shock (see table 4). Also, we observe that the welfare cost is an increasing function of our income groups as observed in the welfare cost of cycles.

In general, we find a higher welfare cost due to economic fluctuations than the related literature. Estimations of Lucas (1987) and Issler et al. (2014) present a smaller welfare cost than our numbers, because their measure of the variance of the shocks on consumption are smaller than the numbers in table 1. Therefore, we have a evidence that a disaggregation of the consumption can reveal a higher welfare cost than was previous suggested.

Our results also contrast with the literature that measure the welfare cost of cycles using heterogeneous agents and incomplete markets. In general, those papers find a very small cost of cycles and only in extreme cases, welfare costs due to economic fluctuations reresents a

[5] You should note that both the cost and the marginal cost of cycles presented in section 2 do not depend on the discount factor. Thus, we present some estimations for those number only for different ϕ's.

[6] Despite we follow Issler et al. (2014), we do not measure the welfare cost for $\phi = 20$ because we do not guarantee the convergence conditions exposed in section (2) for high-income consumers.

Table 3: Welfare Cost of Economic Growth Variation (1996-2014) - % consumption.

	Welfare cost				**Marginal welfare cost**			
ϕ	1	3	5	10	1	3	5	10
β=0.95								
Group 1	0.25	0.70	1.10	1.98	0.51	1.43	2.29	4.51
Group 2	0.25	0.67	0.99	1.62	0.51	1.35	2.06	3.61
Group 3	1.64	4.57	7.58	30.80	3.37	10.36	20.78	-
β=0.97								
Group 1	0.43	1.14	1.72	2.94	0.87	2.35	3.67	7.14
Group 2	0.43	1.05	1.48	2.22	0.87	2.15	3.12	5.15
Group 3	2.81	7.45	12.44	-	5.88	18.39	43.47	-
β=0.99								
Group 1	1.33	2.82	3.75	5.54	2.72	6.08	8.63	16.24
Group 2	1.33	2.31	2.77	3.47	2.71	4.91	6.15	8.74
Group 3	8.87	18.98	33.93	-	20.49	71.77	-	-

We reported a '-' in cases where we do not find a real number for the welfare cost.

Table 4: Welfare Cost of All Macroeconomic Uncertainty (1996-2014) - % consumption.

	Welfare cost				**Marginal welfare cost**			
ϕ	1	3	5	10	1	3	5	10
β=0.95								
Group 1	0.27	0.76	1.19	2.15	0.54	1.54	2.47	4.86
Group 2	0.30	0.80	1.22	2.08	0.60	1.63	2.52	4.54
Group 3	1.79	5.02	8.36	32.69	3.67	11.32	22.52	-
β=0.97								
Group 1	0.45	1.19	1.81	3.11	0.91	2.46	3.84	7.50
Group 2	0.48	1.18	1.70	2.68	0.96	2.43	3.58	6.10
Group 3	2.96	7.91	13.24	-	6.19	19.42	45.54	-
β=0.99								
Group 1	1.35	2.87	3.84	5.72	2.75	6.18	8.82	16.64
Group 2	1.38	2.45	3.00	3.93	2.81	5.20	6.63	9.72
Group 3	9.02	19.50	34.90	-	20.84	73.26	-	-

We reported a '-' in cases where we do not find a real number for the welfare cost.

bigger number. For example, Krusell and Smith (1999) argues that only very poor consumers can present a cost up to 2%.[7]

[7] However, Krusell et al. (2009) present a new evidence that welfare costs can be higher (about 1%).

In the appendix, we present a exercise where we increase the number of income groups. This exercise indicates that our finding of a higher welfare cost than previous literature is robust to a increase in the number of groups.

5 Final remarks

In this paper, we use data from individual consumers to compute the welfare cost of economic fluctuations for different income-group agents. We use a method similar to Issler et al. (2014) that split off the cost in welfare costs due to permanent shocks and due to transitory shocks. Our estimation is based in a state-space model and uses Kalman Filter to identify the different kinds of shocks. Our estimations indicate that the welfare costs of business cycles are bigger than previous works with similar techniques found. In addition, we present a robustness exercise where we increase the number of groups of income and find a stronger result: with a bigger number of groups, there is an increase in the welfare costs in all groups except for the group with the higher income. We interpret this exercise as a evidence that exploring some heterogeneity of consumers can reveal a higher measure of the welfare cost of economic fluctuations.

In general, our results indicate that the welfare cost of economic fluctuations can vary from 0.20% to 35%, but it is not difficult to find a number around 2% of consumption. We use data from individual consumers to compute averages for groups of consumers, which contains more variation than the aggregate consumption used in similar empirical works. Even compared to Issler et al. (2014) - our inspiration to split the variation in two kind of shocks - our estimations indicate a higher cost of business cycles and economic growth variation. It is important to note that they permit a more flexible form for the relation between shocks.

Future work can benefit from our finds that the assumption of representative consumer is not a neutral one. There is also many of our assumptions that can be relaxed in future work, for example: (a) we only use three and four classes of consumers, maybe with more classes there will be heterogeneity in the welfare cost of business cycles, but we believe that our general finds will keep; (b) the independence assumption can be relaxed in order to explore the correlation between permanent and transitory shocks.

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Appendix

In this appendix, we present the results of our estimations of the welfare costs in the presence of permanent and transitory shocks with four groups of income. We use the same procedure to create these groups. Given the dataset where for each period consumers where sorted by income, we create the following groups:

- Group 1: consumers with $I_t^i \in [I_{\ell t}, I_{ht}/4)$;
- Group 2: consumers with $I_t^i \in [I_{ht}/4, I_{ht}/2)$;
- Group 3: consumers with $I_t^i \in [I_{ht}/2, 3I_{ht}/4)$;
- Group 4: consumers with $I_t^i \in [3I_{ht}/4, I_{ht}]$.

In table 5 we present the parameters estimated using the Kalman filter. Comparing the results with the estimations using three groups of income, we notice that there is a decrease in the volatility of both transitory and permanent shocks in the group with the highest income, while there is a increase the remaining groups. As we point out in the main text, there are two reason for this effect. We are reducing the denominator used to take the averages of groups, then in the income groups where there was a big amount of people (groups 1 and 2 in the main text) the average is not a big smoother of the aggregate group consumption. Only part of the heterogeneity in group 3 of the main text is inside the group 3 of this appendix. Figure 3 shows the estimated the stochastic trend and the consumption series of all new income groups.

Table 5: Estimated parameters (1996-2014)

Class	$ln(1+\alpha_1)$	σ_{11}	σ_{22}
Group 1	0.0021681	0.0002778	0.0004911
Group 2	0.0042161	0.0003999	0.0004143
Group 3	0.0034533	0.0003325	0.0027437
Group 4	0.0033973	0.0009283	0.0050116

Tables 6, 7 and 8 presents the estimations of the welfare costs of economic fluctuations. As a general result, we find higher estimated welfare costs as we increase the number of the groups of income, except for the groups with the highest income. This result makes our exercise of breaking the assumption of a representative agent more robust. It indicates us that expending the heterogeneity of consumers can reveal higher welfare costs of economic fluctuations.

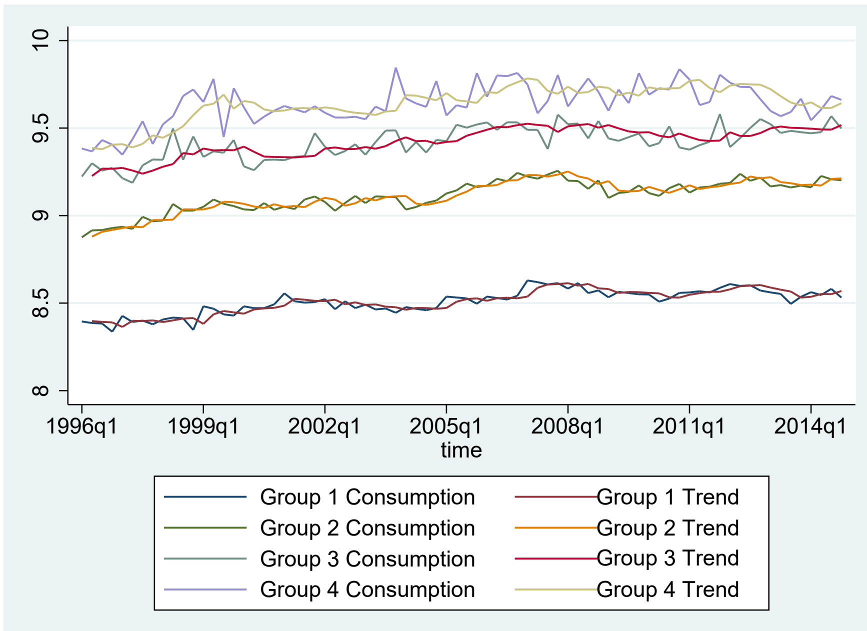

Figure 3: Consumption per income level profile (deseasonalized logs)

Table 6: Welfare Cost of Business Cycle (1996-2014) - % consumption.

	Welfare cost				**Marginal welfare cost**			
ϕ	1	3	5	10	1	3	5	10
Group 1	0.02	0.07	0.12	0.25	0.05	0.15	0.25	0.49
Group 2	0.02	0.06	0.10	0.21	0.04	0.12	0.21	0.42
Group 3	0.14	0.41	0.69	1.38	0.27	0.83	1.38	2.78
Group 4	0.25	0.75	1.26	2.54	0.50	1.51	2.54	5.14

Table 7: Welfare Cost of Economic Growth Variation (4 groups) - % consumption.

	Welfare cost				**Marginal welfare cost**			
ϕ	1	3	5	10	1	3	5	10
$\boldsymbol{\beta}$**=0.95**								
Group 1	0.26	0.74	1.16	2.11	0.53	1.50	2.42	4.86
Group 2	0.38	0.99	1.47	2.44	0.77	2.03	3.12	5.74
Group 3	0.32	0.84	1.28	2.17	0.64	1.72	2.68	5.02
Group 4	0.89	2.42	3.82	8.01	1.80	5.16	8.86	29.58
$\boldsymbol{\beta}$**=0.97**								
Group 1	0.45	1.20	1.82	3.18	0.91	2.47	3.90	7.86
Group 2	0.65	1.55	2.18	3.35	1.31	3.23	4.74	8.42
Group 3	0.54	1.34	1.93	3.06	1.09	2.77	4.15	7.52
Group 4	1.51	3.89	5.98	13.43	3.10	8.64	15.15	92.62
$\boldsymbol{\beta}$**=0.99**								
Group 1	1.38	3.01	4.06	6.23	2.83	6.51	9.47	19.31
Group 2	2.00	3.39	4.06	5.27	4.12	7.40	9.47	15.20
Group 3	1.66	3.05	3.78	5.07	3.40	6.62	8.73	14.40
Group 4	4.70	9.39	13.17	38.65	10.13	24.55	47.55	-

We reported a '-' in cases where we do not find a real number for the welfare cost.

Table 8: Welfare Cost of All Macroeconomic Uncertainty (4 groups) - % consumption.

	Welfare cost				**Marginal welfare cost**			
ϕ	1	3	5	10	1	3	5	10
$\boldsymbol{\beta}$**=0.95**								
Group 1	0.29	0.81	1.28	2.36	0.58	1.65	2.67	5.38
Group 2	0.40	1.05	1.58	2.65	0.81	2.16	3.33	6.18
Group 3	0.45	1.26	1.98	3.58	0.91	2.57	4.10	7.94
Group 4	1.14	3.19	5.13	10.76	2.31	6.75	11.62	36.24
$\boldsymbol{\beta}$**=0.97**								
Group 1	0.47	1.27	1.95	3.43	0.96	2.62	4.16	8.39
Group 2	0.67	1.61	2.29	3.57	1.35	3.36	4.96	8.87
Group 3	0.68	1.76	2.63	4.49	1.36	3.62	5.59	10.51
Group 4	1.77	4.67	7.31	16.31	3.61	10.29	18.08	-
$\boldsymbol{\beta}$**=0.99**								
Group 1	1.41	3.08	4.19	6.49	2.88	6.67	9.74	19.90
Group 2	2.02	3.45	4.17	5.49	4.17	7.54	9.69	15.68
Group 3	2.80	3.48	4.50	6.53	3.69	7.50	10.23	17.58
Group 4	4.96	10.21	14.59	42.16	10.68	26.44	51.29	-

We reported a '-' in cases where we do not find a real number for the welfare cost.