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CONFIDENCE, FUNDAMENTALS, AND CONSUMPTION

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Confidence, Fundamentals, and Consumption*

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Abstract

We offer a structural interpretation of survey measures of consumer confidence. Our approach is based on a simple forward-looking model of consumption. The model decomposes observed consumption fluctuations in changes due to fundamentals, and changes due to temporary errors caused by noisy information. Our model-based measure, estimated using national accounts, closely mimics out-of-sample survey data in the U.S. and a majority of European countries. The results provide a theoretical foundation for the use of survey-based consumer confidence indices. In addition, since national accounts are an internationally consistent measure of activity, our structural method provides an alternative and internationally consistent measure of consumer confidence.

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 about 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 Directorate-General Economic and Financial Affairs (DG ECFIN) of the European Commission publishes the Consumer Confidence Indicator (CCI) monthly, which is a leading indicator based on households' current and expected plans for major purchases and beliefs about 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 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 the 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 a detailed description of 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. The dataset is also available from the Organisation for Economic Co-operation and Development (OECD).

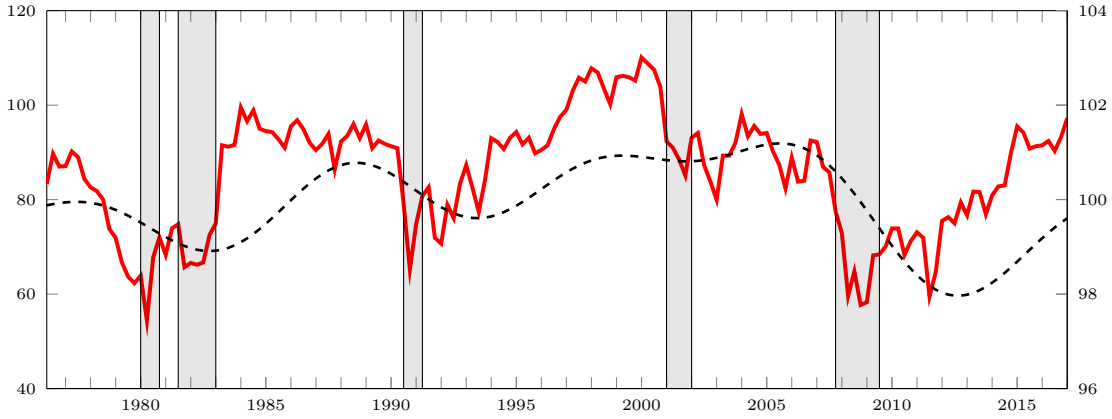


Figure 1: Consumer confidence and consumption-to-output ratio

Notes: Shaded areas indicate U.S. recessions. The red solid line denotes the Michigan Survey of Consumer Confidence whereas the black dashed line denotes the 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 the consumption-to-output ratio to the right y-axis.

While such indices provide an appealing visual description of 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?

Moreover, while survey-based consumer confidence indices are internationally available, a potential drawback is that survey measures may not necessarily be consistent internationally. Indeed, even if the questions asked by surveys (and other determinants of the outcome, for example, the timing of the survey or surveying strategy) were identical across countries, not even this would guarantee international consistency of the measure for cultural reasons. For instance, Danes are well-known for being prudent and cautious in their judgment, whereas in most Latin American countries people are well-known for having a happy and optimistic attitude towards life, sometimes even disregarding threatening events.

In this paper, we attempt to provide an informational mechanism to conceptualize and construct consumer confidence measurements based on national accounts. By introducing an informational foundation for the extraction of consumer confidence, we validate the use of confidence indices and show that consumer confidence, orthogonal to current and lagged public information, carries an important piece of

information that affects aggregate quantities. Since its inception in 1953, the System of National Accounts constitutes, in principle, an internationally consistent and coherent measure of activity. Thus, a structural method based on national accounts can provide a measure for consumer confidence that is internationally consistent. This structural measure can be consulted along with survey measures to identify consumers' perception of the economy.

We first lay out a foundation to measure *model-based* 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 of extracting consumer confidence from an estimated simple consumption model where consumers learn about future income under noisy information.[3]

As shown in Figure 1, changes in consumer confidence precede changes in consumption relative to productivity by several years. Consumer confidence peaks and troughs lead to similar movements for the ratio of consumption-to-productivity by two to four years. Our learning model captures the idea that waves of optimism and pessimism are related to the dynamics of spending (relative to productivity). Our approach is based on L'Huillier and Yoo (2017). There, agents' perception of the future changes due to fundamentals and due to information *unrelated* to fundamentals. Specifically, in our attempt to estimate consumer confidence, we make two strong assumptions regarding (1) agents' information structure to 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 permanent productivity of the economy. According to the permanent income logic, consumers choose spending based on their expected future income. Thus, estimating the parameters of the model and making inferences is feasible by looking at productivity and consumption trends. We, as econometricians, are able 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 the evolution of agents' perception about the state of

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

[4]See, for example, Blanchard, L'Huillier, and Lorenzoni (2013) and Cao and L'Huillier (2018).

the economy.

By decomposing changes in consumption as described, consumer confidence is measured structurally by the discrepancy between consumers' (ex-ante) beliefs about permanent income and beliefs after processing newly arrived information. Having estimated consumer confidence, we proceed to compare it with survey-based confidence indices. We call our measure 'model-based consumer confidence'. We use U.S. national accounts data to estimate model-based consumer confidence and compare it with the ICS. A key contribution of our paper is to show that model-based consumer confidence matches the ICS quite well, with a statistically significant ($< 1\%$) correlation of 0.52 between the two.

We also compare our model-based consumer confidence with the CCI in fourteen European countries. Our results show that model-based measures are estimated to be highly correlated with the survey-based measure for nine out of fourteen countries in our sample even if we do not use the survey measures as an input.

Our partial equilibrium consumption model lacks many interesting structural shocks and frictions widely used in modern general equilibrium macroeconomic models, but it does a fairly good job of matching the dynamics of the survey-based consumer confidence index in general. This 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.

At the same time, there exists a great deal of heterogeneity such that for countries like Austria, Belgium, Germany, Finland, and Sweden, our measure fails to match the CCI. Since our measure is estimated using actual consumption and productivity series, it may be useful to understand the behavior of consumer confidence by other means.

Relation to the 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), Cao and L'Huillier (2018), 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 (2019) disentangling the effects of different signals on aggregate fluctuations.

Using consumer confidence to forecast aggregate quantities, Batchelor and Dua (1998) show that paying attention to the sharp fall in consumer confidence would have helped predict the 1991 recession. However, consumer confidence would have not been helpful in forecasting recessions in other years. Howrey (2001) shows that the U.S.'s ICS is a statistically significant predictor for forecasting the near-term probability of a recession when used independently or in conjunction with other indicators.[5] 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. Barsky and Sims (2012) use structural estimation to assess the impact of consumer confidence in a model that features signal extraction.

Our modeling approach originates in the path-breaking contributions by Beaudry and Portier (2004, 2006) They were the first to point out that news shocks offer a useful interpretation of macroeconomic data. More recently, Schmitt-Grohé and Uribe (2012) investigated the impact of news shocks in a structural model. More recently, Chahrour and Jurado (2018, 2021) have made important advances in the identification of this type of shocks.

Other parallel strands of the literature also investigate the impact of swings in private sector confidence but use very different models. We only mention a few of the key papers. In an influential contribution, Ilut and Schneider (2014) use ambiguity. Angeletos and La'O (2013) use shocks akin to sunspots that operate in unique equilibrium models. To the best of our knowledge, none of these strands of the literature has taken a similar focus on survey data as we do.

The rest of the paper is organized as follows. Section 2 describes the model and discusses how to extract consumer confidence. Sections 3 and 4 discuss quantitative results. Section 5 concludes.

[5]These indicators include 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.

2 A simple consumption model

In this economy, consumption is the only endogenous variable and the behavior of consumption is described by a random walk:

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

which can be derived from first principles. For details, see Blanchard et al. (2013).

There is no capital, and output is completely determined by the demand side where consumption is the only determinant of demand:

$$y_t = c_t$$

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

We consider a single, representative information set by Blanchard et al. (2013) where fundamentals are stochastic processes describing exogenous changes in productivity or income summarized by a_t. Productivity 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 estimate the persistent parameter ρ and the variance σ_u^2 and recover σ_ϵ^2 and σ_η^2 indirectly.[6]

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.[7] Since the

[6]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 A5 in Appendix E compares estimated consumer confidence for the two cases.

[7]For the rest of the paper we use the terms *agents* and *consumers* interchangeably.

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, agents observe a noisy signal s_t about permanent productivity:

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

where ν_t is an i.i.d Gaussian shock with mean zero and variance σ_ν^2, and the shock ν_t is a noise shock because it affects agents' beliefs but is independent of fundamentals.

This noisy signal denotes the additional informative signal that agents receive which is a straightforward interpretation of Equation (4). Ultimately, the presence of this noisy information helps 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 filter to solve a signal extraction problem for the expectation about future productivity $a_{t+\infty}$. First, solving Equation (1), we get

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

where $x_{t|t} \equiv \mathbb{E}[x_t|\mathcal{I}_t] \equiv \mathbb{E}_t[x_t]$ and $x_{t-1|t} \equiv \mathbb{E}[x_{t-1}|\mathcal{I}_t] \equiv \mathbb{E}_t[x_{t-1}]$ represent agents' beliefs about current and lagged permanent productivity, respectively. Here, the agents' information set at time t, $\mathcal{I}_t$, includes current productivity, a_t, a noisy signal, s_t, and lagged information, $\mathcal{I}_t$:

$$\mathcal{I}_t = (a_t, s_t, \mathcal{I}_{t-1})$$

where $\mathcal{I}_0 = (a_0, s_0)$.

Second, agents' beliefs about the permanent state of the economy ($x_{t|t}$ and $x_{t-1|t}$) can be obtained by solving a signal extraction problem where an unobserv-

able state vector $\mathbf{x}_t$ is given by $\mathbf{x}_t = (x_t,\ x_{t-1},\ z_t)'$, and an observable vector is given by $\mathbf{s}_t = (a_t,\ s_t)'$:

$$\mathbf{x}_{t|t} = \big[I - \kappa \times C\big] A\mathbf{x}_{t-1|t-1} + \kappa \times \mathbf{s}_t \tag{6}$$

where $\mathbf{x}_{t|t} = (x_{t|t},\ x_{t-1|t},\ z_{t|t})'$ and $\mathbf{x}_{t-1|t-1} = (x_{t-1|t-1},\ x_{t-2|t-1},\ z_{t-1|t-1})'$ are agents' beliefs about $\mathbf{x}_t$ at time t and $\mathbf{x}_{t-1}$ at time $t-1$ respectively, κ is a vector of steady-state 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 Equation (6) onto Equation (5), we can easily solve the model for consumption.[8]

2.2 A mechanism to extract consumer confidence

To extract our measure of 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 (2019). Specifically, we attempt to disentangle the effects of two signals, productivity a_t and a noisy signal s_t, on consumption fluctuations.

Denote agents' expectations about a state vector $\mathbf{x}_t$ with current productivity and lagged information by

$$\mathbf{x}_{t|a_t} = \mathbb{E}[\mathbf{x}_t|\Omega_t]$$

where $\Omega_t = (a_t, \mathcal{I}_{t-1})$ such that $\Omega_t \in \mathcal{I}_t$ and $\Omega_t \cup s_t \equiv \mathcal{I}_t$.

Conditional on agents' beliefs at time $t-1$, $\mathbf{x}_{t-1|t-1}$, where agents' information set includes only productivity a_t (other than those available at time $t-1$), the belief updating is given by

$$\mathbf{x}_{t|a_t} = A\mathbf{x}_{t-1|t-1} + H(a_t - a_{t|t-1}) \tag{7}$$

where $\mathbf{x}_{t|a_t} = (x_{t|a_t}, x_{t-1|a_t}, z_{t|a_t})'$ and H is the steady state Kalman gain for observing productivity a_t.

Moreover, conditional on agents' beliefs $\mathbf{x}_{t|a_t}$, updating beliefs with the noisy

[8] See Appendix C.1 for a detailed derivation of the model solution.

signal s_t leads to

$$\mathbf{x}_{t|t} = \mathbf{x}_{t|a_t} + G(s_t - s_{t|t-1})$$

To study the role of information unrelated to fundamentals in consumption dynamics, we consider the level of spending agents would have chosen with the information set Ω_t denoted by $c_{t|a_t}$:

$$c_{t|a_t} = \frac{1}{1-\rho}\big(x_{t|a_t} - \rho x_{t-1|a_t}\big)$$

such that without observing a noisy signal s_t, agents choose spending as a function of their beliefs about the current and lagged permanent productivity with the information set Ω_t.

We further define $\Delta c_{t|s_t}$ as consumption changes at time t due to information unrelated to fundamentals:

$$\Delta c_{t|s_t} = \left(\frac{1}{1-\rho}\big(G^1 - \rho G^2\big)\right)\big(s_t - x_{t|a_t}\big)$$

where G^1 and G^2 are the first and second components of the steady-state Kalman gain G and represent respectively the gain of observing noisy signals on x_t and x_{t-1}. Thus, when s_t is greater than $x_{t|a_t}$, $\Delta c_{t|s_t}$ would be positive. Intuitively, when agents receive good information about the state of the economy ($s_t > x_{t|a_t}$), they would be willing to increase spending.

It is straightforward to show that

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

We can also define $\Delta c_{t|a_t}$, consumption changes at time t from the previous period's consumption due to fundamentals:

$$\Delta c_{t|a_t} = c_{t|a_t} - c_{t-1}$$

From Equation (7) and the definition of c_{t-1}, we have

$$\Delta c_{t|a_t} = \left(\frac{1}{1-\rho} \left(H^1 - \rho H^2 \right) \right) \left(a_t - x_{t|t-1} \right)$$

where H^1 and H^2 are the first and second components of the steady-state Kalman gain H and represent respectively the gain of observing productivity on x_t and x_{t-1}. Whenever a_t is greater than $x_{t|t-1}$, the last period's forecast on the permanent productivity component, $\Delta c_{t|a_t}$ is positive and vice versa: When agents receive good information compared to a benchmark (in this case, the last period's estimate on x_t), they would increase spending.

We have thus successfully disentangled changes in consumption into changes due to fundamentals and changes due to information unrelated to fundamentals:

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

such that we can easily decompose the rate of consumption growth into two subcomponents.

We obtain our measure of consumer confidence as follows.

Definition 1 The *Model-Based Consumer Confidence Index* (MB-CCI) at time t is given by

$$\text{Model-Based Consumer Confidence Index}_t = \left(\hat{s}_t - \hat{x}_{t|a_t} \right)$$

where $\hat{s}_t$ and $\hat{x}_{t|a_t}$ are the estimated noisy signal and beliefs about the permanent productivity component updated through the observation of productivity at time t.

The Model-Based Consumer Confidence Index (MB-CCI) retrieves the contribution of information orthogonal to fundamentals on actual consumption changes. Our interpretation of consumer confidence emphasizes that it is a relative measure. Confidence is inherently related to agents' information, but we are being careful to distinguish the sources of information when measuring confidence. It is our strong conjecture that consumer confidence can be measured the way we have illustrated here. However, our expenditure-based confidence measure provides an

internationally consistent measure of activity.

Throughout the paper, we also consider the medium-frequency MB-CCI, which we obtain by applying a band-pass filter at 32-200 frequencies. The main purpose of exploiting this medium frequency measure is to clearly visualize the slow-moving dynamics of MB-CCI, which is highly volatile due to the presence of noise shocks in our model.

In the next section, we estimate the MB-CCI and compare it against the survey-based counterpart for the U.S.

3 Results for the U.S.

As discussed in the previous section, we solve the model sequentially and proceed to estimation. 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 productivity and consumption. Consumers' expectations are part of the unobserved state vector of the econometrician. The econometrician's Kalman filter is used to construct the likelihood function and to estimate the parameters of the model. Appendix C.2 discusses the econometrician's filtering in detail.

Following Blanchard et al. (2013) and L'Huillier and Yoo (2017), our estimation includes the demeaned first differences of the logarithm of labor productivity and of the logarithm of per-capita consumption as observables. The simplicity of this model allows extracting 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. Our sample is given by the period 1976:II–2019:III, which includes the recent Great Recession.

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 capita 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 the consumer confidence index, we use the Index of Consumer Sentiment (ICS) from the University of Michigan.

3.2 Model estimation

We first present the estimation results for the sequentially solved permanent income consumption model with noisy information in Section 2. 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–2019:III

Parameter	Description	Value	s.e.
ρ	Persistence productivity	0.9613	0.0068
σ_u	Std dev. productivity	0.0058	0.0002
σ_ϵ	Std dev. permanent shock (implied)	0.0002	-
σ_η	Std dev. transitory shock (implied)	0.0057	-
σ_ν	Std dev. noise shock	0.0121	0.0036

Notes: σ_ϵ and σ_η are recovered from the estimated ρ and σ_u according to Equations (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 to normal over time. Following a noise shock, consumption initially increases and slowly declines.

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 volatility, explaining more than 60% of consumption volatility at a one-year horizon (light gray areas). On the contrary,

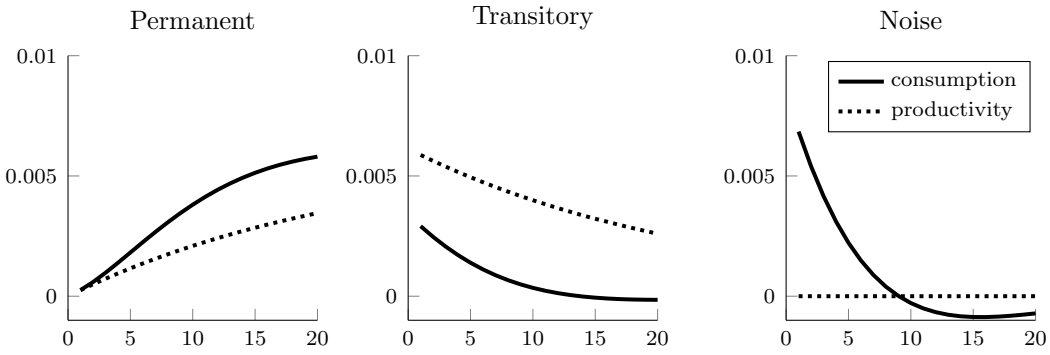


Figure 2: Impulse responses

Notes: Productivity does not respond to a noise shock.

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.

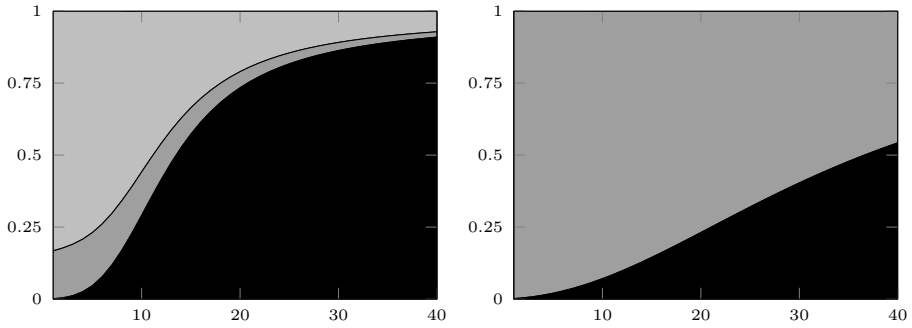


Figure 3: Variance decomposition: consumption (left) and productivity (right)

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.

3.3 Model-based consumer confidence for the U.S.

We now follow the procedure discussed in the last section and extract MB-CCI by smooth-estimating structural shocks and state variables. The solid lines in Figure 4 denote our model-based measures estimated for the sample period, and

to compare our model-based consumer confidence to survey-based one, we also plot the Index of Consumer Sentiment from the University of Michigan (the thin and dashed, black line). The high-frequency measure (thin and full, red line) denotes our confidence measure as defined in Definition 1, and the medium frequency measure (thick and full, blue line) is the one isolating medium-run dynamics using a band-pass filter at 32-200 frequencies.

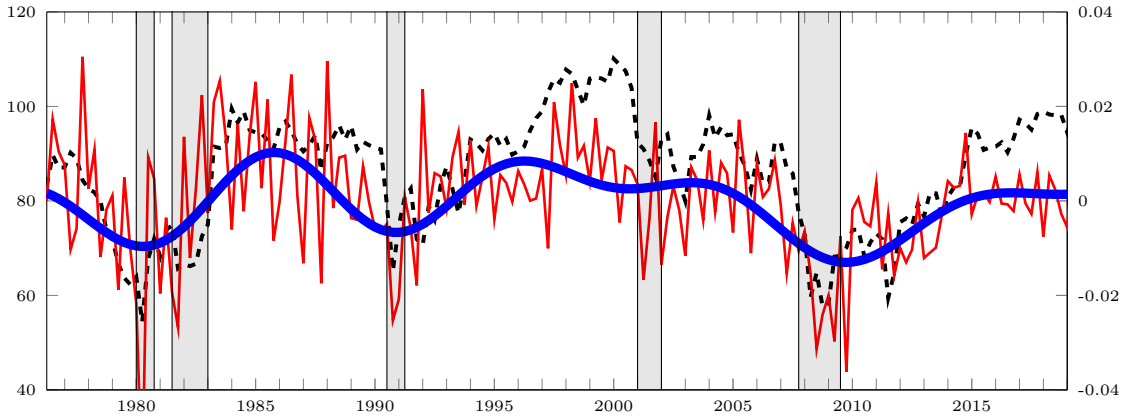


Figure 4: Estimated consumer confidence (solid) and the Index of Consumer Sentiment (dashed)

Notes: Shaded areas indicate U.S. recessions. The red and thin solid line denotes the MB-CCI (blue and thick solid for the medium frequency MB-CCI), whereas the black and thin dashed line denotes the Michigan Survey of Consumer Confidence whereas . The ICS corresponds to the left y-axis and the MB-CCI to the right y-axis.

Our result shows that the correlation between the two indices is strictly positive (0.52) and statistically significant at the 1% level. For the medium frequency confidence measure the correlation is estimated at 0.79. In addition, most of U.S. recessions are characterized by preceding downward shifts and subsequent recovery in consumer confidence in both measures. Therefore, while it would be far-fetched to draw a firm conclusion, our approach to extracting consumer confidence does a good job of mimicking the dynamics of the survey-based confidence index for the U.S. data.[9]

[9]The Michigan Survey of Consumer Confidence does have two separate components - *Expected Index* and *Current Index*. *Expected Index* is aggregated using the answers to the forward-looking questions, whereas *Current Index* to the questions regarding the current situation. Separately estimating the correlation between these indices and our measure of consumer confidence, the correlation between *Expected Index* and our measure is 0.51 and the one between *Current Index* and our measure is 0.49.

In order to justify our focus on what we have defined as MB-CCI, we also consider all other available estimated series of beliefs, shocks and states within our model. We compute their correlation with the survey-based consumer confidence measure. Table 2 reports the results. While some have a positive, statistically significant correlation with the survey-based confidence, namely beliefs about the long-run ($corr = 0.37$), permanent TFP ($corr = 0.16$), noisy signals ($corr = 0.23$), and noise shocks ($corr = 0.26$), our confidence measure exhibits a higher correlation than any other series of beliefs, shocks and states.

Table 2: Estimated unobserved shocks and states and the survey-based confidence

	Description	Correlation	p-val
$\hat{s}_t - \hat{x}_{t\|a_t}$	Our confidence measure (MB-CCI)	0.52	0.0001
	Our confidence measure (MB-CCI, medium frequency)	0.79	0.0001
$\hat{a}_{t+\infty\|t}$	Beliefs about the long-run	0.37	0.0001
$\hat{\nu}_t$	Noise shocks	0.26	0.0006
$\hat{s}_t$	Noisy signals	0.23	0.0022
$\hat{x}_t$	Permanent component	0.16	0.0397
$\hat{z}_{t\|t}$	Beliefs about transitory component	0.08	0.2979
$\hat{x}_{t\|t}$	Beliefs about permanent component	0.05	0.5387
$\hat{\eta}_t$	Transitory productivity shocks	0.05	0.4956
$\hat{\epsilon}_t$	Permanent productivity shocks	0.03	0.6722
$\hat{x}_{t-1\|t}$	Beliefs about lagged permanent component	0.03	0.7146
$\hat{x}_{t\|a_t}$	Beliefs about permanent component (with info. set Ω_t)	0.02	0.8287
$\hat{z}_t$	Transitory component	-0.10	0.1743

Notes: Correlation and *p-val* report the Pearson correlation coefficient and the associated p-value between the survey-based consumer confidence and the estimated variable of interest.

The finding that the MB-CCI is the measure that correlates the most with the ICS is of independent interest for the news shocks literature. Ex-ante, it is unclear why this measure ought to have the highest correlation, and not, for example, beliefs about the long run ($\hat{a}_{t+\infty|t}$) or the noisy signal ($\hat{s}_t$). This offers a theoretical window to interpret what lies behind fluctuations in the ICS: most of the fluctuations represent fluctuations in beliefs that go beyond the beliefs that are implied by the observation of fundamentals as productivity or income.

To conclude, our main empirical contribution is to establish that the MB-CCI we have defined above closely mimics the University of Michigan's ICS. We

emphasize that this is achieved out-of-sample (the ICS is not used in the model estimation.) Therefore, conceptually, this establishes a bridge between the survey measure, and the news and noise model of consumer beliefs. Next, we will apply this insight to a cross-country exploration.

4 Consumer confidence across Europe

In this section, we extract model-based consumer confidence for fourteen selected European countries and make a comparison with European consumer confidence indices. (Below we explain our focus on these countries.) Similar to the observation in the U.S., recent economic crises have been associated with deteriorating consumer confidence in Europe as well.

4.1 Model estimation

We first present the estimation results for the model discussed in Section 2. The sample is from 1995:II–2019:III. Our dataset includes series on labor productivity and per capita real consumption expenditure, and our sample includes fourteen European countries: the five founding member states of the EU - Belgium (BEL), France (FRA), (West) Germany (DEU), Italy (ITA), and the Netherlands (NLD) - along with nine other member states who joined the EU on or before January 1995 - Austria (AUT), Denmark (DNK), Finland (FIN), Greece (GRC), Ireland (IRL), Portugal (PRT), Spain (ESP), Sweden (SWE), and the United Kingdom (GBR). We focus on these fourteen countries in part due to data availability. Harmonized consumer surveys are conducted by the Directorate General for Economic and Financial Affairs for the European Union (EU) and the applicant countries.[10] However, for some countries, the harmonized survey is only available from 2001 (Bulgaria, Cyprus, Latvia, Lithuania, Poland, and Romania), 2002 (Luxembourg and Malta), 2005 (Croatia), 2007 (Turkey), 2012 (Montenegro and North Macedonia), 2013 (Serbia), and 2016 (Albania). Thus, we do not include these countries along with other countries who became member states of the EU in the fourth wave of the enlargement in 2004.

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

[10]The full list includes Belgium, Bulgaria, the Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, the Slovak Republic, Finland, Sweden, the United Kingdom, Montenegro, North Macedonia, Albania, Serbia, and Turkey.

construct a series for per capita 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 the survey-based measure, 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.

The estimation 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 considerably across countries.[11]

4.2 Model-based consumer confidence across Europe

We extract consumer confidence by estimating the series of structural shocks and state variables using a Kalman smoother. We then use the same procedure described above and used for the U.S.

We first present a figure comparing the MB-CCI and the CCI for each country. Among the high- and medium-frequency measures of MB-CCI, the medium-frequency measure allows for a clearer visual comparison to the CCI, and therefore we present this one here in the body. (See Figure A6 in Appendix F for the other one.) See Figure 5. It plots the MB-CCI using solid lines, and the CCI from OECD using dashed lines.

As it is clear from the figure, most countries exhibit sizable fluctuations in confidence according to both measures. Consumer confidence appears to be persistent. In several cases, there is a decline of confidence that is contemporaneous to or lags the global financial crisis of 2008. We observe that there is an extended period of lack of consumer confidence for many countries, which corresponds well to the slow and anemic recovery from the Great Recession across Europe. As one would expect, this decline in confidence is more protracted for periphery countries as Portugal and Greece. Portugal and most countries exhibit high confidence in the early part of the sample, which presumably is related to widespread optimism

[11] Table A1 in Appendix D reports the estimation results.

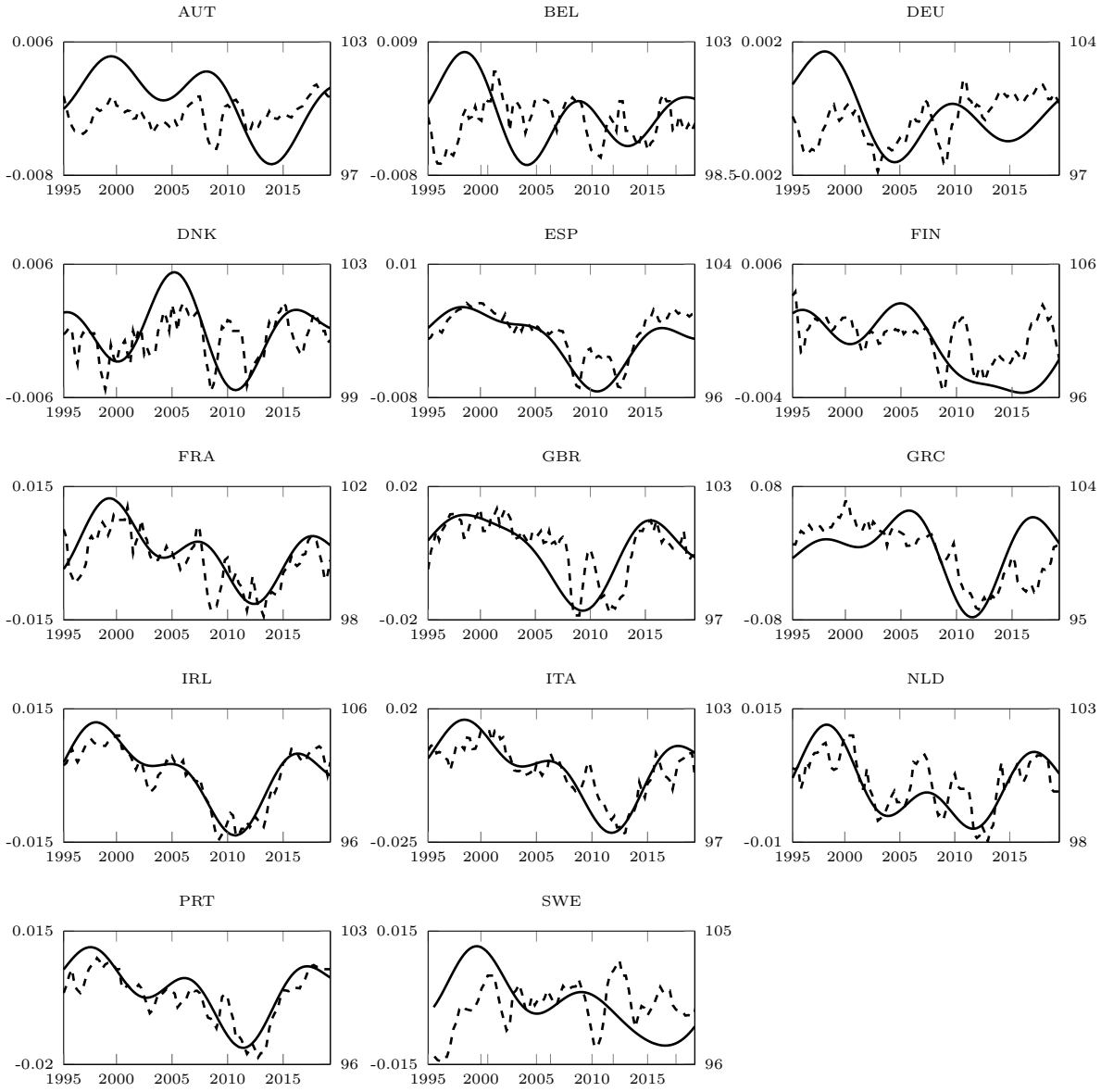


Figure 5: Model-based consumer confidence (medium frequency) and OECD Consumer Confidence Index

Notes: The solid lines denote the MB-CCI (medium frequency) isolated with the band-pass filter at 32-200 frequencies. The dashed lines denote the (quarterly) Consumer Confidence Index (CCI) available 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. The MB-CCI is plotted against the right y-axis, and OECD consumer confidence against to the left y-axis. For Sweden, the CCI is available only from 1995:IV (SWE).

regarding the European Economic and Monetary Union in the late 1990s.

Another interesting observation is that both measures seem to correlate strongly

for some countries (as Italy), but less so for other countries (as, for instance, Germany). In other to look more deeply at this aspect, we compute the correlation between both measures and report it in Table 3. The table reports the correlation between our confidence measure and the survey-based counterpart. We report this correlation both for our high-frequency MB-CCI and for our medium-frequency MB-CCI. As explained in Section 2.2, the high-frequency MB-CCI corresponds simply to the measure obtained as in Definition 1. The medium-frequency MB-CCI corresponds to the resulting series after using a band-pass filter at 32-200 frequencies.

We find that, for most countries, the correlations between the two indices are strictly positive and statistically significant at the 1% level: for Spain, Italy, Portugal, the UK, Netherlands, Ireland, France, and Greece, for example, the correlations are estimated to be around 0.4 or greater, showing a clear correlation between the two indices. For some countries like Spain, Italy, Portugal, or the U.K., the degree of correlation is remarkable: higher than 0.70 in the case of the medium-frequency MB-CCI. At the same time, there are cases in which the correlations are quite small, as in the case of Austria, Belgium, or Sweden.

We draw two main conclusions from these results.

First, considering the high correlation of the MB-CCI with the CCI produced by the OECD based on a survey, the MB-CCI does seem like a valid approach to measure consumer confidence. This is more clearly the case for countries that exhibit a high correlation (top rows on Table 3), which is most European countries (these tend to be countries for which there appear to have been larger confidence swings, as we will discuss below.) Moreover, given the solid theoretical basis of the MB-CCI and how easily it can be obtained from national accounts data, it is, at the very least, a complementary measure to the CCI in the case of all the other countries.

Second, there is a striking amount of heterogeneity in the correlation between the MB-CCI and CCI. Indeed, this correlation behaves like in the U.S. for some countries (high and statistically significant correlation, as in the case of Spain with a correlation of 0.63), and with the opposite pattern for other countries (as in the case of Belgium, with a correlation of 0.01). This is a puzzling observation given that the input used to obtain the MB-CCI is obtained from uniformly constructed data, with an identical model and estimation procedure for all countries. Moreover,

Table 3: Correlation between our model-based confidence measure and OECD consumer confidence index (14 European countries)

	Correlation			
	High frequency	p-val	Medium frequency	p-val
ESP	0.63	0.0001	0.85	0.0001
ITA	0.54	0.0001	0.85	0.0001
PRT	0.53	0.0001	0.87	0.0001
GBR	0.49	0.0001	0.71	0.0001
NLD	0.48	0.0001	0.76	0.0001
IRL	0.46	0.0001	0.93	0.0001
FRA	0.41	0.0001	0.77	0.0001
GRC	0.39	0.0001	0.52	0.0001
DNK	0.25	0.0119	0.52	0.0001
SWE	0.15	0.1384	0.04	0.7087
DEU	0.07	0.5159	-0.03	0.7522
FIN	0.02	0.8108	0.39	0.0001
BEL	0.01	0.9680	-0.13	0.1893
AUT	-0.05	0.6497	0.08	0.4443

Notes: Correlation and *p-val* report the Pearson correlation coefficient and the associated p-value. *The high-frequency measure* denotes the smoothed-estimated confidence as in Definition 1, and *the medium frequency measure* is the one isolating medium-run dynamics using a band-pass filter at 32-200 frequencies.

the CCI survey is conducted by the same institution, and as far as we can tell from studying its description, it is based on a uniform set of questions and procedures.[12] Hence, an obvious question is to what extent one can shed light on this finding. We briefly look at this next.

4.3 What could explain the heterogeneity across countries?

As shown earlier, we observe a surprisingly high amount of heterogeneity in the relation of MB-CCI and the CCI of the OECD. What accounts for such observed

[12]The CCI survey is part of regular harmonized surveys conducted by the Directorate General for Economic and Financial Affairs for different sectors of the economies in the European Union (EU) and in the applicant countries. The methodology of the survey including national questionnaires, partner institutes, and guidelines are available from the following link: https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/business-and-consumer-surveys/methodology-business-and-consumer-surveys_en.

heterogeneity?

In our sample, the high correlation countries include the U.K., Netherlands, France, and the PIIGS countries, i.e., Portugal, Ireland, Italy, and Spain. One possibility from this observed pattern is the presence of large fluctuations, particularly during the 2008 global financial crisis and its aftermath in Europe. To illustrate this point, consider Figure 6, plotting the MB-CCI and annualized quarterly consumption growth rates for two polar countries, Italy and Germany. Italy was hard hit by the European debt crisis, and this generated a protracted consumption recession starting. Instead, consumption recovered quickly after 2008 in the case of Germany. As a result, the swings in consumer confidence in Italy are more dramatic. Accordingly, the correlation between the MB-CCI and the CCI is high for Italy (0.54), and low for Germany (0.07).

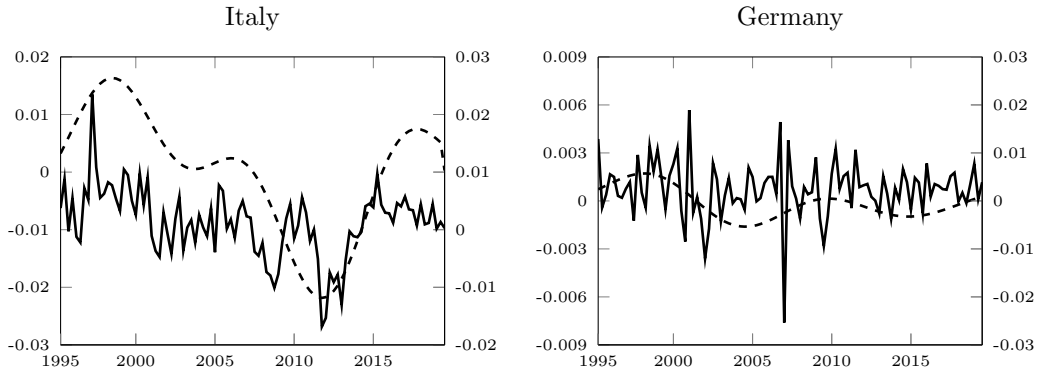


Figure 6: Model-based consumer confidence (dashed) and consumption growth rates (solid): Italy (left) and Germany (right)

Notes: The solid lines denote annualized quarterly consumption growth rates. The dashed lines denote the MB-CCI (medium frequency) isolated with a band-pass filter at 32-200 frequencies. The consumption growth rates correspond to the right y-axis and the MB-CCI to the left y-axis.

To make this point more precisely, we consider this heterogeneity from a statistical perspective. Let the MB-CCI, $s_{1,t}$, be the 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. Similarly, let the CCI, $s_{2,t}$, be the 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 model-based measure of confidence is very simple and clearly imperfect. It is impressive that it is correlated with survey confidence, but we would not claim it is true confidence measured without error.

As shown by this Equation (8)

$$\text{Corr} = \frac{var(\kappa)}{\big((var(\kappa) + var(e_1))(var(\kappa) + var(e_2))\big)^{1/2}} \tag{8}$$

the correlation between s_1 and s_2 is an increasing function of the variance of true confidence κ_t. Thus, if the differences across countries are mostly $var(\kappa)$, that is, the variance of true confidence, the correlation between MB-CCI and CCI should be high.

Let us take the survey confidence measure itself to compute its volatility. Table 4 suggests that the correlation between the two measures of consumer confidence is related to the volatility of the survey confidence measure: a high correlation between two measures of consumer confidence is related to a larger volatility of the survey index.

Finally, we look at the observed heterogeneity from a socio-economic perspective. Given the small sample size ($n = 14$), it is difficult to determine structural factors delivering heterogeneity in terms of the correlation across countries. However, we can still see if the correlations reported on Table 3 are related to a range of indicators of social, economic, and financial development. To this end, we show Figure 7 the relationship between observed correlation heterogeneity with selected economic, social, and institutional factors.[13] Those that can potentially explain observed heterogeneity include public spending on education, general government

[13] Appendix A.3 gives a detailed description of these factors.

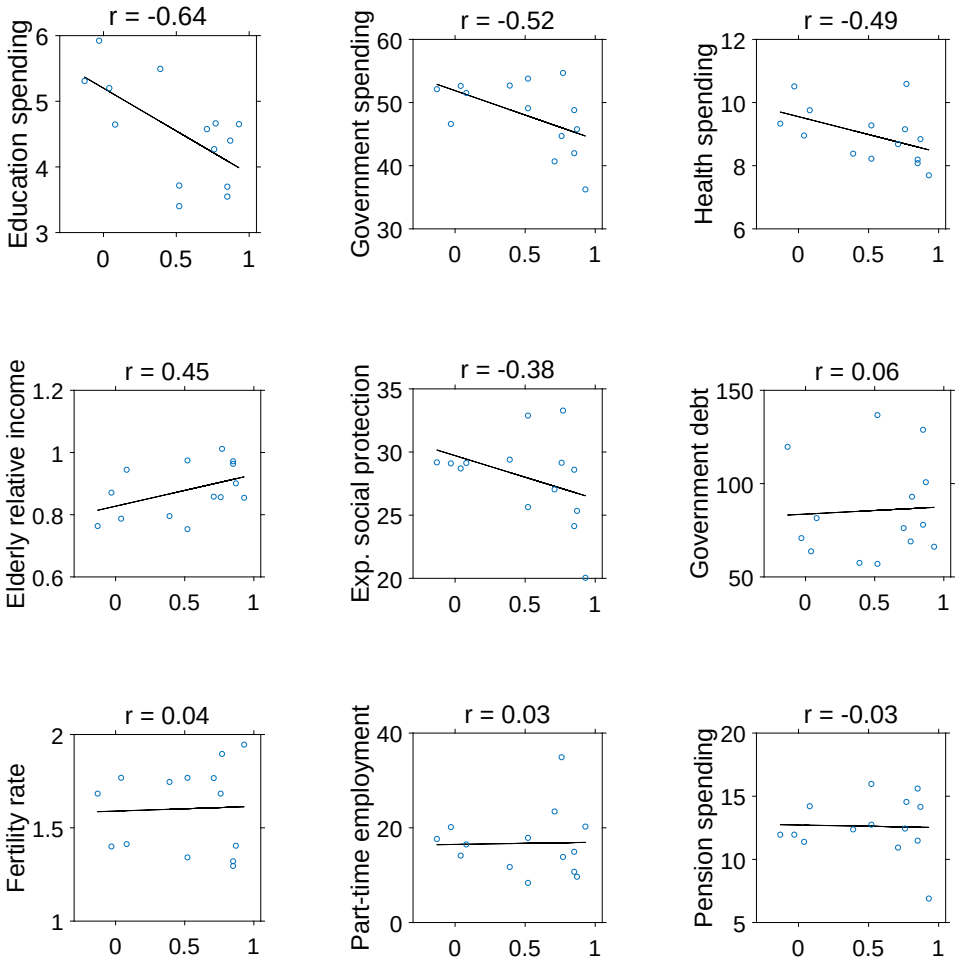
Table 4: The volatility of confidence index and correlation between the two confidence measures

	Correlation		Volatility
	High frequency	Medium frequency	
Whole sample	0.31	0.51	1.213
High correlation	0.49	0.78	1.363
Low correlation	0.08	0.15	1.012

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 0.39 and includes Spain, Italy, Portugal, the UK, Netherlands, Ireland, France, and Greece; the second sub-sample (low correlation) contains those with the correlation smaller than 0.25 in absolute terms and includes Austria, Belgium, Finland, Germany, and Sweden.

spending, total health spending, and a median relative income of elderly people among others whereas general government debt, fertility rates, the part-time employment rate, and the expenditure on pensions exhibit virtually no relationship with the observed confidence correlation. (Figures A7 and A8 in Appendix F report results for another set of socio-economic variables.)

Figure 7: Correlation of confidence indices and economic, social, and institutional factors



Notes: The panels show the relationship between various economic, social, institutional measures and the correlation of two confidence indices. r reports the Pearson correlation coefficient. *Education spending* denotes public spending on education; *Government spending* denotes general government spending; *Health spending* denotes total health spending; *Elderly relative income* denotes a median relative income of elderly people; *Exp. social protection* denotes expenditure on social protection; *Government debt* denotes general government debt; *Pension spending* denotes the expenditure on pensions. For a detailed description of the variables, see Appendix A.3.2.

5 Final remarks

We have shown how to extract consumer confidence using aggregate macroeconomic data based on a structural framework with imperfect information. We view ours as a viable approach to study consumer confidence, which is based on a standard consumer theory and the state-of-the-art macroeconomic toolbox. Not only do our efforts provide a theoretical interpretation to survey measures of confidence, but they also offer an internationally consistent measure of confidence grounded on the System of National Accounts.

We compare our measure of confidence with its survey-based counterpart by calculating the correlation between the two measures of consumer confidence. We have shown that the correlation between the two measures is remarkable for the U.S. and a range of European countries.

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.

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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 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 are chosen from the full set of questions in the individual survey and are given 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."

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

A.3 Economic and social factors

This section provides a detailed description of the variables used in Section 4.3 and Appendix F. The nine financial development indices are from the IMF Financial

Development Index Database which is maintained by the IMF Strategy, Policy, and Review Department.[14] Other variables are from the OECD database.

A.3.1 IMF Financial Development index

The Financial Development index is constructed using a three-step approach reducing multidimensional data into one summary index: (i) normalization of relevant variables; (ii) aggregation of normalized variables into the sub-indices representing a particular functional dimension; and (iii) aggregation of the sub-indices into the final index.[15]

Specifically, **Financial Development index** (FD) is the highest level aggregate index representing a relative ranking of countries on the depth, access, and efficiency of their financial institutions and financial markets. It is an aggregate of the Financial Institutions index and the Financial Markets index.

The Financial Institutions index (FI) is an aggregate of **the Financial Institutions Depth index** (FID), **the Financial Institutions Access index** (FIA), and **the Financial Institutions Efficiency index** (FIE). FID compiles data on bank credit to the private sector in percent of GDP, pension fund assets to GDP, mutual fund assets to GDP, and insurance premiums, life and non-life to GDP; FIA compiles data on bank branches per 100,000 adults and ATMs per 100,000 adults; FIE compiles data on banking sector net interest margin, lending-deposits spread, non-interest income to total income, overhead costs to total assets, return on assets, and return on equity.

The Financial Markets index (FM) is an aggregate of **The Financial Markets Depth index** (FMD), **The Financial Markets Access index** (FMA), and **The Financial Markets Efficiency index** (FME). FMD compiles data on stock market capitalization to GDP, stocks traded to GDP, international debt securities of government to GDP, and total debt securities of financial and non-financial corporations to GDP; FMA compiles data on the percent of market capitalization outside of 10 largest companies and the total number of issuers of debt (domestic and external, nonfinancial and financial corporations) per 100,000 adults; FME compiles data on the stock market turnover ratio (stocks traded to capitalization).

[14] See Sahay et al. (2015) for details.

[15] IMF Financial Development Index Database contains information on its methodology and dataset (https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B).

For a detailed description, see Svirydzenka (2016).

A.3.2 OECD data

The following variables are taken from the OECD database: variables on education (public spending on education), on society (expenditure on social protection, median relative income of elderly people, pension spending, the aggregate replacement ratio, total fertility rate), on health (health spending), on government (general government debt, general government deficit, general government financial wealth, general government spending), on jobs (adequacy of minimum income benefits, employment rates, hours worked, part-time employment, the gender wage gap), and on the economy (household saving, household spending).

Public spending on education includes direct expenditure on educational institutions as well as educational-related public subsidies given to households and administered by educational institutions. This indicator is shown as a percentage of GDP, divided by primary, primary to post-secondary non-tertiary, and tertiary levels. Public spending includes expenditure on schools, universities, and other public and private institutions delivering or supporting educational services.

Expenditure on social protection contains social benefits, which consist of transfers, in cash or in-kind, to households and individuals to relieve them of the burden of a defined set of risks or needs; administration costs, which represent the costs charged to the scheme for its management and administration; other expenditure, which consists of miscellaneous expenditure by social protection schemes (payment of property income and other). **Median relative income of elderly people** is defined as the ratio between the median equivalized disposable income of persons aged 65 or over and the median equivalized disposable income of persons aged between 0 and 64. **Pension spending** is defined as all cash expenditures (including lump-sum payments) on old-age and survivors pensions. Old-age cash benefits provide an income for persons retired from the labor market or guarantee incomes when a person has reached a 'standard' pensionable age or fulfilled the necessary contributory requirements. This indicator is measured in percentage of GDP. **The aggregate replacement ratio** is the gross median individual pension income of the population aged 65-74 relative to gross median individual earnings from work of the population aged 50-59, excluding other social benefits. **Total**

fertility rate in a specific year is defined as the total number of children that would be born to each woman if she were to live to the end of her child-bearing years and give birth to children in alignment with the prevailing age-specific fertility rates. It is calculated by totaling the age-specific fertility rates as defined over five-year intervals. This indicator is measured in children per woman.

Health spending measures the final consumption of health care goods and services (i.e. current health expenditure) including personal health care (curative care, rehabilitative care, long-term care, ancillary services, and medical goods) and collective services (prevention and public health services as well as health administration), but excluding spending on investments. It is measured as a share of GDP, as a share of total health spending, and in USD per capita (using economy-wide PPPs).

General government debt measures the gross debt of the general government as a percentage of GDP. Debt is calculated as the sum of the following liability categories (as applicable): currency and deposits; debt securities, loans; insurance, pensions, and standardized guarantee schemes, and other accounts payable. **General government spending** indicates the size of government across countries. This indicator is measured in terms of thousand USD per capita and as a percentage of GDP. **General government deficit** is defined as the balance of income and expenditure of government, including capital income and capital expenditures. This indicator is measured as a percentage of GDP. **General government financial wealth** is the total value of its financial assets minus the total value of its outstanding liabilities. The general government sector consists of central, state, and local governments as well as social security funds. This indicator is measured as a percentage of gross domestic product. For these variables, all OECD countries compile their data according to the 2008 System of National Accounts (SNA).

Part-time employment is defined as people in employment (whether employees or self-employed) who usually work less than 30 hours per week in their main job. Employed people are those aged 15 and over who report that they have worked in gainful employment for at least one hour in the previous week or who had a job but were absent from work during the reference week while having a formal job attachment. This indicator shows the proportion of persons employed part-time among all employed persons. **The gender wage gap** is defined as the difference between median earnings of men and women relative to the median

earnings of men. Data refer to full-time employees on the one hand and to self-employed on the other. **(Average annual) hours worked** is defined as the total number of hours actually worked per year divided by the average number of people in employment per year. Actual hours worked include regular work hours of full-time, part-time, and part-year workers, paid and unpaid overtime, hours worked in additional jobs, and exclude time not worked because of public holidays, annual paid leave, own illness, injury and temporary disability, maternity leave, parental leave, schooling or training, slack work for technical or economic reasons, strike or labor dispute, bad weather, compensation leave, and other reasons. The data cover employees and self-employed workers. This indicator is measured in terms of hours per worker per year. **Adequacy of minimum income benefits** measures the income of jobless families relying on guaranteed minimum income benefits as a percentage of the median disposable income in the country. Housing supplements are included subject to relevant eligibility conditions. **Employment rates** are calculated as the ratio of the employed to the working-age population. Employed people are those aged 15 or over who report that they have worked in gainful employment for at least one hour in the previous week or who had a job but were absent from work during the reference week. The working-age population refers to people aged 15 to 64. This indicator is seasonally adjusted and it is measured in terms of thousand persons aged 15 and over; in numbers of employed persons aged 15 to 64 as a percentage of working-age population.

(Net) household saving is defined as household net disposable income plus the adjustment for the change in pension entitlements less household final consumption expenditure (households also include non-profit institutions serving households). The adjustment item concerns (mandatory) saving of households, by building up funds in employment-related pension schemes. The net household saving rate represents the total amount of net saving as a percentage of net household disposable income. It thus shows how much households are saving out of current income and also how much income they have added to their net wealth. **Household spending** is the amount of final consumption expenditure made by resident households to meet their everyday needs, such as food, clothing, housing (rent), energy, transport, durable goods (notably cars), health costs, leisure, and miscellaneous services. Household spending including government transfers (referred to as "actual individual consumption" in national accounts) is equal to households'

consumption expenditure plus those expenditures of general government and non-profit institutions serving households (NPISHs) that directly benefit households, such as health care and education. Household spending including government transfers is measured as a percentage of GDP. For these variables, all OECD countries compile their data according to the 2008 System of National Accounts (SNA 2008).

B Consumption and confidence in the model

In this section, we look at how consumption and MB-CCI comove (in the model). Figure A1 shows the dynamics of consumption and confidence following alternative structural shocks affecting the economy: Specifically, we consider the impulse responses of consumption and confidence following one standard deviation negative shock to permanent productivity, transitory productivity, and the signal. In our description, we focus mainly on the sign of the responses.

With a permanent decrease in productivity, consumption slowly decreases to its new long-run level while confidence does not get affected by much. A (negative) transitory shock generates an initial decrease in consumption, but consumption returns to its original level. On the contrary, confidence initially moves in the opposite direction of consumption and returns to its original level in the long run. Following a negative noise shock, consumption behaves qualitatively similar to the response to a negative transitory shock. However, the response of confidence is much greater on impact as it moves in the same direction with consumption. After the first period, the behavior is qualitatively similar to the ones with a transitory shock. Quantitatively, we can see that the dynamics of confidence are mostly driven by noise shocks.

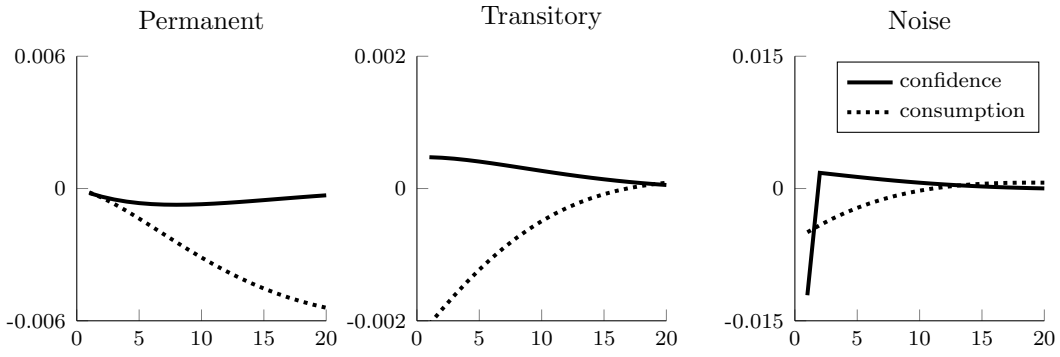

Figure A1: Impulse responses: confidence and consumption

Notes: We use parameter values estimated in Table 1 to deliver impulse responses following one standard deviation negative shocks.

C Solution

C.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 $\mathbf{x}_t = (x_t,\ x_{t-1},\ z_t)'$, $\mathbf{v}_t = (\epsilon_t,\ \eta_t,\ \nu_t)'$, $\mathbf{s}_t = (a_t,\ s_t)'$,

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

Conditional on observing current productivity a_t, consumers' beliefs $\mathbf{x}_{t|a_t}$ are given by

$$\begin{aligned} \mathbf{x}_{t|a_t} &= A\mathbf{x}_{t-1|t-1} + H(a_t - a_{t|t-1}) \\ &= [I - HC_1]A\mathbf{x}_{t-1|t-1} + Ha_t \end{aligned} \tag{9}$$

where H is the Kalman gain for observing productivity,

$$a_t = C_1\mathbf{x}_t + D_1\mathbf{v}_t$$

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

Then, observing a noisy signal s_t consumers' beliefs $\mathbf{x}_{t|t}$ are given by

$$\begin{aligned} \mathbf{x}_{t|t} &= \mathbf{x}_{t|a_t} + G(s_t - s_{t|a_t}) \\ &= [I - GC_2]\mathbf{x}_{t|a_t} + Gs_t \end{aligned} \tag{10}$$

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 Equation (9) into Equation (10), we consumers' expectations $\mathbf{x}_{t|t}$ are given by

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

Once consumers' expectations are formed, consumption can be solved:

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

C.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:

$$\mathbf{x}_{t|a_t} = \begin{bmatrix} x_{t|a_t} \\ x_{t-1|a_t} \\ z_{t|a_t} \end{bmatrix} = A \begin{bmatrix} x_{t-1|t-1} \\ x_{t-2|t-1} \\ z_{t-1|t-1} \end{bmatrix} + H \begin{bmatrix} 1+\rho & -\rho & -\rho \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_{t-2} \\ z_{t-1} \end{bmatrix} + H\epsilon_t + H\eta_t \quad (11)$$

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

$$\begin{bmatrix} x_{t|t} \\ x_{t-1|t} \\ z_{t|t} \end{bmatrix} = \begin{bmatrix} x_{t|a_t} \\ x_{t-1|a_t} \\ z_{t|a_t} \end{bmatrix} + G \begin{bmatrix} 1+\rho & -\rho & 0 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ x_{t-2} \\ z_{t-1} \end{bmatrix} + G\epsilon_t + G\eta_t + G\nu_t \quad (12)$$

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

$$\mathbf{x}_t^E = Q\mathbf{x}_{t-1}^E + R(\epsilon_t,\ \eta_t,\ \nu_t)' \tag{13}$$

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

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

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

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

The observation equation is given by

$$(a_t,\ c_t) = T\mathbf{X}_t^E \tag{14}$$

where

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

We then can build the state space representation of the model using (11), (12), (13) and (14) and structurally estimate it.

[**FOR ONLINE PUBLICATION**]

Supplementary Material for "Confidence, Fundamentals, and Consumption"

Jean-Paul L'Huillier, Robert Waldmann, Donghoon Yoo

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D Estimation results for the European countries

Table A1: Parameter estimates (14 European countries), 1995:II-2019:III

	Persistence (ρ)	Std. Perm. (σ_ϵ)	Std. Tran. (σ_η)	Std. Noise (σ_ν)
AUT	0.9825 (0.0082)	$\leq$0.0001	0.0052	0.0119 (0.0061)
BEL	0.9511 (0.0137)	0.0002	0.0044	0.0112 (0.0046)
DEU	0.9067 (0.0338)	0.0007	0.0069	0.0041 (0.0026)
DNK	0.9312 (0.0283)	0.0007	0.0099	0.0084 (0.0048)
ESP	0.9942 (0.0021)	$\leq$ 0.0001	0.0068	0.0039 (0.0015)
FIN	0.9185 (0.0455)	0.0009	0.0111	0.0144 (0.0087)
FRA	0.9630 (0.0095)	0.0002	0.0041	0.0155 (0.0050)
GBR	0.9748 (0.0069)	0.0001	0.0058	0.0153 (0.0052)
GRC	0.9713 (0.0074)	0.0004	0.0142	0.0716 (0.0213)
IRL	0.9868 (0.0082)	0.0003	0.0230	0.0283 (0.0204)
ITA	0.9658 (0.0086)	0.0002	0.0061	0.0190 (0.0083)
NLD	0.9693 (0.0085)	0.0002	0.0080	0.0124 (0.0053)
PRT	0.9720 (0.0118)	0.0003	0.0091	0.0130 (0.0089)
SWE	0.9388 (0.0169)	0.0005	0.0076	0.0233 (0.0072)

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

Figures A2 and A3 report impulse responses of productivity and consumption following three exogenous shocks for the fifteen countries in the sample. We use the estimated parameters in Table A1. 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.

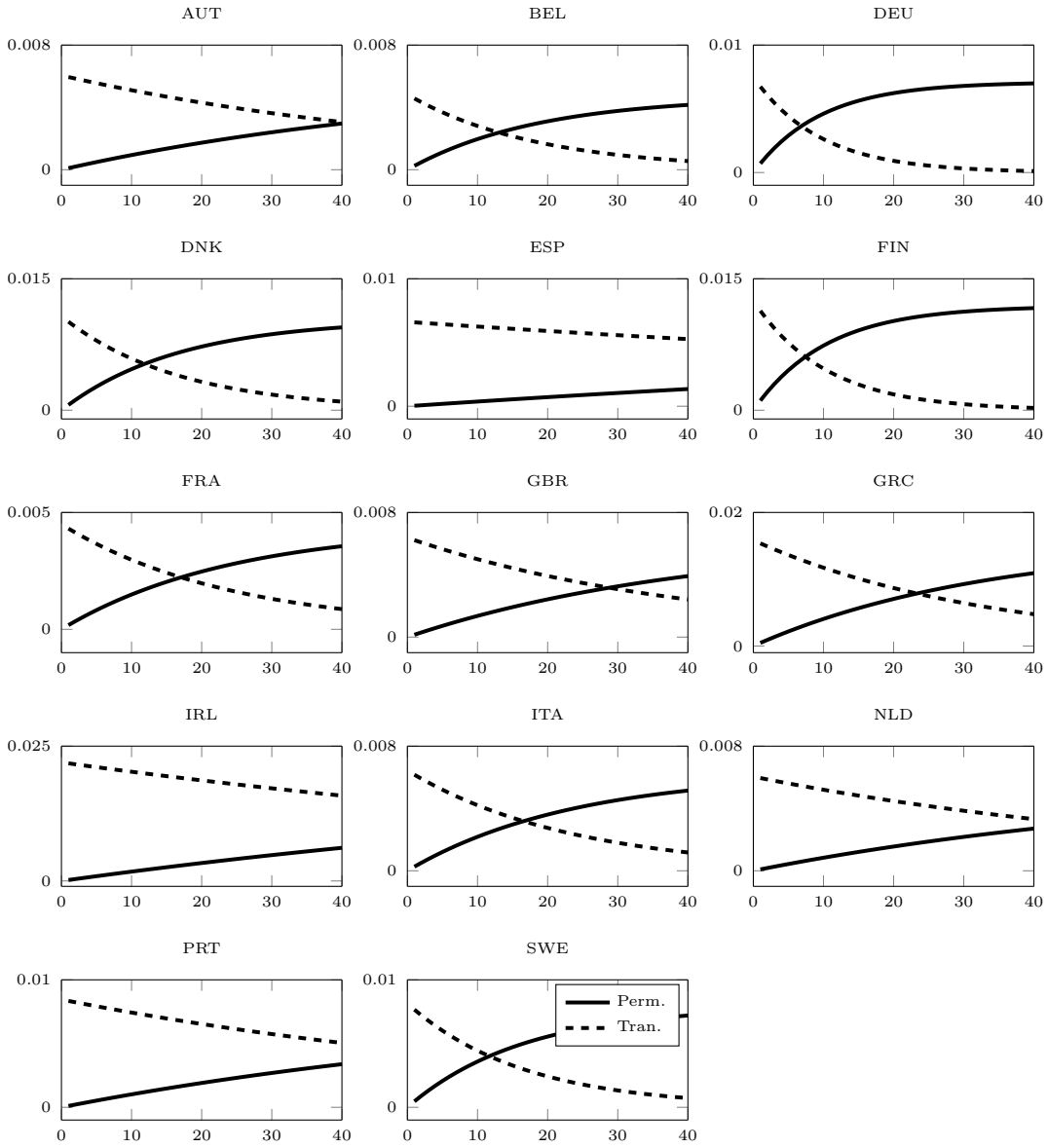


Figure A2: Impulse responses: productivity

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

Figure A3 shows that consumption slowly increases following a permanent tech shock. This is because the large volatilities in transitory productivity and noise

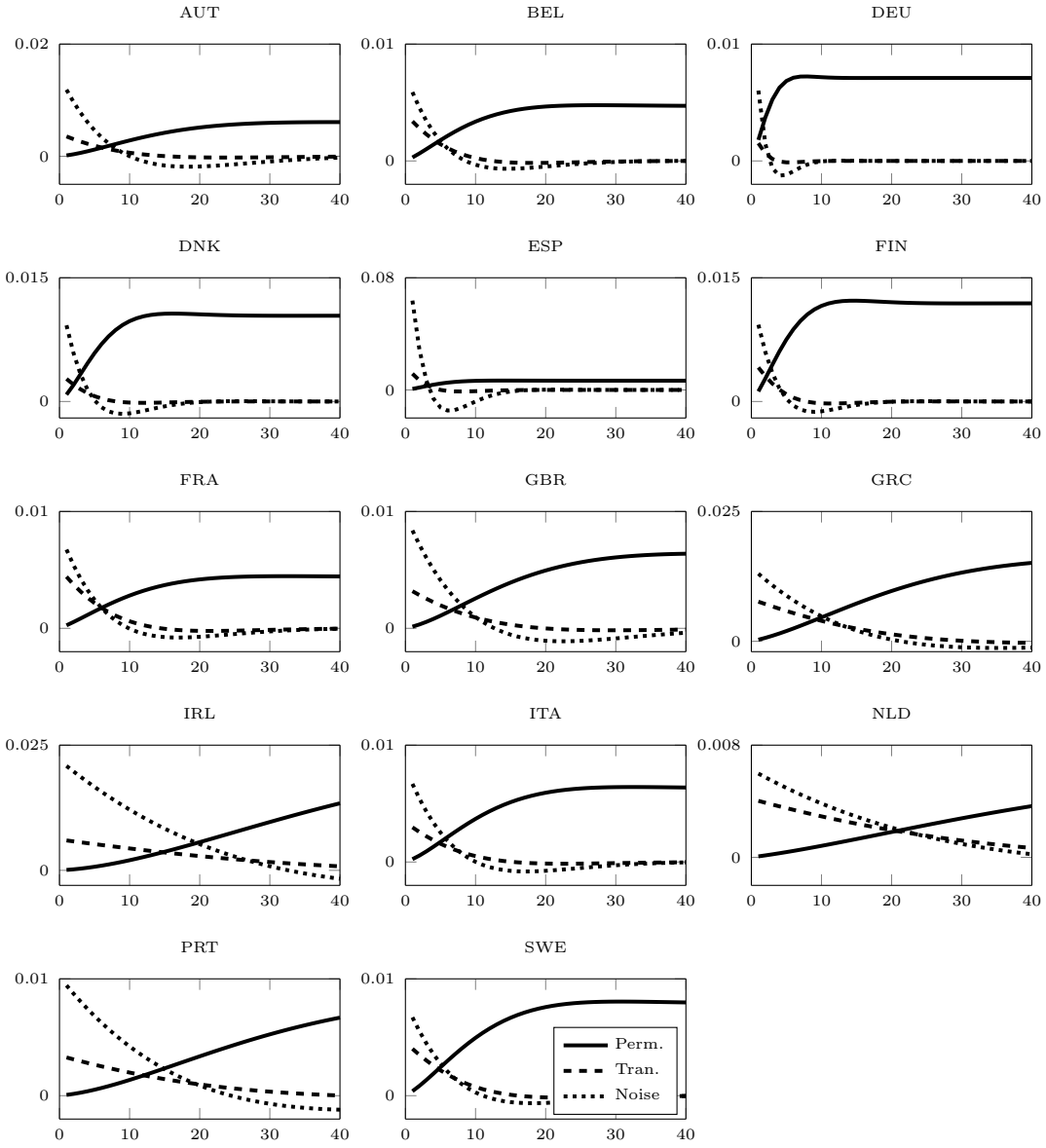


Figure A3: Impulse responses: consumption

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

shocks prohibit agents from immediately recognizing 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 depends on the estimated volatilities of the shocks.

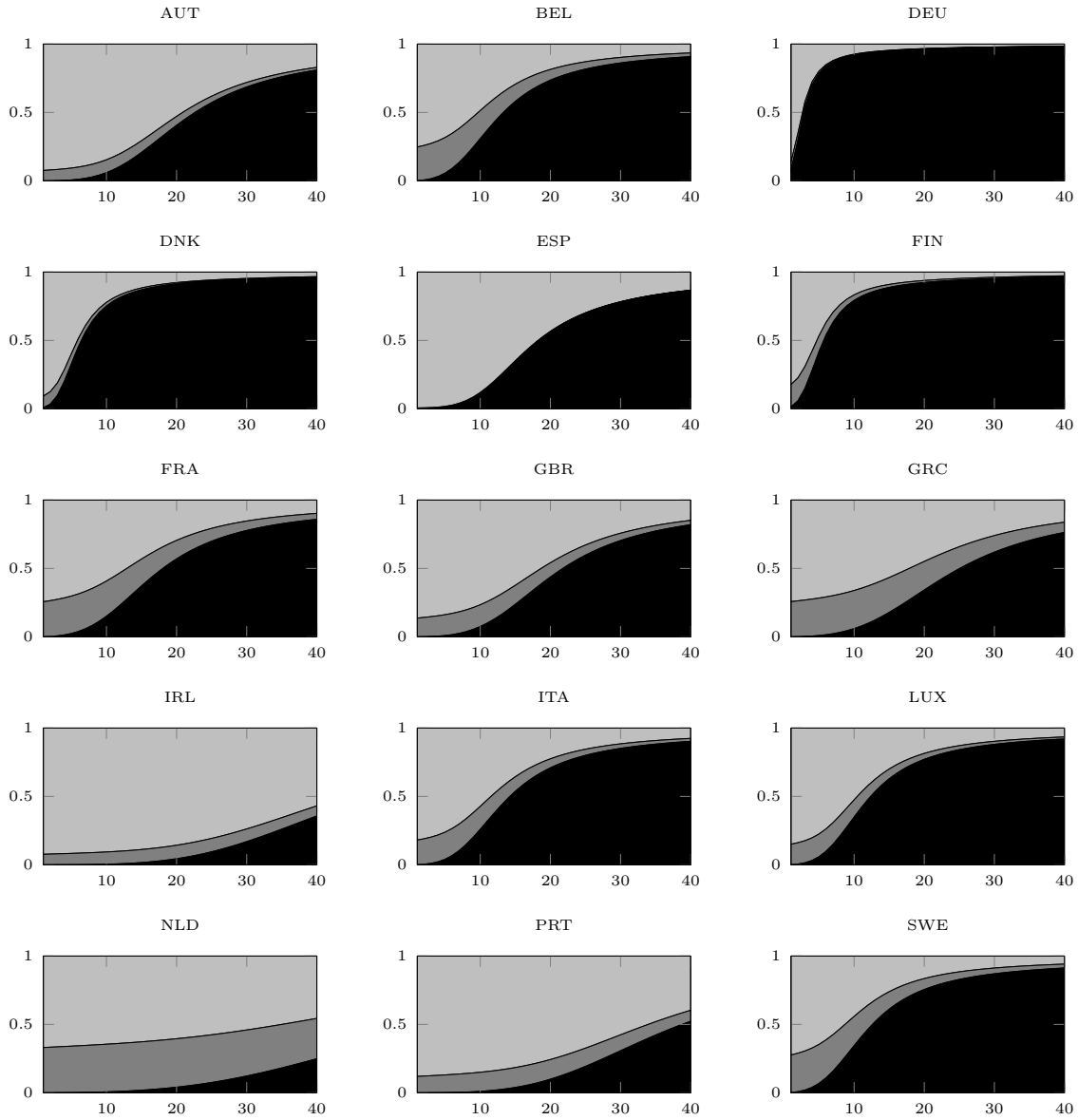


Figure A4: Variance Decomposition, 1995:II-2016:III

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.

Figure A4 reports the implications of the estimated parameters in Table A1 for 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 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. 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.

E The alternative productivity process specification and estimated consumer confidence

We relax the parameter restrictions from Equations (2) and (3) and present the estimation results for the model in Section 2. Table A2 reports the estimation results, and Figure A5 depicts estimated consumer confidence.

Table A2: Parameter estimates, US 1976:II–2019:III

Parameter	Description	Value	s.e.
ρ_x	Persistence permanent productivity	0.9612	0.0021
ρ_z	Persistence transitory productivity	0.9611	0.0027
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	0.0122	0.0037

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.

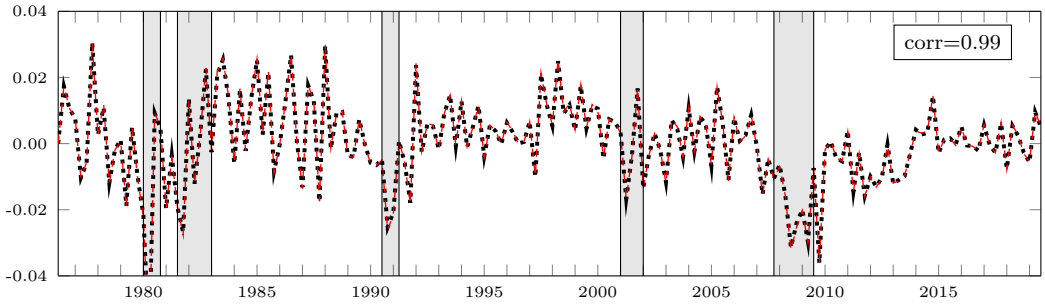


Figure A5: Estimated model-based consumer confidence index: 1976:II–2019:III

Notes: Shaded areas indicate U.S. recessions. The dashed line denotes the MB-CCI estimated with parameters in Table 1 whereas the solid line denotes the MB-CCI estimated with parameters in Table A2. *corr* denotes the correlation coefficient between them.

F Extra figures

Figure A6 plots our consumer confidence estimated for the sample period (solid lines) along with Consumer Confidence Index from OEDC (dashed lines). We also show the relationship between observed heterogeneity across countries and IMF financial development index (Figure A7) and various economic, social, and institutional factors (Figure A8).

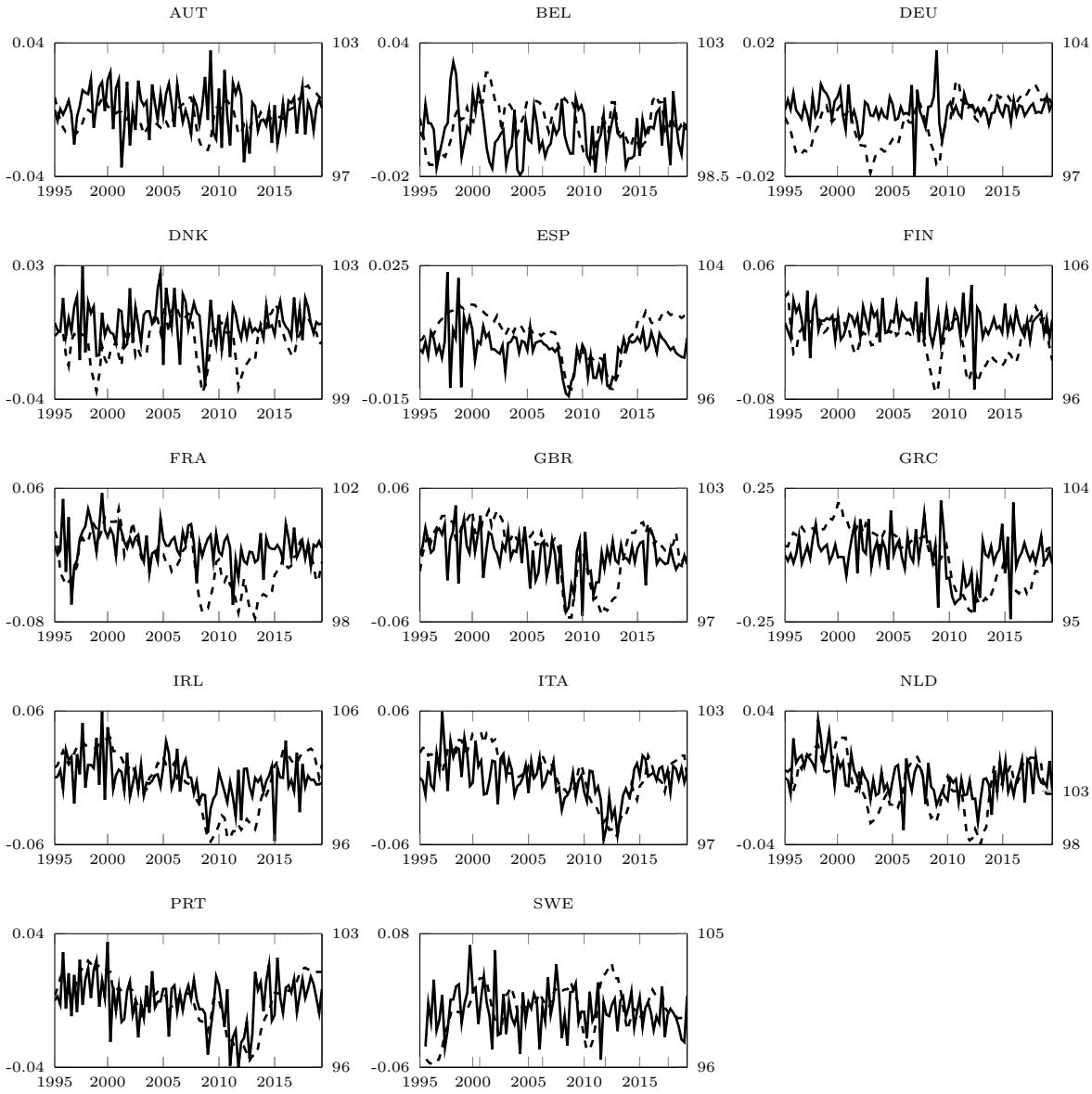
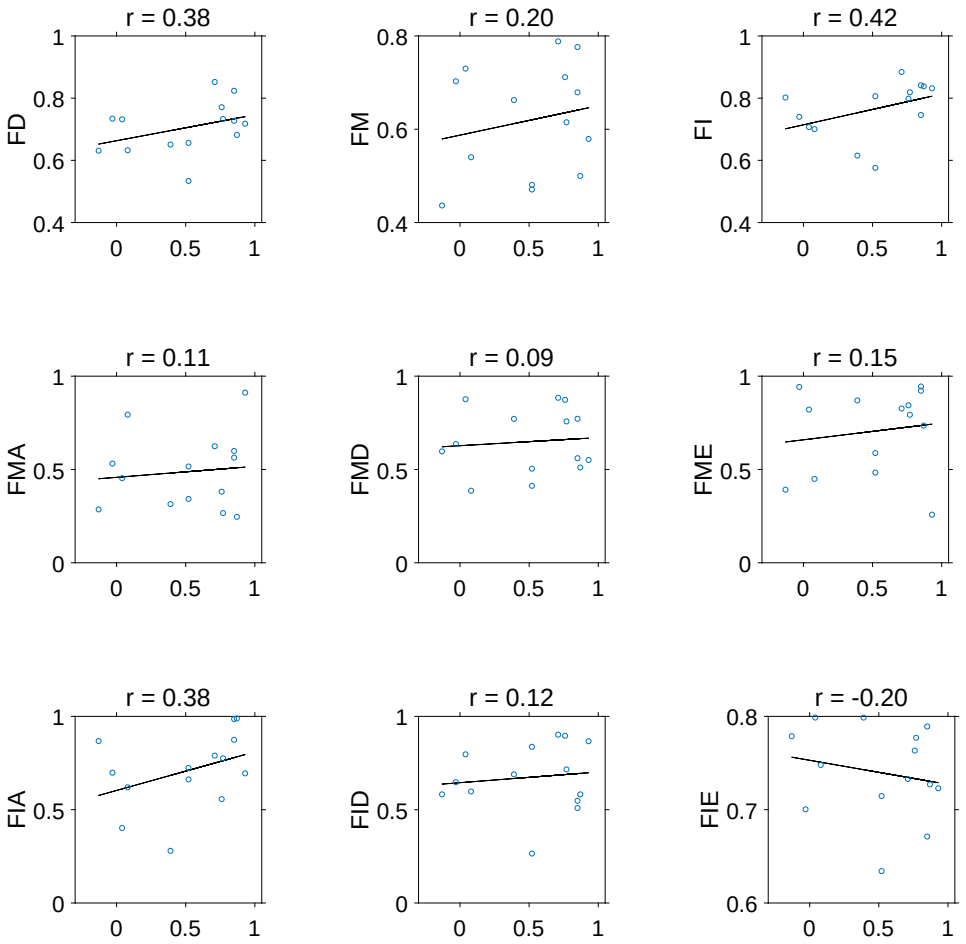


Figure A6: Consumer confidence and OECD Confidence Index

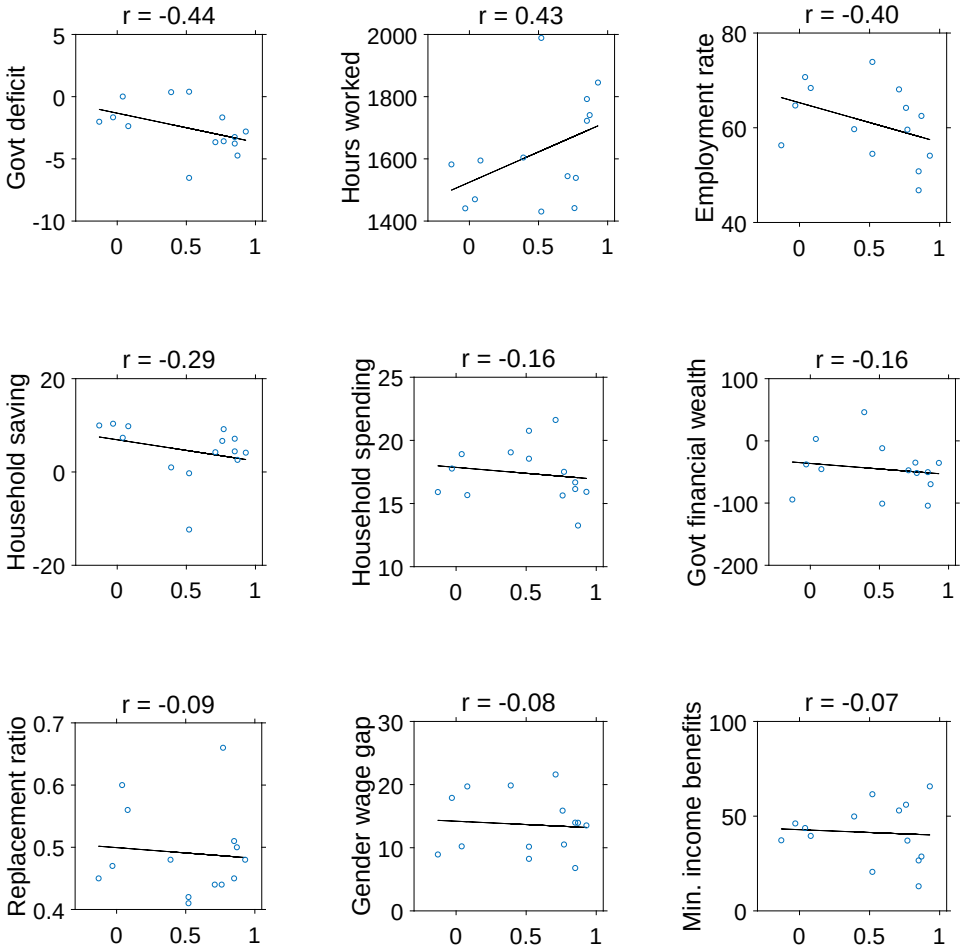
Notes: The dashed lines denote the (quarterly) Consumer Confidence Index (CCI) available from the OECD. Since it is published in monthly frequency, we change it to quarterly frequency by computing the quarterly arithmetic average at every quarter. The solid lines denote the MB-CCI. OECD consumer confidence corresponds to the right y-axis and the MB-CCI to the left y-axis. For Sweden, the CCI is available only from 1995:IV (SWE).

Figure A7: Correlation of confidence indices and IMF financial development indices



Notes: The panels show the relationship between IMF financial development indices and the correlation of two confidence indices. r reports the Pearson correlation coefficient. *FD* denotes the Financial Development index; *FM* denotes the Financial Markets index; *FI* denotes the Financial Institutions index; *FMA* denotes the Financial Markets Access index; *FMD* denotes the Financial Markets Depth index; *FME* denotes the Financial Markets Efficiency index; *FIA* denotes the Financial Institutions Access index; *FID* denotes the Financial Institutions Depth index; *FIE* denotes the Financial Institutions Efficiency index. For detailed description of the variables, see Appendix A.3.1.

Figure A8: Correlation of confidence indices and economics, social, and institutional factors



Notes: The panels show the relationship between economics, social, and institutional factors and the correlation of two confidence indices. r reports the Pearson correlation coefficient. *Govt deficit* denotes general government deficit; *Hours worked* denotes average annual hours worked; *Govt financial wealth* denotes general government financial wealth; *Replacement ratio* denotes the aggregate replacement ratio; *Min. income benefits* denote the adequacy of minimum income benefits. For detailed description of the variables, see see Appendix A.3.2.