# The distributional effects of peer and aspirational pressure*

Konstantinos Angelopoulos
University of Glasgow and CESifo

Spyridon Lazarakis
University of Glasgow

James Malley
University of Glasgow and CESifo

September 3, 2019

**Abstract**

We develop a theoretical framework where the cross-sectional distributions of hours, earnings, wealth and consumption are determined jointly with a set of expenditure targets defining peer and aspirational pressure for members of different social classes. We show existence of a stationary socio-economic equilibrium, under idiosyncratic stochastic productivity and socio-economic class participation. We calibrate a model belonging to this framework using British data and find that it captures the main patterns of inequality, between and within the social groupings. We find that the effects of peer pressure on within-group inequality differ between groups. We also find that wealth and consumption inequality increase within groups who aspire to match social targets from a higher class, despite a reduction in within-group inequality in hours and earnings.

Keywords: inequality, incomplete markets, peer pressure, aspirations
JEL Classification: E21, E25, D01, D31

*We would like to thank seminar participants at the University of Southampton and the London Metropolitan University, as well as participants at 5th International Conference in Applied Theory, Macro and Empirical Finance for comments and suggestions. We are also grateful for financial support from the Economic and Social Research Council and the Scottish Government. The views expressed here are solely our own.

# 1 Introduction

There is a significant body of research examining the importance of social influences on economic outcomes (see e.g. Benhabib *et al.* (2011) for an overview of this literature). A subset of this literature has focused on the role of group pressure to achieve socially determined economic targets.[1] This has been motivated by long-standing theories of relative consumption and/or income, related to a desire for status (see Veblen (1899), Duesenberry (1949)), and empirical evidence that the implied social influence on one's preferences matters for economic decision making, including consumption, savings and labour supply choices (see e.g. Heffetz and Frank (2011) and De Giorgi *et al.* (2019)). At the same time, an extensive literature, building on the contributions by Bewley (1986), Huggett (1993) and Aiyagari (1994), shows that under incomplete markets, the distribution of these choices across individuals, in response to the idiosyncratic shocks that they receive, leads to hours, earnings, wealth and consumption (HEWC) inequality.

Combining the ideas underpinning these two strands of research, it is natural to expect that social pressure should contribute to the patterns of observed inequality. There is a growing literature which theoretically examines the link between socially determined reference points (including those related to status-seeking and aspirations) with inequality and persistent poverty (see e.g. Becker *et al.* (2005), Mookherjee *et al.* (2010), Ray and Robson (2012), Dalton *et al.* (2016), Genicot and Ray (2017)). However, the distributional effects of socio-economic class-related peer and aspirational pressure, under stochastic productivity and class participation, have not been examined.[2]

This paper aims to fill this gap, focusing on a quantitative analysis of the distributional effects of these forms of social pressure on HEWC across the socio-economic spectrum both between and within the socio-economic classes. This allows us to examine heterogeneity in the effects of social pressure on inequality across social groups and economic outcomes, and thus obtain more information on the socio-economic implications of changes in

[1] See e.g. Akerlof (1980), Jones (1984), Abel (1990), Cole *et al.* (1992), Bernheim (1994), Gali (1994), Campbell and Cochrane (1999), Hopkins and Kornienko (2004), Postlewaite (2011) and Roussanov (2010) for examples in game theory, labour, macroeconomics, growth, finance, and reviews of the literature. A comparison of our work relative to the literature is the next section.

[2] This is despite empirical evidence on (i) the strength of social pressure from the group of peers on savings, consumption and effort choices (see e.g. Brown *et al.* (2008), Mas and Moretti (2009), Mugerman *et al.* (2014), and De Giorgi *et al.* (2019)), and (ii) the extent and importance of the idiosyncratic component of earnings (see e.g. Meghir and Pistaferri (2011) for a review of this research and Blundell and Etheridge (2010) regarding evidence for the UK).

the form and strength of social pressure. Such change may arise with socio-economic developments that characterise our times (e.g. greater social interaction and widespread access to social media) or as a result of intentional long-term policy interventions to instigate societal change (e.g. policies to support integration and confidence, or to provide role models and success stories, to increase aspirations). In particular, we are interested in identifying: (i) social groups that, following changes in social pressure, are more likely to experience increases in the dispersion of economic outcomes, despite potential material benefits in absolute terms; and (ii) economic outcomes in which we observe divergence/convergence between groups.

### 1.0.1 Theoretical framework and data fit

The theoretical framework we develop incorporates: (i) persistent, idiosyncratic shocks to productivity and socio-economic class participation, determining social mobility in addition to wages; (ii) flexible forms of peer and aspirational pressure related to class-relevant consumption targets, which are determined in equilibrium by the aggregation of relevant household-level consumption choices; and (iii) endogenously determined cross-sectional distributions of HEWC. A household's utility depends, in addition to its own consumption and leisure, on a socially determined target that is given by some aggregate measure of consumption (e.g. the mean or any percentile) of their peers' consumption (i.e. of households in their own socio-economic class), or of members of other socio-economic classes (allowing, e.g., for "upward looking" aspirations). Since households face the prospect of upward or downward mobility, the whole set of social targets matter for each individual's decision making, albeit with implicit weights determined by its current state and the conditional probabilities determining social mobility.

The flexibility in the determination of the consumption targets permits the study of varying strengths of peer pressure, and of different forms of aspirations. Motivated by empirical evidence in e.g. De Giorgi *et al.* (2019), who estimate significant "keeping-up-with-the-Joneses" effects of co-workers' aggregate consumption on a household's own consumption, the group of peers is defined as the group of households who have the same type of occupation. Moreover, existing research (see e.g. Appadurai (2004), Ray (2006), Dalton *et al.* (2016), Genicot and Ray (2017)) has analysed the importance of different forms of "upward looking" aspirations for decision making and economic outcomes. We differentiate between aspirations that are constrained to conform to peer behaviour and those where a household aspires to achieve outcomes typically associated with higher income classes.

In our framework, inequality is determined by individual responses to uninsured idiosyncratic shocks (defined here to include the social class shocks), as well as social pressure. In turn, the extent of peer or aspirational pressure is an equilibrium outcome, determined jointly with the distributions of the economic outcomes that it contributes to. The equilibrium is obtained when household level decision-making is consistent with the aggregate-level social targets. In other words, when the consumption target for each group equals the respective moment of the distribution of consumption that arises under the whole set of consumption targets.

We show existence of a stationary socio-economic equilibrium where social pressure targets are fixed quantities and are jointly determined with the (invariant) cross-sectional distributions. This extends the stationary equilibrium results in Bewley (1986) - Huggett (1993) - Aiyagari (1994) models (BHA) of wealth, earnings and consumption inequality (see e.g. Acikgoz (2018) and Zhu (2018)). The socio-economic equilibrium in our model is a generalisation of the stationary equilibrium concept in the Pijoan-Mas (2006), Marcet *et al.* (2007), and Zhu (2018) version of the BHA incomplete markets models with endogenous labour supply. We build on the approach in Zhu (2018) and show that under peer pressure a stationary socio-economic equilibrium exists and it is characterised by a unique household-level invariant asset-shock distribution.[3]

We then show that quantitative analysis based on this framework can match the stylised patterns of inequality between and within the professional groups that we observe in the data for Great Britain. We consider four professional groups, based on the National Statistics Socio-Economic Classification (NS-SEC) (see Rose and O'Reilly (2005) for more detail). These groups are denoted as "routine" (including routine and semi-routine occupations), "intermediate" (including clerical, sales and service, as well as lower supervisory and technical occupations), "lower professional" (including lower management and professional occupations) and "higher professional" (including higher management and professional occupations). We choose these groups because the classification generates a discernible pattern for between and within group inequality. Using data on the distribution of: (a) hours and earnings from the Understanding Society dataset; (b) wealth from the Wealth and Asset Survey; and (c) consumption from the Living Cost and Food Survey, we find that: (i) mean hours, earnings, wealth and consumption increase with professional classes which have higher mean wages; (ii) within group hours, earnings and wealth inequality varies substantially between the groups, and decreases for groups with higher means. In contrast, within

[3] The latter property of the equilibrium is very helpful in that it facilitates a feasible computation.

group consumption inequality does not vary much between groups; and, (iii) overall inequality (across the whole sample) is highest for wealth and lowest for consumption, as is typically found in the data (see e.g. Quadrini and Rios-Rull (2015) for the US). We calibrate the model using data on professional class and wage dynamics from the Understanding Society dataset and, based on available econometric evidence from De Giorgi *et al.* (2019), peer pressure that implies "keeping-up-with-the-Joneses" and "jealousy" motives. Social targets are determined by the mean consumption of the socio-economic group to which the household belongs. We find that the model captures the main patterns of inequality in the data in hours worked, earnings, wealth and consumption, between and within the professional classes.

## 1.1 Peer pressure

We use our framework to shed light on the contribution of "keeping-up-with-the-Joneses" peer pressure on inequality in HEWC, between and within the socio-economic groups that we consider. Intuition suggests that social pressure to achieve a target that summarises behaviour in one's own class, which is implied by "keeping-up-with-the-Joneses" peer pressure, should create incentives to induce within-cluster convergence and, likely, cross-cluster divergence.[4] In other words, groups become more sharply distinguishable, while the individuals within the groups become more similar, as a result of the pressure to conform to targets that differ between groups. While these effects are present in the economy that we consider, we uncover a richer interaction between peer pressure and distributional outcomes, characterised by the co-existence of (i) between group convergence in some outcomes with divergence in others; and (ii) within-group divergence for some groups and in some outcomes, with convergence for others. We find that, as a result of "keeping-up-with-the-Joneses" peer pressure, within group hours and earnings inequality falls for the higher mean wages groups and within group wealth and consumption inequality reduces for the lower mean wage groups. In contrast, within group wealth and consumption inequality increases for the higher mean wage groups and within group hours and earnings inequality rises for the lower mean wage groups. Hence, the inequality effects of peer pressure to meet social targets are not uniform across social groups. At

[4] Indeed, this is consistent with the results in Genicot and Ray (2017), who link aspirations-defining social targets to a type of clustering that is characterised by within-cluster convergence and cross-cluster inequality, when the clusters are defined based on similarity in terms of income. Likewise, Luo and Young (2009) find that a common preference for social status across the whole distribution (i.e. when there is "one cluster") implies a reduction in wealth inequality.

the same time, between group inequality increases for hours, earnings and consumption, but falls for wealth.

The complexity in the effects of peer pressure summarised above arises because we study an environment with stochastic productivity and social transitions (which implies that all agents acknowledge that with some probability all social targets might become relevant), which distinguishes earnings from asset income. The prospect of upward mobility, associated with stochastic socio-economic class participation, embeds an upward looking element in peer pressure. Under peer pressure, the prospect of upward mobility implies a possibility for increased peer pressure. Thus, it stimulates savings, working to decrease between group wealth inequality and further contributing to the asymmetric change in within group inequality across groups and economic outcomes.[5] The added realism in our framework implies that, following changes in the type of peer pressure, the interaction of intra- and inter-temporal decision margins (under idiosyncratic productivity and the prospect of upward mobility) imply differential effects of social targets across groups. This leads to the asymmetric pattern of both convergence and divergence, between and within groups, depending on social class and the inequality measure considered.

## 1.2 Aspirations

Peer pressure incorporates an aspirational element, because it instills a desire to match a pre-specified level of success. We investigate the effects of a stronger aspirational aspect of peer pressure, associated with group members targeting the consumption of more successful members of their groups, instead of the "typical" member. We find that such social behaviour is associated with significant and positive effects, on average, for all groups. It is related with falls in within group inequality as well as in the gap between the highest mean wage group and the other groups regarding hours and earnings. On the other hand, between and within group inequality in consumption and wealth do not change much and do not follow an obvious pattern. On balance, when aspirations are determined within the social class, there are positive implications of a more strongly aspirational peer pressure for hours and earnings, without significant and clear effects on wealth and consumption.

The form of aspirations discussed above can be thought of as more a result of pressure from peers to meet a group-level target (and is thus reflecting

[5] Stochastic socio-economic class participation also embeds a risk of downward mobility, which works in the opposite way to lower savings for the higher mean wage groups, further enhancing the effects described here.

a form of social conformism), rather than a situation where an agent truly aspires to behaviour associated with "higher classes". We aim to understand the potentially different inequality implications of aspirations that are constrained by pressure to conform to peers, from an aspiration to succeed by doing better than the peers. To this end, we exploit the flexible form of target functions employed in the theoretical framework when comparing these two types of social pressure. We define above-peer aspiration as the situation where the social target is the mean consumption (or relevant percentile) of the socio-economic group that has a higher mean wage than the group of peers.

We find that above-peer aspiration, compared with peer pressure, has positive effects on mean quantities for all socio-economic classes. However, while it allows the groups with the raised aspirations (lower mean wage groups) to close the gap with the top mean wage group in hours, earnings and consumption, it increases the gap in terms of wealth.[6] However, when focusing on the three lower mean wage groups, for which there are truly "higher" aspirations, by disentangling asset income as a source of income from hours and earnings, we find that wealth and consumption inequality within-groups increases under higher aspirations. This is despite a reduction in within-group inequality in hours and earnings and thus highlights the importance of allowing for idiosyncratic earnings variation and the insurance value of wealth when examining wealth inequality. Therefore, the improvement in average material wealth that is implied by higher, above class, aspirations, can be associated with an increase in social dissatisfaction, as a result of an increased dispersion in the magnitude and probability of underachievement.

# 2 Related literature

Our framework and analysis builds on the class of models with idiosyncratic shocks and incomplete markets, which, following the contributions by Bewley (1986), Huggett (1993) and Aiyagari (1994), has been used to study quantitatively wealth inequality in a stationary equilibrium (see e.g. Quadrini and Rios-Rull (2015) and Benhabib *et al.* (2017) for reviews and extensions; and Acikgoz (2018) for a proof of existence of stationary equilibrium under per-

[6] The wealth inequality result has similarities to results in Genicot and Ray (2017), where stronger aspirations increase between group wealth inequality. However, in our model, this result is obtained even when aspirations have monotonic effects on savings, and is driven by an upper bound of aspirations to the level of peer pressure for the higher socio-economic class. In effect, there is a direct non-monotonic increase in aspirations across the classes that drives the specific result here.

sistent shock processes in the benchmark model with exogenous earnings). Our extension is based on generalisations as in e.g. Pijoan-Mas (2006) and Marcet *et al.* (2007) and thus on a framework where HEWC inequality are jointly determined in response to exogenous shocks. Zhu (2018) shows existence of stationary equilibrium in the benchmark model with endogenous earnings and persistent productivity shocks.

Our modelling framework contributes to this research by adding peer pressure in an environment with professional mobility, defining a socio-economic equilibrium, and establishing its existence and its relevance for quantitative analysis of between and within group inequality.[7] An additional difference relative to the quantitative analyses in the literature relates to the characterisation of productivity shocks. Agents in our model receive shocks that determine their occupation type and their productivity in their occupation. In the model calibration, we use Understanding Society data to measure transitions from any occupation type, and any productivity level, to any other.

Existing research has introduced social effects in the form of "keeping-up-with-the-Joneses" relative consumption considerations in representative agent dynamic general equilibrium models, to study their effects on macroeconomic outcomes and asset pricing, following the contributions by e.g. Abel (1990), Gali (1994) and Campbell and Cochrane (1999). Instead, we are interested in the joint determination of distributions with socio-economic targets and we work in an environment with heterogeneous agents, who are subjected to idiosyncratic shocks and pressure from a specific group of peers. We focus on peer pressure associated with consumption targets. In our framework each social group has its own target, where all targets are jointly determined in equilibrium with the distribution for consumption for all groups and we establish existence of such a socio-economic equilibrium.[8] Roussanov (2010) introduces status seeking related wealth targets in the utility function in a model with heterogeneous agents but does not study peer pressure. Instead, the social target in Roussanov (2010) is average wealth across the whole distribution, and the model is used to quantitatively examine the effect of such social factors on financial decision-making and portfolio allocations.

Peer pressure, and analysis of the resulting socio-economic equilibrium, has been examined rigorously in static settings (e.g. Akerlof (1980), Jones (1984), Bernheim (1994), Calvo-Armengol and Jackson (2010) and Ghiglino and Goyal (2010)), and in conjunction with income inequality (e.g. Hop-

[7] Note that when defining the socio-economic equilibrium, social targets that influence economic decisions are determined jointly with the distributions that they affect.

[8] Note, given social mobility, all social targets matter for any individual agent's decision making.

kins and Kornienko (2004)). We take the individual's desire to conform to socially-defined targets as given, and focus on the joint determination of inequality in HEWC with the level of the social targets (and thus the extent of peer pressure), in an environment where the agents are subjected to idiosyncratic productivity and social class shocks.

There is also a significant literature that has examined the importance of status seeking, aspirations and relative consumption considerations for economic growth and inequality, including the effect of such social factors on savings and growth, the qualitative properties of the distribution of wealth and/or income over generations and the possibility of poverty traps in the process for development (see e.g. Cole *et al.* (1992), Hopkins and Kornienko (2006), Ray and Robson (2012), Genicot and Ray (2017), who also review further contributions in this literature). In addition, the joint determination of inequality with occupational mobility has been theoretically examined in the literature, (e.g. Mookherjee and Ray (2003)) and quantitatively (e.g. Quadrini (2000) and Cagetti and De Nardi (2006)) without social pressure, and in a theoretical analysis of skill acquisition under aspirations in Mookherjee *et al.* (2010).

Our analysis complements this research, by: (i) focusing on the group of peers determined by (stochastic) socio-economic class participation, as opposed to proximity in measures of income to determine social pressure, either from peers, or in the form of above-peer aspirations (see e.g. Genicot and Ray (2017, p. 494) on the novelty of such extensions); (ii) examining the joint determination of the distributions of HEWC with the set of social targets, in a stationary equilibrium and under stochastic productivity; and (iii) focusing explicitly on a framework to be used for quantitative analysis in an empirically relevant model, calibrated using data on the distributions of idiosyncratic shocks, to examine the interplay between peer pressure and inequality between and within the socio-economic class, as well as the effect of changes in the aspirational value of social targets on these inequalities.

We focus on cross-sectional distributions with individual-level stochasticity and dynamics within a stationary equilibrium, and do not examine dynamics in aggregate quantities (see e.g. Aiyagari (1994), Pijoan-Mas (2006) and Benhabib *et al.* (2015) for analysis of stationary stochastic equilibrium). Moreover, since we are interested in the effects of social pressure on inequality under the possibility of upward or downward mobility, and not on the effects of social pressure on mobility, we keep the latter as a stochastic process which we calibrate to the data for the quantitative analysis. It would of course be a very interesting, and non-trivial, extension to this framework to analyse a situation where the prospect of upward mobility interacts with the prospect of increased peer pressure to determine jointly cross-sectional distributions, in addition to decision making that influences class participation.[9]

# 3 A general theoretical framework

We consider an economy that is composed of a continuum of infinitely lived agents (households) distributed on the interval $I = [0, 1]$. Households derive utility from consumption and leisure and by comparing their consumption with that of their different socio-economic groups, which can be the group of their peers. We define peers to be all the members of the same socio-economic group. Participation in a socio-economic group is determined by a stochastic process at the level of the household, which also determines the household's returns to hours worked. Households draw idiosyncratic shocks independently from each other and cannot fully insure against shocks to labour income, because financial markets are incomplete. More specifically, there is a single asset in the economy. We examine stationary equilibria in which aggregate quantities are constant. Time is discrete and denoted by $t = 0, 1, 2, ....$

## 3.1 Households

Each household is endowed with one unit of time which is allocated between leisure and labour. We do not explicitly model differences in labour productivity and earnings between household members and assume for simplicity that the household offers a uniform labour supply. Each household wishes to maximise her expected lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t, C_t), \tag{1}$$

where $\beta \in (0, 1)$ is the time discount factor, $c$ is consumption, $l$ is leisure and $C$ is a quantity capturing the property of the consumption distribution to which the household compares their level of consumption to derive utility. At the level of the household, the social targets are taken as given. Households may differ in the reference value for consumption, but they are identical in their deep preferences.

[9] See e.g. Piketty (1995) and Benabou and Ok (2001) for examples of studies where the prospect of upward mobility can affect choices, in those cases relating to the demand for redistribution.

### 3.1.1 Idiosyncratic shocks

The household is subject to idiosyncratic shocks that determine its professional class (or occupation type) and its productivity within that professional class, thus determining the overall labour efficiency of the household. We assume that the household can work in $M$ professional classes (reflecting, e.g., higher and lower managerial or professional occupations, lower supervisory and intermediate jobs, or a routine and semi-routine jobs), and within each class there are $N$ productivity states. For example, a household may work as a highly productive lower supervisory worker, thus earning more income than the average lower supervisory worker, or it may be a manager not meeting her targets and thus earning less than the average manager. The $(M, N)$ specification may also capture the effect of the second earner in a household. In particular, we can let the $M$ states capture the professional or socioeconomic class of the household, as determined by the higher earner/head of the household, and in turn allow the $N$ states to determine the household's total earnings, from all members, within the $M$ professional class. Together, $M$ and $N$ capture labour efficiency of the household, which, in conjunction with labour supply and the wage rate per labour efficiency unit, $w$, determine labour income. At the household level, and in a stationary equilibrium, $w$ is constant and exogenously given.

The stochastic process for the joint distribution of idiosyncratic shocks $(z_t)_{t=0}^{\infty}$ is a Markov chain with transition matrix $Q$ and state space $Z = [\overline{z}_1, \overline{z}_2, ..., \overline{z}_H]$, $H = M \times N$, where for $h = 1, ...H$, $\overline{z}_h \equiv \overline{z}_{m,n}$ for all $m = 1, ..., M$ and all $n = 1, ..., N$. The elements of the transition matrix $Q$ are denoted $\pi(z_{t+1}|z_t)$, and $\sum\limits_{z_{t+1}} \pi(z_{t+1}|z_t) = 1$ for all $z_t \in Z$. Additionally, we assume that $\pi(z_{t+1}|z_t) > 0$ for all $z_t, z_{t+1} \in Z$. Hence, the Markov chain has a unique invariant distribution, with probability measure that we denote by $\xi$.

The stochastic process $(z_t)$ determines labour income as well as consumption related peer or above-peer pressure, by determining the relevant target level for relative consumption comparisons. Denoting $e(z_t) : Z \rightarrow E = [\overline{e}_1, \overline{e}_2, .., \overline{e}_H] \equiv [\overline{e}(\overline{z}_1), \overline{e}(\overline{z}_2), .., \overline{e}(\overline{z}_H)]$ as labour efficiency, labour income is given by $we(z_t)(1 - l_t)$. The elements $\overline{z}_h$ in $Z$ can be ordered such that $0 < \overline{e}^{\min} = \min(E) < \cdots < \overline{e}^{\max} = \max(E)$. Moreover, socioeconomic class participation is determined by $s(z_t) : Z \rightarrow [1, ..., M]$, where $s(\overline{z}_{m=j,n}) = j$, for $j = 1, ..., M$, and implies a reference point for consumption, relative to which individual level consumption is compared. In particular, $C(z_t) \equiv C(s(z_t)) : Z \rightarrow \widetilde{C}$, where $\widetilde{C} = \{\overline{C}_1, \overline{C}_2, .., \overline{C}_M\}$. The elements in $\widetilde{C}$ can refer to different percentiles or the mean of the distribution of consumption for the different classes.

At the level of the household, $\widetilde{C}$ is given. However, in equilibrium, the reference points $\overline{C}_j$ are determined endogenously by the distribution of consumption in the specific class that the individual compares its consumption to. Note that this setup implies that there is a unique transition matrix $Q$ that determines the evolution of both stochastic processes $e(z_t)$ and $C(s(z_t))$.

### 3.1.2 Peer and above-peer pressure

The social target can be defined as capturing pressure from one's peers to achieve a target related to group behaviour, or as capturing aspirations to achieve a target related to more successful groups. Under peer pressure, $C$ can be, for example, the average consumption of the group of peers, or any percentile of that distribution that forms the appropriate level of comparison. Consistent with empirical evidence from De Giorgi *et al.* (2019), which suggests that the peer pressure effects are determined by the professional environment, we assume that the reference group, the peers, is the professional, socio-economic class to which the household belongs. Hence, under peer pressure, professional class determines the reference point for consumption, in addition to affecting labour income. In particular, under peer pressure, the function $C(s(z_t))$ is given by:

$$C(s(z_t) = j) = \overline{C}_j, \text{ for } j = 1, ..., M.$$

Alternatively, the social target may capture the aspirations of the household to achieve a consumption level of households of "higher", in terms of economic outcomes, socio-economic classes. Under such above-peer aspirations, $C$ can be, for example, the average consumption of groups of households from classes with higher consumption, or any percentile of that distribution. In this case, the function $C(s(z_t))$ is given by:

$$\begin{aligned} C(s(z_t) = j) &= \overline{C}_{j+1}, \text{ for } j = 1, ..., M-1, \\ C(s(z_t) = M) &= \overline{C}_M, \text{ for } j = M. \end{aligned}$$

We assume that the instantaneous utility function $u(c, l, C)$ satisfies:

`Assumption 1`

$u : \mathbb{R}_+ \times [0,1] \times \mathbb{R}_+ \to \mathbb{R}$ is bounded and twice continuously differentiable; $u(c, l, C)$ is strictly increasing in $(c, l)$ and strictly concave in $(c, l, C)$; $\lim_{c \to 0} u_1(c, l, C) = +\infty$, $\forall l \in [0, 1]$ and $\forall C \geq 0$, and $\lim_{l \to 0} u_2(c, l, C) = +\infty$, $\forall c \geq 0$ and $\forall C \geq 0$; $u_{12} \geq 0$ i.e. consumption and leisure are normal goods and complementary to each other.

The assumptions regarding leisure follow from Zhu (2018). Under peer pressure, the marginal effect of $C$ determines its type: (a) either $\frac{\partial u}{\partial C} < 0$ ("jealousy"), or $\frac{\partial u}{\partial C} > 0$ ("admiration"), and, (b) either $\frac{\partial^2 u}{\partial c \partial C} > 0$ ("keeping-up-with-the-Joneses"), or $\frac{\partial^2 u}{\partial c \partial C} < 0$ ("running-away-from-the-Joneses"). When peer pressure is consistent with jealousy and keeping-up-with-the-Joneses (see e.g. Gali (1994), Dupor and Liu (2003), and De Giorgi *et al.* (2019)), it creates incentives to increase consumption and under save. When peer pressure is consistent with admiration and running-away-from-the-Joneses (see e.g. Dupor and Liu (2003) and Roussanov (2010)), it creates incentives to decrease consumption. Under above-peer aspirations, the marginal effect of $C$ satisfies $\frac{\partial u}{\partial C} < 0$ and $\frac{\partial^2 u}{\partial c \partial C} > 0$. Compared with the specifications of aspirations in Mookherjee *et al.* (2010), Dalton *et al.* (2016) and Genicot and Ray (2017), we focus here on the aspiration to achieve the consumption level of the higher, in terms of income, socio-economic class relative to one's own class.

### 3.1.3 Optimal choices

There is a single risk-free asset in the economy, which generates interest income from accumulated assets $ra_t$, where $r$ is the interest rate and $a$ denotes assets. Households' labour efficiency shock $e(z_t)$ is observed at the beginning of period $t$. Households use their income for consumption and to invest in future assets $a_{t+1}$. Moreover, the households cannot borrow assets from other households and thus $a_{t+1} \geq 0$.[10] Thus, the household's budget constraint is:

$$c_t + a_{t+1} = (1+r)\, a_t + we(z_t)(1 - l_t), \tag{2}$$

with $c \geq 0$ and $a_{t+1} \geq 0$. The household's state can be described by $(a, z) \in A \times Z$, where $A = [0, +\infty)$. The interest rate and wage rate are taken as given and satisfy $r > -1$ and $w > 0$. To allow for an equilibrium with non-degenerate distributions in economic outcomes, we assume that $\beta(1+r) < 1$ (see e.g. Marcet *et al.* (2007) and Zhu (2018)).

Taking prices and consumption targets as given, and given initial values $(a_0, z_0) \in A \times Z$, the household chooses plans $(a_{t+1})_{t=0}^{\infty}$, $(c_t)_{t=0}^{\infty}$ and $(l_t)_{t=0}^{\infty}$

[10] Since the household can choose to set $l = 1$, the natural borrowing limit in this context is zero. We could allow for borrowing, if, for example, we made the additional assumption that even under zero labour income, net household income is positive (reflecting for example family support and/or public transfers). To keep the exposition compact we do not introduce such assumptions.

that solve the maximisation problem:

$$
\begin{aligned}
V(a_0, z_0) = \max_{(c_t, a_{t+1}, l_t)_{t=0}^{\infty}} & E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t, C(s(z_t))), \\
s.t. & \\
c_t + a_{t+1} = & (1+r)\, a_t + w(1-l_t)e(z_t), \\
c_t, a_{t+1}, l_t \geq & 0, \\
1 \geq & l_t.
\end{aligned} \tag{3}
$$

To obtain the dynamic programming formulation of the household's problem, let $V\left(a_t, z_t; \widetilde{C}\right)$ denote the optimal value of the objective function starting from asset-productivity state $(a_t, z_t)$ and given the values of the reference points $\widetilde{C}$.[11] The Bellman equation is:

$$
V\left(a_t, z_t; \widetilde{C}\right) = \tag{4}
$$

$$
= \max_{\substack{a_{t+1} \geq 0 \\ c_t, l_t \geq 0 \\ 1 \geq l_t}} \left\{ u(c_t, l_t, C(s(z_t))) + \beta \sum_{z_{t+1} \in Z} \pi(z_{t+1}|z_t)\, V\left(a_{t+1}, z_{t+1}; \widetilde{C}\right) \right\},
$$

where $c_t + a_{t+1} = (1+r)\, a_t + w(1-l_t)e(z_t)$.

As discussed in more detail in Appendix A, building on analysis in e.g. Stokey *et al.* (1989), Miao (2014) and Acikgoz (2018), and applying results from Zhu (2018), it can be shown that there exists a unique value function $V\left(a_t, z_t; \widetilde{C}\right)$ that solves the problem in (4) and policy functions $a_{t+1} = g\left(a_t, z_t; \widetilde{C}\right)$, $c_t = q\left(a_t, z_t; \widetilde{C}\right)$ and $l_t = l\left(a_t, z_t; \widetilde{C}\right)$, which generate the optimal sequences $\left(a_{t+1}^*\right)_{t=0}^{\infty}$, $(c_t^*)_{t=0}^{\infty}$ and $(l_t^*)_{t=0}^{\infty}$ that solve (3), with properties including the following. The functions $g(a, z; \widetilde{C})$ and $l(a, z; \widetilde{C})$ are continuous and weakly increasing in $a$, and the function $q(a, z; \widetilde{C})$ is continuous and strictly increasing in $a$, while $l(a, z; \widetilde{C}) = 1\ \forall z \in Z$, when $a$ is sufficiently large. Moreover, there is an upper bound for asset accumulation, denoted by $\overline{a}$, and there is $X = [0, \overline{a}] \times Z$ such that if a household starts with state $(a, z)$ in $X$, then the agent stays in $X$, and if a household starts outside

[11] To simplify notation, we suppress the explicit dependence of the value and policy functions on the interest and wage rates.

of $X$, it will arrive in $X$ almost surely. Finally, by defining the transition function $\Lambda^{\widetilde{C}}$ as:

$$\Lambda^{\widetilde{C}}\left[(a,z), A' \times \{z'\}\right] = \begin{Bmatrix} \pi(z'|z), \text{ if } g\left(a,z;\widetilde{C}\right) \in A' \\ 0, \text{ if } g\left(a,z;\widetilde{C}\right) \notin A' \end{Bmatrix}, \tag{5}$$

for all $(a,z) \in X$, $A' \times \{z'\} \in \mathcal{B}(X)$, the process $\{(a,z)\}_{t=0}^{\infty}$ with transition matrix $\Lambda^{\widetilde{C}}$ has a unique invariant distribution $\lambda^{\widetilde{C}}$ on $X$.

## 3.2 Socio-economic equilibrium

We define a socio-economic equilibrium given prices, where consumption reference points are consistent with household-level actions. Since there is a unique invariant distribution at the household level, $\lambda^{\widetilde{C}}$, which the same for all households, $\lambda^{\widetilde{C}}$ is also the cross-sectional distribution.[12] Therefore, the distributions of consumption, assets and labour supply per socio-economic class are invariant.[13] Thus, in a stationary equilibrium, given prices, $(w,r)$, there are $M$ consistency conditions, which will determine the elements in $\widetilde{C} = \left(\overline{C}_1, \overline{C}_2, .., \overline{C}_M\right)$:

$$\overline{C}_j = R\left(q\left(a_t, z_t; \widetilde{C}\right) : s(z_t) = j\right), \text{ for } j = 1, ..., M, \tag{6}$$

where the function $R(\cdot)$ refers to the relevant percentile of the distribution of consumption that defines the benchmark reference point for class $s_t$. When the reference point is determined by the mean consumption of the households in the social class that the household belongs to, the $M$ consistency conditions will determine:

$$\overline{C}_j = \left(\frac{1}{\xi_{m=j}}\right) \int_X \left(q\left(a,z;\widetilde{C}\right) : s = j\right) \lambda^{\widetilde{C}}(da,dz), \text{ for } j = 1, ..., M, \tag{7}$$

where $\xi_{m=j}$ denotes the proportion of households that experience socio-economic class $m = j$ and is obtained as the relevant marginal distribution of the unconditional joint distribution $\xi$.

[12] See e.g. Uhlig (1996), Al-Najjar (2008) and Acemoglu and Jensen (2016) for versions of the Strong Law of Large Numbers that apply in this class of models.

[13] Note that since the unconditional joint distribution $\lambda^{\widetilde{C}}(a,z)$ is invariant, the marginal distributions $\lambda_j^{\widetilde{C}}(a,z) \equiv \lambda^{\widetilde{C}}(\{a,z : s = j\}) = \sum_{n=1}^{N} \lambda^{\widetilde{C}}(a, z_{j,n})$, for $j = 1, ..., M$, are also invariant.

### 3.2.1 Equilibrium and existence

We formally define a stationary recursive equilibrium with peer pressure given aggregate prices, which we term as socio-economic equilibrium.[14]

`Definition: Stationary Recursive Socio-economic Equilibrium`

For given prices $r$ and $w$, a *Stationary Recursive Socio-economic Equilibrium* is an aggregate stationary distribution $\lambda^{\widetilde{C}}$ on $X$, policy functions $a_{t+1} = g\left(a_t, z_t; \widetilde{C}\right) : X \to A$, $c_t = q\left(a_t, z_t; \widetilde{C}\right) : X \to \mathbb{R}_+$ and $l_t = l\left(a_t, z_t; \widetilde{C}\right) : X \to [0,1]$, value function $V\left(a_t, z_t; \widetilde{C}\right) : X \to \mathbb{R}$, and positive real numbers in $\widetilde{C}$, such that:

1. Given the values in $\widetilde{C}$, the value function and the policy functions $g\left(a_t, z_t; \widetilde{C}\right)$, $c_t = q\left(a_t, z_t; \widetilde{C}\right)$, and $l_t = l\left(a_t, z_t; \widetilde{C}\right)$ solve the typical household's optimum problem in (4).

2. Given the values in $\widetilde{C}$, $\lambda^{\widetilde{C}}$ is a stationary distribution under the transition function $\Lambda^{\widetilde{C}}\left[(a,z), A' \times \{z'\}\right]$ implied by household's decision rules (determined by (5)). In particular, $\lambda^{\widetilde{C}}$ satisfies:

$$\lambda^{\widetilde{C}}([0,\overline{a}] \times \{z'\}) = \int_X \Lambda^{\widetilde{C}}\left[(a,z), A' \times \{z'\}\right] \lambda^{\widetilde{C}}(da, dz),$$

   for all $(a,z) \in X$, $A' \times \{z'\} \in \mathcal{B}(X)$.

3. When $\lambda^{\widetilde{C}}$ describes the cross-section of households at each date, the reference points in $\widetilde{C} = \left(\overline{C}_1, \overline{C}_2, .., \overline{C}_M\right)$ are given by the relevant percentiles of the distribution of consumption across the relevant social class in (6) or by the means in (7).

`Proposition 1:` *A stationary recursive socio-economic equilibrium exists.*

**Proof:** To show that an equilibrium allocation of $\left(\overline{C}_1, \overline{C}_2, .., \overline{C}_M\right)$, i.e. of the elements of the set $\widetilde{C}$, defining a stationary recursive socio-economic equilibrium exists, we use a fixed point theorem. In particular, define the set $\mathcal{C} \subseteq \mathbb{R}^m$ as the Cartesian product $\mathcal{C} = [0, c^{\max}] \times [0, c^{\max}] \times \cdots \times [0, c^{\max}]$. Note that for a given set $\widetilde{C}$ there is always an upper bound for consumption which is implied by the upper bound on assets, $\overline{a}_{\widetilde{C}}$, and is given by $c^{\max}_{\widetilde{C}} =$

[14] We also investigate later potential additional effects of social pressure on inequality via endogenously determined prices in the context of the calibration for the UK, by defining and establishing existence of a general equilibrium in an open economy setup.

$(1+r)\,\overline{a}_{\widetilde{C}} + w\overline{e}^{\max}$. We define $c^{\max}$ as the maximum of all possible $c_{\widetilde{C}}^{\max}$'s. Thus, $\mathcal{C}$ is compact and convex, so that $\widetilde{C} \in \mathcal{C}$. Define the operator $T(\widetilde{C}) : \mathcal{C} \to \mathcal{C}$ to be given by the set of equations in the right hand side of (6) or (7). Lemma 1 in Appendix B establishes continuity of the policy function $c_t = q\left(a_t, z_t, \widetilde{C}\right)$ in $\widetilde{C}$, and thus continuity of the operator in (6). Moreover, Lemma B in Appendix 2 establishes continuity of the integrals in (7) in $\widetilde{C}$, thereby establishing that the operator in (7) is continuous. Then, Brouwer's fixed point theorem applies and implies that an allocation $\left(\overline{C}_1, \overline{C}_2, .., \overline{C}_M\right)$ to solve (6) or (7) exists. ■

We describe an algorithm to solve iteratively for this stationary equilibrium after we discuss the calibration of the model below. As is commonly the case with equilibrium in heterogeneous agent models, although existence of equilibrium can be shown, we cannot show that the equilibrium is unique in general (see e.g. Aiyagari (1994), Miao (2014), Zhu (2018) and Acikgoz (2018)). In this model, this happens because changes in the reference points, $\left(\overline{C}_1, \overline{C}_2, .., \overline{C}_M\right)$, need not have monotonic effects on household policy functions. For example, in the applications below, we find that an increase in $\overline{C}_m$ tends to increase consumption for households in the $m^{th}$ social group. However, we also find that the increase in $\overline{C}_m$ also lowers consumption, to increase savings, for those is other groups who face the prospect of moving to that group and are thus faced with the prospect of higher peer pressure. In our applications, we have numerically explored the potential multiplicity of solutions for the set of parameter values that we use to calibrate the model. We have found a unique equilibrium for the set of parameters considered.[15] This is discussed in more detail below.

# 4 Data and stylised facts

We use British data on wages, hours worked, earnings, wealth, consumption and professional class participation, to calibrate the model and evaluate its predictions. In this section, we summarise the key properties in the data, To capture the uncertainty in labour productivity (wages) and socio-economic class participation, we use data from the Understanding Society Survey 2009-2017 (University of Essex, 2018), hereafter UnSoc. Data on the distributions of wealth are obtained from the Wealth and Assets Survey (ONS, 2018),

[15] This is similar to the variations of the Aiyagari (1994) model solved in the literature, in that although uniqueness typically cannot be established, a unique equilibrium for common calibrations is the norm.

hereafter WAS, on earnings and hours from the UnSoc, and consumption from the Living Cost and Food Survey (ONS, 2017), hereafter LCF.[16] Details on the data and sample selection are reported in Appendix C.

## 4.1 Social class, wages and hours

We first calculate the socio-economic transition matrix and productivity risk within socio-economic classes. We make use of the UnSoc data, which is the latest longitudinal dataset for the UK containing information on individuals and households from 2009 to 2017 (8 waves). We keep households when the head[17] is an employee and, if there is a spouse who also works, when she/he is also an employee. We drop the households if either the head or the spouse (if any) is self employed. We keep households when both the head and the spouse (if any) have non-missing usual gross earnings per month at the current job and non-missing number of weekly hours normally worked. However, we keep households if one of the two spouses does not work i.e. if there is a spouse with zero earnings and zero hours. We also drop the households with positive incomes but reported zero hours. We further restrict the dataset by retaining households where the head of the households is aged 25-59 and dropping observations with missing values for socio-economic class (to be defined below).[18] To approximate the household's effective wage, we first translate the usual gross earnings per month at the current job to weekly gross earnings by multiplying by 12 and dividing by 52, and then, we divide the sum of weekly gross earnings of the spouses by the sum of typical total weekly hours of the spouses.[19] We drop the top 0.5% and the bottom 0.5% of the observations with positive household's effective wage, to avoid extreme cases (e.g. possible outliers in effective wages) which may affect results (see e.g. Blundell and Etheridge (2010) for similar treatment). This effectively means that we drop households that appear to be working for less than half

[16] The WAS dataset covers Great Britain only. For consistency, we use the sub-sample for Great Britain from UnSoc and LCF below. However, the results are very similar if we use the whole sample from UnSoc and LCF.

[17] We follow the ONS definition for the Household reference person (HRP) to define the head of the household. In particular, the HRP is the owner or renter of the accommodation in which the household lives. If there are multiple owners or renters, it is the eldest of them.

[18] Details on sample selection are in Appendix C. For similar sample selection criteria in terms of focusing on employees and working age groups, see, e.g. Blundell and Etheridge (2010), Heathcote *et al.* (2010)).

[19] Constructing an effective wage by dividing earnings by hours worked is common (see e.g. Blundell and Etheridge (2010), Blundell *et al.* (2007) or Bayer and Juessen (2012) for household effective wage).

the minimum wage. Finally, we keep those households that have at least two consecutive observations with positive household effective wage.

We approximate the socio-economic class of the household with the higher of the professional classes of the head or of the spouse. We use the National Statistics Socio-economic Classification (NS-SEC), which is the official socio-economic classification in the UK. In particular, starting from the Eight Class NS-SEC, we create the following groups in which we can allocate all heads and spouses: "Higher management and professionals occupations" (denoted *Higher Professional*), "Lower management and professional occupations" (denoted *Lower Professional*), "Intermediate occupations (clerical, sales, service) and lower supervisory and technical occupations" (denoted *Intermediate*), "Routine and semi-routine occupations" (denoted *Routine*). The first group merges two separate categories in the official NS-SEC since the higher managerial groups are small after the exclusion of employers. The third group is made up of two groups in the official NS-SEC categories, "Intermediate occupations (clerical, sales, service)" and "Lower supervisory and technical occupations", which we have added into one group because the statistics that we examine below for these two groups do not differ significantly, so that, for the purposes of our analysis, these two groups are observationally equivalent. For similar reasons, we add in one group the two groups "Routine occupations" and "Semi-routine occupations".

To approximate productivity risk within the socio-economic class, we first partial out the variation in wages between workers and over time that is not due to the professional class, but to other observable characteristics. Second, we discretise residual wages within each professional class. To implement the first step, we follow Kambourov and Manovskii (2009) and calculate the wages net of the predicted component based on observable characteristics. In particular, we consider a regression:

$$\ln W_{it} = \beta X_{it} + \pi Z_{it} + \epsilon_{it}, \tag{8}$$

where $X_{it}$ includes a constant term, a quadratic in experience approximated by age, dummies for region of residence, dummy for gender and time fixed effects. Moreover, $Z_{it}$ contains a set of dummy variables for the socio-economic classes as defined above. We do not include a variable for education because it is highly correlated to the socio-economic class and it will absorb all the differences between the groups. We pool the data and run an OLS regression to estimate the parameters. Then, we define the measure of residual (log) wages as:

$$\ln \widetilde{W}_{it} = \ln W_{it} - \beta X_{it}. \tag{9}$$

To implement the second step, we discretise the distribution of these residual wages, for each wave, by first splitting the households into the $M = 4$

groups according to their socio-economic class. Then, within each group we split the ordered wage distribution into $N = 3$ parts each containing a third of the socio-economic class. Thus, in each wave, we also allocate each household into one of the $H = 4 \times 3 = 12$ groups. We track transitions of households between the four professional classes and between the 12 wages states, and calculate the transition matrix for socioeconomic class (capturing underlying social mobility) and for wages (corresponding to the $Q$ matrix in the model) by creating a pooled sample of all transitions over the 8 waves. The wage transitions matrix (reported in Appendix C) has higher probabilities along the diagonal, ranging between 0.55 to 0.77, and is associated with a unique stationary distribution. To derive the relevant state space $E$ (also reported in Appendix C), we first calculate mean wages for each group $h \in H$ in each wave and then we calculate the average over the waves, which we normalise to one. The stationary distribution associated with the modelled stochastic process for wages predicts a coefficient of variation of 0.419 and a Gini index of 0.235, which are close to the respective statistics in the data, i.e. 0.483 and 0.257.

The social mobility transition matrix accompanying wage transitions (where $R$, $I$, $LP$ and $HP$ refer to *Routine*, *Intermediate*, *Lower Professional* and *Higher Professional* respectively), is given by:

$$\begin{bmatrix} & R & I & LP & HP \\ R & 0.9146 & 0.0577 & 0.0221 & 0.0056 \\ I & 0.0427 & 0.8746 & 0.0681 & 0.0146 \\ LP & 0.0125 & 0.0284 & 0.9218 & 0.0374 \\ HP & 0.0033 & 0.0111 & 0.0574 & 0.9282 \end{bmatrix}. \tag{10}$$

The diagonal of this matrix shows that there is high probability of remaining in the same professional class and thus is indicative of low social mobility. This is in line with previous findings on transitions between professional groups in the UK using the British Household Panel Survey (Upward and Wright (2007)), which is the precursor of UnSoc, and with evidence on occupational and wealth mobility in the US (see e.g. Kambourov and Manovskii (2008) and Kuhn and Rios-Rull (2016)).

We also summarise in Table 1 the means and the Gini index per professional group of residual wages (normalised) and of the typical hours worked.[20] As can be seen, higher mean wages moving up the professional classes are generally accompanied by higher within class wage inequality (for the highest wage group the Gini does not increase relative to the second highest).

[20] Typical hours in Table 1 are obtained by dividing usual weekly hours (the sum of hours worked by both spouses) by $N_s$*14*7, where $N_s$ is the number of the spouses (i.e. assuming that a worker has up to 14 hours a day to choose to allocate to work or leisure).

Regarding typical hours worked, the relationship is reversed. In particular, groups with higher typical hours worked on average are characterised by a lower inequality in terms of hours. Moreover, there is a positive correlation between mean wages and mean hours suggesting that on average higher wages encourage higher work.

Table 1: Summary statistics of wages & hours worked

| NS-SEC | Mean | Gini |
|---|---|---|
| Effective wages | | |
| routine and semi-routine | 0.623 | 0.184 |
| intermediate low supervisory | 0.814 | 0.202 |
| lower management and professional | 1.081 | 0.212 |
| higher management and professional | 1.398 | 0.203 |
| total | 1.000 | 0.257 |
| Average typical hours worked | | |
| routine and semi-routine | 0.296 | 0.223 |
| intermediate low supervisory | 0.330 | 0.152 |
| lower management and professional | 0.346 | 0.127 |
| higher management and professional | 0.346 | 0.121 |
| total | 0.333 | 0.153 |

Source: Understanding Society, own calculations. We report the average statistics over waves 1-8. All monetary values are expressed in 2015 prices as measured by CPIH.

## 4.2 Earnings, wealth and consumption inequality

We summarise the data predictions on earnings, wealth and consumption inequality between and within the professional classes in Table 2. Details on the data and samples are in Appendix C.[21] We calculate the mean of the relevant quantities (normalised so that the mean across the whole sample is one) and the within group Gini index for the four groups. A comparison of the means across groups provides an indication of between group inequality.

As expected, mean earnings, wealth and consumption increase with professional classes that have higher mean wages. However, within group earnings and wealth inequality decreases, whereas within group consumption inequality does not vary much between groups. Note that overall inequality is highest for wealth and lowest for consumption, as is typically found in the data (see e.g. Quadrini and Rios-Rull (2015) for the US). In this case, this

[21] The measure of consumption includes non-durable goods, services and semi-durable goods. To have a user-cost measure of housing, we follow Blundell and Etheridge (2010) and include rent, mortgage interest payments and housing taxes.

is evident both in terms of the Gini for the whole sample and by noting that between group inequality is highest for wealth and lowest for consumption.

Table 2: Summary statistics of total earnings, net worth & consumption

| NS-SEC | Mean | Gini |
|---|---|---|
| | total earnings* | |
| routine and semi-routine | 0.549 | 0.314 |
| intermediate low supervisory | 0.794 | 0.263 |
| lower management and professional | 1.100 | 0.243 |
| higher management and professional | 1.454 | 0.235 |
| total | 1.000 | 0.308 |
| | net worth† | |
| routine and semi-routine | 0.387 | 0.775 |
| intermediate low supervisory | 0.696 | 0.662 |
| lower management and professional | 1.101 | 0.628 |
| higher management and professional | 1.702 | 0.593 |
| total | 1.000 | 0.670 |
| | consumption‡ | |
| routine and semi-routine | 0.774 | 0.248 |
| intermediate low supervisory | 0.901 | 0.258 |
| lower management and professional | 1.068 | 0.260 |
| higher management and professional | 1.231 | 0.274 |
| total | 1.000 | 0.276 |

*Source: Understanding Society, own calculations. Total earnings refers to the sum of the weekly net earnings of the two spouses. We report the average statistics over waves 1-8.

†Source: Wealth and Assets Survey, own calculations. We report the average statistics over waves 1-5. Net-worth refers to the sum of property and net financial wealth of the household.

‡Source: Living Costs and Food Survey, own calculations. Consumption refers to equivalised weekly non-durable consumption plus real housing costs. We report the average statistics over year 2009-2017. All monetary values for all three variables in this table are expressed in 2015 prices as measured by CPIH.

# 5 Calibration, solution and model fit

In this section, we discuss the calibration and numerical solution and establish that the model does a good job in capturing the key stylised facts on within and between group inequality summarised in the previous Section.

## 5.1 Calibration

We calibrate the model parameters to match underlying dimensions in the data. We capture stochasticity by using the transition matrix calculated from the UnSoc data as explained in the previous Section. Regarding the utility function, we use a CRRA utility function which is additively separable in consumption and leisure, augmented with relative consumption considerations (see also Jappeli and Pistaferri (2017) and De Giorgi *et al.* (2019)):

$$u(c,l,C) = \frac{c^{1-\sigma}}{1-\sigma}C^{\gamma} + \chi\frac{l^{1-\phi}}{1-\phi}, \tag{11}$$

where $\sigma, \phi > 1$, $\chi > 0$. This functional form has the advantage that it nests different possibilities regarding the type of social interactions that lead to peer pressure. In particular, conditional on $\sigma > 1$, for $\gamma > 0$ equation (11) implies that $\frac{\partial u}{\partial C} < 0$ ("jealousy") and $\frac{\partial^2 u}{\partial c \partial C} > 0$ ("keeping-up-with-the-Joneses"), whereas for $\gamma < 0$ equation (11) implies that $\frac{\partial u}{\partial C} > 0$ ("admiration") and $\frac{\partial^2 u}{\partial c \partial C} < 0$ ("running-away-from-the-Joneses").[22] Therefore, the sign of $\gamma$ determines the type of peer pressure.[23] Naturally, when $\gamma = 0$, equation (11) delivers as a special case the benchmark model without social factors, and in this case the utility function used is the same as in Pijoan-Mas (2006). The elasticity of own consumption with respect to the target level of consumption is given by $\varepsilon_{cC} \approx \frac{\gamma}{\sigma}$ (see Appendix D for details). Hence, conditional on a value for $\sigma$, the absolute value of $\gamma$ determines the size of the responsiveness of agent-level choices to social targets, i.e. it determines the strength of peer pressure.

We calibrate the utility function as follows. We first set $\sigma = 1.5$, which is a commonly used value (see e.g. Harrison and Oomen (2010) for the UK). Then, following e.g. Pijoan-Mas (2006), we choose $\phi$ and $\chi$ so that the model's predictions are consistent with working hours in the data, in terms of average and inequality in hours worked. More specifically, we calibrate $\chi$ so that mean hours worked equal 0.33 and $\phi$ so that the Gini in hours worked predicted by the model is equal to 0.153 (see Table 1 for the data targets). The calibrated values are shown in Table 3 (see also Table D1 in Appendix D which reports the long form of the rounded up entries in Table 3). Finally,

[22] See Appendix D for details.

[23] Note that for $0 < \gamma < 1.5$ equation (11) does not satisfy the sufficient condition of joint concavity (the Hessian with respect to $(c, l, C)$ is neither negative nor positive definite), although it is concave with respect to $c, l$ for given $C$. The theoretical results at the level of the household in this case still hold, implying a unique invariant distribution. Moreover, although existence of a socio-economic equilibrium is not guaranteed by Proposition 1, an equilibrium is found for the calibrations used below.

for our base results we choose a value for $\gamma$ so that $\varepsilon_{cC} = 0.5$, which is in the range of the estimates of this elasticity from De Giorgi *et al.* (2019), who estimate the elasticity of own consumption with respect to that of peers to be between 0.3 and 0.6. The predictions of the model and main qualitative results are broadly similar in this range of elasticities.[24] To investigate the importance of peer pressure for the model's predictions, we analyse in detail below, in Section 5, the between and within group inequality implications of the type of peer pressure, by re-calibrating the model parameters when $\gamma$ is such that $\varepsilon_{cC} = 0$ or $\varepsilon_{cC} = -0.5$.

Table 3: Calibrated parameters

| $\beta$ | $\sigma$ | $\phi$ | $\alpha$ | $\gamma$ | $\chi$ | $r$ | $w$ | $\delta$ |
|---|---|---|---|---|---|---|---|---|
| 0.9655 | 1.50 | 1.6051 | 0.30 | 0.75 | 1.0347 | 0.0217 | 1.0367 | 0.0983 |

The prices $r$ and $w$ are set so that the model is consistent with a typical production sector assumed in calibrated models. In particular, the interest rate is set to be 0.0217, which is the average value of the real short-term yields in the data for UK for the period 1990-2013 (see Carvalho *et al.* 2016). We choose the wage rate so that is consistent with this interest rate under the assumption that the production sector is given by a profit maximising firm, using a Cobb-Douglas production function with constant returns to scale with respect to its inputs, capital $K$ and labour $L$:

$$Y = F(K, L) = TK^{\alpha}L^{1-\alpha}, \tag{12}$$

$$\Rightarrow \frac{Y}{L} = T\left(\frac{K}{L}\right)^{\alpha}, \tag{13}$$

for which we normalise $T \equiv 1$ and set $\alpha$ to 0.3 (see e.g. Harrison and Oomen (2010)), and is subject to an annual depreciation rate, $0 < \delta < 1$, that is set to $\delta = 0.0983$ so that the capital over output ratio is 2.5.[25] In other words, the first order conditions for profit maximisation:

$$r + \delta = \partial F(K, L)/\partial K \equiv F_1\left(\frac{K}{L}, 1\right), \tag{14}$$

$$w = \partial F(K, L)/\partial L \equiv F_2\left(\frac{K}{L}, 1\right), \tag{15}$$

[24] On balance, the model predictions are closer to the data for more inequality measures under $\varepsilon_{cC} = 0.5$, compared with a lower elasticity of e.g. $\varepsilon_{cC} = 0.33$ (see Appendix D, Table D2 for these results).

[25] This is very close to the values in Faccini *et al.* (2011) and Harrison and Oomen (2010).

determine $\delta$ and $w$, given $r$ and $\frac{K}{L}$ such that $K/Y = 2.5$ from equation (13).

Finally, the time preference parameter, $\beta = 0.9655$, is chosen so that the asset supply predicted by the model given the remaining parameters matches the data, and, in particular, a net foreign asset ($NFA$) position, $\frac{K-A}{Y}$, of 8.1%.[26] Note that the aggregate resource constraint is given by $Y = C+I+rNFA$. In Appendix E, we explicitly integrate the socio-economic equilibrium in an open economy general equilibrium setup also employed in Angelopoulos *et al.* (2019), consistent with the above calibration for the UK. This allows us to investigate the quantitative implications of peer pressure on inequality by accounting for potential general equilibrium effects via prices. Since the main results are very similar, we focus on the case with fixed prices for the analysis which follows.

## 5.2 Numerical solution

We solve for the socio-economic equilibrium, given prices, using the following algorithm:

`Computational algorithm for the socio-economic equilibrium`

1. Guess values for $\widetilde{C}_n = \left(\overline{C}_1, \overline{C}_2, .., \overline{C}_m\right)$ from the domain $\mathcal{C}$.
2. Solve the "typical" household's problem to obtain $g\left(a, z, \widetilde{C}_n\right)$, $q\left(a, z, \widetilde{C}_n\right)$ and $l\left(a, z, \widetilde{C}_n\right)$.
3. Use $g\left(a, s, \widetilde{C}_n\right)$ and the properties of the Markov processes $(z_t)$ to construct the transition function $\Lambda^{\widetilde{C}}$. Using $\Lambda^{\widetilde{C}}$, calculate the stationary distribution $\lambda^{\widetilde{C}}$.
4. Using $\lambda^{\widetilde{C}}$, compute the consumption reference points $\widetilde{C}_n^*$ using (6) or (7).
5. If $\left|\widetilde{C}_n^* - \widetilde{C}_n\right| < \varepsilon$, where $\varepsilon$ is a pre-specified tolerance level, a stationary equilibrium has been found. If not, go back to step 1, and update $\widetilde{C}_{n+1} = (1-\varsigma)\,\widetilde{C}_n + \varsigma\widetilde{C}_n^*$ with $0 < \varsigma \leq 1$.

An important theoretical result allowing the implementation of this algorithm is that $\lambda^{\widetilde{C}}$ is the unique invariant distribution for the typical household

[26] This is the average value for the UK,1990-2013, in Extended External Wealth of Nations Mark II database (see also Lane and Milesi-Ferretti (2007)).

for given $\widetilde{C}_n$. This process implies that we assume an upper bound $c^{\max}$ in step 1, to determine $\mathcal{C}$. We check that in equilibrium this is not binding. To implement this algorithm, we set $\varepsilon = 10^{-4}$ and $m = 4$. To confirm uniqueness of the socio-economic equilibrium, we solve the model for a range of social targets $\widetilde{C} = \left(\overline{C}_1, \overline{C}_2, \overline{C}_3, \overline{C}_4\right)$ and check whether the corresponding equilibrium quantities, obtained using equation (6) or (7), equal the social targets used for that case in more than cases. We work as follows:

1. We find the socio-economic equilibrium following the computational algorithm described above.

2. We construct a grid of 20 values for each of the consumption targets, $\overline{C}_j$, $j = 1, 2, 3, 4$. We set a small value, 0.01 as the minimum of the grid, and three times the mean consumption as the maximum of the grid.

3. Since the grid does not need to contain the original solution, we add to the grid the equilibrium points we found in step 1. Thus, we have in total 21 grid points for each consumption target.

4. We construct the Cartesian product of all the possible combinations of consumption targets, i.e.

$$\underline{C} \equiv \overline{C}_1 \times \overline{C}_2 \times \overline{C}_3 \times \overline{C}_4 = \left[\overline{C}_1^1, \overline{C}_1^2, ..., \overline{C}_1^{21}\right] \times ... \times \left[\overline{C}_4^1, \overline{C}_4^2, ..., \overline{C}_4^{21}\right],$$

   which implies 194,481 different combinations of consumption targets $\widehat{C}$, where $\widehat{C} \in \underline{C}$.

5. For each combination, $\widehat{C}$, we solve the "typical" household's problem to obtain $g\left(a, z, \widehat{C}\right)$, $q\left(a, z, \widehat{C}\right)$ and $l\left(a, z, \widehat{C}\right)$, construct the transition function $\Lambda^{\widehat{C}}$, calculate the stationary distribution $\lambda^{\widehat{C}}$, and compute the consumption reference points $\widehat{C}^*$ using equation (6) or (7).

6. Check whether $\left|\widehat{C}_j - \widehat{C}_j^*\right| < \varepsilon$, for all $j = 1, 2, 3, 4$ in more than one of the 194,481 combinations, and that for $\widehat{C}^*$ that satisfies this condition it is true that $\widehat{C}^* = \widetilde{C}_n^*$.

We find a unique equilibrium for all solutions presented in the tables with results below.[27] We represent this graphically in Appendix Figure D1,

[27] Each test for uniqueness, for each model solution presented below, requires approximately 36 hours on a cluster computer, using parallel processing (16 cores) with Matlab 2018a.

by noting that the condition $\left|\widehat{C}_j - \widehat{C}_j^*\right| < \varepsilon$, for all $j = 1, 2, 3, 4$, implies and is implied by the condition $\max_j \left|\widehat{C}_j - \widehat{C}_j^*\right| < \varepsilon$. Hence, we order the values of $\max_j \left|\widehat{C}_j - \widehat{C}_j^*\right|$ and plot the first 14,000 in Figure D1. There is always a unique value of $\max_j \left|\widehat{C}_j - \widehat{C}_j^*\right| < 10^{-4}$.[28]

## 5.3 Within and between-class inequality predictions

We demonstrate the model's ability to capture the patterns in the data on inequality in HEWC, between and within socio-economic classes in Table 4.[29] In the first two columns of Table 4, we report the mean assets, earnings, consumption and hours worked for each of the four socio-economic classes in the data and for the model solution. For wealth, earnings and consumption, quantities are normalised relative to the mean for the aggregate economy. In the final two columns of Table 4, we report the Gini indices for the four variables, again for both the data and the model solution, for each of the four classes, as well as for the total economy. The figures for the data in Table 4 are the same as those in Section 3 (see Table 2), but are repeated here next to the model predictions for convenience.

Overall, the model captures the main patterns regarding between and within group inequality observed in the data. Starting with wealth, as discussed in Section 3, the data show higher mean wealth for the higher mean wage socio-economic classes, but lower within group wealth inequality. Both patterns are predicted by the model.[30] Notably, the lower Gini index in the model for higher mean wage classes is quantitatively significant, similar to what is observed in the data. On the other hand, the model underpredicts wealth inequality quantitatively, as is typically the case for this class of models, where wealth inequality is driven solely by uninsured idiosyncratic shocks that affect earnings (see e.g. Aiyagari (1994), Benhabib *et al.* (2017), and Stachurski and Toda (2019)).[31] Similarly to the existing research using incomplete markets heterogeneous agent models, the model here

[28] Note that we repeat this exercise for each model solution in Figures D2-D5, except for the $\gamma = 0$ case for which we know that there is a unique equilibrium.

[29] In the next section, we further explain in more detail the contribution of peer pressure, in an environment of stochastic social mobility, to generating the predicted patterns.

[30] About 11% of households have zero wealth in the model. In the WAS sample for which we calculate the distributional statistics, the proportion of households with non-positive wealth is about 15%. Note that the percentage of households with zero wealth is endogenously determined in the model, since we do not impose an *ad hoc* positive borrowing limit.

[31] A large literature has recently focused on extensions to this class of models aimed

correctly predicts lower consumption inequality relative to wealth inequality, and under-predicts consumption inequality compared with the data.[32] The model predicts higher between group inequality compared with the LCF data, and lower within group inequality. The model does not predict a specific pattern for within group consumption inequality for groups with higher mean wages, while in the LCF data we see a small increase in within group Ginis.

The model's predictions regarding the overall earnings inequality are very similar to the base model with incomplete markets and endogenous labour supply in Pijoan-Mas (2006). In addition, the model also matches the main pattern of increasing means but decreasing Ginis for earnings for socio-economic classes with higher mean wages. In particular, the model matches between group earnings inequality to those observed in the data. It slightly over-predicts the earnings Gini for the aggregate economy, which is driven by a small exaggeration of the within group Gini for the two higher classes. In other words, the within group earnings Gini does not fall in the model by as much as in the data for the higher mean wage socio-economic classes.

The model has been calibrated to match mean hours worked of 0.333. Notably, the model predicts that hours worked fall with higher mean wages across the socio-economic classes. This success is important because the theoretical framework implies a negative correlation between hours worked and assets at the household level[33] (see Section 2, and also Zhu (2018) for theoretical analysis and Pijoan-Mas (2006) for a quantitative examination).

Since as already discussed (see Table 4) mean assets per group increase with mean wages, the negative correlation between hours and assets tends to generate a negative relationship between higher mean wages and mean hours across the groups, which is at odds with the empirical observations. Indeed, as will also be discussed below, in the absence of "keeping-up-with-the-Joneses" peer pressure, the model predicts lower mean hours for groups with higher mean wages relative to the groups with lower mean wages. In contrast, for sufficiently strong "jealousy" and "keeping-up-with-the-Joneses" effects, mean hours increase with mean wages across groups, despite the negative correlation between assets and hours at the household level. As

at improving predictions regarding the extent of wealth concentration at the upper end (see e.g. De Nardi (2015), Quadrini and Rios-Rull (2015), and Benhabib *et al.* (2017) for reviews). In this paper, instead, our interest is in the patterns of inequality between and within socio-economic groups.

[32] See e.g. Aiyagari (1994), De Nardi (2015) and Krueger *et al.* (2016) on the general properties of these models in this respect, in particular the success with respect to predicting lower consumption versus wealth inequality, despite predicting lower consumption inequality compared with the data.

[33] This is in turn implied by the assumption that leisure is a normal good, leading to strong income effects, which is needed for boundedness (see Zhu (2018, Proposition 3)).

explained in more detail below, under this form of social pressure, the relative importance of consumption versus leisure increases with professional class. In particular, households in socio-economic classes with higher mean wages, and thus higher mean assets and consumption, face an increased return from consumption relative to leisure. This encourages higher work hours relative to groups with lower mean wages, despite the effect of higher assets, which tend, *ceteris paribus*, to reduce hours. The model has also been calibrated to match the Gini index in hours of 0.153. Further disaggregating differences in hours worked within groups, the model predicts that the Gini index decreases with higher mean wages across the socio-economic classes. This is consistent with the data, although the relationship is steeper in the data.

Table 4: Base calibration

| | Data | $\varepsilon_{cC}=$ 0.5 | | Data | $\varepsilon_{cC}=$ 0.5 |
|---|---|---|---|---|---|
| $\frac{\overline{A}_R}{\overline{A}}$ | 0.387 | 0.409 | Gini $A_R$ | 0.775 | 0.619 |
| $\frac{\overline{A}_I}{\overline{A}}$ | 0.696 | 0.644 | Gini $A_I$ | 0.662 | 0.573 |
| $\frac{\overline{A}_{LP}}{\overline{A}}$ | 1.101 | 1.044 | Gini $A_{LP}$ | 0.628 | 0.517 |
| $\frac{\overline{A}_{HP}}{\overline{A}}$ | 1.702 | 1.515 | Gini $A_{HP}$ | 0.593 | 0.470 |
| $\overline{A}$ | | 1.271 | Gini $A$ | 0.670 | 0.557 |
| | | | | | |
| $\frac{\overline{C}_R}{\overline{C}}$ | 0.774 | 0.563 | Gini $C_R$ | 0.248 | 0.106 |
| $\frac{\overline{C}_I}{\overline{C}}$ | 0.901 | 0.756 | Gini $C_I$ | 0.258 | 0.110 |
| $\frac{\overline{C}_{LP}}{\overline{C}}$ | 1.068 | 1.037 | Gini $C_{LP}$ | 0.260 | 0.103 |
| $\frac{\overline{C}_{HP}}{\overline{C}}$ | 1.231 | 1.362 | Gini $C_{HP}$ | 0.274 | 0.088 |
| $\overline{C}$ | | 0.395 | Gini $C$ | 0.276 | 0.186 |
| | | | | | |
| $\frac{\overline{E}_R}{\overline{E}}$ | 0.549 | 0.516 | Gini $E_R$ | 0.314 | 0.289 |
| $\frac{\overline{E}_I}{\overline{E}}$ | 0.794 | 0.721 | Gini $E_I$ | 0.263 | 0.286 |
| $\frac{\overline{E}_{LP}}{\overline{E}}$ | 1.100 | 1.033 | Gini $E_{LP}$ | 0.243 | 0.284 |
| $\frac{\overline{E}_{HP}}{\overline{E}}$ | 1.454 | 1.418 | Gini $E_{HP}$ | 0.235 | 0.272 |
| $\overline{E}$ | | 0.368 | Gini $E$ | 0.308 | 0.335 |
| | | | | | |
| $\overline{H}_R$ | 0.296 | 0.298 | Gini $H_R$ | 0.223 | 0.180 |
| $\overline{H}_I$ | 0.330 | 0.316 | Gini $H_I$ | 0.152 | 0.159 |
| $\overline{H}_{LP}$ | 0.346 | 0.337 | Gini $H_{LP}$ | 0.127 | 0.147 |
| $\overline{H}_{HP}$ | 0.346 | 0.358 | Gini $H_{HP}$ | 0.121 | 0.131 |
| $\overline{H}$ | | 0.333 | Gini $H$ | 0.153 | 0.153 |

# 6 Peer pressure with stochastic mobility

In this section we analyse how peer pressure and stochastic social transitions interact to contribute to the patterns of inequality summarised in the previous Section. Recall that the theoretical analysis and choice for the functional form allows for different forms of pressure from the peers in one's social class to influence economic decisions under stochastic social class participation. In particular, for $\gamma > 0$ the model incorporates "jealousy" ($\frac{\partial u}{\partial C} < 0$) and "keeping-up-with-the-Joneses" ($\frac{\partial^2 u}{\partial c \partial C} > 0$), whereas for $\gamma < 0$, social pressure takes the form of "admiration" ($\frac{\partial u}{\partial C} > 0$) and "running-away-from-the-Joneses" ($\frac{\partial^2 u}{\partial c \partial C} < 0$). In Table 5 we summarise the between and within group inequality effects of peer pressure, by comparing results under the base calibration of "keeping-up-with-the-Joneses" peer pressure, $\varepsilon_{cC} = 0.5$, to a situation without peer pressure, $\varepsilon_{cC} = 0$, and to one where peer pressure is of the "running-away-from-the-Joneses" type (i.e. $\varepsilon_{cC} = -0.5$). In each case, we re-calibrate the model working as in Section 4. In particular, we re-calibrate $\chi$, $\phi$ and $\beta$ to ensure that all cases match average hours, hours inequality and assets as a share of output in the data respectively (the new parameters are recorded in the notes to Table 5).

## 6.1 Hours & earnings (intra-temporal margin)

Peer pressure has significant effects on hours and earnings. Starting with hours, we see in Table 5 (and Figure 1) that in an environment where $\varepsilon_{cC} = 0$ or $\varepsilon_{cC} = -0.5$, mean hours fall as we move from groups with lower to those with higher mean wages, whereas in the data and in the base case of $\varepsilon_{cC} = 0.5$, the relationship between mean hours and mean wages across the groups is positive. As was noted in the previous Section, the negative relationship between mean hours and mean wages when $\varepsilon_{cC} = 0$ and $\varepsilon_{cC} = -0.5$ is driven by a negative correlation between hours worked and assets at the household level, resulting from strong income effects. Hence, in these cases, higher mean wages, implying higher mean assets, lead to lower work hours on average. Peer pressure changes this relationship, because the relative importance of consumption versus leisure increases with professional class. As can be seen in the intra-temporal first order condition:

$$we(z_t)(C_t)^\gamma c_t^{-\sigma} = \chi l_t^{-\phi}, \tag{16}$$

when $\gamma > 0$, a higher consumption target $C_t$, for the higher mean wage classes, increases the relative weight to consumption between classes. In other words, social targets change the relative weights between consumption and leisure differentially across social groups, and in the case of $\varepsilon_{cC} = 0.5$, this makes consumption relatively more valuable (or else, leisure relatively less valuable) for the groups with higher consumption targets, which are the groups with higher mean wages. Therefore, under peer pressure, there are stronger incentives to work for the higher wage - higher assets groups. This effect disappears when $\varepsilon_{cC} = 0$, leading to the negative relationship between mean hours and mean wages across the groups in Table 5, and is reversed when $\varepsilon_{cC} = -0.5$, making this relationship stronger.

Table 5: Alternative calibrations

| | Data | $\varepsilon_{cC}=$ 0.5 | $\varepsilon_{cC}=$ 0 | $\varepsilon_{cC}=$ −0.5 | | Data | $\varepsilon_{cC}=$ 0.5 | $\varepsilon_{cC}=$ 0 | $\varepsilon_{cC}=$ −0.5 |
|---|---|---|---|---|---|---|---|---|---|
| $\frac{\overline{A}_R}{\overline{A}}$ | 0.387 | 0.409 | 0.333 | 0.302 | Gini $A_R$ | 0.775 | 0.619 | 0.658 | 0.677 |
| $\frac{\overline{A}_I}{\overline{A}}$ | 0.696 | 0.644 | 0.571 | 0.543 | Gini $A_I$ | 0.662 | 0.573 | 0.602 | 0.612 |
| $\frac{\overline{A}_{LP}}{\overline{A}}$ | 1.101 | 1.044 | 1.030 | 1.026 | Gini $A_{LP}$ | 0.628 | 0.517 | 0.528 | 0.527 |
| $\frac{\overline{A}_{HP}}{\overline{A}}$ | 1.702 | 1.515 | 1.629 | 1.672 | Gini $A_{HP}$ | 0.593 | 0.470 | 0.464 | 0.457 |
| $\overline{A}$ | | 1.271 | 1.238 | 1.217 | Gini $A$ | 0.670 | 0.557 | 0.576 | 0.581 |
| | | | | | | | | | |
| $\frac{\overline{C}_R}{\overline{C}}$ | 0.774 | 0.563 | 0.678 | 0.742 | Gini $C_R$ | 0.248 | 0.106 | 0.121 | 0.129 |
| $\frac{\overline{C}_I}{\overline{C}}$ | 0.901 | 0.756 | 0.836 | 0.876 | Gini $C_I$ | 0.258 | 0.110 | 0.121 | 0.126 |
| $\frac{\overline{C}_{LP}}{\overline{C}}$ | 1.068 | 1.037 | 1.037 | 1.034 | Gini $C_{LP}$ | 0.260 | 0.103 | 0.107 | 0.108 |
| $\frac{\overline{C}_{HP}}{\overline{C}}$ | 1.231 | 1.362 | 1.241 | 1.181 | Gini $C_{HP}$ | 0.274 | 0.088 | 0.086 | 0.085 |
| $\overline{C}$ | | 0.395 | 0.385 | 0.379 | Gini $C$ | 0.276 | 0.186 | 0.149 | 0.133 |
| | | | | | | | | | |
| $\frac{\overline{E}_R}{\overline{E}}$ | 0.549 | 0.516 | 0.634 | 0.697 | Gini $E_R$ | 0.314 | 0.289 | 0.245 | 0.222 |
| $\frac{\overline{E}_I}{\overline{E}}$ | 0.794 | 0.721 | 0.793 | 0.829 | Gini $E_I$ | 0.263 | 0.286 | 0.264 | 0.249 |
| $\frac{\overline{E}_{LP}}{\overline{E}}$ | 1.100 | 1.033 | 1.026 | 1.020 | Gini $E_{LP}$ | 0.243 | 0.284 | 0.287 | 0.281 |
| $\frac{\overline{E}_{HP}}{\overline{E}}$ | 1.454 | 1.418 | 1.313 | 1.259 | Gini $E_{HP}$ | 0.235 | 0.272 | 0.296 | 0.300 |
| $\overline{E}$ | | 0.368 | 0.358 | 0.352 | Gini $E$ | 0.308 | 0.335 | 0.317 | 0.302 |
| | | | | | | | | | |
| $\overline{H}_R$ | 0.296 | 0.298 | 0.363 | 0.396 | Gini $H_R$ | 0.223 | 0.180 | 0.133 | 0.109 |
| $\overline{H}_I$ | 0.330 | 0.316 | 0.343 | 0.356 | Gini $H_I$ | 0.152 | 0.159 | 0.140 | 0.123 |
| $\overline{H}_{LP}$ | 0.346 | 0.337 | 0.326 | 0.320 | Gini $H_{LP}$ | 0.127 | 0.147 | 0.154 | 0.146 |
| $\overline{H}_{HP}$ | 0.346 | 0.358 | 0.319 | 0.300 | Gini $H_{HP}$ | 0.121 | 0.131 | 0.161 | 0.165 |
| $\overline{H}$ | | 0.333 | 0.333 | 0.333 | Gini $H$ | 0.153 | 0.153 | 0.153 | 0.153 |

Notes: For the case where $\varepsilon_{cC} = 0.5$ the parameters are as in Table 3. For the $\varepsilon_{cC} = 0$ case, $\beta = 0.9625$, $\chi = 2.2134$ and $\phi = 1.5446$ and the rest are as in Table 3. For the $\varepsilon_{cC} = -0.5$ case, $\beta = 0.9611$, $\chi = 4.4693$ and $\phi = 1.6632$ and the rest are as in Table 3.

A similar qualitative change is noted when we examine inequality in hours within the groups. As we see in Table 5, moving from an environment where $\varepsilon_{cC} = 0$ or $\varepsilon_{cC} = -0.5$ to one where $\varepsilon_{cC} = 0.5$, the relationship between within group hours inequality and mean wages across groups changes from positive to negative, consistent with the data. Peer pressure, when it has the "keeping-up-with-the-Joneses" form, implies a desire for likeness in terms of consumption and thus in terms of hours worked, to finance this closeness in consumption. In particular, as can be seen from equation (16), under peer pressure, there is a social factor, which is common to all households, in addition to idiosyncratic productivity. Under "keeping-up-with-the-Joneses" peer pressure, the higher social targets, for the higher mean wage groups, imply that this common social factor is relatively stronger, leading to a reduction in the spread of choices for these groups relative to lower mean wage groups. Hence, there is less within-group hours dispersion in higher mean wage groups, compared with lower mean wage groups.

The between group inequality in hours under "keeping-up-with-the-Joneses" peer pressure, under $\varepsilon_{cC} = 0.5$, leads to increased between group earnings inequality (Table 5 and Figure 1). In addition, the differences in within group hours inequality lead to the differences in within group earnings inequality. In particular, recall that the stochastic process (and thus productivity risk) is the same for all model versions. Hence, within group inequality in earnings follows within group inequality in hours. This is true for all types of peer pressure. Therefore, since under "keeping-up-with-the-Joneses" peer pressure ($\varepsilon_{cC} = 0.5$ case), the relationship between the Gini in hours and mean wages across the groups is positive, this is also the case for the relationship between the Gini in earnings and mean wages. This pattern is consistent with the data. Under $\varepsilon_{cC} = 0$ and $\varepsilon_{cC} = -0.5$, the absence of the social discipline mechanism associated with "keeping-up-with-the-Joneses", for the given stochastic environment, leads to the reverse relationship.

Overall, "keeping-up-with-the-Joneses" peer pressure works to lower the mean and increase the dispersion for both hours and earnings for the lower mean wage groups. However, there is no pattern for the higher mean wage group (see also Appendix D, Table D3 which shows the levels and of the means and variances). Note also that although mean hours across the population have not changed between the cases considered, as $\gamma$ changes, since we have in each case re-calibrated to adjust the relative weights to consumption and leisure (see (16)), mean earnings increase when $\gamma$ increases. This happens because the covariance between hours and wages across the population increases with $\gamma$ (recall that mean effective wages have not changed), which is related to the positive relationship between mean hours and mean wages across the groups that is observed for higher values of $\gamma$, as discussed above.[34]

## 6.2 Consumption & wealth (inter-temporal margin)

We next examine the effect of increases in $\gamma$ on between and within group inequality on consumption and wealth. In general, the higher earnings in the economy with "keeping-up-with-the-Joneses" peer pressure imply higher wealth and consumption on average. However, the results in Table 5 show that households in all groups, apart from the top mean wage group, increase their wealth (both in absolute terms and as a share of total assets), while households in the highest mean wage groups decrease savings on average and own a lower share of total wealth. This result is driven by a differential "prospect for upward mobility" and its implications for the expected future peer pressure.

The mechanism by which the "prospect for upward mobility" creates these effects can be illustrated by examining the inter-temporal first order condition:

$$(C_t)^{\gamma} c_t^{-\sigma} = \beta(1+r) E_t (C_{t+1})^{\gamma} c_{t+1}^{-\sigma}. \tag{17}$$

As can be seen, a type of "keeping-up-with-the-Joneses" ("running-away-from-the-Joneses") peer pressure, affects the weight attached to current consumption, as well as the weight attached to future consumption. The magnitude of the relative effect $E_t(C_{t+1})^{\gamma}/C_t)^{\gamma}$ depends on the current social class of the household, because this will determine the value of the conditional expectation relative to the current target. In particular, consider the case when $\gamma > 0$, relative to the base case of $\gamma = 0$ (and vice versa when $\gamma < 0$). In this case, the added effect on the valuation of future consumption relative to current consumption is higher conditional on being on a lower mean wage class, given that possible mobility is mainly upwards, thus towards a social group that will exert pressure for higher future consumption, relative to the current target. The effect is reversed for households in higher mean wage social classes. Hence, the prospect of upward mobility, under "keeping-up-with-the-Joneses" peer pressure, contributes to a decrease in between group wealth inequality. On the contrary, and despite the reduction in between group wealth inequality, between group consumption inequality is increased, under "keeping-up-with-the-Joneses" peer pressure. This is the result of the significant effect of such peer pressure to increase between groups earnings inequality, as was discussed in the previous subsection.

[34] Indeed, $cov(w,h) = \{0.022, 0.015, 0.012\}$ for $\varepsilon_{cC} = \{0.5, 0. - 05\}$ respectively. In contrast, there is no clear pattern between the covariance between hours and wages and $\gamma$ within the socio-economic groups.

The effects of peer pressure on between group inequality in HEWC, as well as the effects on within group earnings inequality, contribute to explaining the changes in within group inequality in wealth and consumption. Note, first, that social groups with lower mean wages decrease mean earnings and increase mean wealth as $\gamma$ increases. Therefore, in relative terms, asset income becomes more important than earnings, as $\gamma$ increases. Given that the stochastic environment has not changed, the increased share of asset income implies that the variation in earnings is less important for total income, and thus for savings, leading to a reduction in within group wealth inequality (which falls for the first two groups and increases for the top one). For the third one there is no pattern. These effects are reversed for the higher mean wage groups, leading to an increase in within group wealth inequality. At the aggregate level, the effects associated with the lower mean wage groups (i.e. the decrease in the importance of asset income), and the decrease in between group wealth inequality dominate, so that wealth inequality for the whole economy is lower. The effects on within group consumption inequality follow from the changes in within group wealth inequality, although they are significantly less pronounced. As a result, the increase in between group consumption inequality is strong enough to lead to an increase in overall consumption inequality.

# 7 Peer pressure and aspirations

The prospect of upward mobility, associated with stochastic socio-economic class participation, embeds an upward looking element in peer pressure. We examined the effects of this component of peer pressure on inequality in the previous Section, documenting that it works to decrease between group wealth inequality, further contributing to the asymmetric change in within group inequality. Moreover, peer pressure has an aspirational element, because it instills a desire to match a pre-specified level of success. In the previous section, this level was determined by mean group consumption. Here, we study forms of social pressure that imply stronger aspirational effects than those studied in the previous section, and we examine their inequality implications.

We first consider the case of an increase in the aspirational element embodied in peer pressure, and we then consider a situation where social pressure is explicitly aspirational in nature. Such differences may arise as social norms change following socio-economic development (e.g. greater social interaction, television, internet and social media) or long-term policy interventions to support integration and build confidence for higher aspirations (e.g.

role models and success stories and well as increased information).[35]

## 7.1 The aspirational element of peer pressure

We consider the situation where the reference point for consumption in the utility function is the consumption of a specific type of the socio-economic class that a household belongs to, capturing social norms that define aspirations by promoting specific group-relevant attributes that the household aims to achieve. By defining social targets as those associated with the consumption of higher percentiles of the distribution of consumption, we examine the inequality implications of a stronger aspirational element of peer pressure.

### 7.1.1 Different aspirational strengths of peer pressure

To implement this, we plot, in Figures 1-2, mean quantities and Ginis, per socio-economic class, for HEWC, for a range of consumption targets, and in particular ranging from consumption at the 10th percentile, to consumption at the 90th percentile. To contextualise the effect of stronger aspirations, we compare the results when the target is a very successful type of the group of peers, namely the 90th percentile, to the situation in the previous Section, where the social target was determined by mean consumption, which captures average behaviour. In the columns of Table 6 under the heading p90, we summarise the between/within group inequality implications when the social target is given by the consumption of the household at the 90th percentile of the distribution of consumption for the class that the household belongs to. We compare these results to the base case of peer pressure analysed above, i.e. when the target is the mean consumption of the members of the socio-economic class (repeated in Table 6, in the columns under the heading $\varepsilon_{cC} = 0.5$).

[35] Examples of such policies in the UK include: "Careers strategy: making the most of everyone's skills and talents", see assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664319/Careers_strategy.pdf and "Learning to improve the lives and aspirations of young people in Scotland", see education.gov.scot/Documents/LearningtoImprove LivesYoungPeople.pdf.

Table 6: The effects of aspirational pressure

| | $\varepsilon_{cC}$= 0.5 | p90th | mean above | p90 above | | $\varepsilon_{cC}$= 0.5 | p90 | mean above | p90 above |
|---|---|---|---|---|---|---|---|---|---|
| $\frac{\overline{A}_R}{\overline{A}}$ | 0.409 | 0.411 | 0.388 | 0.386 | Gini $A_R$ | 0.619 | 0.616 | 0.633 | 0.634 |
| $\frac{\overline{A}_I}{\overline{A}}$ | 0.644 | 0.641 | 0.601 | 0.598 | Gini $A_I$ | 0.573 | 0.573 | 0.588 | 0.589 |
| $\frac{\overline{A}_{LP}}{\overline{A}}$ | 1.044 | 1.039 | 1.010 | 1.013 | Gini $A_{LP}$ | 0.517 | 0.518 | 0.524 | 0.522 |
| $\frac{\overline{A}_{HP}}{\overline{A}}$ | 1.515 | 1.523 | 1.607 | 1.606 | Gini $A_{HP}$ | 0.470 | 0.469 | 0.456 | 0.454 |
| $\overline{A}$ | 1.271 | 1.317 | 1.457 | 1.518 | Gini $A$ | 0.557 | 0.557 | 0.564 | 0.563 |
| | | | | | | | | | |
| $\frac{\overline{C}_R}{\overline{C}}$ | 0.563 | 0.567 | 0.606 | 0.616 | Gini $C_R$ | 0.106 | 0.106 | 0.111 | 0.113 |
| $\frac{\overline{C}_I}{\overline{C}}$ | 0.756 | 0.765 | 0.810 | 0.815 | Gini $C_I$ | 0.110 | 0.111 | 0.116 | 0.117 |
| $\frac{\overline{C}_{LP}}{\overline{C}}$ | 1.037 | 1.041 | 1.061 | 1.057 | Gini $C_{LP}$ | 0.103 | 0.104 | 0.106 | 0.106 |
| $\frac{\overline{C}_{HP}}{\overline{C}}$ | 1.362 | 1.347 | 1.264 | 1.261 | Gini $C_{HP}$ | 0.088 | 0.088 | 0.084 | 0.084 |
| $\overline{C}$ | 0.395 | 0.428 | 0.422 | 0.453 | Gini $C$ | 0.186 | 0.183 | 0.163 | 0.161 |
| | | | | | | | | | |
| $\frac{\overline{E}_R}{\overline{E}}$ | 0.516 | 0.524 | 0.558 | 0.568 | Gini $E_R$ | 0.289 | 0.272 | 0.265 | 0.25 |
| $\frac{\overline{E}_I}{\overline{E}}$ | 0.721 | 0.731 | 0.763 | 0.769 | Gini $E_I$ | 0.286 | 0.269 | 0.266 | 0.254 |
| $\frac{\overline{E}_{LP}}{\overline{E}}$ | 1.033 | 1.036 | 1.044 | 1.042 | Gini $E_{LP}$ | 0.284 | 0.269 | 0.273 | 0.263 |
| $\frac{\overline{E}_{HP}}{\overline{E}}$ | 1.418 | 1.402 | 1.348 | 1.343 | Gini $E_{HP}$ | 0.272 | 0.261 | 0.278 | 0.267 |
| $\overline{E}$ | 0.368 | 0.399 | 0.390 | 0.420 | Gini $E$ | 0.335 | 0.270 | 0.318 | 0.306 |
| | | | | | | | | | |
| $\frac{\overline{H}_R}{\overline{H}}$ | 0.895 | 0.905 | 0.961 | 0.977 | Gini $H_R$ | 0.180 | 0.159 | 0.153 | 0.135 |
| $\frac{\overline{H}_I}{\overline{H}}$ | 0.951 | 0.962 | 1.000 | 1.006 | Gini $H_I$ | 0.159 | 0.139 | 0.138 | 0.123 |
| $\frac{\overline{H}_{LP}}{\overline{H}}$ | 1.013 | 1.014 | 1.014 | 1.009 | Gini $H_{LP}$ | 0.147 | 0.128 | 0.135 | 0.121 |
| $\frac{\overline{H}_{HP}}{\overline{H}}$ | 1.075 | 1.060 | 1.002 | 0.996 | Gini $H_{HP}$ | 0.131 | 0.117 | 0.137 | 0.122 |
| $\overline{H}$ | 0.333 | 0.365 | 0.359 | 0.389 | Gini $H$ | 0.153 | 0.134 | 0.139 | 0.124 |

Figure 1: Success Stories Within Peers, between group inequality

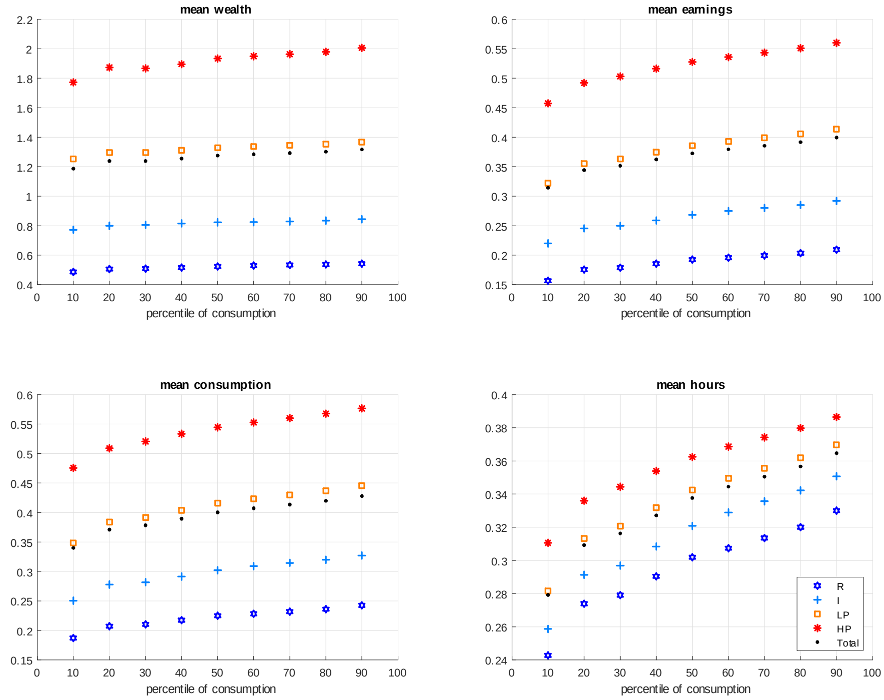
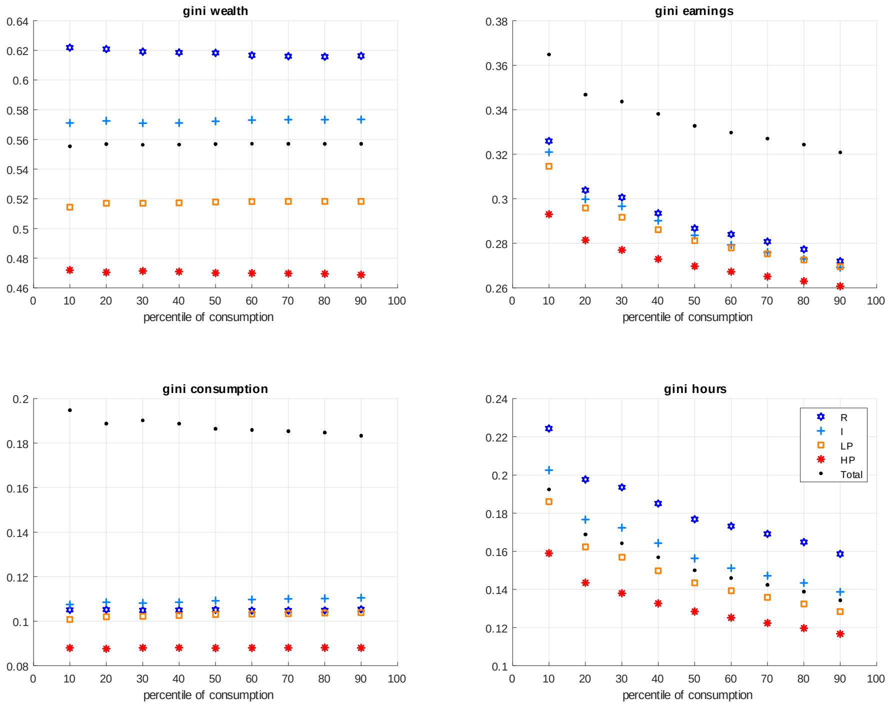



Figure 2: Success Stories Within Peers, within group inequality



As can be seen in Figures 1-2, a stronger aspirational element of peer pressure has a significant and positive effects on all mean quantities, while decreasing within group inequality in hours and earnings and between group inequality in hours and earnings, in terms of the gap between the highest mean wage group and the other groups. On the other hand, between and within group inequality in consumption and wealth do not change much and do not follow an obvious pattern. We analyse the mechanism behind the effects of a stronger aspirational element of peer pressure by comparing the results from the two specific experiments in Table 6, which summarise the patterns in Figures 1-2. Overall, the effects of stronger within class aspirations are quantitatively small when we move from the mean to the 90th percentile, consistent with Figures 1-2. However, given the monotonicity of the effects summarised in the figures, the direction of the effects is the same for bigger or smaller changes in the strength of aspirations.

As can be seen by comparing the two first columns of Table 6, the higher aspirations implied by social targets that refer to members with higher consumption encourage an increase in mean hours worked,[36] which leads to increases in mean earnings, wealth and consumption for all socio-economic groups. However, the increase in mean hours is stronger for the lower socio-economic classes (relative to the highest class). This is because the lower socio-economic classes have higher within group consumption inequality, which means that the distance of the 90th percentile to the mean is higher. Hence, when the social target changes from the mean to the 90th percentile, the increase in the social target is bigger, and thus the aspirational pressure for higher hours is greater for these classes. As a result, between group inequality in hours is reduced, and more specifically the three lower mean wage groups close the gap with the top mean wage group. Moreover, the increased pressure to converge to a higher target induces more similarity in terms of hours within the socio-economic classes, so that within group inequality is reduced for all.[37] The changes in hours pass through to earnings, for which between and within group inequality follows a similar pattern.

The pattern of wealth inequality between the groups is more complex. Mean wealth increases in absolute terms for all groups. However, relative mean wealth increases for the groups with highest and lowest mean earnings, while decreasing for the middle groups. Changes in the social target from

[36]For example, via equation (16), we can see that the increase in the left hand side, as a result of the more aspirational social target, implies that leisure must fall, so that the right hand side increases too.

[37]In particular, the importance of the common (social) factor, relative to the idiosyncratic (productivity), in determining choices, is increased, leading to a reduction in the spread of choices.

the mean (or a lower percentile) to the 90th percentile of consumption have two effects on the consumption-savings margin. On one hand, the higher aspirational component in social pressure works to increase the relative weight of future consumption, and thus of savings. This works via the prospects for upward mobility that determine the expected value of the social target (and thus the relative weight of future consumption) in equation (17). The strength of this channel differs between the social classes, depending on the social transition matrix. On the other hand, a higher social target increases the relative weight to current consumption too, and the strength of this channel depends of the extent of within group consumption inequality.

The trade-off that a more aspirational peer pressure introduces in the inter-temporal margin leads to relative increases in wealth for the highest and lowest mean wage groups and relative reductions for the others. For the highest mean wage groups, this happens because consumption inequality is relatively low, implying that the effect of a higher social consumption target on the left hand side of the Euler equation, described above, is low. On the other hand, for the lowest mean wage group this happens because the prospect for upward mobility implies that the next period effect, on the right hand side of the Euler equation described above, is relatively big. In contrast, for the two middle groups, both effects are relatively smaller, hence the increase in mean savings is not as big. The effects on within group wealth inequality are small and do not exhibit a clear pattern between the groups. Finally, consumption is affected by changes in both wealth and earnings, which together lead to a reduction in between group consumption inequality following the pattern of changes in earnings inequality, and, in effect, no change in within group inequality.

## 7.2 Above-peer aspirations

We next consider a scenario where social pressure is related explicitly to aspirations to achieve the consumption levels of a higher class, compared with aspirations constrained by pressure to conform to peers. In particular, we consider the case where the reference point in the utility function is given by the mean or the 90th percentile of the socio-economic group with the immediately higher mean wage than the current group. For the highest mean wage group, there is no change. In this sense, the consumption level that the household aspires to achieve is determined by the behaviour of higher socio-economic groups, for the first three mean wage groups, giving rise to upward looking aspirations.

We summarise the between group inequality effects of above-peer aspirations in the columns of Table 6 under the headings "mean above" and "P90 above". There are substantial quantitative differences between the distributional implications of aspirational targets and those of peer pressure. The results are similar when comparing the change of the target from mean of the group of peers to mean of the group above peers, with the change of the target from the 90th percentile of the group of peers to the 90th percentile of the group above peers.

To understand the effects of above-peer aspirations, relative to peer pressure, the following observation is helpful. Comparing peer pressure to above-peer aspirations, there is a difference between the first three and the highest mean wage groups regarding how the change in social targets affects decision making. In particular, for the first three groups, the intra-temporal decision margin is affected directly and most significantly, since only one side of it is affected, compared with the inter-temporal margin, where both sides of the Euler equation are affected. In contrast, the inter-temporal margin is not directly affected for the highest mean wage group, which means that the effects work first via the inter-temporal margin, and then affect the intra-temporal margin via the equilibrium effects on the social target that they imply. Therefore, to understand the effects of above-peer aspirations for the first three groups, we examine first hours and earnings, where the effect is direct; whereas, for the highest mean wage group, we examine the inter-temporal margin effects since they are stronger.

### 7.2.1 Differential effects on group averages

Mean hours and earnings increase when the social targets change from those determined by peers to those determined by the group that has a higher mean wage than the peers. On the other hand, the increase in mean hours and earnings for the highest mean wage group is relatively smaller, so that between group inequality in hours and earnings decrease, in that the lower mean wage groups close the gap with the top. As can be seen in equation (16), there is an increase in the relative weight to consumption for the lower mean wage groups (compared with the top mean wage group), since the new, aspirational, target refers to the higher mean consumption of the higher mean wage socio-economic group in each case and hence increases directly the relative weight to consumption. In contrast, for the highest mean wage group, there is no direct change in aspirations/social target, and thus in the relative weight to consumption. However, as will be explained below, mean wealth and mean consumption have increased in this group as well, implying, via equation (16), an effective increase in the social target $(C_t)^\gamma$, which tends to incentivise higher consumption and work hours (and thus earnings), leading to the changes in mean hours and earnings observed. Since this is only an equilibrium effect, this increase is relatively smaller for the highest mean wage group. As a result, between group inequality in hours and earnings is reduced.

The increased earnings tend to increase wealth and consumption for all groups. However, relative wealth falls for the three lower mean wage groups, leading to increased between group wealth inequality. Looking at equation (17), we can see that upward looking aspirations, compared to peer pressure, increase the relative weight to current consumption directly and thus create disincentives to save. On the other hand, this effect is not present for the highest mean wage group; on the contrary, the higher social targets for the lower groups increase the expected value of future consumption targets in equation (17) for this group, whilst leaving the current consumption target unchanged. Thus, for the highest mean wage group, the relative weight to current consumption falls, which works to increase savings. These effects combine to lead to the reduction in relative wealth for the three lower mean wage groups and the increase in the highest mean wage group. The increased wealth in the higher mean wage group further drives the increase in consumption in this group, setting in motion a consistent increase in hours and earnings, which was described above. Between group consumption inequality falls in terms of the relative consumption of the highest to the remaining groups, driven by the positive earnings effects for the three lower mean wage groups, which are very strong.

Overall, regarding between group inequality, stronger aspirations increase between group wealth inequality, by increasing the gap between the top earners and the remaining socio-economic classes. Although driven by a different mechanism, aspirations also lead to an increase in between group wealth inequality in Genicot and Ray (2017) (see also footnote 4 in the Introduction). However, in the framework employed in Genicot and Ray (2017), income is the wealth (inherited from the parents) and consumption follows only from wealth, i.e. there is no distinction between asset and labour income. By distinguishing asset from labour income, and studying wealth inequality in conjunction with hours, earnings and consumption, we find that above-peer aspirations lower between group inequality in these three economic variables, by closing the gap between the top group and the rest. The effect of aspirations on between group inequality is thus not symmetric across economic outcomes.

### 7.2.2 Within group inequality

Above peer aspirations, compared with the situation where social pressure implies conformity with peers, further lead to a complex pattern of changes in within group inequality. For the three lower mean wage groups, there is a reduction in hours and earnings within group inequality, because the higher social targets create stronger, and common to all households within a group, incentives to increase hours and earnings. There is thus an increase in the relative importance of the social, common factor driving hours and earnings, relative to the idiosyncratic, productivity related factor, which induces higher equity within the groups. However, the increased levels of earnings in absolute terms for these groups, mean that even a lower hours Gini implies a higher earnings variance. Thus, a greater difference in the level of earnings between those with high and those with low earnings. In turn, these greater differences in earnings lead to greater differences in savings. Hence, leading to an increase in within group wealth inequality for these groups alongside the increase in mean wealth. In turn, this feeds into an increase in within group consumption inequality.

For the highest income group, the substantial increase in mean wealth works to reduce the variation in income due to earnings risk (especially since the increase in the level of (mean) earnings is small). Thus, reducing wealth and consumption inequality. The higher level (mean) of consumption implies that the lower Gini in consumption is in fact consistent with a higher spread in terms of distance from the mean. Via equation (16), this is consistent with a higher spread in leisure, which leads to the marginally higher Gini in hours and earnings, despite the lower Gini in consumption for this group.

Overall, a qualitative strengthening of aspirations (by comparing above-peer aspirations to peer pressure) does not imply a universal decrease in within group inequality across all economic outcomes, suggesting instead a complex pattern of changes in within cluster inequality. Even when focusing on the three lower mean wage groups, for which there are truly "higher" aspirations, we note that by disentangling hours and earnings as sources of income that are subject to idiosyncratic shocks, from asset income, we find that wealth and consumption inequality within groups increases under above-peer aspirations, implying that social dissatisfaction may accompany the positive average effects for these groups that were discussed earlier.[38] This increase in within group asset and consumption inequality is obtained despite the reduction in within group inequality in hours and earnings, and thus highlights the importance of allowing for idiosyncratic variation and the insurance value of wealth when examining wealth inequality.

[38] Note that this is without introducing explicit aspiration failure and frustration as in e.g. Genicot and Ray (2017).

# 8 Conclusions

This paper developed a theoretical framework to examine inequality between and within groups of households (peers) that are defined based on socio-economic class. The model incorporated both peer pressure, where consumption levels achieved by members of the socio-economic class (the group of peers) determine a social target which acts as a reference point for consumption for each member of the class; and above-peer aspirations, defined as aspirations for consumption that are determined by the social class that has the next higher mean wage (and earnings) than the group of peers. We showed existence of stationary equilibrium, when the social targets are determined jointly with the distributions of HEWC, under stochastic social class participation and idiosyncratic productivity.

We calibrated a model that belongs to this framework to British data, under "keeping-up-with-the-Joneses" peer pressure, and we found that it predicts all main patterns in the data regarding between and within group inequality. In particular, the contribution of "keeping-up-with-the-Joneses" peer pressure, calibrated based on econometric evidence on peer pressure from De Giorgi *et al.* (2019), is critical in helping the model's predictions match the empirical patterns regarding between group hours inequality and cross-group qualitative differences with respect to within group hours and earnings inequality.

More generally, we find that in stationary equilibria characterised by "keeping-up-with-the-Joneses" peer pressure, for groups with higher mean wages, within group inequality is lower in terms of hours and earnings, and higher in terms of wealth and consumption, relative to economies without peer pressure. In contrast, for lower mean wage groups, within group inequality is higher in terms of wealth and consumption and lower in terms of hours and earnings. At the same time, between group inequality is lower for hours, earnings and consumption, but higher for wealth.

Compared with peer pressure, above-peer aspirations allow the groups with the higher aspirations (lower mean wage groups) to close the gap with the top mean wage group in terms of hours, earnings and consumption, while this increases in terms of wealth. However, wealth and consumption inequality within-group is higher, despite a reduction in within-group inequality in hours and earnings.

We conclude from our analysis of the properties of stationary equilibria under different social norms regarding peer pressure and above-peer aspiration that: (i) social pressure determined with reference to a group of peers, directly (peer pressure) or indirectly (above-peer aspirations), has a differential effect on households, depending on their class; and it incorporates forces that, other things equal, tend to generate convergence within cluster and divergence between classes; (ii) the prospect of upward/downward mobility also contributes to the effects of peer pressure and above-peer aspirations, tending to lower between group divergence; and (iii) there are important insights for the study of consumption/wealth inequality under peer pressure and aspirations, in a framework where wealth inequality reflects both the dispersion of earnings and motives for wealth accumulation stemming from inter-temporal smoothing and the insurance value of wealth. In this environment, peer pressure and above-peer aspirations affect incentives to work and save differently, thus implying non-uniform changes in wealth and earnings inequality, which in turn implies that there are opposite effects on consumption inequality and social dissatisfaction.

Our findings suggest that above peer aspirations, compared with a situation where households aim to meet targets defined by the behaviour of peers, lead to increased within group dispersion in economic achievement, despite improvements in material wealth and consumption on average. This finding implies that in a more socially connected world, when aspirations become more upward looking, improvements in wealth and consumption may nevertheless be accompanied by social dissatisfaction.

# References


[1] Abel, A. B. (1990). Asset prices under habit formation and catching up with the Joneses, NBER Working Papers 3279, National Bureau of Economic Research, Inc.

[2] Acemoglu, D. and M. Jensen (2015). Robust comparative statics in large dynamic economies, *Journal of Political Economy*, 123, 587-641.

[3] Acikgoz, O. T. (2018). On the existence and uniqueness of stationary equilibrium in Bewley economies with production, *Journal of Economic Theory*, 173, 18-55.

[4] Akerlof, G. A. (1980). A theory of social custom, of which unemployment may be one consequence. *The Quarterly Journal of Economics*, 94, 749-775.

[5] Al-Najjar, N. (2004). Aggregation and the law of large numbers in large economies, *Games and Economic Behavior*, 47, 1-35.

[6] Aiyagari, R. (1994). Uninsured idiosyncratic risk and aggregate saving, *Quarterly Journal of Economics*, 109, 659-684.

[7] Angelopoulos, K., Lazarakis, S. and J. Malley (2019). Savings externalities and wealth inequality, CESifo Working Paper 7619.

[8] Appadurai A. (2004). The Capacity to Aspire: Culture and the Terms of Recognition, in *Culture and Public Action*, The World Bank.

[9] Bayer, C. and F. Juessen (2012). The life-cycle and the business-cycle of wage risk: Cross-country comparisons, *Economic Letters*, 117, 831-833.

[10] Becker, G. S., Murphy, K. M., and I. Werning (2005). The equilibrium distribution of income and the market for status, *Journal of Political Economy*, 113, 282-310.

[11] Benabou, R., and E.A. Ok (2001). Social mobility and the demand for redistribution: the POUM hypothesis, *The Quarterly Journal of Economics*, 116, 447-487.

[12] Benhabib, J., Bisin, A., and M. O. Jackson (Eds.) (2011). *Handbook of Social Economics*. Elsevier.

[13] Benhabib, J., Bisin, A., and M. Luo (2017). Earnings inequality and other determinants of wealth inequality, *American Economic Review*, 107, 593-97.

[14] Bernheim, B. D. (1994). A theory of conformity, *Journal of political Economy*, 102, 841-877.

[15] Bewley, T. (1986). Stationary monetary equilibrium with a continuum of independently fluctuating consumers, In Werner Hildenbrand and Andreu Mas-Collel (editors), *Contributions to Mathematical Economics in Honor of Gerard Debreu*, North Holland.

[16] Blundell, R., Gosling, A., Ichimura, H., and C. Meghir (2007). Changes in the distribution of male and female wages accounting for employment composition using bounds, *Econometrica*, 75, 323-363.

[17] Blundell, R. and B. Etheridge (2010). Consumption, income and earnings inequality in Britain, *Review of Economic Dynamics*, 13, 76–102.

[18] Brown, G. D., Gardner, J., Oswald, A. J., and J. Qian (2008). Does wage rank affect employees' well-being?, *Industrial Relations: A Journal of Economy and Society*, 47, 355-389.

[19] Cagetti, M., and M. De Nardi (2006). Entrepreneurship, frictions, and wealth, *Journal of Political Economy*, 114, 835-870.

[20] Calvó-Armengol, A., and M. O. Jackson (2010). Peer pressure, *Journal of the European Economic Association*, 8, 62-89.

[21] Campbell, J. Y., and J. H. Cochrane (1999). By force of habit: A consumption-based explanation of aggregate stock market behavior, *Journal of Political Economy*, 107, 205-251.

[22] Carroll, C. D. (2006). The method of endogenous gridpoints for solving dynamic stochastic optimization problems, *Economics letters*, 91, 312-320.

[23] Carvalho, C., Ferrero, A., and F. Nechio (2016). Demographics and real interest rates: Inspecting the mechanism, *European Economic Review*, 88, 208-226.

[24] Cole, H. L., Mailath, G. J., and A. Postlewaite (1992). Social norms, savings behavior, and growth, *Journal of Political economy*, 100, 1092-1125.

[25] Dalton, P. S., Ghosal, S., and A. Mani (2015). Poverty and aspirations failure, *The Economic Journal*, 126, 165-188.

[26] De Giorgi, G., Frederiksen, A., and L. Pistaferri (2019). Consumption Network Effects, *The Review of Economic Studies*, 026.

[27] De Nardi, M. (2015). Quantitative models of wealth inequality: A survey, NBER Working Papers 21106, National Bureau of Economic Research, Inc.

[28] Duesenberry, J. S. (1949). *Income, saving, and the theory of consumer behavior*, Harvard University Press.

[29] Dupor, B., and W. F. Liu (2003). Jealousy and equilibrium overconsumption, *American Economic Review*, 93, 423-428.

[30] Faccini, R., Millard, S., and F. Zanetti (2013). Wage rigidities in an estimated dynamic, stochastic, general equilibrium model of the UK labour market, *The Manchester School*, 81, 66-99.

[31] Gali, J. (1994). Keeping up with the Joneses: Consumption externalities, portfolio choice, and asset prices, *Journal of Money, Credit and Banking*, 26, 1-8.

[32] Genicot, G., and D. Ray (2017). Aspirations and inequality, *Econometrica*, 85, 489-519.

[33] Ghiglino, C., and S. Goyal (2010). Keeping up with the neighbors: social interaction in a market economy, *Journal of the European Economic Association*, 8, 90-119.

[34] Harrison, R. and O. Oomen (2010). Evaluating and estimating a DSGE model for the United Kingdom, Bank of England Working Paper No. 380.

[35] Heffetz, O., and R. H. Frank (2011). Preferences for status: Evidence and economic implications, in *Handbook of Social Economics* (Vol. 1, pp. 69-91). North-Holland.

[36] Hopkins, E., and T. Kornienko (2004). Running to keep in the same place: Consumer choice as a game of status, *American Economic Review*, 94, 1085-1107.

[37] Hopkins, E., and T. Kornienko (2006). Inequality and Growth in the Presence of Competition for Status, *Economics Letters*, 93, 291-296.

[38] Huggett, M. (1993). The risk-free rate in heterogeneous-agent incomplete-insurance economies, *Journal of Economic Dynamics and Control*, 17, 953–969.

[39] Jappelli, T., and L. Pistaferri (2017). *The economics of consumption: theory and evidence*, Oxford University Press.

[40] Jones, S. R. (1984). *The economics of conformism.* Blackwell.

[41] Kambourov, G., and I. Manovskii (2008). Rising occupational and industry mobility in the United States: 1968–97, *International Economic Review*, 49, 41-79.

[42] Kambourov, G., and I. Manovskii (2009). Occupational mobility and wage inequality, *The Review of Economic Studies*, 76, 731-759.

[43] Kraay, A. and J. Ventura (2000). Current accounts in debtor and creditor countries, *Quarterly Journal of Economics*, 115, 1137–1166.

[44] Krueger, D., Mitman, K., and F. Perri (2016). Macroeconomics and household heterogeneity, in *Handbook of Macroeconomics* (Vol. 2, pp. 843-921), Elsevier.

[45] Kuhn, M., and J. V. Ríos-Rull (2016). 2013 Update on the US earnings, income, and wealth distributional facts: A View from Macroeconomics. *Federal Reserve Bank of Minneapolis Quarterly Review*, 37, 2-73.

[46] Knies, G. (2018). Understanding Society: The UK household longitudinal study, waves, 1-8, User Guide, Colchester: University of Essex.

[47] Krueger, D., Mitman, K. and F. Perri (2016). Macroeconomics and household heterogeneity, *Handbook of Macroeconomics*, 2, 843-921.

[48] Lane, P. R., and G. M. Milesi-Ferretti (2007). The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970–2004, *Journal of International Economics*, 73, 223-250.

[49] Luo, Y., and E. R. Young (2009). The wealth distribution and the demand for status, *Macroeconomic Dynamics*, 13, 1-30.

[50] Marcet, A., Obiols-Homs, F., and Weil, P. (2007). Incomplete markets, labor supply and capital accumulation, *Journal of Monetary Economics*, 54, 2621-2635.

[51] Mas, A., and E. Moretti (2009). Peers at work, *American Economic Review*, 99, 112-45.

[52] Meghir, C., and L. Pistaferri (2011). Earnings, consumption and life cycle choices, in *Handbook of Labor Economics* (Vol. 4, pp. 773-854), Elsevier.

[53] Miao, J. (2014). *Economic Dynamics in Discrete Time*, The MIT Press.

[54] Mookherjee, D., and D. Ray (2003). Persistent inequality, *The Review of Economic Studies*, 70, 369-393.

[55] Mookherjee, D., Ray, D., and S. Napel (2010). Aspirations, segregation, and occupational choice, *Journal of the European Economic Association*, 8, 139-168.

[56] Mugerman, Y., Sade, O., and M. Shayo (2014). Long term savings decisions: Financial reform, peer effects and ethnicity, *Journal of Economic Behavior & Organization*, 106, 235-253.

[57] Office for National Statistics (ONS), Social Survey Division (2018). *Wealth and Assets Survey, Waves 1-5, 2006-2016*, 6th Edition, UK Data Service, SN: 7215.

[58] Pijoan-Mas, J. (2006). Precautionary savings or working longer hours?, *Review of Economic dynamics,* 9, 326-352.

[59] Piketty, T. (1995). Social mobility and redistributive politics, *The Quarterly Journal of Economics*, 110, 551-584.

[60] Postlewaite, A. (2011). Social Norms and Preferences, in *Handbook of social economics* (Vol. 1, pp. 31-67). North-Holland.

[61] Quadrini, V. (2000). Entrepreneurship, saving, and social mobility, *Review of economic dynamics*, 3, 1-40.

[62] Quadrini, V. and J. Rios-Rull (2015). Inequality in macroeconomics, in *Handbook of Income Distribution*, vol. 2B, Elsevier.

[63] Ray, D., and A. Robson (2012). Status, Intertemporal Choice, and Risk-Taking, *Econometrica*, 80, 1505-1531.

[64] Ray, D. (2006). Aspirations, poverty, and economic change, in *Understanding Poverty*, Oxford University Press.

[65] Rose, D., Pevalin, D. J., and K. O'Reilly (2005). The National Statistics Socio-economic Classification: origins, development and use. Palgrave Macmillan.

[66] Roussanov, N. (2010). Diversification and its discontents: Idiosyncratic and entrepreneurial risk in the quest for social status, *The Journal of Finance*, 65, 1755-1788.

[67] Schmidt-Grohe, S. and M. Uribe (2003). Closing small open economy models, *Journal of International Economics*, 61, 163-185.

[68] Stachurski, J., and A. A. Toda (2019). An impossibility theorem for wealth in heterogeneous-agent models with limited heterogeneity, *Journal of Economic Theory*, 182, 1-24.

[69] Stokey, N., Lucas, R. and E. Prescott (1989). *Recursive Methods in Economic Dynamics*, Harvard University Press.

[70] Uhlig, H. (1996). A law of large numbers for large economies, *Economic Theory*, 8, 41-50.

[71] University of Essex, Institute for Social and Economic Research (2018). *Understanding Society: Waves 1-8, 2009-2017 and Harmonised BHPS: Waves 1-18, 1991-2009*, 11th Edition, UK Data Service. SN: 6614.

[72] Upward, R., and P. W. Wright (2007). Snakes or Ladders? Skill Upgrading and Occupational Mobility in the US and the UK during the 1990s, *Working Paper*.

[73] Veblen, T. (1899). *The theory of the leisure class.* Routledge 2017.

[74] Zhu, S. (2018). Existence of equilibrium in an incomplete market model with endogenous labor supply, *Working Paper*, University of International Business and Economics.

# 9 Appendix A

We summarise the properties of the solution to the household optimisation problem, following the approach taken in Zhu (2018). The main idea is to study the problem of the household in two steps. First, we examine the intratemporal problem in which the consumer chooses consumption and leisure to maximize the intratemporal utility given expenditure. Second, we examine the intertemporal problem which determines the optimal expenditure and saving decisions over time. To do this, we use the indirect utility function from the first step as the objective function in the second step.

The intratemporal utility function is given by $u(c, l, C(s(z)))$, or $u(c, l, z; \widetilde{C})$, making explicit the dependence on the elements in $\widetilde{C}$. Define $y$ as the expenditure on consumption $c$ and leisure $l$, i.e. $y = c + we(z)\, l$. The intratemporal problem is then given by:

$$\begin{aligned} J(y, z; \widetilde{C}) &= \max_{c,l} u(c, l, z; \widetilde{C}), \\ s.t.\ c + we(z)\, l &= y, \\ l &\leq 1, \\ c, l &\geq 0. \end{aligned} \tag{A.1}$$

The first order condition of this problem is:

$$\frac{u_2(c, l, z; \widetilde{C})}{u_1(c, l, z; \widetilde{C})} \geq we(z)\,, \text{ with equality if } l < 1. \tag{A.2}$$

Proposition 1 in Zhu (2018) also applies for the household problem in Section 2 and implies that for given $z$ and $\widetilde{C}$, $J(y, z; \widetilde{C})$ is bounded, strictly increasing and strictly concave in $y$, and continuously differentiable in $y$, with $J_1(y, z; \widetilde{C}) = u_1(q(y, z), l(y, z), z; \widetilde{C})$, $\forall y \in (0, +\infty)$.

The original intertemporal optimisation problem (3) becomes:

$$\max_{a_{t+1};y_t} E_0 \sum_{t=0}^{\infty} \beta^t J(y_t, z_t; \widetilde{C}),$$
$$\begin{aligned} s.t.\ y_t + a_{t+1} &= (1+r)a_t + we(z_t), \\ y_t &\geq 0, \\ a_{t+1} &\geq 0. \end{aligned} \tag{A.3}$$

Letting $V(a, z; \widetilde{C})$ be the value function, the Bellman equation that describes the household's decision problem is:

$$\begin{aligned} V(a, z; \widetilde{C}) = \max_{a' \in \Gamma(a,z)} \{ & J\left((1+r)a + we(z) - a', z; \widetilde{C}\right) + \\ & + \beta E\left[V(a', z'; \widetilde{C})|z\right]\}, \end{aligned} \tag{A.4}$$

where

$$\Gamma(a, z) = \{a' : 0 \leq a' \leq (1+r)a + we(z)\}. \tag{A.5}$$

Let $g(a, z; \widetilde{C})$ and $y(a, z; \widetilde{C})$ be the optimal decision rules of the asset for next period and the total expenditure for the current period respectively. Given the properties for the indirect utility function $J(y, z; \widetilde{C})$, Proposition 2 in Zhu (2018) then shows that $V(a, z; \widetilde{C})$ is continuous, strictly increasing, strictly concave in $a$; $V(a, z; \widetilde{C})$ is continuously differentiable in $a$, and $V_1(a, z; \widetilde{C}) = (1+r)J_1(y(a, z; \widetilde{C}), z; \widetilde{C})$, $\forall a \in [0, +\infty)$; $g(a, z; \widetilde{C})$ is continuous and weakly increasing in $a$; and $y(a, z; \widetilde{C})$ is strictly increasing in $a$.

Let $q(a, z; \widetilde{C})$ and $l(a, z; \widetilde{C})$ represent $q(y(a, z; \widetilde{C}), z; \widetilde{C})$ and $l(y(a, z; \widetilde{C}), z; \widetilde{C})$. Then (see Proposition 3 in Zhu (2018)), we have that $q(a, z; \widetilde{C})$ and $l(a, z; \widetilde{C})$ are continuous and increasing with respect to $a$ and that $l(a, z; \widetilde{C}) = 1$ $\forall z \in Z$, when $a$ is sufficiently large. Finally, Lemmata 4-6 and Propositions 6-7 in Zhu (2018) provide the remaining properties of the joint distribution summarised in Section 2.

# 10 Appendix B

`Lemma 1`: The policy function $q(a, z, \widetilde{C}) : X \times \mathcal{C} \to [0, c^{\max}]$ is continuous in $(a, \widetilde{C})$.[39]

**Proof:**

Let $\widetilde{C} = \left(\overline{C}_1, \overline{C}_2, .., \overline{C}_M\right)$ take values in $\mathcal{C} = [0, c^{\max}] \times [0, c^{\max}] \times ... [0, c^{\max}]$ which is a compact and convex subset of $\mathbb{R}^M$. We write $C\left(z, \widetilde{C}\right) : Z \times \mathcal{C} \to [0, c^{\max}]$ as an indicator function:

$$C = \begin{cases} \overline{C}_1, \text{ if } s\left(z\right) = 1 \\ \vdots \\ \overline{C}_M, \text{ if } s\left(z\right) = M \end{cases}, \tag{B.1}$$

where the realisation of $z$ determines which identity function is used. Note that for given $z$, $C\left(z, \widetilde{C}\right) = C\left(z, \overline{C}_1, \overline{C}_2, .., \overline{C}_M\right) = \overline{C}_m : s\left(z\right) = m$, i.e. a given $z$ defines $C\left(z, \cdot\right)$ as an identify function which is continuous, strictly increasing and (trivially) concave. Given the assumptions on the utility function, for given $z$, $u\left(c, l, C\left(z, \widetilde{C}\right)\right) = u(c, l, \widetilde{C})$ is jointly concave with respect to $(c, l, \widetilde{C})$.

The intratemporal problem is then given by:

$$\begin{array}{l} J(y, z, \widetilde{C}) = \max_{c,l} u(c, l, \widetilde{C}), \\ s.t.\ c + we\left(z\right) l = y, \\ l \leq 1, \\ c, l \geq 0. \end{array} \tag{B.2}$$

Following Zhu (2018) we can show that for given $z$, $J(y, z, \widetilde{C})$ is bounded and strictly concave in $y$ and $\widetilde{C}$ for given $z$. To see the latter, note that given $z$ for any $\left(y', \widetilde{C}'\right)$, $\left(y'', \widetilde{C}''\right) \in [0, c^{\max} + w\overline{e}\left(\overline{z}_H\right)] \times [0, c^{\max}]$ and for all $\kappa \in (0, 1)$, we have:

[39] Clearly, the policy functions and the value function depend also on the prices $r$ and $w$. For notational convenience we omit them since these remain fixed at the level of the socio-economic equilibrium as defined here.

$$
\begin{aligned}
& J[\kappa y' + (1-\kappa)y'', z, \kappa\widetilde{C}' + (1-\kappa)\widetilde{C}''], \\
& = u(q(\kappa y' + (1-\kappa)y'', z, \kappa\widetilde{C}' + (1-\kappa)\widetilde{C}''), l(\kappa y' + \\
& \quad +(1-\kappa)y'', z, \kappa\widetilde{C}' + (1-\kappa)\widetilde{C}''), \kappa\widetilde{C}' + (1-\kappa)\widetilde{C}''), \\
& \\
& \geq u(\kappa q(y', z, \widetilde{C}') + (1-\kappa)q(y'', z, \widetilde{C}''), \kappa l(y', z, \widetilde{C}') + \\
& \quad +(1-\kappa)l(y'', z, \widetilde{C}''), \kappa\widetilde{C}' + (1-\kappa)\widetilde{C}''), \\
& \\
& > \kappa u(q(y', z, \widetilde{C}'), l(y', z, \widetilde{C}'), \widetilde{C}') + \\
& \quad +(1-\kappa)u(q(y'', z, \widetilde{C}''), l(y'', z, \widetilde{C}''), \widetilde{C}''), \\
& \\
& = \kappa J(y', z, \widetilde{C}') + (1-\kappa)J(y'', z, \widetilde{C}''),
\end{aligned}
\tag{B.3}
$$

where the fifth line follows from optimality of $J(y, z, \widetilde{C})$, while the eighth line follows from the concavity of the utility function with respect to $(c, l, \widetilde{C})$.

Consider then the maximisation problem:

$$
\begin{aligned}
V(a, z, \widetilde{C}) = \max\nolimits_{a' \in \Gamma(a,z)} \{ & J\left((1+r)a + we(z) - a', z, \widetilde{C}\right) + \\
& +\beta E\left[V(a', z', \widetilde{C})|z\right]\},
\end{aligned}
\tag{B.4}
$$

where

$$
\begin{aligned}
& \Gamma(a, z) = \{a' : 0 \leq a' \leq (1+r)a + we(z)\} \text{ and} \\
& \widetilde{C} = \left(\overline{C}_1, \overline{C}_2, .., \overline{C}_M\right).
\end{aligned}
\tag{B.5}
$$

Given continuity and concavity of $J(y, z, \widetilde{C})$, Theorem 9.8 in Stokey *et al.* (1989) implies that $V(a, z, \widetilde{C}) \equiv V(a, z, \overline{C}_1, \overline{C}_2, .., \overline{C}_M)$ is concave in $(a, \widetilde{C})$ and $a' = g(a, z, \widetilde{C}) : X \times \mathcal{C} \rightarrow \Gamma(a, z)$ is single-valued (a function) that is continuous in $\left(a, \widetilde{C}\right)$ for given $z$. Therefore, the optimal expenditure function $y = y\left(a, z, \widetilde{C}\right) = (1+r)a + we(z) - g(a, z, \widetilde{C})$ must be also continuous in $(a, \widetilde{C})$. By the Theorem of the Maximum, which implies that $q(a, z, \widetilde{C})$ and $l(a, z, \widetilde{C})$ are continuous in $(y, \widetilde{C})$ in the intratemporal problem of the household, $q(a, z, \widetilde{C})$ and $l(a, z, \widetilde{C})$ are continuous in $(a, \widetilde{C})$ as well. ■

`Lemma 2`: The integrals $\int_X \left(q\left(a, z, \widetilde{C}\right) : s = j\right) \lambda^{\widetilde{C}}(da, dz)$, $j = 1, ..., m$, are continuous in $\widetilde{C} \in \mathcal{C}$.

**Proof:** The proof follows similar arguments as in Acikgoz (2018, Appendix G). First, note that $\Lambda^{\widetilde{C}}\left[(a, z), A' \times \{z'\}\right]$ in (5) is continuous in $\widetilde{C} \in \mathcal{C}$. To see this, recall from (5) that $\widetilde{C}$ affects $\Lambda^{\widetilde{C}}\left[(a, z), A' \times \{z'\}\right]$ via the policy function $g(a,z,\widetilde{C})$, which is dependent on $\widetilde{C}$, while $Q(z,\{z'\})$ is independent of $\widetilde{C}$. Since, by Lemma 1 $g\left(a,z,\widetilde{C}\right)$ is continuous in $\widetilde{C}$ (and thus measurable), we can write $\Lambda^{\widetilde{C}}\left[(a,z),A'\times\{z'\}\right] = \mathbf{1}_A\left(g\left(a,z,\widetilde{C}\right)\right)Q\left(z,\{z'\}\right)$ (see Theorem 9.13 in Stokey *et al.* (1989), which requires measurability of $g\left(a,z,\widetilde{C}\right)$ to define $\Lambda^{\widetilde{C}}\left[(a,z),A'\times\{z'\}\right]$ as the transition function for the joint Markov process in $[0,\overline{a}]\times Z\times\mathcal{C}$). By Stokey *et al.* (1989, Exercise 12.7), convergence of $\left\{\Lambda^{\widetilde{C}_n}\left[(a_n,z_n),A'\times\{z'\}\right]\right\}$ to $\Lambda^{\widetilde{C}}\left[(a,z),A'\times\{z'\}\right]$ for every sequence $\left\{\left(a_n,z_n,\widetilde{C}_n\right)\right\}$ in $[0,\overline{a}]\times Z\times\mathcal{C}$ that converges to $\left(a,z,\widetilde{C}\right)$ is equivalent to the operator $\left(T_\Lambda f\right)(a,z) = \int_X f\left(a',z'\right)\Lambda^{\widetilde{C}}\left[(a,z),d\left(a',z'\right)\right]$ having the Feller property, i.e. for every continuous function $f$, $(T_\Lambda f)$ is also continuous. By Stokey *et al.* (1989, Exercise 9.15), $\int_X f\left(a',z'\right)\Lambda^{\widetilde{C}}\left[(a,z),d\left(a',z'\right)\right] = \int_Z f\left(g\left(a,z,\widetilde{C}\right),z'\right)Q\left(z,dz'\right) \equiv \left(T_Q f\right)(a,z)$, so that $\left(T_\Lambda f\right)(a,z) = \left(T_Q f\right)(a,z)$. By Stokey *et al.* (1989, Lemma 9.5), $\left(T_Q f\right)(a,z)$ has the Feller property, i.e. if $f$ is continuous, so is $\left(T_Q f\right)(a,z)$ and thus so is $\left(T_\Lambda f\right)(a,z)$. We have thus shown that $\Lambda^{\widetilde{C}}\left[(a,z),A'\times\{z'\}\right]$ satisfies the required condition.

Second, continuity of $\Lambda^{\widetilde{C}}\left[(a,z),A'\times\{z'\}\right]$ in $\widetilde{C}$, implies, using Theorem 12.13 in Stokey *et al.* (1989), that the invariant distribution $\lambda^{\widetilde{C}}$ is continuous in $\widetilde{C}\in\mathcal{C}$. In particular, since (i) $[0,\overline{a}]\times Z$ is compact, i.e. closed and bounded, which is here as the Cartesian product of compact sets; (ii) the sequence of the transition function $\left\{\Lambda^{\widetilde{C}_n}\left[(a_n,z_n),A'\times\{z'\}\right]\right\}$ converges weakly (pointwise) to $\Lambda^{\widetilde{C}}\left[(a,z),A'\times\{z'\}\right]$ for every sequence $\left\{\left(a_n,z_n,\widetilde{C}_n\right)\right\}$ in $[0,\overline{a}]\times Z\times\mathcal{C}$ that converges to $(a,z,C)$; and (iii) there exists a unique invariant $\lambda$ for each value of $\widetilde{C}$, which has been shown in this context. Then, Theorem 12.13 in Stokey *et al.* (1989) establishes that the measure, $\lambda$ is continuous in $\widetilde{C}$, i.e. as $\widetilde{C}_n\to C$, $\lambda^{\widetilde{C}_n}\to\lambda^{\widetilde{C}}$.

Finally, given that $q\left(a,z,\widetilde{C}\right)\leq c^{\max}$, the Lebesgue Dominated Convergence Theorem and Theorem 12.3 in Stokey *et al.* (1989) establish that continuity of $\lambda^{\widetilde{C}}$ and of $q\left(a,z,\widetilde{C}\right)$ in $\widetilde{C}\in\mathcal{C}$ imply continuity of $\int_X q\left(a,z,\widetilde{C}\right)\lambda^{\widetilde{C}}(da,dz)$ and thus of $\int_X\left(q\left(a,z,\widetilde{C}\right):s=j\right)\lambda^{\widetilde{C}}(da,dz)$.■

# 11 Appendix C

Understanding Society (UnSoc) is a large longitudinal survey which follows approximately 40,000 households (at Wave 1) in the UK. UnSoc covers a wide range of social, economic and behavioural factors making it relevant to a wide range of researchers and policy makers. Data collection for each wave takes place over a 24-month period and the first wave occurred between January 2009 and January 2011. Note that the periods of waves overlap, but the individual respondents are interviewed around the same time each year. Thus, there is no respondent who is interviewed twice within a wave or a calendar year (see e.g. Knies (2018)).

The Wealth and Assets Survey (WAS) started in July 2006 with a first wave of interviews carried out over two years to June 2008. The WAS interviewed approximately 30,500 households including 53,300 adult household members in Wave 1. The same households were approached again for a Wave 2 interview between July 2008 and June 2010. In this wave 20,170 households responded (around 70 percent success) including 35,000 adult household members. Waves 3-5 covered the periods between July and June for the years 2010-12, 2012-14 and 2014-16 respectively. After Wave 2, due to sample attrition, the WAS started implementing boost samples in each wave to keep the number of interviewed households around 20,000 and 35,000-40,000 adult household members.

The Living Costs and Food Survey (LCF) is a repeated cross section survey which follows approximately 13,000 households in the UK. The Living Costs and Food Survey (LCF) began in 2008, replacing the Expenditure and Food Survey (EFS) and is conducted by the Office for National Statistics. Data collection for each wave takes place over a 12-month period, across the whole of the UK, and is the most significant survey on household spending in the UK. The LCF not only covers a wide range of social, economic measures and making it relevant to a wide range of researchers, policy makers, but also provides key information for the consumer prices index and for National statistics regarding consumption expenditure.

The WAS, UnSoc and LCF data sets employed in this paper refer to the free "End User Licence" versions of the datasets. In particular, we use the following datasets:

- WAS: SN-7215.
- UnSoc: SN: 6614.
- LCF: SN-6655, SN-6945, SN-7272, SN-7472, SN-7702, SN-7992, SN-8210, SN-8351, SN-8459.

## 11.1 Demographics (WAS)

1. **Head of the Household**: We define the head of household as the principal owner or renter of the property, and, when there is more than one head, the eldest takes precedence. This follows the ONS definition for the Household reference person (HRP). We use of the following variables: (HhldrW), (HiHNumW), (DVAGEw) and/or (DVAge17w).

2. **Socio-Economic Class:** Eight Class NS-SEC (NSSEC8W). We approximate the socio-economic class of the household with the higher of the professional classes of the head or of the spouse.

3. **Employment Status:** We use the variables for economic activity: (ecactw) for Waves 1-3 and (DVecactw) for Waves 4-5.

## 11.2 Definition of income variable (WAS)

1. **Individual earnings**:[40] it is the sum of gross annual earnings from first and second job. We use of the following variables: (DVGrsPayW), (DVGrsJob2W1) for wave 1 and (dvGrsempsecjobW) for waves 2-5.

## 11.3 Definition of wealth (WAS)

1. **Net property wealth**: is the sum of all property values minus the value of all mortgages and amounts owed as a result of equity release. (HPROPWW).

2. **Net financial wealth**: is the sum of the values of formal and informal financial assets, plus the value of certain assets held in the names of children, plus the value of endowments purchased to repay mortgages, less the value of non-mortgage debt. The informal financial assets exclude very small amounts (less than £250) and the financial liabilities are the sum of current account overdrafts plus amounts owed on credit cards, store cards, mail order, hire purchase and loans plus amounts owed in arrears. Finally, money held in Trusts, other than Child Trust Funds, is not included. (HFINWNTW_sum).

3. **Net Worth:** is the sum of the net property wealth and net financial wealth.

[40] All monetary values are expressed in 2012 prices as measured by CPIH.

## 11.4 Sample selection (WAS)

We keep households when the head is an employee and, if there is a spouse who also works, when she/he is also an employee. We keep households when both the head and the spouse (if any) have non-missing earnings. However, we keep households if one of the two spouses does not work i.e. if there is a spouse with zero earnings. We drop the households when either the head or the spouse (if any) is self employed and we drop the households with no labour income (i.e. neither the head nor the spouse (if any) having positive individual earnings). We further restrict the dataset by retaining households where the head of the households is aged 25-59 and dropping observations with missing values for socio-economic class.

Table C1: Household sample selection WAS

| selection step | Total |
|---|---|
| 1. Whole sample of households | 110,963 |
| 2. Drop households with mis-reported age variable | 110,937 |
| 3. Drop households with duplicate hh grid numbers | 110,910 |
| 4. Drop if head or spouse is self-employed | 99,562 |
| 5. Drop if head or spouse has missing earnings | 98,601 |
| 6. Drop if NS-SEC is missing | 92,094 |
| 7. Keep if heads' age $\geq$25, $\leq$59 | 47,328 |
| 8. Keep if positive household labour income | 39,731 |
| Average net worth obs per wave | 7.946 |

## 11.5 Demographics (UnSoc)

1. **Head of the Household**: We use the UnSoc definition of the head of household which follows the ONS definition for the Household reference person (HRP). The head of household is defined as the principal owner or renter of the property, and, where there is more than one head, the eldest takes precedence (w_hrpid, where the prefix w denotes wave).

2. **Socio-Economic Class:** Eight Class NS-SEC (w_jbnssec8_dv). We approximate the socio-economic class of the household with the higher of the professional classes of the head or of the spouse.

3. **Employment Status:** we use the variable reporting if the respondent is employed or self-employed at the current job (w_jbsemp).

## 11.6 Definition of wages, hours and earnings (UnSoc)

1. **Weekly Gross Earnings**: we use the usual gross pay per month at the current job (w_paygu_dv) and we to weekly gross earnings by multiplying by 12 and dividing by 52.

2. **Typical Weekly Hours:** number of hours normally worked per week (w_jbhrs).

3. **Total Hours**: sum of typical total weekly hours of the spouses.

4. **Total Earnings**: sum of weekly gross earnings of the spouses.

5. **Effective Wages**: it is the total household earnings over total household hours.

6. **Average typical hours worked**: sum of typical total weekly hours of the spouses.

## 11.7 Sample selection (UnSoc)

Our main sample consists of the General Population Sample plus the former British Household Panel Survey sample (BHPS), and we exclude the Ethnic Minority Boost Sample and the Immigrant and Ethnic Minority Boost Sample. For consistency with the WAS dataset, we also drop the households located in Northern Ireland. The inclusion of the boost samples and Northern Ireland sample, or the exclusion of the former BHPS sample does not effectively change our results either quantitatively or qualitatively. We keep households when the head is an employee and, if there is a spouse who also works, when she/he is also an employee. We keep households when both the head and the spouse (if any) have non-missing usual gross earnings per month at the current job and non-missing number of weekly hours normally worked. However, we keep households if one of the two spouses does not work i.e. if there is a spouse with zero earnings and zero hours. We also drop the households with positive incomes but reported zero hours. We further restrict the dataset by retaining households where the head of the households is aged 25-59 and dropping observations with missing values for socio-economic class. We also drop the households when either the head or the spouse (if any) is self employed. We drop the top 0.5% and the bottom 0.5% of the observations with positive household's effective wage, to avoid extreme cases (e.g. possible outliers in effective wages) which may affect results (see e.g. Blundell and Etheridge (2010) for similar treatment). This effectively means that we drop households that appear to be working for less than half the minimum wage. Finally, we keep those households that have at least two consecutive observations with positive household effective wage.

Table C2: Household sample selection UnSoc

| selection step | Total |
|---|---|
| 1. Whole sample | 208,200 |
| 2. Drop proxy & non-full interviews | 157,187 |
| 3. Original sample & BHPS sample | 122,193 |
| 4. Drop if relevant information is missing from either the head or spouse | 116,261 |
| 5. Drop if either the head or spouse is self employed | 103,731 |
| 6. Drop if total earnings are zero | 51,884 |
| 7. Drop if total hours are zero | 51,764 |
| 8. Keep if heads' age $\geq$25, $\leq$59 | 43,056 |
| 9. Drop top and bottom 0.5% of observations per wave | 42,635 |
| 10. Keep if present at least at 2 consecutive waves | 35,812 |
| Average obs per wave | 4,476 |
| Number of unique households | 8,303 |

Table C3: State space and invariant distribution

| | $s$ | $e$ | $\xi$ |
|---|---|---|---|
| | Q1 | 0.4031 | 0.049218 |
| $R$ | Q2 | 0.5351 | 0.050822 |
| | Q3 | 0.8076 | 0.053517 |
| | Q1 | 0.5015 | 0.058192 |
| $I$ | Q2 | 0.6966 | 0.058168 |
| | Q3 | 1.0840 | 0.064639 |
| | Q1 | 0.6337 | 0.120355 |
| $LP$ | Q2 | 0.9430 | 0.13237 |
| | Q3 | 1.4508 | 0.145599 |
| | Q1 | 0.8366 | 0.080876 |
| $HP$ | Q2 | 1.2272 | 0.088263 |
| | Q3 | 1.8541 | 0.097982 |

Note: $e' \times \xi = 1$.

## 11.8 Markov Chain (UnSoc)

Table C4: Transition Matrix

| | | *R* | | | *I* | | | *LP* | | | *HP* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q1 | Q2 | Q3 | Q1 | Q2 | Q3 | Q1 | Q2 | Q3 |
| | Q1 | 0.6721 | 0.1938 | 0.0598 | 0.0443 | 0.0066 | 0.0018 | 0.0150 | 0.0012 | 0.0006 | 0.0036 | 0.0006 | 0.0006 |
| *R* | Q2 | 0.1960 | 0.5540 | 0.1670 | 0.0369 | 0.0205 | 0.0023 | 0.0170 | 0.0017 | 0.0023 | 0.0023 | 0.0000 | 0.0000 |
| | Q3 | 0.0508 | 0.1674 | 0.6831 | 0.0179 | 0.0248 | 0.0179 | 0.0144 | 0.0110 | 0.0029 | 0.0069 | 0.0023 | 0.0006 |
| | Q1 | 0.0269 | 0.0317 | 0.0158 | 0.6605 | 0.1653 | 0.0269 | 0.0623 | 0.0037 | 0.0016 | 0.0048 | 0.0000 | 0.0005 |
| *I* | Q2 | 0.0040 | 0.0101 | 0.0196 | 0.1611 | 0.5761 | 0.1430 | 0.0539 | 0.0156 | 0.0010 | 0.0141 | 0.0015 | 0.0000 |
| | Q3 | 0.0021 | 0.0031 | 0.0155 | 0.0259 | 0.1236 | 0.7408 | 0.0150 | 0.0295 | 0.0217 | 0.0124 | 0.0047 | 0.0057 |
| | Q1 | 0.0077 | 0.0096 | 0.0099 | 0.0232 | 0.0170 | 0.0059 | 0.7089 | 0.1710 | 0.0279 | 0.0155 | 0.0019 | 0.0015 |
| *LP* | Q2 | 0.0015 | 0.0009 | 0.0043 | 0.0018 | 0.0067 | 0.0141 | 0.1497 | 0.6198 | 0.1655 | 0.0217 | 0.0119 | 0.0021 |
| | Q3 | 0.0015 | 0.0003 | 0.0018 | 0.0028 | 0.0018 | 0.0120 | 0.0208 | 0.1520 | 0.7497 | 0.0055 | 0.0208 | 0.0310 |
| | Q1 | 0.0000 | 0.0021 | 0.0026 | 0.0026 | 0.0109 | 0.0078 | 0.0197 | 0.0322 | 0.0099 | 0.7208 | 0.1675 | 0.0239 |
| *HP* | Q2 | 0.0015 | 0.0000 | 0.0021 | 0.0000 | 0.0026 | 0.0062 | 0.0015 | 0.0118 | 0.0436 | 0.1446 | 0.6343 | 0.1518 |
| | Q3 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0021 | 0.0037 | 0.0021 | 0.0477 | 0.0175 | 0.1363 | 0.7881 |

## 11.9 Demographics (LCF)

1. **Head of the Household**: We use the LCF definition of the head of household which follows the ONS definition for the Household reference person (HRP). The head of household is defined as the principal owner or renter of the property, and, where there is more than one head, the eldest takes precedence. (A003)

2. **Socio-Economic Class:** NS - SEC 8 Class of household reference person (A094).We do not have information for the NS-SEC of the spouse, and consequently we cannot approximate the socio-economic class of the household with the higher of the professional classes of the head or of the spouse.

## 11.10 Definition of income (LCF)

1. **Weekly Gross Earnings**: is usual labour earnings plus any bonuses (p008 + p011 + b312).

2. **Total Earnings**: sum of weekly gross earnings of the spouses.

3. **Total Hours**: sum of typical total weekly hours (a220) of the spouses.

## 11.11 Definition of Consumption(LCF)

1. **Household Consumption**: includes non-durable goods, services and semi-durable goods. We use the classification of household consumption headings from ONS to categorise the household expenditures into non-durable goods, services and semi-durable goods. To have a user-cost measure of housing, we follow Blundell and Etheridge (2010) and include rent, mortgage interest payments and housing taxes. One drawback is that the LCF does not easily permit a calculation of imputed rents for homeowners as it does not include house prices, and this might affect the calculation of the consumption inequality, especially for the richer households. Analytically, household consumption includes the following variables - COICOP: total food and nonalcoholic beverage (P601t); COICOP: total alcoholic beverages and tobacco (P602t); COICOP: total clothing and footwear (P603t); COICOP: total housing, water, electricity (P604t); COICOP: total health expenditure (P606t); COICOP: total transport costs (P607t) minus acquisitions of cars/vans/motorcycles (b244, b2441, b245, b2451, b247, c71111c,

c71112t, c71121c, c71122t, c71211c, c71212t, c71411t); COICOP: total recreation (P609t) minus acquisitions of durable recreation equipment (c92111t, c92112t, c92114t, c92115c, c92116t, c92117t, c92211t, c92221t); COICOP: total restaurants and hotels (P611t); COICOP: total miscellaneous goods and services (P612t).

2. **Equivalence scale:** We follow Blundell and Etheridge and we use the OECD (1982) equivalence scale. This assigns a value of 1 to the first household member, of 0.7 to each additional adult and of 0.5 to each child. (OECD (1982), The OECD List of Social Indicators, Paris.)

3. **Equivalised Consumption:** is household consumption divided by the equivalence scale.

## 11.12 Sample selection (LCF)

We keep households when the head is an employee and, if there is a spouse who also works, when she/he is also an employee. We keep households when both the head and the spouse (if any) have non-missing earnings. However, we keep households if one of the two spouses does not work i.e. if there is a spouse with zero earnings. We drop the households when either the head or the spouse (if any) is self employed and we drop the households with no labour income (i.e. neither the head nor the spouse (if any) having positive individual earnings). We also drop the households with positive incomes but reported zero hours. We further restrict the dataset by retaining households where the head of the households is aged 25-59 and dropping observations with missing values for socio-economic class. Note that from 2015 and on, LCF changed to financial year data collection (Apr-Mar) instead of a calendar year data collection (Jan-Dec). Nevertheless, in 2015 LCF also collected the data for first quarter of this year, and hence, we can calculate the measures of interest in calendar year frequency for the whole sample.

Table C5: Household sample selection LCF

| selection step | Total |
|---|---|
| 1. Whole sample | 49,326 |
| 2. Drop if 2018 | 47,856 |
| 3. Drop if head's region is N. Ireland | 45,580 |
| 4. Drop if food consumption is zero | 45,294 |
| 5. Drop if either the head or spouse is self employed | 40,093 |
| 6. Drop if Total Earnings are zero | 23,064 |
| 7. Drop if Total hours are zero | 22,852 |
| 4. Drop if the socio-economic class of the head is missing | 21,800 |
| 7. Keep if heads' age ≥25, ≤59 | 18,574 |
| 11. Drop top and bottom 0.5% of observations | 18,159 |
| Average obs per year | 2,018 |

Table C6: Summary statistics of total earnings from LCF

| NS-SEC | Mean | Gini |
|---|---|---|
| | total earnings* | |
| routine and semi-routine | 0.555 | 0.371 |
| intermediate low supervisory | 0.821 | 0.328 |
| lower management and professional | 1.121 | 0.301 |
| higher management and professional | 1.459 | 0.283 |
| total | 1.000 | 0.358 |

‡Source: Living Costs and Food Survey, own calculations. Consumption refers to equivalised weekly non-durable consumption plus real housing costs. We report the average statistics over years 2009-2017. All monetary values for all three variables in this table are expressed in 2015 prices as measured by CPIH.

# 12 Appendix D

The utility function is given by:

$$u(c,l,C) = \frac{c^{1-\sigma}}{1-\sigma}C^{\gamma} + \chi\frac{l^{1-\phi}}{1-\phi}, \tag{D.1}$$

where $\sigma, \phi > 1$, $\chi > 0$. Note that:

$$\frac{\partial u}{\partial C} = \gamma\frac{c^{1-\sigma}}{1-\sigma}C^{\gamma-1}, \text{ and} \tag{D.2}$$

$$\frac{\partial^2 u}{\partial c\partial C} = \gamma c^{-\sigma}C^{\gamma-1}. \tag{D.3}$$

Assuming that there is no uncertainty, the elasticity $\varepsilon_{cC} \equiv \frac{\%\Delta c}{\%\Delta C}$ can be approximated from the Euler equation as follows:

$$\begin{aligned} &(C_t)^{\gamma}c_t^{-\sigma} = (1+r)\beta(C_{t+1})^{\gamma}c_{t+1}^{-\sigma}, \\ &\Rightarrow \gamma\ln(C_t) - \sigma\ln(c_t) = \ln((1+r)\beta) + \gamma\ln(C_{t+1}) - \sigma\ln(c_{t+1}), \\ &\Rightarrow \sigma\Delta\ln(c_{t+1}) = \ln((1+r)\beta) + \gamma\Delta\ln(C_{t+1}), \\ &\Rightarrow \Delta\ln(c_{it+1}) = \tfrac{\ln((1+r)\beta)}{\sigma} + \tfrac{\gamma}{\sigma}\Delta\ln(C_{t+1}), \end{aligned} \tag{D.4}$$

but since $\frac{\ln((1+r)\beta)}{\sigma}$ is a very small number, we can approximate $\varepsilon_{cC}$ as follows:

$$\begin{aligned} &\Delta\ln(c_{it+1}) \approx \tfrac{\gamma}{\sigma}\Delta\ln(C_{t+1}), \\ &\Rightarrow \Delta\ln(c_{it+1})/\Delta\ln(C_{t+1}) \approx \tfrac{\gamma}{\sigma}, \\ &\Rightarrow \varepsilon_{cC} \approx \tfrac{\gamma}{\sigma}. \end{aligned} \tag{D.5}$$

The parameters (in long form) used for the base results in Tables 4 are in Table D1.

Table D1: Calibrated parameters

| $\beta$ | $\sigma$ | $\phi$ | $\alpha$ | $\gamma$ | $\chi$ | $r$ | $w$ | $\delta$ |
|---|---|---|---|---|---|---|---|---|
| 0.965479 | 1.50 | 1.603704 | 0.30 | 0.75 | 1.035185 | 0.0217 | 1.036678 | 0.0983 |

Figure D1: Uniqueness, Benchmark Case

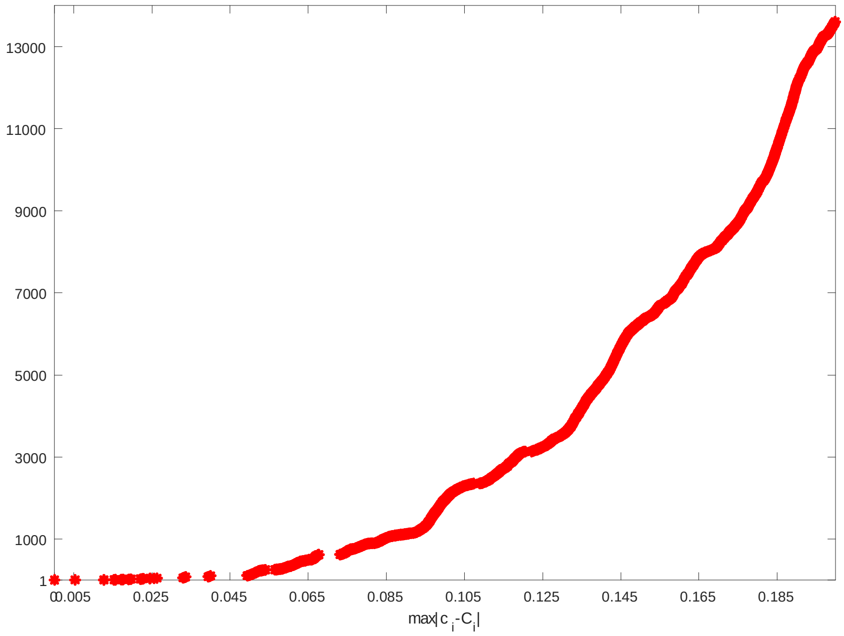



Figure D2: Uniqueness, Negative Elasticity Case

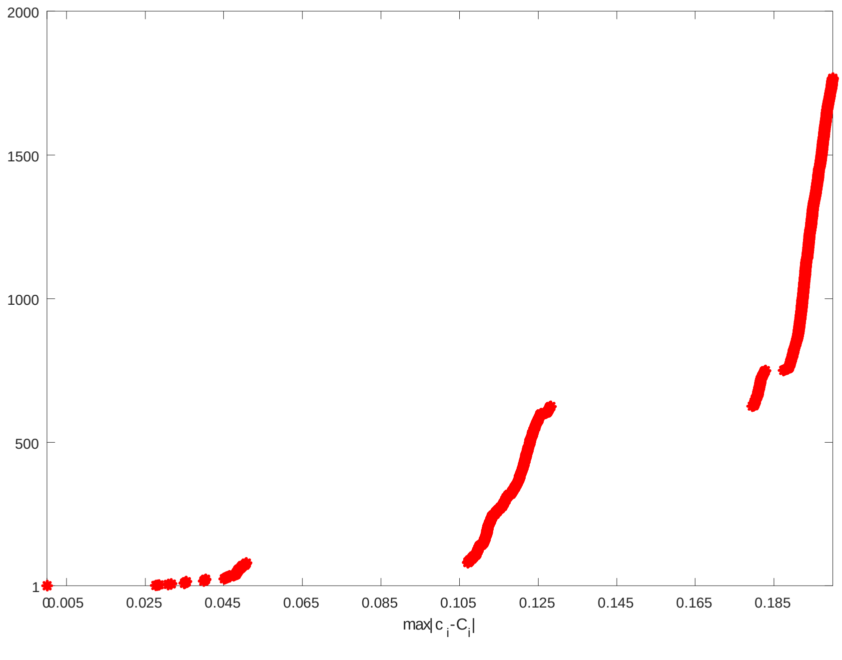


Figure D3: Uniqueness, 90th Percentile Case

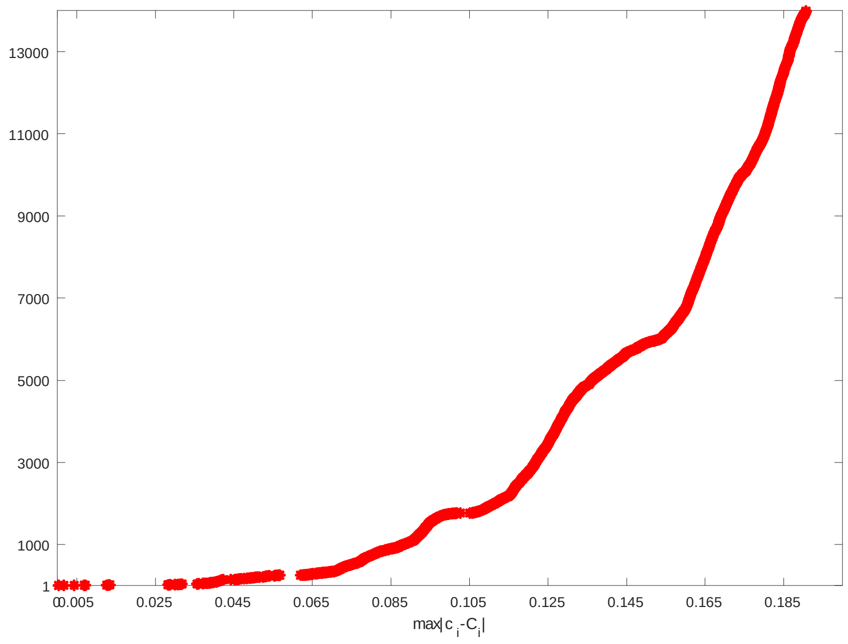



Figure D4: Uniqueness, Mean Above Case

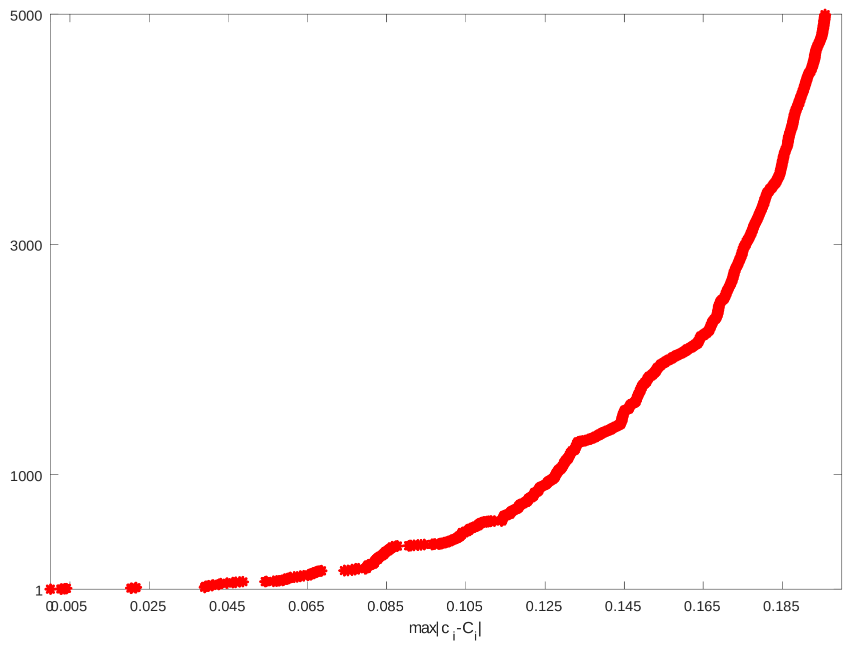


Figure D5: Uniqueness, 90th Percentile Case above

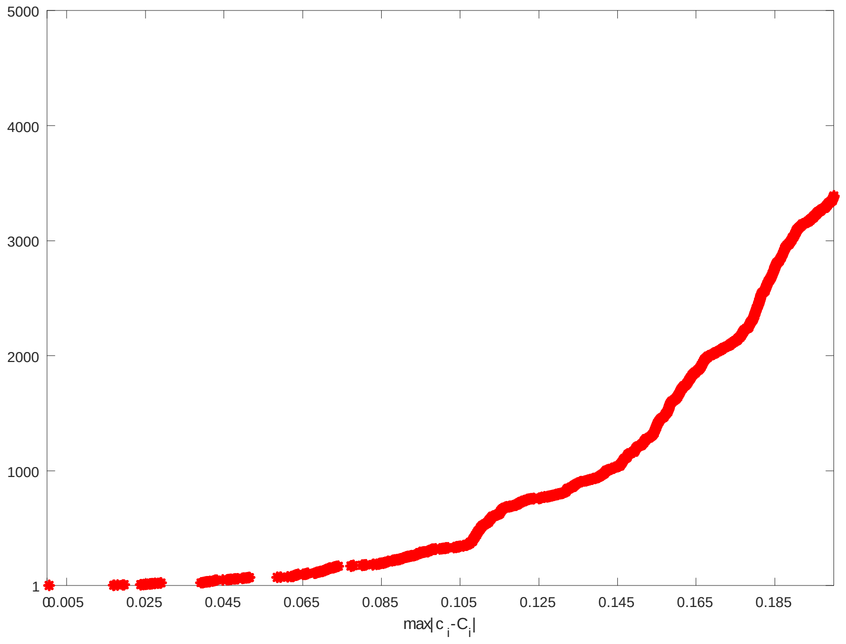


Table D2: Calibration with lower elasticity

| | Data | $\varepsilon_{cC}$= 0.333 | | Data | $\varepsilon_{cC}$= 0.333 |
|---|---|---|---|---|---|
| $\frac{\overline{A}_R}{\overline{A}}$ | 0.387 | 0.373 | Gini $A_R$ | 0.775 | 0.637 |
| $\frac{\overline{A}_I}{\overline{A}}$ | 0.696 | 0.610 | Gini $A_I$ | 0.662 | 0.587 |
| $\frac{\overline{A}_{LP}}{\overline{A}}$ | 1.101 | 1.037 | Gini $A_{LP}$ | 0.628 | 0.523 |
| $\frac{\overline{A}_{HP}}{\overline{A}}$ | 1.702 | 1.569 | Gini $A_{HP}$ | 0.593 | 0.469 |
| $\overline{A}$ | | 1.256 | Gini $A$ | 0.670 | 0.567 |
| | | | | | |
| $\frac{\overline{C}_R}{\overline{C}}$ | 0.774 | 0.610 | Gini $C_R$ | 0.248 | 0.112 |
| $\frac{\overline{C}_I}{\overline{C}}$ | 0.901 | 0.789 | Gini $C_I$ | 0.258 | 0.115 |
| $\frac{\overline{C}_{LP}}{\overline{C}}$ | 1.068 | 1.037 | Gini $C_{LP}$ | 0.260 | 0.105 |
| $\frac{\overline{C}_{HP}}{\overline{C}}$ | 1.231 | 1.311 | Gini $C_{HP}$ | 0.274 | 0.087 |
| $\overline{C}$ | | 0.392 | Gini $C$ | 0.276 | 0.170 |
| | | | | | |
| $\frac{\overline{E}_R}{\overline{E}}$ | 0.549 | 0.564 | Gini $E_R$ | 0.314 | 0.271 |
| $\frac{\overline{E}_I}{\overline{E}}$ | 0.794 | 0.750 | Gini $E_I$ | 0.263 | 0.279 |
| $\frac{\overline{E}_{LP}}{\overline{E}}$ | 1.100 | 1.031 | Gini $E_{LP}$ | 0.243 | 0.288 |
| $\frac{\overline{E}_{HP}}{\overline{E}}$ | 1.454 | 1.374 | Gini $E_{HP}$ | 0.235 | 0.284 |
| $\overline{E}$ | | 0.364 | Gini $E$ | 0.308 | 0.329 |
| | | | | | |
| $\overline{H}_R$ | 0.296 | 0.325 | Gini $H_R$ | 0.223 | 0.161 |
| $\overline{H}_I$ | 0.330 | 0.328 | Gini $H_I$ | 0.152 | 0.154 |
| $\overline{H}_{LP}$ | 0.346 | 0.333 | Gini $H_{LP}$ | 0.127 | 0.153 |
| $\overline{H}_{HP}$ | 0.346 | 0.341 | Gini $H_{HP}$ | 0.121 | 0.147 |
| $\overline{H}$ | | 0.333 | Gini $H$ | 0.153 | 0.153 |

Table D3: Levels of the means and variances

| | $\varepsilon_{cC}=$ 0.5 | $\varepsilon_{cC}=$ 0 | $\varepsilon_{cC}=$ $-0.5$ | | $\varepsilon_{cC}=$ 0.5 | $\varepsilon_{cC}=$ 0 | $\varepsilon_{cC}=$ $-0.5$ |
|---|---|---|---|---|---|---|---|
| $\overline{A}_R$ | 0.520 | 0.412 | 0.367 | $\text{var}_{A_R}$ | 49.26 | 39.68 | 35.44 |
| $\overline{A}_I$ | 0.819 | 0.707 | 0.661 | $\text{var}_{A_I}$ | 86.02 | 75.55 | 70.216 |
| $\overline{A}_{LP}$ | 1.327 | 1.275 | 1.249 | $\text{var}_{A_{LP}}$ | 163.16 | 159.51 | 153.47 |
| $\overline{A}_{HP}$ | 1.926 | 2.017 | 2.035 | $\text{var}_{A_{HP}}$ | 265.46 | 283.36 | 278.38 |
| $\overline{A}$ | 1.271 | 1.238 | 1.217 | $\text{var}_{A}$ | 182.99 | 190.84 | 188.24 |
| | | | | | | | |
| $\overline{C}_R$ | 0.223 | 0.261 | 0.281 | $\text{var}_{C_R}$ | 0.152 | 0.254 | 0.330 |
| $\overline{C}_I$ | 0.299 | 0.322 | 0.332 | $\text{var}_{C_I}$ | 0.296 | 0.399 | 0.458 |
| $\overline{C}_{LP}$ | 0.410 | 0.399 | 0.392 | $\text{var}_{C_{LP}}$ | 0.516 | 0.522 | 0.515 |
| $\overline{C}_{HP}$ | 0.539 | 0.478 | 0.447 | $\text{var}_{C_{HP}}$ | 0.672 | 0.505 | 0.433 |
| $\overline{C}$ | 0.395 | 0.385 | 0.379 | $\text{var}_{C}$ | 1.645 | 1.001 | 0.773 |
| | | | | | | | |
| $\overline{E}_R$ | 0.190 | 0.227 | 0.246 | $\text{var}_{E_R}$ | 0.933 | 0.971 | 0.939 |
| $\overline{E}_I$ | 0.265 | 0.284 | 0.292 | $\text{var}_{E_I}$ | 1.772 | 1.752 | 1.649 |
| $\overline{E}_{LP}$ | 0.380 | 0.368 | 0.359 | $\text{var}_{E_{LP}}$ | 3.592 | 3.436 | 3.146 |
| $\overline{E}_{HP}$ | 0.522 | 0.470 | 0.444 | $\text{var}_{E_{HP}}$ | 6.227 | 5.994 | 5.447 |
| $\overline{E}$ | 0.368 | 0.358 | 0.352 | $\text{var}_{E}$ | 4.873 | 4.139 | 3.616 |
| | | | | | | | |
| $\overline{H}_R$ | 0.298 | 0.363 | 0.396 | $\text{var}_{H_R}$ | 1.025 | 0.928 | 0.772 |
| $\overline{H}_I$ | 0.316 | 0.343 | 0.356 | $\text{var}_{H_I}$ | 0.908 | 0.861 | 0.733 |
| $\overline{H}_{LP}$ | 0.337 | 0.326 | 0.320 | $\text{var}_{H_{LP}}$ | 0.852 | 0.88 | 0.767 |
| $\overline{H}_{HP}$ | 0.358 | 0.319 | 0.300 | $\text{var}_{H_{HP}}$ | 0.735 | 0.876 | 0.802 |
| $\overline{H}$ | 0.333 | 0.333 | 0.333 | $\text{var}_{H}$ | 0.899 | 0.906 | 0.877 |

Notes: For the case where $\varepsilon_{cC}= 0.5$ the parameters are as in Table 3. For the $\varepsilon_{cC} = 0$ case, $\beta = 0.9625$, $\chi = 2.2134$ and $\phi = 1.5446$ and the rest are as in Table 3. For the $\varepsilon_{cC} = -0.5$ case, $\beta = 0.9611$, $\chi = 4.4693$ and $\phi = 1.6632$ and the rest are as in Table 3. All var terms are multiplied by 100.

# 13 Appendix E: Endogenous prices

We integrate the socio-economic equilibrium in a small open economy general equilibrium also employed in Angelopoulos *et al.* (2019), since our calibration is for the UK. In particular, we consider an open economy trading in global capital markets taking the real interest rate as given, where aggregate household savings, $A$, can differ from capital demanded by firms, $K$. The difference between domestic savings and domestic capital defines the net foreign asset position, $NFA \equiv K - A$, for the domestic economy. Given the country's net foreign asset position, the country makes interest payments to foreign households equal to $rNFA$, where $r$ is the interest rate at which the country can borrow from abroad.

We assume that the country faces a world risk-free interest rate $r^*$ plus a risk premium which is a function of the net foreign asset position (see e.g. Kraay and Ventura, (2000) for foreign-assets-elastic interest rate or Schmidt-Grohe and Uribe (2003) for debt-elastic interest rate). In particular, we assume that the risk premium is positively correlated with foreign debt relative GDP i.e. with $NFA$ over output:

$$r = r^* + \psi \left[ \exp(\frac{NFA}{Y}) - 1 \right], \tag{18}$$

for $0 < \psi < r^* + \delta$, which is well defined for $r > r^* - \psi$, and where $\psi$ measures the elasticity of the country specific interest rate premium relative to the net foreign asset position.[41] Household optimisation and (18) jointly define a constraint set for the interest rate in general equilibrium, $R^{ge}$, given by $r \in R^{ge} = \left( r^* - \psi, \frac{1}{\beta} - 1 \right)$. Firms borrow assets at the rate $r$ to maximise profits, giving rise to the usual first-order conditions in (15)-(14) and technology is given by a constant returns to scale production function satisfying usual Inada conditions $Y = F(K, L)$. Formally, we require that $F$ displays constant returns to scale, with $F_1, F_2 > 0$, $F_{11}, F_{22} < 0$, and it satisfies the conditions $\lim_{K \to +\infty} F_1(K, 1) = 0$ and $\lim_{K \to 0} F_1(K, 1) = +\infty$. Note, then, that the condition that $\psi < r^* + \delta$, implying $r^* - \psi > -\delta$, and given that $r > r^* - \psi$, ensures that domestic firm's demand is finite in the international market, and also guarantees that $r > -1$.

We define a stationary recursive general equilibrium in the open economy, establish existence and present an algorithm to compute the equilibrium.

[41] Note that $r > r^* - \psi$ is automatically satisfied for a country with negative net foreign assets when $\psi > 0$, as is the case in the calibration for the UK.

`Stationary Recursive Open Economy Equilibrium`

A *Stationary Recursive General Equilibrium* is an aggregate stationary distribution $\lambda^{\widetilde{C}}$ on $X$, policy functions $a' = g\left(a, z; \widetilde{C}\right) : X \rightarrow A$, $c_t = q\left(a, z; \widetilde{C}\right) : X \rightarrow \mathbb{R}_+$ and $l = l\left(a, z; \widetilde{C}\right) : X \rightarrow [0,1]$, value function $V\left(a, z; \widetilde{C}\right) : X \rightarrow \mathbb{R}$, positive real numbers in $\widetilde{C}$, and real numbers $K$, $L$, $w(\frac{K}{L})$ and $r(\frac{K}{L})$ such that:

1. The firm maximises its profits given prices, so that the latter satisfy (15) and (14).

2. The value function and the policy functions $g\left(a, z; \widetilde{C}\right)$, $q\left(a, z; \widetilde{C}\right)$, and $l\left(a, z; \widetilde{C}\right)$ solve the household's optimum problem in (4), given prices and aggregate quantities in $\widetilde{C}$.

3. Given prices and aggregate quantities, $\lambda^{\widetilde{C}}$ is a stationary distribution under the transition function $\Lambda^{\widetilde{C}}\left[(a, z), A' \times \{z'\}\right]$ implied by household's decision rules (determined by (5)). In particular, $\lambda^{\widetilde{C}}$ satisfies

$$\lambda^{\widetilde{C}}([0, \overline{a}] \times \{z'\}) = \int_X \Lambda^{\widetilde{C}}\left[(a, z), A' \times \{z'\}\right] \lambda^{\widetilde{C}}(da, dz)$$

for all $(a, z) \in X$, $A' \times \{z'\} \in \mathcal{B}(X)$.

4. When $\lambda^{\widetilde{C}}$ describes the cross-section of households at each date, the reference points in $\widetilde{C} = \left\{\overline{C}_1, \overline{C}_2, .., \overline{C}_m\right\}$ are given by the relevant percentiles of the distribution of consumption across the relevant social class in (6) or by the means in (7). Additionally, the domestic labour market clears:

$$L = \int_X e(z)\left(1 - l\left(a, z, \widetilde{C}\right)\right) \lambda^{\widetilde{C}}(da, dz) \equiv L^s; \qquad (19)$$

and the world asset market clears, satisfying

$$r = r^* + \psi\left[\exp\left(\frac{K - A^s}{F(K, L)}\right) - 1\right],$$

where

$$A^s \equiv \int_X g\left(a, z; \widetilde{C}\right) \lambda^{\widetilde{C}}(da, dz). \qquad (20)$$

Given that we have shown the existence of a socio-economic equilibrium given $r$ and $w$, what needs to be shown is that $r$ and $w$ exist for market clearing. Conditions for this are specified in the proposition below.

`Proposition 2`

Assume that there exists a unique socio-economic equilibrium given $r$ and $w$. Then, for $\phi$ sufficiently large, $\phi > \phi^{\min}$ satisfying $\frac{K}{Y}(r) > \ln\left(\frac{r-r^*+\phi^{\min}}{\phi^{\min}}\right)$, a stationary recursive general equilibrium exists.

**Proof:** The properties of the production function imply that the wage rate is a monotonic function of the interest rate. Hence, $w$, and indeed the general equilibrium quantities, can be expressed as a function of $r$. In particular, the capital to labour ratio demanded by the firms, $\frac{K}{L}$, is a decreasing function of $r$, as are the ratios $\frac{Y}{L}$ and $\frac{K}{Y}$. Given the interest rate, firm demand for assets and production implies a demand for assets over labour, $\left(\frac{A}{L}\right)^d$, via the international market and in particular (18), given by

$$\left(\frac{A}{L}\right)^d = \left[\left(\frac{K}{Y}\right) - \ln\left(\frac{r-r^*+\phi}{\phi}\right)\right]\left(\frac{Y}{L}\right),$$

which is a continuous function in $r$. When $\frac{r-r^*+\phi}{\phi}$ is small enough such that $\frac{K}{Y} > \ln\left(\frac{r-r^*+\phi}{\phi}\right)$, $\frac{d\left(\frac{A}{L}\right)^d}{dr} < 0$. Moreover, when $r \to \frac{1}{\beta} - 1$, $\left(\frac{A}{L}\right)^d \to \left(\frac{A}{L}\right)^{\min} < +\infty$, whereas when $r \to r^* + \phi$, $\left(\frac{A}{L}\right)^d \to +\infty$. Given $r$ (and $w(r)$), there is a unique socio-economic equilibrium, implying a unique aggregate supply of assets, $A^s = \int_X g\left(a, z; \widetilde{C}\right) \lambda^{\widetilde{C}}(da, dz)$ and a unique aggregate supply of labour $L^s = \int_X e(z)\left(1 - l\left(a, z, \widetilde{C}\right)\right) \lambda^{\widetilde{C}}(da, dz)$, and thus implying an asset-to-labour supply $\left(\frac{A}{L}\right)^s \equiv \frac{A^s}{L^s}$. As shown in Zhu (2018), this is continuous with respect to $r$ and $r \to \frac{1}{\beta}-1$, $\left(\frac{A}{L}\right)^s \to +\infty$. Moreover, when $r \to -1$, $\left(\frac{A}{L}\right)^s \to 0$. Therefore, an intersection point of the supply and demand curves $\left(\frac{A}{L}\right)^s$ and $\left(\frac{A}{L}\right)^d$ exists. This pins down $r$ and $\left(\frac{A}{L}\right)^s = \left(\frac{A}{L}\right)^d \equiv \frac{A}{L}$; these determine $\frac{K}{L}$ (from (14)), $w$ (from (15)), $A^s$ (from (20)), $L^s$ and $L$ (from (19)), which, in turn, determine $K$ and $F(K, L)$. ■

Note that the sufficient condition $\phi > \phi^{\min}$ is easy to satisfy for realistic calibrations for developed economies, where the interest rate $r$ does not differ much from the international interest rate and the capital to output ratio is higher than two, implying values for $\phi^{\min}$ in the third decimal point. To solve the model allowing for feedback from the supply of assets to the interest rate, we implement the following algorithm (which follows from Proposition 2):

`Computational algorithm for the open economy equilibrium`

1. Guess a value for $r^n$, which, given the first-order conditions (15) and (14) implies a value for $\left(\frac{K}{L}\right)^n$ and $w^n$.

2. Calculate the demand for domestic assets to labour implied by the international asset markets via (18), given by

$$\left(\frac{A}{L}\right)^n = \left[\left(\frac{K}{Y}\right)^n - \ln\left(r^n - r^* + \phi\right) + \ln\phi\right]\left(\frac{Y}{L}\right)^n,$$

   where $\left(\frac{Y}{L}\right)^n = T\left(\left(\frac{K}{L}\right)^n\right)^a$.

3. Given $r^0$ and $w^0$, we solve the socio-economic equilibrium (implementing the algorithm for the socio-economic equilibrium), check that it is unique, and calculate the aggregate values of $L^s\left(r^n\right)$ and $A^s\left(r^n\right)$ and thus of $\left(\frac{A}{L}\right)^s\left(r^n\right)$ that is supplied by the domestic economy.

4. Calculate the updated value of

$$r^{n^*} = r^* + \phi\left[\exp\left(\frac{(K/L)^n - (A/L)^s}{(Y/L)^n}\right) - 1\right].$$

5. If $\left|\left(\frac{A}{L}\right)^s - \left(\frac{A}{L}\right)^n\right| < \varepsilon$, where $\varepsilon$ is a pre-specified tolerance level, a stationary open economy general equilibrium has been found. If not, go back to step 1, and update $r^{n+1} = (1-\varsigma)\, r^n + \varsigma r^{n^*}$ with $0 < \varsigma \leq 1$.

To calibrate the open economy general equilibrium model, we use the same parameters and procedure as above for the socio-economic equilibrium. In addition, we set the world interest rate, $r^*$, equal to 2.15% which is the average short-run world real interest rate over all the countries in the dataset in Carvalho *et al.* (2016). Moreover, we choose $\psi$ so that the interest rate is 0.0217 in equilibrium, as in the socio-economic equilibrium. In particular, for given targets $\frac{K-A}{Y} = 8.1\%$, $r = 2.17\%$, and given $r^* = 2.15\%$, $\psi$ is given by $\psi = \frac{r-r^*}{\left[\exp\left(\frac{NFA}{Y}\right)-1\right]} = 0.0024$. This implies that the predictions of the model for the base calibration of $\gamma = 0.75$ are identical to those from the socio-economic equilibrium in Section 4. We then use this equilibrium to re-compute the results in Tables 5 and 6. Results are very similar in both cases.