ASSET PRICES, LIMITED PARTICIPATION, AND INCOME INEQUALITY

BY

XIAOLIN ZHAO

A DOCTORAL DISSERTATION SUBMITTED TO
THE FACULTY OF THE GRADUATE SCHOOL AT
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ABSTRACT

In this dissertation, the short- and long-run effects of stock price appreciation on household income inequality under limited stock market participation are empirically and theoretically studied. This is achieved by characterizing the dynamics of the income inequality between stockholders and nonstockholders using Panel Study of Income Dynamics (PSID) data and a heterogeneous agent general equilibrium model.

The main finding is that there is no trend in income inequality between stockholders and nonstockholders for the period 1980 to 2001, during which time the stock market appreciated more than five times. Obviously stock market appreciation had not contributed to the trend of the observed Gini index. In the short run, however, stock market appreciation is found to increase income inequality between stockholders and nonstockholders. The estimation method controls for household idiosyncratic unemployment as well as household demographics via a fixed-effect panel data regression model. The finding also suggests that increasing premiums of skills contributed substantially to income inequality.

The heterogeneous agent general equilibrium model shows that stock market appreciation, given limited stock market participation, has no effect on income inequality in the long run, which is consistent with the empirical findings. In the short run, the effect of stock market appreciation on income inequality is mild and depends on the type of productivity shift that causes the appreciation. Stock price appreciation that results from a total factor productivity change has less effect on income inequality than stock appreciation that results from a skill-biased technological change. The analysis also finds

that increasing stock market participation of and increasing skill acquisition by nonstockholders, who are typically less skilled, could decrease the level of income inequality.

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CHAPTER 1

INTRODUCTION

Income inequality—as measured by the Gini coefficient—remained relatively stable in the United States from the early 1950s to the 1960s. Since the 1970s, however, there has been a trend toward increasing income inequality. In recent years, quite a few studies have been conducted to identify the possible causes of the upward trend and the business cycle dynamics in income inequality.[1] In general, the increase in skill premiums is found to be the primary cause of the trend in income inequality (Krueger 1993; Berman et al. 1994; Krusell et al. 1997; Acemoglu 2002; Johnson 1997; Murphy et al. 2001), and the stock market boom is suggested as a possible contributor to the dynamics of this trend (Smith 2001; Piketty and Emmanuel 2001; Clark 2002; Wolff 2000).[2] However, the effects of stock market appreciation on income inequality have not been rigorously studied. The issue has important public policy implications on dividend and/or capital gain taxation policies, which affect investment and ultimately economic growth. The purpose of this dissertation is to study whether and how equity appreciation affects income inequality both empirically and theoretically.

Empirically, the analysis is conducted in two phases. First, the effects of the trend in equity prices on the trend in income inequality are quantified. This is a long-run analysis. The study uses the Panel Study of Income Dynamics Data and splits the sample into two groups: stockholders and nonstockholders. A time series of the income inequality index between stockholders and nonstockholders is constructed, and the

[1] See Levy and Murnane (1992) and Burtless (1995) for a survey.
[2] Chapter 2 presents a survey of literature.

correlation of this inequality index and the stock market index (S&P 500) is analyzed. It is natural to make the split; if the stock market has any effects on income inequality, it should be evident on the income inequality between stockholders and nonstockholders.

Second, the marginal effect of equity appreciation on income inequality is estimated and simulated. This is a short-run analysis. A regression analysis of the different income responsiveness parameters of stockholders and nonstockholders to the stock market is conducted, after controlling for economic growth, household idiosyncratic unemployment, and household demographics.

To determine the long-run effects of stock price appreciation on income inequality and its contribution to fluctuations in income inequality, this study develops a general equilibrium real business cycle model with heterogeneous agents: stockholders and nonstockholders. Stock valuation is assumed based on the economy's fundamental characteristics, especially the economy's level of technology. Furthermore, the model assumes stockholders are skilled workers and nonstockholders are unskilled workers. The motivation behind this construction is that stockholders are typically more skilled than nonstockholders, and that skill-biased technological changes (SBTC) have been found to contribute substantially to the secular trend in income inequality. The same technology has obviously boosted productivity and the stock market valuation. Thus a stockholder benefits from an SBTC through both the labor market and the equity market. This assumption helps differentiate the income inequality effect of equity appreciation from that of skill premium changes.

The model is first solved analytically assuming a Cobb-Douglas production function and then evaluated numerically assuming a more elaborate constant elasticity of substitution (CES) production function. The CES production function allows for two possible types of technological shocks: total factor productivity shocks (TFP) and skill-biased technological changes (SBTC). The model quantifies the business-cycle effects of TFP shocks and SBTC shocks on income inequality through equity appreciation and changes in the skill premium. The main findings of the dissertation are the following:

(1) Trend in stock market appreciation has no effect on income inequality trend.

(2) Deviation of stock market growth from its long-run trend increases income inequality temporarily.

(3) Stock market appreciation as a result of an investment-specific, skill-biased technological shock has a larger effect on income inequality than stock market appreciation that results from a TFP shock.

(4) Increases in skill premiums contribute substantially to increases in income inequality.

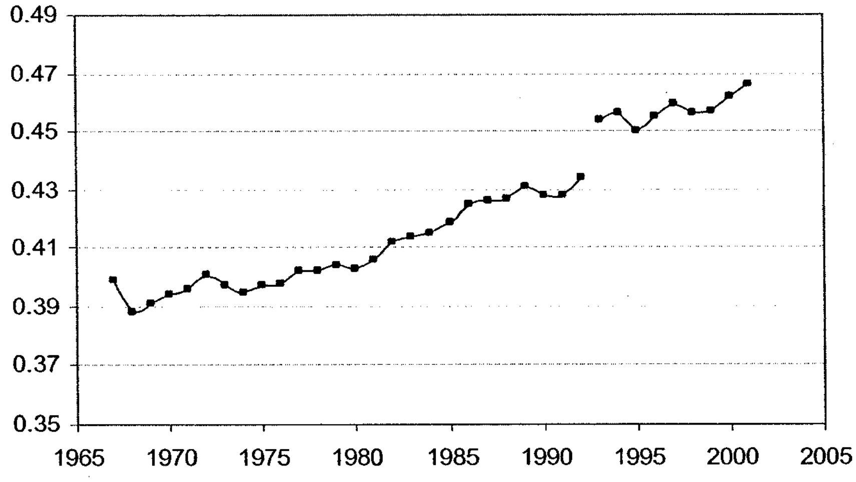
This dissertation is organized as follows. Chapter 2 presents an overview of increasing income inequality in the U.S. and a literature review of possible causes. Chapter 3 presents the data, the sample selection method, and the summary statistics of the sample. Estimates and simulation results of the effects of the stock market on income inequality are discussed. Chapter 4 develops a general equilibrium model with heterogeneous agents to replicate the empirical findings of Chapter 3. Chapter 5 concludes with a discussion of the results.

CHAPTER 2

Overview of and Explanations for Rising Income Inequality in the U.S.

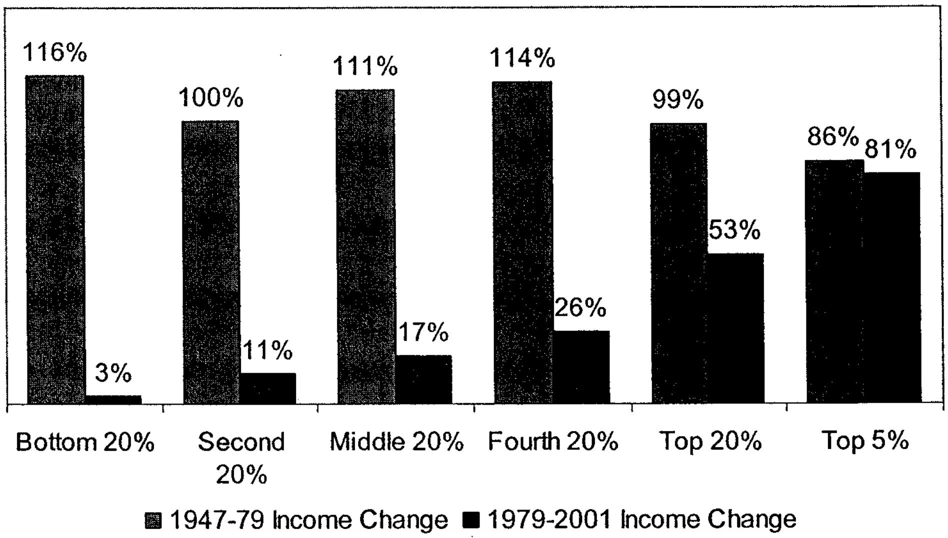
2.1. Rising Income Inequality in the U.S.

Income inequality in the U.S. has been increasing by different measurements since at least the early 1980s. Figure 2.1 presents the income Gini index. It has been steadily increasing over the past 30 years. Figure 2.2 presents the growth rate of the average income received by each income distribution quintile and the top 5 percent over time. From 1947 to 1979, household income doubled for all quintiles. Middle-class and lower-income households experienced slightly higher income growth than upper-class households. All income quintiles shared in the growth of the economy. However, from 1979 to 2001, the picture is quite different. Households with higher incomes in 1979 experienced higher income growth over this period. For example, the income growth rate of the top quintile is twice that of the fourth quintile and more than 15 times that of the bottom quintile. Households have been drifting apart in terms of income growth in the past two decades. Over the same period, average annual real GDP growth has been about three percent, and the real stock market index appreciated more than five times from the early 1980s to 2001. Apparently, the growth of the economy has not benefited all segments of the population to the same extent over this period.



Note: The gap results from a change in the measurement method in income Gini index.
Source: Current Population Survey, Annual Demographic Supplements. The Gini index is calculated based on the pretax and after-transfer income.

FIGURE 2.1: Household Income Inequality in the U.S. as Measured by the Gini Index



Source: Analysis of U.S. Census Bureau data by Economic Policy Institute.

FIGURE 2.2: Income Growth by Quantile and Top 5 Percent

2.2. Possible Causes: A Literature Review

Increasing income inequality has attracted substantial attention from the government, academia, and the public at large. A few studies have tried to identify the causes and dynamics of increasing income inequality.

A main factor driving the increase in income inequality is the steady increase in skill premiums resulting from skill-biased technological changes (Krueger 1993; Berman et al. 1994; Krusell et al. 1997; Acemoglu 2002; Johnson 1997; Murphy et al. 2001). Skill differences and greater demand for skilled workers have been found driving the upward trend in the skill premium. This factor alone accounts for about two-thirds of the increase in income inequality.

International trade and globalization are other factors contributing to the increase in income inequality (Cline 2001; Lloyd-Ellis 1999; Burtless 1995; Freeman 1995; Richardson 1995; Wood 1995). Increase in imports of manufactured goods from less-developed countries, outsourcing, and production transfer to less-developed countries exert a downward pressure on wage rates and employment in the manufacturing sector, which in turn negatively affects wage and employment in related industries, especially the service sector. Wages in the export sector are not affected by or even benefit from international trade. Thus income inequality increases. Although there are some conflicting results, international trade and globalization are generally found to contribute a relatively small amount (less than 10 percent) to the increase in income inequality.

Demographic changes also contribute to the increase in income inequality (Deaton and Paxson 1994; Karoly and Burtless 1995; Lloyd-Ellis 1999; Burtless 1999).

The increase in women's labor force participation, the growing correlation between husband's and wife's wage incomes, and the increase in single-adult families are found to be contributing factors. For example, Burtless (1999) found that positive wage correlation between men and women accounts for about 13 percent of the increase in inequality from 1979 to 1996. The sharp increase in the number of single-parent families may account for 21-25 percent of the increase in inequality. Deaton and Paxson (1994) found that income inequality increases over age, and the aging of baby boomers in the U.S. may have contributed to the increase in income inequality.

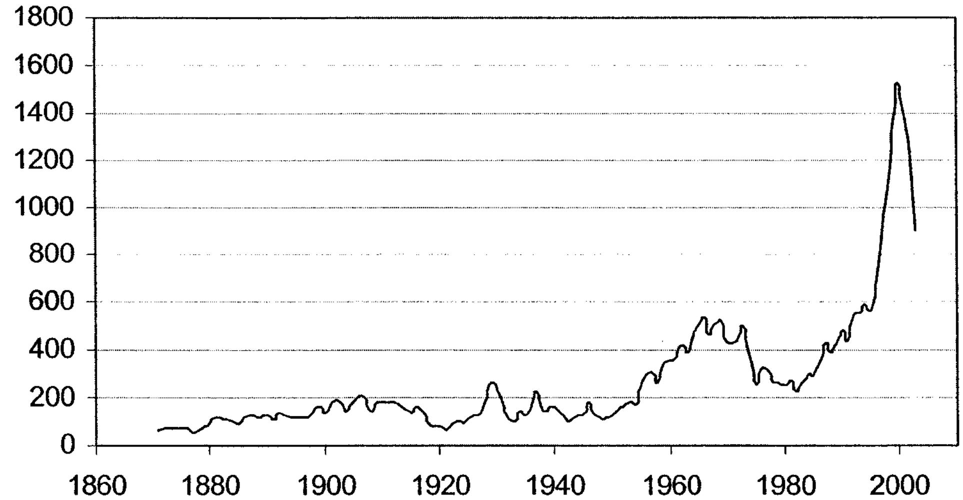
Institutional changes also contribute to the increase in income inequality (Fortin and Lemieux 1997; Card and DiNardo 2002). The decline in the real minimum wage, the decline in unionization, economic deregulation movements, and changes in taxation policy have contributed to the increase in income inequality. For example, Fortin and Lemieux (1997) find these institutional changes can account for one-third of the increase in inequality.

Other factors contributing to the increase in income inequality include idiosyncratic earning risks (Castañeda et al. 1997, 2003; Primiceri and Ren 2002), the intergenerational transmission of earning inequality (Solon 1992; Gokhale et al. 2001; De Nardi 2002; Bowles and Gintis 2002), and immigration, especially illegal immigration of unskilled workers (Topel 1997). The stock market boom is suggested as a contributing factor to the increase in income inequality (Smith 2001; Piketty and Emmanuel 2001; Piketty 2003; Clark 2002; Wolff 2000). For surveys of the causes of the trend in income inequality, see Levy and Murnane (1992), Burtless (1995), and Johnson (1997).

2.3. Is the Booming Stock Market a Cause? An Overview

The boom in the stock market has been suggested as a potential cause of increasing income inequality in both the media and academic research. In the past 20 years, the U.S. stock market has appreciated substantially. From 1980 to 2000, the S&P 500 index increased by more than five times (Figure 2.3). Due to limited household participation in the stock market as a result of liquidity constraint and/or participation cost (Vissing-Jorgensen 2002), wealth inequality between stockholders and nonstockholders increased. This is because most wealth for nonstockholders is in the form of residential housing, which does not generate a flow of income, and/or in assets with a relatively low return, such as a savings account (Vissing-Jorgensen 2002; Halliassos and Jappelli 2001). Smith (2001) shows that the boom in the stock market can account for most of the increase in wealth inequality during the 1980s and 1990s.

Does growing wealth inequality cause growing income inequality? The issue may not have a straightforward answer. Wealth is a stock, and income is a flow. Wealth grows either from an increase in net savings and/or from a positive investment return. Wealth is a source of income when there is interest or dividend income and/or when at least a portion of the assets is liquidated. A household may opt not to realize return or to liquidate assets for an extended period of time—for example, retirement saving. In such a case, changes in the stock of wealth would have little effect on income. However, at the



Note: The index value is CPI adjusted in 2003 dollar value.
Source: www.econ.yale.edu/~shiller/data.htm.

FIGURE 2.3: S&P 500 Index

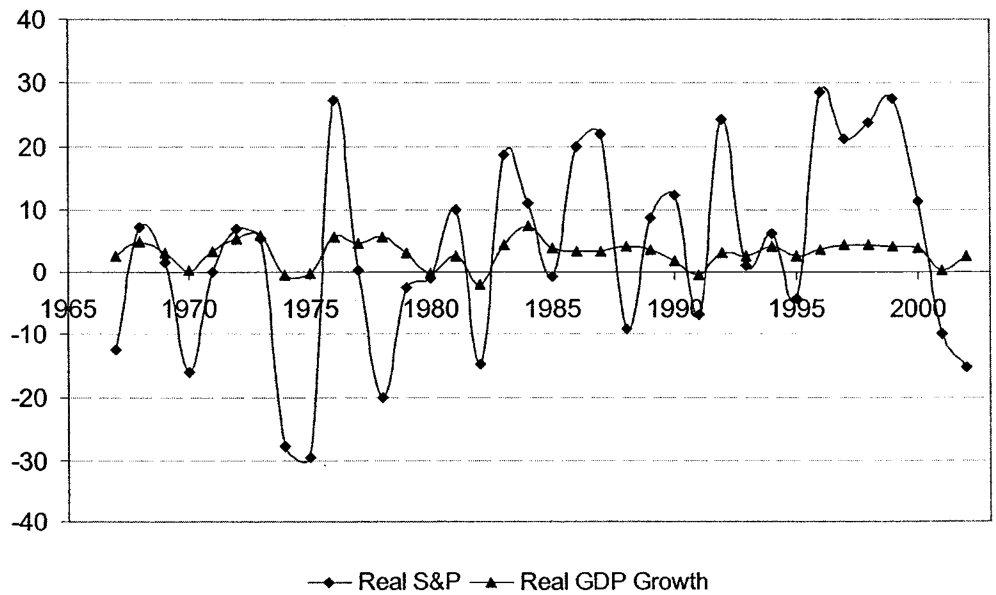


FIGURE 2.4: Real GDP Growth versus S&P Index Growth

aggregate level, on average, wealth is certainly a source of income. In any period, there are presumably always some households that choose to realize return on savings or to liquidate wealth holdings due to differences in ages, idiosyncratic income risks and preferences, and portfolio reallocation. It is likely that more households would realize their return on savings in a booming market. Thus, a booming market may induce an increase in income inequality due to higher realized return from portfolio investment. Meanwhile, a booming stock market is typically associated with higher productivity and GDP growth, which raises households' labor earnings. Figure 1.4 plots the time series of the growth rates of the S&P 500 stock price index and of GDP. The two series are positively correlated with a correlation coefficient of 0.55 for the time period 1970 to 2001. As the income of households at the lower end of the income distribution is more sensitive to real GDP growth, mainly due to the employment effect (Zhao and Zietz, 2004), a booming stock market may actually be associated with a decrease in income inequality, ceteris paribus. Blank (1989) confirms that income inequality narrows in economic expansions, which is proposed by earlier studies using aggregate data. Thus, the effect of stock market appreciation on income inequality is ambiguous.

Relatively few studies have focused on the stock market's impact on income inequality. Several studies focus on the causal relationship between economic growth and income inequality. Since stock market growth is cointegrated with economic growth, the causal relation between growth and inequality may shed light on the effect of the stock market on income inequality.

2.3.1. Stock Price and Income Inequality: A Literature Review

Smith (2001), relying on Panel Study of Income Dynamics (PSID) data and Health and Retirement Survey[3] (HRS) data, shows that wealth inequality has risen dramatically since at least the mid-1980s. After taking into account the amount of net investment in the stock market, Smith finds that the increase in wealth inequality has mainly resulted from capital gains in the equity market that accrued only to stockholders. Smith's study is based on a rigorous statistical analysis. It does not theoretically model the process of increasing wealth inequality caused by the stock market. Clark (2002) argues that the amount of wealth has grown much faster than output since the 1980s; "part of it has to come from either redistribution of existing wealth or from a shifting of costs away from capital towards workers and communities." He suggests that the stock market boom is accompanied by a real income decline of the poor, thus increasing income inequality.

Piketty (2001, 2003) uses time series data from income tax returns, wage tax returns, and inheritance tax returns from as early as the 1910s to 2000 to study the long-term dynamics of income inequality in the U.S. and France. He finds that the secular decline or increase in income shares of the top tenth percentile of households is for the most part a capital income phenomenon: "Holders of larger fortunes were badly hurt by major shocks during the 1914-45 periods, and they were never able to fully recover from these shocks, probably because of the dynamic effect of progressive taxation on capital accumulation and pretax income inequality." He implies the stock market has a positive effect on the cyclicality of income inequality, but the effect is nonsymmetric: the negative

[3] PSID website: http://psidonline.isr.umich.edu/; HRS website: http://hrsonline.isr.umich.edu/.

effect when the stock market is down is larger than the positive effect when the stock market is booming, because of the progressive taxation effect.

Das and Mohapatra (2003) study empirically income inequality implications of liberalizing emerging stock markets. They find that the income share of the top quintile of income distribution grows at the expense of the "middle class," which is defined as the three middle quintiles of income distribution. The share of the lowest income quintile remains effectively unchanged in the event of liberalization.

2.3.2. Economic Growth and Income Inequality: A Literature Review

Kuznets (1955) states that output growth is accompanied in the early stages of development by an increase in inequality, whereas in the later stage the reverse happens. He suggests that inequality is of a transitory nature as long as the economy keeps growing. By his theory, income inequality should be decreasing in the U.S. along with growth of the economy. Glomm and Ravikumar's (1994) infinite horizon growth model suggests economic growth affects the growth rate of per capita income but has no impact on income inequality. They find no trade-off between long-run growth and income inequality. Deininger and Squire's (1996) study cannot establish a systematic link between growth and changes in aggregate inequality.

No research appears to have studied systematically the effect of the stock market on the trend and cyclical properties of income inequality in the U.S. That is the focus of this dissertation.

CHAPTER 3

STOCK PRICES AND INCOME INEQUALITY: EMPIRICAL EVIDENCE

This chapter describes data, sample selection methods, and summary statistics of the sample. Next, the income inequality index between stockholders and nonstockholders is calculated. Then a fixed-effect regression model is applied to the stockholder and nonstockholder samples, respectively, to estimate and simulate the marginal effect of stock price appreciation on income inequality.

3.1. Data and Sample Selection

3.1.1. Data

The data source is the University of Michigan's Panel Study of Income Dynamics (PSID). The PSID is a longitudinal survey study of income of samples of U.S. individuals (men, women, and children) and their households. It emphasizes "the dynamic aspects of economic and demographic behavior" of a household over time. PSID data are composed of two subsamples since its inception in 1968: a cross-sectional national sample and a national sample of low-income families. The former is an equal probability sample of households from the 48 contiguous states and was designed to yield about 3,000 completed interviews. It is called the SRC (Survey Research Center) sample. The latter is called the SEO (Survey of Economic Opportunity) sample and includes about 2,000 families. This study uses the SRC sample from 1980 to 2001 for the study. Since it is a nationally representative sample, no weights are applied in this study.

The growth rates of the real annual S&P 500 stock price index[4] and of real GDP are used as indicators of the business cycle. The time series of the S&P 500 index is deflated by the urban, seasonally adjusted Consumer Price Index.

3.1.2. Sample Selection and Definition of Variables

In the PSID data, household income is defined as the sum of the incomes of all members of a household. Household income changes significantly over time as the household composition and/or incomes of household members change. The split-off of a family can decrease the total household income dramatically. To avoid unnecessary complications due to changes in family structure, this study uses the sum of the taxable income of the household head and his/her spouse as a proxy for household income. The head of a household may change, for example, because a married couple may get divorced or widowed or because a single head may get married. The PSID dataset has a set of variables indicating these changes, such as a marriage indicator and a "same-head-of-household" indicator. The joint taxable income of household head and spouse[5] (*HWTY*) is defined as the sum of labor earnings and capital income of both members, before taxes. Transfer income for the head and spouse is added to *HWTY* to generate an alternative

[4] The index is taken from R. Shiller's website: www.econ.yale.edu/~shiller/data.htm.
[5] PSID calls it the head and wife's taxable income; this is because PSID assigns the male as a household head no matter who is the real head of a household.

measure of household income. In this study, household income is deflated by the urban, seasonally adjusted Consumer Price Index.

In this study, PSID data from 1980 to 2001 are used. The sample selection process can be summarized as follows. Households in the 1980 survey and that remain in the survey until 2001[6] are selected. Newly formed households—for example, as a result of split-offs—are left out as are households introduced into the panel after 1980 as part of a new sample. After omitting observations with missing values, about 1,600 households are left in this sample. Among the variables extracted from the data set are the taxable income of the household head and his/her spouse, the transfer income of the head and his/her spouse,[7] the head's level of education, the spouse's level of education, the head's age and race, the metropolitan statistical area (MSA) indicator of residence, the marital status, and the "same-head-or-not" indicator. Both the head's and spouse's education levels are indicator variables before 1992 and continuous variables afterwards. The continuous variables are converted to indicator variables to assure comparability before and after 1992. All other variables are indicator variables except for the taxable income of head and spouse, transfer income, and age. The stock market participation indicator and the value of stocks owned are selected for each household from the supplemental wealth file of the PSID. Each household's wealth status is surveyed every five years in the PSID starting in 1984. In the wealth file, the same households are asked about their stock market participation status, the value of their stock positions, and the value of other

[6] This is done by using the unique 1980 family ID with the 2000 family ID and setting the unique personal identification number equal to 1, the number assigned only to the head of a household. As the head dies or is no longer a head, another member will assume the head status; the same head variable captures this change.

[7] PSID data have no transfer income data for the head and his/her spouse before 1980.

asset holdings. A household is categorized as a stock market participant if the household reports any positive amount of stockholding, through investing in the stock market either directly or indirectly through a pension fund, mutual fund, individual retirement account (IRA), etc. The wealth data are merged with the household income file by the unique 1999 household identification numbers. The variables used in this study are defined in Table 3.1.

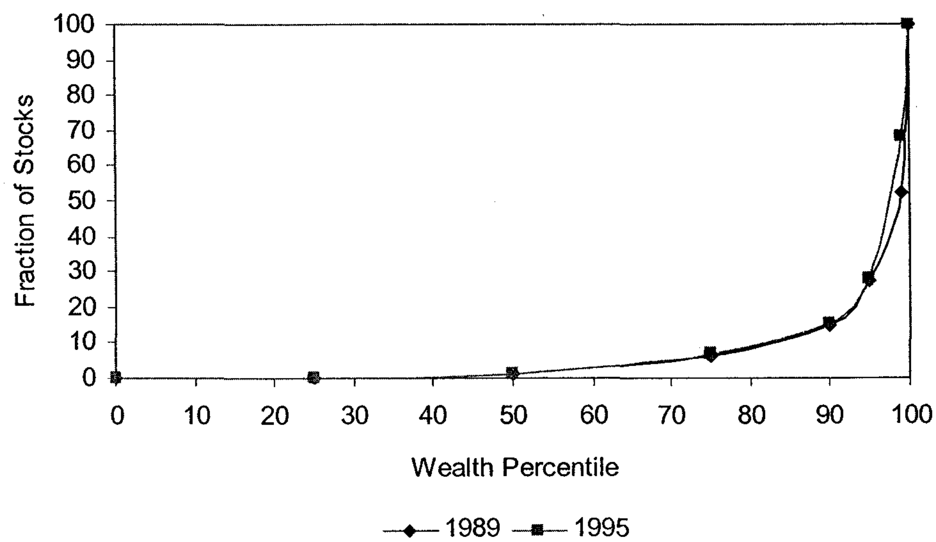
In order to study income inequality between stockholders and nonstockholders over time, the panel data are split into two subsamples by the stock market participation status of households in both 1984 and 1989.[8] A household is considered a stockholder if and only if the household reported being a stockholder in both 1984 and 1989. This is an imperfect way of splitting the sample since some households were stockholders in 1984 but not in 1989 and vice versa. Additionally, some households that were stockholders in some of the years between 1984 and 1989 and some households that entered the stock market after 1989 are categorized as nonstockholders. This may introduce potential bias when calculating the income inequality between stockholders and nonstockholders and the marginal effect of the stock market. The rationale for this splitting is that a true stock market participant tends to be in the market all the time although the amount of stockholding may change substantially from period to period. Other stockholders are "marginal" stockholders relative to the long-term participants. "Marginal" means that the amount of stockholding for these stockholders is relatively small, and its effect on house-

[8] Mankiw and Zeldes (1991), Vissing-Jorgensen (2002), and Guvenen (2002) also split the panel data into stockholders and nonstockholders to study the intertemporal choices of stockholders and nonstockholders. To check for robustness, this paper splits the sample by stock market participation status in 1989 and 1994. The pattern of income inequality between stockholders and nonstockholders remains essentially the same.

TABLE 3.1: Definition of Variables, 1980-2002

Variable	Definition
HWTY	Household head and spouse's taxable income in year 2000 $ value
HAGE	Household head's age
HAGESQ	Square of the head's age
HHRS	Head's number of hours worked
WHRS	Spouse's number of hours worked
HRS	Total number of hours worked for both head and spouse
HEDUH	Indicator variable: = 1 if head has at most high school diploma
HEDUSC	Indicator variable: = 1 if head has some college but no college degree
HEDUC	Indicator variable: = 1 if head has college degree or higher
WEDUH	Indicator variable: = 1 if spouse has at most high school diploma
WEDUSC	Indicator variable: = 1 if spouse has some college but no college degree
WEDUC	Indicator variable: = 1 if spouse has college degree or higher
SINGLE	Indicator variable: = 1 if not married, separated, divorced, or widowed
URBAN	Indicator variable: = 1 if household lives in MSA area
HUNEMPL	Indicator variable: = 1 if head is unemployed or out of labor force
WUNEMPL	Indicator variable: = 1 if spouse is unemployed or out of labor force
DHEAD	Indicator variable: = 1 if household has a different head from the previous year
STOC84	Indicator variable: = 1 if household reported to be a stockholder in 1984
STOC89	Indicator variable: = 1 if household reported to be a stockholder in 1989
STOC94	Indicator variable: = 1 if household reported to be a stockholder in 1994
STOC84-89	Indicator variable: = 1 if household reported to be a stockholder in both 1984 and 1989
STOC84-94	Indicator variable: = 1 if household reported to be a stockholder in both 1984 and 1994
STOC89-94	Indicator variable: = 1 if household reported to be a stockholder in both 1989 and 1994
STOCV84	Amount of stockholding in 1984 in year 2000 $ value
STOCV89	Amount of stockholding in 1989 in year 2000 $ value
STOCV94	Amount of stockholding in 1994 in year 2000 $ value
GSP	S&P index growth
GSPL1	S&P index growth in the previous year
GGDP	Real GDP growth
GGDPL1	Real GDP growth in the previous year

hold income is small as well. Wolff (2000) and Heaton and Lucas (1999), among others, find that stockholding is highly concentrated and highly persistent over time. Increasing stock market participation starting from the late 1980s, and especially after the mid-1990s, had a rather small effect on changing stockholding concentration. Figure 3.1 presents the Lorence curve of the percentage of stocks held by wealth percentiles. As is evident, stockholding concentration did not change much from 1989 to 1995, although the stock market participation rate increased from less than 35 percent to nearly 50 percent (Table 3.2).



Source: Heaton and Lucas (1999)

FIGURE 3.1: Percentage of Stock Held by Wealth Percentile

TABLE 3.2: Stock Market Participation Rate

Variables	Mean
STOC84	0.34
STOC89	0.40
STOC94	0.47
STOC84-89	0.24
STOC84-94	0.20
STOC89-94	0.31

3.1.3. Key Statistics on Stock Market Participation

The stock market participation rate is presented in Table 3.2 by years and different definitions of participation. From 1984 to 1994, the stock market participation rate increases from 34 percent to 47 percent. However, many of the market participants are relatively short-term investors. For example, only about 64 percent of stockholders in 1984 remain in the market in 1989, and only 54 percent remain in the market until 1994. By 1999, only 41 percent of those that were stockholders in 1984 are still in the market.[9] There are numerous studies on the pattern of household participation in the stock market, including Haliassos and Bertaut (1995), Bertaut (1998), Heaton and Lucas (1999), Haliassos and Michaelides (2003), Poterba (2001), and Vissing-Jorgensen (2002). None, however, explains how limited participation affects household income inequality.

The summary statistics of the sample are presented in Table 3.3. Stockholders are about three years older than nonstockholders. Both head and spouse of a stockholder

[9] These numbers are calculated as the participation rate in each of the respective years divided by the participation rate of 1984.

household are more educated than those in a nonstockholder household. For example, 49 percent of the heads and 38 percent of the spouses of stockholder households are college-educated, compared with only 24 percent and 16 percent, respectively, of the heads and spouses of households that are nonstockholders. Stockholder households are more likely to be married with a more stable family structure than those of nonstockholders. Stockholders are also more likely to be living in urban area than nonstockholders.

TABLE 3.3: Summary Statistics: The Sample Average

Variable	Nonstockholders	Stockholders
HEDUH	0.26	0.16
HEDUSC	0.29	0.29
HEDUC	0.23	0.48
WEDUH	0.39	0.30
WEDUSC	0.28	0.27
WEDUC	0.16	0.38
SINGLE	0.29	0.19
HAGE	45.90	49.00
URBAN	0.50	0.62
HUNEMP	0.16	0.15
WUNEMP	0.23	0.30
HHRS	1778.80	1829.70
WHRS	1047.40	912.40
DHEAD	0.007	0.001

3.2. Income Inequality between Stockholders and Nonstockholders

The average taxable incomes of stockholders and nonstockholders are plotted in Figure 3.2. Stockholder income is more than 70 percent higher than that of nonstockholders for most of the years. The income gap between the two types of households has remained relatively stable over the past 20 years. Transfer income is about 3 percent of household income for stockholders and 6 percent for nonstockholders in the early 1980s; the numbers increased to about 14 and 11 percent, respectively, in 2000. Part of the increase may be due to the aging of the households. The income ratio between the two types of households is plotted in Figure 3.3. The ratio remains relatively stable. No clear trend emerges over the sample period.

The income Gini index between stockholders and nonstockholders is constructed based on the average income of the two types of households and the stock market participation rate by the following formula:[10]

$$Gini = 1 - \frac{\overline{Y}_t^w}{(1-p)\overline{Y}_t^w + p\overline{Y}_t^s}$$

where p is stock market participation rate. Y_t^w and Y_t^s are the average income of nonstockholders and stockholders, respectively. The Gini index is a function of the stock market participation rate p and the income ratio of the two types of households. Given the participation pattern, the Gini index is a linear transformation of the income ratio of

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[10] The original formula as used in Fowler (2003) is $Gini = 1 - \frac{n\overline{Y}_t^w}{(n\overline{Y}_t^w + m\overline{Y}_t^s)}\frac{(n+m)}{n}$, where n is number of nonstockholders and m is number of stockholders. After simplification, we get the above formula.

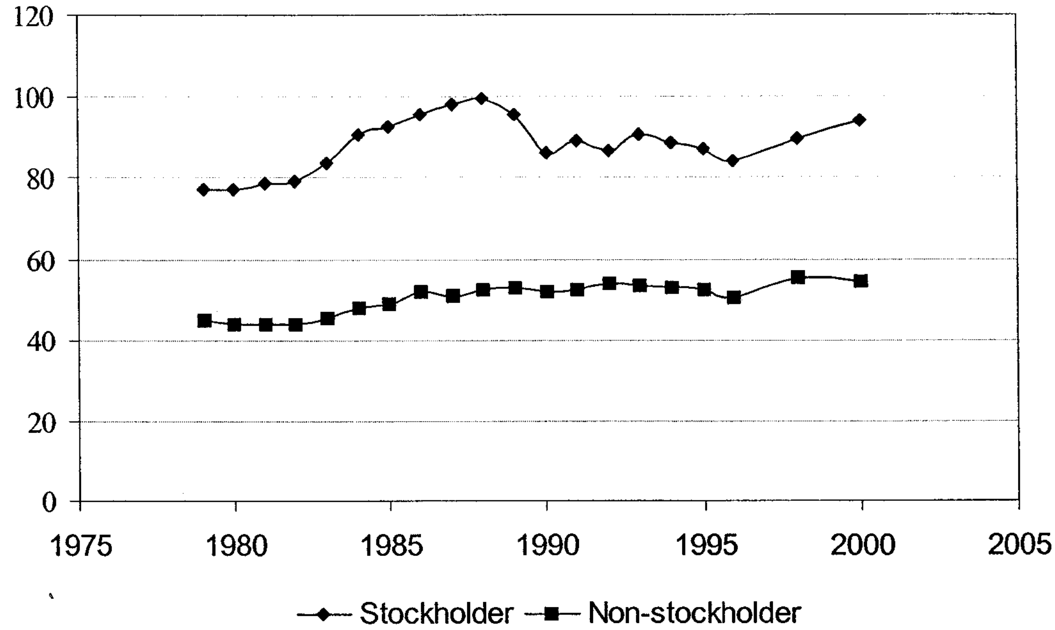

FIGURE 3.2: Head and Spouse's Average Taxable Income ($000)

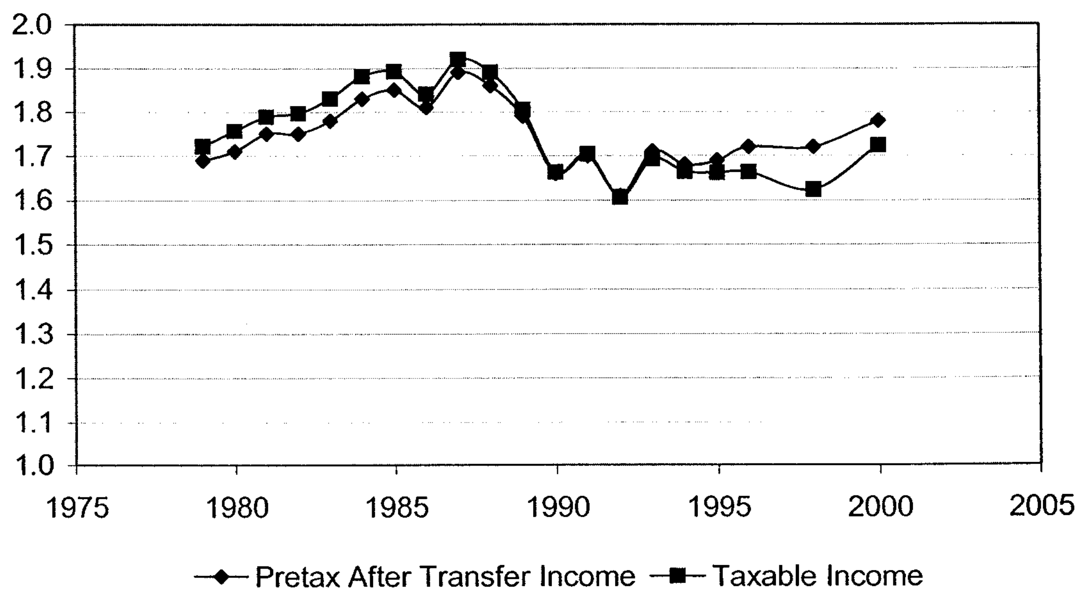

FIGURE 3.3: Income Ratio between Stockholders and Nonstockholders

stockholders to nonstockholders. The pattern of the Gini index follows exactly that of the income ratio (Figure 3.3). The index increased from the early 1980s up to 1987, then decreased until 1993, after which it increased again, but not to the extent as in the 1980s. There is no clear trend of an increase in income inequality between the two types of households during the period. The correlation coefficient between the constructed income Gini index and the S&P 500 index is close to zero. Since the Gini index is the linear transformation of the income ratio between the two types of households, this study also uses the income ratio as a measure of income inequality. By alternative definitions of stockholders and nonstockholders, there is also no clear income inequality trend as measured by the income ratio between the two types of households (Figure 3.4).

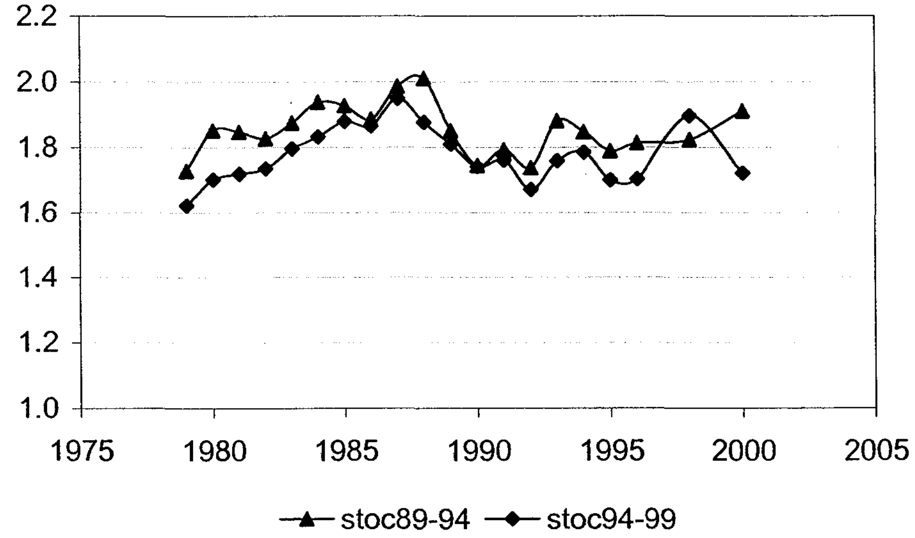

FIGURE 3.4: Income Ratio between Stockholders and Nonstockholders by Different Definitions of Stockholders and Nonstockholders

The movements in income inequality between stockholders and nonstockholders do not necessarily result from the stock market. They could be related to changes in skill premiums. As shown in Table 3.3, stockholders, on average, are more educated than nonstockholders, and the literature shows that skill premiums have been increasing in the past 20 years, especially in the first half of the 1980s (Krusell et al. 1997; Acemoglu 1998). To identify skill premium changes' effect on income inequality, Figure 3.5 presents the income ratio between households with a college-educated head and households with a less-than-college-educated head. The ratio has been steadily increasing over time. It increased more than 60 percent from 1.5 in 1979 to 2.4 in 2000. This finding conforms to the literature that the increasing skill premium has contributed significantly to the trend in income inequality.

Differences in the labor market behavior of the two types of households may also have an effect on the pattern of income inequality between the two types of households. Figure 3.6 presents the average rate of unemployment or out-of-the-labor-force rate for both stockholders and nonstockholders. Before the late 1980s, either the head or spouse of a stockholder household is less likely to be unemployed or out of the labor force than in a nonstockholder household. After the late 1980s, the labor market behaviors of the two types of households are quite similar to each other. This may partly explain the higher income ratio between stockholders and nonstockholders from 1980 to 1987: stockholders work more hours than nonstockholders.

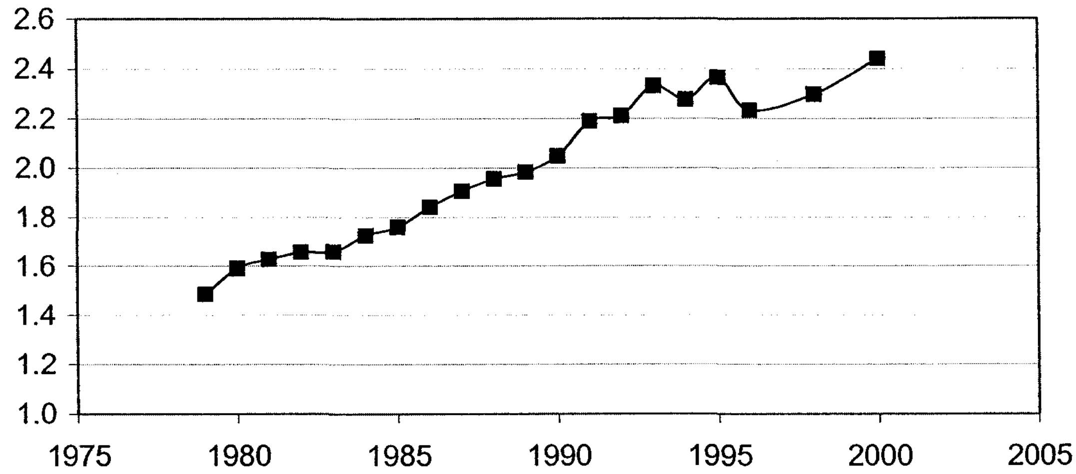

FIGURE 3.5: Income Ratio between Households with a College-Educated Head and Households Whose Head is Not College-Educated

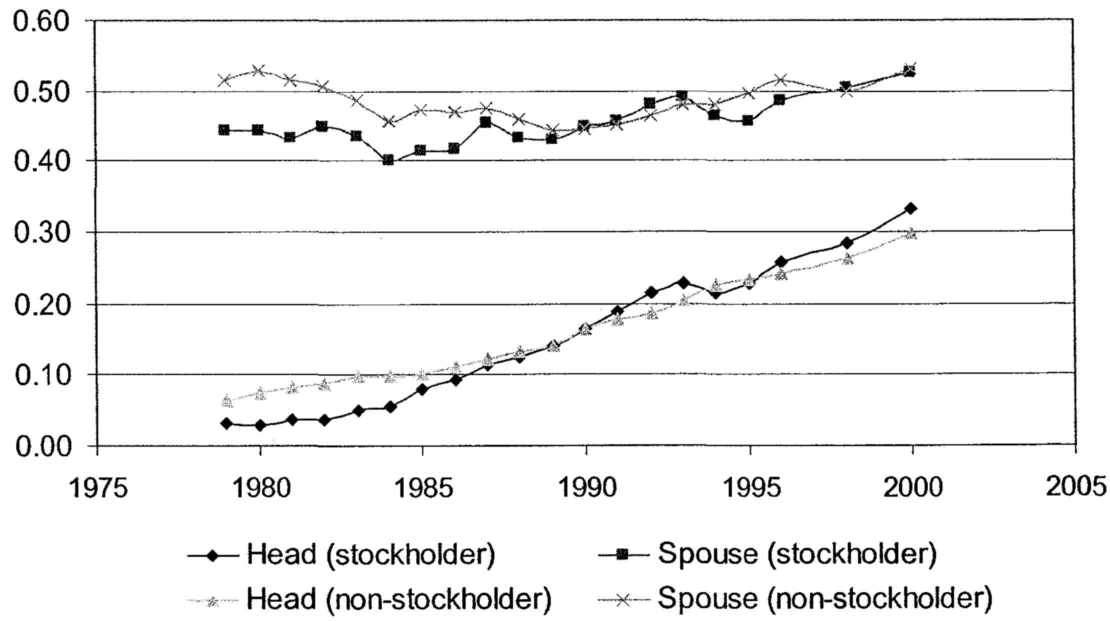

FIGURE 3.6: Rate of Unemployed or Out of Labor Force

3.3. Regression Analysis

The following regression analysis studies the marginal effects of stock market appreciation on households' income and on income inequality, controlling for economic growth effect; the households' labor market behavior, level of education, and demographics; and a time trend.[11]

3.3.1. Fixed-Effect Model

The regression model is set as:

$$Y_{i,t} = C + X_{SP}\beta_1 + X_{GDP}\beta_2 + X_{i,t}\beta_3 + \beta_4 YEAR + c_i + \varepsilon_{i,t}$$

where $Y_{i,t}$ is ith household's head and spouse's taxable income at time t. X_{SP} is a one-by-two vector of growth rates of the S&P 500 index in year t and $t-1$. X_{GDP} is a one-by-two vector of the growth rate of real GDP in year t and $t-1$. X_{GDP} controls for the effect of economic growth on household income, and X_{SP} captures the capital gain effect of the stock market. β_1 and β_2 are two-by-one vectors of coefficients for X_{sp} and X_{GDP}, respectively. The vector $X_{i,t}$ includes the employment indicator, the level of education of both the head and his/her spouse, the head's age, and the MSA indicator of residence.

[11] The study assumes that an average household income follows a deterministic trend.

The marriage status and the "same head or not" indicator is also included in $X_{i,t}$ to capture income changes as a result of family structure changes. The *YEAR* variable captures the possible trend effect on household income. C is the intercept, and $\varepsilon_{i,t}$ is the disturbance term. c_i is the individual fixed-effect that is invariant over time; this term captures the unobserved heterogeneity such as ability and/or household preference for consumption and investment choices and/or labor/leisure choices. c_i is very likely correlated with education and possibly labor market behavior. Leaving c_i in the error term brings an endogeneity problem that biases the estimates.[12] The problem can be controlled by first differencing or by subtracting from variables on both sides of the model their respective averages, by cross sectional units. This procedure removes c_i. An alternative approach is creating an indicator variable for each cross-sectional unit, which captures c_i in the intercept specific to the cross-sectional unit or a household in this case. This study adopts the last approach.

The fixed-effect regression is applied separately to the stockholder sample and the nonstockholder sample. To enhance efficiency, the two fixed-effect regressions are estimated simultaneously in a seemingly unrelated regression (SUR) framework. This is because the error terms across stockholder and nonstockholder regressions are likely correlated because of other unobserved factors that may affect both stockholders' and nonstockholders' income, such as international trade and globalization, institutional changes, etc. A SUR method is a two-stage regression: first it estimates the models

[12] An F test is applied to the model to test the null hypothesis of no fixed-effect. The null hypothesis is rejected for both stockholder and nonstockholder regressions.

separately for the coefficients by OLS; then it estimates the standard errors of coefficients by minimizing the sum of the squared errors of both models jointly. A SUR method can potentially enhance efficiency. After the SUR regression, an F test is applied to test the null hypothesis of no differences of coefficients across stockholder and nonstockholder regressions.

The study also tests the possible simultaneity between household income and the growth rate of the stock market. The growth rate of the S&P index is used as the dependent variable, and *HWTY* and its lagged value along with two lags of the dependent variable are used as the regressors. The *t* statistics for the estimate of either current or lagged *HWTY* is close to zero, which suggests that household income level has no statistically significant effect on the stock price. Thus, simultaneity is not a concern in the model.

The estimation results are presented in Table 3.4. As expected, stockholders' incomes are more sensitive to stock market appreciation than those of nonstockholders.[13] The lag effect is larger than the current effect. A one percent appreciation in the stock market index increases stockholders' income by about $50 in the current period and about $150 in the next period. The larger lag effect may be because stockholders do not typically immediately realize capital gains at the start of a booming stock market. This applies especially for long-term stockholders. The stock market appreciation shows no statistically significant effect on nonstockholders' average income. This is because nonstockholders have no capital gain from the stock market. Real GDP growth increases

[13] F-tests reject the null hypothesis of equal parameters between stockholders and nonstockholders, either jointly for all parameters or specifically for the stock price appreciation parameter. Both test statistics are highly significant ($P < 0.001$).

household income of both stockholders and nonstockholders. The lagged effect is more significant than the current effect. The lagged effect is significant at the 5 percent level for nonstockholders and marginally significant at the 10 percent level for stockholders.

TABLE 3.4: Marginal Effect of Stock Market Growth on Household Income, a Fixed-Effect Model

	Stockholders		Nonstockholders	
Variable	Estimates	P-value	Estimates	P-value
GSP	55.98	0.52	4.57	0.88
GSPL1	155.27	0.05	-18.49	0.49
GGDP	679.89	0.18	11.21	0.95
GGDPL1	691.95	0.13	324.92	0.04
HUNEMP	-48963.10	0.00	-29663.30	0.00
WUNEMP	-13067.00	0.00	-12447.40	0.00
HEDUH	1909.53	0.85	1242.75	0.61
HEDUSC	2973.88	0.77	5163.37	0.04
HEDUC	-11460.80	0.33	11787.30	0.00
WEDUH	16415.42	0.01	12367.18	0.00
WEDUSC	22165.87	0.00	15335.96	0.00
WEDUC	28124.83	0.00	27771.59	0.00
HAGE	4255.73	0.12	1833.45	0.03
HAGESQ	-62.72	0.00	-26.05	0.00
SINGLE	-2825.91	0.52	-4533.93	0.00
URBAN	-948.72	0.75	781.18	0.45
DHEAD	-1956.30	0.95	-4062.80	0.45
YEAR	2782.48	0.30	1276.29	0.12
No. of Obs.	393		1225	
Time Period	20		20	
Adj. R^2	0.6		0.53	
F-Test for No Fixed-Effect	F-value: 20.07 P-value: 0.00		F-value: 11.15 P-value: 0.00	

This may be a result of the positive correlation of stock index growth and real GDP growth. Another reason may be that the economic growth effect is captured by the unemployment variables. Households with an unemployed or out-of-labor-force head or spouse have a substantially lower income. Their taxable incomes are only about half as much as those of other households. The regression also shows a significant education premium for both household head and spouse. Both stockholders' and nonstockholders' incomes have a positive trend. The trend is not significant at conventional levels for stockholders and marginally significant at the 10 percent level for nonstockholders.

3.3.2. Simulation

To simulate the effect of the stock market on household income inequality, an impulse response technique is applied. The study first estimates the Vector Autoregressive (VAR) process of the growth rate of the S&P 500 index and the real GDP on annual data from 1980 to 2001; then it creates a one-period shock to the growth rate of the stock market index and simulates the responses of the S&P 500 index growth and real GDP growth, taking into account the correlation of the two series. Then the income responses of both stockholders and nonstockholders are simulated and the changes of the Gini index between the two types of households are calculated.

A VAR model treats all variables symmetrically without making reference to the issue of dependence versus independence. The VAR regression in this study is specified as:

$$X_t = C + A_1 X_{t-1} + V\varepsilon_t$$

where X_t is a two-by-one vector of the deflated growth rate of the S&P 500 index and of GDP at time t, A_1 is a two-by-two coefficient matrix of X_{t-1}, ε_t is a two-by-one matrix of the standardized disturbance, and V is the variance-covariance matrix of ε_t.

The simulation assumes the shock occurs to the stock market at period t; the magnitude of the shock is one standard deviation of the S&P 500-index growth rate, which is about 14 percent. By the vector autoregressive process, the shock turns into negative 0.7 percent in the second period and returns to its long-run steady state in about five periods. Because of the correlation between the growth of the stock market and real GDP, the shock to the stock market is associated with real GDP growth of about 1.2 percent in the same period. Figure 3.7 plots the impulse response of the growth rates of the stock price and GDP to the shock.

The simulation for household income is specified as:

$$\hat{Y}_t = C_0 + \hat{X}_{SP}\beta_1 + \hat{X}_{GDP}\beta_2 .$$

$\hat{Y}_t$ is the simulated household income as a result of the shock to the stock market, holding household demographics constant. $\hat{X}_{SP}$ is a one-by-two vector of growth rates of the simulated S&P 500 index in years t and $t-1$ respectively, which is propagated by the shock to the stock market in time t. X_{GDP} is a one-by-two vector of the simulated growth rate of real GDP in years t and $t-1$ from the same shock. Both β_1 and β_2 are two-by-one vectors of estimates from the previous fixed-effect model. C_0 is the initial level of household income, which is set equal to the average household income of stockholders or nonstockholders when the same simulation model is applied to nonstockholders.

After obtaining the simulated income series of stockholders and nonstockholders, the Gini index is constructed and a percentage change of the Gini index calculated. The impulse response of the Gini index as a result of the shock to the stock market is plotted in Figure 3.8. One standard deviation positive shock to the growth rate of the stock market index increases the income Gini index between stockholders and nonstockholders by about 1.7 percent in the shock period and more than 5 percent in the next period. The income Gini index decreases mildly in the following three periods and converges to its long-run steady states.

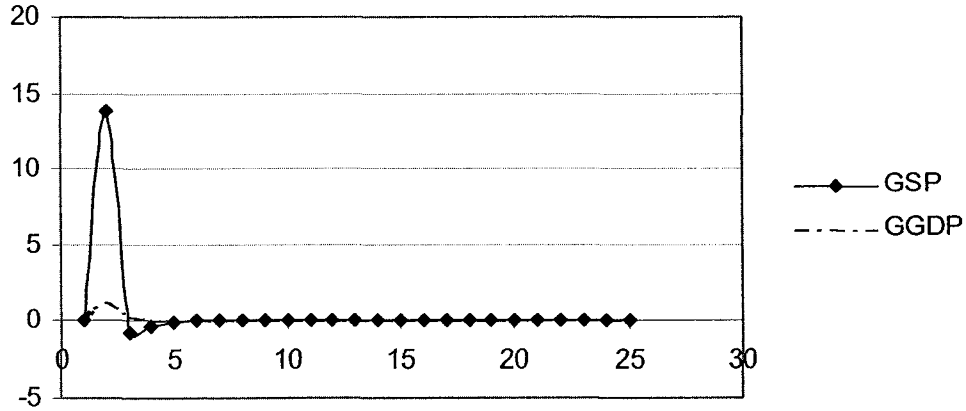

FIGURE 3.7: The Impulse Responses of Growth of the S&P 500 Index and Real GDP to One Standard Deviation Shock to the S&P 500 Index (%)

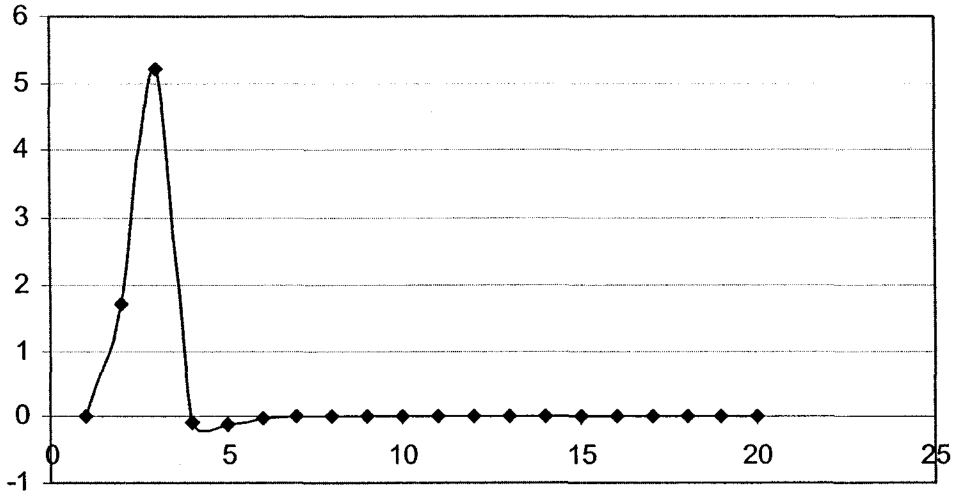

FIGURE 3.8: The Impulse Response of the Gini Index to One Standard Deviation Shock to the S&P 500 Index (%)

3.4. Summary

This chapter uses household income panel data from the PSID and the annual S&P 500 index to study empirically the long- and short-run effects of stock price appreciation on household income inequality in the U.S. The findings of this chapter are that stock price appreciation has no long-run effects on income inequality. This is because, while the stock market index appreciated more than five times from 1980 to 2001, income inequality between stockholders and nonstockholders was trendless during this period. This chapter, however, finds a steadfast upward trend of the average income ratio between households with a college-educated head and households whose head is not college-educated. This finding conforms to the literature that increasing skill premiums have substantially contributed to the trend in income inequality.

By a fixed-effect panel regression analysis, stock market appreciation is found to have contributed positively to income inequality in the short run. The result is robust after controlling for idiosyncratic unemployment as well as household demographics. By simulation, one standard deviation appreciation of the S&P 500 index (14%) from its long-term trend brings about a 5 percent increase in the income Gini index between stockholders and nonstockholders, taking into account the correlation between stock market and GDP growth.

CHAPTER 4

THE THEORETICAL MODEL

This chapter presents a perfectly competitive general equilibrium economy to replicate the empirical findings from Chapter 3. The model economy consists of two types of agents, stockholders and nonstockholders. It allows for differences in labor efficiency and economic growth as propagated by technological progresses. The model intends to capture the effect of stock market appreciation on income inequality with skill-neutral and skill-biased technological progress, both analytically and numerically. Distinguishing between stockholders and nonstockholders is motivated by the limited participation pattern and by heterogeneous effects of the stock market on household income growth as studied in Chapter 3 and in Zhao and Zietz (2004). The purpose of distinguishing between skill-neutral and skill-biased technological progress is to separate the effect of capital gain from the effect of increasing skill premiums on income inequality.

4.1. Model Economy

4.1.1. Background

The model economy has two types of household agents: stockholders and nonstockholders. Both agents live infinitely in the economy. At time 0, stockholders are endowed with the capital stock of the economy and human capital; the nonstockholders are endowed with human capital only. Human capital is measured as effective labor.

Nonstockholders are assumed not to save. Thus, stockholders hold all of the capital the economy possesses in every period. The rationale for this simplification is from the data. Both PSID and the Survey of Consumer Finance (SCF) data show that about one-third of U.S. households hold no investment assets at all, while another third holds only a minimum amount of liquid assets. The remaining third holds more than 90 percent of all investment assets (Wolff, 2000). The average real return on liquid assets is negligible after deducting transaction costs. Aggregate net saving of these low- and middle-income households plays a small role in the aggregate investment of the economy.

4.1.2. Households

Both households are assumed to make labor/leisure choices to maximize utility, which is a function of consumption and leisure. Stockholders also make dynamic choices of consumption and saving to maximize expected lifetime utility.

Household preferences are represented by a constant relative risk aversion (CRRA) utility function that is time separable and also separable in its arguments: consumption and leisure. The utility function is of the form

$$u(c_t, l_t) = \frac{c_t^{1-\gamma}}{1-\gamma} + \chi \frac{l_t^{1-\rho}}{1-\rho}, \ \gamma \geq 0 \ \rho \geq 0,$$

where consumption is denoted by c_t and leisure by l_t. l_t is equal to $T - n_t$, where T is the total endowment of hours per period, and n_t is the number of hours worked. χ is the utility weight applied to leisure, and γ and ρ are coefficients of relative risk aversion and labor's elasticity, respectively.

The dynamic programming problem of households is to choose the amount of consumption (c_t) and leisure hours (l_t) to maximize expected lifetime utility,

$$\underset{c_t, l_t}{Max}\, E[\sum_{i=1}^{\infty} \beta^t u(c_t, l_t)], \tag{1}$$

subject to the following budget constraints for stockholders,

$$c_t^s + x_t^s = r_t k_t^s + w_t e_t^s n_t^s \tag{2}$$

$$x_t^s = k_{t+1}^s - (1-\delta) k_t^s,$$

where x is net investment in the capital market, k is the amount of saving in the form of capital stock, and δ is the rate of depreciation of the capital. e is labor efficiency, n is the number of hours worked, $w_t e_t^s$ is stockholders' wage rate at time t, and r is the rate of return to capital. Superscript s denotes stockholders. Subscript t stands for time.

Nonstockholders are subject to the following budget constraint:

$$c_t^w = w_t e_t^w n^w, \tag{3}$$

where superscript w denotes nonstockholders.

4.1.3. Firms

Firms combine labor services rented from both types of households and capital from stockholders to produce a single good to maximize the net present value of the expected future dividend D_{t+i},

$$\underset{K_t, N_t}{Max}\, E[\sum_{i=1}^{\infty} p_{t+i} D_{t+i}], \tag{4}$$

where p_{t+i} is the present value of one unit of dividend received at time $t+i$. The value of a unit of dividend is measured by the marginal utility of the owner of the firm or the stockholders,

$$p_t = \frac{\partial u(c_t)}{\partial c_t} \quad \text{and} \quad p_{t+i} = \beta^i \frac{\partial u(c_{t+i})}{\partial c_t}. \tag{5}$$

Dividend D_t is defined as the residual output of the economy after paying wages to both types of households and putting aside the amount of investment for the next period, or

$$D_t = F(A_t, K_t, N_t) - w_t N_t - [K_{t+1} - (1-\delta)K_t],$$

where N_t is the total effective labor supply of both stockholders and nonstockholders. The variable K_t is the total capital stock.

4.1.4. Equilibrium

The equilibrium in the economy is a set of prices w_t, r_t and quantities c_t^s, c_t^w, x_t^s that solve the dynamic programming problem of stockholders and nonstockholders, the profit maximization problem of firms, and the economy-wide resource constraint

$$Y_t = \sum_i c_t^i + \sum_j c_t^j + \sum_i x_t^i,$$

for all t. Superscript i indexes stockholder households, and j indexes nonstockholder households.

The following sections specify the production technologies of the model economy so as to quantify the effect of the stock market on income inequality both in the short run and the long run.

4.2. Model Economy with a Cobb-Douglas Production Function

In order to determine the long-run effect of the stock market on income inequality analytically, this study assumes a Cobb-Douglas production function of the form

$$F(A_t, N_t, K_t) = A_t K_t^{\alpha} N_t^{1-\alpha}, \tag{6}$$

where A_t is total factor productivity[14] and where N_t is defined as

$$N_t = Ie_t^s n_t^s + Je_t^w n_t^w,$$

where I and J denote the total number of stockholders and nonstockholders, respectively; variable e denotes labor efficiency; and n denotes the number of hours worked. The study assumes homogeneity among stockholders and among nonstockholders. Evolution of e_t presents the process of labor augmenting technological progress. For simplicity, the model assumes that the economy's technology progress is fully captured by changes in total factor productivity A_t. Thus e_t is fixed for both stockholders and nonstockholders.

Assume the long-run average growth rate of the economy is g_y. Balanced growth implies that total consumption C_t, investment X_t and capital stock K_t all grow by the same rate g_y. Rewrite (6) in growth form,

$$\begin{aligned} g_y &= g_A + \alpha g_K + (1-\alpha) g_N \\ &= g_A + \alpha g_y \;, \end{aligned} \tag{7}$$

[14] In a Cobb-Douglas production function, either labor augmenting technology or capital-augmenting technology can be transformed into a TFP change.

where g_k is the growth of total capital stock, g_A is the growth of the economy's total factor productivity, and g_N is the growth of total labor supply. Labor supply is assumed fixed; thus $g_N = 0$.

In a balanced, growing economy, the economy's total factor productivity growth g_A can be derived from (7) as:

$$g_A = (1-\alpha)g_y. \tag{7a}$$

4.2.1. Equilibrium Factor Return and Asset Prices

Equilibrium implies that the wage rate equals the marginal product of effective labor and capital rent equals the marginal product of capital:

$$w_t = (1-\alpha)A_t K_t^{\alpha} N_t^{-\alpha} \tag{8}$$

$$r_t = aA_t K_t^{\alpha-1} N_t^{1-\alpha}. \tag{9}$$

The wage rates of stockholders and nonstockholders are $e_t^s w_t$ and $e_t^w w_t$, respectively.

In a perfectly competitive economy with a constant-returns-to-scale technology, if both work hours N_t and investment I_t are determined in the previous period or the current shock affects the economy with a one-period time lag, the equilibrium real stock price, here denoted as $P_t^{'}$, must be equal to the economy's capital stock K_t (Rouwenhorst, 1995). The proof of $P_t^{'} = K_t$ is shown in appendix A.

This model assumes no lags for the effect of the productivity shock as a standard RBC model does. Thus, the real stock price can be viewed as the capital stock K_t plus a random term τ_t that is brought about by a shock to the economy A_t, or

$$P_t = K_t + \tau_t . \tag{10}$$

TFP A_t and τ_t are positively correlated because a positive shock to the economy will increase productivity and profitability of firms.

4.2.2. Equilibrium Income Inequality

For analytical simplicity, it is assumed that stockholders and nonstockholders supply the same fixed amount of labor to the market.[15] Stockholders get income from both labor earnings and capital return while nonstockholders' labor earnings are their only source of income. The income ratio between stockholders and nonstockholders, denoted as $\Re_t$, is used as a measure of income inequality as in Chapter 3. The income ratio can be derived as[16]

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[15] The assumption should not affect the qualitative result since this study focuses on how asset prices affect income inequality.
[16] See Appendix B for the derivation.

$$\Re_t = \frac{w_t^s n_t^s + (r_t - \delta)k_t}{w_t^w n_t^w} = \lambda_t + [\frac{a}{(1-a)} - \frac{\delta}{A_t(1-\alpha)}(\frac{K_t}{N_t})^{1-\alpha}](1+\frac{1-p}{p}\lambda_t) \quad , \tag{11}$$

where λ is the labor efficiency of stockholders relative to that of nonstockholders, $\lambda_t = e_t^s / e_t^w$, and p is the stock market participation rate, defined as the percentage of stockholder households in the economy, or $p = I/(I+J)$, where I is the number of stockholders and J is the number of nonstockholders.

'The long-run effects of stock-price appreciation on income inequality can be found by examining the stationarity of the income ratio $\Re_t$ in a growing economy. Along a balanced growth path, a growing economy always brings an upward trend in capital stock K_t and stock price P_t. If $\Re_t$ is stationary or trendless, the trend growth in stock price cannot have a long-run effect on income inequality. From (11), the relative labor efficiency λ_t, total labor supply N_t, and stock market participation rate p_t are stationary or fixed by construction; thus stationarity of the income ratio $\Re_t$ depends on the stationarity of the economy's capital stock K_t and the level of productivity A_t. Both K_t and A_t are growing over time at the rate of g_A and g_K, respectively. From (7a), along a balanced growth path, $g_A = (1-\alpha)g_K$. The ratio $K_t^{1-\alpha}/A_t$ can be derived as $1/[g_K^\alpha(1-a)]$, which has no trend. Consequently $\Re_t$ is stationary. The trend in stock price has no effect on income inequality. This finding is consistent with the empirical finding in Chapter 3.

The variable λ_t is the labor efficiency of stockholders relative to that of nonstockholders. As is evident from equation (11), it plays a big role in determining the level of income inequality between stockholders and nonstockholders. An increase in λ_t increases not only the wage inequality between the two types of households but also income inequality through the equity market as a result of limited participation. It amplifies the income inequality effect in the equity market. A skill-biased technological innovation will increase λ_t if stockholders are more skilled than nonstockholders; thus it increases income inequality more than a skill-neutral technological innovation. However, a Cobb-Douglas production function cannot separate the effects of a skill-neutral from a skill-biased technological change. The next section, by utilizing a CES production function, quantifies the partial effect of both types of technology on income inequality through a change in the wage premium and a change in the return from the equity market.

The stock market participation rate p also has a significant effect on the level and changes in income inequality. An increase in p decreases income inequality. For example, if the stock market participation rate increases from 25 percent to 50 percent, the multiplier $(1-p)/p$ decreases from 3 to 1. Consequently, this substantially decreases the income inequality arising from the equity market.

The model could not replicate the business cycle dynamics of income inequality because the model produces a fixed inequality index when the relative labor efficiency is fixed. This is because the model economy assumes a Cobb-Douglas production function, which produces a fixed income share of capital and labor. The U.S. National Income and Product Account data show that although the long-run average of income shares of capital and labor are roughly constant, they do have a cyclical movement. The capital share is procyclical while the labor share is countercyclical. This renders it inappropriate to assume a Cobb-Douglas production function to assess the cyclical property of income inequality between stockholders and nonstockholders, while it is reasonable and convenient to study the trend effect, if any, as this study has done. The following section assumes a constant elasticity of substitution (CES) production function, which produces a cyclical movement of output shares of factors of production. It is designed to study how shocks to the stock market affect the business cycle dynamics of income inequality.

Increasing skill premiums have been found to contribute significantly to the trend in income inequality in the literature and are confirmed in the empirical part of this dissertation. A skill-biased technological change, especially in computer technology, is widely agreed to be the cause of the trend growth of skill premiums. The same technology has also contributed to the boom in the stock market. To identify the effects of stock market boom on income inequality in a general equilibrium model, one needs to separate the effect of changing skill premiums from that of stock price appreciation. The following CES production function incorporates both a skill-biased technological change and a skill-neutral technological change, which allows one to study the effect of stock market appreciation on income inequality under different technological shock processes and to separate the effect from that of changing skill premiums.

4.3. Model Economy with a CES Production Function

To quantify the effect of different types of technological changes on stock price and on income inequality, this chapter sets up a model with a CES production function. The production function incorporates both a skill-biased technological change and a skill-neutral technological change.

4.3.1. Production Function

The CES production function follows Krusell et al. (1997), who model SBTC based on (i) the complementarity between equipment capital and skilled labor and (ii) the substitutability between equipment capital and unskilled labor. Their study focuses on the wage premium in a partial equilibrium framework. This study focuses on total income inequality as a result of changes in skill premium and capital return associated with limited participation in a general equilibrium model.

The CES production function is given as

$$Y_t = e^{(z_t)} K_{s,t}^{\theta}[\tau N_{w,t}^{v} + (1-\tau)[\pi K_{e,t}^{\varphi} + (1-\pi)N_{s,t}^{\varphi}]^{v/\varphi}]^{(1-\theta)/v} \quad (12)$$

$$\theta, \tau, \pi \in (0,1);\ v, \varphi \in (-\infty, 1);\ v, \varphi \neq 0 .$$

Variables $K_{s,t}$ and $K_{e,t}$ denote the aggregate stock of capital structures and capital equipment, respectively. Variable $N_{s,t}$ identifies the aggregate efficiency hours supplied by skilled agents, and $N_{w,t}$ denotes the aggregate efficiency hours supplied by unskilled agents. Stockholders are assumed to be skilled and nonstockholders unskilled in this production function. The term z_t is a random technological shock to total factor productivity. Parameter θ determines the output share of capital in the form of structures. The parameters θ, τ, and π jointly determine the output shares of unskilled labor, skilled labor and capital equipment, respectively. Parameters ν and φ determine the elasticity of substitution between unskilled workers and skilled workers. The elasticity of substitution between equipment and unskilled labor is the same as that between skilled labor and unskilled labor. Skilled workers and capital equipment are imperfect complements, while unskilled workers and capital equipment are imperfect substitutes. A technological change that is augmenting capital equipment would increase demand for skilled workers and, at the same time, decrease demand for unskilled workers. The skill-biased technological change (SBTC) is specific to new investment and applies only to equipment capital, as in Greenwood et al. (1997, 2000).

The law of motion for aggregate structural capital is given by

$$K_{s,t+1} = (1-\delta_s)K_{s,t} + X_{s,t} \text{ , } 0 \le \delta_s \le 1,$$

where $X_{s,t}$ is the aggregate investment in capital structures, and δ_s is the rate of depreciation of capital structures.

The law of motion for aggregate equipment capital is

$$K_{e,t+1} = (1-\delta_e)K_{e,t} + X_{e,t}e^{(q_t)} \quad 0 \le \delta_e \le 1,$$

where $X_{e,t}$ is the aggregate investment in equipment capital, and δ_e is the rate of depreciation of equipment capital. The variable e^{q_t} is the capital-augmenting technological change specific to new investment in equipment capital. Greenwood et al. (1997, 2000) find that introducing an investment-specific technological change is important to explain both the long-term growth and business cycles of real output. By construction, the variable e^{q_t} is also the source of skill-biased technological changes.

For simplicity, it is assumed that there is no heterogeneity among stockholders and nonstockholders. Thus, $N_{s,t} = Ie_s n_{s,t}$, and $N_{w,t} = Je_w n_{w,t}$, where I and J are the total numbers of stockholders and nonstockholders, respectively, and e and n denote labor efficiency and number of hours worked. Subscripts s and w identify stockholders/skilled workers and nonstockholders/unskilled workers, respectively. The following equalities hold:

$$K_{s,t} = Ik_{s,t},\ K_{e,t} = Ik_{e,t}.$$

Both z_t and q_t are assumed to follow a Markov process; that is,

$$z_t = \rho_z z_{t-1} + \varepsilon_{z,t}$$

$$q_t = \rho_q q_{t-1} + \varepsilon_{q,t}.$$

Both ρ_z and ρ_q are between 0 and 1 to ensure stationarity. The vector $\lfloor \varepsilon_{z,t}, \varepsilon_{q,t} \rfloor$ is drawn from a bivariate normal distribution with

$$\varepsilon_z \sim N(\mu_z, \delta_z^2)$$

$$\varepsilon_q \sim N(\mu_q, \delta_q^2),$$

where $E[\mu_z]=0$ and $E[\mu_q]=0$. The shocks to investment-specific technology and the shocks to neutral technology are assumed to be independent.

4.3.2. Household Optimization Problem

The Bellman equation of stockholders' dynamic programming problem is given as

$$V_t(K_{s,t}, K_{e,t}, k_{s,t}, k_{e,t}, z_t, q_t, \varepsilon_{z,t}, \varepsilon_{q,t})$$
$$= Max_{k_{s,t+1}, k_{e,t+1}, n_{s,t}} \left\{ \frac{c_{s,t}^{1-\gamma}-1}{1-\gamma} + \chi \frac{l_{s,t}^{1-\rho}-1}{1-\rho} + E_t[\beta V_{t+1}(K_{s,t+1}, K_{t,t+1}, k_{s,t+1}, k_{e,t+1}, z_{t+1}, q_{t+1}, \varepsilon_{z,t+1}, \varepsilon_{q,t+1})] \right\} \tag{13}$$

subject to

$$c_{s,t} + x_t = r_{s,t}k_{s,t} + r_{e,t}k_{e,t} + w_t e_{s,t} n_{s,t} \tag{14}$$

$$x_t = k_{s,t+1} - (1-\delta_s)k_{s,t} + [k_{e,t+1} - (1-\delta_e)k_{e,t}] / \exp(q_{t+1})$$

where $\{K_{s,t}, K_{e,t}\}$ are aggregate state variables of the economy and $\{k_{s,t}, k_{e,t}, z_t, q_t, \varepsilon_{z,t}, \varepsilon_{q,t}\}$ are individual state variables at time t. Stockholders choose between labor $n_{s,t}$ and leisure $T - n_{s,t}$, decide on the amount of saving x_t and the split of saving between structural capital $k_{s,t+1}$ and equipment capital $k_{e,t+1}$ investment for period $t+1$. The stockholders' optimization problem is recursive for all time periods. Nonstockholders choose the amount of labor $n_{w,t}$ and leisure $T - n_{w,t}$ hours and consume what they earn (that is, $c_{w,t} = w_t e_{w,t} n_{w,t}$) to maximize utility in each period.

The dynamic programming problems of both types of households imply the following optimality conditions:

$$u_l(c_{w,t}, l_{w,t}) = -[Y_{N_w}(Ks_t, Ke_t, N_{s,t}, N_{w,t}) e_{w,t}] u_c(c_{w,t}, l_{w,t}) \tag{15}$$

$$u_l(c_{s,t}, l_{s,t}) = -[Y_{N_s}(Ks_t, Ke_t, N_{s,t}, N_{w,t}) e_{s,t}] u_c(c_{s,t}, l_{s,t}) \tag{16}$$

$$u_c(c_{s,t}, l_{s,t}) = E_t\{\beta u_c(c_{s,t+1}, l_{s,t+1})[Y_{Ks}(Ks_{t+1}, Ke_{t+1}, N_{s,t+1}, N_{w,t+1}) + (1 - \delta_{Ks})]\} \tag{17}$$

$$\begin{aligned} u_c(c_{s,t}, l_{s,t}) / \exp(q_{t+1}) = E_t\{\beta u_c(c_{s,t+1}, l_{s,t+1})[Y_{Ke}(Ks_{t+1}, Ke_{t+1}, N_{s,t+1}, N_{w,t+1}) \\ + (1 - \delta_{Ke}) / \exp(q_{t+2})]\} \end{aligned} \tag{18}$$

The optimality conditions that are derived from the Bellman equation are commonly referred to as Euler equations. Euler equations (15) and (16) state that households choose the amount of leisure hours (or work hours) so that the utility from an additional hour of leisure is equal to the utility from working one more hour, which is the utility of consuming the wage from the extra hour of working. Equation (17) states that the intertemporal choices of the stockholder are made such that the utility of consuming an additional unit in period t equals the expected discounted utility of consumption in period $t+1$, which is the marginal product of structural capital plus the undepreciated part of that capital. Equation (18) states the intertemporal choice of equipment capital is made such that the marginal cost of investment equals the discounted marginal benefit after adjusting for the investment technological change that is specific to new investment in equipment capital.

A recursive equilibrium exists when (1) the factor prices equal their respective marginal products; (2) the four optimality conditions (15) – (18) are satisfied; and (3) the aggregate resource constraint below is satisfied for all t:

$$C_{s,t} + C_{w,t} + X_{s,t} + X_{e,t} = Y_t .$$

4.3.3. Equilibrium Asset Pricing

The budget constraint of the stockholders, as described in equation (14), can also be written as

$$c_{s,t} + p_t \kappa_t = w_{s,t} n_{s,t} + (p_t + d_t)\kappa_{t-1},$$

where p_t is the price of equity, κ_t is the number of shares of equity that are held, and d_t is the dividend per share at time t. The total stock shares are normalized to be equal to unity; at equilibrium, $I\kappa_t = 1$. The right-hand side of the equation is household i's total income and the left-hand side is the total expenditure.

According to the production-based, capital-asset-pricing model (Cochrane, 1991), the stock price can be derived as

$$p_t = \underset{t}{E}[\beta \frac{u'(c_{t+1})}{u'(c_t)}(p_{t+1} + d_{t+1})],$$

where d is the amount of dividend paid to stockholders, $d_t = Y_t - w_{k,t}N_{k,t} - w_{w,t}N_{w,t} - X_{t+1}$, and X_{t+1} is net investment in period t. Parameter β is the rate of time preference. By repeated substitution, p_t can be found as the discounted value of all future dividends d_{t+i},

$$p_t = \underset{t}{E}[\sum_{i=1}^{\infty} M_{t+i} d_{t+i}],$$

where M_{t+i} is the stochastic discount factor, $M_{t+i} = \beta^i \frac{u'(c_{t+i})}{u'(c_t)}$.

4.3.4. Solution Strategy: Perturbation

The model cannot be solved analytically for stock prices and income inequality between stockholders and nonstockholders. The perturbation method (Judd 1998; Gaspar and Judd 1997; Schmitt-Grohé and Uribe 2002; Fowler 2003) is used to solve the model.

The first step of the solution process consists of solving for the steady state values of $\overline{K}_s$, $\overline{K}_e$, $\overline{N}_s$, $\overline{N}_w$, using the four Euler equations (14) – (18) under the assumption of no shocks to the economy; that is, $z = q = \varepsilon_z = \varepsilon_q = 0$. Next, first- and second-order Taylor series expansions are calculated for the four equations around the deterministic steady states and solved for the policy functions of $K_{s,t}$, $K_{e,t}$, $N_{s,t}$, $N_{w,t}$. Based on the policy functions, the model economy is simulated for wage rates, wage premium, stock price, household incomes, and income inequality indices. The dynamics of the evolution of the variables are captured through an impulse response function analysis.

The perturbation method is a numerical method in macroeconomics to approximate the higher-order solution to a nonlinear general equilibrium model. The perturbation method, as developed by Judd (1998) and Gaspard and Judd (1997), has been shown by Schmitt-Grohe and Uribe (2002) to be a convenient higher-order solution method for the representative agent model. The traditional first-order approximation is found not to be well suited for studying stochastic models, especially real-business-cycle models. Fowler (2003) has extended the perturbation method to the study of heterogeneous-agent models. His approach is followed here.

In this model, the Euler equations (15) and (16) can be written as

$$F(k_{s,t+1}, s_t) = 0 \tag{19}$$

and

$$F(k_{e,t+1}, s_t) = 0 \ , \tag{20}$$

and equations (17) and (18) can be written as

$$F(h_{s,t}, s_t) = 0 \tag{21}$$

and

$$F(h_{w,t}, s_t) = 0, \tag{22}$$

where s_t is the economy's state at time *t*, and $s_t = \{k_{s,t}, k_{e,t}, z_t, q_t, \delta_z, \delta_q\}$. A solution to equations (19) and (20) is a first-order difference equation or a transition equation relating today's state to tomorrow's state. The solution is denoted as

$$k_{i,t+1} = f(s_t),\ i = s, e.$$

Since the transition function cannot be found directly in this highly nonlinear model, the solution is approximated by the Taylor series expansion,

$$
\begin{aligned}
k_{i,t+1} &= f(k_{s,t}, k_{e,t}, z_t, q_t, \delta_z, \delta_q) \\
&= f_0 + f_1(k_{s,t} - \bar{k}_s) + f_2(k_{e,t} - \bar{k}_e) + f_3(z_t - \bar{z}) + \ldots \\
&\quad + \frac{1}{2} f_{11}(k_{s,t} - \bar{k}_s)^2 + \frac{1}{2} f_{22}(k_{e,t} - \bar{k}_e)^2 + \frac{1}{2} f_{33}(z_t - \bar{z})^2 + \ldots \\
&\quad + f_{12}(k_{s,t} - \bar{k}_s)(k_{e,t} - \bar{k}_e) + f_{13}(k_{s,t} - \bar{k}_s)(z_t - \bar{z}) + f_{14}(k_{s,t} - \bar{k}_s)(q_t - \bar{q}) \\
&\quad + f_{15}(k_{s,t} - \bar{k}_s)\delta_z + f_{16}(k_{s,t} - \bar{k})\delta_q + f_{23}(k_{e,t} - \bar{k}_e)(z_t - \bar{z}) + \ldots \quad ,
\end{aligned} \tag{27}
$$

where the coefficients are $f_0 = f(s_t)|_{s_t = \bar{s}}$, $f_1 = \frac{\partial f(s_t)}{\partial k_{s,t}}|_{s_t = \bar{s}}$, $f_{11} = \frac{\partial^2 f(s_t)}{\partial k_{s,t}, \partial k_{s,t}}|_{s_t = \bar{s}}$, ... and where $\bar{s}_t = \{\bar{k}_s, \bar{k}_e, \bar{z}, \bar{q}, \delta_z, \delta_q\}$ represents the economy's deterministic steady state, which is characterized by the absence of any shock to the economy ($\bar{z} = 0, \bar{q} = 0, \delta_z = 0, \delta_q = 0$) and the absence of growth ($k_{s,t} = \bar{k}_s$, $k_{e,t} = \bar{k}_e$ for all t).

The central idea of perturbation is to solve for the coefficients f_i in the Taylor series expansion and then to get an approximation of $f(s_t)$. A natural choice for f_0 is the deterministic steady state of the economy. Because an economy will not deviate from its steady state path in the absence of uncertainty, the steady state value is the most commonly used expansion point. The steady state points ($\bar{k}_s, \bar{k}_e, \bar{h}_s, \bar{h}_e$) can be found using the four Euler equations. Newton's method is typically employed for this first step. From the steady state values, one can derive the first coefficient (f_0). To get f_1, one can use the fact that the expansion of equation (19) around $\bar{k}$ must also be equal to 0,

$$0 = \frac{\partial F(k_{s,t+1}, s_t)}{\partial k_t}\Big|_{s_t=\bar{s}} + \frac{\partial F(k_{s,t+1}, s_t)}{\partial k_{t+1}} \frac{\partial f(s_t)}{\partial k_t}\Big|_{s_t=\bar{s}} . \tag{24}$$

Rearranging terms gives a solution for the first-order expansion coefficient,

$$f_1 = -\overline{F}_1 / \overline{F}_2,$$

where $\overline{F}_1 = \frac{\partial F(.)}{\partial k_t} | s_t = \bar{s}$ and $\overline{F}_2 = \frac{\partial F(.)}{\partial k_{t+1}} | s_t = \bar{s}$. The other first-order and higher-order coefficients are solved in a similar manner. The model is solved in the following order: first, the steady state values; second, the lower-order solution; third, the higher-order solution. The order matters because lower-order solutions are used to solve for higher-order coefficients. The solutions of equations (20) to (22) can be approximated with the same method.

After obtaining the policy functions for labor/leisure choice and investment choice, the model economy is simulated 5,200 periods into the future. The first two hundred simulations are dropped to remove the effect of the initial values. Based on the simulations, average values are derived for the investment output ratio, the capital output ratio, hours worked by both skilled and unskilled workers, wage rates, the skill premium, and the income ratio. Finally, the dynamics of the evolution of the economy are presented using impulse response functions.

4.3.5. Calibrations and Targets

To solve and simulate the model economy numerically, values have to be assigned to the following parameters:

Preferences: β, γ, ρ, χ;

Technology: θ, v, φ, τ, π, δ_s, δ_e, σ_q, σ_z;

Population: I, J.

The study follows the calibration procedure advanced by Kydland and Prescott (1982). In line with this approach, as many parameters as possible are set in advance based upon either a priori information or the objective to replicate key U.S. macroeconomic ratios.

For the parameters that appear in the production function, this study uses the estimates of Krusell et al. (1997) and follows Greenwood et al. (1997) in choosing values for the depreciation rates that apply to structure capital and equipment capital (δ_s and δ_e). The quarterly depreciation rates are converted to annual rates. The consumption parameter γ and the leisure parameter ρ as well as the relative weight of leisure in the utility function χ are set at values that follow the calibration of Castañeda et al. (2003).

The number of stockholders (I) and nonstockholders (J) are set to be 30 and 70, respectively, so the stock market participation rate is 30 percent. This is the average participation rate in the 1980s and 1990s. The time endowment T is set to five for each period so that the average number of working hours equals one-third of the total time endowment. The time discount factor β is calibrated to be 0.97, which is in the range of 0.95 to 0.99 that most of the literature uses. All parameters are listed with their assumed values in Table 4.1.

TABLE 4.1: Parameter Calibrations for the SBTC Model:

Parameter	*Value*
I	30
J	70
θ	0.13
β	0.97
δ_s	0.04
δ_e	0.10
v	0.401
φ	-0.495
τ	0.413
π	0.553
α	0.611
ρ_q	0.640
ρ_z	0.950
σ_z	0.008
σ_q	0.12
T	5

The model targets a capital-output ratio (K/Y) of 3.20, a capital-income share of 0.33, an investment-to-output ratio (I/Y) of 18.6 percent, and an average working time of one-third of total time endowment. The capital-output ratio target follows the calculations of Castañeda et al. (2003), based on the Economic Report of the President for 1992. The other targets are calculated based on the National Income and Product Accounts (NIPA) data of the same year.

4.3.6. Equilibrium Income Inequality

At equilibrium, the skill premium is derived as[17]

$$\frac{w_{s,t}}{w_{w,t}} = \frac{(1-\tau)(1-\pi)}{\tau}\left[\pi\left(\frac{K_{e,t}}{N_{s,t}}\right)^{\varphi} + (1-\pi)\right]^{(\nu-\varphi)/\varphi}\left(\frac{N_{w,t}}{N_{s,t}}\right)^{1-\nu}\frac{e_s}{e_w}. \tag{25}$$

When $1 > \nu > \varphi$, a rise in the stock of capital equipment $K_{e,t}$ will, ceteris paribus, raise the skill premium. Krusell et al. (1997) call this the capital-skill complementarity effect. A rise in the ratio of unskilled to skilled hours worked $N_{w,t} / N_{s,t}$, will raise the skill premium. Krusell et al. (1997) call this the relative supply effect. Following Krusell et al. (1997), the study assumes the ratio of labor efficiency of skilled to unskilled labor is equal to 1, or $\frac{e_s}{e_w} = 1$.

A skill-biased technological change increases the wage premium of skilled over unskilled labor and thereby increases the degree of earnings inequality, while a total factor productivity innovation has no direct effect on the wage premium between stockholders and nonstockholders. Both sources of technological progress contribute to

[17] See the Appendix C for a derivation.

stock market appreciation because of associated higher productivity. The income distributional effect through the stock market cannot be solved analytically due to the high degree of nonlinearity of the model. Perturbation methods described above are used to solve the model. Numerical results are presented below.

4.3.7. Numerical Results

The simulated model economy's main aggregate ratios along with the targets are presented in Table 4.2. The model economy's aggregate ratios match the data well. The capital-output ratio and the investment-output ratios are slightly higher than their targets. This may be because the model economy assumes no taxes, which would have a negative effect on investment and capital stock. The steady state wage premium between stockholders and nonstockholders matches the data as well.

TABLE 4.2: Value of the Targeted Ratios and Aggregates in the United States and in the Model Economy

	K/Y	I/Y	H	Capital Share	Labor Share	Wage Premium
U.S.	3.2	0.186	0.33	0.33	0.67	2.18
Model economy	3.26	0.214	0.34	0.32	0.68	2.15

Note: the Macro-statistics of the U.S. is based on the 1992 value.

The dynamic effects of a technological shock on income inequality are analyzed through an impulse response function. Impulse response functions show the dynamic effect of a one-time shock to the model economy's level of technology on the economy's performance over time. The shock changes the returns to factors of production and thus alters households' intratemporal labor/leisure choices and intertemporal consumption and saving decisions. Because stockholders' consumption and saving choices are of a dynamic nature, a one-period shock to the economy will have multi-period effects.[18] The dynamic effects of the shock are presented in a sequence of figures below.

Figure 4.1 illustrates the impulse responses of work hours of stockholders and those of nonstockholders as a result of one standard deviation of SBTC shock, or a 3.5 percent increase in the level of skill-biased technology. Both stockholders' and nonstockholders' work hours are not sensitive to the technological shock. Stockholders increase working hours by only 0.1 percent in the shock period and 0.7 percent in the next period. From the fourth period on, stockholders reverse their labor market behavior. They work slightly fewer hours and converge to steady state value in about 20 periods.

The increase in working hours in the shock period and the next period are due to the complementarity between equipment capital and skilled labor. Increase in working hours boosts return to capital. Stockholders get higher income not only from working more hours but also from an increased return on capital investment. The decrease in labor supply in the later periods results from the income effect. Households value extra leisure more than the wage income from extra working when they have higher than steady state income. Nonstockholders' labor choices are almost unaffected by the skill-biased technological shock because their wage rates are almost unaffected by the SBTC shock.

[18] In this analysis, the shock occurs in the second period.

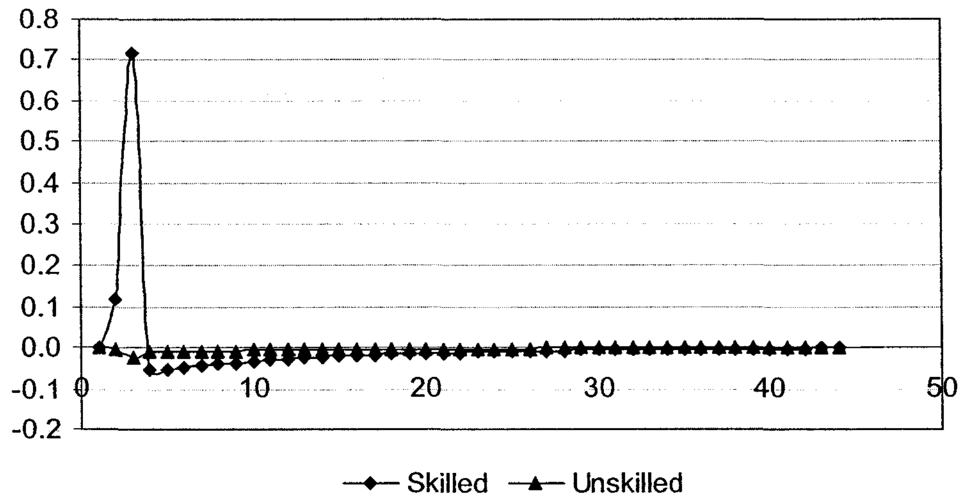

FIGURE 4.1: Impulse Response of Work Hours to One Standard Deviation (3.5%) Shock to the SBTC (%)

Figure 4.2 presents the investment response to the SBTC shock. Total investment increases by about 0.6 percent in the shock period followed by an investment spike of about 2.5 percent growth from its steady state. Following the relatively high growth of investment, investment is slightly lower compared to the steady state for as long as 20 periods. The increase in investment is to exploit the opportunity of a higher return to capital and a higher skill premium. Because the technological shock is specific to new investment in equipment, the productivity of capital equipment is higher than that of capital structure.[19] Although the total capital stock increases by less than 0.3 percent,

[19] This is shown in data as price decrease of capital equipment relative to capital structure; see Greenwood et al. (1997, 2000) for details. In this dissertation, capital equipment and equipment capital are interchangeable, and so are capital structure and structure capital.

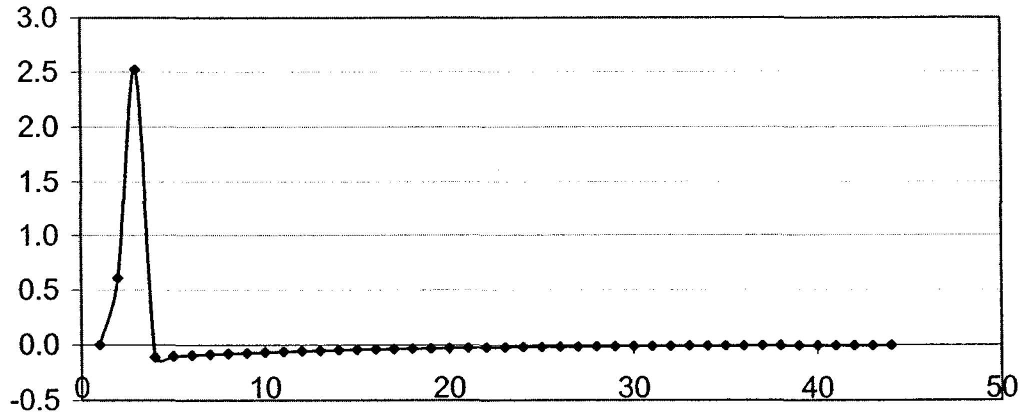

FIGURE 4.2: The Impulse Response of Investment to One Standard Deviation Shock to the SBTC (%)

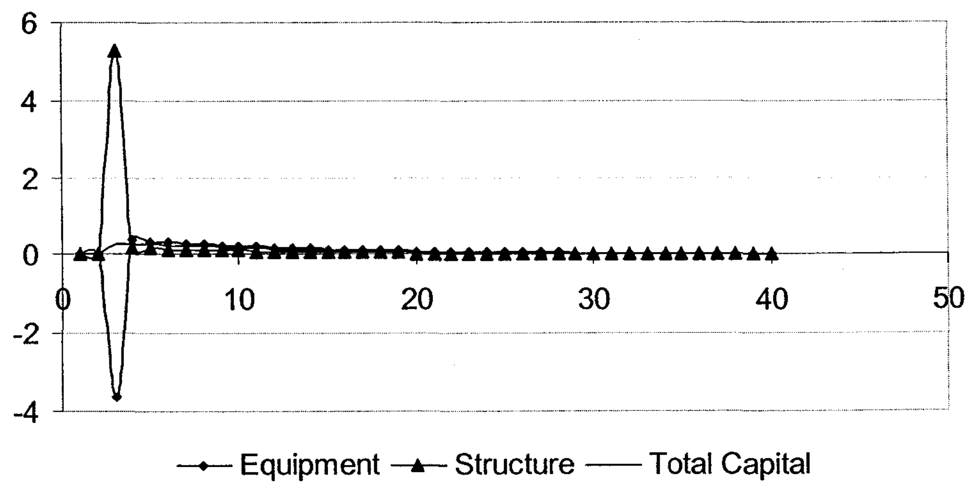

FIGURE 4.3: The Impulse Response of Capital Stock to One Standard Deviation Shock to the SBTC (%)

equipment capital stock increases by more than 5 percent while the structure capital stock decreases by about 4 percent. The decrease in the structural capital is a result of depreciation, and the new investment in structures does not fully offset the depreciation. This partly explains why the share of equipment capital kept increasing while that of structure capital kept decreasing in the past 30 years (Greenwood, 1997).

Figure 4.4 presents the impulse response of wage rates of stockholders and nonstockholders to the skilled-biased technological shock. Stockholders' wages increase by more than 1.2 percent following the shock and remain slightly above their long-run steady state values for more than 20 periods. The increase in the productivity of equipment capital increases the productivity of skilled labor, because equipment capital complements skilled labor. Nonstockholders' wages also increase following the technological shock, but the magnitude of the increase is substantially lower than for stockholders. The substitutability of equipment capital and unskilled labor offsets much of the growth effect from the technological shock.

Figure 4.5 illustrates the impulse response of the stock price to the SBTC shock. The stock price decreases about 0.5 percent in the shock period and then increases more than 0.8 percent in the next period. The decrease in the stock price following the SBTC seems counterintuitive—people expect higher stock prices as a result of higher capital productivities—but is due to the fact that this study defines dividends as output minus labor income minus investment. The investment spike following the productivity shock

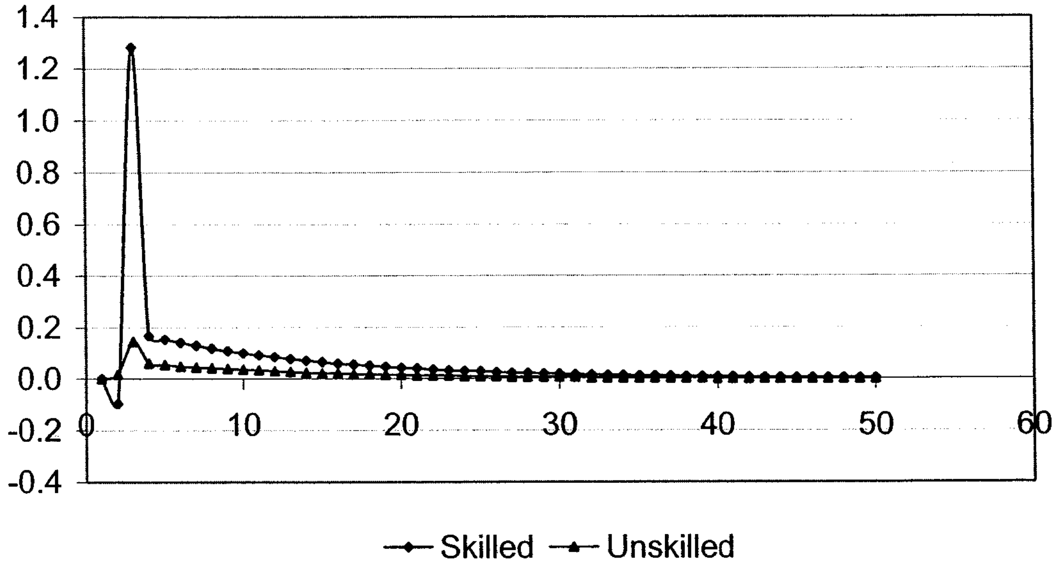

FIGURE 4.4: Impulse Response of Wage Rate to One Standard Deviation Shock to the SBTC (%)

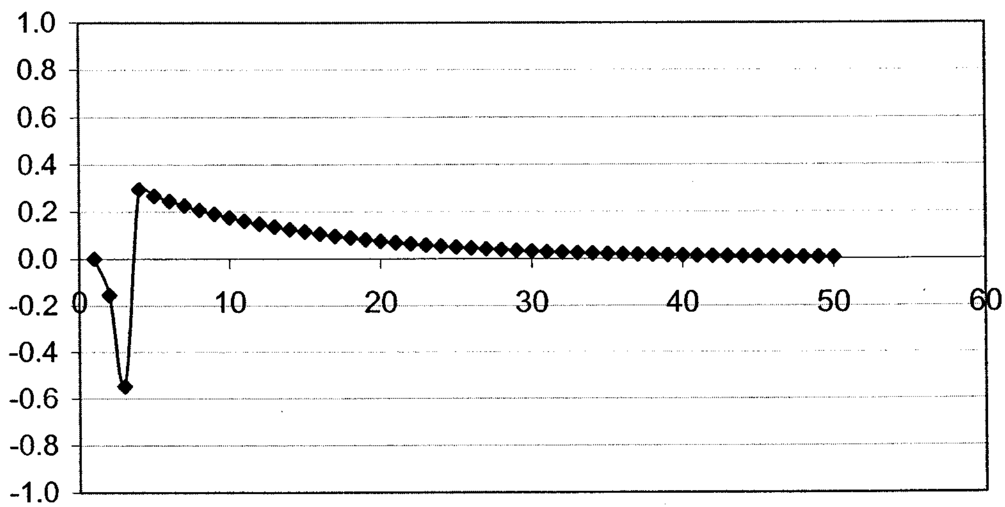

FIGURE 4.5: Impulse Response of the Stock Price to One Standard Deviation Shock to the SBTC (%)

outweighs the increase in capital income. The stock price increase in the next period more than offsets the decline of stock prices in the previous period. Although the magnitude of the stock price appreciation is not large, the stock price remains above and converges to the steady state value in as long as 50 periods.

Figure 4.6 presents the impulse response of the skill premium and the Gini index to the SBTC shock. The wage premium decreases slightly in the shock period and then increases by a more than 1 percent increase in the following period. The initial decrease is due to the increase in the labor supply of skilled workers and the resulting diminishing return for skilled workers as the unskilled workers' labor supply changes little in the shock period. In the following two periods, increase in capital equipment investment boosts the wage premium by more than 1 percent. The increase in the wage premium is through the complementarity of equipment capital and skilled labor and the substitutability of equipment capital and unskilled labor. The Gini index increases by about 0.7 percent. The increase in the Gini index is mainly from two sources: the increase in the skill premium and the increase in the asset return as indicated by asset prices. Yet the capital gain's effect on the Gini index is quite small compared to the wage premium effect. Asset appreciation is less than 0.3 percent compared to the more than 1 percent skill premium increase.

Both the skill premium and the stock price show no lagged effect on the Gini index although both the stock price appreciation and the wage premium are higher than their respective steady state values with long lags. This is because stockholders reverse their saving behavior after the technological shock, which reduces the jump in investment

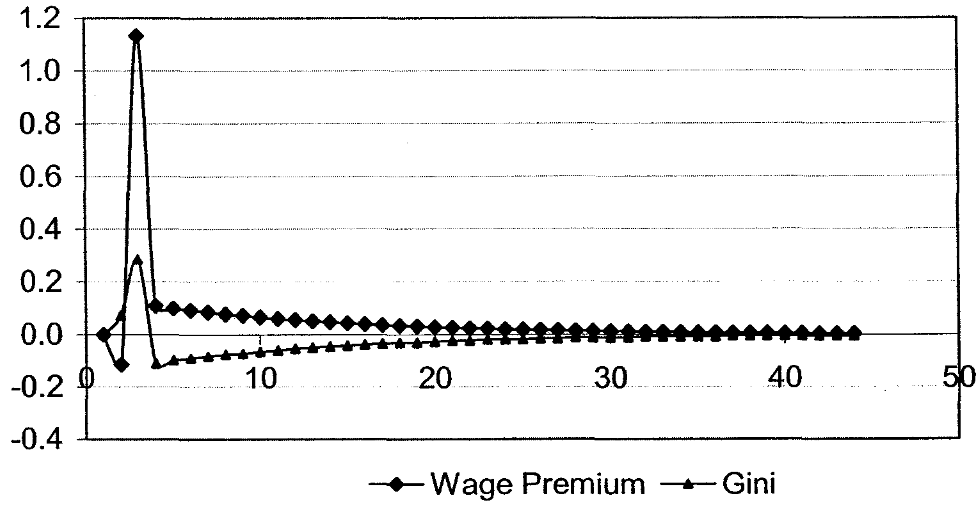

FIGURE 4.6: Impulse Response of the Wage Premium and the Gini index to One Standard Deviation Shock to the SBTC (%)

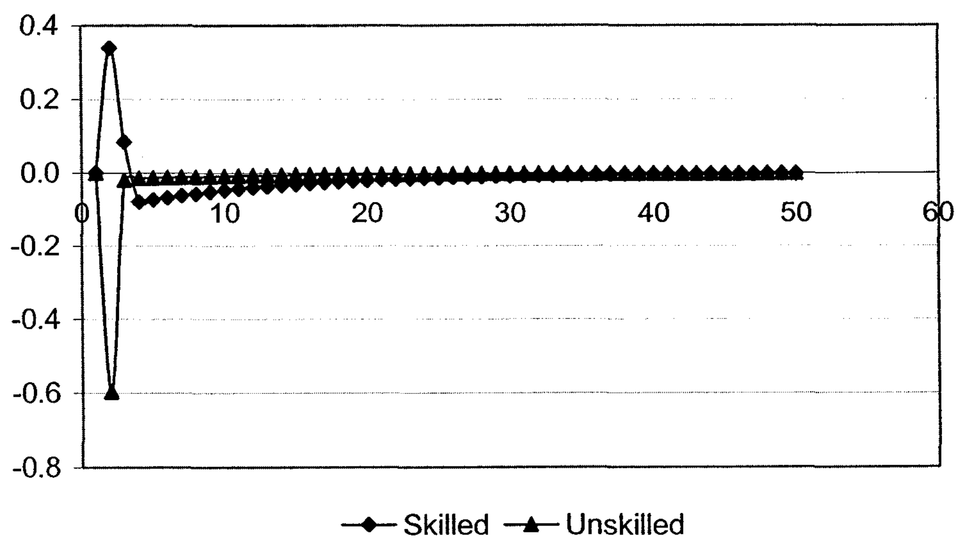

FIGURE 4.7: Impulse Response of Work Hours to a 3.5 Percent TFP Change

income. The reverse in the increase in labor supply of stockholders after the investment spike reduces their total labor earnings. Nonstockholders also decrease their labor supply as a result of the income effect induced by the technological shock, but not to the same extent as stockholders. These factors drive the Gini index back to its steady state.

The effects of the TFP shocks on the model economy are different from the SBTC shocks. First, skilled workers' and unskilled workers' labor market choices are quite different. Skilled workers increase their labor supply by 0.3 percent, about half of the increase caused by a skill-biased technological shock of the same magnitude. Nonstockholders decrease their labor supply by more than 0.6 percent, and their labor supply is not quite as responsive to a skill-biased technological shock (Figure 4.7). Stockholders increase their supply of labor hours to gain from the complementarity of equipment capital and skilled labor, and the unskilled workers decrease their labor supply and enjoy more leisure hours as a result of a higher wage rate.

Stockholders and nonstockholders get a wage rate increase of more than 3 percent and 3.5 percent, respectively, from the total factor productivity shock (Figure 4.8). The wage premium decreases as a result of the increase in the labor supply of skilled workers relative to that of unskilled workers, as is shown in equation (25). Krusell et al. (1997) call this the relative supply effect.

The total factor productivity shock boosts investment substantially. Investment increases by more than 6 percent following the shock. This effect is more than twice as large as that of an SBTC shock (Figure 4.9). This investment spike has a long-lasting effect on total capital stock. Both equipment capital and structural capital increase as a

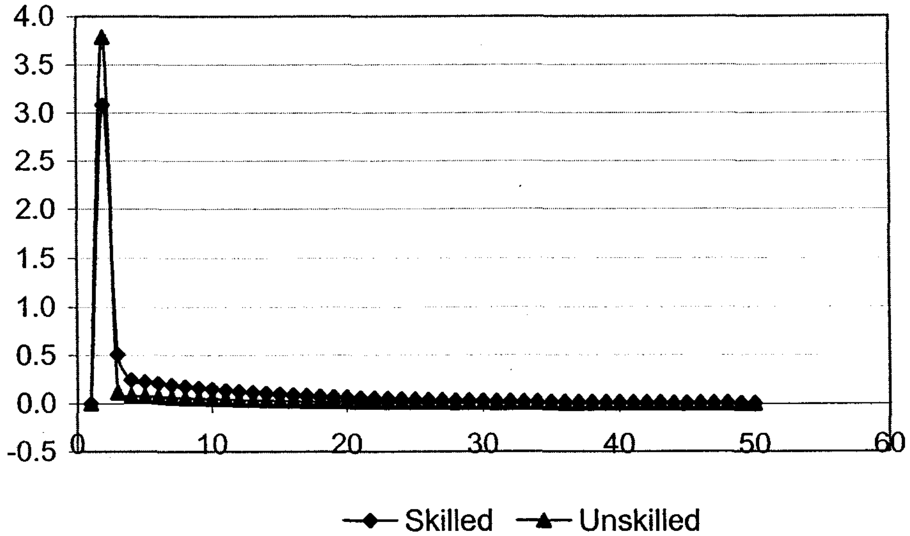

FIGURE 4.8: The Impulse Response of Wage Rates to a 3.5% TFP Change (%)

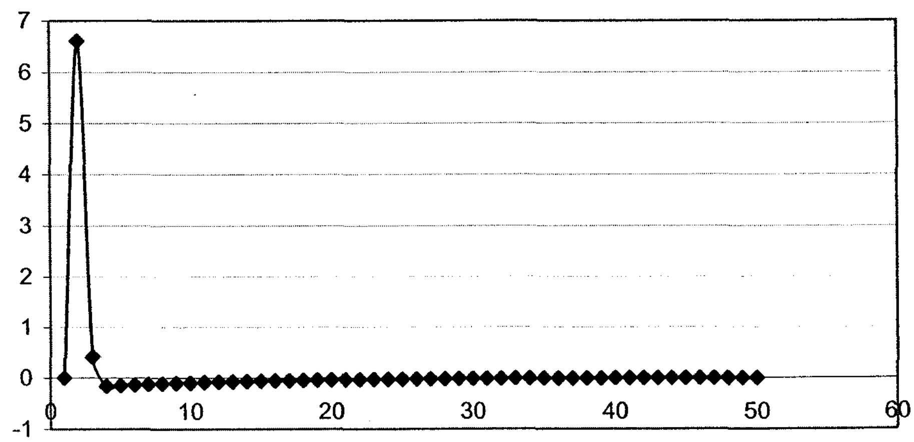

FIGURE 4.9: The Impulse Response of Investment to a 3.5 Percent TFP Change (%)

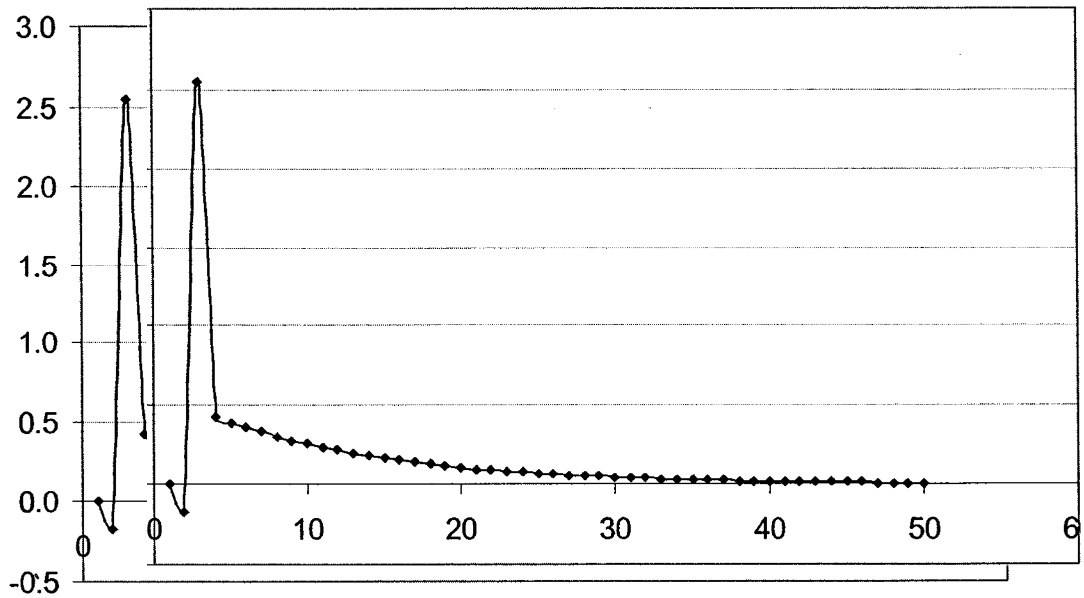

FIGURE 4.10: The Impulse Response of Stock Price to a 3.5 Percent TFP Change (%)

result of the investment spike. However, the investment is mainly allocated to equipment capital investment in the shock period, and in the following periods, more investment is allocated to structures. The investment is allocated so that stockholders' total income is maximized.

The impulse response of stock prices is presented in Figure 4.10. The stock price increases by more than 2.5 percent following the TFP shock and remains above its long-run steady state for more than 30 periods. Compared to an SBTC shock of equal scale, the TFP shock has a much larger effect on the stock price. This is because an SBTC shock affects productivity of only new capital investment, while a TFP shock affects productivity for all factors of production, which in turn boosts firms' profitability and, consequently, stock prices. Since stock price appreciation benefits only stockholders, the income gap between stockholders and nonstockholders enlarges. However, this does not necessarily increase the Gini index. If nonstockholders' labor income, which is their only source of income, increases by more than the appreciation rate of the stock price, the boom in the stock market will not have a positive effect on income inequality. As is shown in the next section, nonstockholders' income increases by more than 3 percent, which is higher than the 2.5 percent stock price increase. Thus, the stock market appreciation brought about by a TFP shock is not a factor that increases the income Gini index.

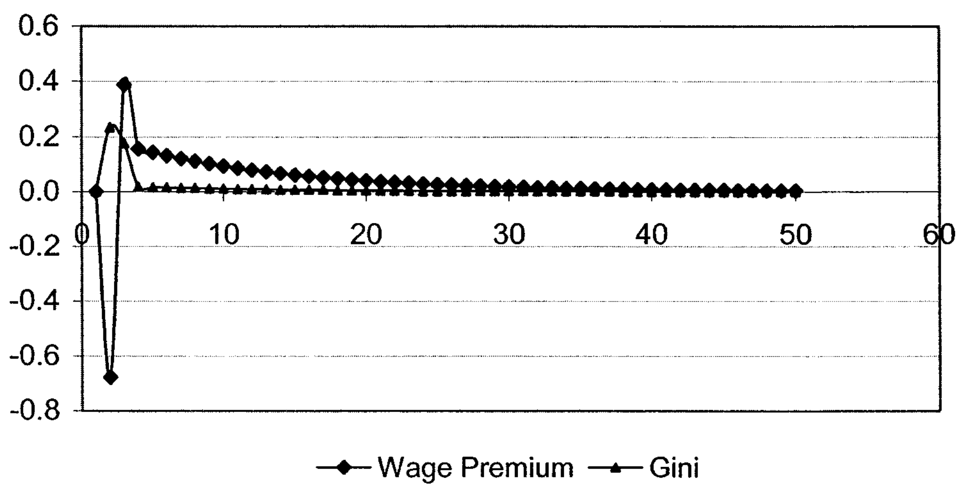

FIGURE 4.11: The Impulse Response of the Skill Premium and the Gini Index to a 3.5 Percent TFP Change (%)

The wage premium decreases about 0.6 percent in the period when the shock occurs and increases more than 1 percent in the following period. It remains above the steady state value with long lags (Figure 4.11). The change in the wage premium is a result of different labor/leisure choices of stockholders and nonstockholders, as discussed above. Although the wage premium decreases in the shock period, the total income inequality, as measured by the Gini index, still increases. This is because the opposite labor/leisure choices of stockholders and nonstockholders more than offset the decrease of the skill premium. The total labor income of stockholders increases by about 3.4 percent while that of nonstockholders increases by about 3.1 percent. The Gini index increases by about 0.2 percent.

4.4. Summary

Through a heterogeneous-agent, general equilibrium model, this chapter studies the income inequality effect of stock price appreciation both in the long run and in the short run. Assuming a Cobb-Douglas production function, this chapter shows that stock market appreciation has no effect on income inequality. This is because both stockholders' and nonstockholders' incomes grow at the same rate, which renders the income inequality index, measured by the income ratio between stockholders and nonstockholders, constant.

To study the business cycle effect of stock price appreciation on income inequality, the model assumes a CES production function that incorporates both a skill-biased technological change and a total factor productivity change. The model economy is solved numerically, and it replicates well a few main aggregate economic ratios in the U.S. By impulse response analysis, this chapter examines the different business cycle effects on income inequality of both types of technological shocks through labor earning and through the stock market. The main finding is that positive technological shocks increase the incomes of both stockholders and nonstockholders. Nevertheless, the income inequality also increases. Stockholders gain more from technological shock than nonstockholders do. However, this higher gain for stockholders derives mainly from labor income rather than from the equity market.

Different types of technological shocks have different effects on income inequality. If the technological shock is skill-biased and investment-specific as proposed by Greenwood et al. (1997, 1999), the increase in income inequality is greater than a TFP technological shock of the same magnitude would. The increase in income inequality associated with an SBTC shock is mainly through an increase in the skill premium. Equity appreciation also contributes, although marginally, to the increase in income inequality. The increase in inequality as associated with a TFP shock is mainly the result of different labor/leisure choices of stockholders and nonstockholders. Although stock price appreciation caused by a TFP shock is substantially higher than that caused by an SBTC shock, the stock price appreciation has no positive effect on income inequality. This is because the labor income of nonstockholders increases more than the stock price.

Stock market appreciation's effect on income inequality is small in the SBTC case or negative in the TFP case, which is inconsistent with the empirical findings. This may be due to the fact that, in the real economy, the wage rate typically does not adjust to technological shock instantaneously. There is strong evidence of wage rigidity (Ghosal and Loungani, 1996; Kahn, 1997; Lebow et al. 1995). The stock market provides an effective buffer against shocks to the economy. This boosts the positive business cycle effects of the stock market on income inequality.

The model assumes that stockholders are skilled workers and nonstockholders are unskilled workers. As illustrated in Chapter 3, an increase in stock market participation decreases income inequality, and an increase in the skilled labor supply also decreases income inequality. Thus, the impulse response of income inequality in this chapter may be viewed as an upper bound of the income inequality effect of stock market appreciation as a result of technological progress.

CHAPTER 5

CONCLUSION

In the past 30 years, income inequality in the U.S. has been increasing steadily. Over the same period, average real GDP growth has been about three percent per year, and the stock market has appreciated dramatically. Did the growth of the economy benefit only high-income households and leave the poor out? Did the stock market boom contribute to increasing inequality as suggested in some of the literature?

By using the Panel Study of Income Dynamics (PSID) data from 1980 to 2001, the author studies income inequality effects of the stock market valuation. The study finds that income inequality between stockholders and nonstockholders—as measured by the average income ratio between the two—has no trend while the stock market index appreciated more than five hundred percent. The author thus concludes that the stock market boom in the 1980s and 1990s had not contributed to the trend in income inequality. It is much more likely that increasing skill premiums substantially contributed to the trend in income inequality as found in the literature.

In the short run, however, stock market appreciation is found to increase income inequality temporarily via a fixed-effect panel data regression model. The estimation method controls for economic growth, household idiosyncratic unemployment, as well as household demographics. A simulation shows that one standard deviation (14%) positive shock to the stock price brings a temporary increase in the income Gini index between stockholders and nonstockholders of about 5 percent, taking into account the correlation between the stock price index appreciation rate and real GDP growth.

A general equilibrium real business cycle model with two types of households (stockholders and nonstockholders) is built to replicate these empirical findings. Income inequality effect of stock market valuation is studied by analyzing the dynamics of the income inequality between stockholders and nonstockholders. With a Cobb-Douglas production function and assuming a growing economy, the model shows analytically that stock market boom has no long run effect on income inequality, which is consistent with the empirical findings. However, the model could not replicate the business cycle effect of stock market appreciation on income inequality. This is because the model economy with a Cobb-Douglas production function produces a fixed output share of capital and labor. Thus, this study adds a CES production function that produces cyclical factor shares of output.

The CES production function incorporates both skill-biased technological and skill-neutral technological changes. This is because skill-biased technological changes are found to contribute substantially to the long-term trend in income inequality. In order to differentiate the income inequality effect of stock price appreciation from skill premium changes as propagated by SBTC and/or TFP shocks, the model further assumes that stockholders are skilled workers, nonstockholders are unskilled workers. Due to different labor/leisure choices and intertemporal choices, the two types of technological changes show different effects on stock prices, household income, and income inequality.

If the technological shock is skill-biased and investment-specific, as proposed by Greenwood et al. (1997, 1999), it increases income inequality more than a TFP technological shock of the same magnitude. The increase in income inequality associated with an SBTC shock is mainly through an increase in the skill premium. The equity appreciation also contributes, although marginally, to the increase in income inequality. The increase in inequality associated with a TFP shock is mainly the result of different labor/leisure choices of stockholders and nonstockholders. Although stock price appreciation caused by a TFP shock is substantially higher than that of an SBTC shock of equivalent scale, it has no positive effect on income inequality. This is because the labor income of nonstockholders increases more than the stock price.

By assuming no skill acquisition and a fixed participation pattern to the stock market, the income inequality implied by this model may be viewed as an upper limit of the stock market effect on income inequality. Increases in stock market participation and acquisition of skills by unskilled workers would both decrease income inequality as induced by a technological shock.

Since the stock market valuation has no long run effect on income inequality and the short-run effect of the stock market on income inequality is small, it may not be wise to target the stock market to tackle the issue of increasing income inequality. Encouraging stock market participation and skill acquisition is probably a more effective way to decrease income inequality.

This study assumes a perfect competitive economy with full employment. This assumption is crucial to reconciling the finding in this study with the literature, such as Castañeda et al. (1998), who find that income inequality is countercyclical and the countercyclicity of idiosyncratic unemployment risk is the main cause of the counter cyclical movement of income inequality. The findings in this dissertation show that income inequality is procyclical between stockholders and nonstockholders after controlling for unemployment.

The impulse response of stock price appreciation propagated by technological shocks in the model is not as large as that from the data studied in Chapter 3. By assuming some degree of rigidity in wage rates, the cyclical dynamics of the stock market effect on income inequality may better match data. Furthermore, this study does not preclude the stock market's effect on income inequality through other possible avenues, such as political power associated with the concentration of wealth (Durham et al., 1998), which may affect the distribution of income share between capital and labor. Further research may be done along these lines.

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Appendix A:

The equality $P_t^{'} = K_t$ is shown in the following proof.

Proof. With a Cobb-Douglas production function, the dividend D_{t+1} is calculated as

$$\begin{aligned} D_{t+1} &= A_{t+1}K_t^{\alpha}N_t^{1-\alpha} - N_t w_{t+1} - I_{t+1} \\ &= A_{t+1}\alpha K_t^{\alpha}N_t^{1-\alpha} - I_{t+1} \\ &= A_{t+1}\alpha K_t^{\alpha}N_t^{1-\alpha} - (K_{t+1} - (1-\delta)K_t). \end{aligned}$$

Rearranging terms in the last expression results in:

$$\frac{K_{t+1} + D_{t+1}}{K_t} = A_{t+1}\alpha K_t^{\alpha-1}N_t^{1-\alpha} + (1-\delta). \qquad (11')$$

Stockholders' optimum dynamic choice implies

$$E_t[p_{t+1}(A_{t+1}\alpha K_t^{\alpha-1}N_t^{1-\alpha} + 1 - \delta)] = p_t, \qquad (12')$$

where p_t and p_{t+1} are defined in equation (5). This equation states that stockholders make consumption and saving decisions so that the marginal disutility of saving today equals the discounted marginal utility from the investment return tomorrow. Substitute (11') into (12') to get

$$p_t = E_t[p_{t+1}\frac{K_{t+1}+D_{t+1}}{K_t}].$$

Rearrange to obtain

$$K_t = E_t[\frac{p_{t+1}}{p_t}(K_{t+1}+D_{t+1})].$$

The optimality conditions for stockholders can also be written as:

$$p_t P_t^{'} = E[p_{t+1}(P_{t+1}^{'}+D_{t+1})],$$

where P_t is the real stock price. The equation states that the real stock price is such that the marginal disutility of buying an additional share of equity today equals the discounted marginal utility of the expected pay-off tomorrow. This can be rearranged to read

$$P_t^{'} = E_t[\frac{p_{t+1}}{p_t}(P_{t+1}^{'}+D_{t+1})].$$

Combining (13) and (14) one gets $P_t^{'} = K_t$ for all t.■

Appendix B:

Derivation of income ratio between stockholders and nonstockholders:

$$\frac{w_t e_t^k n_t^k + (r_t - \delta)k_t}{w_t e_t^w n_t^w}$$

$$= \lambda_t + \frac{r_t - \delta}{w_t e_t^w} \frac{k_t}{n_t^w}$$

$$= \lambda_t + \frac{A_t \alpha K_t^{\alpha-1} N_t^{1-\alpha} - \delta}{A_t(1-\alpha)K_t^{\alpha} N_t^{-\alpha} e_t^w} \frac{k_t}{n_t^w}$$

$$= \lambda_t + [\frac{a}{(1-a)e_t^w \omega_t} - \frac{\delta}{A_t(1-\alpha)e_t^w \omega_t^{\alpha}}] \frac{K_t / i}{[N_t / e_t^w (i + j\lambda_t)]}$$

$$= \lambda_t + [\frac{a}{(1-a)\omega_t} - \frac{\delta}{A_t(1-\alpha)\omega_t^{\alpha}}] \frac{K_t / i}{[N_t /(i + j\lambda_t)]}$$

$$= \lambda_t + [\frac{a}{(1-a)\omega_t} - \frac{\delta}{A_t(1-\alpha)\omega_t^{\alpha}}] \omega_t \frac{(i + j\lambda_t)}{i}$$

$$= \lambda_t + [\frac{a}{(1-a)} - \frac{\delta \omega_t^{1-\alpha}}{A_t(1-\alpha)}] \frac{(i + j\lambda_t)}{i}$$

$$= \lambda_t + [\frac{a}{(1-a)} - \frac{\delta}{A_t(1-\alpha)} (\frac{K_t}{N_t})^{1-\alpha}](1 + \frac{1-p}{p}\lambda_t)$$

$$= \lambda_t + [\frac{a}{(1-a)} - \frac{\delta}{A_t(1-\alpha)} (\frac{P_t - \tau_t}{N_t})^{1-\alpha}](1 + \frac{1-p}{p}\lambda_t)$$

Appendix C:

Calculation of the skill premium:

$$\frac{w_{s,t}}{w_{u,t}} = \frac{(1-\tau)[\pi K_{e,t}^{\varphi} + (1-\pi)N_{s,t}^{\varphi}]^{\frac{v}{\varphi}}(1-\pi)N_{s,t}^{\varphi}N_{w,t}e_{s,t}}{(\pi K_{e,t}^{\varphi} + (1-\pi)N_{s,t}^{\varphi})\tau N_{w,t}^{v}N_{s,t}e_{w,t}}$$

$$= \frac{(1-\tau)(1-\pi)}{\tau}[\pi + (1-\pi)(\frac{N_{s,t}}{K_{e,t}})^{\varphi}]^{\frac{v-\varphi}{\varphi}} K_{e,t}^{v-\varphi}\frac{N_{s,t}^{\varphi-1}}{N_{w,t}^{v-1}}$$

$$= \frac{(1-\tau)(1-\pi)}{\tau}[\pi + (1-\pi)(\frac{N_{s,t}}{K_{e,t}})^{\varphi}]^{\frac{v-\varphi}{\varphi}} (\frac{K_{e,t}}{N_{s,t}})^{v-\varphi}(\frac{N_{w,t}}{N_{s,t}})^{1-v}$$

$$= \frac{(1-\tau)(1-\pi)}{\tau}[\pi(\frac{K_{e,t}}{N_{s,t}})^{\varphi} + (1-\pi)]^{\frac{v-\varphi}{\varphi}} (\frac{K_{e,t}}{N_{s,t}})^{\varphi-v}(\frac{K_{e,t}}{N_{s,t}})^{v-\varphi}(\frac{N_{w,t}}{N_{s,t}})^{1-v}$$

$$= \frac{(1-\tau)(1-\pi)}{\tau}[\pi(\frac{K_{e,t}}{N_{s,t}})^{\varphi} + (1-\pi)]^{\frac{v-\varphi}{\varphi}} (\frac{N_{w,t}}{N_{s,t}})^{1-v}(\frac{e_{s,t}}{e_{w,t}})$$