QUALITATIVE SURVEYS AND MARGINS OF ADJUSTMENT IN HETEROGENEOUS AGENT ECONOMIES

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Abstract. Frictions at the microeconomic level generate distortions to macroeconomic aggregates along the extensive and the intensive margin. How can we measure these margins and identify their interaction with aggregate fluctuations? This paper advocates the use of qualitative survey data. Credible measurement of distortions necessitates the use of restrictions that are consistent with a variety of mechanisms and naturally leads to loss of point identification. Survey data can be used to tighten the identified set and separately identify the two margins. The paper provides a formal treatment both at the partial and general equilibrium level. Using the Business and Consumer Survey collected by the European Commission, I identify distortions due to consumer and firm financial frictions in the Spanish economy and provide decompositions of the margins of adjustment. Preliminary results suggest that most of the adjustment during the financial crisis happened through the intensive margin while aggregate consumption and investment distortions operated through production e.g. through endogenous total factor productivity losses.

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1. Introduction

During the last three decades, the literature on heterogeneous agent models has explored various types of frictions and heterogeneity which can successfully explain several stylized facts obtained from firm and household level data. While very recent advances have made it possible to evaluate the business cycle implications of agent heterogeneity (i.e. Ahn, Kaplan, Moll, Winberry, and Wolf (2017); Challe, Matheron, Ragot, and Rubio-Ramirez (2017)), the mapping from primitives to outcomes is arguably complex and model dependent.

Conclusions based on models akin to the Aiyagari-Huggett-İmrohoroğlu (incomplete markets) type depend on assumptions such as the type and degree of heterogeneity present in the economy or the nature of idiosyncratic risk (Buera and Moll, 2015).

A closely related question is what kind of data or moments are informative both for estimating and evaluating heterogeneous agent models. The predominant approach is to match some features of the agents' invariant distribution to its empirical counterparts e.g. features of the wealth or earnings distribution at a particular point in time. A recent strand of the literature [1] has advocated a sufficient statistic approach to compute the impact effect of a policy shock in economies that only feature idiosyncratic risk by plugging-in microeconomic estimates of the marginal propensities to consume. The environment becomes slightly more complex once we admit that aggregate shocks can also alter the way idiosyncratic risk matters.

This paper strives for a better understanding of the *empirical* implications of the interactions between heterogeneity and frictions. Although similar in spirit to the literature on incorporating microeconomic information in macroeconomic models, it asks a different question: what kind of aggregated microeconomic information could be informative about the effects of frictions on aggregate fluctuations and vice versa?

This paper advocates the use of qualitative survey data and in particular surveys that ask firms and consumers directly about their current and expected future financial constraints on consumption investment and production. Using a semi-structural approach, I show that qualitative survey data provide critical information that would otherwise require a well specified heterogeneous agent model

[1]See Farhi and Werning (2016); Auclert, Rognlie, and Straub (2018); Auclert (2017) for a partial and a general equilibrium setting and Chetty (2009) for a review of the sufficient statistics approach to program evaluation.

to uncover[2]. I analyze both the limited information case of distortions to optimality conditions and the "full information" case of distortions in the aggregate law of motion.

Frictions such as market incompleteness generate distortions to macroeconomic aggregates along two dimensions: the extensive and the intensive margin[3]. I argue that aggregated qualitative surveys provide a direct measure of the extensive margin, which allows us to identify the intensive margin as well. Moreover, since we do not use the full model to uniquely pin down the mechanism, we are only able to set identify the parameters of the benchmark representative agent model and the resulting wedges. Qualitative survey data contribute to estimating these wedges more precisely by shrinking the identified set.

Moving from wedges in optimality conditions to distortions in the aggregate law of motion requires slightly stronger assumptions. While this paper is not about constructing precise mappings from *particular* heterogeneous agent economies to wedges in the equilibrium prices and quantities, it illustrates that under the assumption that aggregate wedges will only depend -to a first order approximation - on the aggregate state variables, there is a precise mapping between wedges in the optimality conditions and wedges in the equilibrium law of motion [4].

This existence result allows me to semi-parametrically identify the margins of adjustment in macroeconomic variables due to frictions and their interaction with aggregate shocks. The identified margins provide semi-structural evidence on the relative importance of different channels through which (financial) frictions at the microeconomic level can affect macroeconomic outcomes. More importantly, *qualitative surveys* are able to capture idiosyncratic effects of frictions at the extensive margin in a disciplined but not model driven way. The identified effects can then be potentially used to judge the performance of fully fledged heterogeneous agent models as they are less model dependent.

The paper contributes to different strands of the literature. The first strand is related to the intricacies of parameter calibration/identification in representative agents models when the data

[2]The underlying assumption is that aggregated surveys are not systematically biased. This is likely to be true for two reasons. First, due to their qualitative nature, survey data that ask subjects about their status rather than their precise income are much more robust to measurement error. Second, since this data is aggregated, the effect of individual misreporting becomes much less important.

[3]For example, the distribution of the marginal propensities to consume is affected by both margins.

[4]Chari, Kehoe, and McGrattan (2007), CKM hereafter, compute wedges in the optimality conditions of a frictionless model for a given set of calibrated parameters that produce the same equilibrium allocations in economies with specific parametric choices for the frictions. I also take the frictionless representative agent model as a benchmark but contrary to CKM I map the wedge in the optimality conditions to wedges in the decision rules.

is in fact generated by heterogeneous agent economies. Browning, Hansen, and Heckman (1999) argue that the mapping from parameterizations in aggregate macroeconomic models to parameters identified using microeconomic data is complicated by aggregation and sample selection issues[5], casting doubt on the whole endeavor of calibrating parameters using microeconomic studies. In similar vein, Guvenen (2006) finds that estimates of the elasticity of intertemporal substitution (EIS) using aggregate consumption data reflects the behaviour of poorer agents who have a high EIS while Constantinides and Duffie (1996) find that in a no trade equilibrium, estimates of risk aversion are biased due to cross sectional heterogeneity. Chang, Kim, and Schorfheide (2013) find that preference and technology parameters are not invariant to policy when heterogeneity is ignored.

The empirical strategy of this paper controls for heterogeneity and delivers the set of macroeconomic estimates that are consistent with it, and accounts for the the lack of policy invariance. Moreover, qualitative survey data control for the extensive margin of adjustment whose variation would otherwise by absorbed by the structural parameters, bridging the gap between micro and macro elasticities.

In the representative agent macro-econometric literature, survey data are typically linked to model based random variables using additional observation equations with additive measurement error (see e.g. Del Negro and Schorfheide (2013)). In this paper, I link qualitative survey data to the objective beliefs of agents in the model.

This paper also belongs to the strand of the macroeconometric literature that deals with set identification in structural macroeconomic models (e.g. Lubik and Schorfheide (2004); Coroneo, Corradi, and Santos Monteiro (2011)) and the literature on applications of moment inequality models, see Pakes, Porter, Ho, and Ishii (2015); Ho and Rosen (2017) and references therein. Moment inequality restrictions have been used to characterize frictions in specific markets, see for example Luttmer (1996) and Chetty (2012). The approximation to the HA model can also generate moment inequality restrictions for aggregate variables that nest both the representative agent case and deviations from it. To my knowledge, this is the first paper that characterizes the relationship between wedges in dynamic equilibrium models and these moment inequality restrictions.

[5]Popular examples include labour supply where most of the variation is on the extensive margin, pooling agents of different risk classes and demographic groups etcetera.

Using the Business and Consumer Survey collected by the European Commission, I identify distortions due to consumer and firm financial frictions in the Spanish economy and provide decompositions of the margins of adjustment. Preliminary results suggest that most of the adjustment during the financial crisis happened through the intensive margin while aggregate consumption and investment distortions operated through production e.g. through endogenous total factor productivity losses.

The rest paper is organized as follows. In Section 2 provides an extended analysis of the methodology in a *partial equilibrium* context. In Section 3 introduces the benchmark two asset heterogeneous agent model, the first order approximation and the corresponding empirical implications of financial frictions in the form of restrictions on collateralized borrowing. Section 4 analyzes the use of aggregated qualitative surveys and the corresponding empirical restrictions, while Section 5 provides the corresponding identification analysis based on the Generalized Method of Moments (GMM) framework. Section 6 deals with the full information case and provide the result on the relation between wedges in the optimality conditions and the decision rules. Section 7 presents the empirical application and Section 8 concludes. Appendix A contains the proofs and more information on the treatment of balance statistics for aggregated surveys.

Finally, a word on notation. Tsignifies the length of both the aggregate and average survey data, and L the number of agents. $\theta \in \Theta$ signifies the parameters of interest with Θ_{α}^{CS} the corresponding $1-\alpha$ level confidence set, and by $q_j(;\theta)$ a measurable function. Bold capital letters e.g. $\mathbf{Y}^{\tau}$ denote a matrix containing observations of vector Y_t up to time τ, $\{Y_j\}_{j\leqslant\tau}$. $\mathcal{N}(\mu,\sigma^2)$ is the Normal distribution, with probability density and cumulative density functions $\varphi_{(\mu,\sigma^2)}(.)$ and $\Phi_{(\mu,\sigma^2)}(.)$ respectively; $||.||$ is the Euclidean norm unless otherwise stated; $\perp$ signifies the orthogonal complement and $\varnothing$ the empty set.

2. Partial Equilibrium Distortions and Surveys

I first motivate this paper's approach by illustrating what can be learned from observing the behavior of a single household maximizing time separable lifetime utility. Assuming an instantaneous utility function $U(c_{i,t};\omega)$, where ω signifies preference related parameters, the household receives a random exogenous endowment $y_{i,t}$ and makes consumption-savings decisions $(c_{i,t}, s_{i,t})$ taking prices as given. As in Zeldes (1989), wealth $w_{i,t}$ earns a riskless return $R = 1 + r$ and there is a borrowing limit at zero. The household solves the following problem:

$$\begin{aligned}
& \max_{\{c_{i,t},w_{i,t+1}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_{i,t};\omega) \\
s.t. \quad y_{i,t} &= s_{i,t} + c_{i,t} \\
a_{i,t+1} &= (1+r)a_{i,t} + s_{i,t} \\
c_{i,t}, a_{i,t} &\geqslant 0, \forall t
\end{aligned}$$

Denoting the marginal utility of consumption by $U'(c_{i,t};\omega)$, the consumption Euler equation is distorted by the non-negative Lagrange multiplier on the occasionally binding liquidity constraint, denoted by $\lambda_{i,t}$, which is positive when the borrowing constraint is binding :

$$U'(c_{i,t};\omega) = \beta(1+r)\mathbb{E}_t U'(c_{i,t+1};\omega) + \lambda_{i,t} \tag{1}$$

Given this setup, what is unknown and could be potentially learned from cross sectional data is the preference parameters (β, ω) and the multiplier $\lambda_{i,t}$, which is an endogenous variable. There are of course alternative ways of achieving this. For example, one can split the sample into unconstrained and hand to mouth households using some criterion as in the seminal work of Zeldes (1989) [6]. Different choices can lead to different sample selection and thus different conclusions on whether liquidity constraints are present. The alternative way is a structural treatment which amounts to writing down an estimated income process and derive optimal consumption. One would therefore need to place much more belief on the technology of the borrowing constraint which in this case is a hard constraint at zero, and the nature of idiosyncratic income risk.

An arguably more credible way to identify (β, ω) is to use a more general implication of borrowing constraints, which would be true across models with different types of heterogeneity, insurance mechanisms and borrowing limit technologies, and would give rise to different specifications for $\lambda_{i,t}$. This general implication is that liquidity constraints generate a positive discrepancy between todays

[6] Zeldes (1989) uses a cut-off rule for end of period financial wealth at zero and discusses different rules that could have been used, as well as liquidity constraints arising from credit market imperfections and illiquid assets as e.g. in Pissarides (1978). The importance of illiquid assets has been recently revived by the heterogeneous agent literature, see for example Kaplan, Violante, and Weidner (2014) and references therein, where they also identify groups of liquid and illiquid hand to mouth consumers using different rules.

and tomorrows marginal utility of consumption, as the household cannot smooth consumption as much as it desires[7].

Whether $\lambda_{i,t}$ is positive or not depends on the household's expectations about the future. Consequently, condition (1) is a conditional moment inequality. Using $y_{i,t}$ as an instrument, the following unconditional moment inequality holds:

$$\mathbb{E}\left[(U'(c_{i,t};\omega) - \beta(1+r)U'(c_{i,t+1};\omega))y_{i,t}\right] \;\; \geqslant \;\; 0 \tag{2}$$

Given the inequality, there is no unique vector of preference parameters (ω, β) that satisfies it, and we therefore no longer have point identification. The latter is of course the price one has to pay for not exploiting the information given by a full model. In order to derive explicit identification regions, I adopt the approximation of Hall (1978) using $U(c_{i,t};\omega) := \frac{c_{i,t}^{1-\omega}-1}{1-\omega}$, which implies the following law of motion for consumption:

$$c_{i,t+1} \;\; = \;\; \rho_\mu c_{i,t} + \epsilon_{i,t+1} + \tilde{\lambda}_{i,t} \tag{3}$$

where $\tilde{\lambda}_{i,t} \equiv -(U''(c_{i,t};\omega))^{-1}\lambda_{i,t}$, $U''(c_{i,t};\omega)$ is the second derivative of the utility function and $\epsilon_{i,t+1}$ is the rational forecast error such that $\mathbb{E}_t\epsilon_{t+1} = 0$.

Since ρ_μ may exceed one if $\beta(1+r) > 1$ and vice versa [8], I re-express 3 in terms of consumption growth,

$$\Delta c_{i,t+1} = \tilde{\rho}_\mu c_{i,t} + \epsilon_{t+1} + \tilde{\lambda}_{i,t}$$

where $\tilde{\rho}_\mu := \rho_\mu - 1$. Using income $y_{i,t}$ as an instrument, the identified set for ρ_μ is :

$$\rho_{\mu,ID,1} \;\; := \;\; \left(0, 1 + \frac{Cov(y_{i,t}\Delta c_{i,t+1})}{Cov(y_{i,t}c_{i,t})}\right] \tag{4}$$

As we can readily see from (4), the inherent unobservability of $\tilde{\lambda}_{i,t}$ is the root of the loss of point identification of ρ_μ. Avoiding to take a stance on the exact nature of $\lambda_{i,}$, which can involve a vast amount of unobserved information results in set identification. Nevertheless, we are still able to infer certain facts about the household's preferences and economic behavior and conclusions are valid across alternative environments.

[7]Similar restrictions arise in the context of limited commitment and endogenous solvency constraints as in Alvarez and Jermann (2015).

[8]In fact, ρ_μ is equal to $(\beta(1+r))^{-\frac{U'(c_{i,t};\omega)}{c_{i,t}U''(c_{i,t};\omega)}} > 0$, and is constant under CRRA utility.

Informative Bounds on Risk Aversion and ex-ante Measures of Consumption Loss.

Given $\rho_{\mu,ID}$ we can recover the implied identified set for the risk aversion parameter, ω_{ID}. As is typical in the empirical macro literature, (r,β) are not identified from the dynamic properties of the model but rather from other information, i.e steady states. In the case when $\beta(1+r)=1$, risk aversion is unidentified ($\omega_{ID}=\mathbb{R}^+$), as consumption follows a random walk. If $\beta(1+r)\neq 1$, then risk aversion is set identified and has a very intuitive interpretation, as it reflects restrictions on preferences implied by the presence of non-diversifiable income risk. Using (4) and $\beta(1+r)<1$, the household is impatient and does not accumulate wealth indefinitely. Since income and consumption growth are negatively correlated, which is usually the case when liquidity constraints are present (Deaton, 1991), risk aversion is bounded by above and the set of values consistent with the data is as follows:

$$\omega_{ID,1}=\left\{\omega\in\mathbb{R}^+ : \omega<\frac{\|\log(\beta(1+r))\|}{\log Cov(y_{i,t}c_{i,t})-\log\left(Cov(y_{i,t}c_{i,t})-\|Cov(y_{i,t}\Delta c_{i,t+1})\|\right)}\right\}$$

The stronger the negative correlation, the lower the upper bound on risk aversion, indicating that the less risk averse household is not accumulating enough wealth to fully insure against income risk. On the contrary, weak negative correlation permits higher estimates of risk aversion. Similar to Arellano, Hansen, and Sentana (2012), the degree of under-identification depends on this correlation, which is itself a function of (ω,β,r).

In terms of examining the implications of incomplete markets, one can use $\rho_{\mu,ID,1}$ to identify the range of consumption losses due to incomplete markets. Studying directly the implications for consumption is consistent with our agnostic view on the mechanisms generating the liquidity constraints, and is further motivated by the fact that there is a multiplicity of mechanisms that can at least provide partial insurance and no structural model can do a fair job in accurately describing the totality of these complex interactions[9]. Towards this end, bounds $(\underline{\rho}_{\mu,ID},\bar{\rho}_{\mu,ID})$, can be used to construct (interval) estimates of distortions in consumption growth implied by liquidity constraints by plugging-in the identified set and averaging over the observations. In population, this produces an identified set for distortions:

$$\mathbb{E}\lambda_{i,t}\ \in\ \left[\mathbb{E}(c_{i,t+1}-\bar{\rho}_{\mu,ID}c_{i,t}),\mathbb{E}(c_{i,t+1}-\underline{\rho}_{\mu,ID}c_{i,t})\right] \tag{5}$$

[9]This observation dates back to Deaton (1997) and has motivated structural and semi-structural studies on quantifying the degree of risk sharing, see for example Blundell, Pistaferri, and Preston (2008) and Heathcote, Storesletten, and Violante (2014).

An interesting question, which is also the main point of this paper in an aggregate context, is whether qualitative data can be informative about risk aversion and consumption behaviour in general. The answer is affirmative.

The role of Qualitative Data. Suppose now that we observe the dichotomous response of the household over time to a survey question that asks whether the household is (or expects to be) financially constrained. An honest household will answer positively whenever $\lambda_{i,t} > 0$.

Had we known the mechanism that generates this distortion to consumption we could easily control for the occasionally binding constraint by including the interaction term $\tilde{\chi}_{i,t} g(x_{i,t})$ where $g(x_{i,t})$ is the parametrized distortion which is a function of cash on hand $x_{i,t} := y_{i,t} + (1+r)a_{i,t}$. This would restore point identification of ρ_μ, ω and $\mathbb{E}\lambda_{i,t}$. I instead examine what can be learned from these observations without explicit knowledge of $g(x_{i,t})$. The time series of responses $\{\tilde{\chi}_{i,t}\}_{t \leqslant N}$ for $\tilde{\chi}_{i,t} \equiv \mathbf{1}('\lambda_{i,t} > 0')$ can be used to estimate $\mathbb{P}_t(\lambda_{i,t} > 0)$ by using e.g. a probit model[10]. Therefore, the conditional probability distribution of $\Delta c_{i,t+1}$, $\mathbb{P}_t(\Delta c_{i,t+1} < v)$ for $v \in \mathbb{R}$ is equal to:

$$\mathbb{P}_t(\epsilon_{i,t+1} < v - \tilde{\rho}_\mu c_{i,t})\mathbb{P}_t(\lambda_{i,t} = 0) + \mathbb{P}_t(\epsilon_{i,t+1} < v - \tilde{\rho}_\mu c_{i,t} - \lambda_{i,t})\mathbb{P}_t(\lambda_{i,t} > 0) \tag{6}$$

For $\epsilon_{t+1} \sim N(0, \sigma_\epsilon^2)$, (6) simplifies further to,

$$\Phi_{0,\sigma_\epsilon^2}(v - \tilde{\rho}_\mu c_{i,t})\mathbb{P}_t(\lambda_{i,t} = 0) + \Phi_{0,\sigma_\epsilon^2}(v - \tilde{\rho}_\mu c_{i,t} - \lambda_{i,t})\mathbb{P}_t(\lambda_{i,t} > 0) \tag{7}$$

A key observation is that the distortion $\lambda_{i,t}$ is positive only when the state variables $(a_{i,t}, y_{i,t})$ lie in a particular area of their domain $\mathcal{A}$ which is determined by an unknown threshold (w_i^*, y_i^*), e.g. $\mathcal{A} := \{(a_{i,t}, y_{i,t}) \in \mathbb{R}^2 : a_{i,t} \leqslant w_i^* \wedge y_{i,t} \leqslant y_i^*\}$. A *complete* model would pin down, analytically or numerically this domain. Observing $\tilde{\chi}_{i,t}$ dispenses us with the need to characterize $\mathcal{A}$ (or equivalently the corresponding part of the domain $x_{i,t}$).

In order to analyze the implications of observing $\tilde{\chi}_{i,t}$, I next characterize the form of $\lambda_{i,t}$ had it been generated by the model with the hard constraint at zero. For analytical tractability, I approximate consumption in incomplete markets by a piecewise function. When the household is constrained, $c_{i,t}^{inc,con} = x_{i,t}$ while when income is not autocorrelated, unconstrained consumption

[10]Note that contrary to $g(x_{i,t})$, which can involve kinks and other nonlinearities, $\mathbb{P}_t(\lambda_{i,t} > 0)$ is much simpler to characterize as the budget constraint is by construction linear in $x_{i,t}$, and the distribution of any unobserved components of $x_{i,t}$ can be modeled using i.e. a mixture of distributions: $\mathbb{P}_t(\lambda_{i,t} > 0) = \mathbb{P}_t(x_{i,t} < x^\star)$ where $x^\star$ is constant by construction.

is equal to $c_{i,t}^{inc,unc} = \frac{(1+r-\rho_\mu)}{1+r} x_{i,t}$. The latter is parallel to the perfect foresight solution, $c_{i,t}^{pf} = (1+r-\rho_\mu)a_{i,t} + \frac{1+r-\rho_\mu}{1+r}(y_{i,t} + \frac{\bar{y}}{r}) = \frac{(1+r-\rho_\mu)}{1+r}(x_{i,t} + \frac{\bar{y}}{r})$ where $\frac{(1+r-\rho_\mu)}{1+r}\frac{\bar{y}}{r}$ can be interpreted as the share of permanent income ($\bar{y} \equiv \mathbb{E} y_{i,t}$) that is precautionary savings[11].

In the appendix, I show that consumption growth under incomplete markets can be written as follows:

$$\begin{aligned} \Delta c_{i,t+1}^{inc} &= \tilde{\rho}_\mu c_{i,t} + \epsilon_{t+1} + \mathbf{1}(\lambda_{i,t} > 0)\left(-\rho_\mu c_{i,t} + \bar{y}\left(1 - \frac{\rho_\mu}{1+r}(1 - F_y(x^\star))\right)\right) \\ &:= \tilde{\rho}_\mu c_{i,t} + \epsilon_{t+1} + \mathbf{1}(\lambda_{i,t} > 0)\left(\lambda_1 c_{i,t} + \lambda_0\right) \end{aligned}$$

Therefore, substituting $\lambda_{i,t}$ in (7), yields the following restriction[12]:

$$\begin{aligned} \mathbb{P}_t(\Delta c_{i,t+1} < v) &= \Phi_{0,\sigma_\epsilon^2}(v - \tilde{\rho}_\mu c_{i,t})\mathbb{P}_t(\lambda_{i,t} = 0) + \Phi_{0,\sigma_\epsilon^2}(v - (\tilde{\rho}_\mu + \lambda_1)c_{i,t} - \lambda_0)\mathbb{P}_t(\lambda_{i,t} > 0) \\ &\leqslant \Phi_{0,\sigma_\epsilon^2}(v - \tilde{\rho}_\mu c_{i,t})\mathbb{P}_t(\lambda_{i,t} = 0) + \Phi_{0,\sigma_\epsilon^2}(v - \tilde{\rho}_{\mu,ols} c_{i,t})\mathbb{P}_t(\lambda_{i,t} > 0) \end{aligned} \tag{8}$$

where $\tilde{\rho}_{\mu,ols}$ is the least squares estimate when regressing consumption growth on past consumption, that is:

$$\tilde{\rho}_{\mu,ols} = \tilde{\rho}_\mu + \underbrace{\left(\frac{\mathbb{E} c_{i,t}^2 \mathbb{P}_t(\lambda_{i,t} > 0)}{\mathbb{E} c_{i,t}^2}\right)\lambda_1}_{\text{Bias from Incomplete Markets}} := \tilde{\rho}_\mu + p\lambda_1$$

I now ask: How does this additional restriction refine the identified set in (4)?. Denote by $\rho_{\mu,ID,2}$ the set of ρ_μ consistent with the unconditional moment inequality constructed using $y_{i,t}$ and (8). The simplest way to show the refinement of (4) is to show that there exists a $\rho_\mu \in \rho_{\mu,ID,1}$ that does not belong to $\rho_{\mu,ID,2}$. In the appendix, I show that using $\rho_{\mu,ols}$ as the test point, (8) is not satisfied when

$$\mathbb{P}_t(\lambda_{i,t} > 0) \in (g_t, 1) \tag{9}$$

where $g_t := \frac{\Phi(v - \tilde{\rho}_\mu c_{i,t}) - \Phi(v - \tilde{\rho}_{\mu,ols} c_{i,t})}{\Phi(v - \tilde{\rho}_\mu c_{i,t}) - \Phi(v - \lambda_0 - (\tilde{\rho}_\mu + \lambda_1)c_{i,t})}$.

To gain intuition, consider the extreme cases where $\mathbb{P}_t(\lambda_{i,t} > 0)$ is zero or one. Condition (9) becomes invalid as $(0,1)$ and $(1,1)$ do not contain $\mathbb{P}_t(\lambda_{i,t} > 0)$. This was nevertheless expected, as in either case, additional survey information is redundant. In the intermediate case in which

[11] Please see Figure 8.

[12] The inequality in (8) uses that $p \in (0,1)$ and $\lambda_0 > 0$, the latter being true when the agent is impatient $\beta(1+r) < 1$, and this is the case in which liquidity constraints matter.

liquidity constraints are occasionally binding, survey information matters as long as (9) is a proper interval. As we show in the Appendix, this will be the case as long as $v < \tilde{\rho}_{\mu,ols} c_{i,t}$, which implies that g_t is concave in $\mathbb{P}(\lambda_{i,t} > 0)$. We plot below an example of such a case. What is evident is that for higher values of λ_1, i.e. $2\lambda_1$, concavity increases, and the admissible range (grey shade) becomes larger. The more severe the distortions, the more likely is (in an unconditional sense) that additional information matters. Conversely, in the frictionless limit, $g_t \underset{\lambda_1 \to 0}{\to} \mathbb{P}_t(\lambda_{i,t} > 0)$, contradicting (9). As evident, quality survey data can provide additional information that can help narrow down the set of plausible values for the reduced form parameter ρ_μ, and therefore ω.

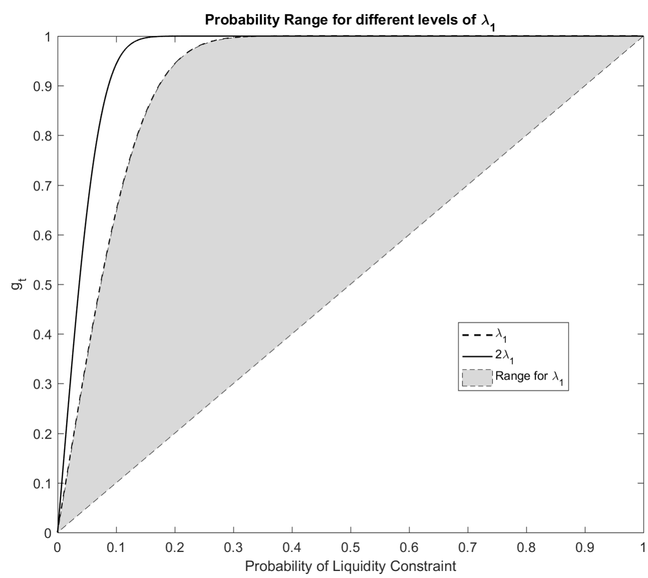

FIGURE 1. Range for $v = 0, c_{i,t} = 1, r = 0.05, \sigma_\epsilon = 0.1$

Sharper estimates of ω imply sharper estimates of the consumption loss (5) as well. While this is an important result in itself, qualitative data on constraints are actually even more informative. When $\chi_{i,t}$ varies over time, $\mathbb{E}(c_{t,t+1} - \rho_\mu c_{i,t})$ underestimates the level of distortions, as it identifies the total effect $\mathbb{P}(\lambda_{i,t} > 0)\mathbb{E}(\lambda_{i,t}|\lambda_{i,t} > 0)$ rather than the adjustment on the intensive margin, $\mathbb{E}(\lambda_{i,t}|\lambda_{i,t} > 0)$. Since survey data can be used to estimate $\mathbb{P}(\lambda_{i,t} \neq 0)$, the intensive margin can be separately identified. This is important as a policy maker may not weigh equally a low probability-high consumption loss and a high probability-small consumption loss. This will be even more important when we consider aggregate fluctuations in the next section, as under ergodicity this probability will describe the mass of agents that are affected by financial frictions over time.

The rest of the paper characterizes the case for general equilibrium models and what information aggregated qualitative surveys can provide, based on similar assumptions to those made in the simple example. To do so, I provide below the benchmark general equilibrium model.

3. An Approximate Heterogeneous Agent Model

To illustrate the restrictions implied from market incompleteness in general equilibrium I consider a two asset economy where households can save in capital as well as in bonds. Positive capital holdings makes households effective entrepreneurs, who are akin to intermediate producers facing a downward sloping demand curve. Moreover, aggregate output is a CES aggregate of intermediate goods. I first present the frictionless model where I will demonstrate that heterogeneity is not of first order importance. However, this will not be true in an economy with frictions. In the rest of the paper I denote by $\Lambda_t(i)$ the cross sectional distribution of agents across state variables at time t[13], and the corresponding aggregate variables by capital letters i.e. $X_t \equiv \int x_{i,t} d\Lambda_t(i)$. Similarly, I define by $\Lambda_{t,t+1}(i)$ to be the joint distribution of individual states at time t and $t+1$.

3.1. **The Frictionless Model.**

3.1.1. *Household-Entrepreneurs and Aggregate Output.* Under monopolistic competition in the intermediate goods sector, the supply side has a standard formulation. The final good firm chooses aggregate and firm specific output $(Y_t, y_{i,t})$ to maximize profits $P_t Y_t - \int p_{i,t} y_{i,t} d\Lambda_t(i)$ subject to a CES aggregate constraint, $Y_t^{\frac{\epsilon-1}{\epsilon}} = \int y_{i,t}^{\frac{\epsilon-1}{\epsilon}} d\Lambda_t(i)$, leading to a downward sloping demand curve for each firm i, $y_{i,t} = \left(\frac{p_{i,t}}{P_t}\right)^{-\epsilon} Y_t$.

The problem solved by the effective entrepreneur $(k_{i,t} > 0)$, is to hire labour $(l_{i,t}^d)$ to minimize the cost of production $W_t l_{i,t}^d$ subject to producing a certain level of output $(z_{i,t} k_{i,t})^{\alpha} (l_{i,t}^d)^{1-\alpha} \geqslant y_{i,t}$. This yields nominal labour costs equal to $W_t l_{i,t}^d = (1-\alpha)\theta_i y_{i,t}$ where $(1-\alpha)\theta_i$ has the interpretation of marginal cost[14]. Correspondingly, output at the optimal choice of labour is equal to $y_{i,t} = z_i k_i \theta_{i,t}^{\frac{1-\alpha}{\alpha}} \zeta_t$ where $\zeta_t \equiv \left(\frac{1-\alpha}{W_t}\right)^{\frac{1-\alpha}{\alpha}}$ and the indirect profit function is $pr_{i,t} = y_{i,t}(p_{i,t} - (1-\alpha)\theta_{i,t})$. Moreover, it can be shown that $p_{i,t} = \frac{\epsilon}{\epsilon-1}\theta_{i,t}$, that is, the entrepreneur prices $y_{i,t}$ at a constant mark-up over marginal cost. Thus, aggregate labour costs can be rewritten as $W_t L_t = (1-\alpha)\frac{\epsilon-1}{\epsilon} P_t Y_t$.

[13] For example, in Section 2 the relevant state variables are $y_{i,t}$ and $a_{i,t}$, and thus $\Lambda_t(i)$ denotes the joint distribution function at time t, $\mathbb{P}_t(y_{i,t} \leqslant y, a_{i,t} \leqslant a)$. In this section, the joint distribution is $\mathbb{P}_t(z_{i,t} \leqslant y, k_{i,t} \leqslant k)$.

[14] As usual, θ_i is the multiplier on the output constraint.

3.1.2. *Households.* Dynastic households decide over consumption, working hours and total net worth to be carried over to the next period, $(c_{i,t}, l^s_{i,t}, a_{i,t+1})$. In turn, $a_{i,t}$ is split between bonds $b_{i,t}$ earning a gross interest rate R_t and capital $k_{i,t}$, earning a gross return $R^k_{i,t+1}$. Individual investment decisions $(\iota_{i,t})$ increase the availability of capital for next period, up to a certain level of depreciation. Gross individual income is therefore equal to $\bar{y}_{i,t} = W_t l_{i,t} + (1-\delta)k_{i,t} + pr_{i,t}$. If $k_{i,t} = 0$, the household-worker receives only labour income. The household's decision problem is therefore as follows:

$$\max_{\{y_{i,t},k_{i,t+1},w_{i,t+1},\iota_{i,t}\}_1^\infty} \mathbb{E}_0 \sum_{t=1}^{\infty} \beta^t \left(\frac{c_{i,t}^{1-\omega}-1}{1-\omega} - \frac{l_{i,t}^{1+\eta}}{1+\eta} \right)$$

$$\begin{aligned}
s.t. \quad a_{i,t+1} &= R_t w_{i,t} + \bar{y}_{i,t} - P_t c_{i,t} \\
a_{i,t+1} &= P_t k_{i,t+1} + w_{i,t+1} \\
\bar{y}_{i,t} &= W_t l_{i,t} + (1-\delta) P_t k_{i,t} + pr_{i,t} \\
k_{i,t+1} &= (1-\delta) k_{i,t} + \iota_{i,t} \\
k_{i,t+1} &\geqslant 0
\end{aligned}$$

The corresponding first order conditions are as follows :

$$\begin{aligned}
c_{i,t}^{-\omega} &= \beta \mathbb{E}_t c_{i,t+1}^{-\omega} R^k_{i,t+1} - v_{i,t} \\
c_{i,t}^{-\omega} &= \beta \mathbb{E}_t c_{i,t+1}^{-\omega} \pi_{t+1}^{-1} R_{t+1} \\
l_{i,t}^{\eta} &= \frac{W_t}{P_t} c_{i,t}^{-\omega} \\
v_{i,t} k_{i,t+1} &= 0
\end{aligned}$$

which implies that:

$$v_{i,t} = \beta \mathbb{E}_t c_{i,t+1}^{-\omega} \left(R^k_{i,t+1} - \pi_{t+1}^{-1} R_{t+1} \right)$$

where $v_{i,t}$ is the multiplier on the non-negativity constraint on $k_{i,t}$, $R^k_{i,t+1} = (1-\delta) + \frac{\partial pr_{i,t+1}}{\partial k_{i,t+1}} \frac{1}{P_{t+1}}$ and $\pi_{t+1} = \frac{P_{t+1}}{P_t}$. If $z_{i,t}$ is highly autocorrelated, then bad productivity realizations can induce the household to hit the non-negativity constraint $(v_{i,t} > 0)$. For example, under perfect competition marginal profit is increasing in $z_{i,t}$ and thus there exists a threshold $z^\star$ below which it is optimal for the household to not hold any capital stock and only receive a working wage and save in bonds.

Note also that we have not assumed any borrowing limits and thus workers can effectively save to self insure against idiosyncratic risk.

3.2. **Approximation, Aggregation and Equilibrium.** To facilitate the analysis, I proceed by approximating individual marginal utility around the marginal utility of the representative agent:

$$c_{i,t}^{-\omega} \approx C_t^{-\omega} - \omega C_t^{-\omega-1}(c_{i,t} - C_t) + \frac{\omega(\omega+1)}{2} C_t^{-\omega-2}(c_{i,t} - C_t)^2$$

If markets are complete, then expected marginal utility growth is equalized across agents, $\mathbb{E}_t \left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{-\omega} = \mathbb{E}_t \left(\frac{c_{j,t+1}}{c_{j,t}}\right)^{-\omega}$. This implies that individual consumption is proportional to aggregate consumption, $c_{i,t} = c_i C_t$ and cross sectional variation becomes time invariant as

$$\int c_{i,t}^{-\omega} \Lambda_t(i) = C_t^{-\omega} \left(1 + \frac{\omega(\omega+1)}{2} \int (c_i - 1)^2 d\Lambda_t(i) + o(1)\right)$$

and the representative agent approximation becomes exact:

$$C_t^{-\omega} \quad = \quad \beta \mathbb{E}_t C_{t+1}^{-\omega} \pi_{t+1}^{-1} R_{t+1}$$

With regard to the first order condition for capital, multiplying by $k_{i,t+1}$, applying the same approximation to marginal utility and aggregating using $\Lambda_{t+1}(i)$ yields that[15]:

$$C_t^{-\omega} K_{t+1} \quad = \quad \beta \mathbb{E}_t C_{t+1}^{-\omega} \int R_{i,t+1}^k k_{i,t+1} d\Lambda_{t+1}(i)$$

where $\int R_{i,t+1}^k k_{i,t+1} d\Lambda_{t+1,t}(i) = (1-\delta)K_{t+1} + \int \frac{\partial pr_{i,t}}{\partial k_{i,t}} k_{i,t} d\Lambda_{t+1}(i) \frac{1}{P_{t+1}} = (1-\delta)K_{t+1} + \alpha(1 + \frac{1-\alpha}{\alpha\epsilon})Y_{t+1}$. Since K_{t+1} is determined at time t,

$$C_t^{-\omega} \quad = \quad \beta \mathbb{E}_t C_{t+1}^{-\omega} \left((1-\delta) + \alpha \left(1 + \frac{1-\alpha}{\alpha\epsilon}\right) \frac{Y_{t+1}}{K_{t+1}}\right)$$

When $\epsilon \to \infty$, this condition is isomorphic to the condition obtained in a representative agent model where aggregate production is Cobb- Douglas and $\frac{Y_{t+1}}{K_{t+1}}$ is the marginal product of capital (and profits disappear).

[15]The same result goes through if we keep the second order approximation for marginal utility, integrate using the joint distribution $\mathbb{P}_t(z_{i,t} \leqslant z, k_{i,t} \leqslant k)$ and then set higher order moments to zero.

Regarding aggregate output, integrating over $pr_{i,t}$ and solving for Y_t, $Y_t = \frac{W_t}{P_t} L_t \frac{\epsilon-1}{\epsilon}(1-\alpha)$. Moreover, integrating the firm revenue function and solving for Y_t yields

$$Y_t = \left(\int z_i k_i \left(\frac{p_{i,t}}{P_t} \right)^{\frac{1}{\alpha}} d\Lambda_t(i) \right)^{\alpha} L_t^{1-\alpha}$$

Using that up to first order, $Y_t \approx \left(\int z_i k_i d\Lambda_t(i) \right)^{\alpha} L_t^{1-\alpha}$ and that $(z_{i,t}, k_{i,t})$ are conditionally independent, the aggregate production function is also of Cobb-Douglas form.

Finally, using the first order condition for hours worked under the same approximation for the marginal utility of consumption, aggregate labour supply is equal to $L_t = \left(\frac{W_t}{Pt}\right)^{\frac{1}{\eta}} C_t^{-\frac{\omega}{\eta}}$. Imposing equilibrium in the labour market implies that $\frac{\epsilon-1}{\epsilon}(1-\alpha)Y_t = \left(\frac{W_t}{Pt}\right)^{1+\frac{1}{\eta}} C_t^{-\frac{\omega}{\eta}}$.

Denoting by $\tilde{X}$ the percentage deviations of any aggregate variable X_t from aggregate steady state x_{ss}, the system of aggregate linearized equilibrium and market clearing conditions are standard:

$$\begin{aligned}
-\omega\tilde{C}_t - (1-\beta(1-\delta))\mathbb{E}_t\tilde{R}^k_{t+1} + \omega\bar{\mathbb{E}}_t\tilde{C}_{t+1} &= 0 \\
y_{ss}\tilde{Y}_t - c_{ss}\tilde{C}_t - i_{ss}\tilde{I}_t &= 0 \\
\tilde{K}_{t+1} - (1-\delta)\tilde{K}_t - \delta\tilde{I}_t &= 0 \\
\tilde{Y}_t - \alpha\tilde{Z}_t - \alpha\tilde{K}_t - (1-\alpha)\tilde{L}_t &= 0 \\
\tilde{R}^k_t - \alpha\tilde{Z}_t + (1-\alpha)\tilde{K}_t - (1-\alpha)\tilde{L}_t &= 0 \\
\tilde{W}_t - \omega\tilde{C}_t - \eta\tilde{L}_t &= 0 \\
\tilde{W}_t - \tilde{Y}_t + \tilde{L}_t &= 0
\end{aligned}$$

Using standard methods, one can obtain the aggregate decision rules for X_t, which will depend on predetermined capital stock $\tilde{K}_t$ and on aggregate conditional expectations on productivity for some j periods ahead, $\mathbb{E}_t\tilde{Z}_{t+j}$.

3.3. **When is heterogeneity of first order importance for aggregate fluctuations?** A repeated theme of the previous derivations is that heterogeneity was negligible to first order. The key assumption was obviously the lack of frictions. In this section I will show that, as expected, in the presence of frictions, heterogeneity matters to first order. In particular, wedges in the "representative agent" equilibrium conditions above vary according to an extensive and an intensive margin. In the previous section I considered only one source of heterogeneity, that of productivity. In this section, I consider an additional dimension of heterogeneity, that of investment efficiency. Both productivity and investment efficiency shocks, $z_{i,t}$ and $\eta_{i,t}$ respectively, can potentially affect aggregate consumption and investment through different channels[16].

Below, I consider a modification of the benchmark model that considers the interaction of these dimensions of heterogeneity together with a borrowing constraint on net worth [17]. The modified problem for the household is as follows:

$$\max_{\{y_{i,t},k_{i,t+1},w_{i,t+1},\iota_{i,t}\}_1^{\infty}} \mathbb{E}_0 \sum_{t=1}^{\infty} \beta^t \left(\frac{c_{i,t}^{1-\omega}-1}{1-\omega} - \frac{l_{i,t}^{1+\eta}}{1+\eta} \right)$$

$$\begin{aligned}
s.t. \quad a_{i,t+1} &= R_t w_{i,t} + \bar{y}_{i,t} - P_t c_{i,t} \\
a_{i,t+1} &= P_t \eta_{i,t} k_{i,t+1} + w_{i,t+1} \\
\bar{y}_{i,t} &= W_t l_{i,t} + (1-\delta) P_t \eta_{i,t} k_{i,t} + pr_{i,t} \\
k_{i,t+1} &= (1-\delta) k_{i,t} + \frac{\iota_{i,t}}{\eta_{i,t}} \\
k_{i,t+1} &\geqslant 0 \\
w_{i,t+1} &\geqslant -P_t \varphi_{i,t} k_{i,t+1}
\end{aligned}$$

where the first order conditions with respect to capital and bonds are as follows:

$$\begin{aligned}
\eta_{i,t} c_{i,t}^{-\omega} &= \beta \mathbb{E}_t c_{i,t+1}^{-\omega} R_{i,t+1}^k + v_{i,t} + \varphi_{i,t} \mu_{i,t} \\
c_{i,t}^{-\omega} &= \beta \mathbb{E}_t c_{i,t+1}^{-\omega} \pi_{t+1}^{-1} R_{t+1} + \mu_{i,t}
\end{aligned}$$

where $\mu_{i,t}$ is the multiplier on the occasionally binding borrowing constraint. Combining the two conditions, $\mu_{i,t}$ when non zero is equal to $\left(\beta \mathbb{E}_t c_{i,t+1}^{-\omega} \left(\frac{R_{i,t+1}^k - \eta_{i,t} \pi_{t+1}^{-1} R_{t+1}}{\eta_{i,t} - \varphi_{i,t}} \right) + \frac{v_{i,t}}{\eta_{i,t} - \varphi_{i,t}} \right)$. Since borrowing constraints can bind, household-workers or household-entrepreneurs are not perfectly insured, so consumption inequality is not negligible. To simplify notation, let $s_{i,t} \equiv (z_{i,t}, \eta_{i,t}, k_{i,t}, w_{i,t})$ and S_t be the vector that includes all aggregate information, including the distribution of $s_{i,t}$.

[16] Buera and Moll (2015) studied these channels in isolation and concluded that heterogeneity in productivity is the most likely form of heterogeneity as it leads to a fall in total factor productivity (TFP), as is often observed in recessions. Nevertheless, Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas Sanchez (2017) have argued that models of financial frictions that link TFP to financial frictions predict an increase in TFP after a financial liberalization episode, which is inconsistent with the experience of Southern Europe, including Spain.

[17] The way I specify the borrowing constraint does not affect the qualitative statements made for the distortions ; $\phi_{i,t}$ could in principle depend on the size of the firm $k_{i,t+1}$ as in Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas Sanchez (2017) or the market value of its capital stock, $(\eta_{i,t})$.

Aggregating the bond Euler equation using $p(s_{i,t}|S_t)$, and using that agent expectations are formed using $p(s_{i,t+1}, S_{t+1}|s_{i,t}, S_t)$, the approximate aggregated first order condition for bonds is equal to:

$$\Xi_t C_t^{-\omega} = \beta \mathbb{E}_t C_{t+1}^{-\omega} \pi_{t+1}^{-1} \Xi_{t,t+1} R_{t+1} + \int \mu_{i,t} d\Lambda_t(i) \tag{10}$$

where for $C_{t+1} \equiv \int c_{i,t+1} p(s_{i,t+1}|S_{t+1}, S_t) d(s_{i,t+1}, s_{i,t})$ and $C_t \equiv \int c_{i,t} p(s_{i,t}|S_t) d(s_{i,t})$, $\Xi_t \equiv 1 + \frac{\omega(\omega+1)}{2} C_t^{-2} Var_t(c_{i,t})$ and $\Xi_{t,t+1} \equiv 1 + \frac{\omega(\omega+1)}{2} C_{t+1}^{-2} Var_t(c_{i,t+1})$. Correspondingly, the approximate aggregate condition for the investment Euler equation is

$$\Xi_t C_t^{-\omega} = \beta \mathbb{E}_t C_{t+1}^{-\omega} \Xi_{t,t+1} \int R_{i,t+1}^k d\Lambda_t(i) + \int \mu_{i,t}^k d\Lambda_t(i) \tag{11}$$

where $\mu_{i,t}^k = \beta \mathbb{E}_t c_{i,t+1}^{-\omega} \left(\frac{((1-\eta_{i,t}+\varphi_{i,t}))R_{i,t+1}^k - \pi_{t+1}^{-1} R_{t+1}}{\eta_{i,t}-\varphi_{i,t}} \right) + \frac{v_{i,t}}{\eta_{i,t}-\varphi_{i,t}}$.

There are two important observations regarding distortions to the bond and capital investment Euler equations. First, $\mu_{i,t}$ is weakly positive by construction and therefore the aggregate distortion to the bond Euler equation, $\int \mu_{i,t} d\Lambda_t(i) \equiv \int \mu_{i,t} p(s_{i,t|S_t}) d(s_{i,t})$, will be a weakly positive random variable as well. Correspondingly, the aggregate investment Euler equation will be generally distorted as well. Second, while we know the sign of the distortion to the bond Euler equation, $\mu_t \equiv \int \mu_{i,t} d\Lambda_t(i)$, the same is not true for the distortion to the investment Euler equation, $\mu_t^k \equiv \int \mu_{i,t}^k d\Lambda_t(i)$, as it depends on the net external financial position of the households[18].

Condition (10) is therefore more amenable to empirical analysis. In particular, if data on the cross sectional variance of consumption is also available to the econometrician, it immediately follows that

$$\begin{aligned} C_t^{-\omega} &= \beta \mathbb{E}_t C_{t+1}^{-\omega} \pi_{t+1}^{-1} R_{t+1} + \beta \mathbb{E}_t C_{t+1}^{-\omega} \pi_{t+1}^{-1} \left(\frac{\Xi_{t,t+1}}{\Xi_t} - 1 \right) R_{t+1} + \int \mu_{i,t} d\Lambda_t(i) \\ &\equiv C_{f,t}^{-\omega} + \beta \mathbb{E}_t C_{t+1}^{-\omega} \pi_{t+1}^{-1} \left(\frac{\Xi_{t,t+1}}{\Xi_t} - 1 \right) R_{t+1} + \mu_t \end{aligned}$$

[18]Notice that in the absence of investment efficiency shocks and foreign capital markets, if we apply same approximation to marginal utility, the additive distortion is eliminated as multiplying the investment Euler equation by $k_{i,t+1}$, aggregating using $p(s_{i,t}, s_{i,t+1}|S_t, S_{t+1}) \equiv \frac{d\Lambda_{t,t+1}(i)}{d(s_{i,t}, s_{i,t+1})}$ and ignoring higher order terms, $\int \varphi_{i,t} \mu_{i,t} d\Lambda_{t,t+1}(i) = -\left(C_t^{-\omega} - \beta \mathbb{E}_t C_{t+1}^{-\omega} \pi_{t+1}^{-1} R_{t+1}\right) \int \frac{w_{i,t+1}}{P_t} p(s_{i,t}, s_{i,t+1}|S_t, S_{t+1}) d(s_{i,t}, s_{i,t+1}) = 0$ as bonds are in zero net supply. This is similar to the result of Buera and Moll (2015). Otherwise, depending on whether net foreign lending is positive or negative, the sign of the aggregate distortion can change.

Taking unconditional expectations using i.e. K_t as an instrument gives rise to the following moment inequality[19],

$$\mathbb{E}\left(C_t^{-\omega} - C_{f,t}^{-\omega} - \beta C_{t+1}^{-\omega}\pi_{t+1}^{-1}\left(\frac{\Xi_{t,t+1}}{\Xi_t} - 1\right)R_{t+1}\right)K_t \geqslant 0 \tag{12}$$

Having characterized the aggregate distortions that can arise due to investment and productivity shocks, we next analyze what we learn about the aggregate distortions and the model in general from aggregated qualitative surveys.

4. Accounting for Heterogeneity through Aggregated Surveys

I focus on qualitative survey data because they contain distributional information that can be directly linked to μ_t. This is especially true for economies with frictions, as the proportion of agents whose behavior is distorted is an important statistic. An example of a distributional statistic that has been routinely used to judge the validity of *complete* models is the proportion of firms which cannot change prices in New Keynesian models featuring a Calvo adjustment mechanism. We thus view our approach as a significant generalization of the treatment of microeconomic information in dynamic equilibrium models.

Qualitative survey data are usually available in the form of aggregate statistics, where aggregation is performed over categories of answers to particular questions. As in micro-econometric studies, the categorical variable is a function of a continuous latent variable. In a structural context, there is a measurable mapping from the categories of answers to the random variables relevant to the decision of each agent. For example, if the question is of the type "How do you expect your financial situation to change over the next quarter" and the answer is trichotomous, i.e "Better", "Same" and "Worse", then the answers map to a set of partitions of the end of period assets a_{t+1}: $a_{t+1} \in [a_t + \epsilon, \infty)$, $a_{t+1} \in (a_t - \epsilon, a_t + \epsilon)$ and $a_{t+1} \in (-\infty, a_t - \epsilon]$ for some $\epsilon_t > 0$. These partitions have a one to one mapping to partitions of the information set of the agent, $(s_{i,t}, S_t)$. For example, if the agent receives a bad draw in income, and α_t is low enough, then she will choose "Worse". Similarly, questions that ask for the current state of the agent have an identical interpretation in terms of partitions of the information set.

[19]Notice that $C_{f,t}^{-\omega}$ is the frictionless model prediction, which under rational expectations should be equal to $\beta\mathbb{E}_t C_{t+1}^{-\omega}\pi_{t+1}^{-1}R_{t+1}$ by construction.

To formalize this, denote by $\{\mathfrak{S}_{i,t}\}_{i\leqslant N}$ the survey sample over a period of length T, for N respondents. Let C_l be the l^{th} categorical answer and $\hat{\xi}_{i,t}$ the respondent's choice. The proportion of respondents for each category l are therefore equal to $\hat{\mathcal{B}}_t^l = \sum_{i\leqslant N} \mathbf{1}(\hat{\xi}_{i,t} \in C_l)$. Under truth telling, we can map the answer to agent beliefs i.e. there exists a mapping $h : \hat{\xi}_{i,t} \to s_{i,t} \equiv \mathbb{E}_{i,t}(x_{i,t+1}|(s_{i,t}, S_t))$. Moreover, since the conditional expectation is a function of the information set, say $g(s_{i,t}, S_t)$, let $\mathcal{S}_t^\star \equiv \{(s_{i,t}, S_t) \in \mathbb{R}^{2(n_x+n_z)} : g(s_{i,t}, S_t) \in B_l\}$ for $B_l := h(C_l)$, that is, $\mathcal{S}_t^\star$ belongs to the partition of the support of $(s_{i,t}, S_t)$ that corresponds to category C^l. Consequently, the survey statistic has the following theoretical form, which can be linked to the model:

$$\hat{\mathcal{B}}_t^l = \sum_{i\leqslant N} \mathbf{1}(\mathbb{E}_{i,t}(s_{i,t+1}, S_t)|(s_{i,t}, S_t)) \in B_l) \tag{13}$$

Given this form, I next characterize the additional restrictions that survey data impose on the estimation. Let Y_t^f be the frictionless model prediction and let $\lambda_t \equiv Y_t - Y_t^f = \lambda_t^o + \lambda_t^{un}$ where λ_t^o is the observable component (up to the parameter vector θ) of the aggregate distortion and λ_t^{un} the unobservable component. For example, in the previous section, $\lambda_t^o \equiv -\beta C_{t+1}^{-\omega} \pi_{t+1}^{-1} \left(\frac{\Xi_{t,t+1}}{\Xi_t} - 1\right) R_{t+1}$ while $\lambda_t^{un} \equiv \mu_t$.

Since $\mu_t \equiv \int \mu_{i,t} d\Lambda_t(i) = \int_{s_{i,t}:\mu_{i,t}\neq 0} \mu_{i,t} d\Lambda_t(i)$ using Bayes law, we decompose μ_t into two multiplicative components:

$$\begin{aligned}\int_{s_{i,t}:\mu_{i,t}\neq 0} \mu_{i,t} d\Lambda_t(i) &= \mathbb{E}_t(\mu_{i,t}|\mu_{i,t} \neq 0)\mathbb{P}_t(\mu_{i,t} \neq 0) \\ &\equiv \kappa_t B_t\end{aligned}$$

where κ_t is the intensive margin, that is "the average distortion conditional on the household being constrained", and B_t the extensive margin. Notice that since $B_t \in (0, 1]$, κ_t and μ_t will have the same sign.

4.1. **Empirical Restrictions.** Assuming that the aggregate moment conditions are additively separable in λ_t, the following proposition characterizes the restrictions implied by frictions and heterogeneity when survey data is present or not:

Proposition 1. *For $\hat{\mathcal{B}}_t^l \to B_t \in (0,1]$, a positive random variable X_{t-1} which is Y_{t-1} measurable and known sign of μ_t (or $\mathbb{E}_t(\mu_t)$) then*

$$\text{(14)} \qquad sign\left(\mathbb{E}\left(g\left(Y_t, Y_{t+1}, \theta\right) - \lambda_t^o(Y_t, Y_{t+1}, \theta)\right) X_{t-1} B_t^{-1}\right) \;=\; sign\left(\mathbb{E}(\kappa_t X_{t-1})\right)$$

When $\hat{\mathcal{B}}_t^l$ is not available, then

$$\text{(15)} \qquad sign\left(\mathbb{E}\left(g\left(Y_t, Y_{t+1}, \theta\right) - \lambda_t^o(Y_t, Y_{t+1}, \theta)\right) X_{t-1}\right) \;=\; sign\left(\mathbb{E}(\mu_t X_{t-1})\right)$$

Proof. See Appendix A □

Obviously, when B_t is zero for all t, then condition (14) collapses to the standard moment equality restriction i.e. the one implied by the frictionless model. Moreover, conditions (14) and (15) are moment (in)equality conditions and feature alternative restrictions depending on the availability of qualitative survey data.

4.2. **Full Information Analysis.** The analysis above was based on estimation that utilizes the moment inequality restrictions arising from the equilibrium conditions of the model. However, one might want to conduct experiments using a full information approach. I next illustrate how this becomes possible with a representation result that allows us to work with distortions in the aggregate decision rules of the economy.

As already illustrated in Section 3, the aggregate equilibrium conditions can be distorted. Denoting the aggregate endogenous and exogenous states by $X_t = \int x_{i,t} d\Lambda_t(i)$ and $Z_t = \int z_{i,t} d\Lambda_t(i)$[20], the general log-linearized aggregate conditions are as follows:

$$\text{(16)} \qquad G(\theta)X_t \;=\; F(\theta)\mathbb{E}_t(X_{t+1}|X_t) + L(\theta)Z_t + \tilde{\mu}_t$$

Under complete markets, the model reduces to the frictionless representative agent model, where $\tilde{\mu}_t = 0$. To achieve maximum generality, I also assume that a subset of parameters in θ, say θ_2, is also set to zero. In the context of Section 3, this can correspond to eliminating $\tilde{\Xi}_t$, the log-linearized version of the cross sectional consumption variance, which does not appear under complete markets.

[20]Note that the representation I choose for $x_{i,t}$ and $z_{i,t}$ is general enough, as it can include past endogenous variables and quantities that are determined by aggregate behavior. For example, in section 3, $\tilde{R}_t$ can be included both in $x_{i,t}$ and X_t.

I thus partition the vector θ into two subsets, (θ_1, θ_2), and the frictionless economy can then be summarized by:

$$G(\theta_1, 0)X_t = F(\theta_1, 0)\mathbb{E}_t(X_{t+1}|X_t, Z_t) + L(\theta_1, 0)Z_t \tag{17}$$

$$Z_t = R(\theta)Z_{t-1} + \epsilon_t \tag{18}$$

Using the decision rule in the expectational system (17) and solving for the undetermined coefficients [21], a Rational Expectations equilibrium for the frictionless economy exists if the following assumption is satisfied:

1. *ASSUMPTION-EQ*

There exist unique matrices $\underset{n_x \times n_x}{P^*(\theta_1, 0)}, \underset{n_x \times n_z}{Q^*(\theta_1, 0)}$ *satisfying:*

$$\begin{aligned} (F(\theta_1, 0)P^*(\theta_1, 0) - G^*(\theta_1, 0))P^*(\theta_1, 0) &= 0 \\ (R(\theta)^T \otimes F(\theta_1, 0) + I_z \otimes (-F(\theta_1, 0)P^*(\theta_1, 0) + G^*(\theta_1, 0)))vec(Q(\theta_1, 0)) &= -vec(L(\theta_1, 0)) \end{aligned}$$

such that $X_t = P^*(\theta_1, 0)X_{t-1} + Q^*(\theta_1, 0)Z_t$ *is a competitive equilibrium.*

4.3. **Representation : From Wedges to Decisions.** I next characterize the relationship between $\tilde{\mu}_t$ and a set of candidate decision rules that depend on the endogenous states and some unobserved process, $\tilde{\lambda}_t$. Proposition 2 states sufficient conditions such that decision rules are consistent with $\tilde{\mu}_t$.

Proposition 2. *If there exist matrices* (M_1, M_2) *such that* $\tilde{\mu}_t = M_1 X_{t-1} + M_2 Z_t$*, then*

(1) *There exists a distorted aggregate decision rule* $X_t = X_t^{f,RE} + \tilde{\lambda}_t$ *which satisfies* (16)

(2) *There exists a matrix* H *such that* $\tilde{\lambda}_t = H\tilde{\mu}_t$ *where*

$$\begin{aligned} vec(H) &= \left(M_1' \otimes G(\theta_1, 0) - (M_1 P^\star(\theta_1, \theta_2))' \otimes F\right)^{-1} vec(M_1) \\ vec(M_2) &= \left(I_{n_x n_z} - R' \otimes H - I_{n_z} \otimes (GH)\right)^{-1} \left((M_1 Q^\star(\theta_1, \theta_2))' \otimes F\right) vec(H) \end{aligned}$$

where and $(P^\star(\theta_1, \theta_2), Q^\star(\theta_1, \theta_2))$ *is the Rational Expectations solution to* (16).

Proof. See Appendix ∎

[21]See for example Marimon and Scott (1998).

Proposition 2 illustrates that there is a linear relationship between λ_t and $\tilde{\mu}_t$ while H is a nonlinear function of (M_1, M_2) due to cross equation restrictions. From an econometric point of view, this implies that the wedge in the moment conditions translates to a distortions in the decision rules which can be parameterized by $\tilde{\lambda}_t = HM_1X_{t-1}+HM_2Z_t \equiv H_1X_{t-1}+H_2Z_t$. The assumption that $\tilde{\mu}_t$ is a linear function of the states merits some discussion. Essentially, there is an implicit assumption that the average value of $x_{i,t}$ and $z_{i,t}$ is sufficient to predict future variables i.e. the distribution does not matter. This is also reminiscent of the approach of Krusell and Smith (1998).

The implication of Proposition 2 is that despite the incompleteness of the structural model, in the sense that the precise mapping of the wedge to parameters is unknown, a likelihood function can be constructed and estimation can be carried through. This, nevertheless, will not lead to point identification for (θ, H_1, H_2) in general. Log-linearisation makes it is hard to know whether certain restrictions can hold a priori. Nevertheless, likelihood based inference can be conducted using identification robust methods like the one adopted in the empirical part of section 7.

I next discuss the identification of the frictionless model given the information contained in the moment restrictions derived in Proposition 1.

5. Identification

5.1. **Identification without B_t.** Revisiting the moment inequality restrictions derived in the previous section, condition (15) is a standard moment inequality restriction, which can be expressed as follows:

$$(19)\qquad \mathbb{E}\left(\underset{r\times 1}{g}(Y_t, Y_{t+1}, \theta) - \underset{r\times 1}{\lambda_t}{}^{o}(Y_t, Y_{t+1}, \theta)\right)\phi(\mathbf{Y}^{\tau-1}) = \mathbb{E}\mu_t\phi(\mathbf{Y}^{\tau-1}) \equiv U \in [0, \infty)$$

where $\phi(.)$ is an *inequality preserving* function of $\mathbf{Y}^{\tau-1}$ and U is a vector of nuisance parameters that restore the moment equality. From an economic point of view, the set of model completions is simply the set of all possible mechanisms that generate the wedge μ_t such that $U \geqslant 0$. The identified set is thus defined as follows:

$$(20)\qquad \Theta_I \quad := \quad \left\{\theta \in \Theta : \exists U \in \bigtimes_{r} \mathbb{R}^{+}; \mathbb{E}\left(m(Y_t, Y_{t+1}, \theta)\phi(\mathbf{Y_{t-1}})\right) - U = 0\right\}$$

where $m(Y_t, Y_{t+1}, \theta) := (g\,(Y_t, Y_{t+1}, \theta) - \lambda_t^o(Y_t, Y_{t+1}, \theta))$.

In the next proposition, we will use the notion of correct specification and conditional identification, which we define below:

Definition 1. We say that $m(Y_t, Y_{t+1}, \theta)$ is correctly specified if there exists $\theta_0 \in \Theta$ such that if $U = 0$, $\mathbb{E}m(Y_t, Y_{t+1}, \theta_0) = 0$.

Definition 2. For some $U \in \bigtimes_{\dim U} \mathbb{R}^+$, $\theta_1(U)$ is conditionally identified if there does not exist any other $\theta \in \Theta$, $\theta_2(U)$ such that $\mathbb{E}m(Y_t, Y_{t+1}, \theta_1(U)) = \mathbb{E}m(Y_t, Y_{t+1}, \theta_2(U))$.

Correct specification ensures that the identified set is not empty, while definition 2 is important for guaranteeing that more information on the wedge U leads to a smaller identified set for θ.

We next clarify the distinction between just identifying information and overidentifying information in a the set identification context, which will be useful for our main result on qualitative survey data.

Proposition 3. Θ_I ***when*** $r = n_\theta$

Under correct specification of $m(.)$ *and conditional identification,*

$$\exists! \text{ invertible mapping } \mathcal{G} : \Theta_I = \mathcal{G}^{-1}(U) \cap \Theta$$

Proof. See Appendix □

Proposition 3 establishes that fixing a value for the wedge U, there exists a unique value for θ, defined as $\theta(U)$, that satisfies 19. This is akin to the order condition for identification in moment equality models.

Given this one to one mapping, any additional information is likely to make the identified set smaller.

5.2. **Identification with B_t.** Our final aim is to illustrate that access to qualitative survey data is likely to be reduce the identified set, we distinguish between moments $m_{\alpha,t}(\theta)$, the necessary moments functions for Proposition 3 being true and $m_{\beta,t}(\theta)$ the additional moment functions where for notational brevity, we have dropped the dependence on $\mathbf{Y}^{\tau-1}$. Moreover, let $\hat{m}_{\alpha,t}(\theta) := m_{\alpha,t}(\theta)\phi_t$ and $\hat{m}_{\beta,t}(\theta) := m_{\beta,t}(\theta)\phi_t$, $\hat{\mathbf{m}}_\alpha(\theta)$ and $\hat{\mathbf{m}}_\beta(\theta)$ the corresponding vectors, and $\bar{\mathbf{m}}_\alpha(\theta)$ and $\bar{\mathbf{m}}_\beta(\theta)$ the vector means. Moreover, let W be a real valued, possibly random weighting matrix, diagonal in

(W_α, W_β). Furthermore, denote by Q_α the conditional expectation operator when conditioning on $W_\alpha^{\frac{1}{2}T}\hat{\mathbf{m}}_\alpha(\theta)$ and by $Q_\alpha^\perp$ the residual operator.

The following proposition specifies that as expected, for the identified set to be weakly smaller, the additional moments have to be less than perfectly correlated with the necessary conditions:

Proposition 4. *The Identified Set with Additional Conditions*

(1) Proposition 3

(2) $\mathcal{U}_t = \{U_t \in [\underline{U}, \bar{U}]\}$, *with* $\underline{U} \equiv (W_\alpha^{\frac{1}{2}T}\underline{\mathcal{V}}_\alpha + W_\beta^{\frac{1}{2}T}\underline{\mathcal{V}}_\beta)\phi_t$, $\bar{U} \equiv (W_\alpha^{\frac{1}{2}T}\bar{\mathcal{V}}_{\alpha_t} + W_\beta^{\frac{1}{2}T}\bar{\mathcal{V}}_\beta)\phi_t$ *and define*

$$\mathcal{U}_t^c = \left\{U_t \in [\underline{U}, \bar{U}] : \mathbb{E}Q_\alpha^\perp\left(W_\beta^{\frac{1}{2}T}\mathbf{m}_\beta(\theta(U)) - U_t\right) = 0\right\}$$

Then,

$$\Theta_I' \subset \Theta_I \quad \textit{iff} \quad \mathcal{U}_t^c \subset \mathcal{U}_t \tag{21}$$

Proof. See the Appendix □

Given these identification results, we can analyze identification arising from any inequality restriction, and therefore any additional type of information can be potentially analyzed. Below, we discuss and formally show how qualitative survey data can provide additional restrictions that are informative about aggregative models of economies with frictions. Such information constrains further the stochastic properties of μ_t, and therefore the size of Θ_I.

Proposition 5. *Identification with* B_t

(1) If $\hat{\mathcal{B}}_t^k \to B_t \in (0,1)$, $\Theta_I' \subset \Theta_I$.

(2) Impossibility of point identification: When $B_t \neq 0$, Θ_I *is not a singleton*

Proof. See Appendix □

The set of admissible structures becomes smaller, and we can therefore make more precise statements regarding parameters and conditional predictions.

6. Evidence on Financial Frictions using Spanish Survey Data

The economy of Spain has experienced a severe financial crisis during the period 2008-2014. The burst of the housing bubble which was supported by unrestrained credit growth in the past has resulted in firm bankruptcies and a large drop in investment. Similarly, household indebtedness which was also supported by a strong credit growth before the crisis was succeeded by de-leveraging. In the upper panel of Figure 7 we plot the cyclical components for consumption, investment and output after 1999.

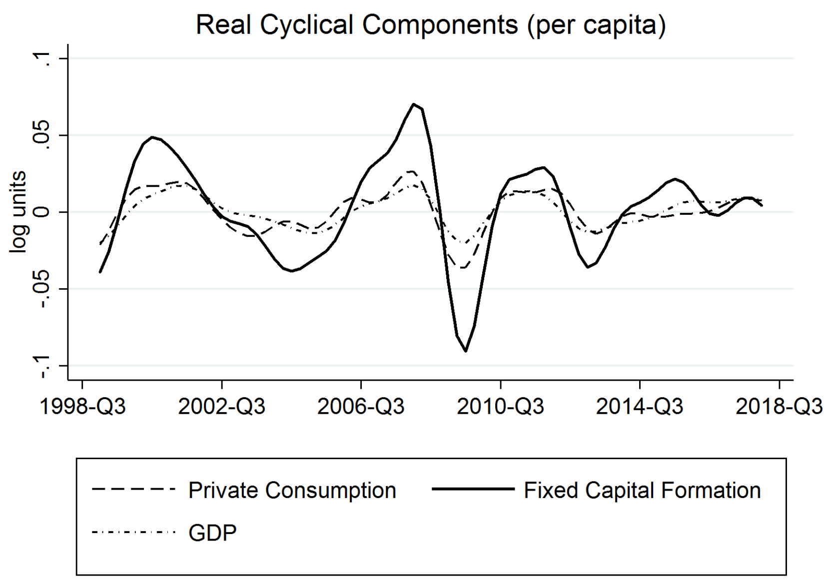

Figure 2

A similar picture can be drawn if one looks at the aggregated surveys of firms and consumers. In the lower panel of Figure 2 we plot the proportion of firms that reported financial constraints (question 8F) while for consumers we plot the proportion of consumers reporting that their current and future financial situation will worsen i.e. they are likely to go into debt.

Since a fraction of these households are likely to face borrowing constraints in the future (Q2 and Q12 n the monthly consumer survey), the number we report is an upper bound to that fraction [22]. Nevertheless, as evident from Figure 3, the fraction measured by the Business and Consumer

[22] Detailed information on this survey data can be found at: http://ec.europa.eu/economy_finance/db_indicators/surveys/index_en.htm

Survey tracks quite well the exact measure obtained from the Survey of Consumer Finances, up to 2012Q4.

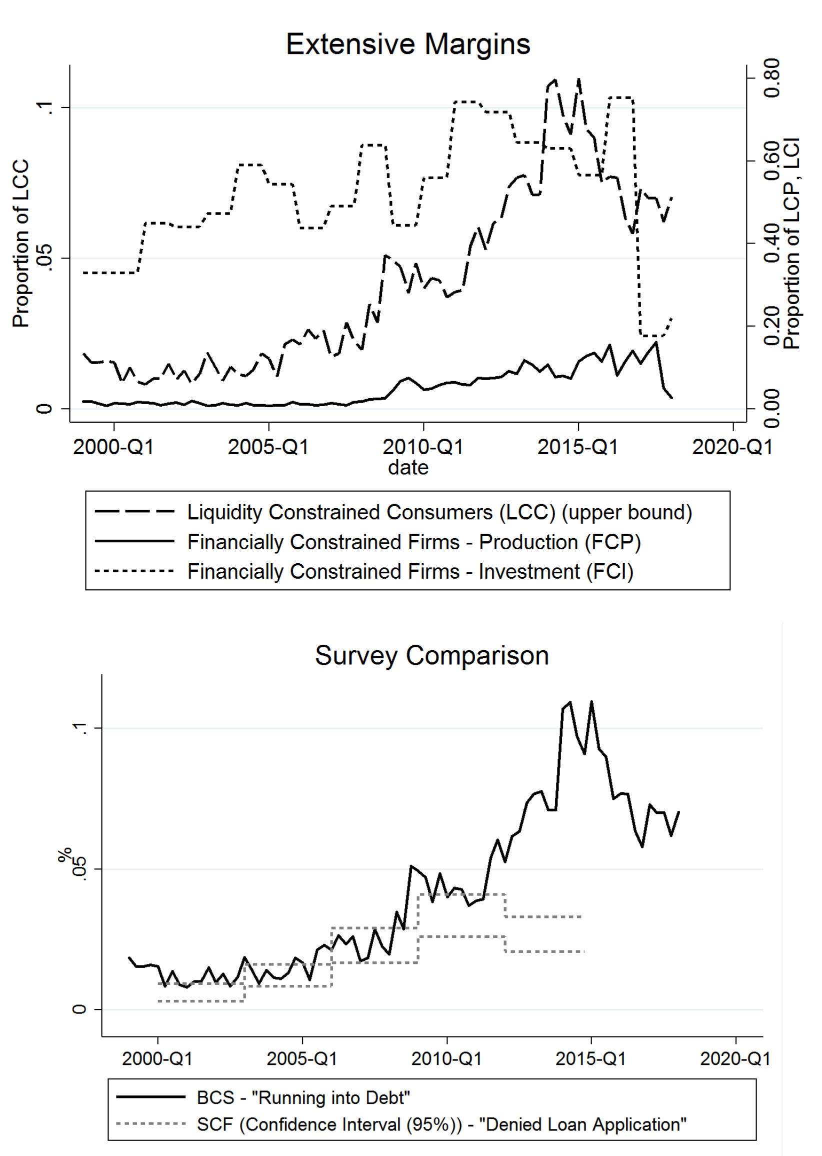

FIGURE 3

6.1. **Does heterogeneity matter? Some preliminary evidence from an SVAR.** A reasonable question to ask is whether heterogeneity does matter for the determination of aggregate outcomes in Spain. To investigate this, we first estimate a vector autoregressive model (SVAR) that includes the aggregated qualitative surveys presented in Figure 2. (cite Schoefheide) More particularly, let $\mathbf{Y}_t$ be the vector that includes aggregate investment (I), consumption (C), the real interest rate (EONIA) (R) and LCC, FCP, FCI. The corresponding structural model is therefore:

$$B\mathbf{Y}_t \quad = A\mathbf{Y}_{t-1} + e_t \tag{22}$$

where $u_t = B^{-1}e_t$ and $e_t \sim (0, I_{n_\epsilon})$. To provide a semi-structural interpretation to innovations in (LCC, FCP, FCI), we employ a Cholesky identification scheme with Y_t ordered as follows: $(FCP, RR, LCC, C, FCI, I)$. The proportion of firms claiming production related financial constraints FCP is unrelated to the consumption or investment side, while investment is likely to respond contemporaneously to both desired savings by households - constrained and unconstrained, and the real rate. Correspondingly, aggregate consumption is contemporaneously affected by FCP and the real rate but not investment and LCI, which probably affect it with a lag. To assess the validity of our restrictions, we also employ the restrictions that $a_{31} = a_{21} = 0$, where the latter acknowledges that RR is to a large extent exogenous. This also delivers a likelihood ratio test (over-identification) with $p_{5\%}^{val} = 0.672$. Since this is a likelihood ratio test, all the restrictions are considered jointly valid. The identified impulse responses to innovations in the extensive margins are as follows:

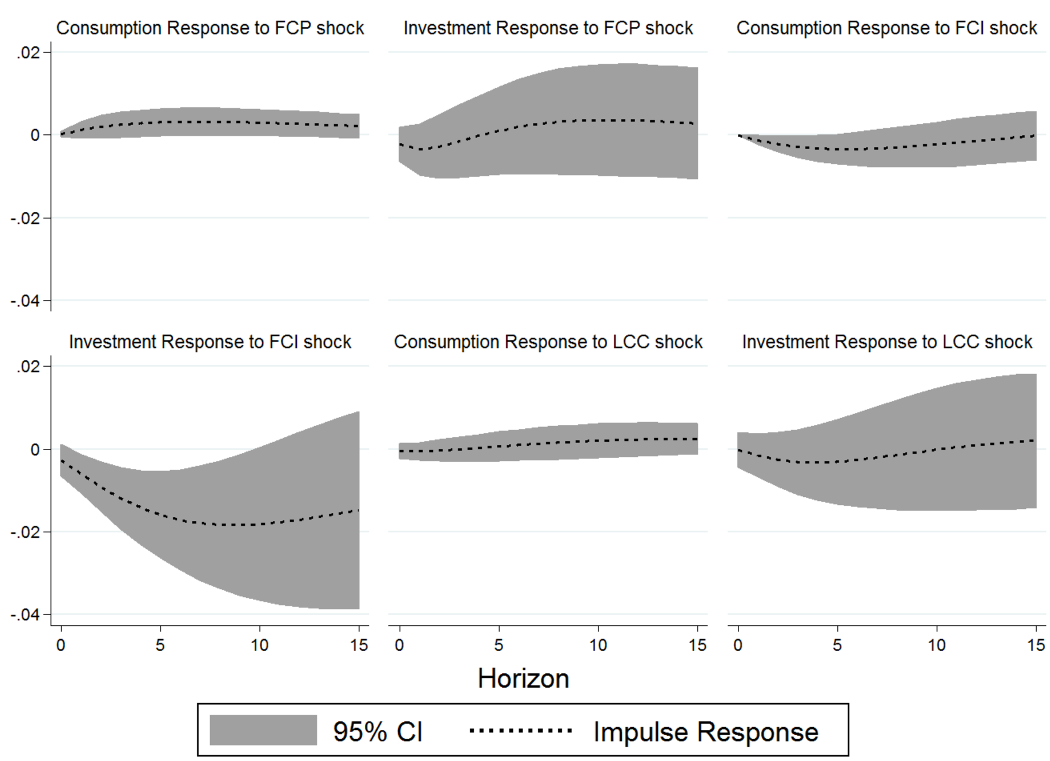

Figure 4

The strongest and most significant response to variations in the intensive margin for financially constrained firms is, as expected, that of aggregate investment. A one standard deviation increase in the proportion of investment firms claiming financial constraints causes a fall to aggregate investment, which reaches its maximum in around two years, while it decreases consumption, with the maximum decrease within one year (borderline significant at 10% level for three to four quarters ahead). Correspondingly, one standard deviation increase in the proportion of firms that claim production related financial constraints lead to an initial drop in investment and a very mild increase on consumption after six quarters,which is both economically and statistically insignificant. Finally, a one standard deviation increase in the proportion of constrained consumers leads to an (bound) an initial drop in investment, as entrepreneurs cannot borrow.

Though preliminary, the SVAR evidence reveals that the extensive margins are significant drivers of fluctuations in the Spanish economy, at least for investment. However, such evidence is to be taken with a grain of salt, as we still need to measure the extensive margin.

6.2. **Real Business Cycles and Financial Frictions.** To further understand the interactions of financial frictions and macro-aggregates in the Spanish economy, we estimate the real business cycle model presented in Section 3, slightly modified to take into account of capital utilization and the openness of the Spanish economy. Before presenting the estimation results, we first examine whether additional moment conditions generated by consumer survey data are informative for structural parameter estimates. We use the following moment conditions to estimate the coefficient of relative risk aversion and the Frisch elasticity of labour supply, ω and η respectively.

$$\mathbb{E}\left(C_t^{-\omega} - \beta C_{t+1}^{-\omega}\pi_{t+1}^{-1}\left(\frac{\Xi_{t,t+1}}{\Xi_t}\right)R_{t+1}\right)Y_{t-1}B_t^{-1} \geqslant 0 \tag{23}$$

$$\mathbb{E}\left(L_t^{\eta} - W_t C_t^{-\omega}\Xi_t\right)Y_{t-1} = 0 \tag{24}$$

As evident, the posterior distribution for ω becomes less dispersed and more sharply peaked, and the confidence set for the identified set becomes narrower[23]. The arguably small change in the posterior is perfectly in line with Proposition 5: The percentage of consumers which report liquidity constraints was roughly constant before 2008, while it varies from zero to 0.5% over the rest of the

[23]Notice that the MCMC chain was generated using the same seed. Thus, any differences in the posteriors are entirely attributed to identification power.

period. If B_t is entirely constant, then there is no additional information. The corresponding (projections) of the 95% joint confidence set obtained using quantiles from the posterior draws of the objective function as in Chen, Christensen, O'Hara, and Tamer (2016) confirm the observations from Figure 5.

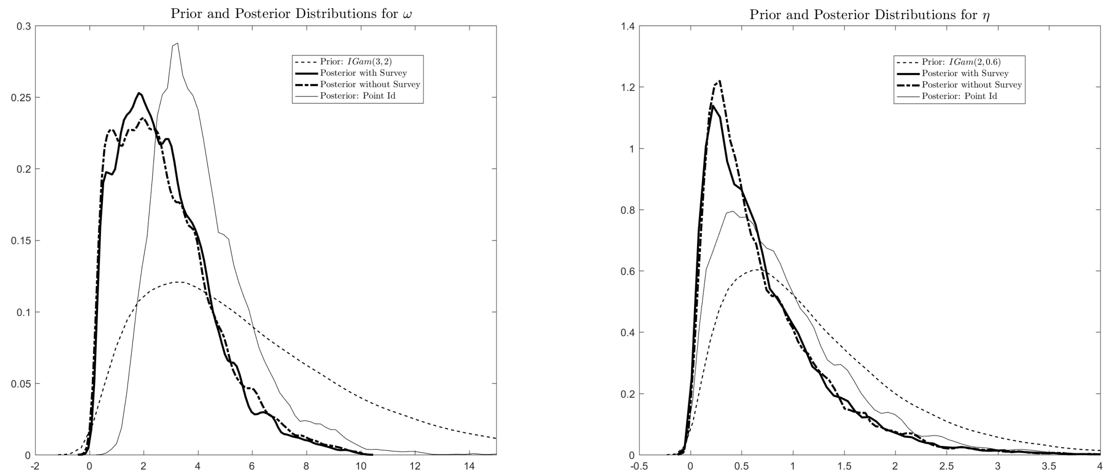

FIGURE 5

Turning to full information analysis, the log-linearized model is as follows:

$$
\begin{aligned}
S_t - C_t + C_{t,f} &= 0 \\
\psi U_t - (1-\psi) R_t^k &= 0 \\
K_t^u - K_{t-1} + U_t &= 0 \\
-\omega \tilde{C}_t - (1-\beta(1-\delta))\mathbb{E}_t \tilde{R}_{t+1}^k + \omega \bar{\mathbb{E}}_t \tilde{C}_{t+1} &= 0 \\
y_{ss}\tilde{Y}_t - c_{ss}\tilde{C}_t - i_{ss}\tilde{I}_t - G_t - u_{ss}U_t - vS_t &= 0 \\
\tilde{K}_{t+1} - (1-\delta)\tilde{K}_t - \delta \tilde{I}_t &= 0 \\
\tilde{Y}_t - \alpha \tilde{Z}_t - \alpha \tilde{K}_t - (1-\alpha)\tilde{L}_t &= 0 \\
\tilde{R}_t^k - \alpha \tilde{Z}_t + (1-\alpha)\tilde{K}_t - (1-\alpha)\tilde{L}_t &= 0 \\
\tilde{W}_t - \omega \tilde{C}_t - \eta \tilde{L}_t &= 0 \\
\tilde{W}_t - \tilde{Y}_t + \tilde{L}_t &= 0
\end{aligned}
$$

where S_t is the exchange rate with respect to the rest of the world, while $C_{t,f}$ is exogenous net aggregate demand. To construct $\Theta^{CS}_{5\%}$ for the identified set we use a recent computationally attractive procedure proposed by Chen, Christensen, O'Hara, and Tamer (2016). To obtain the parameter draws, we use a 2-block RW-MCMC with uniform priors for all parameters[24].

Below, I plot the identified total distortions to Consumption, Hours and Investment:

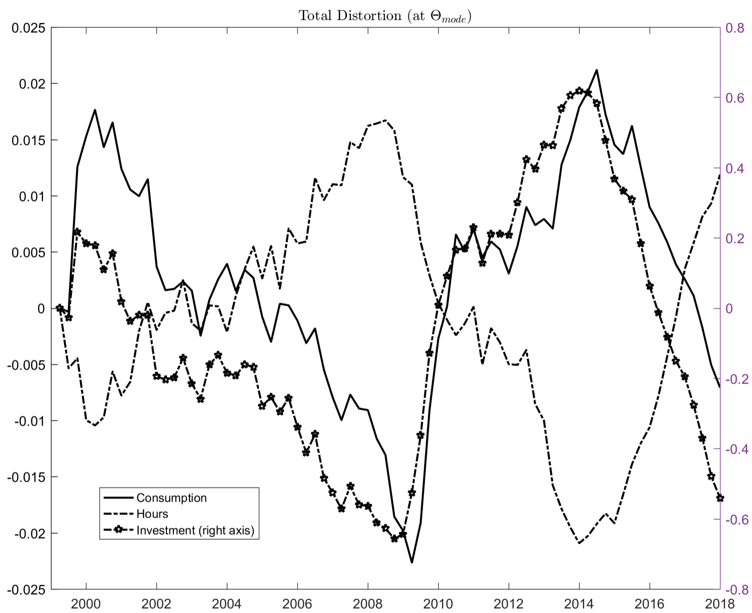

Figure 6

Given the confidence sets for λ_c and λ_{inv}, I compute the corresponding extensive and intensive margins:

[24]We keep the last 300000 draws for inference.

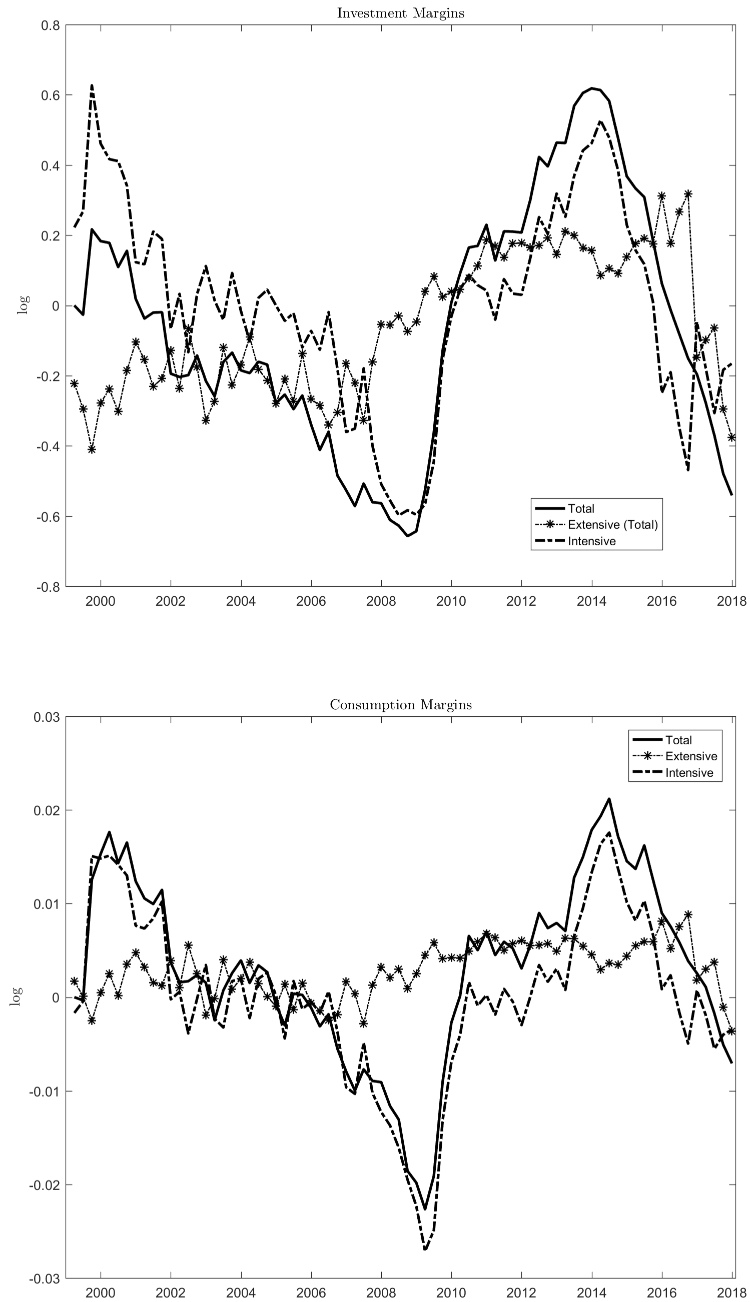

FIGURE 7

Moreover, OLS confidence intervals from projecting the total distortion on the extensive margins reveals that the proportion of constrained agents is insignificant for aggregate consumption, while the proportion of firms that claimed productive constraints are significant predictors of the consumption distortions. This suggests that aggregate consumption has suffered mostly through TFP losses:

Table 1. Confidence Set for Proj(λ_c)

Parameter	$q_{2.5\%}$	$q_{97.5\%}$
B_t^{LCC}	-0.0096	0.0017
B_t^{LCP}	0.0002	0.0089
B_t^{LCI}	-0.0029	0.0097

On the other hand, aggregate investment seems to have suffered through both TFP losses and liquidity constraints of firms producing investment specific goods. Although not statistically significant, liquidity constrained consumers seem to have contributed positively to investment through savings.

Table 2. Confidence Set for Proj(λ_{inv})

Parameter	$q_{2.5\%}$	$q_{97.5\%}$
B_t^{LCC}	-0.2690	0.0855
B_t^{LCP}	0.0716	0.3435
B_t^{LCI}	0.0719	0.4672

7. Conclusion

This paper has shown that inference about the direction and severity of frictions in an economy can be improved with the use of qualitative surveys. The latter can provide additional distributional information, which is crucial in economies with ex post heterogeneity and frictions. In general, survey data provide a sufficient statistic for this information that would otherwise have to be generated by a heterogeneous agent model.

8. Appendix A

Proof. **of Proposition 1**.

Recall the representation for the model with frictions, that is,

$$G(\theta_1, 0)X_t \quad = \quad F(\theta_1, 0)\mathbb{E}_t(X_{t+1}|X_t) + L(\theta_1, 0)Z_t + \tilde{\mu}_t$$

Plugging in the candidate distorted decision rule: $X_t^* = X_t^{f,RE} + \tilde{\lambda}_t$ and using the competitive equilibrium conditions for the frictionless model $\underset{n_x \times n_x}{F(\theta_1, 0)}\underset{n_x \times n_x}{P^*(\theta_1, 0)} + \underset{n_x \times n_x}{G^*(\theta_1, 0)} = 0$ and $(\underset{n_z \times n_z}{R(\theta_1, 0)^T} \otimes F(\theta_1, 0) + I_z \otimes (F(\theta_1, 0)P^*(\theta_1, 0) + G^*(\theta_1, 0)))vec(Q(\theta_1, 0)) = -vec(L(\theta_1, 0))$ leads to:

$$G(\theta_1, 0)\tilde{\lambda}_t = \mathbb{E}_t F(\theta_1, 0)\lambda_{t+1} + \tilde{\mu}_t$$

Substituting for $\tilde{mu}_t = M_1 X_{t-1} + M_2 Z_t$ and $\tilde{\lambda}_t = H\tilde{\mu}_t$ and matching coefficients on X_{t-1} and Z_t we arrive at

$$\begin{aligned}
vec(H) \quad &= \quad \left(M_1' \otimes G(\theta_1, 0) - (M_1 P^\star(\theta_1, \theta_2))' \otimes F\right)^{-1} vec(M_1) \\
vec(M_2) \quad &= \quad \left(I_{n_x n_z} - R' \otimes H - I_{n_z} \otimes (GH)\right)^{-1} \left((M_1 Q^\star(\theta_1, \theta_2))' \otimes F\right) vec(H)
\end{aligned}$$

□

Proof. **of Proposition 6**:

Let $\tilde{W}_{i,t} := (x_{i,t-1}, z_{i,t})$ and denote by $\mathcal{W}_t^\star := (\mathcal{X}_t^\star, \mathcal{Z}_t^\star)$ the support of the subset of $\tilde{W}_{i,t}$ such that $\lambda_{i,t} \neq 0$, and by $\mathcal{W}_t^{\star,c}$ their complements in $(\mathcal{X}, \mathcal{Z})$.

First, notice that the survey statistic is unbiased for the proportion of agents facing frictions in the model at time t. Using $\Lambda_t(i) := \mathbb{P}_{t-1}(x_{i,t-1} \leqslant x, z_{i,t} \leqslant z)$ to compute conditional expectations,

$$\begin{aligned}
B_t := \mathbb{E}_{t-1}\hat{\mathcal{B}}_{k,t} \quad &= \quad \sum_{i \leqslant N} W_i \mathbb{E}_{t-1}(\mathbf{1}\left[\tilde{W}_{i,t} \in \mathcal{W}_t^\star\right]) \\
&= \quad \mathbb{P}_{t-1}(\tilde{W}_{i,t} \in \mathcal{W}_t^\star) \\
&= \quad \mathbb{P}_{t-1}(\lambda_{i,t} \neq 0)
\end{aligned}$$

□

Proof. **of Proposition 4** $(n_\theta = r)$

Fix $\underset{n_\theta \times 1}{U} \in (\underline{U}, \bar{U}]$. Assuming conditional identification (Definition 2), there is a unique value of θ^* such that $\mathbb{E}m(Z_t, \theta^*) \equiv \mathcal{G}(\theta^*) = \underset{n_\theta \times 1}{U}$. Thus, $\Theta_I = \Theta \cap \mathcal{G}^{-1}((U))$. $\square$

Proof. **of Proposition 5** Denote the moment conditions using n_y macroeconomic variables by $q_1(\theta, \mathbf{Y}^{\tau-1})$ and moment conditions using $m - n_y$ survey variables by $q_2(\theta, \mathbf{Y}^{\tau-1})$:

$$\begin{aligned}
\underset{n_y \times 1}{q_1(\theta, \mathbf{Y}^{\tau-1})} &= \mathcal{V}_1(\mathbf{Y}^{\tau-1}) \in [\underline{\mathcal{V}}(\mathbf{Y}_t)_1, \bar{\mathcal{V}}(\mathbf{Y}_t)_1] \\
\underset{(n_y - k) \times 1}{q_2(\theta, \mathbf{Y}^{\tau-1})} &= \mathcal{V}_2(\mathbf{Y}^{\tau-1}) \in [\underline{\mathcal{V}}(\mathbf{Y}_t)_2, \bar{\mathcal{V}}(\mathbf{Y}_t)_2]
\end{aligned}$$

which again imply the following unconditional moment restrictions of the form $\mathbb{E}m(.) = 0$:

$$\begin{aligned}
\mathbb{E}(\phi(Z_t)(q_1(\theta, \mathbf{Y}^{\tau-1}) - \mathcal{V}_1(\mathbf{Y}^{\tau-1})) &= 0 \\
\mathbb{E}(\phi(Z_t)(q_2(\theta, \mathbf{Y}^{\tau-1}) - \mathcal{V}_2(\mathbf{Y}^{\tau-1})) &= 0
\end{aligned}$$

Partition the vector $m \equiv (m_\alpha^T, m_\beta^T)^T$ where m_α contains the first n_θ moments. Since $m > n_\theta$, and given a general weighting matrix W, we have the following first order conditions:

$$\mathbb{E}J(\theta)^T (W_\alpha^{\frac{1}{2}T} m_\alpha + W_\beta^{\frac{1}{2}T} m_\beta - V(Z_t)\phi(Z_t)) = 0$$

where the Jacobian $\underset{n_m \times n_\theta}{J(\theta)}$ has full rank. To economize on notation, redefine the weights after pre-multiplication with the Jacobian, which implies that: $\mathbb{E}(W_\alpha^{\frac{1}{2}T} m_\alpha + W_\beta^{\frac{1}{2}T} m_\beta) - \underset{n_\theta \times 1}{U} = 0$. This is a projection of m on a lower dimensional subspace. Since W is an arbitrary matrix, and (m_α, m_β) are possibly correlated, we reproject the sum onto the space spanned by $W_\alpha^{\frac{1}{2}T} \mathbf{m}_\alpha$. Define $Q_\alpha := W_\alpha^{\frac{1}{2}T} \mathbf{m}_\alpha (\mathbf{m}_\alpha^T W_\alpha^T \mathbf{m}_\alpha)^{-1} \mathbf{m}_\alpha^T W_\alpha^{\frac{1}{2}}$, the projection, and $Q_\alpha^\perp$ the orthogonal projection. Since the original sum satisfies the moment condition, then the two orthogonal complements will also satisfy it: Therefore,

$$\begin{aligned}
Q_\alpha \left(W_\alpha^{\frac{1}{2}T} \mathbf{m}_\alpha + W_\beta^{\frac{1}{2}T} \mathbf{m}_\beta - U \right) &= W_\alpha^{\frac{1}{2}T} \mathbf{m}_\alpha + Q_\alpha \left(W_\beta^{\frac{1}{2}T} \mathbf{m}_\beta - U \right) = 0 \\
Q_\alpha^\perp \left(W_\alpha^{\frac{1}{2}T} \mathbf{m}_\alpha + W_\beta^{\frac{1}{2}T} \mathbf{m}_\beta - U \right) &= Q_\alpha^\perp \left(W_\beta^{\frac{1}{2}T} \mathbf{m}_\beta - U \right) = 0
\end{aligned}$$

where $U \in [W_\alpha^{\frac{1}{2}T} \underline{\mathcal{V}}(\mathbf{Y}_t)_\alpha + W_\beta^{\frac{1}{2}T} \underline{\mathcal{V}}(\mathbf{Y}_t)_\beta, \quad W_\alpha^{\frac{1}{2}T} \bar{\mathcal{V}}(\mathbf{Y}_t)_\alpha + W_\beta^{\frac{1}{2}T} \bar{\mathcal{V}}(\mathbf{Y}_t)_\beta] \otimes \phi(\mathbf{Y}_t)$.

As in Proposition 4, the first set of restrictions identifies a one to one mapping from U to Θ_I, and therefore $\theta^*(U) \equiv \mathcal{G}^{-1}(U)$. Plugging this in the second set of restrictions eliminates dependence on m_α and imposes further restrictions on the domain of variation of U. Thus

$$Q_\alpha^\perp \left(W_\beta^{\frac{1}{2}T} \mathbf{m}_\beta(U) - U \right) \quad = \quad 0$$

The admissible set for U is now $\left\{ U \in (-\inf, \bar{U}) : Q_\alpha^\perp \left(W_\beta^{\frac{1}{2}T} \mathbf{m}_\beta(U) - U \right) = 0 \right\}$. Therefore, $\exists \theta \in \theta(U) : \theta \notin \Theta_I(U')$ and consequently $\Theta_I' \subset \Theta_I$.

The same result carries through if we replace the linear projection with conditional expectations. In this case, Q_α is the conditional expectation operator, which also implies that any integrable moment function m can be decomposed as $m = Q_\alpha m + Q_\alpha^\perp m$ such that $Q_\alpha(m - Q_\alpha m) = 0$. □

Proof. **of Corollary 7**

(1): When $B_t = 0$, $\mathbb{E}\left(g\left(Y_t, Y_{t+1}, \theta\right) - \lambda_t^o(Y_t, Y_{t+1}, \theta)\right) X_{t-1} = 0$ which trivially restores point identification. When $B_t = 1$, 14 collapse to 15

$$sign\left(\mathbb{E}\left(g\left(Y_t, Y_{t+1}, \theta\right) - \lambda_t^o(Y_t, Y_{t+1}, \theta)\right) X_{t-1}\right) = sign\left(\mathbb{E}(\kappa_t X_{t-1})\right) = sign\left(\mathbb{E}(\mu_t X_{t-1})\right)$$

For $B_t \in (0,1)$, the moment conditions in 15 and 14 are not perfectly correlated as $Corr(\kappa_t, \mu_t) = Corr(\kappa_t, B_t \kappa_t) \neq 1$. By proposition 5 we conclude.

(2): Suppose that Θ_I is a singleton. Then it must be that the RHS of 14 is zero: Either $B_t = 0$ for all t, or $\Lambda_t(i)$ has unit mass on one agent who is unconstrained, and thus $B_t = 0$ as well. □

Proof. **of $\boldsymbol{\rho_{\mu,ols}}$** $\notin \rho_{\mu,ID,2}$ in Partial Equilibrium

We first illustrate how we compute the distortion $\lambda_{i,t}$. If the agent is constrained, then according to the Euler equation it has to be the case that $\rho_\mu x_{i,t} = \mathbb{E}(c_{i,t+1} | \lambda_{i,t} > 0) + \lambda_{i,t}$. Expectations about the future have to include the possibilities of being constrained or not in $t+1$, thus:

$$\begin{aligned}
\rho_\mu x_{i,t} &= \mathbb{E}(c_{i,t+1}|\lambda_{i,t}>0)-\lambda_{i,t} \\
&= \mathbb{E}(x_{i,t+1}|\lambda_{i,t}>0)\mathbb{P}(\lambda_{i,t+1}>0|\lambda_{i,t}>0) \\
&\quad +\left(1-\frac{\rho_\mu}{1+r}\right)\mathbb{E}(x_{i,t+1}|\lambda_{i,t}>0)\mathbb{P}(\lambda_{i,t+1}=0|\lambda_{i,t}>0)-\lambda_{i,t} \\
&= \mathbb{E}(x_{i,t+1}|\lambda_{i,t}>0)\left[1-\frac{\rho_\mu}{1+r}\mathbb{P}(\lambda_{i,t+1}=0|\lambda_{i,t}>0)\right]-\lambda_{i,t} \\
&= \bar{y}\left[1-\frac{\rho_\mu}{1+r}\mathbb{P}(\lambda_{i,t+1}=0|\lambda_{i,t}>0)\right]-\lambda_{i,t} \\
&= \bar{y}\left[1-\frac{\rho_\mu}{1+r}(1-F_y(x^\star))\right]-\lambda_{i,t}
\end{aligned}$$

where in the last two lines we use that cash on hand in $t+1$ if constrained at t is equal to y_{t+1} whose expected value is the unconditional mean, while the probability of being constrained in $t+1$ is $F_y(x^\star)$, $x^\star$ being the cash on hand threshold. Thus, $\lambda_{i,t}=-\rho_\mu x_{i,t}+\bar{y}\left[1-\frac{\rho_\mu}{1+r}(1-F_y(x^\star))\right]$ and

$$\begin{aligned}
\Delta c^{inc}_{i,t+1} &= \tilde{\rho}_\mu c_{i,t}+\epsilon_{t+1}+\mathbf{1}(\lambda_{i,t}>0)\left(-\rho_\mu c_{i,t}+\bar{y}\left(1-\frac{\rho_\mu}{1+r}(1-F_y(x^\star))\right)\right) \\
&:= \tilde{\rho}_\mu c_{i,t}+\epsilon_{t+1}+\mathbf{1}(\lambda_{i,t}>0)\left(\lambda_1 c_{i,t}+\lambda_0\right)
\end{aligned}$$

To derive the bound, let $p_t:=\mathbb{P}_t(\lambda_{i,t}>0)$, $p:=\frac{\mathbb{E}(c^2_{i,t}p_t)}{\mathbb{E}c^2_{i,t}}$ and denote by $\varphi(x)$ the Normal density. If $\rho_{\mu,ols}$ is admissible, then evaluating the LHS of (8) at the true $\tilde{\rho}_{\mu,0}$ and the RHS at $\rho_{\mu,ols}$, and solving for p_t:

$$p_t \leqslant \frac{\Phi(v-\tilde{\rho}_\mu c_{i,t})-\Phi(v-\tilde{\rho}_{\mu,ols}c_{i,t})}{\Phi(v-\tilde{\rho}_\mu c_{i,t})-\Phi(v-\lambda_0-(\tilde{\rho}_\mu+\lambda_1)c_{i,t})}$$

The function $g(p_t):=\frac{\Phi(v-\tilde{\rho}_\mu c_{i,t})-\Phi(v-\tilde{\rho}_{\mu,ols}c_{i,t})}{\Phi(v-\tilde{\rho}_\mu c_{i,t})-\Phi(v-\lambda_0-(\tilde{\rho}_\mu+\lambda_1)c_{i,t})}$ satisfies $g(0)=0$ and $g(1)=1$ and

$$g'(p_t)=\frac{\varphi(v-\tilde{\rho}_{\mu,ols}c_{i,t})(\tilde{\lambda}_1|p=1)c_{i,t}}{\Phi(v-\tilde{\rho}_\mu c_{i,t})-\Phi(v-\lambda_0-(\tilde{\rho}_\mu+\lambda_1)c_{i,t})}>0$$

$$g''(p_t)=\sigma_\epsilon^{-2}(v-\tilde{\rho}_{\mu,ols}c_{i,t})\frac{\varphi(v-\tilde{\rho}_{\mu,ols}c_{i,t})((\tilde{\lambda}_1|p=1)c_{i,t})^2}{\Phi(v-\tilde{\rho}_\mu c_{i,t})-\Phi(v-\lambda_0-(\tilde{\rho}_\mu+\lambda_1)c_{i,t})}$$

$\square$

8.1. **Constrained versus Unconstrained Consumption.** The figure below depicts the consumption function in incomplete markets. Notice that for large values of x_t, C_t^{inc} and C_t^{com} become parallel, as expected.

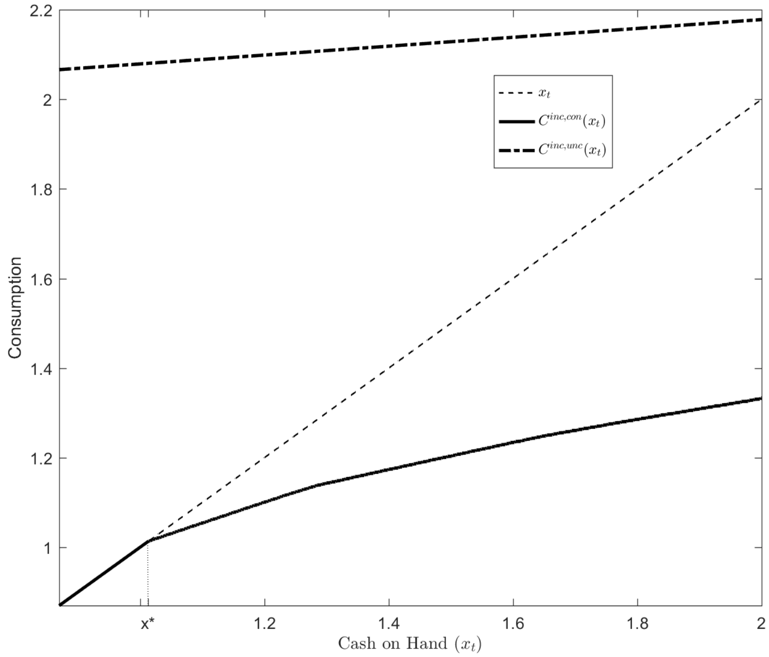

FIGURE 8. Optimal Consumption

TABLE 3. Confidence Set for Θ_{FI}

Parameter	$q_{2.5\%}$	$q_{97.5\%}$
ω	0.906	1.362
η	2.924	3.263
υ	0.006421	0.2531
ψ	0.9627	1.0
ρ_a	0.1836	0.7822
ρ_g	0.000	0.06399
ρ_{for}	0.000	0.192
μ_α	0.004384	0.1249
μ_{for}	0.000	0.001215
μ_k	0.000	0.001438
μ_g	0.01615	0.02727
σ_a	0.2542	0.3385
σ_g	0.3769	0.5511
σ_{for}	0.5466	1.256

8.1.1. ***Data Transformation-Balance Statistics***. Given that in our theoretical analysis we assumed positive balances that directly relate to a probability statement, we need to make a simple transformation of the balance statistics. We have already defined the probability of an event as a certain partition of the relevant random variable of interest. If this random variable is x, then we partition x in i.e. 5 intervals, namely x_1, x_2, x_3, x_4, x_5. The probability mass p_i in a particular partition will therefore give the probability of this random variable lying in this partition of the support. The balance statistic $B = p_5 + 0.5p_4 - p_2 + 0.5p_1$ is equivalent to judging whether there is more mass above or below the median x, $med(x)$ and truncating the distribution on both ends by the same proportion to avoid extremes. Taking the truncated distribution as the true distribution, then the balance statistic is $B \equiv \mathbb{P}(x > med(x)) + \mathbb{P}(x < med(x))$ which implies that $\mathbb{P}(x > med(x)) = \frac{1+B}{2}$.

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