The Slope of the IS Curve: New Evidence*

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Abstract

The degree of asset market participation has important implications for the relationship between the real interest rate and the aggregate demand. Our objective is to provide a quantitative estimate of the proportion of asset holders in the US and Euro Area starting from 1960s and 2000s respectively. In particular, we unveil the sub-periods where this number has fallen so dramatically that the IS curve becomes more vertical, and eventually inverted. We endogenize the identification of these periods through an estimation of a Markov-switching model displaying two (low and high) participation regimes. To account for the zero low bound on the policy rates, our model also features a shift in time preference shock which allows to distinguish between two steady states of the real interest rate, one of which being negative. We show that in the US the number of optimizing agents varied only during the Great Inflation and on the edge of the recent crisis. The proportion of non-participants has increased sufficiently to invert the IS curve. In the EA the asset market participation decreases significantly during a substantial period of the Great Recession, but just enough to provoke an increase in the slope of the IS curve without reverting it. Our result have important implications for the recent discussion on the effects of the unconventional monetary policy.

JEL classification: E32, E44, E52, ...

Key words: Limited asset market participation, Inverted IS curve, Zero lower bound, Great Recession, Bayesian estimation, Markov-switching model.

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1 Introduction

A big economic downturn is an opportunity to revise well-known macroeconomic principles. In this paper we argue that a big financial distress can be the cause of a lower asset market participation and it may disturb the conventional relation between the real interest rate and output growth (captured by the so called IS curve). As shown in Bilbiie (2008), when the proportion of asset market participants is particularly low, a fall in real interest rates causes a contraction in economic activity contrary to a standard logic.

In this paper, we quantify the proportion of the asset market participants in the US and the Euro Area (hereafter EA) in order to identify historical episodes where this proportion is low enough to change the slope of the IS curve. To structurally estimate the time-varying proportion of asset market participants, we have chosen a simple model as in Bilbiie & Straub (2013)) which is built on Bilbiie (2008) and Gali et al. (2007) and incorporates necessary feature for estimation, like price indexation, habits in consumption and nominal interest rate smoothing. It is a New Keynesian DSGE model which features the presence of two representative agents: the one that can perfectly smooth her consumption intertemporally and the one that does not participate on the asset market and consumes only her income (rule-of-thumb). Due to a stronger income effect, this limited asset market participation model predicts different effects for the monetary policy with respect to standard New-Keynesian model. This feature crucially depends on the number of the non-asset holders in the economy. More precisely, the variations in profits earned by shareholders has strong consequences on aggregate fluctuations because they are significantly bigger when shared by a relatively low proportion of the population.

The particularity of the model with limited asset market participation (LAMP model) consists in the nonlinear relation between the effectiveness of the monetary policy and the proportion of non-optimizing agents. As this proportion approaches a certain threshold (at which the IS curve is vertical) the impact of the changes in the real interest rate on the aggregate demand becomes the strongest in absolute terms and the sign of its impact depends whether the proportion of non-optimizers is above or below this threshold.

The goal of this paper is to propose an estimate of the transition probability from one state to another regardless of the reason of these transitions. To do this we deviate from the benchmark model by assuming that the share of non-asset holders is a stochastic process discretized by a Markov chain. We are then able to take into account that the relative importance of each group may vary over time, leading to potential switches in the slope of IS curve. We do not search to microfound the cause of the agents’ decision to participate or not on the asset market since we want our reduced form model to
capture various exogenous processes that make the share of participants vary.\textsuperscript{1} One of the most evident cause of the variation in the number of liquidity constrained agents is the development of financial markets that facilitates the trade of assets for a vaster swathes of population. As for example in 1980’s not only a lot of new securities appeared on the asset market but also the number of the brokerage firms raised dramatically due to deregulation processes.\textsuperscript{2} Relaxation/shrinkage of the credit constraints can be another reason to observe higher proportion of rule-of-thumbers: the deleveraging shock of 2008-2009 shall decrease the number of asset traders whereas an increase of capital inflow during the beginning of 2000s enlarged the access for credit and hence participation. Fluctuations on the labor market may also have direct implications on this number. High levels of unemployment, low job finding rate can be consistent with a larger share of rule-of-thumbers.

As our sample contains periods when the policy rates are constrained by the zero lower bound (ZLB hereafter), the implied nonlinearity is accounted by following Binning & Maih (2016). The probability of being in the ZLB is computed by assuming that the time preference shock follows a Markov chain. This allow as to account for a steady state where the real interest rate is negative and a central bank does not follow the Taylor principle and sets the nominal interest rate at the effective lower bound. Using Bayesian methods, we are then able to estimate the model and recover the historical paths of transitory probabilities of 4 different regimes: (i) high asset market participation and the inflation-targeting regime; (ii) low asset market participation and the inflation-targeting regime; (iii) high asset market participation and the ZLB regime; (iv) low asset market participation and the ZLB regime.\textsuperscript{3}

In the first part of the paper, we study the Great Inflation episode in the US and compare our results with Bilbiie & Straub (2013). As in the latter, we identify two regimes during the period 1960Q1-1997Q4, with the low participation regime prevailing during 1966-1985. Our estimates also imply a reversion of the IS curve during that period. The sign of the curve changes from $-2.2$ to $0.26$. We also confirm that LAMP model does not need to rely on big volatility of the shocks to match the large variations in inflation during 1970s - beginning of 1980s. In the second part, we conduct the same exercise including a more recent data set for the US and considering the case of the EA. We find that another regime switch took place in the US during the Great Recession. According to our estimates, starting from $?$ the IS curve became positively sloped for $?$ quarters, reaching the it pick (number) in $20?$. On the other hand, in the EA the proportion of the

\textsuperscript{1}This is why we are inclined not to use the term "hand-to-mouth" as it does not include all possible groups of agents who do not optimizes their consumption according to the Euler equation.

\textsuperscript{2}The industry employment soared by 54% between 1980-1987.

\textsuperscript{3}Obviously we do not account for the ZLB regime when we estimate on the period 1960:Q1-1997:Q4.
non-asset holders has been increased by 60% (from 0.25 to 0.40) since 2009 and remained high till the end of the sample. In that case, the changes in asset market participation were just enough to strengthen the standard relation between the real interest rate and the output growth, but not to invert it.

Our results have important implications for the policy discussions of the recent years which are characterized by the ZLB on a nominal interest rate. To boost the economy, the presence of the ZLB require actions alternative to conventional monetary policy, among which, highly discussed in the literature, the negative supply side policies and forward guidance. The effectiveness of those tools is supported by the studies of Gauti Eggertsson.\footnote{See for example Eggertsson (2010), Eggertsson (2012), Eggertsson & Krugman (2012).} He shows that in the environment of the sticky prices and conditionally to a big deflationary shock which leads to a liquidity trap, the aggregate demand curve flips sign and inflation stimulates demand by decreasing the real interest rate. It is however conditional on a negative slope of the IS curve. The implication of this paper is two-fold: (i) first, we shall consider with precaution unconventional policies which rely on the AS curve inversion; (ii) second, at some point of the Great Recession an increase of the interest rate might have been more efficient than staying in the ZLB for almost 10 years now. Since an increase in the monetary stance is easier to implement, than other recovery policies, the asset market participation could become another tool of the policymakers to stabilize the economy, by keeping economic agents constraint.\footnote{We are not the first one to claim that financial constraint might be beneficial under certain conditions. Gilchrist et al. (2017) argue that liquidity constrained firms increased prices in 2008 hence reducing the probability of ending in a deflationary spiral during ZLB episodes.}

The paper is organized as following: Section 1 briefly discusses the model. In Section 2 we consider the Great Inflation episode in the US and compare our results with Bilbiie & Straub (2013). Section 3 presents evidences for the period 1987-2015 in the US and the EA. Section 4 concludes.

## 2 The Model

We adopt a regime-switching DSGE model which is otherwise a standard New Keynesian model without capital and with two types of agents. Both types of agents get utility from consumption and disutility from work, but they differ in their opportunity to participate on the asset market. The agents who have an access to the financial markets (hereafter the \textit{participants} or \textit{asset holders}) can smooth their consumption intertemporally by buying or selling bonds and firms’ shares. The agents of the second type do not trade on the asset market: their only income is labor earnings which they consume entirely during the period. We call this agents the \textit{rule-of-thumbers} and their share in the total population...
is $\lambda$. Till here our model corresponds exactly to the one considered in Bilbiie & Straub (2013). We deviate by allowing parameter $\lambda$ to be state dependent and to follow a Markov switching process.\footnote{Our set-up differs from Nisticò (2014). In his paper, he allows for continuous stochastic transition between two types of agents. Each period an agent in this model learns whether she can trade on the asset market. However in each period the number of each type stays constant. We could obtain the sign switching of the aggregate demand curve in this set-up too, but we leave it for further research.} We also add a preference shifter as for example in Binning & Maih (2016) and Braun et al. (2015) that helps us to define two additional steady states of the model, one of which has negative real interest rate. This building-up to our model allows to take into account the ZLB on the nominal interest rate.

In the following, we present a brief description of the model and its reduced form with three essential equations that describe the log-linear dynamics of the model. For more details, we invite the reader to see Bilbiie (2008).

**Households** The utility function is identical for asset and non-asset holders:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \Pi^t_{j=0} d(S^R_j) \right) \left[ \ln(C_{j,t} - \gamma C_{t-1}) - \nu \frac{N_{j,t}^{1+\phi}}{1+\phi} \right]$$

$d(S^R_j)$ is a state-dependent time preference factor, where the state variable $(S^R_j)$ follows a Markov chain. The time preference shifter affects the choice between future consumption and current consumption. We will be more explicit about it later on in the section when we will discuss the monetary policy. $C_j$ and $N_j$ stand for individual consumption and labor respectively and $j = [s, h]$, where $s$ refers to an asset holder agent and $h$ refers to a rule-of-thumber.

Asset (savers) and non-asset holders have different budget constraints because by our assumption: when an agent switch her type, she immediately has the same level of wealth as the others. The savers invest in a state-contingent assets, $B_t$, and in shares of firms with an average market value $V_t$ at time $t$ and dividends $D_t$. The budget constraint of savers reads:

$$B_t + \Omega_{t+1} V_t \leq Z_t + \Omega_t (V_t + P_t D_t) + W_t N_{s,t}^s - P_t C_t^s$$

where $\Omega_t$ are the share holdings and equity market clearing implies that: $\Omega_t = \frac{1}{1-\lambda(S_{t,j})}$. The first order conditions of an asset holder are: $\pi_{t+1} (\Pi^t_{j=0} d(S^R_j)) = \beta^t C_{s,t+1}^{s,t} - \gamma C_{t+1}^{s,t} - C_{t+1}^{s,t}$ and $\nu N_{s,t}^{1+\phi} = C_{t+1}^{s,t} - \gamma C_{t+1}^{s,t}$. On the other hand, the resource constraint of the rule-of-thumb agent is $C_{h,t} - \gamma C_{t-1} = W_t N_{h,t}$ and the first order condition is given by: $\nu N_{h,t}^{1+\phi} = C_{h,t} - \gamma C_{t-1}$. Hence
the labor supply of this agent is always fixed and defined as: \( N_{h,t} = \nu^{-\frac{1}{1+\phi}} \). After log-linearizing all these FOCs and taking into account the fact that \( y_t = c_t = (1-\lambda(S^\lambda_t))c_{s,t} + \lambda(S^\lambda_t)c_{h,t} \) we obtain the following IS curve:

\[
y_t = \frac{\Gamma_1}{\Gamma_1 + \Gamma_2} E_t y_{t+1} + \frac{\Gamma_2}{\Gamma_1 + \Gamma_2} y_{t-1} - \frac{1 - \gamma}{\Gamma_1 + \Gamma_2} (r_t - E_t \pi_{t+1}) + \xi_t
\]

Equation 3 defines the relation between the real interest rate and aggregate demand. \( y_t \) is the output growth, \( r_t \) - nominal interest rate, \( \pi_t \) - inflation, \( \xi_t \) is an aggregate shock that affects the marginal rate of substitution between consumption and labor and we interpret it as an aggregate consumption demand shock. The parameter description can be found in Table 1. Variable \( S^\lambda_t \) is a state variable which follows a Markov chain with transition matrix \( P^\lambda \):

\[
\begin{bmatrix}
1 - p^\lambda_{l-h} & p^\lambda_{l-h} \\
p^\lambda_{h-l} & 1 - p^\lambda_{h-l}
\end{bmatrix}
\]

\( p^\lambda_{l-h} \) is the probability to switch from a regime with a large number of participants (\( \lambda^{low}-state \)) to a regime with a large number of nonasset holders (\( \lambda^{high}-state \)). \( p^\lambda_{h-l} \) is the probability for the reverse case. \( 1 - p^\lambda_{l-h} \) and \( 1 - p^\lambda_{h-l} \) are the probabilities to stay in (\( \lambda^{low}-state \)) and (\( \lambda^{high}-state \)) respectively.

When there is only one type of agents whose consumption decision is defined by the Euler equation, i.e. \( \lambda = 0 \), this equation shrinks to an aggregate demand curve of a standard NK model. When two types of agents are present, the model’s behavior depends on the relative importance of each type and there is a non-linear relation between the \( \lambda \) parameter and the slope of IS curve. The value of \( \lambda \) parameter determines the values of \( \Gamma_1 \) and \( \Gamma_2 \), and hence the way the real interest rate affects demand. When we are in the \( \lambda^{low}-state \) the model behaves according to a the Permanent Income Hypothesis: current income has little influence on current consumption and an increase in the real interest rate has a negative impact on the output growth. When the economy is in the \( \lambda^{high}-state \), the standard logic is reversed only conditionally that \( \frac{1 - \gamma}{\Gamma_1 + \Gamma_2} < 0 \). We do not impose that \( \lambda^{high}-state \) necessarily meets this condition, and let the data speak.
the condition holds, an increase in the real interest rate becomes expansionary. Hence the goal of this paper is precisely to estimate the share of rule-of-thumbers using the data from the US and the EA and to quantify the probability of being in the $\lambda^{high}$ regime for both economies. But the key question of our empirical exercise is to determine whether $\lambda^{high}$ is high enough to reverse the sign of the IS curve during last decades.

**Firms** The firm’s problem is standard. The final good producers are assumed to be in perfect competition while the intermediate producers are monopolists with a production function: $Y_{i,t} = N_{i,t} - F = Y_t \left( \frac{P_{i,t}}{P_t} \right)^{-\epsilon}$, where $F$ is a fixed cost. The marginal cost coming from minimization problem of firms is: $W_t$. The prices are defined by a Phillips curve which is derived from a maximization problem of firm specified as below:

$$E_t \sum_{j=t}^{\infty} (\theta \beta)^{j-t} u_{C_{t+j}} \left\{ P_{i,t} \left( \frac{P_{i,t}}{P_{t+j}} \right)^{-\epsilon} Y_{t+j} - MC_{t+j} \left( \frac{P_{i,t}}{P_{t+j}} \right)^{-\epsilon} Y_{t+j} \right\}$$

Solving for firms’ problem gives us the Phillips curve which links inflation to output growth and defines aggregate supply.

$$\pi_t = \frac{\beta}{1 + \beta \omega} E_t \pi_{t+1} + \frac{\omega}{1 + \beta \omega} \pi_{t-1} - \psi \frac{\gamma}{1 + \gamma} y_{t-1} + \psi \left( \frac{1}{1 - \gamma} + \frac{\phi}{1 + \mu} \right) (y_t - s_t) \quad (4)$$

Here, the rigidity in prices is captured by the mechanism presented by Calvo and Yun. $\theta$ is the probability that a firm is able to re-optimize price. The parameter $\omega$ captures the degree of price indexation. $s_t$ represents an aggregate supply shock that moves the Phillips curve and can be thought as a combination of technology and cost-push shocks. As in many papers (Lubik & Schorfheide (2004), Bilbiie & Straub (2013)) we allow for non-zero correlation ($\rho_{sd}$) between innovations to the consumption demand shock and the supply shock so that the innovations that affect the IS curve could as well affect the Phillips curve.

**The inversion of the IS curve**

The particularity of our benchmark model comes from the fact that the income effect after a change in an interest rate is much more present for high values of the $\lambda$ parameter comparing to a standard New Keynesian model. Consider an increase in the real interest rate. The optimizers answer by reducing their consumption through a substitution effect. These agents also increase their labor supply, which in turn decreases wages and increases profits. Would the decrease in the labor earnings remain at equilibrium, lower consumption arising from non-asset holders would amplify the output decrease. But actually the

\footnote{For more detailed analysis of the theoretical properties of a model with limited asset market participation we refer the reader to Bilbiie (2008).}
equilibrium outcome depends crucially on the relative importance of the number of asset market participants. If their share is relatively small, in $\lambda^{\text{high}}$-state, the profits are shared among fewer savers and hence the income effect becomes larger at the individual level. This explains why ultimately their consumption can be increased, pushing up output, labor demand and wages. As finally labor earnings are higher, non-asset holders benefit from an increase in their income, and then it reinforces the expansionary process after an increase in the real interest rate. It is important to mention that the effect is not monotonic across the space values of $\lambda$. Denote $\lambda^*$ as the number of non-participants at which we observe the transition between "Standard" regime and the "Inverted" one. As long as the $\lambda$ parameter increases but stays lower than $\lambda^*$ an increase in the real interest rate depresses the aggregate demand even more through the impact of falling wages on consumption of the rule-of-thumbers. When $\lambda$ increases more and passes the threshold $\lambda^*$ the effect is inverted and as $\lambda$ tends to 1 the effect of the real interest rate disappears since lesser and lesser agents set their consumption decision with respect to the Euler equation.

**Monetary Policy** To account for the ZLB in our model we follow Binning & Maih (2016). In their paper, they propose to think about the ZLB as a distinct regime of the economy in which the steady state real interest rate is negative. We use the time preference shifter to have two steady states which corresponds to: (i) an inflationary-targeting regime and (ii) ZLB regime.

In the inflationary-targeting regime the central bank follows a Taylor rule of the form:

$$R_t = \phi_r(S^\lambda_t)R_{t-1} + (1 - \phi_r(S^\lambda_t)) \left[\phi_1(S^\lambda_t)\pi_t + \phi_2(S^\lambda_t)y_t\right] + \epsilon^*_t \quad (5)$$

Here, $\epsilon^*_t$ is a monetary policy shock to a Taylor rule. We allow the policy parameters to follow the same Markov chain as the $\lambda$ parameter does. As shown in Bilbiie (2008) an optimal policy should be state-dependent. In an economy with inverted IS curve the nominal interest rate should not to respond strongly to inflation. By allowing policy rule to change whenever there is a change in the number of asset market participants, we can check whether the central bank has led an optimal policy in each regime. Moreover, this assumption ensures the determinacy of the model in every regime: a central bank can

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8Besides of being easy to implement, their method accounts for the expectations the agents form about the ZLB being binding in the future. A piecewise-linear solution method for example is less informative in this sense as the expectation channel is absent.

9Using a steady state formula of the real interest rate ($R \approx \Pi + g - \beta$) the authors compute an implying $\beta$ parameter to be equal to 1.0052 during the period 2009:Q1-2015:Q1 in the US, which is consistent with a gross real interest rate being less than 1. This is the reason why we do not consider a deflationary steady state instead as in Benhabib et al. (2002).
choose to follow the Taylor rule in a "normal" case ($\lambda_{\text{low-state}}$) and to respond to inflation less than one-to-one in an "inverted" case. However it is not a necessary assumption since in our setup violating the "determinacy principal" does not lead to an explosive path since agents are aware that this regime will not persist indefinitely. As for the rest of the estimated parameters ($\gamma$ and $\phi$), we do not allow them to change in the benchmark specification.\(^{10}\)

In the ZLB regime the central bank sets an effective lower bound $R_t^E$:

\[
R_t^E = K + \sigma_t^E \epsilon_t^E
\]  

(6)

$K$ corresponds to the effective lower bound which we set to the mean of the nominal interest rate during the period 2009:Q1-2015:Q1. The ZLB shock $\sigma_t^E \epsilon_t^E$ helps us to account for small variations of the nominal interest rate around $K$ and avoid a stochastic singularity problem.

The state $S_t^R$ of the monetary policy is assumed to follow a markov process defined by the transition matrix:

\[
\begin{bmatrix}
1 - p^{TR} & p^{TR} \\
p^{ZLB} & 1 - p^{ZLB}
\end{bmatrix}
\]

$1 - p^{TR}$ is the probability that an economy enters the ZLB regime ($S_{ZLB}$) where a central bank would be obliged to set a nominal interest rate at an effective lower bound instead of following the Taylor rule as in the previous period. $p^{TR}$ is the probability to stay in the inflation-targeting regime ($S_{TR}$). $1 - p^{ZLB}$ is the probability to switch from the ZLB regime to inflation-targeting regime. $p^{ZLB}$ is the probability to stay in the ZLB steady state. The steady state interest rate is then state-dependent: $\bar{R}(S_t^R)$ with $S_t^R = [S_{TR}^R, S_{ZLB}^R]$. In normal times $\bar{R}(S_{TR}^R) = \frac{\pi}{\beta}$. In the ZLB regime, $\bar{R}(ZLB) = K$.

As in Binning & Maih (2016) and in Braun et al. (2015) we interpret the regime switching as an outcome of the time preference shift $d(S_t^R)$ which has to verify the following steady state restrictions: $d(S_{TR}^R) = 1$ and $d(S_{ZLB}^R) = \frac{\pi}{\beta K} > 1$ given that $\bar{d} = -\frac{\pi}{\beta R(S_t^R)}$.\(^{11}\)

In what follows, we estimate our model which can explore 4 different regimes: (i)
high asset market participation and the inflation-targeting regime; (ii) low asset market participation and the inflation-targeting regime; (iii) high asset market participation and the ZLB regime; (iv) low asset market participation and the ZLB regime. When we estimate on the period 1960:Q1-1997:Q4, we do not account for the ZLB for the reason of its absence even in agents’ expectations.

3 Empirical Results

To see how the $\lambda$ parameter evolves over time we estimate the linear model using Bayesian methods.\(^{12}\) We use Rise toolbox to find a mode of the posterior distribution. Our data set contains three time series that can be found on FRED: real GDP per capita, inflation and nominal interest rate.\(^{13}\) To compute inflation we use GDP deflator. We divide nominal GDP by GDP deflator and civil labor force to obtain real GDP per capita.\(^{14}\)

We first compare the estimation results of our model with Bilbiie & Straub (2013). Then we extend our study, including the period of the Great Recession for the US and the EA.

3.1 Pre-Volcker and Volcker-Greenspan periods

We focus in this section on 1960Q1-1997Q4 period. Over this sample, we do not take into account the possibility of being in the ZLB regime, and restrict our study to a two-regime analysis.

Let us first present the main results obtained in Bilbiie & Straub (2013).\(^{15}\) They argue in their paper that there is no need to rely on policy mistakes of the Federal Reserve (Fed) or anomalously large shocks for explaining the Great Inflation episode.\(^{16}\) Instead they show that this period of high inflation could be explained by the existence of a large share of non-asset holders. In this case, negative supply shocks may exacerbate inflation due to the reverting aggregate demand curve that arises in their model with heterogeneous consumers. Moreover, in this situation to ensure the equilibrium determinacy, the Fed’s reaction to inflation should be passive.

\(^{12}\)See for example An & Schorfheide (2007) for the description of the method.

\(^{13}\)The source of our data set is not the same as in Bilbiie & Straub (2013).

\(^{14}\)We smooth civil labor force to avoid measurement errors as proposed in Pfeifer (2013).

\(^{15}\)In their paper, Bilbiie & Straub (2013) implement an empirical exercise very close to ours: using Bayesian methods they estimate log-linear model. Since for them the number of savers and rule-of-thumbers is fixed during an estimation period and agents do not expect a regime change, they restrict the prior of $\phi_{\pi}$ to be smaller than 1 for the first sub-sample period: 1960:Q1-1979:Q4.

\(^{16}\)This view of the Federal Reserve mistake is supported for example in the paper of Lubik & Schorfheide (2004) and Clarida et al. (1999). These papers accuse monetary policy of being too passive during that period which caused a sunspot fluctuations of arbitrary size.
Their estimation results indeed support this macroeconomic picture. During 1960Q1-1979Q2, they do find that the slope of the IS curve becomes positive (0.34) and that the Fed’s reaction to inflation is 0.4. During 1979Q3-1997Q4, the share of rule-of-thumbers decreases, the slope of the IS curve becomes negative (-0.6) and the monetary policy is active, i.e. $\phi_\pi$ is higher than 1.

Our model with Markov switching regimes allows us to estimate deep parameters of the model using the whole sample: 1960Q1-1997Q4. We underline again that the only difference with Bilbiie & Straub (2013) is that we allow for the $\lambda$ and the parameters of the monetary policy rule to be governed by a Markov chain. In this way, we do not have to split arbitrarily the data sample. For the sake of comparability we assume the same priors as in Bilbiie & Straub (2013), see Table 1 in the Appendix. Calibrated parameters are in Table 3.

Our empirical exercise does confirm the existence of two regimes during this period. The posterior mode is reported in Table 1. One regime corresponds to a standard situation in which the aggregate demand reacts negatively to the changes in the real interest rate and the monetary policy is active: for each increased percentage in the real interest rate output falls by -2.2%. The number of rule-of-thumbers is 25% which is very close to the estimates of Bilbiie & Straub (2013) (18-20%). This regime prevailed before 1966 and after 1985. The second regime corresponds to the case of the reversed IS curve with a slope of 0.26. The share of non-asset holders more than doubles and becomes equal to 63%. The smoothed state probability of being in the $\lambda^{\text{high-state}}$ is shown in Figure 3.1.

Contrary to Bilbiie & Straub (2013), our empirical strategy allows us to reveal that the
first years of the sixties are characterized by a high asset market participation regime. Bilbiie & Straub (2013) interpret the changes in the slope of IS curve over their two sub-samples as being due to the developments on the financial markets. They bring evidences about financial constraint binding in 1970s. In our results, the number of savers at the beginning of 1960s was not lesser than in 1990s. Financial deregulation is not the only reason to have a lot of asset market participants and our model allows us to take into account any reasons for it to change. Clearly, other factors linked to borrower and lender behaviors could be put forward to explain the asset market participation, for instance like changes in confidence state.

Our econometric exercise could also shed some light on the theory of "bad luck". A lot of papers put forward an increase in shock volatility as a cause of the stagflation during late 1960s and throughout 1970s. It is possible to do some counterfactual analysis to unveil the importance of taking into account changes in asset market participation. We compute the paths of the demand and supply shocks as they would have been observed if only one regime prevailed (Figure 3.2). We show that the fluctuations of the shocks would have been very important during 1970s if the asset market participation had been

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17 We check that we are able to replicate the results in Bilbiie & Straub (2013) if we split the sample in two periods: "pre-Volker" regime and "Volker-Greenspan" regime, respectively in 1960-1979 and 1979-1997. So we are sure that the difference in the regime identification does not come from the data.

18 Instead of too much speculative explanations, we prefer to leave that issue for further research.
wrongly considered as high. To replicate the data, the model with only one representative agent that smooth her consumption should rely on a larger negative supply shocks and much more volatile demand shocks.

In our model, low asset participation and reverted IS curve can explain why standard negative supply shocks can generate high inflation. The model indeed predicts higher steady state inflation in $\lambda^{\text{high}}$-state (1.06% against 0.65% in $\lambda^{\text{low}}$-state). It does not need to rely on the negative monetary shocks to explain such high inflation (see red dashed line on Figure 3.3). $\phi_1$ parameter is lower than 1 (0.71) in $\lambda^{\text{high}}$-state. The real interest rate is twice higher in "standard" model than in the reversed case (0.99 against 0.53 respectfully). This is why our analysis does not plead for blaming the monetary policy of not fulfilling the Taylor principle during 1970s. The Fed indeed responds less to inflation, but during this period it was an optimal policy since the number of nonparticipants on the asset market was high.

So why was there high inflation and recessions during 1970s in the first place? To answer this question we plot the output growth, inflation and the path of the supply shocks conditionally on two regimes, see Figure 3.4. A large share of output growth
fluctuations is explained by the supply shocks.\textsuperscript{19} In both regimes negative supply shocks decrease production and push prices up. The dynamics of the output growth is very similar to the supply shock one, and inflation rises by more when $\lambda$ is high. That is consistent with the IRFs produced by the model, see Figure 3.5. On impact, supply shocks increase inflation by almost the same amplitude in both regimes. However the monetary policy prescribes different dynamics afterwards. The $\phi_{\pi}$ parameter in the "Reversed" regime is smaller than it is in the "Standard" case; hence after negative supply shock the real interest rate decreases in the "Reversed" case, which, other things being equal, stimulates consumption of the asset holders and hence expected inflation.\textsuperscript{20} This effect explains why consumption decreases less in the low participant case, and then why inflation is higher in this case at the equilibrium. This weaker elasticity of consumption is shown by the absolute value of the IS curve slope which is ten times lesser. The internal mechanisms of our model are enough to generate high inflation without the existence of big shocks.

\textsuperscript{19}The fact that supply shocks were the first candidates for explaining the cause the recession in the US during 1970s and early 1980s is a widespread opinion. See for example Bilbiie (2008) and search for more papers.

\textsuperscript{20}In other words, we see clear implication of the two opposite effects on consumption of asset holders: (i) the one implied by the substitution effect and (ii) the one which arises due to the income effect.
Figure 3.5: Impulse response function to averse supply shocks

*Note:* Panel(1,1) is nominal interest rate; panel(1,2) is inflation; panel(2,1) is output growth; panel(2,2) - real interest rate.

### 3.2 Robustness check

Here we check the sensitivity of our results to the specification of our estimation procedure. Even though there is no direct reason to think that labor elasticity parameter and consumption habits may be linked to the state of the economy and depend on the slope of the aggregate demand curve, we re-estimate the model considering that $\gamma$ and $\phi$ parameters follow the same Markov chain as $\lambda$. We also allow the innovation processes to be governed by a Markov chain but different from the one of $\lambda$. Our intentions are driven by the results of Sims & Zha (2006) who argues that their best fitting specification is the one when they only allow for variations in shocks variances. Finally in our last specification we allow policy rule parameters to follow a Markov chain different from the one of $\lambda$. The results are available upon request.

### 3.3 Estimating the proportion of Asset Market Participants in the US for 1960:Q1 - 2015:Q1

In this subsection we extend our data sample till 2015:Q1. We believe that the Great Recession may affect the ability of agents to smooth their consumption. The liquidity shock that hit the US asset market in 2007 had strong consequences on the financial vulnerability. The FED’s massive asset purchase programs seem to have a good stabilizing effect on the markets. However there are some empirical evidences that make us wonder
whether the number of participants on these markets has been reduced. Unfortunately we have no direct evidence on the number of shareholders, but many papers suggest that the income permanent hypothesis does not hold in the data during the last decade. The main reason for this is the lack of liquidity assets, which include the corporate bonds.

We use the same data source as before. We modified priors for some parameters, see Table 2. Instead of estimating the real interest rate we estimate discount factor parameter $\beta$ (for some purely computational reasons) without allowing it to change its value across participation regimes. We assumed a lower prior for nonparticipants in the $\lambda^{\text{low}}$-state than in the previous section. We make the prior on the parameter that governs the monetary policy response to inflation less informative. Since our estimation period includes the episode with very low interest rate, we do not want to bias our estimation by associating $\lambda^{\text{high}}$ with low prior on $\phi_{\pi}$. Instead, we impose the same prior for both regimes, but with lower bound of 0.18 and upper bound of 2.36, which correspond to 10th and 90th percentiles respectively. We set the interest rate smoothing and the Taylor rule response to output as in Smets & Wouters (2007). The prior on inflation is set up to be consistent with the sample mean.

The smoothed state probabilities are shown in Figure 3.6. As in our previous exercise we observe a reversion in the IS slope starting in the second half of 1960s till the beginning of 1980s. However now the US economy enters this regime about 2 years later. More im-

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21Interestingly, according to the data from Home mortgage disclosure act (Aggregate report), a decrease in the borrowing constraint was not homogenous across agents. The value of the loans per borrower has not been changed during 2007-2012 and has been even increased for the low income borrowers, since this category becomes more homogenous in terms of risk. What has been changed is the number of loans sold. This does not directly imply a decrease in the number of borrowers, but in light of the former fact, it has a great chance to be the case. This evidence questions the reasoning of Eggertsson & Krugman (2012) in explaining the recession by deleveraging process which they model as a decrease in the debt limit per borrower.

22Studying the implications of the October 2013 US Federal Government shutdown, Gelman et al. (2015) report a rather low capacity of households to smooth their spending with respect to an income shock, even a transitory one. They regard this result as a sign of poor functioning of the financial markets. Several studies refer to the liquidity constraint as a main reason for large correlation between consumption and income among different groups of population (see for example Gelman et al. (2014), Accconcia et al. (2015)).

23In our case, the larger the sample period of the data, the better it is for parameter identification. However because of the financial market developments and the presence of the ZLB at the end of the sample, we might expect that the results would be biased by assuming the same lower and upper bound of the Markov chain for the $\lambda$ parameter. In other words, there is a chance that the IS curve was reverted both during Great Inflation and the Great Recession episodes, however it is hard to assume that both regimes could be characterized with the same state values: $\lambda^{\text{high}}$ and $\lambda^{\text{low}}$.

24An interesting question to explore is whether $\lambda^{\text{high}}$-state corresponds to a regime with lower $\beta$ parameter, implying that agents who cannot smooth their consumption are impatient with binding financial constraint.

25This assumption is plausible due to financial market developments or an increase in economic literacy. Mankiw & Zeldes (1991) state a strong correlation between the level of education and household stockholdings. Also higher fraction of the population are using pension plans.

26The results do not depend on whether the sample mean includes the Great Recession or not.
Figure 3.6: Transition probabilities to enter a low participation regime ($\lambda_{\text{high}}$-state) and a ZLB regime in the US during 1960:Q1 - 2015:Q1.

Note: The blue line correspond to the probability to go to the ZLB; the green dashed line corresponds to the probability to be in $\lambda_{\text{high}}$ regime.

Importantly, there is a dramatic increase in the number of non-asset holders at the beginning of the Great Recession, but this number declines very fast after only few quarters.

There are some small differences in the mode of posterior distribution between the two samples we consider, but they are not significant. The $\phi_\pi$ in $\lambda_{\text{low}}$-state is 0.63 (0.71), (hereafter the parameters in brackets corresponds to the mode in 1960Q1-1997Q4 sample). We do not observe anymore a big difference between the steady states of inflation in different regimes. The reason is straightforward: in the second half of the sample, low asset market participation is associated to a low level of inflation. With opposite shocks to the ones observed during the Great Inflation period, the model predicts excessive deflation (or fall in inflation). The estimate of the time discount factor is 0.993, which corresponds to a quarterly real interest rate steady state before 2007:Q1. The slope of the IS curve is lesser negative: $-0.89$ ($-2.2$), however the difference between the regimes are more exacerbated: the IS slope in $\lambda_{\text{high}}$-state is 0.96 (0.26). The demand shock is twice more volatile, whereas the monetary shock volatility is reduced by two for the Taylor principle. These results are consistent with the facts that the first estimate in the previous section is mostly affected by the Great Inflation episode where the demand shocks played a less important role and the Volker monetary policy made nominal interest rate to jump till 4.45% per quarter.

The smoothed transition probability of being in the ZLB starts to increase from 2008:Q4 and reaches 94.5% in 2009:Q3, staying in this regime till the end of the sample. Interestingly, the decrease in the proportion of non-participants after the dramatic peak coincides with the implementation of unconventional monetary policy, which may
consider as another proof of its effectiveness. By relaxing financial constraints and bringing back stability to the labor markets, the Fed helped economic agents to optimize their consumption path. In this way the Fed managed not only to push the real interest rate down (by reducing deflationary pressures on the US economy) but it made agents react to those changes in the real interest rate the way conventional economics predicts.

Figure 3.7: The impulse response functions to a monetary shock in the Taylor rule

However, according to our results, the Fed had another option to stimulate the US economy. In 2008:Q4, the slope of the IS curve was 1.78, so an increase in the nominal interest rate (and therefore in the real one) would have been expansionary. To illustrate that, we present the IRFs to a monetary policy shock predicted by the model in Figure 3.7. The magnitude of the monetary policy effects in \( \lambda^{\text{high}} \)-state is clearly not as high as in \( \lambda^{\text{low}} \)-state. However, an increase in the nominal interest rate does stimulate the economic growth. On the contrary, the monetary policy shock to the Taylor rule was negative (pushing down the interest rate) during the period of low participation, (see Figure 3.8), which clearly exacerbated the crisis.

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27 To see the time path of the IS curve slope and the proportion of non-participants we refer the reader to Figure 5.1 in the Appendix.

28 The impulse responses we present here are regime-specific. The agents are aware that the probability to switch to another regime is positive, hence their decisions are influenced by the dynamic of the model in other regimes through expectation. However ex-post the economy stays in the same regime as when the shock hits.

29 High fluctuations in the expected smoothed ZLB shock are due to a very small standard deviation of the ZLB shock.
3.4 The Great Recession and the number of asset market participants in the EA

The data series are taken from Fagan et al. (2001). We used the same priors as for the US case for the majority of the parameters, except the steady state value of the real interest rate, inflation and the reaction of the ECB to changes in output growth, see Table 4. Looking at the time series of the nominal interest rate in the Euro area (green line in Figure 3.9), it is hard to think about an effective lower bound. But comparing to the depth of the economic recession, it is hard to contradict the fact that the ECB was not following the Taylor rule from 2009-2010.

As in the previous section we estimate the model with 4 regimes. The effective lower

\[ \text{Output growth} \quad \text{Nominal interest rate} \]

Figure 3.9: Nominal interest rate and detrended output growth in the EA

\[ \text{Output growth} \quad \text{Nominal interest rate} \]

Figure 3.8: Expected smoothed Innovation processes

\[ \text{Monetary policy shock} \quad \text{ZLB shock} \quad \text{Demand shock} \quad \text{Supply shock} \]
bound is set to 0.3% in quarterly terms and $\sigma^F_t$ is set to 0.15 due to much larger variation of the nominal interest rate in the EA than in the US.

![Figure 3.10: Transition probabilities in the EA during 1999:Q1 - 2014:Q4](image)

*Note:* The blue line correspond to the probability to go to the ZLB; the green dashed line corresponds to the probability to be in $\lambda^{high}$ regime.

Figure 3.10 shows that there is a switch in the asset market participation from the low state to the high state at the beginning of the crisis. Contrary to the US case, we do not observe a dramatic spike in the number of rule-of-thumbers: the $\lambda$ parameter shifts from 0.24 to 0.40 but stays at this value till the end of the sample. Regardless a decrease in the number of nonasset holders, the IS slope remains negative. $\phi_\pi$ becomes inferior to 1 at the same period, estimated at 0.81, which is not an optimal monetary policy in this case. After this episode of passive monetary policy, the data eventually favors a ZLB regime from 2009:Q1.

Our results support the implementation of the unconventional policies that act through inflationary expectations since the AD curve becomes indeed positive during the ZLB episode. Moreover the estimated values of our parameters at the mode of the posterior distribution indicate a reinforcement of the positive link between inflation and the aggregate demand. In Figure 3.11 we plot the evolution of the $\lambda$ parameter and the slope of the IS curve at each point in time of our sample. Confirming the prediction of the theoretical model, Figure 3.11 shows that the closer the number of non-participants to $\lambda^*$, which defines the transition between the two regimes (at $\lambda^*$ the IS curve is vertical), the steeper is the IS curve and the stronger is the effect of the monetary policy.

We would like to acknowledge however that this results should be taken with precaution. Our estimate for the number of rule-of-thumbers is very close to the transition point ($\lambda^*$) around which the IS curve may take significantly big values with the sign depending on the regime. For example, taken the rest of the parameters as given, the IS slope for $\lambda = 0.5$ is $-4.44$, whereas the IS slope for $\lambda = 0.55$ is $32.16$. Would the $\lambda$ be 0.55 at the
ZLB, we would be back to a "Standard" case with a negative AD curve.

![Figure 3.11: The evolution of the IS curve slope and the proportion of non-participants in the EA: 1999:Q1-2014Q4](image)

**Note:** The green line represents the derivative of the output growth with respect to the real interest rate (the slope of the IS curve) at each point in time on the estimated sample. The cyan dashed line shows the smoothed lambda parameter computed as a weighted average of the two regimes.

### 4 Conclusion

Probably one of the most important relations the monetary authority cares about is the joint dynamics of the real interest rate and consumption with negative correlation between the two as conventional macroeconomic theory predicts. However, Bilbiie (2008) shows that this relation is subject to a degree of asset market participation. In particular, when the participation is high enough but lower than some critical level, the economy is becoming more Keynesian. When the proportion of participants crosses a certain threshold the slope of the IS curve reverses. In this light we would like to emphasize two contributions of this paper. First one is to evaluate the hypothesis of Bilbiie & Straub (2013) allowing for endogenous "break" in the sample and showing how relevant the LAMP model is for explaining the Great Inflation episode. The second contribution is to evaluate a novel hypothesis of the IS curve inversion during the last financial crises.
## Appendix

<table>
<thead>
<tr>
<th></th>
<th>Prior distribution (mean, std)</th>
<th>Posterior distribution (Mode)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st regime</td>
</tr>
<tr>
<td>Share of rule-of-thumbers</td>
<td>$\lambda$ Beta</td>
<td>(0.3, 0.1)</td>
</tr>
<tr>
<td>Taylor rule response to inflation</td>
<td>$\phi_{\pi}$ Gamma</td>
<td>(1.5, 0.5)</td>
</tr>
<tr>
<td>Interest rate smoothing</td>
<td>$\phi_{r}$ Beta</td>
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</tr>
<tr>
<td>Taylor rule response to output</td>
<td>$\phi_{2}$ Gamma</td>
<td>(0.25, 0.15)</td>
</tr>
<tr>
<td>Real interest rate</td>
<td>$r^*$ Gamma</td>
<td>(0.5, 0.25)</td>
</tr>
<tr>
<td>Inflation</td>
<td>$\pi_s$ Gamma</td>
<td>(1, 0.5)</td>
</tr>
<tr>
<td>AD slope</td>
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<td></td>
</tr>
<tr>
<td>Habit parameter</td>
<td>$\gamma$ Beta</td>
<td>(0.5, 0.2)</td>
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<tr>
<td>The elasticity of labor supply</td>
<td>$\phi_p$ Gamma</td>
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</tr>
<tr>
<td>Transition prob. from $\lambda^{low}$</td>
<td>$p_{l-h}^L$ Beta</td>
<td>(0.1, 0.03)</td>
</tr>
<tr>
<td>Transition prob. from $\lambda^{high}$</td>
<td>$p_{h-l}^H$ Beta</td>
<td>(0.1, 0.03)</td>
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<tr>
<td>(a) Autoregressive parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply shock</td>
<td>$\sigma_s$ Beta</td>
<td>(0.7, 0.1)</td>
</tr>
<tr>
<td>Demand shock</td>
<td>$\sigma_d$ Beta</td>
<td>(0.7, 0.1)</td>
</tr>
<tr>
<td>(b) Standard deviations ( $\sigma_i * 100$ )</td>
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<td></td>
</tr>
<tr>
<td>Supply shock</td>
<td>$\rho_s$ Inv. Gamma</td>
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<tr>
<td>Demand shock</td>
<td>$\rho_d$ Inv. Gamma</td>
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<tr>
<td>Monetary policy shock</td>
<td>$\rho_m$ Inv. Gamma</td>
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<tr>
<td>Autocorrelation supply-demand shock</td>
<td>$\rho_{sd}$ Beta</td>
<td>(0.3, 0.1)</td>
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Table 1: Prior distribution and the mode of the parameters during 1960Q1-1997Q4.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior distribution (mean, std)</th>
<th>Posterior distribution (Mode)</th>
<th>Posterior distribution (Mode)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda^*$</td>
<td>Beta (0.2, 0.1) (0.35, 0.15)</td>
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<tr>
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<td>Gamma (1, 0.7) (1, 0.7)</td>
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<td>0.990</td>
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<td>IS slope</td>
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<td>$\phi_p$ Gamma (3, 0.5)</td>
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<td>$\rho_{ZLB-TR}$ Beta (0.1, 0.03)</td>
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Table 2: Prior distribution and the mode of the parameters during 1960Q1-2015Q1. Comparison with the mode of 1960Q1-1997Q4 sample. Note: parameters with a * in a upper right corner follow a markov chain the same as parameter. The values of $\beta$ parameter in the case of 1960Q1-1997Q4 sample is recoverd by using the formular: $\frac{1}{100} + 1$. 

Note: $c$ parameter is recoverd by using the formular: $\frac{1}{100} + 1$.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>US</th>
<th>EA</th>
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<tr>
<td>Fraction of firms unable to reset prices $\theta$</td>
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<td></td>
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<tr>
<td>Markup $\mu$</td>
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<td>Price indexation $\omega$</td>
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<td>Effective lower bound $K$</td>
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<td>0.3%</td>
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<tr>
<td>Std.dev of the ZLB shock $\sigma^E$</td>
<td>0.01</td>
<td>0.15</td>
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Table 3: Calibrated parameters

Figure 5.1: The evolution of the IS curve slope and the proportion of non-participants in the US: 1960:Q1 - 2015:Q1

Note: The green line represents the derivative of the output growth with respect to the real interest rate (the slope of the IS curve) at each point in time on the estimated sample. The violet dashed line shows the smoothed lambda parameter computed as a weighted average of the two regimes.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior distribution (mean, std)</th>
<th>Posterior distribution (Mode)</th>
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<tr>
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<table>
<thead>
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<th>IS slope</th>
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Table 4: Prior distribution and the mode of the parameters: EA case
References


