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Capital Mobility versus Labor Mobility: Theory and Implications

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ABSTRACT

A random search-based model is proposed to study the impact of the relative mobility of capital with respect to labor on income inequality and financial globalization for the 1st time. Our simulation results indicate that capital is less mobile than labor domestically. Our simulation results further suggest the duality of capital mobility in financial globalization, in which more mobile capital may not always promote financial globalization. Lastly, our simulation results show that the share of labor income in the gross proceeds is negatively related to the relative mobility of capital, the separating rate between capital and labor, and the bargaining power of capital, which may shed light on income inequality in the U.S.

Keywords: Capital Mobility, Labor Mobility, Income Inequality, Financial Globalization, Bargaining, Random Search
JEL Classifications: G00; G15; F65; J61

1. INTRODUCTION

Wealth inequality in the U.S. has become one of the most severe economic and social issues especially after the Great Recession and during the current pandemic. According to one table titled "Wealth by wealth percentile group" from the Fed[1], as of Q 4 of 2021, the top 10% of the richest families in the U.S. held 69.77% of the nation's wealth while the bottom 50% of the poorest families only held 2.62%. Although there are various reasons, such as financial asset ownership or racial considerations which may lead to the disturbing wealth inequality in the U.S., income inequality contributes a significant part to the issue. Based on the OECD data[2], the U.S. has the highest income inequality in terms of the Gini coefficient among the G7 nations. In 2019, the Gini coefficient for the U.S. was 0.395 while the corresponding number for Germany was 0.289.

Since salaries and wages are the main sources of income for laborers while the remaining part of output goes to capitalists, how the final output produced by an economy is allocated between two types of players (laborers and capitalists) may shed light on income inequality in the U.S. Thus, we choose capital mobility from myriads of factors that may influence this allocation as our subject.

Literature on capital mobility concentrates on the role played by capital mobility in macroeconomics. Barro et al. (1995) find that partial capital mobility of an open-economy version of the neoclassical growth model can interpret empirical evidence on convergence, defined as the trend that poor countries grow faster than rich countries on average. Rodrik (1998) proposes a simple model to study the implications of capital mobility for labor and finds that labor may suffer from an increase in the openness of the economy even if the government can increase the tax on capital to compensate labor. Rodrik and Van Ypersele (2001) show that capital mobility may be politically unsustainable though international capital mobility can provide numerous efficiency gains.

Although it seems that capital is more mobile internationally than labor due to cross-border migration barriers or purely home bias of labor (Sjaastad, 1962; Kennan and Walker, 2011), the degree of capital mobility is still unresolved in literature. If

1 https://www.federalreserve.gov/releases/z1/dataviz/dfa/distribute/table/
2 https://data.oecd.org/inequality/income-inequality.htm

capital is perfectly mobile, domestic investment rates should be uncorrelated with domestic saving rates since excess funds from domestic savings would not be invested in the domestic market only and would be invested globally meanwhile the shortage of funds domestically could not block domestic investments and could be easily satisfied by the capital inflow from the global market. However, the Feldstein–Horioka puzzle, first recognized by Feldstein and Horioka (1980), instead shows that domestic investment rates and savings rates are highly correlated in OECD countries, providing evidence against perfect capital mobility. While Coakley et al. (1998) reviewed responses from economists about the puzzle and confirm that the result of the high association between domestic investment rates and domestic saving rates is robust, Coakley et al. (2004) find a lower correlation between them, indicating that capital is highly mobile in the long run for OECD economies. Bibi and Jalil (2016) study a large group of countries from 1980 to 2015 and reconfirm the existence of the Feldstein–Horioka puzzle. Drakos et al. (2017) reexamine the data for 14 EU member countries from 1970 to 2013 and suggest that there indeed exists a close relationship between investment and savings in the long run but there exists some degree of capital mobility as well. Eyuboglu and Uzar (2020) examine the data for the "lucky seven countries" from 1990 to 2017 and show that the Feldstein–Horioka puzzle is still valid in some of those countries.

The measure of capital mobility is not limited to the Feldstein–Horioka condition-the correlation between domestic investment rates and domestic saving rates. Mendoza and Wickham (1992) examine the performance of macroeconomic measures of capital mobility including the consumption smoothing, the savings-investment correlation, and the variability and output-correlation of investment, and find that without consideration of other factors, none of the above is reliable. Frankel (1992) reviews four definitions of perfect capital mobility: the Feldstein–Horioka condition, the real interest parity, the uncovered interest parity, and the covered interest parity, and suggests that only the covered interest parity is the best criterion for "capital mobility."

Zodrow (2010) reviews the degree of capital mobility internationally and its impact on inter-jurisdictional capital tax competitions. Duffie (2010) illustrates asset pricing implications of incomplete capital mobility caused by search frictions, inattentive investors, or the time needed to raise capital by financial intermediaries. Duffie and Strulovici (2012) propose a model to study the equilibrium movement of capital between two partially segmented asset markets with the aid of fee-charging financial intermediaries.

In this paper, we propose a random search-based model to study the impact of the relative mobility of capital with respect to labor on income inequality and financial globalization for the 1st time. Compared with the current literature on capital mobility, our approach has several unique features. *First,* we emphasize that the relative mobility of capital is more meaningful than capital mobility *per se* since the final output can only be produced by the collaboration between capital and labor, and more importantly, the degree of capital mobility requires a reference frame and labor mobility can be a natural choice. *Second,* traditional macroeconomics-based measures of capital mobility are mainly indirect and sometimes not reliable (Mendoza and Wickham, 1992). For instance, the association between domestic investment rates and domestic saving rates (the Feldstein–Horioka condition) is squarely the implication of capital mobility. However, our search model-based measure of capital mobility is more direct, which may better characterize the concept. *Third,* while almost all literature on capital mobility focuses on international capital mobility, known as financial globalization, we consider the duality of capital mobility including both domestic mobility and global mobility, and their interactions. *Last but not least,* the current literature typically considers the tax implications of capital mobility, we, however, target its income inequality implication.

Our simulation results imply that capital is less mobile than labor in the U.S. domestic market in terms of the search model-based measure of mobility. However, with the increase in the relative mobility of capital with respect to labor in the U.S. domestic market, the share of labor income in the gross proceeds or the final output declines, which may partially explain the rising income inequality in the U.S.

Moreover, the excess capital in the U.S. domestic market can flow into the global market. However, the capital outflow from the U.S. to the global market does not have a simple positive relationship to the relative mobility of capital. Although our intuition would suggest that the capital outflow is larger when capital becomes more mobile, our simulation results show that the percentage of capital outflow initially declines along with the increase in the relative mobility of capital until the relative mobility of capital reaches a turning point. We interpret this phenomenon as the result of the interactions or competitions between domestic capital mobility and international capital mobility. Although capital becomes more mobile (before the turning point), it is still meaningless for capital to explore the unknown and risky global market if capital can extract more benefits from the domestic market by matching with labor more efficiently. In brief, our simulation results challenge the traditional view that more capital mobility always promotes financial globalization.

In addition, our simulation results also show that the share of labor income in the gross proceeds is negatively related to the bargaining power of capital and the separating rate between capital and labor. In other words, when the bargaining power of capital and the separating rate between capital and labor increase, the share of labor income will decline, both of which are relevant to the U.S. income inequality.

Our model is based on search theory (Diamond, 1984; Pissarides, 2000; Mortensen and Pissarides, 1994), which is widely applied to investigate search frictions on equilibrium unemployment in labor economics and macroeconomics. However, there are only a few research papers from the literature on the application of search theory in the field of finance. Chen et al. (2015) propose a random search-based model to explore the pre-IPO market search process between private firms and investment banks. Song and Jain (2020) set up a random search model to investigate the search and bargain process between angel investors and entrepreneurs in the very early-stage financing market. Song and Mussa (2021) establish a two-sided random search model to study the trading behaviors between commercial property investment companies in the commercial real estate market.

The rest of this paper proceeds as follows: Section 2 establishes a random search-based model in a two-factor (capital and labor) production economy; Section 3 implements the model simulation and discusses its empirical implications; Section 4 concludes. Appendix A summarizes the symbols and notations used in the paper. Appendix B provides the proofs of propositions and corollaries.

2. MODEL SET-UP

In a simplified two-factor production economy, there are two types of factors and two types of players: capitalists (denoted by the subscript of C) who provide capital such as machines for a joint project, and laborers (denoted by the subscript of L) who provide labor in terms of devoted time and effort into the project. For simplicity, we assume that each capitalist owns one unit of capital and each laborer owns one unit of labor, and each joint project requires one unit of capital and one unit of labor as inputs.

We normalize the measure (or number) of laborers to be 1. At any time point, there may be u measure of laborers who cannot match with capital and thus (1–u) measure of laborers who can match with capital. If the measure of idle capitalists is represented by v, then the total measure of capitalists will be (1–u)+v=1-u+v.

Laborers and capitalists will continuously meet with each other according to a standard Poisson process with the matching rates α_L and α_C respectively. In other words, during each period, a laborer expects to meet α_L number of capitalists and a capitalist expects to meet α_C number of laborers. The relative mobility of capital can be represented by the difference between those two matching rates (α_C–α_L).

During each period, the unemployed laborer will obtain the unemployment benefit b while the unutilized capital will incur the maintenance cost c to capitalists. Meanwhile, when there is a successful match between a laborer and a capitalist, they will bargain on how to allocate the gross proceeds or the final output between them. If the gross proceeds from the project during each period are denoted by R, then the bargaining process makes the share of labor income be w and the share of capital income be the remaining part, R–w. Supposing that the capitalist's bargaining power is θ that falls between 0 and 1, we can apply the generalized Nash bargaining scheme to determine w. Here, the larger the value of θ, the higher the bargaining power of the capitalist over the laborer. In addition, during each period, a matched pair may break up as well either due to a voluntary or forced job quit by the laborer according to another standard Poisson process with a separating rate σ.

Lastly, we assume that time is continuous and goes from zero to infinity and that both types of players are homogeneous and risk-neutral with the same discount rate r, which characterizes the time preference of players.

Since there are two types of players (laborers and capitalists) and each player can be either in the idle state or in the matched state, we can thus definefour value functions as below:
U_C: The value of a capitalist who is searching for labor
V_C: The value of a capitalist who matches with a laborer
U_L: The value of a laborer who is searching for capital
V_L: The value of a laborer who matches with a capitalist.

In short, our two-factor production economy can be illustrated by Figure 1.

Then, we establish four standard Bellman search equations:

$$r\,U_L = b+\alpha_L(V_L-U_L) \quad (1)$$

$$r\,V_L = w+\sigma(U_L-V_L) \quad (2)$$

$$r\,U_C = -c+\alpha_C(V_C-U_C) \quad (3)$$

$$r\,V_C = R-w+\sigma(U_C-V_C) \quad (4)$$

Bellman equations have a consistent structure: The left-hand side is the flow value defined as the product of the discount rate and the corresponding value function; the right-hand side is the benefit or cost of staying in the corresponding state during each period (b, c, w, or R–w) plus the product of the state-change rate (α_L, α_C, or σ) and the value change from the current state. For instance, the left-hand side of Equation (1) represents the flow value of an unemployed laborer who is searching for capital while the right-hand side of Equation (1) indicates that the unemployed laborer will obtain the unemployment benefit b during each period and may change from the idle state to the matched state with the matching rate α_L.

We further assume the free exit and entry for capitalists:

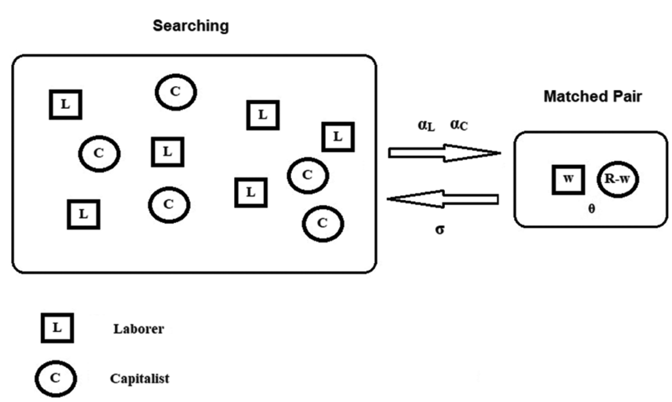
$$U_C=0 \quad (5)$$

We then define two surplus functions, S_C and S_L, for capitalists and laborers, respectively.

$$S_C=V_C-U_C \quad (6)$$

$$S_L=V_L-U_L \quad (7)$$

Figure 1: The schematic of the two-factor production economy



The share of labor income in market equilibrium w* solves the below optimization problem:

$$w^*=\text{Argmax } S_C^{\theta} S_L^{1-\theta} \tag{8}$$

We assume that the matching function M between the unemployed laborer (u) and the unutilized capital (v) is strictly concave and increasing in both arguments with constant returns to scale (CRS):

$$M=M(u,v) \tag{9}$$

If we define a ratio of unutilized capital to unemployed laborer, $\tau = v/u$. Intuitively, the higher this ratio, the more the amount of unutilized capital and the fewer the number of unemployed laborers, hence the easier for an unemployed laborer to match with the unutilized capital in the economy. Due to the constant returns to scale of the matching function M, the matching rates α_L and α_C can be rewritten as

$$\alpha_L \equiv M(u,v)/u=M(u/u,v/u)=M(1,\tau)\equiv m(\tau) \tag{10}$$

$$\alpha_C \equiv M(u,v)/v=[M(u,v)/u]/(v/u)=M(u/u,v/u)/(v/u)=M(1,\tau)/\tau=m(\tau)/\tau \tag{11}$$

Here, the reduced matching function m is an increasing and concave function of τ.

Linking the above equations, we can solve for τ in market equilibrium which is determined by (R, b, c, σ, r, θ) and by the functional form of m as well. Finally, the share of the gross proceeds for labor w can be resolved as well. Propositions 1 and 2 summarize the results.

Proposition 1: The market equilibrium of our two-factor production economy is characterized by the ratio of unutilized capital to unemployed laborer, τ, which satisfies the below equation:

$$\frac{m(\tau)\theta(R-b)}{\tau[r+\sigma+(1-\theta)m(\tau)]}=c \tag{12}$$

Proposition 2: Once the ratio of unutilized capital to unemployed laborer τ is determined from Equation (12), the share of the gross proceeds for labor w in market equilibrium can be expressed:

$$w=b+\frac{\tau[r+\sigma+m(\tau)]}{m(\tau)}\frac{(1-\theta)}{\theta}c \tag{13}$$

To simplify our analysis, we further assume that $m(\tau)$ has the below functional form:

$$m(\tau)=k\tau^{1/2} \tag{14}$$

Here, k is the coefficient for the reduced matching function m. We can then derive two corollaries that will be utilized in the model simulation part.

Corollary 1: Assuming $m(\tau)=k\tau^{1/2}$, the ratio of unutilized capital to unemployed laborer τ in market equilibrium of our two-factor production economy can be expressed:

$$\tau=\frac{(\sqrt{\beta^2+4\alpha\gamma}-\beta)^2}{4\alpha^2} \tag{15}$$

Here, $\alpha=k(1-\theta)c$, $\beta=(r+\sigma)c$, $\gamma=k\theta(R-b)$.

Corollary 2: Assuming $m(\tau)=k\tau^{1/2}$, once τ is determined from Equation (15), the share of the gross proceeds for labor w in market equilibrium can be expressed:

$$w=b+\left[\frac{\tau^{\frac{1}{2}}(r+\sigma)}{k}+\tau\right]\frac{(1-\theta)}{\theta}c \tag{16}$$

Combining equation (15) with equation (16), we can investigate the impacts of various factors such as the relative mobility of capital ($\alpha_C-\alpha_L$) and the bargaining power of capital (θ) on the share of labor income in the gross proceeds (w).

Lastly, since in market equilibrium, during each period the measure of unemployed laborers who turn into employed and match with capital, should equal the measure of employed laborers who become unemployed and break up with capital, we obtain:

$$\alpha_L u=\sigma(1-u) \tag{17}$$

Thus, we have Corollary 3 to summarize the measures of various types of players in market equilibrium.

Corollary 3: Assuming $m(\tau)=k\tau^{1/2}$, once τ is determined from Equation (15), the measures of four types of players in market equilibrium of our two-factor production economy can be expressed:

the measure of unemployed laborers= $u=\dfrac{\sigma}{k\tau^{\frac{1}{2}}+\sigma}$ (18)

the measure of employed laborers or the measure of utilized capital $=1-u=1-\dfrac{\sigma}{k\tau^{\frac{1}{2}}+\sigma}$ (19)

the measure of unutilized capital $=v=u\tau=\dfrac{\sigma}{k\tau^{\frac{1}{2}}+\sigma}$ (20)

the measure of total capital $=1-u+v=1+\dfrac{\sigma(\tau-1)}{k\tau^{\frac{1}{2}}+\sigma}$ (21)

3. SIMULATION

Simulation may better represent those relationships than equations. In this section, we first calibrate the parameters of our model based on the U.S. macroeconomic data. Then we implement simulation to study the impact of the relative mobility of capital on income inequality and financial globalization.

3.1. Calibration

We choose the median of market yields on U.S. Treasury Securities at 10-Year Constant Maturity from January 2000 to March 2022[3],

3 https://fred.stlouisfed.org/series/GS10

3%, as the value of the discount rate r. Based on one report from the U.S. Bureau of Labor Statistics (BLS), the median job tenure for workers was 4.1 years in January 2020[4], thus the job separating rate σ can be estimated as the inverse of the median job tenure, i.e., $\sigma=1/4.1\approx0.24$ per year. As a starting point, assuming that laborers and capitalists have the same bargaining power, then $\theta=0.5$.

Next step, we normalize the gross proceeds or the final output R as 1. According to Manyika et al. (2019), the share of labor income declined from 63.3% in 2000 to 56.7% in 2016. Thus, the average share of labor income is about (63.3%+56.7%)/2=60%. According to the employment & training administration (ETA) of the U.S. Department of Labor, the average unemployment insurance (UI) replacement rate, defined as "*the ratio of the claimants' weekly benefit amount to the claimants' average weekly wage*," is about 40% from 2000 to 2021[5]. Then, the unemployment benefit b=R× the average share of labor income × the average UI replacement rate =1×60%×40%=0.24 (However, Ganong et al., 2020 report that the median statutory UI replacement rate during the pandemic in the U.S. is surprisingly145%!).

We estimate the maintenance cost of unutilized capital incurred by capitalists as c=(GDP-NDP)/GDP, here GDP represents the U.S. gross domestic product and NDP represents the U.S. net domestic product. According to Table 1.7.5 titled "Relation of Gross Domestic Product, Gross National Product, Net National Product, National Income, and Personal Income" from the website of the St. Louis Fed[6], in 2021the U.S GDP and NDP are $22,996 Billion and $19,148 Billion, respectively. Thus, c=(22,996-19,148)/22,996≈0.17.

The most challenging part is to calibrate the value of k, the coefficient for the reduced matching function m. According to a study by Randstad US before the pandemic, it takes a job seeker about 5 months (0.42 years) on average to secure a job,[7] thus the matching rate $\alpha_L\approx$ the inverse of the average job searching time=1/0.42=2.38 per year. Furthermore, based on Equations (10) and (14), $\alpha_L \equiv m(\tau)=k\tau^{1/2}$, then $k=\alpha_L/\tau^{1/2}\approx 2.38/\tau^{1/2}$. As the first-order approximation, if we assume that the measure of unutilized capital is commensurate with the measure of unemployed laborers, i.e., $\tau\approx1$, then k =1. To make our simulation results robust, we choose [0.2, 2] as the possible range of k.

Table 1 summarizes the typical values of parameters and their possible ranges that will be used in the simulation.

4 https://www.bls.gov/news.release/pdf/tenure.pdf
5 https://oui.doleta.gov/unemploy/ui_replacement_rates.asp
6 https://fred.stlouisfed.org/release/tables?rid=53&eid=41999#snid=42030
7 https://nypost.com/2018/10/16/job-hunting-is-at-least-a-5-month-slog/

4. DISCUSSION

4.1 Capital Mobility versus Labor Mobility

4.1.1. The impact of the relative mobility of capital

The relative mobility of capital with respect to labor is measured by the difference between the two matching rates ($\alpha_C-\alpha_L$) in our model. Figure 2a-c shows the impact of the relative mobility of capital on the unemployment rate, the share of labor income, and the percentage of capital outflow. According to our simulation results, the value of the relative mobility of capital is always negative, indicating that capital is less mobile than labor in the domestic market.

In Figure 2a and b, with the increase in the relative mobility of capital, the unemployment rate rises while the share of labor income declines. This result vividly reflects the dynamic interaction of capital mobility and labor mobility and its implication for income inequality. When capital becomes more mobile compared to labor, the better position capitalists may acquire over laborers, thus the smaller the proportion of the gross proceeds shared by laborers and the higher the unemployment rate will be. As the result, the income gap between capitalists and laborers has widened, leading to more severe income inequality for the entire society.

In Figure 2c, we assume that the original amount of capital is larger than the total amount of capital in market equilibrium (if the opposite is assumed, we can still draw a similar conclusion except that the percentage of capital outflow will be altered by the percentage of capital inflow). We find that the percentage of capital outflow initially declines and then rises when the relative mobility of capital keeps increasing. In other words, there exists a minimum point for the percentage of capital outflow. This result implies the "*duality of capital mobility in financial globalization*," in which more mobile capital may not always promote capital outflows and may impede them. One possible explanation is that when capital becomes more mobile, the benefits from the domestic market may discourage the further exploration by capital into the global market until the mobility of capital passes a critical point.

4.1.2. The impact of the separating rate of capital and labor

Capital mobility and labor mobility can also be partially reflected by the separating rate of capital and labor, σ. When σ increases, we can safely claim that both capital mobility and labor mobility rise. However, it is still challenging to identify theoretically whether the relative mobility of capital with respect to labor rises or not.

Figure 3a and b shows the impact of the separating rate of capital and labor on the unemployment rate and the share of labor income.

Table 1: Parameter calibration

Name	Notation	Typical Value	Possible Range
The discount rate	r	3%	/
The bargaining power of capitalists	θ	0.5	0.2~0.8
The separating rate of capital and labor	σ	0.24	0.1~0.4
The coefficient for the reduced matching function	k	1	0.2~2
The gross proceeds or output	R	1	/
The unemployment benefit	b	0.24	/
The maintenance cost of unutilized capital	c	0.17	/

Figure 2: (a-c) The impact of the relative mobility of capital

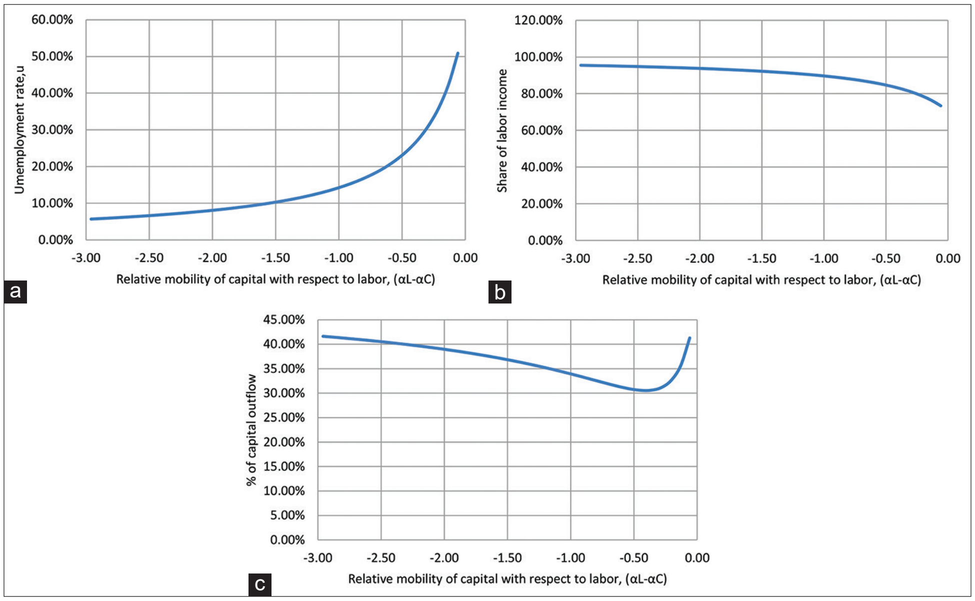
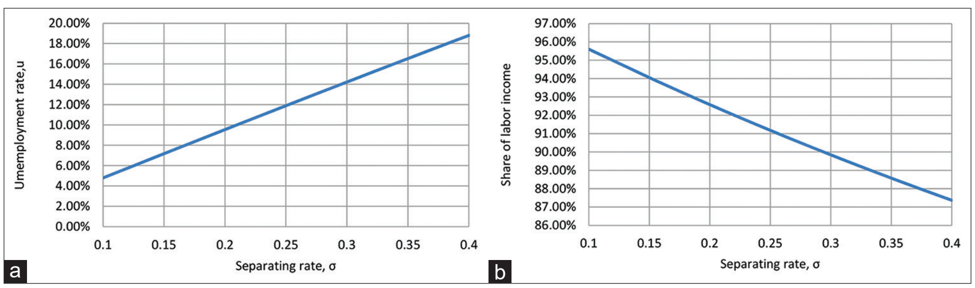


Figure 3: (a and b) The impact of the separating rate of capital and labor



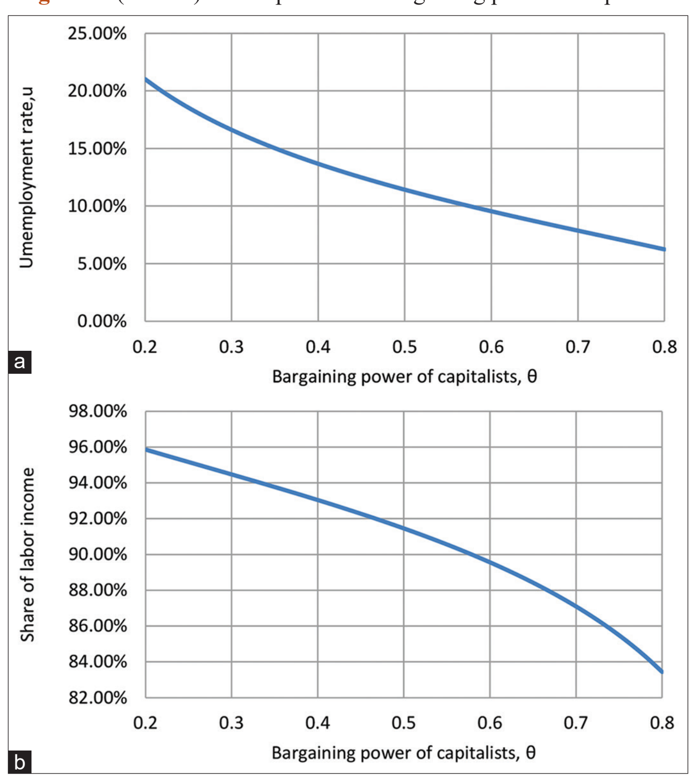
Compared with Figure 2a and b, the separating rate here and the relative mobility of capital studied previously have a rather similar effect. In other words, with the increase in the separating rate, the unemployment rate rises while the share of labor income declines, which may indicate that (1) the increase in the separating rate represents the increase in the relative mobility of capital and (2) capital benefits more from the increase in the separating rate than labor does.

4.2. The Bargaining Power of Capitalists

Another important factor that is relevant to income inequality is the bargaining power of capitalists θ. We initially assume the unbiased bargaining powers of capitalists and laborers with θ=1–θ=0.5. Now we let θ alter from 0.2 to 0.8.

In Figure 4a and b, when the bargaining power of capitalists increases, both the unemployment rate and the share of labor income decline simultaneously. It is no surprise that the share of labor income declines when the bargaining power of capitalists increases. However, our simulation result also implies one interesting benefit of the increase in the bargaining power of capitalists- the reduction of the unemployment rate, which can be explained intuitively as below: with the increase in the bargaining power of capitalists, laborers may become less resistant to accept any job offers.

Figure 4: (a and b) The impact of the bargaining power of capitalists



5. CONCLUSION

As a Nobel Prize winner in economics, Robert Shiller (2012) once expressed his rather optimistic opinion on the role of finance in a good society- "*rather than condemning finance, we need to reclaim it for the common good*". In this paper, we investigate the broad impact of the relative mobility of capital with respect to labor on income inequality and financial globalization for the 1st time via a random search-based model.

We find that the share of labor income in the gross proceeds is negatively related to the relative mobility of capital, the separating rate between capital and labor, and the bargaining power of capital, which are closely related to the rising income inequality in the U.S. Thus, to counteract the current uneasy trend of income inequality, possible policy suggestions would be to encourage the mobility of labor and discourage the mobility of capital, to escalate the cost of firing workers, and to diminish the bargaining power of capital.

Although our simulation results indicate that capital is less mobile than labor in the U.S. domestic market, the excess capital in the U.S. can flow into the global market. More importantly, the relationship between the relative mobility of capital and the capital outflow is not linear but rather complicated. Against our intuition that the higher the relative mobility of capital, the larger the capital outflow to the global market, we instead find that with the increase in the relative mobility of capital, the percentage of capital outflow to the global market declines initially, indicating that more mobile capital may not always promote financial globalization and may even depress it insofar as the benefits from the domestic market may discourage the further exploration by capital into a broader market until a critical point.

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APPENDIX

Appendix A: Symbols and notations

r: The discount rate
θ: The bargaining power of capitalists
σ: The separating rate between capital and labor
M: The matching function
m: The reduced matching function
k: The coefficient for the reduced matching function
α_C: The meeting rate of capitalists to laborers
α_L: The meeting rate of laborers to capitalists
R: The gross proceeds or the final output
w: The share of labor income
b: The unemployment benefit
c: The maintenance cost of unutilized capital
τ: The ratio of unutilized capital to unemployed laborer
U_C: The value of a capitalist who is searching for labor
V_C: The value of a capitalist who matches with a laborer
U_L: The value of a laborer who is searching for capital
V_L: The value of a laborer who matches with a capitalist
1: The measure of laborers (normalized to 1)
u: The measure of unemployed laborers
v: The measure of unutilized capital
1–u: The measure of employed laborers or the measure of utilized capital
1–u+v: The measure of total capital
S_C: The surplus function for capitalists
S_L: The surplus function for laborers

Appendix B: Proofs of Propositions and Corollaries

Proposition 1

Plug (6) and (7) into (8), then the first-order condition for w is:

$$\theta\frac{\partial V_C}{\partial w}(V_C-U_C)^{\theta-1}(V_L-U_L)^{1-\theta}+$$
$$(1-\theta)\frac{\partial V_L}{\partial w}(V_C-U_C)^{\theta}(V_L-U_L)^{-\theta}=0 \qquad \text{(B-1)}$$

Based on (2) and (4), respectively, we obtain:

$$\frac{\partial V_L}{\partial w}=\frac{1}{r+\sigma} \qquad \text{(B–2)}$$

$$\frac{\partial V_C}{\partial w}=-\frac{1}{r+\sigma} \qquad \text{(B–3)}$$

Plug (B-2) and (B-3) into (B-1) and simplify (B-1),

$$(1-\theta)(V_C-U_C)=\theta(V_L-U_L) \qquad \text{(B-4)}$$

Plug (5) into (B-4),

$$V_L-U_L=\frac{1-\theta}{\theta}V_C \qquad \text{(B-5)}$$

(2)-(1) $\rightarrow r\,(V_L-U_L)=w-b-(\alpha_L+\sigma)((V_L-U_L)$

$$w=b+(r+\alpha_L+\sigma)\,(V_L-U_L) \qquad \text{(B-6)}$$

Replace (V_L-U_L) by (B–5) in (B–6),

$$w=b+(r+\alpha_L+\sigma)\frac{1-\theta}{\theta}V_C \qquad \text{(B-6)}$$

Replace w by (B-7) in (4),

$$(r+\sigma)V_C=R-w=R-b-(r+\alpha_L+\sigma)\frac{1-\theta}{\theta}V_C \qquad \text{(B-8)}$$

$$\text{Then, } V_C=\frac{\theta(R-b)}{r+\sigma+(1-\theta)\alpha_L} \qquad \text{(B-9)}$$

Plug (5) into (3),

$$V_C=\frac{c}{\alpha_C} \qquad \text{(B-10)}$$

Link (B-9) and (B-10), we obtain:

$$\frac{\alpha_C\theta(R-b)}{r+\sigma+(1-\theta)\alpha_L}=c \qquad \text{(B-11)}$$

According to (10) and (11), replacing α_C by $m(\tau)/\tau$ and α_L by $m(\tau)$, we obtain:

$$\frac{m(\tau)\theta(R-b)}{\tau[r+\sigma+(1-\theta)m(\tau)]}=c \qquad \text{(12)}$$

Proposition 2

Plug (B-10) into (B-7),

$$w=b+(r+\alpha_L+\sigma)\frac{1-\theta}{\theta}\frac{c}{\alpha_C} \qquad \text{(B-12)}$$

Again, replace α_c by $m(\tau)/\tau$ and α_L by $m(\tau)$, we obtain:

$$w=b+\frac{\tau[r+\sigma+m(\tau)]}{m(\tau)}\frac{(1-\theta)}{\theta}c \qquad \text{(13)}$$

Corollary 1

Replace $m(\tau)$ by $k\tau^{1/2}$ in (12),

$$\frac{k\tau^{\frac{1}{2}}\theta(R-b)}{\tau[r+\sigma+(1-\theta)k\tau^{\frac{1}{2}}]}=c \qquad \text{(B-13)}$$

Simplify (B-13), we obtain:

$$c(1-,)k\tau+c(r+\sigma)\tau^{\frac{1}{2}}-k\theta(R-b)=0 \qquad \text{(B-14)}$$

Define $\alpha=k(1-\theta)c$, $\beta=(r+\sigma)c$, $\gamma=k\theta(R-b)$, and $\chi=\tau^{\frac{1}{2}}$, (B-14) can be rewritten in a quadratic format,

$$\alpha\chi^2+\beta\,\chi-\gamma=0 \qquad \text{(B-15)}$$

The only positive solution to (B-15) is:

$$\tau^{\frac{1}{2}} = \chi = \frac{-\beta + \sqrt{\beta^2 + 4\alpha\gamma}}{2\alpha} \quad \text{(B-16)}$$

Then, $$\tau = \frac{(\sqrt{\beta^2 + 4\alpha\gamma} - \beta)^2}{4\alpha^2} \quad (15)$$

Corollary 2

Replace $m(\tau)$ by $k\tau^{1/2}$ in (13),

$$w = b + \frac{\tau[r + \sigma + k\tau^{\frac{1}{2}}]}{k\tau^{\frac{1}{2}}} \frac{(1-\theta)}{\theta} c \quad \text{(B-17)}$$

Then, $$w = b + [\frac{\tau^{\frac{1}{2}}(r+\sigma)}{k} + \tau] \frac{(1-\theta)}{\theta} c \quad (16)$$

Corollary 3

According to (17), we obtain:

$$u = \frac{\sigma}{\alpha_L + \sigma} \quad \text{(B-18)}$$

Replace α_L by $m(\tau)=k\tau^{1/2}$, we obtain:

$$u = \frac{\sigma}{k\tau^{\frac{1}{2}} + \sigma} \quad (18)$$

Then,

$$1 - u = 1 - \frac{\sigma}{k\tau^{\frac{1}{2}} + \sigma} \quad (19)$$

$$v = u\tau = \frac{\sigma\tau}{k\tau^{\frac{1}{2}} + \sigma} \quad (20)$$

$$1 - u + v = 1 + \frac{\sigma(\tau - 1)}{k\tau^{\frac{1}{2}} + \sigma} \quad (21)$$