THREE ESSAYS ON ASSET PRICING

BY

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DISSERTATION

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ABSTRACT

This dissertation consists of three chapters, each corresponding to an essay on one topic in asset pricing.

Chapter 1 is titled “How Do Oil Shocks Affect Stock Market Risk” and aims to explain some documented comovements between crude oil market and stock market and the predictability of oil prices on stock returns. Firstly, I illustrate a mechanism for oil shocks to translate into stock market risk under a 2-consumption good CCAPM model framework. Then I use U.S. data and a bivariate EGARCH-DCC model to estimate the dynamic second moments of crude oil price changes and stock returns. I find that oil price changes have significant effects on the second moments of the stock market returns but not the other way around. Furthermore, I find remarkable time-variation in both the empirical conditional volatilities and correlations. Based on these estimations, I construct the time-varying empirical risk premia. A preliminary test is done at the end of this paper to see if the empirical risk premia are able to explain the observed predictability of oil price changes on stock returns. The results point to the need for more sophisticated modeling of the interactions between oil and stock market risk.

In Chapter 2 “Income Inequality and Asset Prices: A Cross-country Study”, I study the asset pricing implication of cross-country differences in income inequality. Using panel regression with year fixed effects, I document a strong negative relationship between cross-country stock market levels (as measured by each market’s P/D ratio) and cross-country income inequality levels after controlling for an extensive set of variables including conventional risk factors, country characteristics and degree of global market segmentation. I argue that this relationship
should be interpreted as the negative impact of income inequality on market price. This effect is both statistically and economically significant: On average, one unit increment in inequality (a 0.01 increment in income Gini, which ranges between 0 and 1) is shown to decrease the market P/D ratio by up to 2%. The inverse relationship between income inequality and price is stronger in developed countries than in developing countries. It is robust to alternative measures of stock market levels and income inequality. By decomposing price into expected excess returns and risk-free rates, I empirically identify the main channel through which inequality influences price: The inverse relationship observed between inequality and P/D ratio can almost be completely attributed to strong positive link between income inequality and interest rates; while I find no supporting evidence that cross-country excess returns are correlated with income disparities. These findings have important implications both for asset pricing modeling and for policy making.

Chapter 3, titled “Income Heterogeneity, Inequality and Interest Rates” is an extended work of Chapter 2. It aims to explain the significant positive correlation between the cross-country differences in inequality and the cross-country differences in real interest rates documented in Chapter 2. In a discrete-time asset pricing model with heterogeneity, untradable income risks and CARA utility function, equilibrium interest rate, gross saving rate and consumption inequality are derived in closed-form solutions. It is shown analytically that both consumption inequality and the real interest rate are positively related to income heterogeneity (defined as the dispersion in idiosyncratic income risks in terms of their correlations to the aggregate risk). It is also shown that gross saving rate and the ratio of average consumption risk to average income risk can be used to proxy for income heterogeneity. Empirical tests confirm that saving rate helps reducing the positive role of income inequality in explaining cross-country variations in interest rates.
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1.1 Introduction

In his 1983 paper, Hamilton points out that fluctuations in crude oil prices are a great contributor to many of the U.S. recessions after World War II. Since then numerous efforts have been devoted to the study of impacts of oil shocks on U.S. economy. The conventional wisdom holds that oil price is an important driving force of the stock market. And some recent works find that positive crude oil price changes predict lower aggregate stock market returns. In order to explain the comovements between the two markets and to explain the observed predictability, it is important to understand how oil price changes affect stock returns. It is therefore necessary to take a closer look at the dynamic volatilities of the two series as well as the correlation between them in empirical study. It is also essential incorporate the oil-induced returns volatility as part of the market risk in theoretical modeling.

In this paper, I examine how oil price shocks affect stock market risk. Firstly, I use a two-consumption good CCAPM model to illustrate a mechanism through which oil shocks are transmitted to stock market risk. Traditionally, fluctuations in oil prices are considered to affect the economy mainly through their impact on costs of production. However, Kilian(2008) show that the transmission of oil shocks to the U.S. stock market “is driven not by domestic cost or productivity shocks, but by shifts in the final demand for goods and services.” In my model, a representative agent consumes two goods: oil and non-oil “numeraire” good. In such an economy, the representative agent not only cares about the aggregate consumption bundle, but also the relative consumption/expenditure of oil to the other good. Therefore, in addition to the
“consumption risk” factor as in the single CCAPM model, an extra “composite risk” factor emerges in this two-consumption good setup. For example, if oil and the non-oil (numeraire) good are complements (which is the more realistic case than where they are substitutes), higher consumption of oil (when oil price is low) means the agent needs more of the numeraire consumption good. Thus the marginal utility of numeraire consumption goes up with oil consumption. In other words, the “composite risk” indicated by marginal utility of numeraire consumption increases when oil price declines. Thus if returns of an asset covary negatively (positively) with oil price when the price is high, the asset is a good (bad) hedge against the composite risk and investors request low (high) risk premium. In reality, the contemporaneous correlation between stock market returns and the oil price is usually negative following a large increase in crude oil price. So by linking the oil risk to the stock market risk, the mechanism described in the two-consumption good model sheds light on a risk-based explanation for the observation that positive oil price shocks drive lower stock market returns.

In the paper, a maintained assumption is that only oil price changes caused by exogenous supply shocks have substantial impacts on the economy and the stock market. This is verified by my empirical evidence: Following Sørensen(2009), exogenous supply shocks are identified by important oil events such as turmoil in the Middle East or large OPEC quota changes. I show that almost all of the pronounced variations in the empirical risk premia coincide with these events. To do so, I first use a bivariate EGARCH-dynamic conditional correlation (DCC) model to estimate the conditional volatility of stock returns and oil price changes, and the covariances between them. I find that oil shocks do have significant effects on the second moments of stock market returns, which corroborates the model. Furthermore, there is clear evidence that the empirical second moments of stock returns and the empirical risk premia are time-varying. I then
isolate the exogenous supply shocks by above mentioned method. It can be seen that most of the biggest troughs and spikes in fitted empirical risk premia indeed occur on those oil event dates.

My paper contributes to the literature by firstly proposing a simple mechanism that links crude oil market shocks to stock market risks. It also establishes such cross-market linkage empirically, thus providing propelling evidence supporting a risk-based explanation for the comovements and correlations between markets. This theory has the potential to explain some documented returns predictability of oil shocks on stocks and can be easily extended to study other cross-market linkages (e.g. between other commodities and stock market).

The rest of this chapter is organized as follows. Section 1.2 discusses related literature. Section 1.3 presents the model and derives the pricing kernel as well as an explicit formula for the risk premia. Section 1.4 describes my empirical method, the data and fitted empirical risk premia. It also performs robustness checks and the preliminary predictive regression. Finally, Section 1.5 concludes.

1.2 Related Literature

My paper is motivated by recent studies on relationship between oil price and stock market. For example, Jones and Kaul(1996) report negative relationship between oil price changes and aggregate stock returns. Pollet(2005) finds the predictable components of oil price changes are able to predict stock returns. Kilian and Park(2009) show that oil shocks account for 22% of the long-run variation in US real stock returns. They decompose oil price changes into three categories: oil price changes caused by shocks to oil production, by shocks to the aggregate global demand for commodity, and oil-specific demand shocks like precautionary demand shocks. They conclude that the conventionally documented negative (contemporaneous) relation
between oil price changes & stock returns are mainly due to oil-specific demand shocks. Driesprong et al.(2008) and Sørensen(2009) document changes in oil prices predict stock market returns. Although most of these papers find empirical evidence of the correlation between crude oil price and stock market, little has been done to further analyze the causes of their comovements. To my knowledge, my paper is one of the first to study the mechanism behind. I contribute to the literature by theoretically linking oil shocks to stock market risk as well as presenting empirical evidence of time-varying risk premia that are related to oil shocks.

My work is also related to the studies on stock returns predictability. Among them, Fama and French(1989) argue that default spread and term spread can predict aggregate market returns since they contain information about future business conditions. Campbell and Shiller(1988) and Fama and French(1988) show price-dividend ratio can predict returns. Financial ratios like earnings ratio (Lamont(1998)) are also shown to predict stock returns. Ang and Bekaert(2007) find that real interest rates predict returns to some extent. These predictive factors are not in conflict with EMH since they can be considered to capture time-varying risk. However some researchers argue that certain returns predictors can only be attributed to underreaction or overreaction to information. For example, Hong et al.(2007) find that returns of some industries, including petroleum industry, forecast stock market returns by up to two months. They interpret the finding as evidence of “gradual diffusion” of information among investors. In contrast to Hong et al.(2007)’s interpretation, my work is more in line with the literature that build on time-varying risk and rational stories.

Finally, my paper is closely related to a line of papers on consumption-based CAPM models. Traditional CCAPM literatures assume a single consumption good (single Lucas tree). The representative agent is only concerned about the “consumption risk”, measured by the
conditional covariance of consumption growth with stock market returns. When a second consumption good (second Lucas tree) is considered, an extra risk factor is introduced: representative agent is not only concerned about the “consumption risk”, but also the “composite risk” as measured by the conditional covariance of relative consumption or expenditure of two goods with the stock market returns. The introduction of “composite risk” makes the pricing kernel and risk premium more volatile. Thus it helps provide possible solutions to some asset pricing puzzles. One case in point is Yogo(2006). Assuming a high risk aversion coefficient, Yogo uses a durable/ non-durable two-good model to explain the value premium and size premium as well as counter-cyclicality of risk premia. Another example is Piazzesi et al.(2007). The authors show that a housing/ non-housing model can partly solve the equity premium puzzle. In addition, they find that the share of housing expenditure in all consumptions can be used to forecast excess returns. In both Yogo and Piazzesi et al’s papers, they need the two good to be substitutes to produce desired results. My paper is similar to theirs in set-up of the model. But in my model, oil and non-oil consumptions are found to be complements rather than substitutes. Thus the mechanism of how the “composite risk” works is different from theirs.

1.3 Model

1.3.1 Setup

Consider an economy with large numbers of identical agents who have preference over two consumption goods: Oil \((o_t)\) and Non-oil consumption \((c_t)\). While it may be more realistic to think of oil as an intermediate good that can be both used for consumption and production, I leave it for future study. Here I only view oil as a final good for consumption. This abstraction
from more complicated structure helps us easily isolates the effects of oil price change on the consumption of the other goods. It also helps to solve some measurement issues in my empirical work.

A representative agent maximizes her lifetime utility:

$$E[t \sum_{t=0}^{\infty} \beta^t u(c_t, o_t)]$$

(1)

Where the per-period utility function is:

$$u(c_t, o_t) = \frac{c_t^{(e-1)/e} + \omega o_t^{(e-1)/e} + \gamma_l^{1-1/\sigma}}{1-1/\sigma}$$

(2)

Parameter $e$ is the intratemporal elasticity of substitution between oil and non-oil consumption. The larger the $e$, the more substitutable are the two goods and the smaller the $e$, the more complemental are the two goods. If $e=1$, then the utility function collapses to the Cobb-Douglas utility function. Parameter $\sigma$ is the intertemporal elasticity of substitution that dictates the substitutability between aggregate consumption bundles of different periods.

As long as $e$ is not equal to $\sigma$, the utility is inseparable. Mechanically, this implies an extra term in the pricing kernel that possibly makes it more volatile and helps raising risk premium. Intuitively, if $e$ is equal to $\sigma$, then people are equally willing to substitute across goods and across time. There is then no essential difference between this two-good model and the standard model where people only care about cross-time tradeoffs. Only if $e$ is not equal to $\sigma$, the “composite risk” is isolated from usual “consumption risk” and is priced additionally.
1.3.2 Pricing Kernel and Risk Premia

In the multi-good case, the pricing kernel can be derived in terms of marginal utility of either good. Here I choose non-oil consumption good as the numeraire. This way I can easily compare the result to that of a standard model and identify the unique composite risk term.

The pricing kernel is the present value of an extra unit of future numeraire (non-oil) consumption:

\[
M_{t+1} = \beta \left( \frac{c_{t+1}}{c_t} \right)^{-1} \left( 1 + \omega \frac{o_{t+1}}{c_{t+1}} \right)^{\frac{(\epsilon-1)}{\epsilon}}
\]

And the Euler equation is:

\[
E_t[M_{t+1} R_{t+1}] = 1
\]

The first part of the pricing kernel in equation (3) is what we see in standard single-good CCAPM. It reflects the agent’s concern about the “(numeraire) consumption risk”: If returns of an asset covary positively with the numeraire consumption, then it is not an effective hedge and investors need to be rewarded with higher expected returns for bearing the risk. If \( \epsilon \neq \sigma \), then the utility is inseparable and “composite risk” enters the pricing kernel as the second term. Consider the case of \( \epsilon < \sigma \) and \( \epsilon < 1 \), i.e. oil and the non-oil consumption are complements. Higher consumption of oil (when oil price is low) means the non-oil consumption good is more desirable. Thus the marginal utility goes up. This means when oil price declines the “composite risk” is higher. When price is high, if returns of an asset covary negatively with oil price, the asset is then an effective hedge against the composite risk and the risk premium has negative or
smaller positive value. This mechanism links the oil price shocks to stock market risk and paves the way for a possible risk-based explanation for the predictability of oil shocks.

The pricing kernel in equation (3) is expressed in relative quantity of the two goods. It is difficult to measure the actual quantity of consumption in oil and non-oil goods. On the other hand, the expenditure data of oil and non-oil consumption are more easily available and more reliable. Therefore, I define a new variable, oil/non-oil expenditure ratio, and write the pricing kernel in terms of this new variable. In the following part of this paper, the expenditure ratio will be used as the key state variable.

The expenditure ratio of oil to non-oil consumption $z$ is defined as:

$$ z_t = \frac{p_t^o o_t}{p_t^e c_t} \quad (5) $$

From the static FOC, I have:

$$ \frac{p_t^e}{p_t^o} = \omega^{-1} \left( \frac{C_t}{o_t} \right)^{1-\varepsilon} \quad (6) $$

Substituting into the expenditure ratio:

$$ z_t = \frac{p_t^o o_t}{p_t^e c_t} = \omega^{\varepsilon} \left( \frac{p_t^o}{p_t^e} \right)^{1-\varepsilon} = \omega \left( \frac{o_t}{C_t} \right)^{1-(1/\varepsilon)} \quad (7) $$

From (7) we can see that if $\varepsilon$ is smaller than 1, the relative expenditure of oil goes up with oil price. Intuitively, it is natural to view oil and non-oil consumptions as complements more than substitutes – “You can’t drink gasoline” after all. So people cannot substitute out of the oil consumption too much when oil price rises. Therefore, the drop in oil consumption is not enough
to offset the increase in oil price and expenditure of oil goes in the same direction as price.

The pricing kernel can now be written as:

\[
M_{t+1} = \beta \left( \frac{c_{t+1}}{c_t} \right)^{-\sigma} \left( \frac{1 + z_{t+1}}{1 + z_t} \right)^{\sigma - \epsilon)} \]

Equation (8) is a more concise expression of the pricing kernel. The familiar CCAPM “consumption risk” factor is the first term, (numeraire) consumption growth. The second term is the “composite risk” factor, changes in expenditure ratio. It implies when oil and non-oil are complements (\(\epsilon < \sigma\) and \(\epsilon < 1\)), assets that covary negatively with \(z\) (when oil price is high) have negative (or smaller positive) risk premium.

To see this more clearly, I derive the explicit form of the empirical risk premium:

\[
RP = \frac{1}{\sigma} \text{cov}_t(\Delta \ln c_{t+1}, r_{t+1}) - \frac{\sigma - \epsilon}{\sigma (\epsilon - 1)} \text{cov}_t(\Delta \ln (1 + z_{t+1}), r_{t+1})
\]

Where \(c\) is the non-oil (numeraire) consumption; \(z\) is the expenditure ratio of oil consumption on non-oil consumption; \(r\) is stock market returns.

Following Piazzesi(2007), I use a linearization approximation and write risk premium as:

\[
RP = \frac{1}{\sigma} \text{cov}_t(\Delta \ln c_{t+1}, r_{t+1}) - \frac{\sigma - \epsilon}{\sigma (\epsilon - 1)} \frac{z_t}{1 + z_t} \text{cov}_t(\Delta \ln z_{t+1}, r_{t+1})
\]

From (9) and (10), the risk premium consists of two terms: The first is conditional covariance between numeraire consumption growth and stock market returns. In my model, the numeraire consumption is non-oil consumption, different from (aggregate) consumption of the standard single-good CCAPM. There is no reason to expect that it behaves much different from the NIPA
aggregate consumption. On the other hand, oil prices experience sharp and sustained increase from time to time, resulting in big shifts in expenditure ratio change. Thus I expect the second term of the risk premium to be much more volatile than the first term. To see this, I plot the realized covariance of non-oil consumption with CRSP value-weighted market returns against the covariance of real WTI crude oil price with CRSP returns. Figure 1.1 shows that the former is much smoother than the latter.

So the conditional covariance of expenditure ratio with stock market returns is the key to time-varying risk premium and the key to understanding of the predictability of oil. In what follows, I model the conditional covariance and risk premium empirically and examine the properties of the estimated results.

1.4 Empirical Risk Premium

In this section, a first step is to empirically model the dynamics of covariance between stock market returns & oil/non-oil expenditure ratio. Then I construct empirical risk premia to see if it helps account for the predictability reported in previous literature. Since I expect the second moments to be time-varying, OLS is not appropriate for my estimation. Instead, I use a bivariate EGARCH-DCC type of model to fit the conditional volatility and conditional correlations.

1.4.1 Data

My stock market data are CRSP value-weighted market returns, daily from 1957 to 2008 and monthly from 1925 to 2008.

For the price of crude oil, I follow literatures and use West Texas Intermediate (WTI) crude oil prices from Global Financial Data (GFD). GFD has daily WTI price from 1983 and monthly and
quarterly price data from 1859. Since it is not possible to measure the “non-crude oil” consumption price, I choose the monthly “CPI_all items less energy” (CPI_nonenergy) data from Bureau of Labor Statistics (BLS) instead. To match my use of oil and non-oil price data, I also download corresponding monthly “CPI_energy” and “CPI_energy commodity” series from BLS. All three data series start from 1957.

Accordingly, the main oil expenditure series used in my empirical study is quarterly expenditure of “Gasoline, fuel oil, and other energy goods”, a subcategory in “Non-durable goods” of NIPA Table 2.3.5 (Personal Consumption Expenditure by Major Type of Product). In this series, “other energy goods” mainly refer to coal. Energy Information Administration (EIA) website shows that as of 2005, the total U.S. expenditure on coal is only about 6% of the expenditure on petroleum products. The non-oil expenditure data is the “Non-durable goods” plus “Services” expenditure minus “Gasoline, fuel oil and other energy goods (coal)”. To allow for different measures of oil/energy expenditure, I also download “Energy goods and services” data from NIPA Table 2.3.5. This series includes not only the non-durable consumption expenditures on oil products & coal, but also expenditures on electricity and gas services. The expenditure data are all quarterly data starting from 1947.

I find that the “CPI_energy commodity” price series best corresponds to the expenditure series “Gasoline, fuel oil, and other energy goods” as well as my definition of “oil” consumption. So they are used as benchmark data series of my empirical studies. The price series “CPI_energy” are best matched by expenditure series “Energy goods and services”. Later I use these two series to examine whether my empirical results are robust to different measures and specifications. It turns out that difference in data series has little effect on my estimations.

The use of energy/non-energy data to “proxy” for crude oil/non-oil data can be well justified.
The correlation of the WTI crude oil price series with “CPI_energy commodity” is as high as 0.96 and correlation with “CPI_energy” is 0.91. This is not surprising since oil is by far the most important energy commodity. Energy commodities account for a total of about 75% in the Goldman Sachs Commodity Index, while oil alone accounts for 55% of the index. As is pointed out by Kilian(2008), oil has such a dominating role in energy sector that the fluctuations in U.S. energy expenditure since 1980’s “reflect primarily changes in the crude oil prices rather than shift in energy use.”

The real problem with the downloaded data is the low data frequency: I only have quarterly expenditure data and monthly CPI data. While to estimate the dynamic conditional moments in an EGARCH-DCC system, I need daily data to ensure as many data points as possible.

To solve this problem, I resort to the static FOC of the two-good model:

\[
z_t = \frac{p_t^o o_t}{p_t^e c_t} = \omega^e \left( \frac{p_t^o}{p_t^e} \right)^{1-e} \quad (7*)
\]

Taking log of both sides, I have:

\[
\ln z(t) = \varepsilon \cdot \ln \omega + (1 - \varepsilon) \ln \left( \frac{p_o(t)}{p_e(t)} \right) \quad (11)
\]

I estimate the intratemporal elasticity of substitution\(\varepsilon\) and the constant term from equation (11) using quarterly NIPA expenditure data and CPI data. Then proxies for daily CPI series are created by regressing “CPI_energy commodity” on WTI crude oil prices. Finally, I use the above estimated parameters and the fitted daily price ratio series to construct daily expenditure ratios following equation (7*).

Figure 1.2 shows that the expenditure ratio covaries positively with the price ratio, which
suggests a small $\varepsilon$ value. Indeed, the estimated value of $\varepsilon$ is 0.15, consistent with the conventional wisdom that oil and non-oil consumptions are complements. The accuracy of this estimation relies on the exogeneity assumption though. One may question that the estimated $\varepsilon$ value is too small due to identification problem. However, this should not be a big concern as the exact value of $\varepsilon$ is not essential. It is quite far-fetched to claim oil and non-oil consumptions are substitutes, and $\varepsilon$ value far below 1 should be quite reasonable.

1.4.2 Empirical Method

I use daily CPI ratio and expenditure ratio data series described in previous section to estimate the conditional moments of stock returns ($r_j$) and changes in expenditure ratio ($d\ln z$, denoted by $r_z$). To do so, I employ a bivariate EGARCH-DCC type of model and maximum likelihood estimators (MLE). The model is an equation system of the following form:

The conditional mean equations are:

$$r_j(t) = \mu_j + \sqrt{\text{exp}(h_j(t))} \cdot \xi_j(t), \text{ where } h_j \text{ is the log of conditional variance of } r_j$$
$$r_z(t) = \mu_z + \sqrt{\text{exp}(h_z(t))} \cdot \xi_z(t), \text{ where } h_z \text{ is the log of conditional variance of } r_z$$

$$(\xi_j(t) \quad \xi_z(t)) \sim N(0, R(t)), \text{ where } R(t) = \begin{pmatrix} 1 & \rho(t) \\ \rho(t) & 1 \end{pmatrix}$$

The conditional variance equations (EGARCH) are:

$$h_j(t) = a_j + b_j \cdot h_j(t-1) + c_j \cdot |r_j(t-1)| + d_j \cdot r_j(t-1) + e_j \cdot \ln |r_j(t-1)| + f_j \cdot r_z(t-1)$$
$$h_z(t) = a_z + b_z \cdot h_z(t-1) + c_z \cdot |r_z(t-1)| + d_z \cdot r_z(t-1) + e_z \cdot \ln |r_z(t-1)| + f_z \cdot r_z(t-1)$$

The conditional correlation equation (DCC) is:
\[ p(t) = a_p + b_p \cdot p(t-1) + c_p \cdot r_s(t-1) + d_p \cdot r_r(t-1) + e_p \cdot r_r(t-1) \cdot r_s(t-1) \]

where \( p(t) = a \tanh(\rho(t)) \), and \( \rho(t) \) is the correlation between \( r_s \) & \( r_r \)

The variance equations capture the asymmetric relation between returns and the volatility changes. In particular, coefficients \( c \) & \( e \) in EGARCH equation represent the magnitude effect: if \( d \) & \( f=0 \), \( c>0 \) & \( e>0 \), then increase in returns also raises the volatility. Coefficients \( d \) & \( f \) represent the sign effect: if \( c \) & \( e=0 \), \( d<0 \) & \( f<0 \), then volatility decrease as returns go up.

The correlation equation captures the idea that the conditional correlation can be quite volatile and even switch sign depending on realized \( r_s \) and \( r_r \). The monotonic transformation from \( p \) to \( \rho \) ensures that value of \( \rho \) (correlation) is between -1 and 1.

### 1.4.3 Estimation Results

I have a total of 19 unknown parameters in the above equation system to estimate. They are estimated by MLE.

The estimated conditional variance equations are:

\[
\begin{align*}
    h_s(t) &= -0.90 + 0.92 h_s(t-1) + 13.21 |r_s(t-1)| - 10.63 r_s(t-1) + 1.35 |r_r(t-1)| + 1.69 r_r(t-1) \\
    h_r(t) &= -0.58 + 0.95 h_r(t-1) + 11.36 |r_r(t-1)| + 1.65 r_r(t-1) + 0.61 r_s(t-1) + 1.09 r_s(t-1)
\end{align*}
\]

And the estimated conditional correlation equation is:

\[
p(t) = -0.0008 + 0.93 p(t-1) + 0.57 r_s(t-1) - 0.64 r_r(t-1) + 124.84 r_r(t-1) \cdot r_s(t-1)
\]

To evaluate the significance of estimated parameters, I perform likelihood ratio (LR) tests. LR test reject the hypothesis that coefficients on \( r_s \) terms in \( h_s \) equation are zeroes. This suggests that oil shocks do have significant impact on the volatility of stock returns: increase in oil/non-oil
expenditure ratio caused by sharp upswing in oil price implies higher future returns volatility. On the other hand, LR test failed to reject the hypothesis that coefficients on \( r_s \) terms in \( h_t \) equation are zeroes, implying that fluctuations in stock returns do not lead to more volatile oil movements. Finally, my LR test on the correlation equation strongly rejects the hypothesis that coefficient on either \( r_z \) or the cross product term is zero. So changes in oil/non-oil expenditure ratio also have significant effects on the correlation. Overall, my estimation and the LR results provide strong evidence that oil shocks can be translated into stock market risk.

We can see from equation (10) that conditional covariance between changes in oil/non-oil expenditure ratio and the stock market returns is the key component in the empirical risk premia. Figure 1.3 plots the fitted empirical conditional covariance. To identify oil price changes caused by exogenous supply shocks, I follow Sørensen(2009) and mark a series of important oil events:

At the end of 1985 and in early 1986, the OPEC collapsed when Saudi Arabia abandoned its long-time swing producer role and increased production from 2 million barrels per day (MMBPD) to 5MMBPD. As a result, the crude oil price plummeted by mid 1986. The Iraqi invasion of Kuwait in August 1990 and the ensuing Gulf War resulted in first a spike then a sharp fall in crude oil price. From April 2000 to November 2000, OPEC carried out four successive huge quota increases to stem the surging oil price. After the last quota increase on Nov. 1, 2000, the price eventually took a large downward turn. After the terrorist attack in September 2001, the already gradually declining oil price plummeted again. In response, OPEC and several non-OPEC oil producers including Russia jointly cut their production in January 2002. Their effort successfully brought the oil price back up. In March 2003, the breakout of the Iraq War induced another big spike in crude oil price. A plot of monthly WTI crude oil prices since 1973 with
marked event dates is presented in Appendix.

Figure 1.3 demonstrates remarkable time-variation in fitted daily conditional covariance between expenditure ratio and stock returns. When annualized, the covariance has a magnitude of 1e-2, which is reasonable. More interestingly, most of the biggest variations in the covariance coincide with the important exogenous oil events above, providing strong supporting evidence for my assumption that predictability mainly arises from oil price changes caused by exogenous supply shocks.

How “reliable” are the estimates? To answer, I bin the daily (differenced) expenditure ratios & CRSP market returns data from 1983-2008 into months and compute the realized volatility & correlation within each month. Then I plot them against the fitted values from the model for comparison.

As is shown in Figure 1.4a & 4b, the fitted volatilities do a good job “replicating” realized volatilities. Both volatility series show remarkable time-variation and the patterns of the variation match the realized volatilities well. From Figure 1.4c, the fitted correlation series seems to have correct direction of movements most of the time. But the magnitude of the variation can hardly match that of the realized correlation with only a few exceptions. In terms of picking up big oil price variations, the fitted correlation series seem to do a better job for sharp oil price increases (such as in 1990, during the first Gulf War and in 2003, during the Iraq War) than for large drops in the oil prices. This may imply a need for a more sophisticated model for conditional correlation. Bottom line is: my empirical evidence does show strong link between oil shocks and time-varying conditional covariance and time-varying risk premia. The empirical results and the theory in Section 1.3 suggest a plausible risk-based explanation for the predictability of oil.
1.4.4 Robustness

In this section, I examine if my empirical results are robust to different specifications of model and different measures of expenditure on oil consumption. Both test results are positive, confirming my previous finding of time-varying risk premia.

Lee et al. (1995) argue that “an oil shock is likely to have greater impact in an environment where oil price movement has been stable than ... where oil price movement has been frequent and erratic”. Following this logic, I scale the oil shock by its conditional volatility and estimate a “normalized” bivariate EGARCH-DCC model: I replace \( r_s \) and \( r_z \) by the standardized residual \( \xi_s \) and \( \xi_z \) respectively and estimate the following conditional variance and correlation equations:

\[
\begin{align*}
    h_s(t) &= a_s + b_s \cdot h_s(t-1) + c_s \cdot |\xi_s(t-1)| + d_s \cdot \xi_s(t-1) + e_s \cdot |\xi_s(t-1)| + f_s \cdot \xi_s(t-1) \\
    h_z(t) &= a_z + b_z \cdot h_z(t-1) + c_z \cdot |\xi_z(t-1)| + d_z \cdot \xi_z(t-1) + e_z \cdot |\xi_z(t-1)| + f_z \cdot \xi_z(t-1) \\
    p(t) &= a_p + b_p \cdot p(t-1) + c_p \cdot \xi_s(t-1) + d_p \cdot \xi_z(t-1) + e_p \cdot \xi_s(t-1) \cdot \xi_z(t-1)
\end{align*}
\]

By doing so, I scale up the shocks in a relatively stable period and scale down the shocks in a volatile period.

The fitted conditional volatilities from this normalized model are close to the benchmark (un-normalized) model in section 1.4.3, while the correlation series (Figure 1.5) actually matches the magnitude of realized correlation better than benchmark. As a result, the fitted covariance series (Figure 1.6) is more volatile although the major pattern of variation is similar to benchmark results. I still see clear time variations, especially during the times of important exogenous oil events such as wars in the Middle East and OPEC quota increases/decreases.
The second robustness check is to examine whether different expenditure/price data series change my empirical findings.

In the benchmark case, I build the daily price series based on “CPI_energy commodity” and the daily expenditure series based on NIPA “Gasoline, fuel oil, and other energy goods”. As is mentioned in section 1.3.1, a second choice of price/expenditure combination is to use “CPI_energy” and NIPA “Energy goods and services”. In addition to household spending on oil products and coals, NIPA “Energy goods and services” also include expenditure on natural gas and electricity services. A third choice of price/expenditure data is the original daily WTI crude oil prices and NIPA “Gasoline, fuel oil, and other energy goods”.

I estimated un-normalized and normalized models for both alternative price/expenditure combinations. Figure 1.7a compares the three fitted conditional covariance series from the un-normalized model and Figure 1.7b compares the fitted covariances from the normalized model. The estimations deliver results that are qualitatively and quantitatively similar to the original ones. Again, this is not really surprising considering the overwhelming share of oil in the entire energy sector.

In all, my robustness checks consolidate the empirical evidence found in section 1.4.3: Changes in oil/non-oil expenditure ratios, especially those caused by exogenous supply shocks to oil prices, have significant effects on the volatilities of stock market returns as well as its correlations with stock returns. Both the fitted conditional volatilities and conditional covariances exhibit remarkable time-variation.
1.4.5 Predictability of Oil Shocks

Driesprong et al. (2008) report that positive oil price changes predict lower stock market returns. The predictability is both statistically and economically significant. They claim it is an anomaly that can only be interpreted as investors’ underreaction to information. According to them, the underreaction occurs when investors have difficulty assessing impact of the oil price changes on value of stocks or investors react to information at different points of time. If so, the predictability should weaken in industries that oil prices are likely to have first-order impact on.

This is contradicted by Sørensen (2009), where the author finds evidence that the ICB Automobile sector is strongly forecasted in all markets where data are available. Moreover, Driesprong et al.’s rejection of time-varying risk premia explanation is only based on the interpretation of oil price shock as a supply shock to the cost of production. As we have seen in the introduction, this is challenged by researchers such as Kilian (2008, 2009) and Hamilton (2005) who argue that oil shocks mainly affect the economy through shifts in demand for final products.

My empirical findings, combined with the two-good model, suggest another plausible explanation for the reported predictability: it may be a mere reflection of people’s concern about the time-varying composite risk, namely, the risk that arises due to the impact of volatile oil prices on their consumption pattern. In other words, I observe the predictability from oil price changes because the risk premia share similar variation pattern with them. Therefore, if my estimates of the empirical risk premia are “accurate” enough, they may help account for the predictability of lagged oil price changes. To see if this is the case, I try the following predictive regression using monthly data:

\[ r_s(t) = \alpha + \beta \cdot r_o(t-1) + \gamma \cdot RP_{t-1}(t) + \varepsilon \]
Where $r_s$ is the CRSP value-weighted market returns; $r_o$ is change in WTI crude oil price; and RP is the risk premium:

$$RP_{t-1}(t) = \frac{1}{\sigma} \text{cov}_{t-1}(\Delta \ln c(t), r_s(t)) - \frac{\sigma - \varepsilon}{\sigma (\varepsilon - 1) (1 + z(t-1))} \text{cov}_{t-1}(\Delta \ln z(t), r_s(t))$$

We have shown in section 1.3 that the first term has little variation compared to the second term. It is also difficult to estimate the dynamic covariance between stock and non-oil consumption since I only have quarterly NIPA consumption data. However, the covariance can be written as the products of stock returns volatility $\sigma_s$, consumption growth volatility $\sigma_c$, and correlation between stock and consumption growth $\rho_{sc}$. Since I have estimates of $\sigma_s$, I add it to the regression.

To obtain monthly expected conditional covariances and volatilities, I do 10000 simulations to compute the average. In each simulation, I start from the last day of the current month and iterate forward using estimated equations to compute the next day value till the end of next month. Then the forecasted daily values in each month are summed up to get monthly values.

The final predictive regression is:

$$r_s(t) = \alpha + \beta \cdot r_o(t-1) + \gamma \cdot \sigma_s(t-1) + \delta \cdot \left( \frac{z(t-1)}{1 + z(t-1)} \text{cov}_{t-1}(\Delta \ln z(t), r_s(t)) \right) + \varepsilon$$

If the fitted $\text{cov}_{t-1}(\Delta \ln z(t), r_s(t))$ is “good” enough and the risk-based story holds, then I expect to see a significantly negative $\delta$ and $\beta = 0$.

My initial result shows that $\delta$ is significantly negative as expected. However, the coefficient on lagged oil price change, $\beta$, is also significantly negative. Thus, my current estimated risk premia
are not able to explain the observed predictability.

There are several ways to interpret this result. One possibility is that the predictability is truly an anomaly and cannot be explained by time-varying risk premia. A second possibility is that I need more sophisticated theoretical or empirical models for the interaction between oil shocks and stock market returns. Finally it is quite plausible that measurement errors result in inaccuracy of estimations and unfavorable regression results. Given the empirical evidence of time-variation in returns moments and the problems I see in my correlation estimations, the latter two interpretations seem much more reasonable than the first one. For example, in this paper, I only consider oil as final products that can only be consumed. A model where oil can either be consumed or used as inputs in producing other consumption goods may be more realistic and perform better. Similarly, I notice some problems in estimated conditional correlations that affect the accuracy of fitted risk premia. It is quite plausible that a more sophisticated empirical model on the correlations can improve the final results.

1.5 Conclusion

This paper is motivated by recent studies on the relationship between crude oil price and stock market. I try to understanding of the link between the two by addressing the following questions: What are the dynamic correlations between oil shocks and stock returns? Can oil shocks be translated into stock market risk? Is it possible to provide a rational risk-based explanation for some documented stock returns predictability related to oil shock?

Using a two-consumption good model and U.S. data, I illustrate a mechanism for oil shocks to be “converted” into stock market risk. My empirical estimates show that the effects of changes in oil/non-oil expenditure ratios on the second moments of stock market returns are significant.
I find evidence of remarkable time-variation in both volatilities of stock returns and covariances of returns with changes in expenditure ratios. Most of the largest variations coincide with important exogenous oil events such as large OPEC quota cuts/increases and military conflicts in Middle East. My empirical results and theory shed light on a risk-based explanation for the predictability of oil price changes.

A preliminary predictive regression confirms that my empirical risk premia are strongly significant in the predictive regression. However they are not yet able to account for the predictability of oil price changes. This does not necessarily mean that time-varying risk premium cannot explain the predictability. Combined with the favorable empirical evidence I find, it points to the need for better understanding of the interaction between oil shocks & stock market risk.
2.1 Introduction

Recently income inequality has received renewed interests globally. It is no longer the concern in only those poor countries or emerging economies – the May 2011 report by OECD shows that the gap between the rich and poor in wealthy countries has reached its highest level over the past three decades, even in the traditionally egalitarian countries such as Germany, Denmark and Sweden.

It’s been a prevailing view among the policy and academic elites in the past decades that inequality itself is a less important issue than poverty. This view has never been challenged before like it is challenged nowadays. In America, accompanying the enormous amount of attention on the increasing income disparity itself is the heated debate over President Obama’s deficit-reduction and tax reforming plan that targets the top income population: The plan includes the “Buffet rule” that ensures millionaires to pay no less tax than any middle-class families.

Such debates on inequality and policy cannot be settled without answering some open questions. In particular, what are the effects of the changing inequality and how do we measure them? For financial economists, a relevant question is how inequality affects financial market wealth and returns to investors. Stock market provides the natural environment for such study, as Whitelaw(2000) points out, “…since it (stock market) serves as a proxy for the wealth portfolio that is studied in finance theory”. Answering this question is important for two reasons. Firstly, it directly estimates and quantifies the potential cost or benefit in terms of financial wealth. Thus it presents a non-ideological way of evaluating policies that have impacts on income distributions (for example, taxations on the rich). Meanwhile, as I discuss in detail later in this section, studying
of the effects of income inequality on financial market quantities also has significant implications for asset pricing modeling.

In this paper, I examine the asset pricing implication of income inequality. More precisely, I investigate how the variation in cross-country stock market level is related to cross-country difference in domestic income distributions. I utilize two of the most up-to-date and complete inequality datasets in this study. The main measure of inequality is the income Gini coefficients from World Bank’s “All-the-Ginis” dataset. Robustness tests are performed with income Gini and income ratios data from World Income Inequality Database version 2.0 (WIID2) assembled by the World Institute of Development Economic Research (WIDER). Many of the earlier empirical studies on income suffer from lacking of consistency and reliability in data source. Both datasets used in this paper go a long way to address these concerns by careful selections based on characteristics of source surveys for the observations and by labeling the welfare concepts. Given their partial divergence in initial sources and discrepancy in methods, income inequality measures from both sources are still highly consistent.

This paper has two main results: Firstly, I document a significant negative correlation between income inequality and stock market levels across countries even after controlling for traditional price factors and country characteristics. A 0.01 increase in income Gini coefficient is associated with up to 2% lower stock market price dividend ratio, keeping other things constant. This inverse relationship is especially notable in the more developed countries. Given the academic consensus that domestic income distributions are usually shaped by historical institutional and geographical influences, it is unlikely that varying stock market levels across countries contribute to the diversity in degree of local income disparities. Even if ups and downs in a country’s stock market are

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1 The WIID2 Ginis are mostly calculated from their income decile and quintile data, a method developed by Tony Shorrocks and Guang Hua Wan. When decile/quintile data are not available, WIID2 report Gini values from the compiled sources.
reflected in its inequality level, a positive rather than negative (as in my results) correlation should be observed: the gap between the rich and the poor usually widens in a booming market, as stocks are usually more concentrated in the hands of the wealthier ones. Therefore, it is reasonable to interpret the negative correlation documented in this study as the cross-sectional effect of differing income inequality levels on stock prices. Secondly, I decompose price dividend ratio into risk-free rate and expected excess returns and examine the link between each of the components with inequality. I find that increasing inequality lowers prices mainly by raising interest rates, while there is no evidence that inequality is positively related to excess returns. This is an interesting yet intriguing result, as it poses challenge to the existing asset pricing literature to explain the mechanism behind.

The topic in this paper is related to several distinct research areas of economics and finance.

Firstly, a large body of development economic research (see, among others, Greenwood and Jovanovic(1990), Clarke, Xu and Zou(2006), Beck and Levine(2004), Beck et al(2007), Kappel(2010)) focuses on the role of financial developments, including development in banking system and stock market, in reducing income inequality, poverty rates and improving the life of the poor. Another line of research is devoted to the macroeconomic implications of income inequality, including the interaction between inequality and economic growth, consumption and savings. For example, Galor and Zeira(1993), Benabou(1996a), Barro(2000), Krueger and Perri(2006), and Heathcote et al(2010) develop different theoretical models to investigate the effect of diverse income distributions on growth, on investment and consumption. There doesn’t seem to be a consensus reached by these theories though. And the theoretical ambiguities do seem to correspond to divergence in empirical findings, as can be seen from Perotti(1996), Forbes(2000), Li and Zou(2004), Krueger and Perri(2006) and Heathcote et al(2010).
While my paper draws from these development and macroeconomic literatures in their empirical settings, it is more inspired and linked more closely in spirit to the enormous asset pricing literatures that aspire to solve anomalies such as equity premium puzzle. Before proceeding any further, however, it is probably worth clarifying that the focus of this study is how differing inequality LEVELS are associated with stock prices and asset returns. A related but distinct study can be seen in Johnson(2012), where the author ties differing exposure to inequality RISK with difference in returns.

Now coming back to the asset pricing literature that relates to my paper, the first question to answer is: “When do income distributions matter for asset pricing?”

Under the standard classic assumptions of frictionless, complete market and homogeneous agents with CRRA utilities, only the mean of income or wealth, not their distribution, matters for asset prices. However, this type of models fails to generate risk premia that match magnitudes of the observed data. It is therefore necessary to relax one or more of these assumptions to solve equity premium puzzle. To do so, the existing literature has experimented in a couple directions.

One way is to maintain the complete market assumption and to loosen other assumptions. Gollier(2001) for example, maintains the complete market and removes the CRRA preference assumption. He shows that if agents have concave absolute risk tolerance (the inverse of Arrow-Pratt absolute risk aversion), then deviation from an egalitarian income (initial wealth) distribution increases the equity premium and lowers risk-free rate.

The other way is to relax the complete market or frictionless transaction assumptions:

For instance, Peress(2004) follows this second road by assuming costly acquisition of the information that generates increasing returns. With decreasing absolute risk aversion assumption,
the demand in stocks is convex in wealth. As a result, higher inequality leads to higher stock prices, and this in turn, contributes to more unequal income distribution and wealth accumulation.

Besides Peress’s paper, a thriving branch of literature also takes the second route to answer major asset pricing questions by combining incomplete market models with heterogeneous agents. In some of these models, incomplete market results from aggregate and idiosyncratic income risks, and lacking of or limited access to credit market (borrowing constraints etc.). If idiosyncratic risk is correlated with aggregate risk either by explicit assumption (Constantinides and Duffie(1996), Storesletten, Telmer and Yaron(2007)) or by construction (Guo(2004), Gomes and Michaelides(2008)), then the model can deliver higher risk premium and lower risk-free rate due to precautionary motive. Another strand of models adopts a different mechanism but has similar elements including market frictions, uninsurable income risks and heterogeneity. The key ingredient of this type of models is limited stock market participation. The source of this limitation can either be exogenous (Basak and Cuoco(1998), Guo(2004), Guvenen(2009)) or endogenous due to frictions like an entry cost (Gomes and Michaelides(2008)). The magnitude of fixed costs to entering stock market and their effects on market participation have been estimated in several empirical studies (see, for example, Paiella(2001) and Vissing-Jørgensen(2002)). Limited stock market participation leads to limited risk sharing among shareholders. Consequently, consumptions of stockholders are more volatile and more correlated with aggregate risk compared to those of the non-stockholders. Therefore stockholders require higher risk premium to hold stocks. Several recent papers (Guo(2004), Gomes and Michaelides(2008) and Favilukis(2013)) incorporate both

2 See Heathcote et al.(2009) for an excellent survey of macroeconomic models with heterogeneous households.
3 Telmer(1993), Heaton and Lucas(1996), and Krusell and Smith(1997)’s models also have elements such as incomplete market, idiosyncratic risks, borrowing constraints and heterogeneity. However, their models fail to generate desired risk premia mainly because their models assume that individual heterogeneity is independent of the aggregate risk. In a sense, Polkouvichenko(2004)’s model, although relying on a very different mechanism (limited participation), is quite similar to these models in that he assumes agents derive a substantial part of their wealth from labor income which is uncorrelated with dividends. Like Lucas et al, Polkouvichenko also reaches the conclusion that equity premium puzzle cannot be solved by his type of model.
mechanisms from the two strands into one model and are able to partially match equity premium and risk-free rate, as well as replicating several other salient features of the data.

At the first glance, with the exception of Favilukis(2013), few of the models discussed above have explicitly integrated income inequality or directly linked it to returns and prices. However, there are a couple of reasons why it is not much of a stretch to place income distributions in asset pricing models as a state variable.

First of all, the indispensable ingredient shared by all of these models is the heterogeneity in either the initial wealth distribution of the economy or idiosyncratic income shocks, or both. And these ingredients are exactly where the income inequality originates from. Secondly, given both theoretical and empirical studies of income distribution in the growth literature, it is reasonable to propose that variation in income distributions have asset pricing implication through its effects on the investment and savings. To see this, one can consider the social political channel. The social discontent fueled by widened income gaps may create increasing political instability, driving the entire social economic environment into uncertainty and reducing investment. More importantly, as Barro(2000) points out, “With limited access to credit, the exploitation of investment opportunities depends on individuals’ levels of assets and incomes. Specifically, poor households tend to forego human-capital investments that offer relatively high rates of return ...An offsetting force arises if investments require setup costs...If these kinds of setup costs are large in relation to median income, then a reduction in inequality tends to reduce overall investment. ” These arguments can be easily seamed into the incomplete market models discussed before. With all these in mind, it is not too hard to see why income distribution should be put into the asset pricing picture. However, as far as I know, there has not been a theory that explicitly incorporates inequality and models its price impact, and nor has there been any related empirical work done.
My paper adds to the asset pricing literature by filling this blank and advances literature in two significant ways: To the best of my knowledge, my paper is the first to perform direct empirical tests of inequality effects on the stock market level of a country and to quantify the magnitude of the asset pricing effect of income inequality. It is also the first attempt to break down the price impact of inequality and empirically explore the underlying mechanism. From modeling perspective, the finding of a significant negative correlation between income inequality and stock market level provides strong evidence justifying the integration of heterogeneity in asset pricing models. Moreover, the observed significant positive correlation between interest rate and inequality can hardly be explained by any available model and therefore points to the need of a new theory. From the policy point of view, a conclusion of this research is that policies that lead to increased income inequality are expected to decrease stock market wealth. The effect is both statistically and economically significant: On average an increment of 0.01 in income Gini coefficient, or 1% in the income ratio of the top income decile population to the total of other deciles, is associated with up to 2% drop in the stock market wealth. Hence if the proposed policy results in a reduction in income inequality on the other hand, it is significantly beneficial in terms of wealth.

The remainder of the paper is organized as follows: Section 2.2 describes the methodology, data and variable selection and construction. Section 2.3 presents the empirical results on the relationship between income inequality and stock market levels. Section 2.4 performs robustness tests. Section 2.5 looks into the main channel for inequality to influence price. Section 2.6 concludes.
2.2 Methodology and Data

In this section, I discuss the methodology of this study and describe the data sources as well as the construction of key variables used in regressions.

2.2.1 Main Specification and Identification

In the classic models with frictionless endowment economy and power utility, the dividend price ratio can be simply written as:

\[
\frac{D}{P} = r_f + EP - \mu_c = \phi + (\gamma - 1)\mu_c - 1/2(\gamma - 1)\gamma\sigma_c^2
\]

In this expression, \( r_f = \phi + \gamma\mu_c - 1/2(\gamma + 1)\gamma\sigma_c^2 \) is the risk-free rate and \( EP = \gamma\sigma_c^2 \) is the expected excess rate of return (equity premium). \( \mu_c \) is the growth rate of aggregate consumption (as well as dividend) and \( \sigma_c^2 \) the volatility of aggregate consumption. \( \phi \) represents the rate of time preference. \( \gamma \) is the coefficient of risk aversion.

This representation shows that in this endowment economy, variations in price dividend ratio are mainly driven by changes in growth rate and risk of aggregate consumption (or dividend). Based on this, in the simplest version of the regression model with P/D ratio as dependent variable, the two main independent variables should be dividend growth rate and stock market volatility. However, this type of frictionless homogeneous economy models falls short both in matching the observed individual portfolio choices and in matching the empirical asset pricing moments. Therefore, various frictions have since been introduced into asset pricing theory to generate more realistic results. In empirical study, the set of control variables of regressions based on these models should be expanded accordingly.
In this paper, my main hypothesis is that cross-sectional differences in income distributions have implications for the pattern of cross-sectional prices and returns. As discussed in the introduction, this hypothesis is based on a prospering body of incomplete market models with heterogeneous agents and market frictions. So the basic specification of my regression with panel data is as follows:

$$\log\left(\frac{P}{D}\right)_{it} = \alpha_0 + \alpha_1 \text{Inequality}_{it} + \text{other controls} + \varepsilon_{it}$$

A couple of important issues about this specification need to be addressed before proceeding.

First and foremost, a crucial underlying assumption of this study is that the market is not fully integrated or complete internationally: None of the domestic or local factors should matter in a globally integrated complete market; only when there is some degree of international market segmentation can home-country characteristics like income inequality play a role in the domestic asset pricing. Fortunately, this assumption is consistent with the known fact that the world market is indeed segmented, even with the growing globalization in the last few decades. A related issue is that not only does the degree of segmentation of each country from the global market itself have impact on home country’s stock market; it also affects the weightiness of inequality and other domestic factors’ influence on the domestic market. Specifically, domestic factors play bigger role in determining domestic prices if the home country is more segregated from the world market. I account for effects of global market segmentation in my regressions and present more detailed discussions in section 3.3.

A second issue is about endogeneity and reverse causality. In the regression model specified above, the income inequality needs to be viewed as exogenous. Two main concerns are the omitted variable problem and measurement errors in inequality. To address the former concern, I first
include year-fixed effects in every regression to control for changes in unobserved factors over time. Then I control for an extensive and comprehensive list of country characteristics that are likely to contribute to both the difference in cross-country inequality levels and variation in cross-country stock market levels. These controls cover each country’s social-political condition and stability, indicators of economic and financial market development, institutions and taxation, as well as proxy of degree of domestic market’s segregation from global market. To deal with the concern on measurement error, I employ alternative inequality measures obtained from two distinct sources that contain latest and highest quality income data. My empirical results are significant in almost all regressions and highly consistent across alternative inequality measures. To the extent that both endogeneity concerns are properly addressed, it is also always necessary to interpret the regression coefficients with caution. Can the estimated correlation be viewed as causal effect of income distributions on prices? In this study, the answer is “yes” and it can be justified by two arguments. It is firstly worth pointing out that income distribution is usually the long-term outcome of slow-moving historical, institutional and social-economic forces that are generally not affected by stock market prices. Hence it is unlikely that stock prices have any substantial effect on income inequality. In the short-run, fluctuating market level of a country may temporarily drive a change in the domestic income distribution. If this is the case, the rich (who are usually also the higher-income population) benefit the most from a booming market since they generally hold the most stocks. So a higher stock market level is most likely coupled by larger wedge between high- and low-income populations and higher income inequality. In other words, inequality and market level should be positively correlated if the latter is driving the former. Yet my regressions reveal a significant negative correlation between the two variables, thus provide strong evidence against the reverse causality interpretation.
It is probably also worth discussing the focus of this paper on identifying the cross-country effect of inequality on asset prices. Cross-sectional correlations are a natural candidate for this study and suit the purpose better than time-series effects for two reasons. A first reason is that it is hard to match the frequencies of changes in the two time-series since inequality series over time are much smoother compared to the price series. As a result, it is difficult to interpret results of time-series regressions and draw any conclusion on the equilibrium effect of inequality on price. The other reason lies in the limitation of the obtained data itself. The data on income inequality are only available for a relatively small set of country-years and are distributed quite sporadically, resulting in a highly unbalanced wide panel dataset. Both of the final datasets of income Gini coefficients for my regressions contain a little over 500 observations, spreading across over 40 countries. The final dataset of the WIID2 income deciles for regressions contain less than 400 observations across 40 countries. In view of this, cross-country differences in inequality are also a more natural and reliable source of variation than the time-series variation for this dataset. To better identify the cross-sectional effect of income inequality on market prices, I employ model with year-fixed effect and use cluster-corrected standard errors for inference in all regressions.

In the following sub-sections, I discuss in detail the data sources, selection and construction of the main independent variable (income inequality), dependent variable (stock market level) and main control variables.

**2.2.2 Income Inequality Measures**

The main measure of income inequality in my regressions is the income Gini coefficient. Gini is one of the most commonly used measures of income inequality in the literature. Constructed based
on Lorenz curve\textsuperscript{4}, it measures the income inequality on a scale from 0 to 1, with 0 representing the perfect equality (everyone has the same income) and 1 representing the perfect inequality (one person have all the income). The Gini values are commonly multiplied by 100 to make them easier to compare and understand. In this paper, I follow this convention and use 100*Gini (a value between 0 and 100) instead of the original Gini coefficient values. The income data in this paper are obtained from two sources: the “All-the-Ginis” dataset compiled by Branko Milanovic from World Bank and the World Income Inequality Database (WIID2) dataset of World Institution of Development Economic Research (WIDER).

My main results are obtained using the “All-the-Ginis” dataset, which contains 1541 consistent Gini values from 154 countries covering 1950 to 2008. The dataset is compiled from 5 other Gini databases, including Luxembourg Income Study (LIS), Socio-Economic Database for Latin America (SEDLAC), World Income Distribution (WYD), World Bank Europe and Central Asia (ECA) and WIDER (WIID I ) databases. Only the data that come from nationally-representative household survey are selected. When there is conflict in data from two or more different sources for the same country-year, data are chosen according to the reliability and the degree of standardization of the source. All the data in the resulted “All-the-Ginis” dataset have clear description of welfare concepts (income or expenditure/consumption, net or gross) and unit of recipients (per capita or per household). Compared to some other sources of income distribution data, “All-the-Ginis” has advantage in both the size of the samples and the overall consistency of the concepts and measurements. And all the data in my sample are estimated in per capita units.

\textsuperscript{4} The Lorenz curve plots cumulative percentage of income or expenditure (from 0 to 100 on vertical axis) against the cumulative percentage of the population (from 0 to 100 on horizontal axis). Under perfectly equal distribution, the Lorenz curve is a 45-degree straight line; the more inequal the income or expenditure distribution, the further the Lorenz curve falls away from and skewed to the right of the 45-degree line. Gini coefficient is 2 times the area between the Lorenz curve and the 45-degree line.
Another important source of inequality data, used in my robustness checks, is the World Income Inequality Database (WIID2) dataset of World Institute of Development Economic Research (WIDER). This data is one of the largest and most comprehensive dataset on income distribution, built on the WIID1 dataset but with substantial extension. It is widely used by development economists. It has Gini coefficients as well as income deciles data and provides great alternative measures of inequality to those from “All-the-Ginis”. Since WIID2 is based on a large amount of data sources, there is big variation in the reliability, the definitions and descriptions. WIID2 data are ranked from 1 to 4 by the quality of the data, with 1 being the highest quality (with clear description on all key concepts and verifiable estimates) and 4 being the lowest (observations classified as memorandum items). The statistical units adopted in WIID2 are all adjusted to the equivalence scale of per capita value to account for the differences in household size and composition.

Besides using Gini coefficients directly, I construct another measure of inequality with the income decile data from WIID2: the ratio of the income of the population in the highest income decile to the total income of the other 90% of the population. This income ratio measure is also a popular measure of inequality in economic research.

For WIID2 data, a first step is to eliminate observations that are based on regional surveys and surveys conducted only on certain groups of the population. Then following Campante and Do(2007), I extract data with the top quality ranking (ranked 1 or 2) so that the key descriptions of all observations are available for comparison to the ones in “All-the-Ginis”.

As with most survey data, both “All-the-Ginis” and the WIID2 data suffer from lacking of consistency in the concepts adopted in estimation. There are two main concerns here: Whether the estimates of Ginis are based on income or consumption (expenditure); similarly, whether the
estimates are based on gross or net income (net income is defined as income net of tax and transfers).

To address these concerns, I follow Dollar and Kraay (2002) and adjust both datasets to ensure the consistency in welfare concepts. I regress the inequality measures on a constant, a set of regional dummies and two dummy variables indicating whether the measure is based on gross income or consumption. Then I subtract the estimated mean difference between the alternative welfare concepts-based inequality measures and the omitted category. The adjusted Gini coefficients for regressions can be roughly interpreted as a measure of the disparity in net (disposable) income.

The descriptive statistics of the income inequality measures can be seen in Table 2.1, Panel A. The correlations are shown in Table 2.2.

A quick look at the Table 1 shows substantial variations in income inequality across countries. Gini from “All-the-Ginis” varies from 23.35 (Czech Republic) to 60.49 (South Africa). WIID2 Gini varies from 22.07 (Czech Republic) to 59 (South Africa). The proportion of the income accrued to the richest 10% people relative to the other 90% people, WIID2 IR, is also the lowest in Czech Republic (0.23) and highest in Brazil (0.89), followed by some other Latin American countries. Consistent with common belief, less economically developed countries tend to have greater income inequality and most developed countries have a more equal income distribution. Overall, despite the variation in data sources and possible differences in the construction process, the three alternative income inequality variables have fairly consistent cross-country rankings, although the income ratios have more pronounced values for the most unequal countries. The correlation

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5 The dummies are Asia, Africa, Latin America, and East Europe. The others (“West” countries) are in the omitted category.
6 My main results do not change much if I use other two possibilities: 1. Completely ignoring the differences in welfare concepts, and 2. Include the dummy variables of welfare concepts directly in regressions.
between the two Gini measures is 0.912 and their correlations with the cross-country income ratio are 0.943 and 0.953, respectively.

### 2.2.3 Stock Market Level

The focus of this paper is to examine the link between inequality and asset prices. Therefore the main dependent variable is the stock market level, as measured by price dividend ratio of each country. I obtain stock market data from both MSCI and Global Financial Data (GFD) and construct alternative measures of price dividend ratios.

For each country-year, MSCI P/D ratio is the value of MSCI Global Equity Price Index scaled by dividend. The price indices cover 25 developed countries/regions (for most of which data series begin from 1969) and 20 emerging markets (for which data start from 1987 or 1992). For each country, the standard index covers all investable large and mid-cap securities, accounting for about 85% of the market capitalization.

An alternative measure of stock market level, the inverse of annual dividend yield of each country from Global Financial Data (GFD) between 1970 and 2010, is used to check the robustness of the regression results. These dividend yields are generally based the large-cap stocks that represent about 75% of the market capitalization.

The last two columns of Table 2.1 Panel A report the annual average values of the two price dividend ratios by country. There are substantial international variations in both series. MSCI P/D values range from 19.79 in New Zealand to 138.29 in Russian Federation; GFD P/D is the lowest in Australia at 21.91 and the highest in Russian Federation with a 106.12 value. The average correlation between MSCI and GFD PD ratios across country and over time is 0.516, as shown in Table 2.2.
2.2.4 Other Risk Proxies and Control Variables

The choice of the control variables are based the following two considerations: As in any cross-country study, there are potentially substantial omitted variable problems and possibly mismeasurements. The coverage of the selected controls thus needs to be comprehensive enough that they are able to best solve or mitigate these problems. On the other hand, due to relatively limited data on income inequality, the panel data used in this study is highly unbalanced and sparse. From this perspective, including too many controls significantly reduces the power and reliability of regressions. To achieve the balance between the two considerations and best isolate the connection between inequality and stock price, I draw from the extant literature and control for a multitude of conventional price determinants, risk proxies and time-variant or –invariant country-specific variables that may simultaneously affect stock market level and the income distribution.

Firstly I include the conventional variables that are shown in literature (Campbell and Shiller(1988) etc.) to be closely related to the variation in the price dividend ratios. These variables include the dividend growth (past, present and future), real interest rate, and inflation rate. The annual dividends are calculated using MSCI equity price and total returns indices. Inflation rate data are from the World Development Indicators (WDI) database of World Bank. Interest rate data, including the lending (prime) rates and spreads between prime rates and T-bill rates, are also from WDI.

In addition, the cross-country difference in stock prices may also reflect the difference in aggregate market risk. To capture this, I control for the market volatility of each country in all regressions. The variable is constructed with monthly MSCI equity price index data. Each year it’s computed as
the volatility of the market’s index returns over the 36-months window centering on the December\textsuperscript{7}.

The baseline regression thus includes a measure of inequality and the above variables. However, what we observe from the coefficient of inequality in this regression may simply be proxying for the social economic conditions that are shaping the inequality. To disentangle these effects, I expand the baseline regression to control for a set of variables that may be simultaneously related to both inequality and stock price. In doing so, I borrow from both finance and development economics literature to consider all variables that characterize a country’s economic conditions and financial market development, demographic features, redistribution policy, the soundness of the legal institutions as well as other risk factors including political stability. Table 2.1 Panel B reports the country-by-country mean values of these control variables over the sample period and Table 2.2 presents the descriptive statistics and pairwise correlations for the entire panel.

Annual GDP per Capita (real) from WDI database is used as an indicator of economic development. The negative correlations between GDP per Capita and three inequality measures (-0.444, -0.485 and -0.568, respectively) in Table 2 confirm the common belief that high inequality is usually associated with a backward economy. To capture the development in financial markets, I follow Beck et al(2000), Beck and Levine(2004), and many other development papers to measure the stock market development by turnover ratio \textit{(stturnover)} and the banking system development by ratio of liquid liabilities to GDP \textit{(llgdp)}. \textit{Stturnover} is the value of the trades of shares on domestic exchanges divided by total value of listed shares, a measure of market liquidity. Liquid liabilities are calculated as currency plus demand and interest-bearing liabilities financial intermediaries and nonbank financial intermediaries. These data are obtained from Beck,\textsuperscript{7}

\textsuperscript{7} I’ve also tried calculating the volatility over 36-month window centering on each June. The difference in the construction of volatility doesn’t affect the regression results.

It is widely believed that income inequality is usually associated with lacking legal institutions and political and social instability. Recent studies on law and finance\(^8\) also present convincing evidence linking stock market valuation to these factors. In light of these, I created two country-fixed effect variables “\textit{legal}” and “\textit{icrg10}” as proxies for development of legal regime and overall political risk. I follow Doidge et al.(2007) and Durnev & Kim(2005) and define “\textit{legal}” as the product of “anti-director rights index” and “rule-of-law”. The former measures investor protection and shareholder rights and the data is from Djankov et al.(2008); the latter are measures of law enforcement from (La Porta et al.(1998)). “\textit{icrg10}” is a composite country risk index from International Country Risk Guide (ICRG) that incorporates a comprehensive list of political and social condition measures\(^9\).

Another factor that’s shown in literature to be related to both stock returns (Ang and Maddaloni(2005), Porterba(2001), etc.) and income distribution (Gomez et al.(2003)) is the age structure of a country, especially the fraction of retired people among entire population. I therefore include the variable “\textit{age65}” in the regressions to account for the demographic effects. The variable is calculated as the fraction of the population that’s 65 years or older.

Finally I also take into account the tax rate of each country. Needless to say, taxation policy plays an important role in shaping the income distribution of a country. Studies on the effect of tax rates on portfolio choice and asset prices have produced mixed results. Still, in order to isolate as much

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\(^8\) Most of the research show that legal regimes are associated with corporate governance, firm valuations (La Port et al.(1998, 2002), Durnev and Kim(2005), Doidge et al.(2007), Djankov et al(2008)) and expected stock market returns (Giannetti and Koskinnen(2010)).

\(^9\) Specifically, the ICRG composite risk index incorporates the following measures: government stability, military in politics, socioeconomic conditions, religious tensions, investment profile, internal conflict, ethnic tensions, external conflict, democratic accountability, corruption and bureaucracy quality.
as possible the effect of inequality alone, I control for each country’s tax rate in regressions. For each country, I choose the marginal personal income tax rate for the highest-income tier. Compared to average tax rate, it is more relevant since it reduces the gap between the richest and the others. The rates are cited from PWC’s Worldwide Tax Summaries.

Table 2.1 Panel B presents the summary statistics of the above control variables, with some outliers excluded. Table 2.2 reports statistics over the entire panel and the correlations.

### 2.3 Does Income Inequality Affect Stock Market Level?

In this section, I test the effect of income inequality on stock market level using panel regressions. To better identify the cross-country effect of income distribution on stock markets, I incorporate year-fixed effects in all the regressions. Since each country typically has more than one observation in the sample, it is also important to consider specifications with error clustering at the country level. All the results reported in this paper are cluster-robust statistics. Empirical results obtained with different price dividend ratio measures will be presented and discussed in the first part of this section. In the second part I discuss the implication of global market segmentation on this empirical study.

#### 2.3.1 MSCI price dividend ratio and “All-the-Ginis”

I first use log MSCI price dividend ratio as the dependent variable and Giniall as main independent variable. The basic specification is as follows:

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10 For example, Brazil has an average real interest rate of 52.58% and a whopping inflation rate of 403.19% over some sample periods; Peru also has an extremely negative average interest rate of -185.93% over time once accounting for the huge inflation rate of 270%. I exclude country-years with an inflation rates that’s above 100%. My tests show that the inclusion of these “outliers” in regressions actually makes my results stronger.
\[ \text{logpd}_{i,t} = \alpha_0 + \alpha_1 \cdot \text{Inequality}_{i,t} + \sum_j \alpha_j \cdot X_{i,t} + \sum_k \alpha_k \cdot Z_i + \text{year}_t + \varepsilon_{i,t} \]

Where \( \text{logpd}_{i,t} \) is the logarithm of price dividend ratio (here it is constructed using MSCI equity price and total returns index) of country \( i \) in year \( t \). \( \text{Inequality}_{i,t} \) is a measure of income inequality in each country \( i \) at in year \( t \). \( X_{i,t} \) are a set of country- and time-variant control variables including dividend growth, market volatility, the economic (GDP per Capita, inflation, real interest rate) and financial market development indicators(\text{stturnover, llgdp})^{11} \) and demographics (age65). \( Z_i \) s are country- fixed institutional factors (legal, tax) and composite political risk factor (icrg10). \( \text{year}_t \) is the year-fixed effect.

With this specification, I test the relationship between log MSCI P/D ratio and the Giniall alone and in combination with the various control variables described above. The panel regression results are reported in Table 2.3, under Model 1, 2, 4 and 6. Throughout this paper, t-statistics (in parentheses) are computed based on cluster-robust standard errors.

I start with a simple regression in Model 1 to establish that the log P/D ratio is negatively correlated with income inequality, as measured by Giniall. The estimated correlation is about -0.02, significant at 1% significance level (\( t = -2.82 \)). Then in Model 2, I add in the “traditional” factors that may impact price dividend ratio besides Giniall. These factors are dividend growth, real interest rate, inflation rate, and the market volatility proxying for aggregate stock market risk of each economy. The inclusions of these factors together helps explaining an extra of about 17% of the variation in log P/D ratios across 41 countries. The coefficient on Giniall is still negative and

\(^{11}\) Some development economists consider the ratio of stock market capitalization to GDP as an alternative indicator of stock market development to stturnover. It is also common to use an alternative variable “private credit”, defined as the bank claims on the private sector divided by GDP, to proxy for bank development. I experiment with both sets of indicators and find no noticeable effect on my main regressions results and conclusions. Therefore in this paper I only report regressions with stturnover and llgdp.

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significant at 10% level (t= -1.84). The estimates and t-stats also confirm the systematic correlations between these factors and P/D ratios established in previous literature. We see a significantly negative coefficient on real interest rate (t= -3.01), consistent with conventional wisdom in literature. The significantly positive estimate of coefficient on expected dividend growth (0.27, with t= 4.5) is expected as in works related to present value models. The finding of a big and statistically significantly (t= 2.72) coefficient on market volatility confirms the results in a series of recent empirical and theoretical studies\textsuperscript{12}.

After firstly establishing the inverse relationship between price dividend ratio and inequality with a small set of traditional price factors, I gradually include more controls to examine if this correlation is only proxying for the cross-country difference in social economic environment and variant country characteristics. The influence of economic and financial market development, legal institutions and composite political risks are considered in \textit{Model 4}. In \textit{Model 6} the demographic features and tax rate are also added to the regression. In \textit{Model 4} the t-stat of Giniall coefficient (t= -1.97) is right about the 5% significance level. It is even larger (t= -2.72) in \textit{Model 6} when the effects of age structure\textsuperscript{13} and tax rate are also accounted for. Therefore it seems reasonable to conclude that across countries, higher income dispersion does seem to be associated with lower stock market levels. The negative relation is statistically significant and robust even if we take into account the effects a variety of other country-specific factors\textsuperscript{14}.

\textsuperscript{12} See, among others, Whitelaw(2000), Bekaert and Wu(2000) and Li et al.(2005).

\textsuperscript{13} As shown in Table2, the demographics variable (age65) is highly correlated with GDP per Capita. To address the multicollinearity concern, I compute variance inflation factor (VIF) in regressions with both variables. The outcomes show that there is no multicollinearity problem with these regressions.

\textsuperscript{14} Some researches show that income inequality may be associated with the average education level of a country. Education (financial literacy) is also shown to be related to stock market participation and therefore risk sharing (see, for example, Hong et al(2004), Rooij et al(2011)). In untabulated regressions, I also include a proxy for average education level of each country. The variable \textit{education} is measured by Barro-Lee’s data on average years of secondary schooling received by people of age 15years and above. The data are obtained from World Bank. The addition of this variable does not affect my main results and conclusions and in most regressions it is insignificant.
It’s also important to look at the magnitude of this correlation and assess the economic significance of inequality on prices. In Model 6 where all the country characteristics and economic factors are considered, the estimate of the coefficient on \textit{Giniall} is about -0.02. It means that on average, 1 point increase in \textit{Giniall} (or a 0.01 increase in original income Gini coefficient\footnote{Note that the variables \textit{Giniall} and \textit{WIID2 Gini} used in regression analysis are the original Gini coefficient (which is between 0 and 1) multiplied by 100. \textit{WIID2 IR} (income ratio) is also multiplied by 100 to be consistent with Gini measures.}) translate into 2% drop in market level (P/D). Hence 1 standard deviation change in \textit{Giniall} (9.046) implies an 18.09\% variation in the market. Take the extreme case of moving from one of the most equal countries Czech Republic (with a Gini of 23.35 percent points) to one of the most unequal countries South Africa (with a Gini of 60.49 percent points), this change in Gini alone accounts for a huge drop of 74\% in the market when keeping other things constant. Therefore the inverse relationship between income inequality and stock prices is not only significant in the statistical sense, but of really substantial economic importance.

How should we interpret this negative correlation? In general, a correlation cannot be concluded as a one-way causal relationship. However, in this case it is reasonable to see the observed correlation as reflecting the impact of income inequality on price. As discussed in the introduction, it is unlikely that cross-country pattern of income distributions in the long run can be attributed to cross-country difference in their stock market performances. Even if in short term fluctuation in a country’s stock market can cause a temporary change in the allocation of income or wealth, it should induce a positive rather than negative correlation between the two: people who gain the most from a bull market are usually the wealthier ones, who already hold a larger amount of stocks relative to the poorer guys. Consequently, the rich get richer and the poor stay the same or relatively worse off. In other words, if inequality is affected by stock market and not the other way
around, we should observe positive correlation between the market level and inequality, not negative as in the results in Table 2.3.

Developed countries and emerging markets not only differ substantially in economic environment, but also in their financial system, political condition and institutional structures. Given all these discrepancies, it is natural to ask whether the income dispersion also has distinct effects on market index price dividend ratio for the two types of economy. To answer, I re-run Model 2, 4, 6 but with an extra control variable: the interaction term of Giniall and a dummy variable indicating whether the country is developed or developing country. This dummy Developed is equal to 1 if the country of interest is classified as a “developed market” by MSCI and it is 0 if the country is classified by MSCI as an “Emerging market”. The regression equation is as follows:

\[
\text{logp}_{i,t} = \alpha_0 + \alpha_1 \times \text{Inequality}_{i,t} + \alpha_2 \times \text{Interact}_{i,t} + \sum_j \alpha_j \times X_{i,t} + \sum_k \alpha_k \times Z_i + \text{year}_t + \epsilon_{i,t}
\]

In this equation, all other variables are defined the same way as in the previous equation. \(\text{Interact}_{i,t}\) is the product of Giniall and the dummy variable Developed.

The estimates and t-statistics are presented in Table 2.3, under columns titled Model 3, 5 and 7, respectively. Interestingly, the results show strong negativity of the coefficient on the interaction term. In Model 5 and Model 7 where more control variables are included, the t-stats on this coefficient are -2.61 and -2.76, respectively. It means that the negative relationship between market price and income disparity is more pronounced in developed countries than in under-developed countries.

\[16\] I also try defining developed country to be the ones which have higher per Capita GDP than the sample media per Capita GDP. This definition yields the same outcome as MSCI’s country classification.
The results show that income distributions do matter for prices and thus provide support for the asset pricing models with heterogeneous agents. For example, the finding that inequality matters even more in the developed countries than developing countries are consistent with the limited stock market participation models. In these models, part of the population is restricted from entering stock market because of either borrowing constraints or a fixed entry cost. The larger the fraction of restricted population, the more limited the risk sharing, and the higher the risk premia required by stockholders to compensate for higher individual consumption risk. If the increase in risk premia is big enough, then stock prices are lowered even if risk-free rates drop. Income distribution plays a role here because the participating rate is related to the relative size of the fixed cost (relative to both the mean and median income). In a developed country where average income is relatively high, greater equality means a larger fraction of people are rich enough to pay for the threshold fee and invest in stocks; while in an under-developed country where average income is sufficiently low, egalitarian income allocation may lead to non-participation since everyone is so equally poor. Hence inequality may actually improve the participation rate in this case, as at least the small fraction of those at the tip-top of the income distribution can afford buying stocks. Therefore, inequality can serve as a proxy for participation rate and degree of risk sharing. And we expect inequality to have a stronger effect on stock market in developed countries than in developing countries. Since this type of models implies lower P/D via higher risk premia in higher inequality countries (especially the developed ones), I’ll further test whether this theory indeed matches the excess returns data in section 2.5.1.

2.3.2 GFD Price Dividend Ratio and “All-the-Ginis”

In this section, I test the relationship between an alternative measure of each country’s stock market level and income Gini. The dependent variable is the inverse of annual dividend yield from
Global Financial Data (GFD). The estimates are presented in in Table 2.4. Cluster-corrected t-statistics are reported in parentheses.

In *Model 1, 2, 4* and *6*, GFD price dividend ratio decreases significantly in the inequality measure *Gniall*, even after controlling for a variety of socioeconomic and institutional measures. The estimates of coefficients on *Gniall* are comparable in magnitude to the estimates obtained with MSCI price dividend ratios. In addition, *Model 3, 5* and *7* in Table 2.4 also confirm the significant negative coefficient on the interaction term between *Gniall* and *Developed*.

Regressions with GFD price dividend ratio provide reinforcing evidence that the stock market levels across countries are strongly and negatively related to the international variation in income Gini, especially in developed countries.

**2.3.3 Local Risk Sharing vs. Global Risk Sharing**

Even with the increasing globalization, the world market is far from fully integrated. Literatures have shown that there are still substantial differences in the cross-country degree of market integration, resulting in big variation in levels of global risk sharing. Depending on how integrated a country is from the global market, the impact of domestic factors (e.g. domestic income distributions) on domestic stock market also varies. Therefore, in this section I test if observed negative correlation between inequality and market P/D persists after controlling for degrees of global risk sharing.

I use two measures of global market integration/segmentation: foreign investability (FB) and home bias (HB). The former measures how easy the foreign investors can invest in domestic market, and the latter measures how insufficiently diversified are domestic investors across global market. I follow Lau et al.(2010) and define FB as the ratio of total market value of a country’s domestic
equity held by foreign investors divided by the country’s total market capitalization. Similarly, HB is defined as the share of domestic investors’ holdings of their domestic stocks relative to the weight of the country’s market capitalization in the world market. The equity holdings data are from Coordinated Portfolio Investment Survey (CPIS) of IMF.

Higher FB, or lower HB, proxies for better global risk sharing, and thus contributes to lower cost of capital and higher stock market level. More importantly, as a country is more integrated into the world market, the local factors, including domestic income disparities, should have less impact on its local stock market. Therefore, in addition to FB or HB themselves, I also control for the interaction terms of HB (FB) with inequality. The results from these regressions are reported in Table 2.5.

The left panel shows results using MSCI P/D ratio as dependent variable and the right panel using GFD P/D ratio as dependent variable. In almost all regressions, the interaction term of developed country with Gini has significantly negative coefficient and Gini itself also has negative coefficient. In other words, even after accounting for the global risk-sharing factors, the negative relationship between domestic income inequality and stock price persists, especially in the more developed countries. Also worth noticing is that the interaction term of Gini with FB is significantly positive while the interaction term of Gini with HB is mostly negative. These results confirm the conjecture that as the domestic market is more isolated from the global market (i.e. in case of higher HB and lower FB), the domestic factors play less important role in affecting the domestic market price.
2.4 Robustness

Regressions in the previous section reveal an inverse relation between income inequality as measured by Gini coefficients from “All-the-Ginis” database and stock market levels across countries. The negative correlation is more prominent in economically more developed countries. It persists after controlling for conventional risk factors, a comprehensive set of country-specific political and institutional characteristics and year fixed effects, as well as indicators of degree of global risk sharing. In this section, I perform more tests to evaluate the robustness of the findings above. First, I examine whether the previous findings are sensitive to different sources of income data or alternative inequality measures. Next I consider alternative model specifications and extra factors on stock market.

2.4.1 Alternative Inequality Measures: WIID2 Data

One of the most widely used income dataset by economist is WIID2 database assembled by World Institute of Development Economic Research (WIDER). In this sub-section, I conduct robustness test with two inequality measures from income data in WIID2.

In Table 2.6, I replicate the regressions in section 3 with these WIID2 income inequality measures and MSCI P/D ratios. The left panel reports results using income Gini coefficients from WIID2 database (WIID2 Gini), and the right panel the ratio of income held by the top decile and the other nine deciles (WIID2 IR).

A quick look at Table 2.6A shows that both the magnitude of the coefficients of inequality terms and the degree of statistical significance remain close to their earlier counterparts in Table 2.3 and Table 2.5A. If anything, we see even stronger evidence of negative relationship between market price and inequality from using this new set of income inequality data than from using the All-the-
Ginis inequality. For instance, in the full model with all country characteristic controls and global risk-sharing controls (foreign investability), the coefficient on Gini in Table 2.5A (Model 4) is about -0.030 (t = -3.87) and coefficient on the interaction term of Gini with dummy “Developed” is -0.014 (t = -3.14); while in Table 2.6A (Model 8), the coefficient on \( WIID2 \ Gini \) is about -0.038 (t = -4.78) and that on the interaction term is about -0.024 (t = -4.55). In Table 2.6B, the estimated coefficient on \( WIID2 \ IR \) (income ratio) itself is -0.02 (t = -4.58) in Model 8 of Table 2.6B, and the coefficient on the interaction between \( WIID2 \ IR \) with Developed is -0.018 (t = -2.97). These results are also quite comparable to the results achieved with Ginis in the counterpart regressions.

In conclusion, this section offers solid evidence of a strong negative relation between international stock market levels and degrees of income disparities.

2.4.2 Total GDP and Population

Demand and market size play an important role in the determination of asset prices. Merton(1987) proposes that an increase in investor bases increases a firm’s value. Several papers (see, for example, Shleifer(1986), Kaul et al(2000), and Chen et al(2004)) show a downward sloping demand curve for stocks. Amihud et al(1999) present evidence using Japanese data that an increase in firm’s base of individual investors is associated with significant increase in the stock prices. Given that global market is still segmented, the size of a country is likely to be relevant for the asset pricing. On the other hand, Campante & Do(2007) find a negative relationship between population size and income inequality. Therefore in this section, to isolate the inequality effects from country size effects, I include total population and total GDP of a country in lieu of the GDP per capita in regressions.
Table 2.7 replicates the Model 2, 4 in Table 2.5A, 2.5B and Model 7,8 in Table 2.6A, 2.6B, i.e. the regressions with full set of controls including HB or FB terms indicating degrees of global market segmentation. The first four columns present regressions with Gini all inequality measure and two different P/D ratio measures; column 5-6 present results with WIID2 Gini and column 7-8 with WIID2 IR and (logged) MSCI P/D as dependent variable. A quick look shows that the patterns of cross-country stock market levels remain substantially the same as observed in previous sections. In most of the regressions, even after controlling for proxies of degree of global market integration, domestic income inequality still has statistically significant negative correlation with market P/D ratio. In developed countries, this inverse relationship is even more notable than in developing countries. Estimates show that population is not an economically or statistically significant factor for stock market price except for in one model (column 2), where the coefficient has a t-stat of 2.08. GDP is shown to be positive and significant in most regressions, although the scale is very small. In all, Table 2.7 consolidates that countries with higher inequality tend to have lower stock market.

Overall, this section further corroborates our evidence that difference in domestic income disparities across the wide range of countries has important asset pricing implications. Specifically, international differences in the degree of income inequality are strongly and negatively associated with the cross-sectional variation of the market price and dividend ratio. The conclusion is robust to both measures of inequality and different specifications of regressions.
2.5 Decomposing the PD Ratio

In section 3 and 4, I find significant evidence of a negative relationship between degree of domestic income inequality and stock market levels. The relationship is more pronounced in developed countries than in developing countries. I have put these findings to extensive empirical scrutiny in a cross-country context, and the data robustly confirm them.

While the negative coefficients on income inequality should be interpreted with caution, it is more reasonable to view it as reflecting the influence of inequality on stock prices than the other way around. Even if domestic stock market level does play a role in transitorily altering the income distribution, we should observe larger gap between the rich and the poor during a booming market since the rich usually hold more stocks and benefit more from higher market level. In other words, if there is reverse causality, we should observe positive correlation between inequality and market P/D ratio instead of a negative one. Hence it is reasonable to interpret the income inequality as a state variable in determining stock prices.

Now that I’ve established the negative effect of income inequality on price, a question follows naturally: How does inequality affect stock market level?

In asset pricing theory, price (total expected returns) can be decomposed into expected excess returns (risk premium) and risk-free rate. Income distributions may impact stock prices through either or both of these two channels. In this section, I test whether one channel is dominating the other, and empirically evaluate their importance in explaining the observed cross-country correlation between inequality and price dividend ratio.
2.5.1 Expected Excess Returns

The first channel to consider is the expected excess returns channel. A large body of asset pricing literature has been devoted to solving equity premium puzzle with heterogeneous agents. Among them, most models share the common ingredients of an incomplete market setting, with uninsurable income risk, stock market entrance cost and/or borrowing constraints. The rationale is that the entrance cost (and borrowing constraint) leads to limited stock market participation and limited risk sharing, eventually resulting in higher equity premium. Giannetti and Koskinen (2010) document a significant link between income Gini and stock market participation rate in several of their regressions using cross-country data. Favilukis (2013) combines income inequality, participation cost, and borrowing constraints in a model to jointly explain observed trends in wealth inequality, stock market participation, decreasing interest rate and equity premium puzzle. All these works help to propose a possible explanation of how income inequality affects risk premium and stock price. An important determinant of the decision on whether to participate in stock market is the magnitude of the costs relative to the investor’s income. When these costs are fixed across investors, income distribution thus plays a role on the degree of their participation in domestic market. Therefore, income inequality can be viewed as a proxy for the participation rate of domestic stock market and a proxy for degree of domestic risk sharing.

This theory not only is consistent with evidence of the inverse relationship between inequality and market level across countries, it also potentially explains why this relationship is stronger in developed countries. In developed countries, higher inequality is more likely to lead to lower degree of participation and limited risk sharing than in under-developed countries: Indeed, in a developing country with very low average income, a lower Gini (more “equal”) probably means a larger fraction of poverty among population and therefore fewer people can afford to buy stocks.
While in economies with higher average incomes, lower Ginis usually represent a larger fraction of people belong to middle- or high-income class that are able to pay to enter stock market. In such countries, higher inequality indicates less stock market participation and limited risk sharing among domestic investors. Consequently, the consumption volatility is higher and the risk premium is higher than when income is more equally.

To see if this is the mechanism income distribution impacts returns and stock prices, I employ realized excess market returns from MSCI international equity indices as proxy for risk premia and run them against lagged inequality measures as well as a set of control variables in similar regressions as conducted in Section 2.3 and 2.4. If the above story is true, we should see positive coefficients on inequality. The results are presented in Table 2.8.

\[ r_{it+1} = \alpha_0 + \alpha_1 \times \text{Inequality}_{it} + \alpha_2 \times \text{Interact}_{it} + \sum_j \alpha_j \times X_{jt} + \sum_k \alpha_k \times Z_k + \text{year}_t + \epsilon_{it} \]

Model 1 of Table 2.8 shows the simple regression of realized excess returns on lagged income Gini. The estimated coefficient is -0.15, with a t-stat of merely -0.81. This is contradicting the expected positive sign of inequality in the limited participation theory. When adding in more control variables, I obtain mixed signs on the estimates of Gini and interaction terms of Gini with dummy “Developed”, all of them statistically insignificant. For instance, in the full regression with home bias (Model 5), the estimate on Gini itself is 0.13 (t=0.20), while in most other models, the estimated coefficients on Gini are slightly negative. In the regression with foreign investability (Model 6) where the estimate is about 0 (t=0.01). In more developed countries, estimates on the interaction terms in Model 5 and 6 are -0.25 (t= -0.77) and -0.34 (t= -1.07) respectively, slightly
more significant than in developing countries. Even so, they are still far from 10% significance level and have negative rather than positive signs.

It seems from Table 2.8 that the effect of income inequality on “future” excess returns is really ambiguous and inconclusive at the best. This is contradicting the mechanism discussed above that higher inequality potentially raises equity premium by limiting the rate of stock market participation. However, these results may also be partly due to the fact that realized returns are noisy measures of expected excess returns, as well as the lacking data. Unlike excess returns data, interest rates are more directly and more reliably recorded and thus may provide better tests to draw for conclusions.

2.5.2 Real Interest Rate

A second channel for income distribution to affect prices is through risk-free rate. On the one hand, as discussed in the previous section, higher inequality may mean that a larger fraction of population is restricted from participating in stock market and buffering their idiosyncratic risks. This is more likely to happen in “richer” countries. Consequently, the demand for precautionary saving grows and therefore lowers the interest rates. On the other hand, higher inequality may also imply that a smaller fraction of the population, especially in poorer countries, can even afford to save. This means that inequality can also have a negative effect on the demand for saving and positive effect on the interest rates.

I examine both possibilities with regressions and report results in Table 2.9. The dependent variable in these regressions is the T-bill rates from IMF adjusted for inflation; For the country-years where T-bill rates are not available, I create the “pseudo” T-bill rates by subtracting the cross-country average of spread between prime (lending) rates and T-bill rates from the prime
rates. The spread data are obtained from WDI database of World Bank. Table 2.9 reports the regressions of real interest rates on Gini coefficients and other control variables.

The single regression (Model 1) shows an estimated coefficient of about 0.22 (t= 2.52) on Gini. More regressions in Model 2 to Model 6 confirm the positive relationship between real interest rate and the Ginis.

Beside income inequality, difference in the fractions of saving population across countries may contribute to the difference in interest rates. To examine this effect, I control for net saving rate in model 7 and Model 8 of Table 2.9 in addition to the regressors in Model 5 and 6. Net saving rates are net national savings as percent of Gross National Income (GNI). Here the net national savings are GNI less total consumption (including consumption of fixed capital) and then plus net transfers. Savings data are from WDI database of World Bank. In both Model 7 and 8, real interest rates are significantly negatively related to net saving rate as expected. Nevertheless, the coefficient on Gini in Model 7 with HB (home bias) is still positive (0.19) at about 10% significance level (t=1.70). In Model 8 where global segmentation is proxied by FB (foreign investability), the estimate of coefficient on Gini is even more significant at 1% level (t = 3.22).

A natural question to ask is whether this positive interest rate effect is big enough to explain the inequality effect on P/D. To answer it, I divide the sample into 10 deciles according to the value of Giniall. Moving from decile 1 to decile 10, the average Giniall varies by 29.25 points, from 26.79 to 56.04. Recall that the estimated coefficient on Giniall in the benchmark P/D regression model (Model 6 of Table 2.3) is about -0.02. The P/D therefore drops by 58.5% from its initial value of 41.01 moving from decile 1 to 10. The Gini coefficient in the corresponding interest rate regression

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17 In unreported regressions, I also use prime (lending) rates (from WDI) instead of T-bill rates as dependent variable, or repeat the regressions on the subsample of country-years where the T-bill rates are available. The results remain substantially unchanged.
(Model 4, Table 2.9) implies a 526.5 basis point increase in real interest rate for the same move. Now let’s assume in accordance with the Lucas model that \( P/D \) is roughly equal to \( 1/(r_f + EP - \mu) \), where \( r_f \) is the risk-free rate, \( EP \) is the risk premium and \( \mu \) is the expected dividend growth rate.

Given that the average real interest rate in decile 1 is 2.25%, moving from decile 1 to decile 10 yields a new interest rate of 7.52%. If we further assume that risk premium and dividend growth are of similar size so roughly cancels each other out, the new \( P/D \) resulted from change in real interest rate alone is then about 13.3, a nearly 68% cut from the original value (41.01). This means that the inequality effect on real interest rate is more than enough to explain inequality effect on the market level.

Results in Table 2.9 are both interesting and puzzling. They help verify that inequality influence prices through interest rates channel and not the excess returns channel. However, none of the existing asset pricing models or theories seems able to explain this positive effect. They raise a new question about the mechanism of interaction between inequality and interest rates.

### 2.6 Concluding Remarks

This paper is motivated by both the recent policy-related debates on income inequality and by the large body of asset pricing models with incomplete markets and heterogeneous agents. I try to examine and quantify the effect of income inequality by estimating its impact on stock market wealth. This method provides a non-ideological way to evaluate policies that influence income distribution. Specifically, I argue that with the presence of global market segmentation, the cross-country differences in domestic income distributions may play a role in determining the cross-country variations in stock market levels (scaled by the market’s aggregate dividends). This
hypothesis is consistent (although indirectly) with many asset pricing models that incorporates heterogeneity, uninsurable income risks and limited risk-sharing. Thus testing of the hypothesis also provides a way of indirectly testing these models.

Several important issues are addressed when specifying the regression model and interpreting the empirical results. A first one is that the entire argument of linking the international variation in market levels to international diversity in income inequality relies on the assumption that global market is not fully integrated. This is the maintained assumption throughout the study. Moreover, the degree of global market segmentation interplays with domestic income inequality to affect domestic stock market level. Hence I include two alternative proxies of global risk-sharing in some regressions to control for their effects. Another identification issue is the endogeneity of the main independent variable, income inequality. Econometrically, endogeneity may result from both omitted variables and measurement errors. To address the omitted variable problem, I control for a comprehensive set of variables that are likely related to both income inequality and stock market levels and include year fixed effects in all regressions. I also employ different proxies of income inequality from two sources with highest quality income data to minimize the measurement errors. All the price-inequality regressions consistently and robustly reveal significant negative correlation between the two, despite the various specifications and alternative measures of both dependent and independent variables. This correlation can be viewed to reflect the negative effect of income inequality on stock price. Two arguments help ruling out the reverse causality: One is the fact that income distribution is mainly driven by slow-moving institutional and social components. It is hard to conjecture a mechanism for stock market levels to affect these components or the equilibrium income distributions. Secondly, although stock market fluctuations may temporarily alter income inequality, a positive correlation should be observed to result from this mechanism while my
regressions show a negative correlation that’s not only statistically significant but economically significant as well. Keeping other things constant, a 0.01 increase in income Gini alone can lower the market P/D ratio by up to 2%.

I further discover that the negative effect of income inequality on stock market level is stronger in developed countries than in developing countries, and it is not weakened by the inclusion of proxies for global risk sharing (also measuring the degree of domestic market’s segmentation from the global market). These findings show that income distributions do matter for stock prices. They not only provide supporting evidence for models with heterogeneity, but also point to the possibility to model income distribution directly as a state variable in pricing models. To identify the channel and possible mechanism of how income inequality affects prices, I decompose price into expected excess return and risk-free rate and investigate how each of the two components are related to inequality in cross-country settings. I find that income inequality has strong positive effects on interest rates but hardly seems to have any effect on subsequent excess returns. Therefore I conclude for this part that income distributions mainly affect prices through the risk-free rate channel.

To the best of my knowledge, my research here is the first cross-country study on the price impact of income distributions. It is also the first to explore the main channel linking inequality and prices. From the modeling perspective, the findings in this paper are both novel and puzzling. Evidences of significant negative cross-sectional effect of income inequality on stock market P/D ratio provide strong empirical support for the asset pricing models with heterogeneous agents as well as grounds for theories to incorporate income distribution as state variables. On the other hand, the estimated strong positive correlation between interest rates and income inequality poses a challenge to the existing pricing models since it cannot be explained by any of these models. For
policy makers, my paper provides a straightforward way to quantify the effect of income inequality and directly evaluate the policies that have implications for income distributions. The conclusion in this regards is that policies that increase income inequality are expected to decrease the stock market wealth.
CHAPTER 3: INCOME HETEROGENEITY, INEQUALITY AND INTEREST RATES

3.1 Introduction

The sharp increase in income inequality globally in the past couple of decades is a well-documented fact. Meanwhile there are still great differences in the distribution of income across countries. Understanding the consequences of inequality on various aspects of macroeconomics is a challenge to many economists.

In Chapter 2, I try to contribute to this understanding by studying if and how cross-country variations in domestic income distributions is related to cross-country differences in asset valuations. I find a significant negative correlation between income inequality and stock market levels (measured by price-dividend ratios) after controlling for an extensive set of country-specific risk factors and characteristics. I then decompose price dividend ratio into risk-free rate and expected excess returns and examine the link between each of these components and inequality. I find that increasing income disparity lowers prices mainly by raising real interest rates, while there is no evidence that inequality is positively related to expected excess returns.

Why the interest rate is positively related to income inequality is puzzling and incompatible with most existing theories, as will be discussed later.

Building on the work of Athanasoulis(2005), this paper tries to answer this question by taking a closer look at how interest rate and income inequality are each connected to the heterogeneity in idiosyncratic income risks. I accomplish the task by obtaining and examining closed-form solutions to equilibrium interest rate, portfolio holdings and inequality in a discrete-time asset pricing model that features untradable idiosyncratic income risks and constant absolute risk
aversion (CARA) preference. In this model, individual income risks have different correlations to the aggregate risk, and income heterogeneity is defined as the cross-sectional variance in these correlations. A couple of insights are gained from the model: Firstly, the equilibrium interest rate goes up with dispersion in income risks. The rationale is that, in the same vein as the optimal portfolio diversification, the more dispersed the idiosyncratic risks (in terms of their correlations to the aggregate risk), the easier for agents in the economy to cancel out their risks by trading with others. With improved risk sharing in the economy, the volatility of average consumption growth drops, and this in turn reduces the precautionary saving motive, resulting in higher interest rate in the equilibrium. Meanwhile, the model also shows that consumption inequality, defined as the expected dispersion in consumption growth, is an increasing function in income heterogeneity. These two results provide a possible explanation for the positive correlation we observe between interest rate and the inequality: it may be reflecting both interest rate and inequality’s positive connection to income heterogeneity.

The empirical test of the model requires some measure of income heterogeneity in data. Since the dispersion in the covariances of individual risks with the aggregate risk is not directly observable, I solve for two quantities from the model that can be used to proxy for it in empirical tests. One of them is the ratio of average consumption risk to the average income risk. This ratio measures how dampened the volatility of average consumption is relative to the volatility of income and thus captures the total effectiveness of risk sharing in the economy, including the part that is due to income heterogeneity. Under the model setting, this ratio is increasing in income heterogeneity. The other proxy for income heterogeneity is the saving rate of the

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18 By construction, the income inequality in this model does not rely on dispersion in income risks. It is reasonable to consider consumption inequality instead of income inequality because the two are positively and closely related. Besides, consumption is considered by most economists a more relevant measure of well-being than income.
economy, defined as the cross-sectional variance in the equilibrium bond demands. I show numerically that for reasonable parameter values and sufficient level of income heterogeneity, the saving rate drops as heterogeneity gets higher. Empirical tests confirm that saving rates go some way in reducing the positive coefficient of real interest rate on income inequality. However, the ratio of consumption risk to income risk does not help.

Since the focus of this study is how inequality influences equilibrium pricing, it is natural to look at related works in extant asset pricing literature where heterogeneity is incorporated. There are two types of heterogeneities to be considered: *ex-ante* heterogeneity like dispersion in agents’ preferences and *ex-post* heterogeneity like labor income risks etc. There has been some theoretical and empirical evidence that either one of them or a combination of the two can influence both the income (wealth) inequality and the equilibrium quantities and prices, which I discuss in more details later.

It is worth mentioning first though, as shown in Constantinides(1982), the equilibrium of an economy with heterogeneous agents can be duplicated by the equilibrium in a Lucas representative economy when the assumptions of complete markets, frictionless transaction and CRRA utilities are maintained. In other words, income or wealth distribution does not matter unless one or more of the above assumptions is removed.

Gollier(2001) is an example of maintaining the complete market assumption while removing CRRA preference. He shows that in an Arrow-Debreu economy with otherwise identical agents except for their initial endowment, wealth inequality reduces the equilibrium risk-free rate if agents have concave absolute risk tolerance (the inverse of Arrow-Pratt absolute risk aversion).

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19 Ana Castañeda et al.(2003) shows that uninsured idiosyncratic shocks to ex-ante identical households’ endowments of efficiency labor account for the U.S. earnings and wealth inequality almost exactly; and Cozzi(2011) finds that models calibrated with heterogeneous preference replicates several features of US wealth distribution well, including the bottom and top quintiles.
Instead of relying solely on nonstandard preference, a growing literature takes a different route to examine how heterogeneity influences asset prices by relaxing the complete or frictionless market assumption. For example, Huggett(1993) argues that uninsurable idiosyncratic shocks imply a precautionary motive for saving that increases aggregate wealth and reduces the equilibrium interest rate. In his model, there is no state-contingent security to insure idiosyncratic endowment risk, and only a risk-free asset. In more recent models with heterogeneity and incomplete market, households can usually trade assets other than risk-free bond to hedge their risks. However the implication of heterogeneity on equilibrium level of interest rate remains: the lack of full complete insurance market and limited risk sharing lead to higher average consumption risk of all or part of the agents in the economy, which raises their precautionary saving motive and suppresses the equilibrium interest rate. Athanasoulis(2005) solves a model with uninsurable labor income risks and CARA utility function and analytically shows that interest rate is lowered by the incorporation of untradable idiosyncratic risks. Chien and Lustig(2010) introduces limited liability into their model to create endogenous solvency constraints and delivers substantial variation in equity risk-premiums and a low risk-free rate. Other examples include a large body of asset pricing models with limited stock market participation (Basak and Cuoco(1998) and Polkovnichenko(2004)\textsuperscript{20}, etc.). The mechanism is that the aggregate risk is concentrated in the hands of stock holders and equilibrium interest rate directly responds to the precautionary saving motive of this part of the population, which is higher than in an unrestricted economy. The assumption of borrowing constraints is also effective in delivering a low risk-free rate in a model with idiosyncratic income risks. It works

\textsuperscript{20} Polkovnichenko(2004) reaches the lower interest rate result with the additional assumption that stockholders are more risk averse than nonstockholder.
either on its own (Telmer(1993) and Heaton and Lucas(1996)) or coupled with limited participation (Guo(2004) and Favilukis(2013)).

In addition to the literature with ex-post heterogeneity mentioned above, several papers also reach the conclusion that ex-ante heterogeneity may result in lower interest rate. Guvenen(2009) studies asset prices in a two-agent macroeconomic model with limited stock market participation, heterogeneity in the elasticity of intertemporal substitution in consumption (EIS) and Epstein-Zin preference. His model delivers a much lower risk-free rate compared to that in a standard representative economy\textsuperscript{21}. Cozzi(2011) examines whether heterogeneity in people’s attitude toward risk helps accounting for US wealth inequality. He develops an incomplete model with uninsurable labor income risk and heterogeneity in agents risk aversion. The calibrated\textsuperscript{22} model was able to match several features of the observed wealth distribution, including the bottom and top quintiles. The model also shows that the inclusion of preference heterogeneity gives rise to higher precautionary saving and lower interest rate.

To conclude, all these models imply that higher income inequality, which is usually the outcome of the heterogeneities discussed above, should result in lower interest rate\textsuperscript{23}.

The model in my paper is based on Athanasoulis(2005). However, instead of focusing on the effect of the magnitude of the idiosyncratic income risks on pricing as in his paper and in most of the papers mentioned above, I look at the cross-sectional variations in idiosyncratic income risks. Specifically, I examine if the variations in the correlations of individual risks with the aggregate

\textsuperscript{21} The author argues that “the low risk-free rate is helped by the fact that the model abstracts from long-run growth and preferences are of the Epstein–Zin form.”

\textsuperscript{22} The model is calibrated with preference distributions from Kimball et al.(2009), Harrison et al.(2007) and Chiappori and Pailla(2011) and the three setting result in remarkably similar wealth distribution.

\textsuperscript{23} In addition to the asset pricing theories discussed here, Rajan(2011) provides a different theory for the income inequality to affect interest rate. He argues that politicians respond to rising inequality by giving out easy credits to prop up the living standards of the population with lower income and this eventually leads to financial crisis. If this is the case then we should see a positive correlation between interest rate and inequality. Again this is just the opposite of what I find in Chapter 2.
risk affect the scope of risk sharing and the equilibrium prices. As far as I know, this paper is the first to study the asset pricing implication of heterogeneity from this angle. The emphasis on how aggregate and idiosyncratic fluctuations covary is important for a couple of reasons. Firstly there has been empirical evidence that there is extensive heterogeneity in the correlation between individual income and stock returns (See, for example, Heaton and Lucas (2000), Campbell et al. (2001) and Davis and Willen (2000)). Secondly it allows us to gain better understanding of the extent to which heterogeneity, when coupled with market incompleteness, amplifies the effect of aggregate shocks. Although this paper only zooms in on the influence of heterogeneity in the covariance between individual and aggregate risks on interest rate, the model can obviously be used to examine the role of the heterogeneity on, for example, determining portfolio holdings and in other issues of asset pricing.

Overall, this paper presents some supporting evidence for the model-implied hypothesis that cross-country variations in income heterogeneity is the driving force behind the observed positive real interest rate-inequality relation. However, the evidence is still mixed. While one proxy (saving rate) of income heterogeneity explains away part of the positive coefficient of interest rate with respect to inequality, the other proxy (ratio of the average consumption risk to income risk) does not reduce the coefficient on inequality. This may be partially attributed to the deficiency in the construction of the proxies though. Both measures are created with aggregate income (GDP or GNI) and consumption data from each country, which can be insufficient to capture the cross-sectional variations within the country \(^{24}\). Further tests with income

\(^{24}\) That said, when compared across countries, the differences in these aggregate quantities should be able to reflect differences in the within-country heterogeneity at least to some degree, especially when other country-level characters are controlled for.
heterogeneity proxies constructed from micro-level income and consumption data\textsuperscript{25} can be done to see if this is the case. Taken at face value, the model’s interpretation of the evidence could have implications for predicting the effects of redistributive policies that affect income inequality. The model also implicitly implies the importance of risk sharing channels other than financial market in determining the equilibrium price and quantities. For example, both public and private insurance directly and indirectly\textsuperscript{26} improve the scope and level of risk sharing for a given income distribution and therefore may affect the saving pattern of the economy and the valuations.

The rest of the paper is organized as follows. Section 2 describes an incomplete asset pricing model with income heterogeneity and formulates how interest rates, inequality and two other endogenous quantities are each affected by the heterogeneity. Section 3 empirically tests the hypothesis derived from the model and discusses the role of income heterogeneity in the positive interest rate-inequality correlation. Section 4 concludes.

### 3.2 Model

The model in this section is based on the framework developed by Athanasoulis\textsuperscript{(2005)}, who tries to study how primitives such as endowments, preference and exogenous properties (e.g. stock market participation rate) affect the equity premium and Sharpe ratio etc. When evaluating the effect of income risks on asset prices, Athanasoulis only looks at the magnitudes of the idiosyncratic income risks and does not analyze other heterogeneity in income risks, while my study concentrates on the dispersion of income risks in terms of how they covary with the aggregate dividend risk.

\textsuperscript{25} For example, Luxembourg Income Study (LIS) and Integrated Public Use Microdata Series (IPUMS) have household-level income and consumption data for a list of countries.

\textsuperscript{26} Gormley et al.(2010) shows that access to insurance market helps hedging large negative wealth shock and increases investors’ willingness to participate in stock market.
The model is set up as follows.

The economy is populated with N individuals who are infinitely lived. They each maximize the life-time utility function

\[-\frac{1}{\gamma} \sum_{t=0}^{\infty} \frac{1}{(1+\rho)^t} e^{-\gamma C_t} \]  

(1)

where \( \gamma \) is the risk aversion parameter and \( \rho \) is the discount rate.

The consumption \( C \) comes from two sources: Each agent is endowed with an asset that pays an infinitely-divisible and tradable dividend \( D \) each period. The per capita dividend stream \( D \) follows a random walk with a drift:

\[ \Delta D_t = d + \varepsilon_t \]  

(2)

where \( \varepsilon \) is i.i.d. normal with zero mean and variance \( \sigma^2 \).

In addition, each individual also receives a non-tradable labor income that pays a random walk stream \( Y_i \):

\[ \Delta Y_{i,t} = y_i + \xi_{i,t} \]  

(3)

where \( \xi \) is i.i.d. normal with zero mean and variance \( \sigma_i^2 \). Assume \( \varepsilon \) and \( \xi \) for \( i = 1, \ldots, N \) are jointly normally distributed with correlation \( \theta_i \) and the innovations are uncorrelated across time.

At each time \( t \), the agents can trade their share of \( D \) as well as a one-period bond that has zero net supply, unit price and earn (endogenous) interest rate \( r_t \); Define \( q_i(t) \) and \( b_i(t) \) as the shares of the risky asset and bond held by individual \( i \) at time \( t \), and \( P_t \) as the price of the risky asset. Then \( i \)'s budget constraint at each time \( t \) is:

\[ q_i(t)P_t + b_i(t) + C_{i,t} = q_i(t-1)(P_t + D_t) + Y_{i,t} + b_i(t-1)(1 + r_{t-1}), \forall t \geq 1 \]  

(4)
Under the assumption of CARA utility, the portfolio holding, prices, interest rate in the equilibrium and many other variables can be solved in closed form.

It is worth noting that there are two types of income heterogeneity in this model: the \textit{ex-ante} agent heterogeneity that is due to the dispersion in $\theta_{i,t}$ i.e. the dispersion in idiosyncratic income risks in terms of their correlations to the aggregate risk, and the \textit{ex-post} heterogeneity that is realized through the specific income shocks $\xi_i$. In this paper, the focus is on the former, the cross-sectional variances in $\theta_{i,t}$.

In the following subsections, I show analytically how interest rate, inequality and income heterogeneity are related to each other.

\subsection*{3.2.1. Real Interest Rate}

From here on, for tractability I assume $N \to \infty$ and $\gamma_i \equiv \gamma$, $\sigma_i \equiv \sigma_o$ for all $i$. In addition, I assume $\beta_i$ is symmetrically distributed so that $E[\beta_i^3] = 0$, and $\text{Var}(\beta_i^2) = a(\text{Var}(\beta_i))^2$ for some constant $a \geq 0$.

**Proposition 1:** The equilibrium real interest rate $r_t$ is constant over time, i.e. $r_t = r$ and is an increasing function of income heterogeneity $\text{Var}(\theta_i)$:

\[ r = (1 + \rho)e^{(\gamma y - \frac{1}{2}y^2\sigma_e^2)} - 1 \]  

(5)

Where $\sigma_e^2$ is the average consumption risk:

\[ \sigma_e^2 = \sigma_o^2 - \sigma^2\text{Var}(\beta_i) = \sigma_o^2(1 - \text{Var}(\theta_i)) \]  

(6)

and $\beta_i = \theta_i \frac{\sigma_o \sigma}{\sigma^2}$  

(7)
Proof: Assume at time $t$, agent $i$’s stock holding is $q_i(t) = q_i$, then from Athanasoulis (2005), $r_t = r$ and

$$\ln(1 + r) = \ln(1 + \rho) + \gamma \left( \frac{1}{N} \sum_{i=1}^{N} q_i d + \frac{1}{N} \sum_{i=1}^{N} y_i \right) - \frac{\gamma^2}{2} \frac{1}{N} \sum_{i=1}^{N} \sigma_{c,i}^2$$ (*)

Define $\beta_i = \theta_i \frac{\sigma_i \sigma}{\sigma^2} = \theta_i \frac{\sigma_o \sigma}{\sigma^2}$ and individual $i$’s stock holding at time $t$ is:

$$q_i = \frac{1}{N} + \frac{\sum_{i=1}^{N} \theta_i \sigma_i - \theta_i \sigma_i}{\sigma} = \frac{1}{N} + \bar{\beta} - \beta_i \Rightarrow \frac{1}{N} \sum_{i=1}^{N} q_i = 1 / N$$

And variance in $i$’s innovation in consumption, i.e. agent $i$’s consumption risk:

$$\sigma_{c,i}^2 = q_i^2 \sigma^2 + \sigma_i^2 + 2q_i \theta_i \sigma_i = \sigma^2 (\beta^2 - \beta_i^2) + \sigma_o^2$$

So the average consumption risk is decreasing in $\text{Var}(\theta_i)$ since:

$$\bar{\sigma}_c^2 = \frac{1}{N} \sum_{i=1}^{N} \sigma_{c,i}^2 = \sigma^2 \frac{1}{N} \sum_{i=1}^{N} (\beta^2 - \beta_i^2) + \frac{1}{N} \sum_{i=1}^{N} \sigma_o^2$$

$$= -\sigma^2 \text{Var}(\beta_i) + \sigma_o^2 = \sigma_o^2 (1 - \text{Var}(\theta_i))$$

Substitute into equation (*) and rearrange, we have

$$r = (1 + \rho) e^{(\gamma y - \frac{1}{2} \gamma^2 \sigma_c^2)} - 1$$

Since the discount rate $\rho$ is positive:

$$\frac{\partial r}{\partial (\text{Var}(\theta_i))} = \frac{1}{2} \gamma^2 \sigma_o^2 (1 + \rho) e^{(\gamma y - \frac{1}{2} \gamma^2 \sigma_c^2)} > 0$$

Therefore the equilibrium interest rate $r$ is increasing in the income heterogeneity $\text{Var}(\theta_i)$. ■
Here $\beta_i = \theta_i \frac{\sigma_i \sigma}{\sigma^2}$ is the dividend beta: higher $\beta_i$ means an individual will trade more $D$ to hedge his labor income risk. $\beta_i$ depends on both the magnitude of labor income risk and how individual labor income risk covaries with aggregate (dividend) risk. Income heterogeneity $Var(\theta_i)$ measures how dispersed individual income risks are in terms of their correlation to the aggregate risk. $Var(\beta_i) = \frac{\sigma_\theta^2}{\sigma^2} Var(\theta_i)$ therefore tells us the risk sharing capacity due to this income heterogeneity through trading of the market portfolio.

In short, *Proposition 1* states that income heterogeneity ($Var(\theta_i)$, or $Var(\beta_i)$) increases real interest rate by reducing the average consumption risk. The intuition is that given the existing risk sharing channels, the more diversified the population in terms of their income risk profiles, the higher the chance of the individual risks canceling each other out. In this sense, an economy with high income heterogeneity is similar to a diversified investment portfolio in that risks are minimized due to the diversification. Therefore income heterogeneity contributes to risk sharing and consumption smoothing. People have less precautionary saving motives and thus the interest rate increases.

### 3.2.2. Inequality

In the previous section, I show that interest rate is positively related to the income heterogeneity. In this section I investigate how income heterogeneity is related to *inequality*.

Usually income inequality refers to disparity in income *levels*. However, by model assumptions, income *level* is nonstationary and therefore the inequality is undefinable for the levels. For this reason, the income inequality in this model is defined as expected value of the dispersion in income *growth* (increment). Similarly the consumption inequality is also defined as the dispersion in consumption growth.
According to this definition, *income inequality* in the model is exogenous and is not related to $\text{Var}(\theta_i)$. Since we assume that $N \to \infty$ and $y_i = y$ for all $i$, by Law of Large Numbers, income inequality is

$$
E[\text{Var}_i(\Delta Y_i)] = E[\text{Var}_i(y_i + \xi_{it})] = E[\text{Var}_i(\xi_{it})] = \sigma_0^2
$$

(8)

Therefore the *income inequality* here is not affected by the heterogeneity in covariances between individual and aggregate risks.

However, *consumption inequality* in the model is endogenous. Although the findings that this paper aims to explain are based on *income inequality* data, it is justified to consider *consumption inequality* here for two reasons.

Firstly, consumption is usually deemed a more comprehensive measure of well-being of the consumers and consumption inequality is what really matters. Income inequality is more broadly adopted in empirical studies mainly because income is easier to report than consumption and income data are considered more accurate than consumption data.

On the other hand, what we observe between income inequality and interest rate may indeed be reflecting the relationship between consumption inequality and interest rate. The two inequality measures are closely related and many literatures (Krueger and Perri(2006), Aguiar and Bils(2011) and Meyer(2013) etc.) have confirmed that the two inequality measures usually have the same trend of growth.

**Proposition 2:** *Consumption inequality is monotonically increasing in income heterogeneity $\text{Var}(\theta_i)$ and $\text{Var}(\beta_i)$*

$$
E[\text{Var}_i(\Delta C_{it})] = \sigma_0^2 + \sigma^2 \text{Var}(\beta_i) + \frac{ay^2}{4} \sigma^4 (\text{Var}(\beta_i))^2
$$
\[ = \sigma_\theta^2 + \sigma_\delta^2 \text{Var}(\theta_i) + \frac{\alpha \sigma_\theta^2}{4} \text{Var}(\theta_i)^2 \]  
\(9\)

where \(\alpha\) is a non-negative constant.

**Proof:** Assume at any time \(t\), the stock holding \(q_i(t) = q_l\) and the bond holding \(b_i(t) = b_0 + b_1 t\).

The consumption inequality is defined as:

\[
E[\text{Var}_i(\Delta C_{i,t})] = E[\text{Var}_i(q_i \Delta D_t + \Delta Y_{i,t} + r b_{1,t})]
\]

\[
= E[\text{Var}_i(q_i (d + \varepsilon_t) + (y + \xi_{i,t}) + r b_{1,t})]
\]

Since the stock holding is:

\[
q_i = \frac{1}{N} + \sum_{l=1}^{N} \theta_l \sigma_o \frac{\theta_l \sigma_o}{\sigma} = \bar{\beta} - \beta_l
\]

It will be shown in Proposition 3 that

\[
r b_{1,t} = -[q_i d - \frac{\gamma}{2}(\sigma_{c,l}^2 - \bar{\sigma}_c^2)]
\]

where

\[
\beta_l = \theta_l \sigma_o \sigma^2 \text{ and } \bar{\beta} = \frac{1}{N} \sum_{l=1}^{N} \beta_l, \ N \to \infty
\]

\[
\sigma_{c,l}^2 = q_i^2 \sigma^2 + \sigma_\delta^2 + 2q_i \theta_i \sigma_o \sigma = \sigma^2 (\bar{\beta}^2 - \beta_l^2) + \sigma_\delta^2
\]

\[
\bar{\sigma}_{c}^2 = \frac{1}{N} \sum_{l=1}^{N} \sigma_{c,l}^2 = \sigma_\delta^2 - \sigma^2 \text{Var}(\beta_l) = \sigma_\delta^2 (1 - \text{Var}(\theta_i))
\]

Therefore

\[
\text{Var}_i(\Delta C_{i,t}) = \text{Var}_i \left( (\bar{\beta} - \beta_l) \varepsilon_t + \xi_{i,t} + \frac{\gamma}{2}(\sigma_{c,l}^2 - \bar{\sigma}_c^2) \right)
\]

\[= \text{Var}_i \left( -\varepsilon_t \beta_l + \xi_{i,t} - \frac{\gamma}{2} \sigma^2 \beta_l^2 \right)\]
\[ = \varepsilon_t^2 \text{Var}(\beta_i) + \text{Var}(\xi_{i,t}) + \frac{\gamma^2}{4} \sigma^4 \text{Var}(\beta_i^2) + 2\varepsilon_t \text{Cov}(\beta_i, \xi_{i,t}) + \varepsilon_t \gamma \sigma^2 \text{Cov}(\beta_i, \beta_i^2) \]
\[ - \gamma \sigma^2 \text{Cov}(\xi_{i,t}, \beta_i^2) \]

Using the fact that
\[ \text{Cov}(\beta_i, \xi_{i,t}) = \text{Cov}(\xi_{i,t}, \beta_i^2) = 0 \]

We have
\[ E[\text{Var}(\Delta C_{i,t})] = E[\varepsilon_t^2 \text{Var}(\beta_i) + \text{Var}(\xi_{i,t}) + \frac{\gamma^2}{4} \sigma^4 \text{Var}(\beta_i^2) + \varepsilon_t \gamma \sigma^2 \text{Cov}(\beta_i, \beta_i^2)] \]
\[ = \sigma^2 \text{Var}(\beta_i) + \sigma_o^2 + \frac{\gamma^2}{4} \sigma^4 \text{Var}(\beta_i^2) \]

Since \( \beta_i \) is assumed to be symmetrically distributed, \( E[\beta_i^3] = 0 \); and since \( \text{Var}(\beta_i^2) = a(\text{Var}(\beta_i))^2 \) for some constant \( a \geq 0 \):
\[ E[\text{Var}(\Delta C_{i,t})] = \sigma_o^2 + \sigma^2 \text{Var}(\beta_i) + \frac{ay^2}{4} \sigma^4 (\text{Var}(\beta_i))^2 \]
\[ = \sigma_o^2 + \sigma^2 \text{Var}(\theta_i) + \frac{ay^2}{4} \sigma^4 (\text{Var}(\theta_i))^2 \]

Hence
\[ \frac{\partial E[\text{Var}(\Delta C_{i,t})]}{\partial (\text{Var}(\theta_i))} = \sigma_o^2 + \frac{ay^2}{2} \sigma_o^4 \text{Var}(\theta_i) > 0 \]

\[ \blacksquare \]

The proposition above states that the consumption inequality grows as the idiosyncratic income risks become more diversely distributed. We have also seen in Section 2.1 that equilibrium
interest rate is higher when $Var(\theta_i)$ is higher. Hence income heterogeneity $Var(\theta_i)$ may be the nexus that positively links the consumption inequality to interest rate. Meanwhile, empirical studies have shown that changes in income inequality are of the same directions as those in consumption inequality. So the empirical finding that real interest rate is positively related to income inequality across countries may also be driven by both of their connections to income heterogeneity.

3.2.3. Risk Sharing Measures vs. Income Heterogeneity

The previous two sub-sections have established that both the real interest rate and the (consumption) inequality increase in income heterogeneity $Var(\theta_i)$. I conjecture that the diversity in the labor income risks not only contributes to growing inequality among agents, but also raises the chance for better risk sharing among agents and in turn lifts interest rate of the economy.

The difficulty to test this hypothesis empirically, however, lies in that income heterogeneity $Var(\theta_i)$ is not observable. To solve this problem, I come up with two risk sharing measures that can be used to proxy for income heterogeneity in the empirical tests: The ratio of average income risk to consumption risk, and gross saving rate.

3.2.3.1. Ratio of Average Income Risk to Consumption Risk

If the dispersion in idiosyncratic income risks really promotes risk sharing and we are able to find an empirical measure of this risk sharing effect in data, then it can be used as a proxy for income heterogeneity in the empirical test. One such indicator is ratio of the average labor income risk to the average consumption risk.
This can be seen with some simple calculation:

\[
\frac{\sigma_i^2}{\sigma_o^2} = 1 - \text{Var}(\theta_i) = 1 - \frac{\sigma_i^2}{\sigma_o^2} \text{Var}(\beta_i) \quad (10)
\]

Since the inverse of the above ratio measures how smooth the average consumption is relative to the income, it embodies the total risk sharing effect, through stock market, bonds, and all other available channels, that is due to the income heterogeneity \( \text{Var}(\theta_i) \).

Equation (10) is consistent with the intuition that income heterogeneity \( \text{Var}(\theta_i) \) has positive effect on risk sharing. It also predicts that we should expect a negative (positive) coefficient on the (inverse of the) ratio in Equation (10) if we add it to the regression of interest rate on inequality. If the addition of this factor to the regression equation reduces the positive coefficient on inequality then it provides the evidence that income heterogeneity reduces interest rate by facilitating risk sharing and that the observed interest rate-inequality relationship reflects this effect.

### 3.2.3.2 Gross Saving Rate

In the previous subsection I solve for the ratio that represents the total risk sharing effect of income heterogeneity. Another endogenous quantity that exhibits the specific risk sharing effect of income heterogeneity via the bond market is the saving rate, since the latter captures the heterogeneity in individual borrowing.

**Proposition 3:** At each time \( t \), individual \( i \)'s demand for bond is \( b_{0,i} + b_{1,i} \cdot t \) and \( b_{1,i} \) satisfies

\[
b_{1,i} = \frac{1}{r} \left[ \beta_i - \bar{\beta} \right] d + \left( \sigma_{c,i}^2 - \overline{\sigma_i^2} \right) \frac{\gamma}{2} \quad (11)
\]
Where $\beta_i = \theta_i \frac{\sigma_{\alpha_i}}{\sigma_2} d$ is agent $i$’s dividend beta and $\bar{\beta}$ is the average value of $\beta_i$’s across agents;

$\sigma^2_{c,i} = \sigma^2(\bar{\beta}^2 - \beta_i^2) + \sigma^2_\alpha$ is agent $i$’s consumption risk and $\bar{\sigma}^2_c$ is the average consumption risk.

**Proof:** The Euler equation for the bond price is

$$\frac{1}{1+r} = E_t\left[\frac{1}{(1+\rho)}e^{-\gamma \Delta C_{it}}\right]$$

Substitute in $\Delta C_{it} = q_i \Delta D_t + \Delta Y_{it} + r b_{1,i} = q_i(d + \epsilon_i) + (y + \xi_{i,t}) + r b_{1,i}$, and use the fact that all the terms in the exponents with $i$ subscripts should add up to a constant (call it $\Psi$).

After simplification and rearrangement:

$$\Psi = \frac{\gamma^2 \sigma^2_{c,i}}{2} - \gamma(q_i d + y_i + r b_{1,i}) \quad (**)$$

Since the net supply of bond is zero, i.e. $\sum_{i=1}^{N} b_{1,i} = 0$, summing (**) over $i$ and then take the average, we have

$$\Psi = \frac{\gamma^2}{2} \bar{\sigma}^2_c - \gamma(\bar{q}d + y) = \frac{\gamma^2}{2} \bar{\sigma}^2_c - \gamma y, \text{ as } \bar{q} = 1/N \text{ and } N \to \infty$$

Substitute back into equation (**) and rearrange:

$$b_{1,i} = \frac{1}{r}\left[-q_i d + \left(\sigma^2_{c,i} - \bar{\sigma}^2_c\right)\frac{\gamma}{2}\right] = \frac{1}{r}\left[(\beta_i - \bar{\beta})d + \left(\sigma^2_{c,i} - \bar{\sigma}^2_c\right)\frac{\gamma}{2}\right]$$

The first term of Equation (11), $-q_i d = (\beta_i - \bar{\beta})d$, tells us that individuals whose idiosyncratic risks are less related to the aggregate risks (i.e. smaller $\theta_i$ and $\beta_i$) will buy more stocks to share their income risks and finance their purchase by borrowing. The second term $\left(\sigma^2_{c,i} - \bar{\sigma}^2_c\right)\frac{\gamma}{2}$ shows that people with a consumption path that’s riskier than average will borrow.
Now that we know each individual’s demand for bonds (savings) at each time, we can go ahead and define gross saving rate of the economy.

For analytical tractability, I define the gross saving rate as \( \text{Var}(b_i) \). \( \text{Var}(b_i) \) is monotonically related to average absolute value of individual borrowings.

**Proposition 4:** The gross saving rate \( \text{Var}(b_i) \) can be solved explicitly and be expressed as follows:

\[
\text{Var}(b_{1,i}) = \frac{1}{r^2} \left[ d^2 \frac{\sigma^2}{\sigma^2} \text{Var}(\theta_i) + a \frac{Y^2}{4} \sigma_o^4 \left( \text{Var}(\theta_i) \right)^2 \right]
\]  

(12)

Where the equilibrium interest rate and the average consumption risk are

\[
r = (1 + \rho) e^{(\gamma - \frac{1}{2} \nu^2 \sigma^2)} - 1
\]

(5)

And

\[
\bar{\sigma}^2 = \sigma_o^2 - \sigma^2 \text{Var}(\beta_i) = \sigma_o^2 (1 - \text{Var}(\theta_i))
\]

(6)

**Proof:** From Proposition 3,

\[
b_{1,i} = \frac{1}{r} \left[-q d + (\sigma_{c,i}^2 - \bar{\sigma}^2)^{\frac{Y}{2}} \right] = \frac{1}{r} \left[ (\beta_i - \bar{\beta}) d + (\sigma_{c,i}^2 - \bar{\sigma}^2)^{\frac{Y}{2}} \right]
\]

Where

\[
\beta_i = \theta_i \frac{\sigma_o \sigma}{\sigma^2} d \text{ and } \sigma_{c,i}^2 = \sigma^2 (\bar{\beta}_i^2 - \beta_i^2) + \sigma_o^2
\]

So

\[
\text{Var}(b_{1,i}) = \frac{1}{r^2} \left[ d^2 \text{Var}(\beta_i) + \frac{Y^2}{4} \text{Var}(\sigma_{c,i}^2) + d \gamma \text{Cov}(\beta_i, \sigma_{c,i}^2) \right]
\]

\[
= \frac{1}{r^2} \left[ d^2 \text{Var}(\beta_i) + \frac{Y^2}{4} \sigma^4 \text{Var}(\beta_i^2) - d \gamma \sigma^2 \text{Cov}(\beta_i, \beta_i^2) \right]
\]
Given the assumption that $E[\beta_i^3] = 0$ (hence $E[\beta_i] = \bar{\beta} = 0$), and $\text{Var} (\beta_i^2) = a (\text{Var} (\beta_i))^2$
for some constant $\geq 0$:

$$
\text{Cov}(\beta_i, \beta_i^2) = E[\beta_i^3] - E[\beta_i^2] E[\beta_i] = 0
$$

So

$$
\text{Var}(b_{1,i}) = \frac{1}{r^2} \left[ d^2 \text{Var}(\beta_i) + a \frac{\gamma^2}{4} \sigma^4 (\text{Var}(\beta_i))^2 \right]
$$

$$
= \frac{1}{r^2} \left[ d^2 \frac{\sigma_0^2}{\sigma^2} \text{Var}(\theta_i) + a \frac{\gamma^2}{4} \sigma_\theta^4 (\text{Var}(\theta_i))^2 \right] \quad (12)
$$

And by Proposition 1

$$
r = (1 + \rho) e^{(r\gamma - \frac{1}{2} \gamma^2 \sigma^2)} - 1 \quad (5)
$$

and

$$
\bar{\sigma}_\varepsilon^2 = \sigma_0^2 - \sigma^2 \text{Var}(\beta_i) = \sigma_0^2 (1 - \text{Var}(\theta_i)) \quad (6)
$$

Intuitively, heterogeneity has two effects on saving rate: Higher income heterogeneity drives up saving rate since the dispersion in individual saving is affected by the dispersion in individual’s demand for stocks, which is governed by the diversity of income risks (see Equation (11)). Meanwhile, since heterogeneity in idiosyncratic income risks helps improving risk sharing via diversification, the average consumption risk of the economy drops and thus lowers the precautionary saving motive and in turn the saving rates. Mechanically, since both the denominator and the numerator of the saving rate $\text{Var}(b_{1,i})$ are increasing functions of $\text{Var}(\theta_i)$,
it is hard to tell analytically if the former is increasing or decreasing in the latter. In the next section, I parameterize the model and obtain some numerical results.

3.2.4. Numerical Analysis

While the closed-form solutions from the model provides some easy analytical results and useful intuition on how income heterogeneity may affect inequality and real interest rate, it is not so straightforward to tell from the solutions how saving rate $\text{Var}(b_{1,t})$, income heterogeneity $\text{Var}(\theta_i)$, (consumption) inequality and the equilibrium interest rate $r$ are interrelated. To better identify these links, I conduct some numerical exercises in this section.

3.2.4.1. Parameters

Equations (5), (6), (9) and (12) give expressions of real interest rate, average consumption risk of the economy, consumption inequality and saving rates. To numerically calculate these values as functions of income heterogeneity $\text{Var}(\theta_i)$, I set the following parameter values.

The discount rate $\rho$ is set to be 0.04. For the value of the absolute risk aversion coefficient $\gamma$, I follow Caballero(1991) and Athanasoulis(2005) on their parameterization of CARA utility function and set the absolute risk aversion $\gamma$ equal to the relative risk aversion coefficient divided by consumption. Let relative risk aversion be 3. So $\gamma = 3/C = 3/(Y + D)$, where $Y$ and $D$ are per capita annual labor income and dividend, respectively.

The parameters of the labor income and dividend process are mainly following Lucas(1994). To ensure that the expected ratio of dividend to labor income is constant, both the per capita labor income growth rate and the per capita dividend growth rate are set to 1.8%, i.e. $y/Y = d/D = 0.018$. The value of $\sigma/D$ is set to 0.037, also from Lucas(1994). For the individual labor income
risk $\sigma_o$, MacCurdy(1982) use wages data from Panel Study of Income and Dynamics (PSID) data and find the standard deviation of proportional changes in the annuity value of human wealth to be roughly between 0.123 and 0.247. Based on MacCurdy(1982) and Hau and Mishkin(1982), Caballero(1991) postulates that labor income uncertainty is on the order of 10% and possibly larger. He sets the lower bound and upper bound of the labor income risk to be 0.05 and 0.15 in his study. Meghir and Pistaferri(2004)’s estimate of unconditional variance of the (permanent) income shocks is 0.0313, implying a standard deviation of about 0.177. Guvenen and Smith(2010) tries to quantify the income risk by estimating a structural consumption-saving model using data from PSID and CES. They conclude that the standard deviation of the persistent part of the labor income shock varies from 0.196 to 0.208 and the estimates are robust to a set of sensitivity analyses. Based on these results, I assign five values for $\sigma_o/Y$: 0.05, 0.1, 0.15, 0.2 and 0.25\(^{27}\).

Constantinides et al.(2002) find that the ratio of dividend income to total income is 0.3 and Athanasoulis(2005) finds this ratio to be 0.32 over his sample. So I set $D/(Y + D) = 0.32$ and hence the labor income is about 0.68 of the total personal income. Using US data(1970-2010) from World Bank, the average annual per capita GNI (in $ amount) is about 25,000\(^{28}\), which I use as $(Y + D)$.

Finally for constant $a$ that makes $Var(\theta^2_t) = a(Var(\theta_t))^2$, I set its value to 2\(^{29}\).

\(^{27}\) It is worth noting that although I follow Caballero(1991) and set the lower bound to 0.05, the larger values are probably more realistic estimates of the labor income uncertainty.

\(^{28}\) In unreported results, I test with other $(Y+D)$ values including normalizing it to 1. The exact value of per capita total income$(Y+D)$ does not really matter for my conclusions on the relationship between interest rate, saving rate, inequality and income heterogeneity.

\(^{29}\) I set a value to 2 so that $\theta_t$ is normally distributed. In unreported results I experiment with other values of a between 0 and 100 and it does not affect the conclusion.
3.2.4.2. Results

Based on the parameter values above, I use Equations (5), (6), (9) and (12) to get the real interest rate, average consumption risk of the economy, consumption inequality and saving rates for varying $Var(\theta_i)$, which is between 0 and 1 since $\theta_i$ is the correlation between $i$’s individual income risk and the aggregate risk.

The results for when relative risk aversion is 3 are presented in Figure 3.1.

Panel A of Figure 3.1 plots how the saving rate $Var(b_{1i})$ responds to changes in income heterogeneity. For smaller size of the labor income risk $\sigma_o/Y$, saving rates go up as $Var(\theta_i)$ becomes higher; for larger (and probably more realistic) value of $\sigma_o/Y$, saving rates first increase then decrease in $Var(\theta_i)$. This shows the combined effects of heterogeneity on savings described in the previous subsection: Higher dispersion in income risks facilitate risk sharing through asset trading, which is funded by more borrowing. Therefore saving rate goes up. However the improved risk sharing lowers the average consumption risk and hence reduces precautionary saving motive, resulting in lower saving rate. This graph also shows that if $Var(\theta_i)$ is sufficiently high, then saving rates increases as the magnitude of labor income risks $\sigma_o/Y$, or $\sigma_o$, gets larger.

To make sure that the model produces reasonable results, I plot model generated saving rate against model generated interest rate in Panel B of Figure 3.1. It shows that for reasonable values of labor income uncertainty $\sigma_o/Y$ and positive interest rate, $r$ drops as saving rate rises.

We see from section 2.1 and 2.2 that the model predicts both real interest rate and consumption inequality are increasing in income heterogeneity $Var(\theta_i)$. Panel C of Figure 3.1 presents a more straightforward display of how equilibrium interest rate is correlated with inequality. At
each level of individual income risk $\sigma_o/Y$, the interest rate curve, plotted against inequality, has a positive slope. Additionally, higher values of $\sigma_o/Y$ results in lower interest rate curves in the graph, telling us that interest rate is decreasing in the magnitude of income risks in this model. On the other hand, consumption inequality is higher as $\sigma_o/Y$ gets larger.

Panel D of Figure 3.1 plots interest rate $r$ against both the size of average individual income risks $\sigma_o/Y$, and the dispersion in individual income risks $Var(\theta_i)$. Interestingly, as seen earlier, $\sigma_o/Y$ and $Var(\theta_i)$ has opposite effects on the value of $r$. Intuitively, larger size of labor income risks ($\sigma_o$) raises the average consumption risk and hence increases the precautionary saving motive. Consequently it lowers the interest rate. In contrast, the diversity in labor income risks ($Var(\theta_i)$) facilitates risk sharing among agents and lowers the average consumption risk and in turn raises the interest rate. So while both $\sigma_o$ and $Var(\theta_i)$ boost inequality, only if the effect of high $Var(\theta_i)$ outweighs the effect of high $\sigma_o$ can we see a higher interest rate.

In conclusion, the numerical results complement and confirm the analytical results from earlier sections. They are in line with the intuition that income heterogeneity promotes risk sharing through the diversification effect. As the individual income risks become more dispersed, both consumption inequality and interest rate rise over a plausible region of the parameter space. In addition, the results also confirm two risk sharing measures as proxies for income heterogeneity: the gross saving rates and the ratio of income risk to consumption risks. In the following section, these two variables are added to the interest rate-inequality regression to test if they cut down the positive role of inequality in explaining interest rate.
3.3 Empirical Analysis

The purpose of this empirical study is to examine whether the positive interest rate-inequality relationship in Chapter 2 is driven by the positive influence of income heterogeneity on both. Income heterogeneity $Var(\theta_l)$, defined as the dispersion in idiosyncratic labor income risk in the model, raises equilibrium interest rate by promoting risk sharing and smoothing consumption. Two other quantities that capture this effect are the ratio of average labor income risk to average consumption risk and saving rate. If the actual data of inequality, saving rate and the risk ratio do reflect the income heterogeneity to some degree and if the risk sharing story is true, then the addition of either saving rates or the $\overline{\sigma^2}/\sigma^2$ ratio to the interest rate-inequality regression should reduce the positive coefficient on income inequality.

Specifically, the following regression will be run to test the theory above:

$$ r_{lt} = \alpha_0 + \alpha_1 \cdot \text{Inequality}_{l,t} + \alpha_2 \cdot \text{RiskShare}_{l,t} \ (\text{and/or} \ \text{SavingRate}_{l,t}) $$

$$ + \sum_j \alpha_j \cdot Controls + \epsilon_{l,t} $$

(13)

And the hypothesis is that $\alpha_1$ be smaller and less significant compared to the regression without the $\alpha_2$ terms and $\alpha_2$ be non-zero.

3.3.1 Data and Variables

The dependent variable In Equation (13) is real interest rate (“rrf”). T-bill rates are obtained from IMF and I adjust them to real terms with inflation data from World Bank. For the country-years
where T-bill rates are not available, I create the “pseudo” T-bill rates by subtracting from the prime rates the cross-country average of spread between prime (lending) rates and T-bill rates.\(^\text{30}\)

The income inequality measure here is the income Gini coefficient from the “All-the-Ginis” dataset compiled by Branko Milanovic from World Bank, which contains 1541 consistent Gini values from 154 countries covering 1950 to 2008. Compared to other sources of income distribution data, “All-the-Ginis” has advantage in the size of the samples, reliability of the data source and the clarity in of the welfare concepts and measurements\(^\text{31}\). All the data in my sample are estimated in per capita units and adjusted to be consistent with measure of the disparity in net (disposable) income.\(^\text{32}\)

“RiskShare\(_{t,i}\)” is the ratio of the average income risk to consumption risk, i.e. \(\sigma_i^2 / \sigma_o^2\), which demonstrate the general risk sharing effect due to income heterogeneity. Ideally, this measure should be constructed with micro-level income and consumption data within each country. However due to limitations on data, I use aggregate level income and consumption data from World Bank to construct it. The data covers 45 countries over 49 years (1958-2007). For the best data availability, per capital annual GDP and per capital consumption data are used. Specifically, in each year \(t\), I calculate for each country \(i\) the volatility in GDP growth and in consumption

\(^{30}\) In unreported regressions, I also use prime rates from WDI database of World Banks instead of T-bill rates as dependent variable, or repeat the regressions on the subsample of country-years where the T-bill rates are available. The results remain substantially unchanged.

\(^{31}\) The dataset is compiled from five other Gini databases, including Luxembourg Income Study (LIS), Socio-Economic Database for Latin America (SEDLAC), World Income Distribution (WYD), World Bank Europe and Central Asia (ECA) and WIDER (WIID I ) databases. Only the data that come from nationally-representative household survey are selected. When there is conflict in data from two or more different sources for the same country-year, data are chosen according to the reliability and the degree of standardization of the source. All the data in the resulted “All-the-Ginis” dataset have clear description of welfare concepts (income or expenditure/consumption, net or gross) and unit of recipients (per capita or per household).

\(^{32}\) I follow Dollar and Kraay(2002) and adjust both datasets to ensure the consistency in welfare concepts. I regress the inequality measures on a constant, a set of regional dummies including are Asia, Africa, Latin America, and East Europe (so the “Western” countries are in the omitted category) and two dummy variables indicating whether the measure is based on gross income or consumption. Then I subtract the estimated mean difference between the alternative welfare concepts-based inequality measures and the omitted category. My main results do not change much if I 1. Completely ignoring the differences in welfare concepts, and 2. Include the dummy variables of welfare concepts directly in regressions.
growth over a 9-year rolling window centered on \( t \). The variable \( RiskShare_{t,t} \) is then defined as the log of the ratio of volatility in per capital GDP growth to the volatility in per capita consumption growth.

\( SavingRate_{t,t} \) is the Gross saving rate as percentage of gross national income (GNI) of 45 countries from 1965-2010 from World Bank. Gross savings are calculated as GNI less total consumption, plus net transfers.

Other control variables are the same as in Chapter 2. They are either common risk factors adopted in asset pricing literature or country characteristics that may affect both pricing and income inequality. For example, I have dividend growth (\( \text{div}_g \)), where the annual dividends are calculated using MSCI equity price and total returns indices. Market volatilities (\( \text{vol} \)) are computed as the volatility of the MSCI equity index’s returns over the 36-months window centering on the December. \( \text{gdppercap} \) is annual GDP per Capita (real) from WDI database, an indicator of a country’s economic conditions. Stock market turnover ratio (\( \text{stturnover} \)) and the ratio of liquid liabilities to GDP (\( \text{llgdp} \)) are used to characterize a country’s development in stock market and banking system, respectively. These two are commonly used indicators (see Beck et al.(2000), Beck and Levine(2004), etc.) of a country’s financial market development. The data are obtained from Beck, Demirguc-Kunt and Levine (BKL)’s Database of Financial Development and Structure, an updated version of Beck et al.(2000). \( \text{legal} \) and \( \text{icrg10} \) are two proxies of a country’s development of legal regime and overall political risk. Following Doidge et al.(2007) and Durnev and Kim(2005), \( \text{legal} \) is defined as the product of “anti-

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33 Stturnover is the value of the trades of shares on domestic exchanges divided by total value of listed shares, a measure of market liquidity. Liquid liabilities are calculated as currency plus demand and interest-bearing liabilities financial intermediaries and nonbank financial intermediaries.
director rights index” and “rule-of-law”\textsuperscript{34}. “icrg10” is a composite country risk index from International Country Risk Guide (ICRG) that incorporates a comprehensive list of political and social condition measures\textsuperscript{35}. I account for the demographic feature of a country that may influence income distribution by “age65”, a variable that measures the fraction of the population that’s 65 years or older. The variable “tax” is cited from PWC’s Worldwide Tax Summaries and is the marginal personal income tax rate for the highest-income tier.

If the global market is fully integrated, then the domestic factors do not really matter for pricing. Therefore two measures of global market segmentation are included: Foreign investability (“fb”) measures how easy the foreign investors can invest in domestic market, and home bias (“hb”) measures how insufficiently diversified are domestic investors across global market. I follow Lau et al.(2010) and define “fb” as the ratio of total market value of a country’s domestic equity held by foreign investors divided by the country’s total market capitalization. Similarly, “hb” is defined as the share of domestic investors’ holdings of their domestic stocks relative to the weight of the country’s market capitalization in the world market. The equity holdings data are from Coordinated Portfolio Investment Survey (CPIS) of IMF.

The descriptive statistics are presented in Table 3.1A, 1B and Table 3.2.

\textsuperscript{34} The former measures investor protection and shareholder rights and the data is from Djankov et al.(2008); the latter are measures of law enforcement from (López de Silanes et al.(1998)).

\textsuperscript{35} Specifically, the ICRG composite risk index incorporates the following measures: government stability, military in politics, socioeconomic conditions, religious tensions, investment profile, internal conflict, ethnic tensions, external conflict, democratic accountability, corruption and bureaucracy quality.
3.3.2 Proxies for Income Heterogeneity

Section 2 shows that saving rate captures income heterogeneity’s risk sharing effect and can be used as a proxy for the unobserved income heterogeneity in empirical study. The results of regressions with saving rates are reported in Table 3.3.

For easier comparison, Panel A of Table 3.3 reports the original results of real interest rate (“\( rrf \)”) on income inequality and other variables from Chapter 2, and Panel B of Table 3.3 reports the corresponding results for the same models with saving rates. The stand-out observation is that across all models, the addition of saving rates to the regression reduces the magnitude of the coefficients on inequality terms. For example, Model 1 and 2 are the simplest regressions of interest rate on income Gini and/or the interaction term of Gini coefficient with the developed country indicator. When saving rate is added to the models, coefficient on inequality measure itself is lowered from about 0.22 to about 0.17, a reduction of nearly 1/3. Without the saving rate, a one standard deviation increase in Gini (which is about 0.09\(^{36}\)) implies an increase of roughly 2% in the real interest rate; after take into account for the saving rate, the same increase in Gini yields a growth of 1.53% in interest rate. In most of the models with more regressors, saving rate takes even more away of the positive effect of inequality on interest rate. As for the interaction terms of inequality with the dummy “developed”, although the results in the original regressions are economically small and not significant in most cases, adding saving rate to the models further lowers the value of the coefficient as well as the t-statistics. In the full regression models with global integration measures (Model 6 and 7), the signs of the coefficients are reversed and there is a substantial decrease in the value of the t-statistics (from nearly 1 to -0.13).

\(^{36}\) Note that in all regressions the “GiniAll” variable is the actual Gini value (which is between 0 and 1) multiplied by 100.
Another interesting observation is that when adding the variable “Age65” to the regression in Panel B models (with saving rates), there is a remarkable drop in both the economic and statistical significance of the coefficient on income Gini. From Model 4 to Model 5, the estimate of this coefficient is lowered from 0.17 to 0.1 and t-statistics from 2.67 to 1.31. Age effect on portfolio holdings has been discussed in many studies (some examples are Jagannathan and Kocherlakota(1996), Heaton and Lucas(2000) and Benzoni et al.(2007)). The general agreement is that stockholdings are hump-shaped over the lifecycle and retirement is the typical turning point from increasing to declining stockholdings. “Age65” can be roughly redeemed a measure of the fraction of the retired people in the economy. So it is likely that it works together with saving rate measure to isolate the risk sharing effect of income heterogeneity on interest rate.

Another indicator that may exemplify the risk sharing effect of income heterogeneity is (the log of) ratio of the average income risk to the average consumption risk, log(Vol(ΔY)/Vol(ΔC)). Compared to the saving rate, which reflects only the risk sharing effect of income heterogeneity in the bond market, this ratio is more of a general risk sharing measure. It is an indicator of the overall consumption smoothing effect from risk sharing through all channels, including the stock market, the bond market and others.

I repeat the regressions in Table 3.3 with the exception of replacing saving rate with the income-consumption risk ratio (“riskshare”). If both income inequality and the ratio defined above really catch the within-country heterogeneity and its boosting effect on risk sharing at least to some degree, then we should see a positive coefficient on this risk sharing and a smaller and/or less significant coefficient on the inequality measure.

The results are presented in Table 3.4.
A quick look at Table 3.4 tells us that including this ratio to the interest rate-inequality regression does not alter the results too much from the original regression. In fact, the coefficients on income Gini and the interaction term between Gini and “developed” remain roughly the same in both their economic magnitude and statistical significance. This is not surprising considering that this measure “riskshare” itself is not really significant in the regressions (except for in Model 6 & 7 where the global risk sharing indicators are included).

For better comparison, I include both the saving rate and the ratio of income risk to consumption risk to the original regression and report the results in Table 3.5.

Results in Table 3.5 confirm my findings in Table 3.3 and 4. The inclusion of saving rate to the models lowers the values of coefficients on Gini itself by about 1/3 and reduces both the size and values of the t-stats of coefficients on the interaction term; while the general risk sharing measure “riskshare” is not working as expected and has almost no effect on the coefficient of inequality terms.

### 3.3.3 Discussions

The previous section reveals some results that are consistent with the hypothesis that income heterogeneity drives the observed positive relation between real interest rate and income inequality. In particular, Table 3.3 and 3.5 shows that the addition of gross saving rates to the regression takes away part of the positive effect of the inequality on interest rate. This can be viewed as supporting evidence of the model result that saving rate captures part of the positive effect of income heterogeneity on interest rate that is also displayed through interest rate-inequality correlation.
However, one concern is that an alternative interpretation may be proposed as follows: In under-developed countries with very low average income, some people are so poor that their income is barely enough to cover the subsistence. In this case, higher inequality may indicate that this kind of people, who are too poor to save, makes up a larger fraction of the population. This also means inequality has a negative effect on the demand for saving and positive effect on the interest rates, especially in developing countries. In Table 3.3 and 5, the dampening effect of adding saving rate on the positive interest rate-inequality correlation does seem to be more pronounced in the developing countries. Therefore this interpretation seems quite plausible. However, this explanation is hard to reconcile with the documented fact that household saving rate is higher in developing countries than in developed countries (Modigliani and Cao(2004), Gormley et al.(2010)).

Another concern about the regression results in Table 3.3 and 3.5 is, while they confirm that adding saving rate to the regressions induces smaller coefficients and t-statistics on income Gini, the numbers need to be viewed with caution due to the endogeneity of regressing interest rate on saving rate. For this reason, this paper tries to avoid interpreting the coefficient on saving rate itself. It should be kept in mind that the estimates and inference on income inequality can also be affected by endogeneity and thus conclusions should be drawn only with great caution.

Proceeding to the regressions in Table 3.4 and 3.5 with “riskshare”, there may be several explanations for the unsatisfying results. One of them is that the constructed variable “riskshare” may not be a proper indicator of within-country heterogeneity because it is created with aggregate data instead of micro-level data. And the inadequate measure may potentially cause unreliable estimates of coefficients both on the measure itself and on income inequality. A more accurate measure would be to first compute the volatility (or variance) in consumption growth.
and the volatility (or variance) in income growth for each household and then find the cross-sectional average of the ratios. A second possible explanation is that although the variable “riskshare” embodies the risk sharing effect of heterogeneity, the income inequality measure on the other hand bears no connection to this effect and reflects other different aspects of the interest rate-heterogeneity relation. Finally, these results could be pointing to a different direction in rationalizing and modeling the observed positive relationship between interest rate and inequality. To further test which of these explanations is true, better instrument for within-country income heterogeneity is needed. For example, the income risk to consumption risk ratio may be constructed with household level income and consumption data from Luxembourg Income Study (LIS) and Integrated Public Use Microdata Series (IPUMS) in future studies. Industry composition data of each country, if available, may also be utilized to create indicator of cross-sectional variation in income within the country.

3.4 Conclusion

The existing literatures have in general suggested that higher income inequality lead to lower interest rate. However in Chapter 2, I find a significant positive correlation between cross-country differences in income inequality and cross-country differences in real interest rates.

In this paper, I try to explain this observation under an asset pricing model with CARA utility function, income heterogeneity and untradable labor income risks. In this model, the income heterogeneity is defined as the dispersion in idiosyncratic income risks in terms of their correlations to the aggregate risk. I conjecture that given the channels of risk sharing, higher dispersion in the idiosyncratic income risks promotes risk sharing through diversification. Therefore agents have smoother consumption on average and reduced precautionary saving
motive. As a result, the equilibrium interest rate of the economy declines as the heterogeneity increases. If higher income risk dispersion also contributes to higher inequality, then the observed correlation between inequality and interest rate may be reflecting the effect of heterogeneity on the latter. With the assumption of CARA utility, I am able to derive the risk-free rate and the (consumption) inequality in closed-form solutions and show that both are positively related to income heterogeneity. In addition, two other proxies for income heterogeneity are established from the model to be used in the empirical analysis: the gross saving rate and a general risk sharing measure, the ratio of average consumption risk to average income risk.

The evidence from the empirical tests is mixed. On one hand the results confirm that saving rate helps reducing the positive role of income inequality in explaining higher interest rate, providing supporting evidence that income heterogeneity drives both inequality and real interest rate. On the other hand, the test results with ratio of consumption risk to income risk are not collaborating with the above theory. However, this may be partly caused by the deficiency in the constructed measure due to the use of aggregate data. In the future, international micro-level household income and consumption data may be used to create better within-country heterogeneity proxies for further examination.

While there is no explicit role for insurance market within the model, the implicit implication would be that they also play an important role in determining the equilibrium portfolio holdings as well as pricing. The diversification effect of income heterogeneity is amplified when such risk sharing channels as both the financial markets and social insurance system are well developed. Also, although this paper only targets to explain how heterogeneity in the covariance between
individual and aggregate risks may drive both the interest rate and inequality, it is possible to extend the model to evaluate the effect of heterogeneity on portfolio decision and risk premium.
Reference


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Appendix: Monthly West Texas Intermediate (WTI) Crude Oil Price Since 1973

![Graph showing the monthly WTI crude oil price from 1973 to 2007, with key events labeled.]

- OPEC collapse, Dec. 1985
- Persian Gulf War, Aug. 1990
- OPEC quota increases, Nov. 2000
- Terrorist attack, Sept. 2001
- Iraq War, Mar. 2003

The graph illustrates significant increases in the WTI crude oil price, particularly after key events such as the OPEC collapse and the Persian Gulf War.
CHAPTER 1 FIGURES

Figure 1.1: This Figure 1 plots the realized covariance of CRSP market returns with log changes in expenditure on non-energy consumptions and covariance of CRSP returns with log changes in real WTI oil prices from 1947-2008.
Figure 1.2: This Figure plots the quarterly log expenditure ratio of NIPA non-energy/energy consumption and log CPI_non-energy/CPI_energy from 1957-2009. A positive correlation between the two series implies small (close to zero) intratemporal elasticity of substitution between energy and non-energy goods.
Figure 1.3: This figure plots the fitted daily conditional covariance of CRSP value-weighted market returns with changes in oil/non-oil expenditure ratios from 1983-2008. The parameters are estimated from the following conditional variances and correlation equations in the benchmark (un-normalized) model:

\[
h_1(t) = a_x + b_x \cdot h_1(t-1) + c_x \cdot r_x(t-1) + d_x \cdot r_y(t-1) + e_x \cdot r_z(t-1) + f_x \cdot r_x(t-1) + g_x \cdot r_y(t-1) + h_x \cdot r_z(t-1)
\]

\[
h_2(t) = a_z + b_z \cdot h_2(t-1) + c_z \cdot r_x(t-1) + d_z \cdot r_y(t-1) + e_z \cdot r_z(t-1) + f_z \cdot r_x(t-1) + g_z \cdot r_y(t-1) + h_z \cdot r_z(t-1)
\]

\[
p(t) = a_p + b_p \cdot p(t-1) + c_p \cdot r_x(t-1) + d_p \cdot r_y(t-1) + e_p \cdot r_z(t-1) + f_p \cdot r_x(t-1) + g_p \cdot r_y(t-1) + h_p \cdot r_z(t-1)
\]

where \( p(t) = \tanh(\rho(t)) \), and \( \rho(t) \) is the correlation between \( r_x \) & \( r_z \).
Figure 1.4.a: This Figure plots the realized volatility (1983-2008) of CRSP market returns against the fitted volatility of CRSP market returns from the following EGARCH equation in the benchmark (un-normalized) model:

\[ h_t = a_0 + b_1 h_{t-1} + c_1 \left| r_{t-1} \right| + d_1 \cdot r_{t-1} + e_1 \cdot \left| r_{t-1} \right| + f_1 \cdot r_{t-1} \]
Figure 1.4.b: This Figure plots the realized volatility (1983-2008) of changes in oil/non-oil expenditure ratios against the fitted volatility of expenditure ratios from the following EGARCH equation in the benchmark (un-normalized) model:

\[ h_t = a \cdot h_{t-1} + b \cdot |r_{t-1}| + c \cdot r_{t-1} + d \cdot |r_{t-1}| + e \cdot r_{t-1} + f \cdot r_{t-1} \]
Figure 1.4.c: This Figure plots the realized correlation (1983-2008) of CRSP market returns with changes in oil/non-oil expenditure ratios against the fitted correlation from the following equation in benchmark (un-normalized) DCC model

\[ p(t) = a_p + b_p \cdot p(t-1) + c_p \cdot r_x(t-1) + d_p \cdot r_z(t-1) + e_p \cdot r_x(t-1) \cdot r_z(t-1) \]

where \( p(t) = a \tanh(p(t)) \), and \( p(t) \) is the correlation between \( r_x \) & \( r_z \).
Figure 1.5: This Figure 1. plots the realized correlation (1983-2008) of CRSP market returns with changes in oil/non-oil expenditure ratios against the fitted correlation from the following equation in the NORMALIZED DCC model

\[ p(t) = a + b \cdot p(t-1) + c \cdot \xi_{\rho(t-1)} + d \cdot \xi_{\xi(t-1)} + e \cdot \xi_{(t-1)} \cdot \xi_{(t-1)} \]

where \( p(t) = a \tanh(\rho(t)) \), \( \rho(t) \) is the correlation & \( \xi \)'s are returns scaled by its EGARCH volatilities
Figure 1.6: This figure plots the fitted daily conditional covariance of CRSP value-weighted market returns with changes in oil/non-oil expenditure ratios from 1983-2008. The parameters are estimated from the following conditional variances and correlation equations in the NORMALIZED model:

\[
\begin{align*}
    h_1(t) &= a_1 + b_1 \cdot h_1(t-1) + c_1 \cdot \xi_1(t-1) + d_1 \cdot \xi_1(t-1) + f_1 \cdot \xi_1(t-1) \\
    h_2(t) &= a_2 + b_2 \cdot h_2(t-1) + c_2 \cdot \xi_2(t-1) + d_2 \cdot \xi_2(t-1) + f_2 \cdot \xi_2(t-1) \\
    p(t) &= a_p + b_p \cdot p(t-1) + c_p \cdot \xi_p(t-1) + d_p \cdot \xi_p(t-1) + e_p \cdot \xi_p(t-1) \cdot \xi_p(t-1)
\end{align*}
\]
Figure 1.7a: In this figure, I compare the fitted conditional covariance series from UN-NORMALIZED model using three different combinations of price/consumption expenditure data: 1. CPI_energy commodity & NIPA expenditure data on oil products and other energy goods; 2. CPI_energy & NIPA expenditure data on energy goods and services; 3. WTI crude oil price series & NIPA expenditure data on oil products and other energy goods.
Figure 1.7b: In this figure, I compare the fitted conditional covariance series from NORMALIZED model using three different combinations of price/consumption expenditure data: 1. CPI-energy commodity & NIPA expenditure data on oil products and other energy goods; 2. CPI-energy & NIPA expenditure data on energy goods and services; 3. WTI crude oil price series & NIPA expenditure data on oil products and other energy goods.
### Chapter 2 Tables and Figures

Table 2.1

*Giniall* is the Income Gini measure from Dataset of Branko Milanovic. *WIID2 Gini* is Income Gini from WIID2 database by WIDER. *WIID2 IR* is the ratio of the income of the top 10% income population to the total income of the rest population. *MSCI P/D* is the price dividend ratio computed from MSCI international equity indices. *GFD P/D* is the inverse of dividend yield of each country from Global Financial Data (GFD).

**Panel A: Summary Statistics on Income Inequality and Stock Market P/D**

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Table 2.1 Panel B

gdp_per_cap is the real GDP per capita from World Bank’s WDI database. rrf is the Real Interest Rate. rrf and inflation are also both from WDL ediv_g is the expected dividend growth rate computed from MSCI Equity Index, MSCI Total Returns and Net Returns indices. vol is the volatility of MSCI International Equity index returns. Ilgdp is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of ‘Anti-director rights’ from Djankov et al(2008) & ‘Rule of Law’ from PRS(2009); icrg10 is the country composite risk rating in Jan. 2010 from International Country Risk Guide(ICRG). age65 is the fraction of the population that’s more than 65 years old from World Bank. tax is the persona income tax rates from PWC’s Worldwide Tax Summaries.

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Table 2.2: Pearson's Pairwise Correlation Coefficients

*Giniall* is the Income Gini measure from World Bank Dataset “All-the-Ginis” compiled by Branko Milanovic. *WIID2 Gini* is Income Gini from WIID2 database by WIDER. *WIID2 IR* is the ratio of the income of the top 10% income population to the total income of the rest population. *MSCI P/D* is the price dividend ratio computed from MSCI international equity indices. *GFD P/D* is the inverse of dividend yield of each country from Global Financial Data (GFD). *gdppercap* is the real GDP per capita from World Bank’s WDI database. *rrf* is the Real Interest Rate. *inflation* are also both from WDL. *ediv_g* is the expected dividend growth rate computed from MSCI Equity Index, MSCI Total Returns and Net Returns indices. *Vol* is the volatility of MSCI International Equity index returns. *llgdp* is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al.(2006). *stturnover* is Stock Market Turnover Ratio is also from BKL. *Legal* is the product of ‘Anti-director rights’ from Djankov et al(2008) & ‘Rule of Law’ from PRS(2009); *icrg10* is the country composite risk rating in Jan. 2010 from International Country Risk Guide (ICRG). *age65* is the fraction of the population that’s more than 65 years old from World Bank. *tax* is the persona income tax rates from PWC’s Worldwide Tax Summaries.

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Table 2.3: MSCI P/D ratio vs. Income Gini from World Bank "All-the-Grinis" Dataset

Giniall_adj is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. developed is the dummy variable for developed countries. gdppercap is the real GDP per capita from World Bank’s WDI database. rrf is the Real Interest Rate. rrf and inflation are also both from WDI. ldiv_g, div_g and ediv_g are the lagged, present and expected dividend growth rate computed from MSCI Equity performance and returns indices. vol is the volatility of MSCI International Equity index returns. lldp is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); icrg10 is the country composite risk rating from International Country Risk Guide(ICRG). age65 is the fraction of the population that's more than 65 years old from World Bank. tax is the personal income tax rate from PWC’s Worldwide Tax Summaries.

\[ \log p/d_{it} = \alpha_0 + \alpha_1 \times \text{Inequality}_{it} + \alpha_2 \times \text{Interact}_{it} + \sum_j \alpha_j \times X_{it} + \sum_k \alpha_k \times Z_i + \text{year}_i + \epsilon_{it} \]

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Table 2.4: GFD PD ratio vs. Income Gini from World Bank "All-the-Ginis" Dataset

Giniall_adj is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. developed is the dummy variable for developed countries. gdppercap is the real GDP per capita from World Bank's WDI database. rrf is the Real Interest Rate. rrf and inflation are also both from WDI. div_g, div_g and ediv_g are the lagged, present and expected dividend growth rate computed from MSCI Equity performance and returns indices. vol is the volatility of MSCI International Equity index returns. llgdp is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); icrg10 is the country composite risk rating from International Country Risk Guide(ICRG). age65 is the fraction of the population that's more than 65 years old from World Bank. tax is the personal income tax rate from PWC's Worldwide Tax Summaries.

\[
\log p_{d,t} = \alpha_0 + \alpha_1 \cdot \text{Inequality}_{it} + \alpha_2 \cdot \text{Interact}_{it} + \sum_j \alpha_j \cdot X_{ij} + \sum_k \alpha_k \cdot Z_{ik} + \text{year}_t + \epsilon_{it}
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Table 2.5: Home Bias and Foreign Investability

*Giniall_adj* is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. *developed* is the dummy variable for developed countries. *gdppercap* is the real GDP per capita from World Bank's WDI database. *rrf* is the Real Interest Rate. *rrf* and inflation are also both from WDI. *div_g*, *div_g* and *ediv_g* are the lagged, present and expected dividend growth rate computed from MSCI Equity performance and returns indices. *vol* is the volatility of MSCI International Equity index returns. *llgdp* is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). *stturnover* is Stock Market Turnover Ratio is also from BKL. *Legal* is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); *icrg10* is the country composite risk rating from International Country Risk Guide(ICRG). *age65* is the fraction of the population that's more than 65 years old from World Bank. *tax* is the personal income tax rate from PWC Worldwide Tax Summaries.

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Table 2.6a: Alternative Income Inequality Measures -- WIID2 Gini

WIID2 Gini is Income Gini from WIID2 database by WIDER. developed is the dummy variable for developed countries. \( gdppercap \) is the real GDP per capita from World Bank's WDI database. \( rrf \) is the Real Interest Rate. \( rrf \) and \( inflation \) are also both from WDI. \( ldv_g \), \( div_g \) and \( ediv_g \) are the lagged, present and expected dividend growth rate computed from MSCI Equity performance and returns indices. \( vol \) is the volatility of MSCI International Equity index returns. \( llgdp \) is (Liquid Liabilities/ GDP) from Beck et al(2006). \( stturnover \) is Stock Market Turnover Ratio is also from BKL.

Legal is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); icrg10 is the country composite risk rating from International Country Risk Guide(ICRG). age65 is the fraction of the population that's more than 65 years old from World Bank. tax is the personal income tax rate from PWC's Worldwide Tax Summaries. \( hb \) (home bias) is share of domestic investors' holdings in their country’s stock market capitalization divided by their country’s world-market capitalization weight; \( fb \) (foreign investability) is defined as the ratio of total market value of a country’s domestic equity held by foreign investors relative to the country’s total market capitalization. Both \( hb \) and \( fb \) are calculated from CPIS data.

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**Table 2.6B: Alternative Income Inequality Measure -- WIID2 Income Ratio**

WIID2 IR is the ratio (multiplied by 100) of the income of the top 10% income population to the total income of the rest population. developed is the dummy variable for developed countries. gdppercap is the real GDP per capita from World Bank's WDI database. rrf is the Real Interest Rate. rrf and inflation are also both from WDI. div.g, div.g and ediv.g are the lagged, present and expected dividend growth rate computed from MSCI Equity performance and returns indices. vol is the volatility of MSCI International Equity index returns. llgdp is (Liquid Liabilities/GDP) from BKL dataset in Beck et al (2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of 'Anti-director rights' from Djankov et al (2008) & 'Rule of Law' from PRS (2009); icrg10 is the country composite risk rating from International Country Risk Guide (ICRG). age65 is the fraction of the population that's more than 65 years old from World Bank. tax is the personal income tax rate from PWC’s Worldwide Tax Summaries. hb (home bias) is share of domestic investors’ holdings in their country’s stock market capitalization divided by their country’s world-market capitalization weight; fb (foreign investability) is defined as the ratio of total market value of a country’s domestic equity held by foreign investors relative to the country’s total market capitalization. Both hb and fb are calculated from CPIS data.

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Table 2.7: Robustness check – Total GDP and Population

Gini\_adj is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. WIID2 Gini is Income Gini from WIID2 database by WIDER. WIID2 IR is the ratio (multiplied by 100) of the income of the top 10% income population to the total income of the rest population. developed is the dummy variable for developed countries. gdp is the GDP(constant 2000 US$) from World Bank's WDI database. population is the total population of each country, also from WDI. rrf is the Real Interest Rate. rrf and inflation are also both from WDI. ldiv\_g, div\_g and ediv\_g are the lagged, present and expected dividend growth rate computed from MSCI Equity performance and returns indices. vol is the volatility of MSCI International Equity index returns. llgdp is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); icrg10 is the country composite risk rating from International Country Risk Guide (ICRG). age65 is the fraction of the population that's more than 65 years old from World Bank. tax is the personal income tax rate from PWC’s Worldwide Tax Summaries. hh is the share of domestic investors’ holdings in their country’s stock market capitalization divided by their country’s world-market capitalization weight; fb (foreign investability) is defined as the ratio of total market value of a country’s domestic equity held by foreign investors relative to the country’s total market capitalization. Both hh and fb are calculated from CPIS data.

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Table 2.8: Expected Excess Returns vs. Income Gini from World Bank "All-the-Ginis"

Dataset

*Giniall_adj* is the Income Gini measure that notionally consistent with "net income"-based Gini. adjusted from Dataset of Branko Milanovic from World Bank, *developed* is the dummy variable for developed countries. *lngross* is the log of the price dividend ratio computed from MSCI international equity indices. *gdppercap* is the real GDP per capita from World Bank's WDI database. *rrf* is the Real Interest Rate. *rrf* and *inflation* are also both from WDI. *ediv_g* is the expected dividend growth rate computed from MSCI Equity performance and returns indices. *vol* is the volatility of MSCI International Equity returns. *llgdp* is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). *stturnover* is Stock Market Turnover Ratio is also from BKL. *Legal* is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); *icrg10* is the country composite risk rating from International Country Risk Guide(ICRG). *age65* is the fraction of the population that's more than 65 years old from World Bank. *tax* is the personal income tax rate from PWC's Worldwide Tax Summaries. *hb* (home bias) is share of domestic investors' holdings in their country's stock market capitalization divided by their country's world-market capitalization weight; *fb* (foreign investability) is defined as the ratio of total market value of a country’s stock market held by foreign investors relative to the country’s total market capitalization. Both *hb* and *fb* are calculated from CPIS data.

\[ r_{it+1} = a_0 + a_1 \ast Inequality_{it} + a_2 \ast Interact_{it} + \sum_j a_j \ast X_{it} + \sum_k a_k \ast Z_i + \text{year}_t + \varepsilon_{it} \]

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Table 2.9: Real Interest Rate vs. Income Gini from World Bank "All-the-Ginis" Dataset

Giniall_adj is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. developed is the dummy variable for developed countries, netsaving is the net national savings as percentage of GNI from WDI database of World Bank. gdppercap is the real GDP per capita from World Bank's WDI database. div_g is the dividend growth rate computed from MSCI Equity performance and returns indices. vol is the volatility of MSCI International Equity index returns. llgdp is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); icrg10 is the country composite risk rating from International Country Risk Guide(ICRG). age65 is the fraction of the population that's more than 65 years old from World Bank. tax is the personal income tax rate from PWC's Worldwide Tax Summaries. hb (home bias) is share of domestic investors' holdings in their country's stock market capitalization divided by their country's world-market capitalization weight; fb (foreign investability) is defined as the ratio of total market value of a country's domestic equity held by foreign investors relative to the country's total market capitalization. Both hb and fb are calculated from CPIS data.

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Figure 2.1: Income Inequality Across Countries
### Table 3.1A: Descriptive Statistics: Mean (main variables)

$r_{rff}$ is the T-bill rate obtained from IMF adjusted for inflation. $Gini_{all\_adj}$ is the Income Gini measure that notionally consistent with "net income"-based Gini (multiplied by 100), adjusted from Dataset of Branko Milanovic from World Bank. Type of Market indicates whether the country is developed (DEV) or emerging market (EMG). $grosssaving$ is the gross national savings as percentage of GNI from WDI database of World Bank. $riskshare$ is the log value of ratio of the volatility in Per Capita GDP growth to the volatility of Per Capita consumption growth (i.e. $\text{Vol}(\Delta Y)/\text{Vol}(\Delta C)$ ) from World Bank.

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| No. of Obs | 1196 | 723 | 1438 | 1843 |
Table 3.1B: Descriptive Statistics: Mean (controls)

gdppercap is the real GDP per capita from World Bank's WDI database. \( \text{div}_g \) is the dividend growth rate computed from MSCI Equity performance and returns indices. vol is the volatility of MSCI International Equity index returns. llgd is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); icrg10 is the country composite risk rating from International Country Risk Guide(ICRG). age65 is the fraction of the population that’s more than 65 years old from World Bank. tax is the personal income tax rate from PWC’s Worldwide Tax Summaries. hb (home bias) is share of domestic investors’ holdings in their country’s stock market capitalization divided by their country’s world-market capitalization weight; fb (foreign investability) is defined as the ratio of total market value of a country’s domestic equity held by foreign investors relative to the country’s total market capitalization. Both hb and fb are calculated from CPIS data.

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135
Table 3.2: Descriptive Statistics: Correlations

rrf is the T-bill rate from IMF adjusted for inflation. Giniall_adj is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. Type of Market indicates whether the country is developed(DEV) or emerging market(EMG). gpdp percap is the real GDP per capita from World Bank's WDI database. div_g is the dividend growth rate computed from MSCI Equity performance and returns indices. vol is the volatility of MSCI International Equity index returns. llgdp is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). stturnover is Stock Market Turnover Ratio is also from BKL. Legal is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); icrg10 is the country composite risk rating from International Country Risk Guide(ICRG). age65 is the fraction of the population that's more than 65 years old from World Bank. tax is the personal income tax rate from PWC’s Worldwide Tax Summaries. hb (home bias) is share of domestic investors’ holdings in their country’s stock market capitalization divided by their country’s world-market capitalization weight; fb (foreign investability) is defined as the ratio of total market value of a country’s domestic equity held by foreign investors relative to the country’s total market capitalization. Both hb and fb are calculated from CPIS data. grosssaving is the gross national savings as percentage of GNI from WDI database of World Bank. riskshare is the log value of the ratio of the volatility in Per Capita GDP growth to the volatility of Per Capita consumption growth (i.e. Vol(ΔY)/Vol(ΔC) ) from World Bank.

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Table 3.3: Interest Rate vs. Inequality: Saving Rates

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Table 3.4: Real Interest Rate vs. Income Gini: Risk Sharing Measure

\( \log(\text{Vol}(\Delta Y)/\text{Vol}(\Delta C)) \)

\( \text{giniall\_adj} \) is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. \( \text{developed} \) is the dummy variable for developed countries. \( \text{riskshare} \) is the log value of the ratio of the volatility in Per Capita GDP growth to the volatility of Per Capita consumption growth (i.e. \( \text{Vol}(\Delta Y)/\text{Vol}(\Delta C) \)) from World Bank. \( \text{gdppercap} \) is the real GDP per capita from World Bank's WDI database. \( \text{div\_g} \) is the dividend growth rate computed from MSCI Equity performance and returns indices. \( \text{vol} \) is the volatility of MSCI International Equity index returns. \( \text{lglgd} \) is (Liquid Liabilities/ GDP) from BKL dataset in Beck et al(2006). \( \text{stturnover} \) is Stock Market Turnover Ratio is also from BKL. \( \text{Legal} \) is the product of 'Anti-director rights' from Djankov et al(2008) & 'Rule of Law' from PRS(2009); \( \text{icrg10} \) is the country composite risk rating from International Country Risk Guide(ICRG). \( \text{age65} \) is the fraction of the population that's more than 65 years old from World Bank. \( \text{tax} \) is the personal income tax rate from PWC’s Worldwide Tax Summaries. \( \text{hb} \) (home bias) is share of domestic investors’ holdings in their country’s stock market capitalization divided by their country’s world-market capitalization weight; \( \text{fb} \) (foreign investability) is defined as the ratio of total market value of a country’s domestic equity held by foreign investors relative to the country’s total market capitalization. Both \( \text{hb} \) and \( \text{fb} \) are calculated from CPIS data.

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Table 3.5: Real Interest Rate vs. Income Gini: Risk Sharing Measure

$log(Vol(\Delta Y)/Vol(\Delta C)) \& Saving Rate$

$giniall\_adj$ is the Income Gini measure that notionally consistent with "net income"-based Gini, adjusted from Dataset of Branko Milanovic from World Bank. $developed$ is the dummy variable for developed countries. $riskshare$ is the log value of the ratio of the volatility in Per Capita GDP growth to the volatility of Per Capita consumption growth (i.e. $Vol(\Delta Y)/Vol(\Delta C)$) from World Bank. $gdp\_perc\_cap$ is the real GDP per capita from World Bank’s WDI database.

$div\_g$ is the dividend growth rate computed from MSCI Equity performance and returns indices. $vol$ is the volatility of MSCI International Equity index returns. $llgdp$ is $(Liquid\_Liabilities/\_GDP)$ from BKL dataset in Beck et al(2006). $st\_turnover$ is Stock Market Turnover Ratio is also from BKL. $Legal$ is the product of ’Anti-director rights’ from Djankov et al(2008) & 'Rule of Law' from PRS(2009); $icrg10$ is the country composite risk rating from International Country Risk Guide(ICRG). $age65$ is the fraction of the population that’s more than 65 years old from World Bank.

Dependent Variable: Real Interest Rate

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Figure 3.1

a) Gross saving rates vs. Var(θ): Y/(Y+D) = 0.68, γ = 3/(Y+D)

b) Interest Rate vs. Gross Saving Rates: Y/(Y+D) = 0.68, γ = 3/(Y+D)

c) Inequality vs. Interest Rates: Y/(Y+D) = 0.68, γ = 3/(Y+D)

d) Var(θ) vs. σ/γ vs. Interest Rate: Y/(Y+D) = 0.68, γ = 3/(Y+D)