Measuring Consumer Confidence Using Aggregate Expenditure Data*

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Abstract

We propose to measure consumer confidence by exploiting a discrepancy between observed productivity and information available to consumers. Using a standard signal extraction with noisy information, we estimate *model-based filtered* consumer confidence and compare it to *survey-based* confidence indices for the U.S. and fifteen European countries. The results show that our model-based consumer confidences are positively correlated with the survey-based counterparts, potentially providing a structural interpretation of the survey-based indices widely discussed in the literature.

Keywords: Aggregate spending, confidence indices, noisy information

JEL Classification Codes: E21, E32, E66

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1 Introduction

Consumer confidence indices are often used when forecasting key macro variables. These survey-based indices measure the degree of consumer sentiment on the state of the economy and are widely tracked and discussed by economists and policymakers alike. For example, the Index of Consumer Sentiment (ICS), produced by the Survey Research Center of the University of Michigan, and the Consumer Confidence Index, issued by the Conference Board are well-established indices that measure how U.S. consumers view the overall state of the economy and are the focus of much attention both domestically and internationally.[1] Similarly, the European Union (EU) Commission publishes a consumer confidence indicator for EU member states and candidate countries and the Consumer Confidence Index (CCI), published monthly by the Organisation for Economic Co-operation and Development (OECD), is a leading indicator based on households' current and expected future plans for major purchases and their economic situation.[2] In addition, many national statistical institutes, other government agencies, private research institutes, and central banks collect confidence surveys to monitor the performance of their respective economies. These indicators are used not only as an input for the purpose of model-based forecasts but also as an additional important piece of information about consumer sentiment to describe the economic outlook broadly. This naturally leads to a belief that properly understanding the nature of consumer confidence is very important for its policy relevance.

Consider the following observation that recent economic crises have been associated with deteriorating consumer confidence. Figure 1 depicts fluctuating consumer confidence in the U.S. for the last forty years. It shows that most recent recessions have been preceded by downward shifts in consumer confidence, and subsequent recoveries of confidence have been rather slow. While it is difficult to determine a causal link between an erosion of confidence and macroeconomic performance, the collapse of confidence could as well be the source of the depth and longevity of large scale economic crises.

[1] To calculate the ICS, the Survey of Consumers considers past and future financial, business, and macroeconomic conditions. For detailed description on how the Index of Consumer Sentiment is computed, see Appendix A.1 or the note "Index Calculations" from the University of Michigan Survey of Consumers.

[2] Appendix A.2 details how the Consumer Confidence Index is calculated.

While such indices provide a nice visual description on fluctuating confidence, one may reasonably ask how much such fluctuating confidence directly translates into agents' behavior as observed in the movement of aggregate quantities, and vice versa. More precisely, are we able to characterize the mechanism by which consumers' attitudes influence aggregate consumption fluctuations?

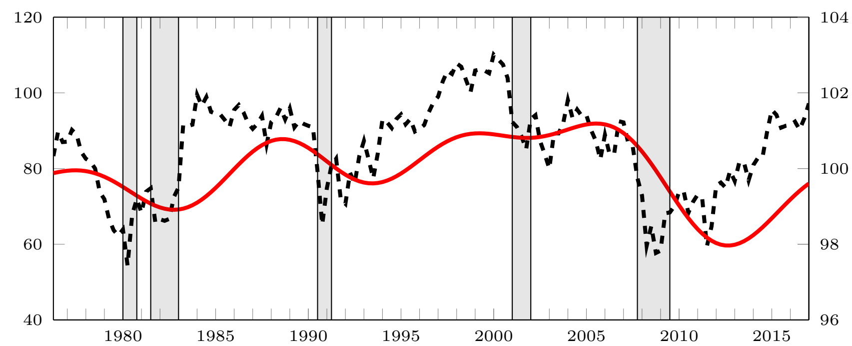

Figure 1: Consumer confidence and consumption-to-output ratio

Notes: Shaded areas indicate U.S. recessions. The black dashed line denotes the Michigan Survey of Consumer Confidence whereas the red solid line denotes consumption-to-productivity ratio (smoothed data using a band pass filter at 32-200 frequencies). The Michigan Survey corresponds to the left y-axis and consumption-to-output ratio the right y-axis.

In this paper, we attempt to provide an informational origin or interpretation to conceptualize and construct consumer confidence measurements. By introducing an informational foundation for the extraction of consumer confidence, we could potentially validate the use of confidence indices and show that consumer confidence, orthogonal to current and lagged productivity, carries an important piece of information which affects aggregate quantities.

To begin with, we first lay out a foundation to measure *model-based filtered* consumer confidence. Our presumption is the fact that consumers cannot perfectly forecast the future can provide a way to estimate confidence *given* a structural interpretation of the economy from the econometrician's point of view. Specifically, instead of working directly with collected survey data on consumer confidence, we suggest an alternative way to extract consumer confidence using aggregate expenditure data and a structural model based on the permanent income hypothesis and learning about future income.[3] As shown in Figure 1, changes in consumer con-

[3]See Lachowska (2016) identifies consumer confidence using daily data.

fidence precede changes in consumption relative to productivity by several years such that consumer confidence peak and trough dates lead corresponding dates for the ratio of consumption-to-productivity by two to four years. This observation that waves of optimism and pessimism are related to the dynamics of spending allows us to introduce a learning ingredient in order to construct a model.

In our attempt to estimate consumer confidence, we make two strong assumptions regarding (1) information structure with which agents forecast the future state of the economy and (2) a structural model that describes agents' consumption behavior: We consider an environment in which productivity is driven by both permanent and transitory shocks, and consumers receive noisy news about the future productivity of the economy. Following the permanent income logic, consumers choose spending according to their expected future income. Thus, estimating parameters of the model and making inferences are feasible by looking at productivity and consumption trends. We as econometricians are, then, able to estimate consumers' beliefs about the future and underlying structural shocks. While incorporating noisy news in a standard model has recently been widely discussed,[4] our focus is on extracting consumer confidence from a structural set-up which is an subject of research untouched in the literature.

In our model, consumer confidence is essentially measured by the discrepancy between *consumers' (ex-ante) belief* about permanent income and *a newly arrived information* about future income and is estimated accordingly. Once we *estimate consumer confidence*, we proceed to compare it with survey-based confidence indices. We use U.S. data to estimate consumer confidence and compare it with *the University of Michigan Consumer Sentiment Index*. Similarly, we also compare filtered consumer confidence with *the Consumer Confidence Index* in fifteen European countries.

Even if our model lacks many interesting structural shocks and frictions widely used in modern day general equilibrium macroeconomic models, it does a fairly good job of matching the dynamics of the survey based consumer confidence index, which suggests that the simple permanent income consumption set-up can be useful for understanding consumers' spending behavior even though it comes up short in other dimensions.

[4]See, for example, Blanchard, L'Huillier, and Lorenzoni (2013) and Cao and L'Huillier (2017).

Relation to literature:

The crucial ingredient of our model to extract consumer confidence is the information structure where agents receive noisy information of permanent productivity of the economy, which is discussed in Boz, Daude, and Durdu (2011), Lorenzoni (2009), Blanchard et al. (2013), and Rousakis (2013) among others. While sharing similar information structures, we attempt to solve a signal extraction problem sequentially as in L'Huillier and Yoo (2017) and Yoo (2017) disentangling the effects of different signals on aggregate fluctuations.

Linking consumer confidence to forecasting aggregate quantities, Batchelor and Dua (1998) show that while consumer confidence could have been used to forecast the 1991 recession, it could have be generalized to other years whereas Howrey (2001) shows that the Index of Consumer Sentiment is a statistically significant predictor for forecasting the near-term probability of a recession when used independently or in conjunction with other indicators such as the spread between long and short-term interest rates, the New York Stock Exchange composite price index, and the Conference Board index of leading indicators. In addition, Lahiri et al. (2015) consider a more realistic and general context to analyze the predictive power of consumer confidence by using monthly and real-time data along with a large number of explanatory variables and show that measures of consumer confidence provide a positive contribution in forecasting consumption expenditure.

The rest of the paper is organized as follow. Section 2 describe the model and discusses how to extract consumer confidence. Section 3 discusses quantitative results. Section 4 concludes.

2 Model

We assume that consumption is characterized by the following consumption' Euler equation:

$$c_t = \mathbb{E}_t[c_{t+1}|\mathcal{I}_t].$$

We consider a case in which there is no capital, and output is completely determined by the demand side where consumption is the only determinant of demand:

$$y_t = c_t.$$

Drastically simplifying the supply side, we assume that the role of labor input is to adjust to the current productivity level a_t and to produce output y_t:

$$y_t = a_t + n_t.$$

Given that the output in the long-rung returns to its natural level

$$\lim_{j \to \infty} \mathbb{E}_t[c_{t+j} - a_{t+j}] = 0,$$

current spending c_t is defined by

$$c_t = \lim_{j \to \infty} \mathbb{E}_t[a_{t+j}] \tag{1}$$

such that (1) suggests consumption depends on the consumers' long-run productivity expectation.

Considering a "news and noise" information structure by Blanchard et al. (2013), the productivity process a_t is characterized by the sum of two components - a permanent component x_t and a transitory component z_t:

$$a_t = x_t + z_t$$

where two components are respectively defined by

$$\Delta x_t = \rho_x \Delta x_{t-1} + \epsilon_t$$
$$z_t = \rho_z z_{t-1} + \eta_t.$$

The permanent component x_t follows a randomly changing trend due to a permanent shock ϵ_t, and the transitory component follows the stationary process with a transitory shock η_t. Two productivity shocks ϵ_t and η_t are assumed to be i.i.d. Gaussian with variances σ_ϵ^2 and σ_η^2. The coefficients ρ_x and ρ_z are in [0, 1).

On these productivity processes, we assume that

$$\rho_x = \rho_z = \rho,$$

and the variances satisfy the restriction

$$\rho \sigma_\epsilon^2 = (1-\rho)^2 \sigma_\eta^2.$$

Blanchard et al. (2013) show that this restriction ensures the univariate productivity process a_t is a random walk that satisfies the following conditions:

$$\rho_\epsilon^2 = (1-\rho)^2 \sigma_u^2 \tag{2}$$

and

$$\sigma_\eta^2 = \rho \sigma_u^2. \tag{3}$$

Therefore, we are able to estimate the persistent parameter ρ and the variance σ_u^2 and recover σ_ϵ^2 and σ_η^2 indirectly.[5]

A key assumption regarding the productivity processes is while agents observe productivity a_t as a whole, they do not observe the components x_t and z_t separately. This informational assumption is very important since agents choose their current spending using their expectations about future productivity. Since the transitory productivity process $z_{t+\infty}$ dies out in the long-run, just observing the whole productivity process a_t is not sufficient to predict the future state of the economy. Thus, agents would need to update their expectations about the future productivity. We assume they do so using the Kalman filter.

Considering the idea that agents have more information than merely about productivity, we also assume that agents receive a noisy signal s_t about permanent productivity:

$$s_t = x_t + \nu_t \tag{4}$$

[5]These parametric conditions are not restrictive in the sense that our estimated consumer confidences are very similar irrespective of whether we impose such restrictions or not. Figure 7 in Appendix C compares estimated consumer confidences for the two cases.

where ν_t is an i.i.d Gaussian shock with mean zero and variance σ_ν^2.

This noisy signal can be thought of as an additional source of information about the permanent component of productivity, which is a straightforward interpretation of Equation (4). Ultimately, the presence of this noisy information help the econometrician make inferences about the (unobserved) long-term productivity trend by looking at the behavior of consumption.

2.1 Solving the model

Solving the model for consumption is a direct implementation of the Kalman filer to extract the expectation about future productivity $a_{t+\infty}$. Firstly, solving Equation (1), we get

$$c_t = \frac{1}{1-\rho}\big(x_{t|t} - \rho x_{t-1|t}\big) \tag{5}$$

where $x_{t|t}$ and $x_{t-1|t}$ represent agents' beliefs about current and lagged permanent productivity, respectively.

Secondly, consumers' expectations about the permanent state of the economy ($x_{t|t}$ and $x_{t-1|t}$) can be obtained by solving the consumers' Kalman filter where an unobservable state vector X_t is given by $X_t = (x_t,\ x_{t-1},\ z_t)'$, and an observable vector is given by $S_t = (a_t,\ s_t)'$:

$$X_{t|t} = \big[I - \kappa_t \times C\big] A X_{t-1|t-1} + \kappa_t \times S_t \tag{6}$$

where $X_{t|t} = (x_{t|t},\ x_{t-1|t},\ z_{t|t})'$ and $X_{t-1|t-1} = (x_{t-1|t-1},\ x_{t-2|t-1},\ z_{t-1|t-1})'$ are consumers' beliefs about X_t at time t and X_{t-1} at time $t-1$, κ_t is a vector of Kalman gains, A and C are the functions of underlying parameters of the model, and I is the 3×3 identity matrix.

Thus, substituting $x_{t|t}$ and $x_{t-1|t}$ obtained in (6) onto (5), we can easily solve the model for consumption.[6]

[6] See Appendix B.1 for a detailed derivation of the model solution.

2.2 Extracting consumer confidence

To extract consumer confidence, we exploit the fact that the signal extraction problem discussed in the last section can also be solved sequentially as in L'Huillier and Yoo (2017) and Yoo (2017). From a signal extraction point of view, we can decompose consumption into two sub-components

$$c_t = \Delta c_{t|s_t} + c_{t|a_t} \tag{7}$$

where $c_{t|a_t}$ is the amount of consumption consumers would have spent without observing a noisy signal s_t, and $\Delta c_{t|s_t}$ is a consumption change due to observing the noisy signal. The variable $\Delta c_{t|s_t}$ is given by

$$\Delta c_{t|s_t} = \kappa_t^s \big(s_t - x_{t|a_t}\big) \tag{8}$$

where $x_{t|a_t}$ is a belief about permanent productivity x_t updated with productivity process a_t and κ_t^s is a non-negative gain of observing the noisy signal, which depends on the quality of the signals, and we define $\big(s_t - x_{t|a_t}\big)$ to be *consumer confidence* at time t such that positive confidence is associated with positive consumption changes and negative confidence induce consumers to reduce spending from the consumption level $c_{t|a_t}$.

Subtracting c_{t-1} from both sides of (7), we have

$$\Delta c_t = \Delta c_{t|s_t} + \Delta c_{t|a_t} \tag{9}$$

where $\Delta c_{t|a_t} = c_{t|a_t} - c_{t-1}$, which implies that we can disentangled consumption changes into those due to changes in actual productivity and those due to fluctuating confidence.

One of the important characteristics of this model of estimated consumer confidence is that it contains meaningful independent information about the economy whose influence on consumption fluctuation can be measured independently from other economic information: for example, from (8) and (9), we can measure the contribution of consumer confidence $(s_t - x_{t|a_t})$ on actual consumption changes independent of the productivity process a_t.

We obtain consumer confidence as follows.

Definition 1 *Filtered consumer confidence* at time t is given by

$$\text{Consumer confidence}_t = \left(\widehat{s}_t - \widehat{x}_{t|a_t}\right)$$

where $\widehat{s}_t$ and $\widehat{x}_{t|a_t}$ are the smooth-estimated noisy signal and a belief updated with productivity observation at time t.

3 Results

We solve the model sequentially as discussed in the last section and proceed to estimate the model. As econometricians, we can represent the dynamics of the model in a state-space form with the appropriate observation equations, which in this case includes the productivity variable a_t and the consumption variable c_t. In our model, consumers' expectations become a part of the unobserved state vector of the econometrician. The econometrician's Kalman filter is used to construct the likelihood function and to estimate parameters of the model. Appendix B.2 discusses the econometrician's filtering in detail.

Following Blanchard et al. (2013) and L'Huillier and Yoo (2017), our estimations include the demeaned first differences of the logarithm of labor productivity and of the logarithm of per-capita consumption. The simplicity of this model allows to extract a significant amount of information using only these two series.

Our goal is to use a *Kalman smoother* to estimate the shocks to the permanent component and the transitory component of productivity, the noise shock, and the unobservable state variables. We report the results for the period including the recent Great Recession (1995:Q2–2017:Q1).

3.1 Data

Our dataset includes series on labor productivity and per capita real consumption expenditure. To construct a series for labor productivity (real GDP divided by the labor input), we use a quarterly real gross domestic product (GDPC1) from the U.S. Bureau of Economic Analysis and employment (LNS12000000Q) from the U.S. Bureau of Labor Statistics. Similarly, to construct a series for per capital real consumption expenditure (real consumption expenditure divided by the total population), we use a quarterly real personal consumption expenditure (PCECC96) and population (LNS10000000Q) where the first series was taken from the Bureau of Economic Analysis and the second series from the U.S. Bureau of Labor Statistics. Recession indicators for the United States are based on NBER-defined recessions. For consumer confidence index, we use *the Index of Consumer Sentiment* from the University of Michigan.

3.2 Filtered consumer confidence

We first present the estimation results for the sequentially solved permanent income consumption model with noisy information in Section 2. The sample is from 1976:II–2017:I. Table 1 reports the estimation results. The results show that the persistence parameter ρ is estimated to be highly persistent. Due to this high persistence, the standard deviation for permanent productivity shocks is very small. The standard deviation for noisy shocks is estimated to be large.

Table 1: Parameter Estimates, US 1976:II–2017:I

Parameter	Description	Value	s.e.
ρ	Persistence productivity	0.9580	0.0076
σ_u	Std dev. productivity	0.0060	0.0003
σ_ϵ	Std dev. permanent shock (implied)	0.0003	-
σ_η	Std dev. transitory shock (implied)	0.0059	-
σ_ν	Std dev. noise shock	0.0133	0.0039

Notes: σ_ϵ and σ_η are recovered from the estimated ρ and σ_u according to (2) and (3). As they are indirectly recovered, no standard errors are given.

Figure 2 reports impulse responses of productivity and consumption following three exogenous shocks. We use the estimated parameters in Table 1. Due to a high productivity persistence, productivity gradually builds up (in the case of permanent technology shock) and slowly declines after an initial increase (in the case of transitory technology shock). A noise shock does not affect productivity. Following a permanent productivity shock, consumption gradually increases. Due to large volatilities in transitory and noise shocks, consumers cannot immediately recognize the permanent shock and adjust consumption slowly. In response to a transitory productivity shock, consumption initially increases but returns back to normal over time. Following a noise shock, consumption initially increases and slowly declines.

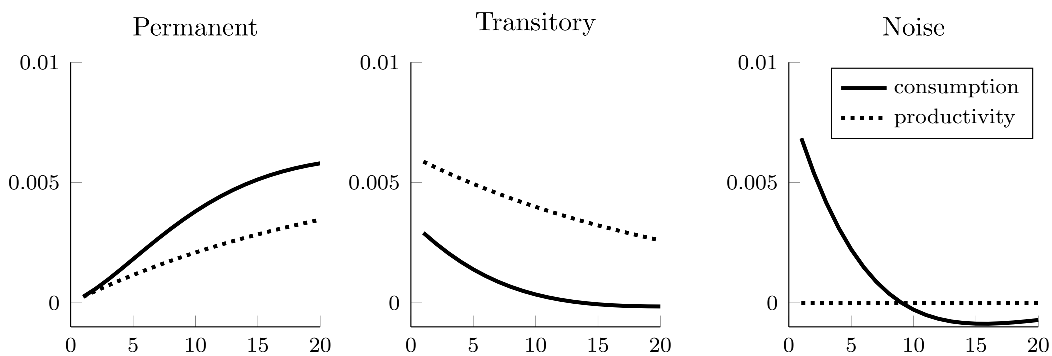

Figure 2: Impulse Responses

Notes: Productivity does not respond to a noise shock.

Figure 3 reports the implications of the estimated parameters in Table 1 for the variance decomposition of consumption, summarizing the contribution of the three shocks to the forecast error variance. We observe that noise shocks are a very important source of short to medium run volatilities, explaining more than 60% of consumption volatility at a one year horizon (light gray areas). On the contrary, both permanent (black areas) and transitory productivity (gray areas) shocks explain a much smaller fraction of consumption fluctuations, having almost no effect on quarterly volatility (permanent) and explaining less than 20% (transitory) at a one year horizon.

We now follow the procedure discussed in the last section and extract consumer confidence by smooth-estimating structural shocks and state variables. The solid line in Figure 4 denotes (HP-filtered) consumer confidence estimated for the sample period, and to compare our filtered consumer confidence to survey-based one, we also plot the the Index of Consumer Sentiment from the University of Michigan (the dashed line).

Can we justify our approach to extracting consumer confidence? Well, if our proposed methodology to extract consumer confidence is indeed a logical way to proceed, we should observe a positive and significant correlation between our estimated consumer confidence and the out-of-sample measure of consumer confidence.

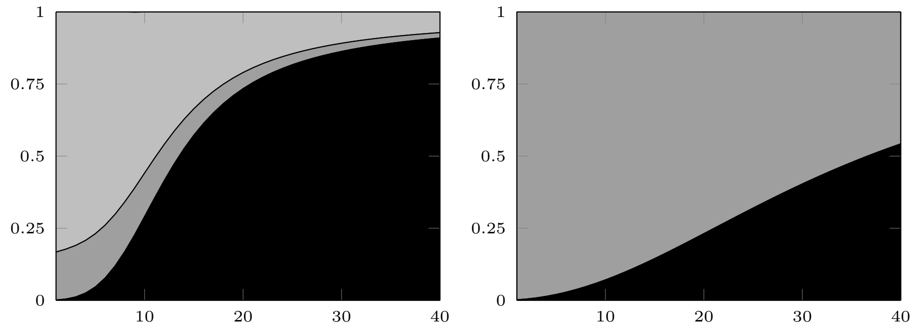

Figure 3: Variance decomposition: consumption (left) and productivity (right)

Notes: The *black* areas, the *gray* areas, and the *light gray* areas respectively represent a contribution of *permanent technology shocks*, *transitory technology shocks*, and *noise shocks* to consumption fluctuations over different time horizons.

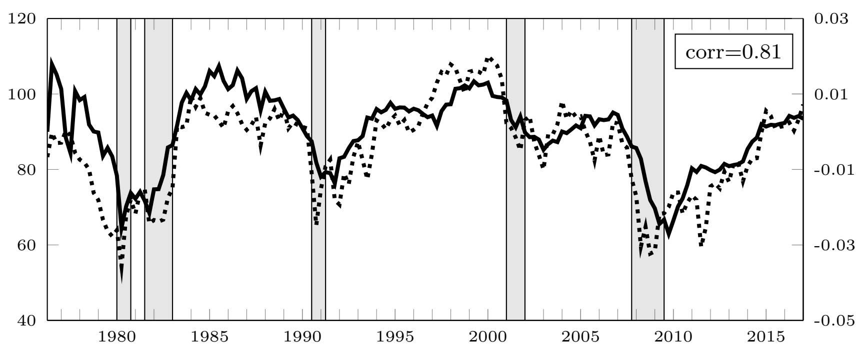

Figure 4: Estimated consumer confidence (solid) and the Index of Consumer Sentiment (dashed): 1976:II–2017:I

Notes: Shaded areas indicate U.S. recessions. The dashed line denotes the Michigan Survey of Consumer Confidence whereas the solid line denotes the estimated (HP-filtered) consumer confidence. The Consumer Confidence Index corresponds to the left y-axis and the estimated consumer confidence to the right y-axis. *corr* denotes the correlation coefficient between the Michigan Survey of Consumer Confidence and the estimated consumer confidence.

Our result is positive: the correlation between the two indices is strictly positive (0.81) and statistically significant at the 1% level. In addition, recessions are characterized by preceding downward shifts and subsequent recovery in consumer confidence in both measures. Nevertheless, while our approach to extracting consumer confidence does a good job of mimicking the dynamics of the survey-based confidence index, it would be far-fetched to draw a firm conclusion. For example, what would be the interpretation of a seemingly surprising correlation between in-sample and out-of-sample confidence measures?

3.3 Consumer confidences in Europe

We also attempt to extract consumer confidence for fifteen European countries and make a comparison with European consumer confidence indices. Similar to the observation in the U.S., recent economic crises have been associated with deteriorating consumer confidence in Europe as well. Figure 5 depicts consumer confidence fluctuations over the last twenty years for selected member states of the European Union (EU).

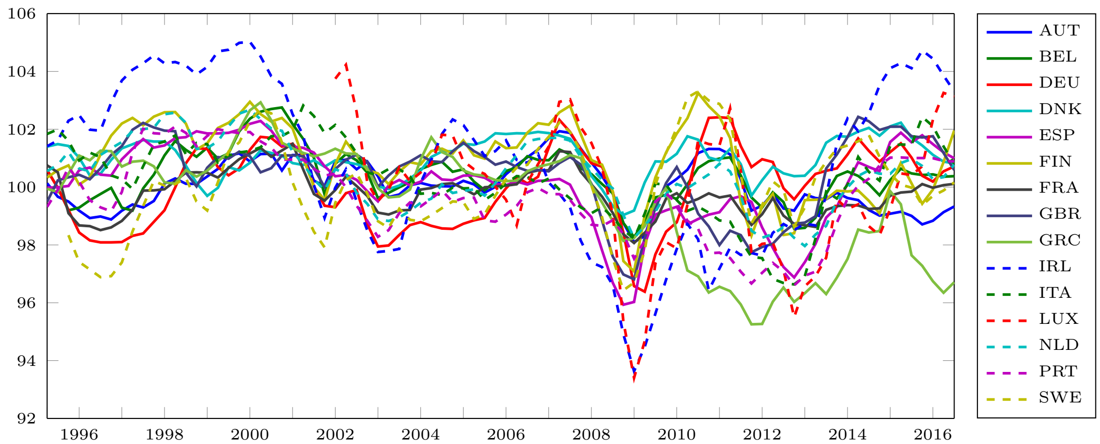

Figure 5: Consumer Confidence Index for 15 EU member states, 1995:II–2016:III

Notes: The lines denote the (quarterly) Consumer Confidence Index (CCI) available from the OECD. Since it is published in monthly frequency, we change it to quarterly by computing the quarterly arithmetic average at every quarter. For Luxembourg and Sweden, the CCI is available only from 2002:Q1 (LUX) and 1995:Q4 (SWE).

We first present the estimation results for the model discussed in Section 2. The sample is from 1995:Q2–2016:Q3. Our dataset includes series on labor productivity and per capita real consumption expenditure, and our sample includes fifteen European countries: the six founding member states of the EU - Belgium, France, (West) Germany, Italy, Luxembourg, and the Netherlands - along with nine other member states who joined the EU on or before January 1995 - Austria, Denmark, Finland, Greece, Ireland, Portugal, Spain, Sweden, and the United Kingdom. We focus on these 15 countries in part due to data availability. To construct a series for labor productivity (real GDP divided by the labor input), we use a quarterly Real

GDP from the OECD contained in the measure VORBASA and Total Employment from the Eurostat in the measure Total Employment - Domestic Concept. Both series are seasonally adjusted. Similarly, to construct a series for per capital real consumption expenditure (real consumption expenditure divided by the total population), we use a quarterly Private Final Consumption Expenditure from the OECD contained in the measure VORBASA and Total Population from the Eurostat in the measure Total Population. Both series are seasonally adjusted. For consumer confidence index, we use *the Consumer Confidence Index* from the OECD. Since it is published in monthly frequency, we change it to quarterly frequency by computing the quarterly arithmetic average at every quarter.

Table 2: Parameter estimates (15 European countries), 1995:II-2016:III

	Persistence (ρ)	Std. Perm. (σ_ϵ)	Std. Tran. (σ_η)	Std. Noise (σ_ν)
AUT	0.9831 (0.0080)	0.0001	0.0059	0.0141 (0.0073)
BEL	0.9473 (0.0168)	0.0002	0.0046	0.0129 (0.0053)
DEU	0.9003 (0.0434)	0.0007	0.0067	0.0026 (0.0027)
DNK	0.9419 (0.0265)	0.0006	0.0101	0.0084 (0.0054)
ESP	0.9943 (0.0020)	$\leq$ 0.0001	0.0066	0.0036 (0.0014)
FIN	0.9079 (0.0596)	0.0011	0.0113	0.0124 (0.0082)
FRA	0.9596 (0.0106)	0.0002	0.0043	0.0164 (0.0053)
GBR	0.9760 (0.0067)	0.0002	0.0062	0.0195 (0.0075)
GRC	0.9704 (0.0082)	0.0005	0.0154	0.0795 (0.0254)
IRL	0.9918 (0.0033)	0.0002	0.0218	0.1072 (0.0540)
ITA	0.9583 (0.0117)	0.0003	0.0062	0.0153 (0.0069)
LUX	0.9570 (0.0262)	0.0007	0.0159	0.0314 (0.0183)
NLD	0.9851 (0.0035)	$\leq$ 0.0001	0.0059	0.0818 (0.0234)
PRT	0.9872 (0.0070)	0.0001	0.0083	0.0421 (0.0192)
SWE	0.9412 (0.0182)	0.0005	0.0077	0.0222 (0.0073)

Notes: Standard errors are in parentheses. σ_ϵ and σ_η are obtained with random walk assumption of (2) and (3). Hence, no standard errors are given.

Table 2 reports the estimation results. The results show that the persistence parameter ρ is estimated to be high for all countries. Due to this high persistence, the standard deviation for permanent productivity shocks is very small. The estimates of the standard deviation for noisy shocks are, in general, large, but vary greatly across countries.

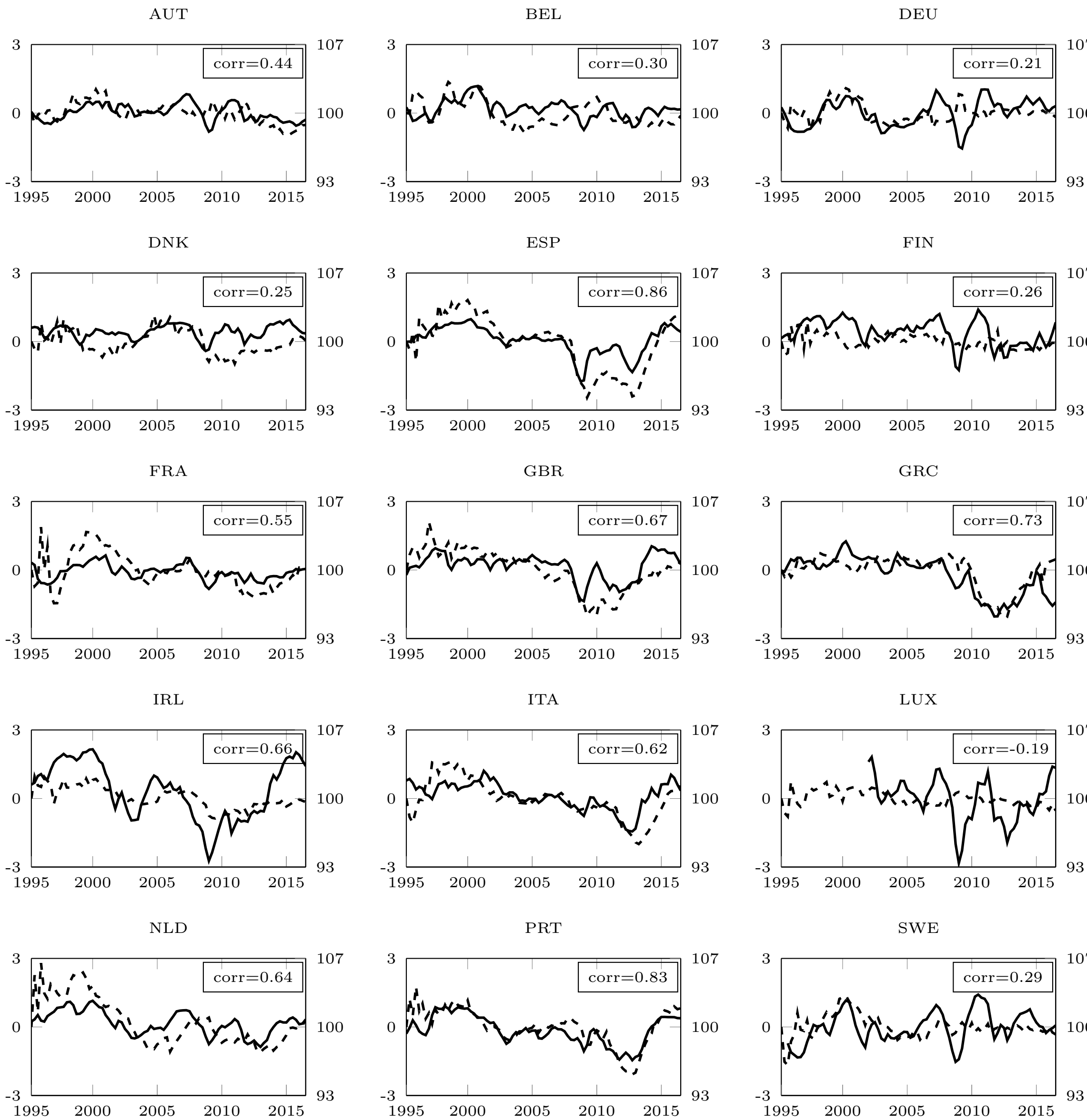

Figure 6: Estimated consumer confidence and the Consumer Confidence Index (OECD), 1995:II-2016:III

Notes: The solid lines denote the (quarterly) Consumer Confidence Index (CCI) available from the OECD. Since it is published in monthly frequency, we change it to quarterly by computing the quarterly arithmetic average at every quarter. The dashed lines denote the estimated (HP-filtered) consumer confidence in the sample, which are normalized by the standard deviation of noise shocks. The consumer confidence indexes correspond to the right y-axis, and the consumer confidence series to the left y-axis. For Luxembourg and Sweden, the CCI is available only from 2002:Q1 (LUX) and 1995:Q4 (SWE).

We now extract consumer confidence by smooth-estimating structural shocks and state variables. Dashed lines in Figure 6 denote (normalized) consumer confidences for the sample period. Consumer confidences appear to be somewhat persistent, and we observe that there is an extend period of *lack of consumer confidence* for many countries, which corresponds to the recent European recession. Similar to our previous exercise with U.S. data, we plot the the Consumer Confidence Index (CCI) from the OECD (the solid lines in Figure 6). Results for the European countries are somewhat mixed. For most countries, the correlations between the two indices are strictly positive and statistically significant at the 1% level: for Greece, Spain, the UK, Ireland, Italy, Netherlands, and Portugal, for example, the correlations are estimated to be at least 0.62 or greater, showing a clear correlation between the two indices. At the same time, there are a few cases in which the correlations are essentially zero: Austria, Germany, Finland, and Luxembourg.

3.4 Heterogeneity across countries

As shown in the last section we observe a somewhat surprisingly high correlation between the two indices: the average correlation coefficient is estimated 0.54. However, there also exists a great deal of heterogeneity: the correlations range from 0.21 (Germany) to 0.86 (Spain).[7] What would then possibly account for such observed heterogeneity?

In our sample, the high correlation countries include the U.K., Netherlands, and the PIIGS countries, i.e., Portugal, Ireland, Italy, Greece, and Spain. One possibility from this observed pattern is that a high correlation between two noisy measures of confidence is associated with a large fluctuation in true underlying confidence, where noisy measures are referred to *model-based filtered* and *survey-based* confidence.[8] For example, the severe recessions of the PIIGS could have caused low confidence reported in surveys and low consumption even given the dynamics of output. The U.K. has a huge financial sector, and it could be that the financial crisis caused extreme fluctuations in confidence. This means that, even

[7]Due to lack of observations, we leave out Luxembourg from further discussion.

[8]Table 3 shows that the observed high correlation between two indices is related to a relatively larger volatility of the survey confidence index itself.

though the U.K. isn't famous for having a severe great recession, there was a lot of fear which affected both consumption and survey responses.

Succinctly and structurally putting this conjecture, let survey-based confidence, $S_{1,t}$, is a sum of true unobservable confidence, κ_t and a disturbance term $e_{1,t}$:

$$S_{1,t} = \kappa_t + e_{1,t}$$

where $e_{1,t}$ is an i.i.d. Gaussian disturbance and filtered confidence, $S_{2,t}$, is also a sum of true confidence and a different disturbance term $e_{2,t}$:

$$S_{2,t} = \kappa_t + e_{2,t}$$

where $e_{2,t}$ is an i.i.d. Gaussian disturbance and $e_{1,t} \perp e_{t+j}$ for all t and j.

The disturbance terms could be interpreted as measurement errors. For the survey measure of confidence, there is the problem of sampling the population. Also, each participant answers the survey on a particular day while consumption and productivity are averages over quarters. This adds measurement error to the survey. In contrast, the filtered measure of confidence is very simple and clearly imperfect. It is impressive that it is correlated with survey confidence, but we wouldn't ever think of claiming it is true confidence measured without error.

As shown in (10), which depicts the correlation between the two measures, the correlation could depend on the variance of true confidence, and if the differences across countries are mostly $var(\kappa)$, that is variance of true confidence, then the pattern could be explained.

$$\text{Corr} = \frac{var(\kappa)}{(var(\kappa) + var(e_1))(var(\kappa) + var(e_2))^{1/2}} \tag{10}$$

Table 4 also suggests that the correlation between the two measures of consumer confidence are loosely related to the estimated standard deviation of noise shocks: a high variance of noise shocks is related to high correlation between two measures of consumer confidence. It could be that this noise is a source of confidence fluctuations, and that high noise means high variance of true confidence.

Finally, as shown in Section 2 we impose a strong assumption that the underlying economy is abstracted by the simple permanent income consumption model. Therefore, it could potentially be a underlying source of estimated low correlations

Table 3: The volatility of confidence index and correlation between the two confidence measures

Sample	Correlation	Volatility
Whole sample	0.5222	1.3582
High correlation	0.7157	1.6468
Low correlation	0.3286	1.0695

Notes: Correlation denotes the average correlation coefficients between the model-based and survey-based consumer confidence in the sample, and *Volatility* denotes the average standard deviation of the survey-based consumer confidence in the respective sample. The first sub-sample (high correlation) contains those countries with the correlation between the model based and survey consumer confidence higher than 0.60 and includes Greece, Netherlands, Ireland, Italy, Portugal, Spain, and UK; the second sub-sample (low correlation) contains those with the correlation smaller than 0.6 and includes Austria, Belgium, Denmark, Finland, France, Germany, and Sweden. We leave Luxembourg out of sample due to a lack of observations.

Table 4: Noisiness and correlation between the two confidence measures

Sample	Correlation	Std. noise shock
Whole sample	0.5222	0.0315
High correlation	0.7157	0.0499
Low correlation	0.3286	0.0131

Notes: Correlation denotes the average correlation coefficients between the model-based and survey-based consumer confidence in the sample, and *Std. noise shock* denotes the estimated standard deviation of the noise shock ($\hat{\sigma}_\nu$) in the respective sample. The first sub-sample (high correlation) contains those countries with the correlation between the model based and survey consumer confidence higher than 0.60 and includes Greece, Netherlands, Ireland, Italy, Portugal, Spain, and UK; the second sub-sample (low correlation) contains those with the correlation smaller than 0.6 and includes Austria, Belgium, Denmark, Finland, France, Germany, and Sweden. We leave Luxembourg out of sample due to a lack of observations.

between two indices for some countries that this particular structural model may be too simple and does not describe these economies particularly well.

4 Conclusion

We have attempted to extract consumer confidence using aggregate macroeconomic data based on a structural framework with imperfect information, and tried to match it with the survey-based counterpart by calculating the correlation between the two measures of consumer confidence. We have shown that, while there exists heterogeneity of estimated correlation coefficients, the correlation between *filtered* and *survey-based* consumer confidences is in general high, providing a way to understand the widely used consumer confidence indices from a (macroeconomic) structural informational perspective.

We have focused on the permanent income consumption hypothesis with noisy information not only because it is analytically convenient, but also because considering its simple nature, the actual performance of the model in terms of generating filtered confidence and matching the survey-based counterpart is striking and somewhat surprising. Nevertheless, it would seem interesting to extend our discussion in a model with more realistic features to examine if we can improve the fit between the two measures.

References

Batchelor, R. and P. Dua (1998). Improving macro-economic forecasting: The role of consumer confidence. *International Journal of Forecasting 14*(1), 71–81.

Blanchard, O. J., J.-P. L'Huillier, and G. Lorenzoni (2013). News, noise, and fluctuations: An empirical exploration. *American Economic Review 103*(7), 3045–3070.

Boz, E., C. Daude, and C. B. Durdu (2011). Emerging market business cycles: Learning about the trend. *Journal of Monetary Economics 58*(6), 616–631.

Cao, D. and J.-P. L'Huillier (2017). Technological revolutions and the three great slumps: a medium-run analysis. *Mimeo*.

European Commission. The Joint Harmonised EU Programme of Business and Consumer Surveys. User Guide (Updated 4 July 2017).

Howrey, E. P. (2001). The predictive power of the index of consumer sentiment. *Brookings Papers on Economic Activity 2001*(1), 175–207.

Lachowska, M. (2016). Expenditure and confidence: using daily data to identify shocks to consumer confidence. *Oxford Economics Papers 68*(4), 920–944.

Lahiri, K., G. Monokroussos, and Y. Zhao (2015). Forecasting consumption: the role of consumer confidence in real time with many predictors. *Journal of Applied Econometrics 31*, 1254–1275.

L'Huillier, J.-P. and D. Yoo (2017). Bad news in the Great Depression, the Great Recession, and other U.S. recessions: a comparative study. *Journal of Economic Dynamics and Control 81*, 79–98.

Lorenzoni, G. (2009). A theory of demand shocks. *American Economic Review 99*(5), 2050–84.

OECD. Consumer confidence index (CCI) (indicator). doi: 10.1787/46434d78-en (Accessed on 30 November 2017).

Rousakis, M. (2013). Expectations and fluctuations: The role of monetary policy. *Mimeo*.

Yoo, D. (2017). Ambiguous information, permanent income, and consumption fluctuations. Mimeo.

A Data appendix

A.1 The Index of Consumer Sentiment

The Index of Consumer Sentiment (ICS) is calculated by computing the relative scores for each of the five index questions on past and future financial, business, and macroeconomics conditions. Specifically, for each index question (Q_i), you subtract the percent giving unfavorable replies from the percent giving favorable replies, then add 100 to compute the relative score X_i:

$$ICS = \frac{X_1 + X_2 + X_3 + X_4 + X_5}{\text{base score}} + 2.0$$

where $X_1, ..., X_5$ denote the relative scores computed for each of the five index questions, *base score* refers to the 1966 base period total of 6.7558, and 2.0 on the second term on the RHS is a constant to correct for sample design changes from the 1950s.

The five index questions are as follows:

Q_1 : "We are interested in how people are getting along financially these days. Would you say that you (and your family living there) are better off or worse off financially than you were a year ago?"

Q_2 : "Now looking ahead–do you think that a year from now you (and your family living there) will be better off financially, or worse off, or just about the same as now?"

Q_3 : "Now turning to business conditions in the country as a whole–do you think that during the next twelve months we'll have good times financially, or bad times, or what?"

Q_4 : "Looking ahead, which would you say is more likely–that in the country as a whole we'll have continuous good times during the next five years or so, or that we will have periods of widespread unemployment or depression, or what?"

Q_5 : "About the big things people buy for their homes–such as furniture, a refrigerator, stove, television, and things like that. Generally speaking, do you think now is a good or bad time for people to buy major household items?"

The Index is available at http://www.sca.isr.umich.edu/tables.html.

A.2 Consumer Confidence Index

The consumer confidence indicator is calculated by computing the simple arithmetic average of the seasonally adjusted balances of answers to the answers to the questions on the financial situation of households, the general economic situation, unemployment expectations and savings over the next 12 months.

The questions relevant for computing the consumer confidence indicator, which are chosen from the full set of questions in individual survey, are as follows:

Q_2 : "How do you expect the financial position of your household to change over the next 12 months? "

Q_4 : "How do you expect the general economic situation in this country to develop over the next 12 months?"

Q_7 : "How do you expect the number of people unemployed in this country to change over the next 12 months?"

Q_{11} : "Over the next 12 months, how likely is it that you save any money?"

For each questions, there are six possible answers, i.e., strongly positive, positive to neutral, negative, and strongly negative, as well as "don't know."

For more details are available from the European Commission Directorate-General For Economic and Financial Affairs (European Commission).

B Solution

B.1 Solving the model

Consider the dynamic system:

$$\mathbf{X}_t = A\mathbf{X}_{t-1} + B\mathbf{V}_t$$
$$\mathbf{S}_t = C\mathbf{X}_t + D\mathbf{V}_t$$

and $\mathbf{X}_t = (x_t,\ x_{t-1},\ z_t)'$, $\mathbf{V}_t = (\epsilon_t,\ \eta_t,\ \nu_t)'$, $\mathbf{S}_t = (a_t,\ s_t)'$,

$$A = \begin{bmatrix} 1+\rho & -\rho & 0 \\ 1 & 0 & 0 \\ 0 & 0 & \rho \end{bmatrix},\ B = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix},\ C = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix},\ D = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Consumers sequentially process two contemporaneous signals a_t and s_t at time t. Thus, at the first subperiod, conditional on observing productivity signal a_t, consumers' beliefs updated with current productivity $\mathbf{x}_{t|a_t}$ are given by

$$\begin{aligned} \mathbf{X}_{t|a_t} &= A\mathbf{X}_{t-1|t-1} + H(a_t - a_{t|t-1}) \\ &= [I - HC_1]A\mathbf{X}_{t-1|t-1} + Ha_t \end{aligned} \tag{11}$$

where H is the Kalman gain for observing productivity,

$$a_t = C_1\mathbf{X}_t + D_1\mathbf{V}_t$$

and $C_1 = \begin{bmatrix} 1 & 0 & 1 \end{bmatrix},\ D_1 = \begin{bmatrix} 0 & 0 & 0 \end{bmatrix}$.

At the second subperiod, by processing a noisy signal s_t consumers' end-of-period beliefs $\mathbf{x}_{t|t}$ become:

$$\begin{aligned} \mathbf{X}_{t|t} &= \mathbf{X}_{t|a_t} + G(s_t - x_{t|a_t}) \\ &= [I - GC_2]\mathbf{X}_{t|a_t} + Gs_t \end{aligned} \tag{12}$$

where G is the gain of observing new information s_t,

$$s_t = C_2\mathbf{X}_t + D_2\mathbf{V}_t$$

and $C_2 = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix},\ D_2 = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}$.

Substituting $\mathbf{X}_{t|a_t}$ from (11) into (12), we represent a vector of consumers' expectations as follows:

$$\mathbf{X}_{t|t} = [I - GC_2][I - HC_1]A\mathbf{X}_{t-1|t-1} + [I - GC_2]Ha_t + Gs_t \tag{13}$$

Once consumers' expectations are formed, consumption can be solve for according to (1):

$$\begin{aligned} c_t &= \mathbb{E}_t\left[a_{t+\infty}\right] = \mathbb{E}_t\left[x_{t+\infty} + z_{t+\infty}\right] \\ &= \frac{1}{1-\rho}\left(x_{t|t} - \rho x_{t-1|t}\right) \end{aligned}$$

B.2 Estimating the model

While the econometrician does not observe noisy signals, her information set includes productivity signals, assumed to be publicly available and consumption observations. Thus, she extracts consumers' beliefs using all available information with the following Kalman filter:

$$\mathbf{X}_{t|a_t} = \begin{bmatrix} x_{t|a_t} \\ x_{t-1|a_t} \\ z_{t|a_t} \end{bmatrix} = A \begin{bmatrix} x_{t-1|t-1} \\ x_{t-2|t-1} \\ z_{t-1|t-1} \end{bmatrix} + H \begin{bmatrix} 1+\rho & -\rho & -\rho \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_{t-2} \\ z_{t-1} \end{bmatrix} + H\epsilon_t + H\eta_t \quad (14)$$

Conditional on $\mathbf{X}_{t|a_t}$, $\mathbf{X}_{t|t}$ is given by

$$\begin{bmatrix} x_{t|t} \\ x_{t-1|t} \\ z_{t|t} \end{bmatrix} = \begin{bmatrix} x_{t|a_t} \\ x_{t-1|a_t} \\ z_{t|a_t} \end{bmatrix} + G \begin{bmatrix} 1+\rho & -\rho & 0 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_{t-2} \\ z_{t-1} \end{bmatrix} + G\epsilon_t + G\eta_t + G\nu_t \qquad (15)$$

We let $\mathbf{X}_t^E$ to represent the state vector of the econometrician where

$$\mathbf{X}_t^E = \left(x_t,\ x_{t-1},\ z_t,\ x_{t|t},\ x_{t-1|t},\ z_{t|t}\right)'$$

then, $\mathbf{X}_t^E$ follows

$$\mathbf{X}_t^E = Q\mathbf{X}_{t-1}^E + R(\epsilon_t,\ \eta_t,\ \nu_t)' \qquad (16)$$

The matrices Q and R, which depend on the underlying parameters of the model, are given respectively by

$$Q = \begin{bmatrix} A & \mathbf{0} \\ \mathbf{Q} & \mathbf{A} \end{bmatrix}$$

$$R = \begin{bmatrix} B \\ \mathbf{R} \end{bmatrix}$$

where $\mathbf{Q}$, $\mathbf{R}$, and $\mathbf{A}$ are given by

$$\mathbf{Q} = B \begin{bmatrix} 1+\rho & -\rho & \rho \\ 1+\rho & -\rho & 0 \end{bmatrix}$$

$$\mathbf{R} = B \begin{bmatrix} 1+\rho & 0 & 0 \\ 1+\rho & 0 & 0 \end{bmatrix} + B \begin{bmatrix} 1+\rho & 0 & 0 \\ 1+\rho & 0 & 0 \end{bmatrix} + B \begin{bmatrix} 1+\rho & 0 & 0 \\ 1+\rho & 0 & 0 \end{bmatrix}$$

$$\mathbf{A} = \left[I - HC_1 \right] \left[I - GC_2 \right] A$$

The observation equation is given by

$$(a_t,\, c_t) = T\mathbf{X}_t^E \tag{17}$$

where

$$T = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1/\left(1-\rho\right) & \rho/\left(1-\rho\right) & 0 \end{bmatrix}$$

We then can build the state space representation of the model using (14), (15), (16) and (17) and structurally estimate it.

C The alternative productivity process specification and estimated consumer confidence

We relax the parameter restrictions (2) and (3) and present the estimation results for the model discussed in Section 2. Table A1 reports the estimation results, and Figure 7 depicts estimated consumer confidence.

D Estimation results for the European countries

Figure 8 and 9 report impulse responses of productivity and consumption following three exogenous shocks for the fifteen countries in the sample. We use the esti-

Table A1: Parameter estimates, US 1976:II–2017:I

Parameter	Description	Value	s.e.
ρ_x	Persistence permanent productivity	0.9725	0.0015
ρ_z	Persistence transitory productivity	0.8310	0.0419
σ_ϵ	Std dev. permanent shock	0.0002	0.0000
σ_η	Std dev. transitory shock	0.0058	0.0003
σ_ν	Std dev. noise shock	0.0086	0.0020

Notes: Instead of imposing assumption (2) and (3), we directly estimate standard deviations of productivity shocks σ_ϵ and σ_η and persistence parameters ρ_x and ρ_z.

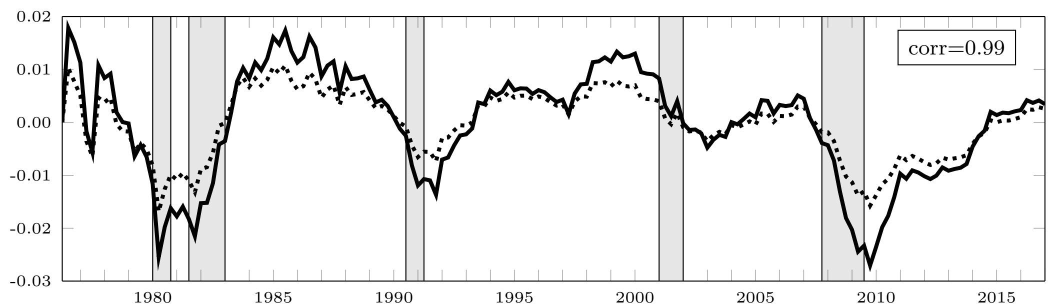

Figure 7: Estimated consumer confidence: 1976:II–2017:I

Notes: Shaded areas indicate U.S. recessions. The dashed line denotes consumer confidence estimated with parameters Table 1 whereas the solid line denotes (HP-filtered) consumer confidence estimated with parameters in Table A1. *corr* denotes the correlation coefficient between them.

mated parameters in Table 2. Due to a high productivity persistence, productivity in general gradually builds up (in the case of permanent tech shock) and slowly declines after an initial increase (in the case of transitory tech shock). A noise shock does not affect productivity.

Figure 9 shows that consumption slowly increases following a permanent tech shock. This is due to the fact that the large volatilities in transitory productivity and noise shocks prohibit agents immediately recognize the permanent productivity change. Thus, they adjust consumption slowly. Similarly, it takes time for consumers to recognize a temporal change in productivity or a noisy disturbance and reduce consumption after an initial impulse following a transitory tech. shock or a noise shock. How fast the adjustment takes place and how large the magnitude of adjustments are depends on the estimated volatilities of the shocks.

Figure 10 reports the implications of the estimated parameters in Table 2 for

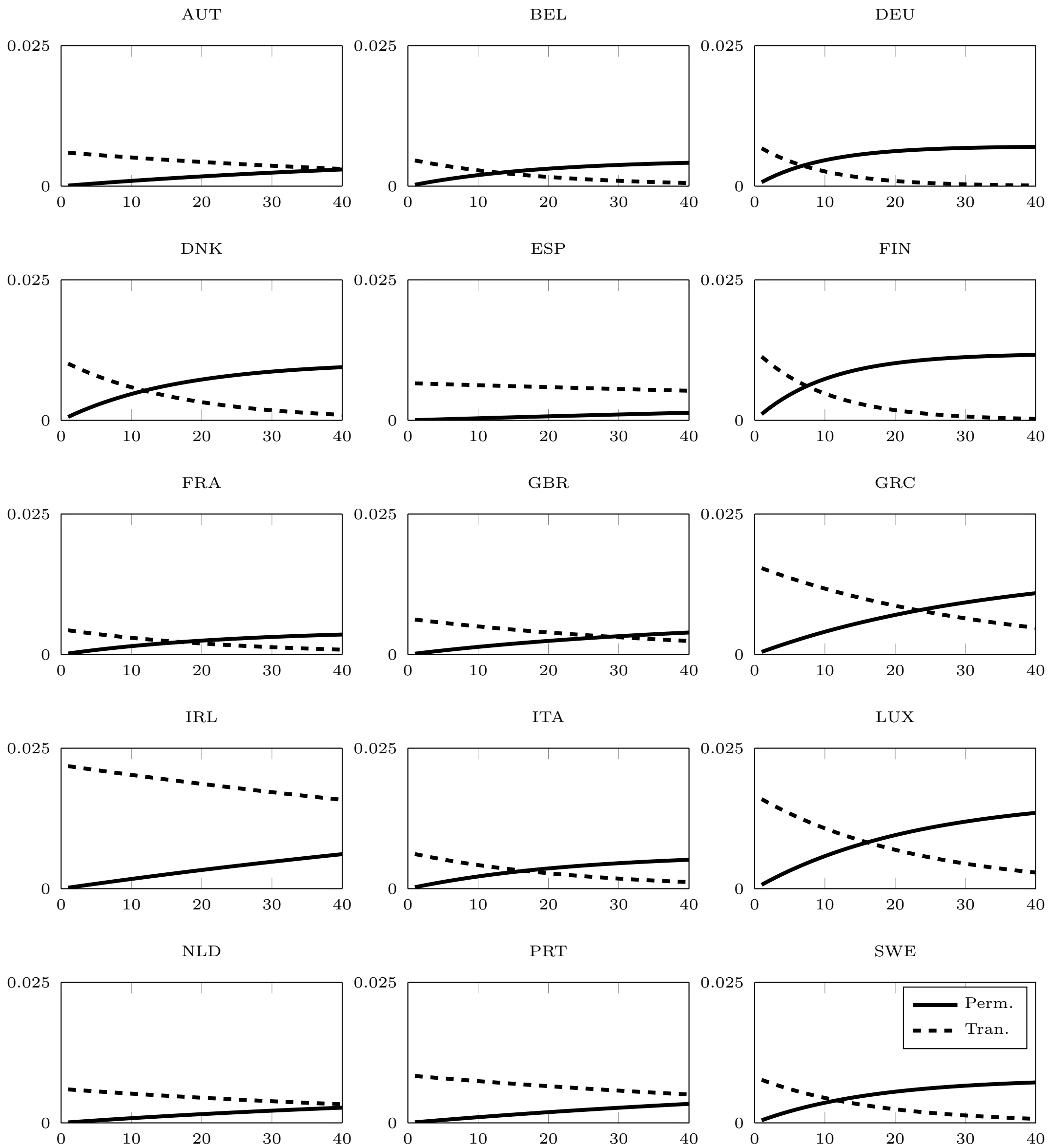

Figure 8: Impulse responses: productivity

Notes: Plots correspond to the IRFs of consumption to three shocks of one standard deviation. The solid lines correspond to the IRFs of permanent productivity shocks; the dashed lines to those of transitory productivity shocks; the dotted lines to those of noise shocks.

the variance decomposition of consumption, summarizing the contribution of the three shocks to the forecast error variance. We observe that across countries noise shocks are a very important source of short to medium run volatilities, explaining more than 60 to more than 90% of consumption volatility at a one year horizon. On

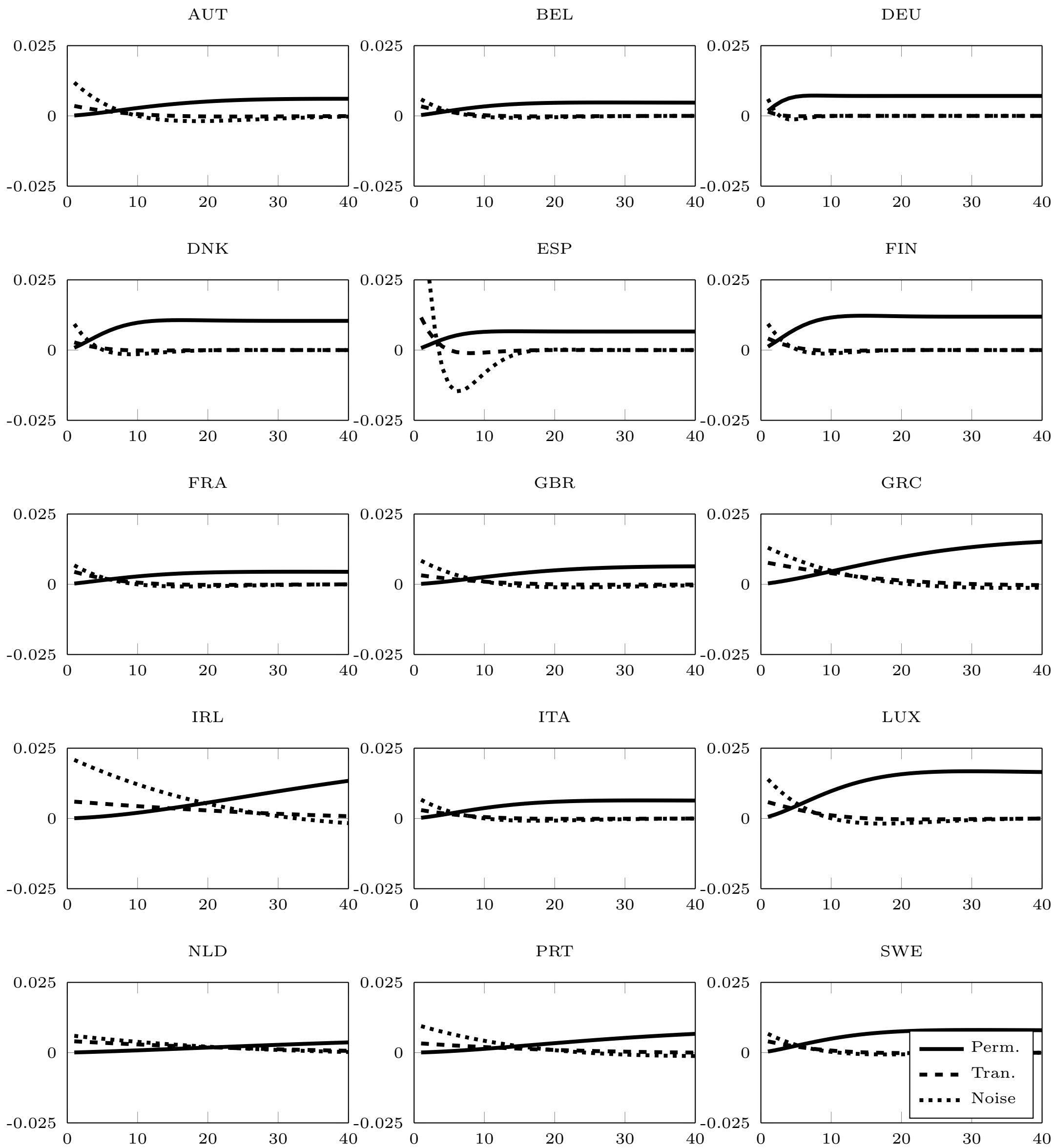

Figure 9: Impulse responses: consumption

Notes: Plots correspond to the IRFs of three shocks of one standard deviation. The solid lines correspond to the IRFs of permanent productivity shocks; the dashed lines to those of transitory productivity shocks. Productivity does not respond to a noise shock.

the contrary, both permanent and transitory productivity shocks explain a much smaller fraction of consumption fluctuations, having almost no effect on quarterly volatility (permanent) and explaining less than 20% (transitory) for most countries at a one year horizon. At the same time, we observe heterogeneity across countries.

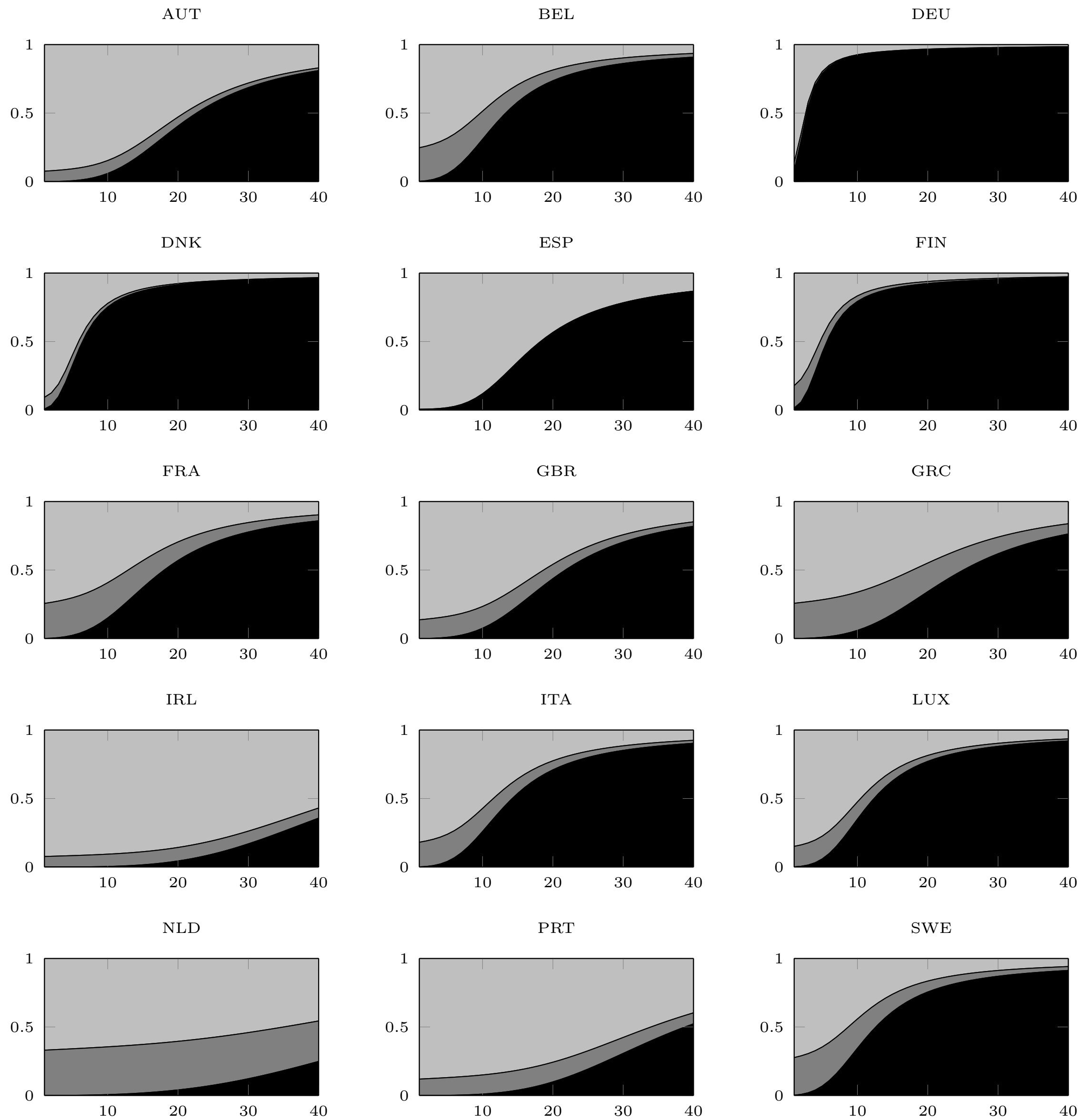

Figure 10: Variance Decomposition, 1995:II-2016:III

Notes: The *black* areas, the *gray* areas, and the *light gray* areas respectively represent a contribution of *permanent technology shocks*, *transitory technology shocks*, and *noise shocks* to consumption fluctuations over different time horizons.

For example, noise shocks are still an important source of consumption fluctuations even at a ten year horizon for countries such as Greece, Ireland, Netherlands, Portugal, Spain, and the UK.