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On income and wealth inequality in Turkey☆

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ABSTRACT

In this paper, we study Turkey's income and wealth distribution using a model-based approach via a modified Aiyagari (1994) model. In doing so, we use recent parameter estimates for Turkey and calibrate our model to match Turkey's income and wealth inequality measures. We document that our calibrated model matches Turkey's empirical economic inequality metrics with high precision, therefore can be used to infer Turkey's wealth distribution, which lacks data and detailed analysis. We compare Turkey's inequality measures with other countries, and display that by any conventional metric, Turkey qualifies as one of the more unequal economies. Finally, we quantify the welfare cost of inequality, and report that in order not to switch to the unequal Turkish economy, a utilitarian benevolent planner of Turkey's counter-factual representative-agent economy would be indifferent to forgoing 25.15% of steady-state consumption along with working an extra 33.61% of steady-state hours indefinitely.

1. Introduction

Concerns over rising economic inequalities have resulted in a rapidly growing body of literature in the economics profession over the last decades. In particular, recent work by Piketty (2014) has motivated a widespread discussion on the nature and evolution of wealth inequalities worldwide.[1] Despite these developments, literature and discussions on economic inequalities in Turkey have been predominantly confined to the study of *income* inequality. Albeit above the OECD average, Turkey's income inequality estimates have been rather stagnant over the last decade, as displayed in Fig. 1.[2] Turkey's *wealth* inequality estimates, however, have been displaying an upward time trend, thereby ranking Turkey second most unequal globally only to the Russian Federation in 2014, as shown in Table A.1.

In light of these developments, we find it important to explore the properties of Turkey's wealth distribution, which has been undiscovered by large. In this paper, we address this issue by taking a model-based approach and investigate Turkey's household wealth distribution via a modified Aiyagari (1994) model. In doing so, we use recent parameter estimates for Turkey and calibrate our model to match Turkey's income and wealth inequalities in 2014. We document that our calibrated model matches Turkey's empirical economic inequality metrics with high precision, therefore can be used to infer Turkey's wealth distribution, which lacks data and detailed analysis. We compare Turkey's model-generated and empirical inequality measures to those of countries with available data, and report that by any conventional inequality metric, Turkey exhibits the highest degree of income inequality in Europe. Further, we show that Turkey's model-generated wealth dispersion compares higher than those of previously studied countries by Cowell et al. (2016). We next turn to quantifying the welfare implications of Turkey's economic inequality, and we report that in order not to switch to the unequal Turkish economy, a utilitarian benevolent planner of Turkey's counter-factual representative-agent economy would be indifferent with forgoing an indefinite 43.24% of steady-state consumption if labor is supplied inelastically, and forgoing 25.15% of steady-state consumption along with working an extra 33.61% of steady-state hours if labor is supplied elastically.

Wealth distribution has major implications on economic performance, as wealth governs capital income and affects households' intratemporal and intertemporal decisions; it steers financial

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[1] For responses to Piketty (2014), see Acemoğlu and Robinson (2015), Krusell and Smith Jr (2015), Jones (2015), and Rognlie (2014), among others.
[2] See OECD Income Inequality Database for details.

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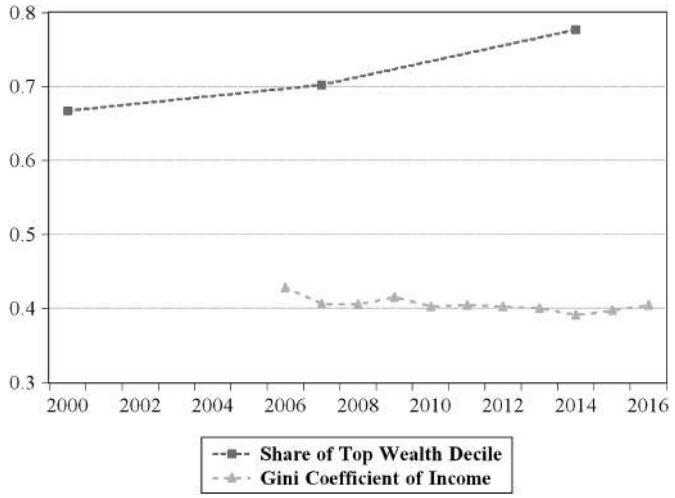

Fig. 1. Income and wealth inequality in Turkey.
† Source: Turkish statistical institute and Credit Suisse Global Wealth Report 2014.

deepening through access to credit channel due to collateral requirements; it interacts with real business cycles, and governs the effectiveness of fiscal and monetary policies.[3] Despite its sizable aggregate economic activity, Turkey lacks a thorough wealth distribution analysis.[4] To the best of our knowledge, this is the first theoretical paper studying Turkey's wealth distribution, and the second academic study on Turkish wealth inequality only to Davies et al. (2011), who empirically compare wealth inequality estimates globally.[5] By this paper, we aim to contribute to the ongoing discussion on income and wealth inequality and hope to contribute to the exploration of income and wealth distribution in Turkey. The rest of the paper is organized as follows: in section 2 we review the related literature, in section 3, we describe the model environment, in section 4 we describe our parametrization and calibration strategy, in section 5 we present our findings, and section 6 concludes.

2. Related literature

This paper relates mainly to two strands of literature. First, by its subject, it relates to the study of economic inequalities in Turkey. The only academic paper that investigates Turkey's *wealth* inequality is by Davies et al. (2011), who report estimates on Turkey's wealth distribution in 2000. Turkey's income, wage/salary/labor income, and consumption inequalities have been subject to several studies. This literature explores several dimensions of economic inequalities in Turkey from individual/household-level inequalities to regional disparities, the role of sector of employment, informality, educational attainment and relevant economic policies.[6] However, to the best of our knowledge, none of these papers study wealth distribution, or the interaction of wealth and wealth dispersion with these highlighted economic inequalities.

Second, by its methodology, this paper relates to the heterogeneous-agent incomplete-market general equilibrium models. The first generation general equilibrium incomplete-market models featuring heterogeneous agents by Bewley (1986), Huggett (1993), and Aiyagari (1994) study economic inequalities by generating endogenous stationary distributions in the presence of uninsurable (or partly insurable) idiosyncratic yet no aggregate shocks. The second generation heterogeneous-agent incomplete-market models à la Krusell and Smith (1998) incorporate aggregate shocks into the first generation models so as to investigate mainly the distributional effects of business cycle fluctuations in rich model settings. Over the recent decades, the first and second generation models and their variants have become academic workhorse models not only for the study of distribution of economic variables,[7] but also for the study of various other major economic issues, including but not limited to the study of optimal income taxation (Conesa et al., 2009), optimal public versus private risk sharing (Krueger and Perri, 2011), propagation of household heterogeneity in response to macroeconomic shocks (Krueger et al., 2016), the amplification of recessions in response to changes in wealth dispersion (Heathcote and Perri, 2017), and the magnitude of fiscal multipliers (Brinca et al., 2016; Hagedorn et al., 2016). This paper is an application of the incomplete-market general equilibrium models with heterogeneous agents for the case of a *developing country*, Turkey. In general, compared to their developed counterparts, developing economies differ considerably in their *deep* structural parameters, such as in their subjective discount rates or their share of capital and labor in their production technologies. As one of the earliest applications of heterogeneous-agent incomplete-market general equilibrium models for developing economies, if not the first, this paper also contributes to the literature on the role of developing-economy-consistent parametrization and calibration in economic outcomes.

3. Model

In order to study economic inequalities in Turkey, we rely on a modified version of the canonical heterogeneous-agent incomplete-market general equilibrium model *à la* Aiyagari (1994).[8,9]

3.1. Households

There is a continuum of infinitely-lived households, the measure of which is normalized to unity. Agents are atomistic and *ex-ante* homogeneous but *ex-post* heterogeneous, depending on the history of their idiosyncratic labor productivity shock realizations. Households have identical preferences defined over consumption and labor, and they face the same budget and borrowing constraints. Markets are incomplete, and households insure against future uncertainty via a risk-free one-period asset. Formally, households maximize:

$$\max_{\{c_t,h_t,a_{t+1}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (u(c_t) - v(h_t)) \tag{1}$$

subject to

[3] See the Related Literature section for further discussion.

[4] According to the World Bank estimates, Turkey ranks 13th globally in PPP-adjusted GDP in 2016.

[5] Davies et al. (2011) report Turkey's wealth Gini coefficient in 2000 (0.718) by relying on UniCredit Group (2005)'s findings, and authors do not report any further wealth inequality metric or distributional moment for Turkey other than the median-to-mean wealth ratio of 0.33.

[6] For regional income inequalities in Turkey, see Altınbaş et al. (2002), Gezici and Hewings (2004), Aldan and Gaygısız (2006), Yıldırım and Öcal (2006), Kırdar and Saraçoğlu (2008), Sarı and Güven (2007), Filiztekin (2015); for the role of education on labor earnings, see Duygan and Güner (2006), Tansel et al. (2014), Tansel and Acar (2016); for inequalities associated with sector of employment, see Derviş and Robinson (1980); for household-level inequalities, see Başlevent and Dayıoğlu (2005), Tansel and Bodur (2012), Bakış and Polat (2015) and Ekşi and Kırdar (2015). For a cross-country comparison of Turkish income, consumption and wage inequalities, see Tamkoç and Torul (2018), and Alvaredo et al. (2017).

[7] Among others, see Castañeda et al. (2003) for income and wealth distribution in the United States.

[8] For elaborate discussions on advances in Bewley-Huggett-Aiyagari-type heterogeneous-agent incomplete market economy models and heterogeneity in macroeconomics in general, see Heathcote et al. (2009), Krueger et al. (2010), and Güvenen (2011), among others.

[9] Our model differs from the canonical Aiyagari (1994) model, as our model endogenizes labor supply decision by households following advances in the distributional macroeconomics literature, whereas the standard Aiyagari (1994) model assumes inelastic (and state-invariant) labor supply. For an example of a Bewley-Huggett-Aiyagari-type heterogeneous-agent incomplete market model featuring endogenous labor supply choice, see Pijoan-Mas (2006).

$$c_t + a_{t+1} = (1+r)a_t + wz_t h_t \tag{2}$$

$$a_{t+1} \geq -b \tag{3}$$

$$z_{t+1} \sim \Pi(z_{t+1}|z_t), \quad z_t,\ z_{t+1} \in Z = \{\bar{z}_1, \ldots, \bar{z}_N\},\ N < \infty \tag{4}$$

$$c_t \geq 0,\ h_t \geq 0 \tag{5}$$

$$\text{given}\ \ a_0\ \&\ z_0 \tag{6}$$

where c_t denotes individual consumption, a_t denotes asset holdings, h_t denotes hours worked, and z_t denotes idiosyncratic labor productivity shock following a stochastic Markov process with the transition probability matrix, $\Pi(z_{t+1}|z_t)$, and realizations drawn from the finite-valued set Z.[10] Further, $\beta \in (0,1)$ refers to subjective discount factor, and $b \geq 0$ refers to individual borrowing constraint. Finally, $w > 0$ denotes the efficiency wage rate and $r > 0$ denotes the interest rate, both of which are determined competitively in equilibrium.[11]

Equivalently, household's problem can be formulated recursively with the following Bellman equation:

$$V(a,z) = \max_{\{c,h,a'\}} [u(c) - v(h) + \beta \mathbb{E} V(a',z')] \tag{7}$$

subject to

$$c + a' = (1+r)a + wzh \tag{8}$$

$$z' \sim \Pi(z'|z) \tag{9}$$

$$a' \geq -b \tag{10}$$

$$c \geq 0,\ h \geq 0, \tag{11}$$

where variables with the prime notation refer to next period variables, and the expectations operator is defined over the possible realizations of labor productivity shock, i.e. $\mathbb{E}V(a',\ z') = \sum_{z' \in Z} \Pi(z'|z) V(a',z')$. Solution to this recursive problem yields the following intratemporal and intertemporal optimal decision rules:

$$v'(h) = u'(c) z w \tag{12}$$

$$u'(c) = \beta \mathbb{E}[u'(c')(1+r)] + \lambda \tag{13}$$

$$\lambda(a'+b) = 0,\ \lambda \geq 0 \tag{14}$$

where λ in Equations (13) and (14) refers to the Lagrange multiplier before the borrowing constraint, which implies that when the borrowing constraint binds, the optimal choice of next period asset position equals $-b$.

3.2. Firms

The competitive representative neoclassical firm faces a constant returns to scale production technology, and maximizes its profits taking factor prices given. Accordingly, the firm solves the following static problem:

$$\max_{\{K,L\}} F(K,L) - (r+\delta)K - wL \tag{15}$$

where δ refers to the constant depreciation rate of physical capital, and K and L denote physical capital and *effective* labor demand by the firm, respectively. Optimal decisions by the firm imply that the real interest rate and the wage rate are determined competitively and equal to the marginal product of capital and effective labor:

$$r = F_K(K,L) - \delta \tag{16}$$

$$w = F_L(K,L) \tag{17}$$

where $F_K(K,L)$ and $F_L(K,L)$ refer to the partial derivative of the production function $F(K,L)$ with respect to physical capital K and effective labor L, respectively.

3.3. Equilibrium

A stationary recursive rational expectations equilibrium consists of factor prices r and w; value function $V(a,z)$ and its subsequent optimal decision rules $c(a,z)$, $h(a,z)$, $a'(a,z)$; stationary (*time-invariant*) distribution of households over states $\mu(a,z)$; and the aggregate stock of physical capital K and effective labor L, such that:

1. **Household optimization**: Given prices r and w, the value function $V(a,z)$ is the solution to household's recursive optimization problem (7), subject to constraints (8), (9), (10), (11), and $c(a,z)$, $h(a,z)$, $a'(a,z)$ are the resultant optimal decision rules.
2. **Firm optimization**: Given prices r and w, firm maximizes its profits (15) so that factor prices are equal to respective marginal products: $r = F_K(K,L) - \delta$ and $w = F_L(K,L)$.
3. **Stationary distribution**: $\mu(a,z)$ is the stationary distribution associated with the transition function implied by the optimal decision rule $a'(a,z)$ and the stochastic process $z' \sim \Pi(z'|z)$ ensuring $\mu(a',z') = \sum_{z \in Z} \Pi(z',z) \int_{a:a'=a(a,z)} d\mu(a,z)$ holds.
4. **Market clearance**: Resultant aggregate quantities are consistent with equilibrium factor prices, i.e. aggregate physical capital demand by the firm equals aggregate total asset holdings by households: $K = \sum_{z \in Z} \int_A a'(a,z)\, d\mu(a,z)$, and aggregate effective labor demand by the firm equals aggregate effective labor supply by households $L = \sum_{z \in Z} \int_A z \times h(a,z)\, d\mu(a,z)$.

4. Parameterization and calibration

4.1. Functional forms

For household preferences over consumption and labor, we use an additively-separable utility function with constant relative risk aversion over consumption and convex disutility over hours worked, as it is common in the heterogeneous-agent incomplete market model environments:

$$U(c,h) = u(c) - v(h) = \frac{c^{1-\gamma}}{1-\gamma} - \frac{h^{1+\frac{1}{\phi}}}{1+\frac{1}{\phi}} \tag{18}$$

where γ refers to the risk aversion parameter, and φ refers to the constant Frisch elasticity of labor supply.[12]

For production technology, we use the Cobb-Douglas form, as it

[10] Note that the Markovian stochastic process $\Pi(z_{t+1}|z_t) \equiv \pi_{n,m} = \Pr(z_{t+1} = \bar{z}_n | z_t = \bar{z}_m),\ \forall n,m \in \{1,\ldots,N\}$ ensures that z_t is sufficient statistics for the history of idiosyncratic realizations. Further, note that $l_t = z_t h_t$ refers to *effective* labor supply by households.

[11] There are no aggregate but only idiosyncratic shocks, accordingly all aggregate variables and factor prices are time-invariant at the stationary equilibrium, hence the lack of time subscripts for factor prices.

[12] Note that Frisch elasticity of labor supply is defined as $\varepsilon = \frac{dh/h}{dw/w}$. Given (18), optimal intratemporal decision (12) requires $\varepsilon = \frac{U_h(c,h)}{hU_{hh}(c,h) - h\frac{U_{ch}^2(c,h)}{U_{cc}(c,h)}} = \phi$. Further, relative risk aversion is defined as $RRA = -\frac{c\,U_{cc}(c,h)}{U_c(c,h)}$, which implies that given (18), $RRA = \gamma$.

is standard in the literature:

$$F(K,L) = K^{\alpha}L^{1-\alpha} \tag{19}$$

4.2. Parameters

We set the model period to one year, and calibrate it to the Turkish economy with the most recent and available wealth inequality data, 2014. For preferences over consumption, following Arrow (1999) we set the coefficient of risk aversion γ to 1.5.[13] In accordance with the earlier literature, we set the Frisch elasticity of labor supply φ to 2/3, i.e. to the multiplicative inverse of γ.[14] For the share of physical capital in production and the depreciation rate, we rely on Penn World Table 9.0 by Feenstra et al. (2015) and set $\alpha = 0.56$ and $\delta = 5.5\%$.[15] In order to calculate the subjective discount rate, β, we first use Turkish capital stock, labor share and depreciation rate data series from the Penn World Table 9.0, and use them jointly with Turkish consumption data so as to calibrate the discount rate parameter via the Euler equation $u'(c_t) = \beta\mathbb{E}[u'(c_{t+1})(1+r_{t+1})]$, where r_{t+1} satisfies $r_{t+1} = F_K(K_{t+1}, L_{t+1}) - \delta_t$ from the data and $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$ with $\gamma = 1.5$, as discussed. Accordingly, we use the resultant subjective discount rate $\beta = 0.89$ for our benchmark parametrization.[16] We summarize our parametrization in Table 1.

4.3. Calibration

We calibrate the model so as to match income and wealth inequality in Turkey. First, according to the Turkish Statistical Institute estimates, Gini coefficient of income in Turkey has been stable over the last decade, and equals 0.39 in 2014. We set this value for the model's income inequality target. Second, as briefly discussed, the only academic paper that reports on Turkey's *wealth* inequality is by Davies et al. (2011), who document a wealth Gini coefficient of 0.718 for the year 2000. Using the wealth concentration data by Credit Suisse Global Wealth Report (2014), we extrapolate Turkey's wealth Gini coefficient in a most *conservative* way, and estimate a wealth Gini coefficient of 0.78 for the year 2014, which we target for the model's wealth inequality target.[17] We calibrate labor productivity z and its stochastic Markov process $z' \sim \Pi(z'|z)$ jointly in order to match our income and wealth inequality targets.[18,19]

Table 1
Benchmark parameters.

Parameter	Symbol	Value	Source
Capital's Share in Production	α	0.560	Penn World Table 9.0
Subjective Discount Rate	β	0.890	Penn World Table 9.0
Depreciation Rate	δ	0.055	Penn World Table 9.0
Relative Risk Aversion	γ	1.500	Arrow (1999)
Frisch Elasticity of Labor Supply	φ	0.667	Fiorito and Zanella (2012)
Borrowing Constraint	b	0.000	Aiyagari (1994)

Table 2
Model's fit with data.

	Measure	Data	Model
Wealth	Gini Coefficient	0.78	0.78
	Top 10%	77.7%	79.5%
Income	Gini Coefficient	0.39	0.39
	Theil's L Index GE(0)	0.28	0.28
	Theil's T Index GE(1)	0.30	0.31
	Atkinson Index $\varepsilon = 0.50$	0.13	0.14
	Atkinson Index $\varepsilon = 1.00$	0.24	0.24
Consumption	Gini Coefficient	0.38	0.38

† Source: Credit Suisse Global Wealth Report, 2014 for top wealth decile, and author calculations for wealth Gini; Turkish Statistical Institute (TurkStat) for income Gini; and Tamkoç and Torul (2018) for Theil and Atkinson indices and non-durable consumption Gini coefficient in 2013 via TurkStat's Household Budget Survey.

We report our calibration results and compare them with Turkish data in Table 2. The *endogenous* wealth distribution by the model generates a Gini coefficient of 0.78, as in the data. In addition, the model generates a top wealth decile ratio of 79.5%, which mimics Turkey's actual wealth concentration in 2014, 77.7% closely. Further, the model generates an *endogenous* income distribution with a Gini coefficient of 0.39, as in the data. In addition, both Theil and Atkinson income indices by the model match data with high precision.[20,21] Finally, Tamkoç and Torul (2018) show that non-durable consumption inequality mimics income inequality in Turkey over time with a minor level difference, and report a consumption inequality of 0.38 in 2014. The model captures this co-movement and offers an *endogenous* consumption Gini coefficient of 0.38.[22,23] Overall, our findings reveal that the proposed model delivers Turkey's economic inequality figures with notable accuracy.

[13] The literature on risk aversion estimation reports country-specific risk aversion coefficients predominantly within the 1–1.5 interval, with developing country estimates being higher on average than their developed counterparts. See Layard et al. (2008) and Gandelman and Hernández-Murillo (2015) for further details.

[14] Note that similar to the Frisch elasticity value we use in our model, $\phi = 2/3$, Fiorito and Zanella (2012) propose the use of a Frisch elasticity of $\phi = 0.68$ and Chetty et al. (2011) propose the use of $\phi = 0.75$ for macroeconomic models. Setting the value of the Frisch elasticity equal to the multiplicative inverse of the risk aversion parameter, $\phi = \frac{1}{\gamma}$ allows us to get an analytical solution for consumption when borrowing constraint binds, i.e. when $a'(a,z) = -b$, thereby facilitating the computation of the stationary equilibrium considerably.

[15] Albeit considerably above the OECD average, the reported share of capital income in Turkey by Penn World Table 9.0 has been steady over time at $\alpha = 0.56$ since 2005. Similarly, the depreciation rate in Turkey by Penn World Table 9.0 has also been stagnant at $\delta = 5.5\%$ over the last decade.

[16] As the Turkish data series in Penn World Table 9.0 vary notably before and after 2005, we use post-2005 data for our calibration. Note that Çiçek and Elgin (2011) also use the same subjective discount rate $\beta = 0.89$ for their analysis on Turkey.

[17] We rely on the power method for our extrapolation in order to come up with the most conservative estimate for the wealth Gini coefficient. The estimated extrapolation equation is $\text{Gini}_i = (67.483 \times i^{0.1319})/100$ where $i = \{1,2,3\}$ refers to the year 2000, 2007 and 2014, respectively.

[18] Note that a wealth Gini coefficient of 0.78 is drastically high, and the plain vanilla Bewley-Huggett-Aiyagari models cannot amplify wealth dispersion to such values via Markov transition probabilities by Aiyagari (1994). In order to tackle this issue, Kindermann and Krueger (2014) use highly persistent states in the Markov transition matrix for *superstar* earners, i.e. those with very high labor productivity states. We pursue a similar methodology and keep the top two (out of five) labor productivity states persistent and immobile to the (three) low productive states. Details are available upon request and can be seen in the provided MATLAB code.

[19] Alstadsæter et al. (2017) argue that *offshore* wealth accounts for 18.64% of Turkey's GDP in 2007, or equivalently 8% of Turkey's capital stock in 2007 according to the Penn World Table 9.0. As we do not have data on the distribution of Turkey's offshore wealth, we refrain from incorporating its impacts.

[20] For a description of inequality measures, see Appendix.

[21] Regarding income quantiles, the model's predictions (and data by Turkish Statistical Institute) are as follows: 1th 20%: 6.2% (6.2%); 2th 20%: 7.7% (10.9%); 3th 20%: 10.1% (15.4%); 4th 20%: 36.8% (21.7%); and 5th 20%: 39.3% (45.9%). In brief, while the model matches the bottom quintile accurately, it slightly understates the top quintile and overstates the fourth quintile, thereby yielding a share ratio (S80/S20) slightly lower than that of the data.

[22] We replicate Tamkoç and Torul (2018)'s results using TurkStat's Household Budget Survey 2014, and verify the same consumption Gini coefficient of 0.38.

[23] Regarding the evolution of income and consumption inequality in Turkey, see Tamkoç and Torul (2018), in which authors study the time-series behavior of Turkey's economic inequalities by adhering to the cross-country comparable methodology suggested by Krueger et al. (2010). In brief, Tamkoç and Torul (2018) report that both income and consumption inequality in Turkey exhibit downward time trends over the 2002–2016 period, which authors attribute mainly to Turkey's high aggregate economic growth, and increasing share of social protection spending (as a share of GDP) during the period of interest.

Table 3
Aggregate variables and factor prices.

Variable	*K*	*H*	*Z*	*L*	*Y*	*C*	*r*	*w*	*rK*	*wL*
Model										
Aiyagari (End. Labor)	7.664	0.840	0.783	0.563	2.430	2.008	0.123	1.892	0.943	1.065
Aiyagari (Exo. Labor)	8.908	0.840	0.783	0.658	2.831	2.342	0.123	1.893	1.095	1.246
RBC (End. Labor)	7.189	0.683	0.783	0.535	2.293	1.897	0.124	1.884	0.889	1.009
RBC (Exo. Labor)	8.839	0.840	0.783	0.658	2.819	2.333	0.124	1.884	1.092	1.240

5. Results

5.1. Aggregate results

We display our calibration results for aggregate variables and factor prices on the first row in Table 3. In order to put the resultant numbers into perspective, we also report findings by three counter-factual scenarios: under our first counter-factual scenario, which we display on the second row in Table 3, we report results by the *exogenous-labor* extension of our heterogeneous-agent general equilibrium model, in which households do not choose the number of hours they work, but supply their labor inelastically and identically at the same *average* level, $H = 0.84$ as in the benchmark model.[24] On the third and fourth rows of Table 3, we report our findings by *representative-agent* counterparts of our heterogeneous-agent models, where agents are ex-ante *and* ex-post identical, hence distribution is degenerate. The two representative-agent models differ over labor supply choice: the *endogenous-labor* representative-agent real business cycle (RBC) model, reported on the third row in Table 3, assumes that the representative household optimally chooses the number of hours worked, whereas the *exogenous-labor* representative-agent RBC model, reported on the fourth row assumes that the representative household supplies labor inelastically at the same level, $H = 0.84$ as in the benchmark heterogeneous-agent model environment.[25]

Table 3 displays that both heterogeneous-agent models generate higher average steady-state capital (and asset) levels than their representative-agent counterparts. This well-established result is due to the *precautionary saving* motive of households under the presence of uninsurable (or partly insurable) idiosyncratic shocks. Despite generating equal average hours worked in equilibrium, the two heterogeneous-agent economies differ notably in their average capital (and asset) levels, which is due to the nature of the intra-temporal margin in the endogenous-labor environment: given the functional forms and parameter values, the *income effect* dominates the *substitution effect*, therefore households with higher labor productivity draws and higher asset levels work fewer hours than their less productive and poorer counterparts.[26] Table 3 further displays that both heterogeneous-agent economies generate higher average output, consumption, capital and labor incomes than their representative-agent counterparts.[27] However, this finding does *not* translate into higher average *welfare* in the heterogeneous-agent environments than their respective representative-agent counterparts, as we discuss in detail in the next subsection.

Table 4
Distributional properties of the benchmark model.

	Wealth	Income	Consumption
Gini Coefficient	0.780	0.386	0.383
Theil's L GE(0) Index	2.189	0.277	0.276
Theil's T GE(1) Index	1.302	0.310	0.309
Atkinson Index $\varepsilon = 0.50$	0.605	0.139	0.139
Atkinson Index $\varepsilon = 1.00$	0.888	0.242	0.241

5.2. Distributional results

We next summarize our distributional results in Table 4.[28] As discussed briefly, our model matches Turkey's wealth, income and consumption Gini coefficients accurately, and generates a wealth Gini coefficient more than twice that of income and consumption.[29] Albeit having similar histogram patterns, variation over model-generated household wealth is almost an order of magnitude higher than that of income and consumption. Accordingly, the model's resultant mean logarithmic deviation of wealth is as much as eight times that of income and consumption, as displayed by the Theil's L indices in Table 4. Theil's T indices for wealth, income and consumption also reveal that the stock variable wealth is distributed much more unevenly than the flow variables income and consumption, albeit with lesser discrepancy than the Theil's L index. The fourth and fifth rows in Table 4 also reveal that under different inequality aversion

[24] Note that this extension is identical to the standard Aiyagari (1994) environment, where *intratemporal* optimality margin is absent. In all counter-factual scenarios, we rely on the same parameter values in Table 1.

[25] We append the details of the representative-agent model environment to Appendix.

[26] Note that while *average* hours worked and labor productivity in the two heterogeneous-agent environments are identical, *average* effective labor in the exogenous-labor model is 17% higher than that of its endogenous-labor counterpart, since wealth, income and consumption distributions are right and hours worked distribution is left-skewed, as shown in Figure A.1. Similarly, at equal *average* productivity levels, hours worked in the benchmark heterogeneous-agent economy with labor supply choice is 23% higher than its representative-agent counterpart. Relying on TurkStat's Structure of Earnings Survey (2014), our estimations verify that wage *negatively* predicts annual hours worked (when controlling for gender, age and age squared, regardless of controlling for education and occupation or not), as in the model. Details of our estimations are available upon request, subject to confidentiality of the data set. Note that Bick et al. (2018) also report negative (and *the highest* cross-country) elasticity of hours worked to wages for the Turkish economy.

[27] Y on the fifth column in Table 3 denotes average output, but *not* income, since the two differ by the amount of depreciating physical capital δK at the steady-state. In other words, while income equals $Y^d = rK + wL$, output equals $Y = Y^d + \delta K = rK + wL + \delta K$.

[28] We report the distributional properties of the heterogeneous-agent economy with exogenous labor supply in TableA.2. In brief, a comparison of Table 4 and A.2 reveals that intratemporal margin moderates wealth, income and consumption inequalities as a result of the dominance of the *income effect*: households with high labor productivity rates and asset levels choose to work fewer hours and enjoy more leisure time than their less fortunate counterparts, which thereby lessens economy-wide wealth, income and consumption dispersion.

[29] In order to put Turkey's inequality estimates into perspective, in Table A.3 we compare Turkey's *income* inequality metrics with those of other European countries. Table A.3 reveals that by *any* conventional inequality metric, Turkey exhibits the highest degree of income inequality in Europe. However, a Transatlantic comparison reveals that Turkey's income inequality measures are lower than those of the United States, whose income Gini coefficient equals 0.48, Theil's L index equals 0.61, Theil's T index equals 0.42, and Atkinson Index with $\varepsilon = 0.5$ equals 0.20 in 2014, according to the US Census Bureau estimates. In Table A.4, we compare our model's implied *wealth* Gini coefficient to a select group of countries by Cowell et al. (2016), and we report that Turkey's model-generated wealth inequality ranks atop among these countries, surpassing even that of the United States when concentrating on *asset* distribution. However, Cowell et al. (2016) also report on *net worth* distribution, the Gini coefficient of which is 0.852 in the United States. Similarly, Wolff (2016) report a net worth Gini coefficient of 0.871 for the United States in 2013. Note that the standard Aiyagari (1994) model environment does not allow asset and net worth positions to differ from one another.

parameters, the necessary fraction of wealth redistribution far exceeds those of income and consumption. In brief, we conclude that all distributional measures signal high levels of economic inequality in Turkey, and given the notable fit of model's distributional predictions with data, the novel wealth distributional metrics our model generates can be utilized in future research, as well as in devising relevant economic policies.

5.3. Welfare cost of inequality

We next turn to quantifying the welfare implications of Turkey's inequality. For this purpose, suppose that social welfare (SW) is defined in a utilitarian way, and equals the sum of present-discounted value of contemporaneous utilities of equally-weighted households. In the heterogeneous-agent general equilibrium model, social welfare then can be calculated as follows:

$$\begin{aligned} SW_{Aiyagari} &= \frac{1}{I}\sum_{i=1}^{I}\sum_{t=0}^{\infty}\beta^t\left(u\left(\bar{c}_{i,t}^{\text{Aiyagari}}\right)-v\left(\bar{h}_{i,t}^{\text{Aiyagari}}\right)\right) \\ &= \frac{1}{1-\beta}\frac{1}{I}\left(\sum_{i=1}^{I}u\left(\bar{c}_{i}^{\text{Aiyagari}}\right)-v\left(\bar{h}_{i}^{\text{Aiyagari}}\right)\right) \end{aligned} \tag{20}$$

where the second equality follows from the constant measure of households at the stationary equilibrium. Similarly, suppose that social welfare in the representative-agent economy with *exogenous labor supply* is defined as the sum of present-discounted value of contemporaneous utilities of the representative household at the respective steady-state, formulated as follows:

$$\begin{aligned} SW_{RBC} &= \sum_{t=0}^{\infty}\beta^t\left(u\left(\bar{c}_{t}^{\text{RBC}}\right)-v\left(\bar{h}_{t}^{\text{RBC}}\right)\right) \\ &= \frac{1}{1-\beta}\left(u\left(\bar{c}^{\text{RBC}}\right)-v\left(\bar{h}^{\text{RBC}}\right)\right) \end{aligned} \tag{21}$$

where the second equality again follows from the definition of the deterministic steady-state. We quantify the *indefinite* consumption-equivalent welfare loss due to inequality as follows:

$$\begin{aligned} &\frac{1}{1-\beta}\left(u\left(\bar{c}^{\text{RBC}}\times\left[1-\omega_1^c\right]\right)-v\left(\bar{h}^{\text{RBC}}\right)\right) \\ &\quad=\frac{1}{1-\beta}\frac{1}{I}\left(\sum_{i=1}^{I}u\left(\bar{c}_{i}^{\text{Aiyagari}}\right)-v\left(\bar{h}_{i}^{\text{Aiyagari}}\right)\right) \end{aligned} \tag{22}$$

where ω_1^c denotes the highest fraction of representative-agent's steady-state consumption a benevolent social planner would be willing to forgo indefinitely so as not to switch to the Aiyagari economy.[30,31]

Also, suppose that social welfare in the representative-agent economy with *endogenous labor supply* choice is also defined as in (21), where steady-state values of variables and factor prices are also of the endogenous-labor RBC model equilibrium. Then, the welfare loss of the representative-agent who *internalizes* the effect of her labor supply choice on factor prices and whose intratemporal optimality condition holds (e.g. as in (12)) can be quantified as follows:

$$\begin{aligned} &\frac{1}{1-\beta}\left(u\left(c\left(\tilde{h}^{RBC}\right)\right)-v\left(\tilde{h}^{RBC}\right)\right) \\ &\quad=\frac{1}{1-\beta}\frac{1}{I}\left(\sum_{i=1}^{I}u\left(\bar{c}_{i}^{\text{Aiyagari}}\right)-v\left(\bar{h}_{i}^{\text{Aiyagari}}\right)\right) \end{aligned} \tag{23}$$

where

$$\tilde{h}^{RBC}=\bar{h}^{\text{RBC}}\times\left[1+\omega_2^h\right]\quad c\left(\tilde{h}\right)=\bar{c}^{\text{RBC}}\times\left[1-\omega_2^c\right] \tag{24}$$

where ω_2^h denotes the indefinite extra fraction of hours worked and ω_2^c denotes the indefinite fraction of forgone consumption so as to leave the representative-household indifferent to switching to the Aiyagari economy.

We find that in the former case, a benevolent social planner would be indifferent with forgoing as much as a sizeable $\omega_1^c = 43.24\%$ of steady-state consumption so as not to switch to the unequal Aiyagari regime. In the latter case, relative to the benchmark representative-agent steady-state values, the representative-household is indifferent with working an extra $\omega_2^h = 33.61\%$ hours, and forgoing $\omega_2^c = 25.16\%$ of her benchmark consumption indefinitely.[32] In light of these findings, we conclude that while the heterogeneous-agent models with elastic and inelastic labor supply choice generate lower *average* steady-state consumption values than their representative-agent counterparts, the unequal distribution of households over consumption and hours worked in the heterogeneous-agent environments generate considerable lower utilitarian social welfare levels and induce drastic consumption-equivalent welfare losses, which we believe is to be taken into consideration seriously when studying Turkey's economic inequalities and devising relevant economic policies.

6. Conclusions

Several data sources and previous literature on Turkish inequalities reveal that by any *income* inequality metric, Turkey qualifies as one of the more unequal economies. However, given data limitations and lack of earlier research, little is known about *wealth* inequality in Turkey. We highlight that while income inequality in Turkey has been stagnant over the last decade, recent evidence signals for an ever-increasing wealth concentration in Turkey, which reaches alarming levels by 2014. In light of these developments, in this paper we investigate Turkey's economic inequalities by relying on a modified Aiyagari (1994) model, which we calibrate to match Turkey's income and wealth inequalities in 2014. We document that our calibrated model matches Turkey's empirical economic inequality metrics with high accuracy in several dimensions, therefore can be used to infer about Turkey's wealth distribution. We compare our findings with data and other related literature to put the resultant figures into perspective, and show that Turkey's income inequality ranks atop in Europe, and Turkey's wealth inequality is among the highest across previously

[30] Note that since labor supply choice in this representative-agent economy exogenous and intratemporal margin is absent, factor prices in the RBC economy are not affected by a such indefinite reduction in consumption.

[31] In addition, one can quantify the *one-time* consumption-equivalent welfare loss relative to the RBC economy with exogenous labor supply as follows: $u(\bar{c}^{\text{RBC}}\times[1-\tilde{\omega}_1^c])+\frac{\beta}{1-\beta}(u(\bar{c}^{\text{RBC}}))-\frac{1}{1-\beta}(v(\bar{h}^{\text{RBC}}))=\frac{1}{1-\beta}\frac{1}{I}(\sum_{i=1}^{I}u(\bar{c}_i^{\text{Aiyagari}})-v(\bar{h}_i^{\text{Aiyagari}}))$ where $\tilde{\omega}_1^c$ denotes the fraction of representative-agent's steady-state consumption to be forgone only for once. Under this scenario, we report a drastic one-time consumption-equivalent welfare loss of. $\tilde{\omega}_1^c = 93.67\%$..

[32] Note that in quantifying consumption-equivalent social welfare loss due to inequality, our model-based approach implicitly assumes that economic dispersion results from the presence of uninsurable idiosyncratic shocks. Therefore, given the nature of the Bewley-Huggett-Aiyagari-type heterogeneous-agent incomplete-market general equilibrium models, one could attribute social welfare loss stemming from *endogenous* dispersion over consumption and hours worked to *exogenous* uninsurable idiosyncratic shocks instead. While we are sympathetic with this view, we would like to express that our goal in quantifying welfare losses is not to pin down the causal origin of inequality, but to infer about its subsequent welfare implications.

studied select group of countries. Next, we quantify the welfare cost of inequality in Turkey, and report that in order not to switch to the unequal Turkish economy, a utilitarian benevolent planner of Turkey's counter-factual representative-agent economy would be indifferent between forgoing an indefinite 43.24% of steady-state consumption if labor is supplied inelastically, or 25.16% of steady-state consumption accompanied by an extra 33.61% of steady-state hours worked if labor is supplied elastically.

We believe data limitations stand as the biggest obstacle in the way for a comprehensive investigation of Turkey's economic inequalities. Availability of detailed micro-level administrative data has contributed to the birth of numerous academic studies addressing economic inequalities in several developed and some developing economies.[33] We further believe that availability of micro-level data on personal finances in Turkey will be of invaluable service for a transparent understanding of the nature, evolution, and sources of wealth inequality in Turkey.[34] In the absence of viable data, we hope that this paper sheds at least some light into Turkey's wealth distribution.

Appendix

A Appendix Figures and Tables

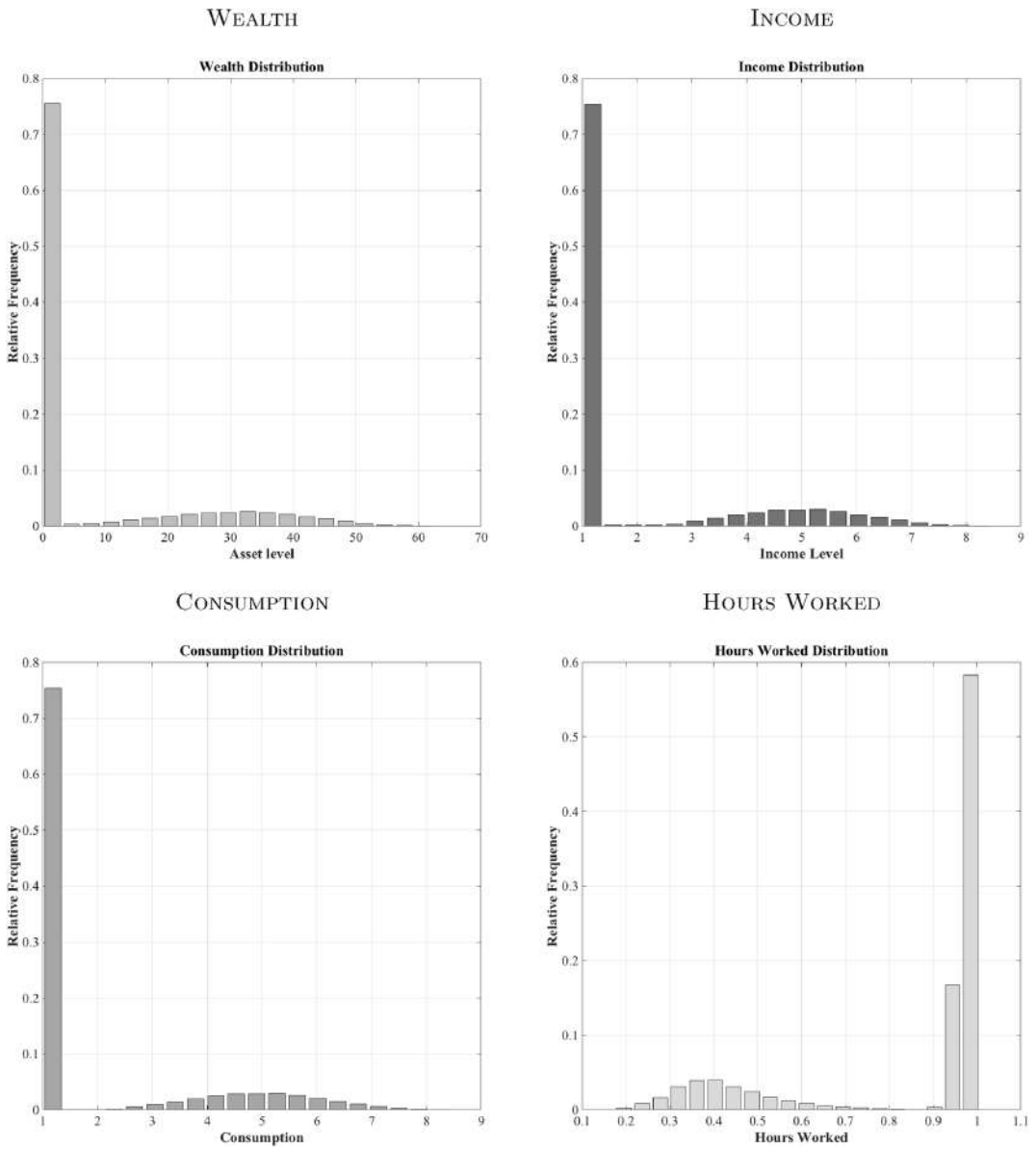

Figure A.1. Histogram for Wealth, Income, Consumption and Hours Worked.
† The four quadrants display the relative frequencies of wealth, income, consumption and hours worked by Monte Carlo simulations, respectively.

[33] See World Wealth & Income Database for a comprehensive wealth data set for a large group of countries.

[34] We particularly believe that *why* and *how* wealth concentration at the top decile in Turkey recently increases while income inequality remains stagnant within the same period of interest is worthy of detailed investigation.

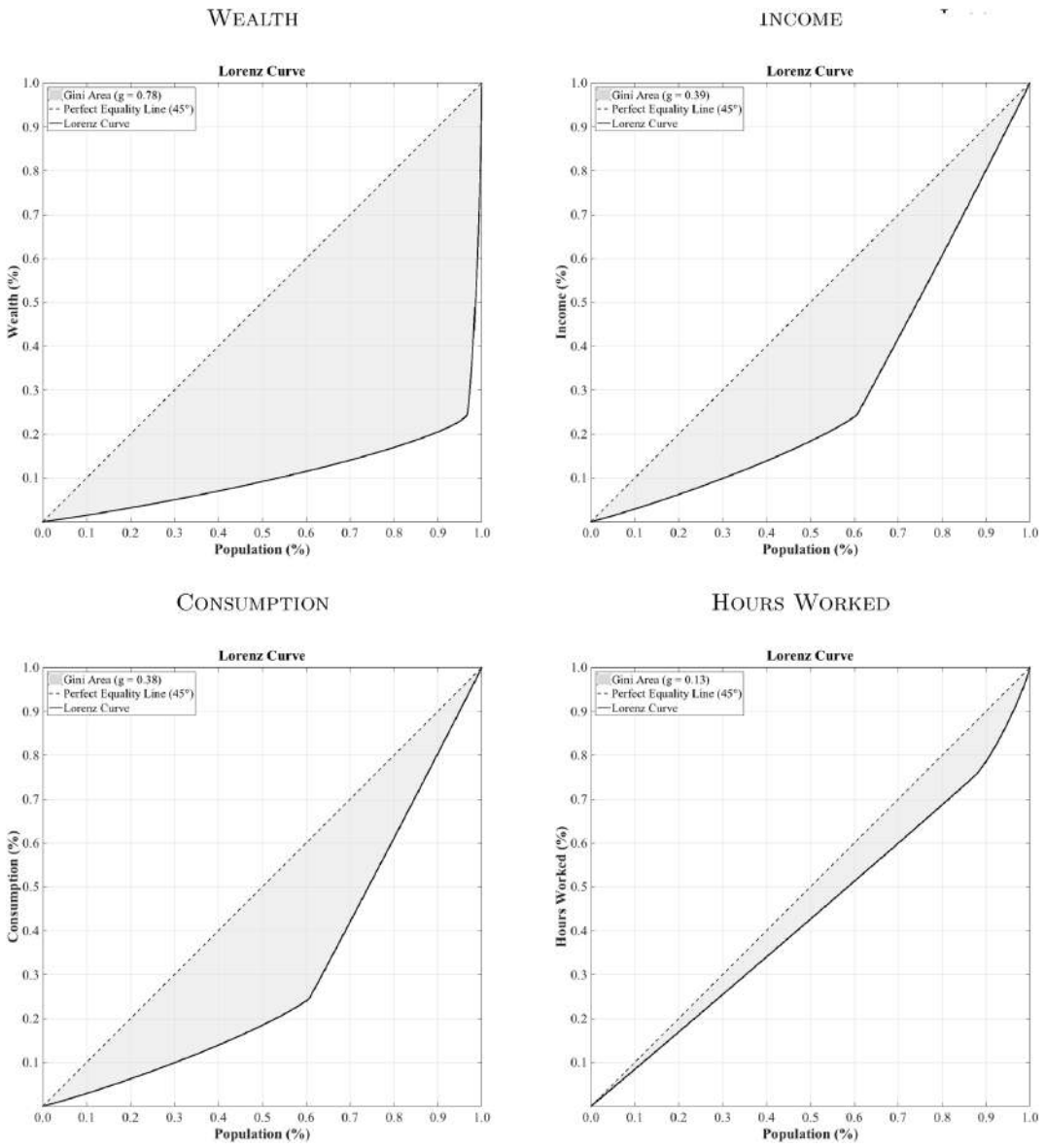

Figure A.2. Lorenz Curve for Wealth, Income, Consumption and Hours Workedn† The four quadrants display the Lorenz curve for wealth, income, consumption and hours worked by Monte Carlo simulations, respectively.

Table A.1
Share of Top Decile in Wealth.

	2000	2007	2014
Russia	77.1	75.4	84.8
Turkey	***66.7***	***70.2***	***77.7***
Hong Kong	65.6	69.3	77.5
Indonesia	71.2	70.2	77.2
Philippines	79.0	69.2	76.0
Thailand	74.4	69.3	75.0
United States	74.6	74.8	74.6
India	65.9	72.3	74.0
Egypt	61.0	65.3	73.3
Brazil	69.4	68.8	73.3
Peru	73.3	73.3	73.3
Switzerland	73.4	72.0	71.9
Argentina	63.1	59.9	71.8
Malaysia	77.0	73.9	71.8
South Africa	72.2	69.0	71.7
Chile	67.6	62.4	68.9
Sweden	69.7	68.6	68.6

Table A.1 (*continued*)

	2000	2007	2014
Denmark	68.9	62.6	67.5
Israel	62.4	64.6	67.3
Czech Republic	62.7	59.3	67.3
Saudi Arabia	73.3	73.4	66.4
Norway	67.0	66.5	65.8
Colombia	69.4	66.4	65.2
Mexico	68.9	63.5	64.4
China	48.6	56.1	64.0
Austria	63.0	63.0	63.8
Korea	53.2	55.2	62.8
Poland	69.9	61.1	62.8
Taiwan	54.3	54.7	62.0
Germany	63.9	61.7	61.7
United Arab Emirates	59.1	60.6	60.4
Singapore	66.0	57.3	59.6
Ireland	58.2	57.8	58.5
Portugal	57.8	56.0	58.3
Canada	61.5	58.0	57.0
New Zealand	62.3	61.2	57.0
Greece	54.8	48.6	56.1
Spain	54.1	52.0	55.6
Netherlands	55.2	53.6	54.8
Finland	55.0	54.5	54.5
United Kingdom	51.5	52.0	54.1
France	56.4	51.1	53.1
Italy	52.6	47.9	51.5
Australia	51.1	50.7	51.1
Japan	51.0	49.4	48.5
Belgium	47.5	47.1	47.2

† Reported numbers are in percentages.
‡ Source: Global Wealth Report, 2014 by Credit Suisse (2014).

Table A.2
Distributional Properties of the Aiyagari Model with Exogenous Labor Supply.

	Wealth	Income	Consumption
Gini Coefficient	0.803	0.500	0.499
Hoover Index	0.736	0.464	0.464
Theil's L GE(0) Index	2.413	0.475	0.474
Theil's T GE(1) Index	1.398	0.515	0.513
Atkinson Index $\varepsilon = 0.50$	0.639	0.226	0.226
Atkinson Index $\varepsilon = 1.00$	0.910	0.378	0.377

Table A.3
Income Inequality Metrics by Country.

	Gini Coefficient	Theil L GE(0) Index	Theil T GE(1) Index	Atkinson Index ($\varepsilon = 0.5$)	Atkinson Index ($\varepsilon = 1.0$)
Austria	0.274	0.142	0.140	0.066	0.132
Belgium	0.257	0.115	0.113	0.055	0.109
Bulgaria	0.353	0.232	0.225	0.106	0.207
Croatia	0.300	0.164	0.148	0.074	0.151
Cyprus	0.347	0.204	0.253	0.106	0.184
Czech Republic	0.249	0.105	0.114	0.053	0.100
Denmark	0.266	0.129	0.145	0.065	0.121
Estonia	0.350	0.217	0.204	0.099	0.195
Finland	0.254	0.109	0.114	0.054	0.104
France	0.288	0.141	0.157	0.071	0.132
Germany	0.294	0.156	0.159	0.074	0.145
Greece	0.342	0.218	0.209	0.100	0.196
Hungary	0.285	0.139	0.145	0.068	0.130
Ireland	0.303	0.163	0.162	0.077	0.150
Italy	0.317	0.194	0.178	0.087	0.177
Latvia	0.351	0.222	0.211	0.101	0.199
Lithuania	0.348	0.212	0.209	0.099	0.191
Luxembourg	0.279	0.132	0.134	0.064	0.124
Malta	0.276	0.126	0.130	0.062	0.118
Netherlands	0.255	0.113	0.119	0.056	0.107
Poland	0.306	0.164	0.162	0.078	0.152
Portugal	0.343	0.215	0.203	0.098	0.194

(*continued on next page*)

Table A.3 (*continued*)

	Gini Coefficient	Theil L GE(0) Index	Theil T GE(1) Index	Atkinson Index ($\varepsilon = 0.5$)	Atkinson Index ($\varepsilon = 1.0$)
Romania	0.342	0.230	0.201	0.100	0.206
Slovakia	0.259	0.125	0.124	0.059	0.117
Slovenia	0.249	0.107	0.104	0.051	0.101
Spain	0.340	0.220	0.193	0.097	0.198
Sweden	0.249	0.118	0.109	0.054	0.112
United Kingdom	0.308	0.164	0.170	0.079	0.151
Turkey (Data)	0.391	0.275	0.305	0.134	0.241
Turkey (Model)	0.386	0.277	0.310	0.139	0.241

† Source: European Commission Social Situation Monitor for European income inequality figures in 2013, Turkish Statistical Institute (TurkStat) for Turkey's income Gini in 2014 and Tamkoç and Torul (2018) for Turkey's inequality indices in 2013 via TurkStat's Household Budget Survey.

Table A.4
Asset Gini Coefficient by Country

	Gini Coefficient of Assets
Spain	0.542
Australia	0.567
United Kingdom	0.571
Italy	0.599
Luxembourg	0.614
France	0.651
Germany	0.725
United States	0.776
Turkey (Model)	0.780

† Source: Cowell et al. (2016).

B Appendix: Computation Algorithm

We calculate the stationary recursive rational expectations equilibrium described in the Equilibrium subsection via policy function iteration and Monte Carlo simulation. In doing so, we first provide an initial guess $r_0 \in [\underline{r}, \bar{r}]$ for the real interest rate, where we set $\bar{r} < \frac{1}{\beta} - 1$ by economic theory.[35] Within this range, for a given interest guess r_0, we calculate the real wage rate implied by optimal decision rules and functional forms i.e. $w_0(r_0) = (1-\alpha)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}}$. For these given prices, we solve for household problem described in (7)–(11). In doing so, we solve for consumption and labor supply decisions jointly, while we take into account whether the borrowing constraint binds or not.[36] Using the resultant consumption, labor supply and asset choice decision rules, we run Monte Carlo simulations for $T = 10^4$ periods with $I = 10^4$ individuals. We calculate resultant equilibrium real interest rate using the last 100 simulation periods with $r_1 = \alpha\left(\frac{K_1}{L_1}\right)^{\alpha-1} - \delta$ where K_1 and L_1 denote the average capital and effective labor supply over the last 100 simulation periods, $K_1 = \frac{1}{100\times I}\sum_{t=T-99}^{T}\sum_{i=1}^{I} a_t^i(r_0)$, $L_1 = \frac{1}{100\times I}\sum_{t=T-99}^{T} I^{-1}\sum_{i=1}^{I} z_t^i h_t^i(r_0)$. If the resultant real interest rate r_1 is not sufficiently close to the given guess r_0, i.e. $|r_1 - r_0| < 10^{-5}$, we update our real interest rate guess and repeat the described steps until convergence is reached. Further details of our computation algorithm can be seen on our MATLAB codes.

[35] We set $\bar{r} = \frac{1}{\beta} - 1 - 10^{-12}$ and $\underline{r} = \frac{1}{\beta} - 1 - 10^{-2}$ while we ensure that neither of the bounds are binding in equilibrium.

[36] Note that when the borrowing constraint binds, under the benchmark parameter setting, the budget constraint $c + a' = (1+r)a + wzh$ and the optimal intratemporal decision, i.e $u'(c) = v'(h)$ or equivalently $h(c,z) = (c^{-3/2}zw)^{2/3}$ jointly imply that $0 = -c + (1+r)a + (c^{-3/2}zw)^{2/3}zw + b$, which suggests consumption can take two values: $c_{1,2} = \frac{[(1+r)a+b] \pm \sqrt{[(1+r)a+b]^2 + 4(zw)^{1+2/3}}}{2}$. We rule out the negative root since it violates the non-negativity constraint of consumption in (11), and set consumption to $c_1(a,z) = \frac{[(1+r)a+b] + \sqrt{[(1+r)a+b]^2 + 4(zw)^{1+2/3}}}{2}$ when the borrowing constraint binds. For asset levels, we use endogenous values via MATLAB's in-built interpolation routines. We use a 5-state labor productivity vector, along with its associated Markov transition probability matrix.

C Appendix: Real Business Cycle Model

In order to compare our findings from the heterogeneous-agent economy with those from its representative-agent equivalent, the plain vanilla real business cycle economy we use can be described briefly as follows:

Households

The representative household maximizes her discounted lifetime utility given the infinite sequence of prices $\{w_t, r_t\}_{t=0}^{t=\infty}$, subject to her dynamic budget constraint. Formally, she solves:

$$\max_{\{c_t, h_t, k_{t+1}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t) - v(h_t) \tag{A.1}$$

subject to

$$c_t + k_{t+1} = w_t z_t h_t + [1 + (r_t - \delta)]k_t \tag{A.2}$$

where $c_t \geq 0$ denotes consumption, $h_t \geq 0$ denotes hours worked, $z_t > 0 \quad z_{t+1}\Pi(z_{t+1}|z_t)$ denotes stochastic labor productivity along with its probability distribution function, $k_t > 0$ denotes physical capital, δ denotes the physical depreciation rate, β denotes the subjective discount factor, and w_t and r_t denote factor prices: real wage, and real interest rate, respectively. Accordingly, optimal intratemporal and intertemporal decision rules of the representative-household requires:

$$v'(h_t) = u'(c_t) z_t w_t \tag{A.3}$$

$$u'(c_t) = \beta \mathbb{E}_t[u'(c_{t+1})(1 + r_{t+1})] \tag{A.4}$$

Firms

The competitive representative neoclassical firm faces a CRTS production technology, and maximizes its profits taking prices, the wage rate and the real interest rate given. Accordingly, the firm solves the following static problem:

$$\max_{\{K_t, L_t\}} F(K_t, L_t) - (r_t + \delta)K_t - w_t L_t \tag{A.5}$$

where K and L denote physical capital and *effective* labor demand by the firm, respectively. Optimal decision by the firm implies that the real interest rate and the wage rate are determined competitively and equal to the marginal product of capital and effective labor,

respectively.

$$r_t = F_K(K_t, L_t) - \delta \tag{A.6}$$

$$w_t = F_L(K_t, L_t) \tag{A.7}$$

where $F_K(K_t, L_t)$ and $F_L(K_t, L_t)$ refer to the partial derivatives of the production function $F(K, L)$ with respect to physical capital K_t and effective labor L_t, respectively.

Steady-State

The deterministic steady-state of this model economy is defined as that the stochastic labor process z_t equals its long-run value $\bar{z}$ and all choice and state variables converge to their long-run values: $c_t = c_{t+1} = \ldots \bar{c}, h_t = h_{t+1} = \ldots \bar{h}, k_t = k_{t+1} = \ldots \bar{k}$, while for given prices, optimality conditions by the representative household (A.3) and (A.4), and by the firm (A.6) and (A.7) hold; and markets clear via factor prices $\bar{r}$ and $\bar{w}$ so that capital and labor demand by the firm equals capital and labor supply by the household. Accordingly, the steady-state of this economy can be characterized by the following equations (A.8)–(A.11):

$$v'\left(\bar{h}\right) = u'(\bar{c})\bar{z}\bar{w} \tag{A.8}$$

$$\begin{aligned} u'(\bar{c}) &= \beta[u'(\bar{c})(1+\bar{r})] \\ \frac{1}{\beta} &= 1 + \bar{r} \end{aligned} \tag{A.9}$$

$$\bar{r} = F_K\left(\bar{K}, \bar{L}\right) - \delta \tag{A.10}$$

$$\bar{w} = F_L\left(\bar{K}, \bar{L}\right) \tag{A.11}$$

As we solve for the deterministic steady-state of the representative-agent economy, we rely on the same functional forms and parameter values as in the heterogeneous-agent economy.

D Appendix: Inequality Measures

The most commonly used inequality measure is the Gini coefficient, which is usually calculated via the Lorenz curve: it is twice the area between the Lorenz curve and the perfect equality line. The Gini coefficient is a measure of relative mean difference, i.e. it is the mean of the difference between every possible pair of individuals I, divided by the mean of the variable of interest, i.e. $\bar{x} = \sum_{i=1}^{I} x_i$.

$$\text{Gini Coefficient} = \frac{\sum_{i=1}^{I}\sum_{j=1}^{I}\left|x_i - x_j\right|}{2I^2\bar{x}} \tag{A.12}$$

Generalized entropy measures are also commonly used to measure economic inequalities due to their desired properties. Generalized entropy measure with a weight of α can be formulated as follows:

$$\text{GE}(\alpha) = \begin{cases} \dfrac{1}{\alpha(\alpha-1)}\left[\dfrac{1}{I}\sum_{i=1}^{I}\left(\dfrac{x_i}{\bar{x}}\right)^{\alpha} - 1\right] & \text{if } \alpha \neq 0, 1 \\ \dfrac{1}{I}\sum_{i=1}^{I}\log\left(\dfrac{x_i}{\bar{x}}\right) & \text{if } \alpha = 0 \text{ (Theil's L Index)} \\ \dfrac{1}{I}\sum_{i=1}^{I}\dfrac{x_i}{\bar{x}}\log\left(\dfrac{x_i}{\bar{x}}\right) & \text{if } \alpha = 1 \text{ (Theil's T Index)} \end{cases} \tag{A.13}$$

In economic inequality literature, the use of GE(0) and GE(1) are particularly popular, which are coined as the Theil's L and Theil's T indices, respectively.[37]

Another common inequality measure in economic inequality literature is the Atkinson index, which quantifies the social welfare gain as a result of complete redistribution. The value of the Atkinson index $A_\varepsilon \in [0, 1]$ is positively governed by an inequality aversion parameter $\varepsilon \in [0, \infty]$.[38] The Atkinson index is formulated as follows[39]:

$$A_\varepsilon = \begin{cases} 1 - \left[\dfrac{1}{I}\sum_{i=1}^{I}\left(\dfrac{x_i}{\bar{x}}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} & \text{if } \varepsilon \neq 1 \\ 1 - \dfrac{\prod_{i=1}^{I} x_i^{\frac{1}{I}}}{\bar{x}} & \text{if } \varepsilon = 1 \end{cases} \tag{A.14}$$

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[37] Note that Theil's L index GE(0) can be interpreted as the mean logarithmic deviation, and the Theil's T index GE(1) as a *weighted* mean logarithmic deviation, where weights are relative distances to the mean.

[38] When inequality aversion parameter equals zero $\varepsilon = 0$, redistribution does not improve social welfare hence the Atkinson index equals zero, whereas when inequality aversion is infinity $\varepsilon = \infty$, gains from redistribution are maximized and the Atkinson index equals unity.

[39] Note that many inequality indices can be transformed into other subclasses. For instance, under a natural logarithmic social welfare function and $\varepsilon = (1-\alpha) \in [0, 1)$, $A_\varepsilon = 1 - e^{-GE(\alpha)}$ holds true.

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