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Education, Technology and Skill Premium : A Dynamic General Equilibrium Analysis

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A DYNAMIC GENERAL EQUILIBRIUM ANALYSIS

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ABSTRACT

Education, Technology and Skill Premium: a Dynamic General Equilibrium Analysis is a two fold attempt to capture skill premium dynamics. First, it examines results across a cross section of model economies at different stages of economic development. It equates these model economies to real economies and compares skill premium results with the measure of income inequality. Second, it makes a valiant attempt to capture the non linear dynamics present in the US skill premium across 20^{th} century, not captured so far in any dynamic general equilibrium model. Though the simplistic nature of the model leaves out many fine trends, the long run dynamics are well captured. The last section of the paper simulates the effect of introducing wage subsidies, on skill premium. In a setting where skill acquisition and wage earning are rival goods, it shows that a declining wage subsidy policy creates the optimal result of a sharp fall in skill premium along with a rise in the supply of educated workers. The paper serves as a base for further study, when the economy is opened to the forces of globalization.

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Introduction

*"The history of progressivism has been one of the markets being protected by its own excesses", s*aid Lawrence Summers in a recent interview with David Leondhart of the New York Times. The age of growth with equity has been replaced by the age of growth with rising inequity, with this inequity most pronounced in income and wage inequality.

The moral side of inequality in wage is a topic of intense ongoing debate. Whether growth and inequality are unavoidably interlinked, is a question with no straightforward answers. But on more solid footing is the fact that inequality is increasing in many countries. A variety of reasons are looked into as causes of inequality. With the onset of the information technology revolution one of the most prominent causes of the increase in inequality has been pitted as the demand for skilled labor. This demand for skill is often attributed to a skill biased technological change whose offshoots are phenomenon such as offshore outsourcing.

Developing nation's especially Asian nations and to a lesser extent, Latin American countries have experienced the full force of globalization, in the past few decades. And now, the two big giants India and China are experiencing it. I use data available on China, India, Japan, Korea, Singapore and the USA to understand the skill premium trends in model economies at different stages of development. I study the US in detail to conclude that rising skill premium is an important component of increasing inequality and that the skill premium is affected by demand and supply changes of labor. I model technological changes that create demand changes as well changes in supply of skilled and unskilled labor, to understand the dynamics of skill premium in the general equilibrium framework.

Taking cue from Goldin and Katz (2007), research on *the race between education and technology*, I seek to explore the role of *demand-supply* dynamics on the wage and income inequality. 'Demand and Supply' analysis has been found to be very effective in explaining long term inequality trends in the US. They show that as standard economic logic goes, in the long run (1895-2005), skill premium is balanced.

They say that "Improvements in technology have raised the gains for those with enough skills to handle complex jobs. The resulting inequalities are bid back down only as more people receive more education and move up the wage ladder" They add further, that, "if workers have flexible skills, and if the educational infrastructure expands sufficiently, then supply of skills will increase as demand increases for them".

Many factors may be responsible for tipping this balance, like immigration, trade liberalization and globalization. For my study, I consider an economy as an independent body, but undergoing exogenous changes. Considering, long term growth propelled by growth in human capital and technology, I evaluate the dynamics of skill premium, as the supply and demand for skilled and unskilled labor changes are affected by these changes.

A comprehensive study done in the US has shown that supply of skilled labor, is highly correlated with the skill premium or returns to skill. A recent article by Gary Becker and Kevin Murphy, '*the upside of income inequality'*, shows the following startling yet comforting result.

Source: Becker and Murphy, (2007). The Upside of Income Inequality. The American magazine.

The Graph above shows that the rising premium to education is reflected in a higher demand for higher education. Even when the wage premium fell in the 1970's, the number of college graduates also fell. This confirms the observation (at least in the USA) that wage premium is a determinant of the supply of skilled labor

Thus keeping the following facts about income dynamics in mind,

1. Supply and Demand of human capital is the most important determinant of income inequality
2. Demand for skilled labor is altered by forces of globalization in recent decades, what in my model, will be accommodated as a skill biased technological change.
3. Supply of skilled labor, is determined by the opportunity cost of acquiring education, which is related to the wage premium. Skill premium is taken as the ratio between the skilled and the unskilled wage.

I proceed with my analysis of the dynamics of skill premium, starting with the definition and causes of income inequality and skill premium in Chapter 1

Chapter 1

I. *Inequality and Skill Premium: Definition and Causes*

a. Measuring Inequality

The most relevant and proper measure for capturing inequality is usually consumption of individual[1]. But due to unavailability of household expenditure data, income based inequality measures are still the main source of measuring inequality. The most commonly used measure is the Gini Coefficient based on the second moments of the observed income distribution.

b. *Theories of Income Inequality*

Some of the general theories of income inequality are outlined below. The more specific reasons for rising skill premium are outlined in part c, after distinguishing between income inequality and skill premium.

1. Immigration/Emigration/Remittances

Effects of immigration in the United States and the emigration effects in developing countries have been found to have a very small impact on income inequality as compared to the other reasons outlined below. The percentage of foreign born migrants was 13% in the US in 2005. These are distinctly part of either the very low skilled or the very high skilled sections of the labor force. For high school dropouts, the impact of immigrants contributes to 9% in the fall in their wages. However the impact on the wages of most of the middle level workers is negligible. The impact was less than 1% on workers with less than 4 years of college education in the United States. There is also a complementary effect that immigrants are found to have if growth in capital is allowed to keep up with the inflow of immigrants. Then the overall impact is positive.

However we must note that with a globalizing world, in the next several decades' immigration may come to play a bigger role. But for our current analysis the impact of immigration is avoided

2. *Gains of the Super Rich*

There is a lot of concern on the growth in wealth of the top 1% earners. Studies done in the US have shown that since 1979, the share of pretax income going to the top 1 percent of American households has risen by 7 percentage points, to 16 percent. Over the same span, the share of income going to the bottom 80 percent has fallen by 7 percentage points. As Lawrence Summers puts it, "it's as if every household in that bottom 80 percent is writing a check for $7,000 every year and sending it to the top 1 percent"

[1] See Angus Deaton (1997)

3. *Superstar Theory*

Sherwin Rosen (1981) showed that a smaller group of people with higher talent tend to capture a larger share of the market and hence, even though they charge a smaller premium over the less talented, the volume of sales translates to larger revenues and disparities in income. This is not exactly measurable, as such qualitative reasons can be hard to quantify.

4. *Trade Liberalization*

The link between trade and income distribution is quite controversial with no single trend seen across countries. Globalizations primary form in many countries like India, Latin America and East Asia has been trade liberalization and it has produced different results in different countries. More and more stylized models incorporating trade in intermediate goods, factor immobility, firm heterogeneity, offshore outsourcing have helped improve our understanding of causes of income inequality today. But the argument remains that trends will always remain country specific, due to the difference in endowments, institutional set up and policies among them. Thus general studies on trade liberalization often fail to apply across countries. These days more country specific studies are reported.

With regard to country specific analysis, general equilibrium models are often used to study the overall effect of trade liberalization on inequality in a country. The general way in which trade liberalization affects inequality is via a change is price level which then affects the households' income and consumption dynamics.

The negative side to such an analysis is that it focuses narrowly on trade impact on inequality. Other policies and changes will affect the parameter estimates, which are not reflected in the analysis.

Studies on the impact of trade policy on inequality are numerous in the literature and continue to be an exciting area of research.

c. Income Inequality and Skill Premium

Income inequality is manifested in terms of the wage inequality, although both are not the same. The rising difference in wage inequality is attributed to the rising premium that is being placed on skill. The increase in the returns to skill over time is known as skill premium.

Rising returns to skill has been acknowledged across the board as an outcome of increased demand for skilled labor and demand and Supply dynamics in supply of skilled labor has been shown above to be the main cause of changes in the skill premium[1].

[1] Goldin and Katz (2007), at least for the USA; also substantiated by standard economic principles

Evidence for increase in the supply of labor can be credited with a high initial stock of high skilled labor due to policies introduced by the Government. In addition, the rising returns to skill can spur people to want to acquire higher education. The inbuilt invisible hand balances out the demand for skilled labor by increasing the supply of labor. As shown earlier in the *introduction*, for the US[1], over the long term rising demand for skilled labor is closely followed by an increase in the supply of skilled labor.

The reasons for rising demand for skilled labor vary, and the major ones are:

1. *International Trade theories*

Trade models like the Specific Factors model, the Heckscher –Ohlin model along with the Stopler Samuelson effects have not been very useful in explaining a widening of inequality in developing nations. Since the results are usually inconclusive, either because of endogenous determination of prices, lower mobility of labor, intra industry change in the demand for skill, this paper does not study the impact of trade. Extension of this model can seek to investigate such forces of globalization.

2. *Role of Intermediate goods and Outsourcing*

Papers by Robert Feenstra and Hanson (1996,1997,1999,2003) show that international trade models incorporating trade in intermediate good, a feature of offshore outsourcing, causes a rise in the demand for skill in both the developed (the importer of the intermediate good). In such models there is a shift within an industry towards demand for higher skill in both developing and developed nations.

Outsourcing has been shown in empirical research to be an important reason for the demand for skilled labor in transition economies as well as other emerging countries like Hong Kong, China, India etc.

3. *Increase in Capital Flows*

The level of liquidity in the world is at an all time high. Since capital flows are believed to be complementary with skilled labor, it is reasonable to expect increased FDI and other capital flows into developing countries to be associated with increase utilization of skilled labor. This aspect is not studied in my current analysis of a closed economy with exogenous shocks.

4. *Skill-Biased Technological Change*

A repeated finding in the literature in country studies has been that share of skilled labor as well as their wages has confirmed the prevalence of a skill bias in

[1] the only county with well documented long term evidence

new technologies. The issue confronting most studies in how to interpret the technology shock in real time data. Exogenous technology shocks that have escaped empirical studies are more easily modeled in general equilibrium studies, which I have done in my analysis.

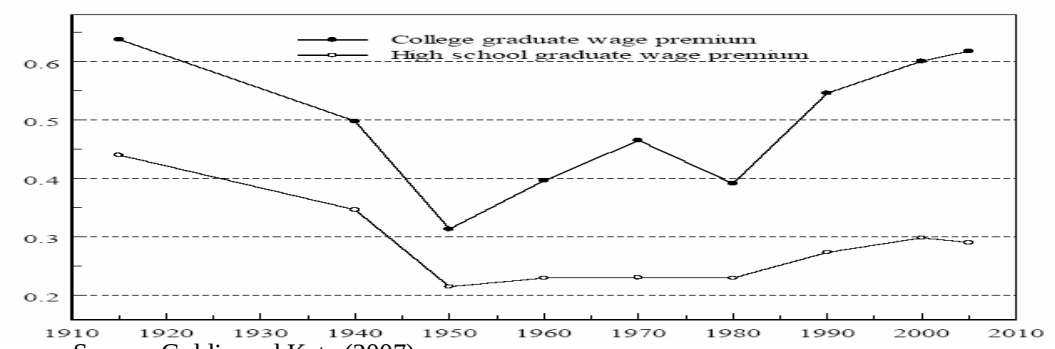
Trade effects and skill biased technological change effects on skill premium are now looked as having interactions with each other and having a combined impact on skill premium dynamics.

For my present analysis, I look at a closed economy with no trade effect, and only an exogenous skill biased technological change.

II. *Literature Review*

"The Race between Education and Technology", Chapter 8, in Goldin and Katz's forthcoming book (in 2008), "The intimate contest between Education and Technology", outlines the evolution of US wage differentials from 1890 to 2005. They trace out three time frames where returns to education showed distinct trends.

1. 1890-1915: They show that earnings in occupations that required higher level of schooling were far greater than those that required lesser education. The skill premium showed a rising trend and peaked at 1915.
2. 1915-1980: There was a fall in the returns to skill until the 1950's, a rise in the premium for two decades and a fall again in the 1970's. But overall a falling trend in that period.
3. 1980-2005: Of recent the trend has returned to higher returns to skill.



Source: Goldin and Katz (2007)

Three reasons were given by economist Paul Douglas,

1. The replacement of low skilled work with capital, therefore deskilling a lot of clerical level employees
2. Immigration, helping to raise the level of earnings of the low skilled earlier, and of recent, helping to reduce the level of earning of the low skilled
3. The supply of skilled labor, increased substantially from 1915 to the 1970's. After 1980, there has been a fall in the supply of skilled labor.

We know that the US has been the leader of the industrialized and the global world. We can assume that technological change was a constant feature throughout this period, with a pick up in pace in the late 1980's and 1990's with the information technology boom. Goldin and Katz, say the since technology could not be responsible for these large vicissitudes, another factor must have been responsible. This they show to be the supply of educated workers, who in this paper are treated as equivalent to skilled workers.

Supply and Demand effects on skilled Workers

1. Supply Effect: This is usually determined by the Supply of skilled workers in an economy. The reasons could be mainly twofold
   a Rising inequality in wages increases the demand for higher education and the hence the supply of skilled workers

   b. Immigration of high skilled workers into the country, usually if the country's supply of skilled labor is not keeping up with the demand
2. Demand Effect: A Skill Biased Technological Change is the one of the leading reasons in the skill premium literature responsible for an increased demand for skilled labor.

In their Analysis, Goldin and Katz do an empirical analysis, given all the data available. In my paper, I wish to simulate the trends observed in the demand supply analysis in a general equilibrium framework.

A paper on a dynamic general equilibrium model to study skill premium has also been done by Heckman *et al*. (1998). They develop a heterogeneous agent dynamic general equilibrium model of labor earnings, using micro data. Their model assumes heterogeneity in ability levels as well as skill level, where different levels of schooling correspond to different skills. They also use an overlapping generation's model and take different price paths facing entry cohorts to produce different earnings growth.

They generalize the *micro economic* model of earning, schooling and on the job training developed by Ben Porath (1967). New stock of human capital is created over time by income maximizing individuals. They improve on the Ben-Porath model by distinguishing between schooling capital and the job training capital as well as by having skills obtained at different schooling levels command different prices.

Their paper also looks into the on the job training effects on skill premium. The model includes human capital accumulation for which they use methods to estimate the stock of human capital. Although they do not use estimates of skill bias on skilled and unskilled labor, I use a labor productivity enhancing parameter that grows exogenously with time.

Their model is far more specific with details about the varying cohort size over time and the impact on them. They also seek to extend their open economy general equilibrium model to allow for investment in sector specific human capital. Comparison with their model is done after the study of the dynamics from my dynamic general equilibrium model.

The simple framework for educational cost being a determinant of the supply of high skilled labor, is used fairly regularly is literature, as it is a direct result of fundamentals of economic theory: 'When the price of a good increases, its supply curve moves outwards'. However the framework in its form used in the paper is borrowed from Ripoll (2005), in her study of impact of trade liberalization on skill premium dynamics.

They also refer to a skill biased technical change in the form of a trend growth in the level of relative wages. In my model however, this is signified in terms of an increase in the demand for skill growth as a trend. The wages are then determined endogenously within the system.

Chapter 2

I. *A Simple Dynamic General Equilibrium model*

Based on the General equilibrium model, used in Ripoll (2005), this paper modifies the specific factor model to an aggregate output model. In her paper, the impact of trade liberalization is found to have non monotonic impact on the skill premium based on the initial endowments of factors. This paper seeks to bring out the impact of supply demand changes on the skill premium.

The following simple General equilibrium framework is adopted. The economy is a competitive economy with the firms and households working together.

1. *Firms*

An economy has an aggregate output given as

$$Y = K^{\alpha} * A * [(\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{1/\rho}]^{1-\alpha}$$

Where:

1. ϕ = the share of skilled labor in the entire labor force and is modeled as a technology shift parameter.
2. A = the Neutral Total Factor Productivity Parameter
3. ρ = the CES parameter which expresses the interrelationship between S and L
4. $1/(1-\rho)$ = the elasticity of substitution between skilled and unskilled labor

The economy is assumed to be made up of a number of identical firms who maximize the following profit function

$$\pi = Y - C = K^{\alpha} * A * [(\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{1/\rho}]^{1-\alpha} - (r * K + wl * U + wh * S)$$

This gives us the following first order conditions:

$$r = \alpha K^{\alpha-1} * A * ((\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{1/\rho})^{1-\alpha} \quad (1)$$

$$ws = K^{\alpha} A * ((\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{(1-\alpha-\rho)/\rho} * (\phi * \rho * (S)^{(\rho-1)})) \quad (2)$$

$$wl = K^{\alpha} * A * ((\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{(1-\alpha-\rho)/\rho} * ((1-\phi) * \rho * (U)^{(\rho-1)})) \quad (3)$$

The relative returns to factor inputs depend on the demand shifter, ϕ and the skill biased technology parameter, the supply of skilled and unskilled labor and the elasticity of substitution between the two groups.

At full employment levels we have the shares of the skilled and unskilled labor equal to 1. The model does not include the growth rate of labor, as it will not make much of a difference to the results of the paper.

$$S/L + U/L = 1 \quad (4)$$

2. *Households*

As is prevalent in the skill premium literature, I consider an Overlapping Generation's model with individuals living over 2 periods and the total population is constant. When individuals are born, they notice the endogenously determined skill premium and decide whether they will acquire education or not. This cost is denoted by π_i >0. As in the paper by Ripoll, I assume the uniform probability distribution of π over [$\bar{\pi}, \underline{\pi}$] where $1 \geq \bar{\pi} > \underline{\pi} > 0$

Going by the empirical evidence shown above that enrolment in tertiary education closely follows the returns to higher education or skill premium, we take the optimum level of education acquired equal to the gap between the skilled and unskilled wage.

Thus, within the OLG framework, young people work and consume c^y when young, and save s which they consume c^o, during old age.

For an individual to become skilled, he has to maximize his net income when he is young:

$$X_{i,t} \equiv \max(w_{h,t} - \pi_i, w_{l,i})$$

This gives us:

$$\pi_t^* = w_{h,t} - w_{l,t} \tag{5}$$

where, $\bar{\pi} > \pi^* > \underline{\pi} > 0$.

Households also maximize utility, and assuming logarithmic utility we have,

$$\text{Max } U(c_t^y, c_{t+1}^o) = \ln(c_t^y) + \beta \ln(c_{t+1}^o)$$

Subject to,

$$c_t^y = X_t - s_t$$

$$c_{t+1}^o = (1 + r_t - \delta)s_t$$

Solving this, we get the following equations:

$$s_t = (\beta/(1+\beta))X_t$$

$$c_t^y = (1/(1+\beta))X_t$$

$$c_{t+1}^o = (1 + r_t - \delta)(\beta/(1+\beta))X_t$$

Since I have assumed uniform probability of the cost of acquiring education, we have:

$$S_t = \phi(\pi_t^*) = \frac{\pi_t^* - \underline{\pi}}{\bar{\pi} - \underline{\pi}} \tag{6}$$

$$U_t = 1 - \phi(\pi_t^*) = \frac{\bar{\pi} - \pi_t^*}{\bar{\pi} - \underline{\pi}}$$

3**.** *Dynamics*

In the second period, on average the individual saves $H_t w_{h,t} + L_t w_{l,t} - E_t$ where

$$E_t = \int_{\underline{\pi}}^{\pi_t^*} \pi_i d\phi(\pi) = \frac{\pi_t^{*2} - \underline{\pi}^2}{2(\overline{\pi} - \underline{\pi})}$$

Thus the capital stock next period is given by

$$K_{t+1} = (1 + r - \delta)s_t = (1 + r - \delta)(\beta/(1+\beta))(H_t w_{h,t} + L_t w_{l,t} - E_t) \quad (7)$$

These 7 equations solve to give steady state values for $w_{l,t}, w_{h,t}, r_t, \pi_t^*, K_t, A_t, S_t, U_t$.

Skill premium is obtained as $\frac{w_{h,t}}{w_{l,t}}$

Drawbacks of our current model:

1. *Capital Skill Complementarities are not included*

In Heckman (1998), this effect is not found to be significant. But there is a section of literature that emphasized the complementarity. Chang Y (2006) finds significant impact in Korea.

2. *Trade and international financial flows are not included*

These effects are widely studied in the literature, and can be seen as an extension to this model

3. *Immigration and Emigration effects are not considered.*

4. *The lag in supply of labor, within the OLG framework is not captured*

Frictions that arise, due to the lag in the supply of labor, is not captured in this model. We assume that skilled labor supply immediately moves up when the wage gap increases. Some minor dynamics is missed out.

5. *Increase in the supply of Labor can be exogenous*

This exogenous increase in the supply of labor is the reason for falling skill premium in a lot of the East Asian countries. This is not captured in the model

II. Ca*libration and Stylized Facts*

From the literature, mainly studies done by Katz and Goldin (2007) and Marla Ripoll (2005), Heckman, Lockner, Taber (1998), I use estimates for the United States as a benchmark. I then go on postulate differences in this parameter for other countries. I also use dynamics in these variables, to trace out the dynamics in skill premium movements over time.

For α, the share of capital in production is fixed at 0.3.

For elasticity of substitution $\sigma = \frac{1}{1-\rho}$, the values commonly used in literature and by Katz and Goldin are 1.4 and 1.66. Johnson estimates 1.5 for the more recent period 1970-1990. With time, elasticity of substitution is more often expected to go down. But if the workers are assumed to have more flexible skills, elasticity of substitution might go up.

The corresponding values of ρ, that give an estimate of the degree of substitution between skilled and unskilled is calculated accordingly as 0.3, 0.4, 0.467.

For values of the relative demand shifter $\phi/(1-\phi)$, for the time frame 1940 to 2005, ranges between 1.92 and 3.74. On average for the US between 1915 and 2005 is taken to be 2.83.

The values of ϕ therefore ranges from 0.60 to 0.77; these are values for the US. For the other countries I use values from 0.3 upward depending on the stage of development and empirical facts. I adjust for other countries according to empirical evidence. Over a century the demand for skilled labor in the United States has been 0.74, while that unskilled labor, 0.26.

The value of β is taken to be its standard value, 0.99 for quarterly data.

The value of δ is adjusted to get a reasonable value for the Capital to Output ratio (3 for yearly data, and around 10 for quarterly data), and is taken as 0.002.

The values of $\underline{\pi}$ and $\bar{\pi}$ is taken as 0 and 1.

Tax rates are not included in this model, as that would spawn a whole new literature by itself.

In Heckman et al. (1998), the elasticity of substitution between capital and labor, is found to be not statistically significantly different from 1. In my model too, the complementary behavior between share of skilled labor and share of capital is not studied. The share of capital is assumed to be constant throughout the period at 0.3. The constancy of share of capital in the United States is reported in Heckman's analysis.

III. *Steady State Results*

1. *The Steady State results of the model, for an Economy*

The values of the standard parameter are fixed at:

$\delta = 0.002 \quad \beta = 0.99 \quad \underline{\pi} = 0 \quad \bar{\pi} = 1$

Comparing the Gini Coefficients for the 6 countries, I try to use that as some measure of the skill premium[1].

a. *Parameter Specification*

Table 7.1

Country	ϕ	ρ	α	A
1	0.1	0.30	0.3	0.1
2	0.2	0.30	0.3	0.1
3	0.4	0.35	0.3	0.61
4	0.55	0.4	0.3	0.58
5	0.6	0.4	0.3	0.4
USA	0.7	0.4	0.3	1

Model economies at different stages of economic development are taken and their estimates of the various parameters relative to the United States are taken. In Appendix 6, six countries, India, China, Singapore, Japan, Korea and USA are seen to match the model economies. Productivity data are taken from Hall and Jones (1996).

b. *Steady State Results*

Table 7.2

Country	Skill Premium	Rate of Return on Capital	Unskilled Wage	Skilled Wage	The Supply of Unskilled Labor	The Supply of Skilled Labor	Capital to Output Ratio
1	1.78	0.05	0.14	0.26	0.88	0.11	2.02
2	2.43	0.054	0.12	0.34	0.74	0.21	2.43
3	1.72	0.045	0.88	1.53	0.35	0.64	10.01
4	2.02	0.044	0.71	1.45	0.26	0.73	8.97
5	2.76	0.048	0.39	1.08	0.30	0.69	7.102
United States	1.44	0.035	2.07	3.01	0.06	0.93	11.7

1:India, 2: China, 3:Singapore, 4: Japan, 5: Korea

[1]It is the closest value for skill premium available for all the 6 countries.

Table 7.3

Country	Skill Premium	Gini coefficient
India	1.78	1.37
China	2.43	1.47
Singapore	1.72	1.47
Japan	2.02	1.33
Korea	2.76	1.37
USA	1.44	1.47

1c. *Observations*

1. *Realistic Estimates of Parameters*

The estimates of interest rate of capital (0.03 to 0.04) and the capital output ratio correspond to values found in the empirical literature. Thus we can expect the values of the other variables to reflect realistic values.

2. *Skill Premium increases varies with demand and total factor productivity*

Countries with a higher demand experience a higher skill premium and countries with a higher total factor productivity experience a fall in skill premium. The two opposing effects with growth serve to balance out rising skill premium

3. *Optimal level of skill premium reflected*

The model reflects the level of skill premium that would have prevailed in these countries if the free hand of the market would have played out.

5. *Skill Premium differs from income inequality*

Inequality and skill premium do not show similar trends across the cross section. Economic policy makers can look at both these factors to estimate appropriate policies. A country with low income inequality but high skill premium may be more effective is making people go for higher education.

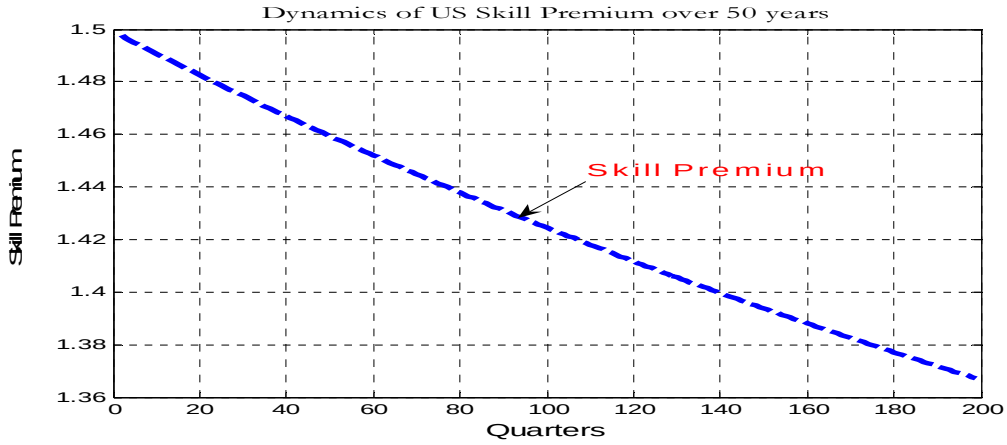
IV *Long Term Dynamics*

I study dynamics in three sections,

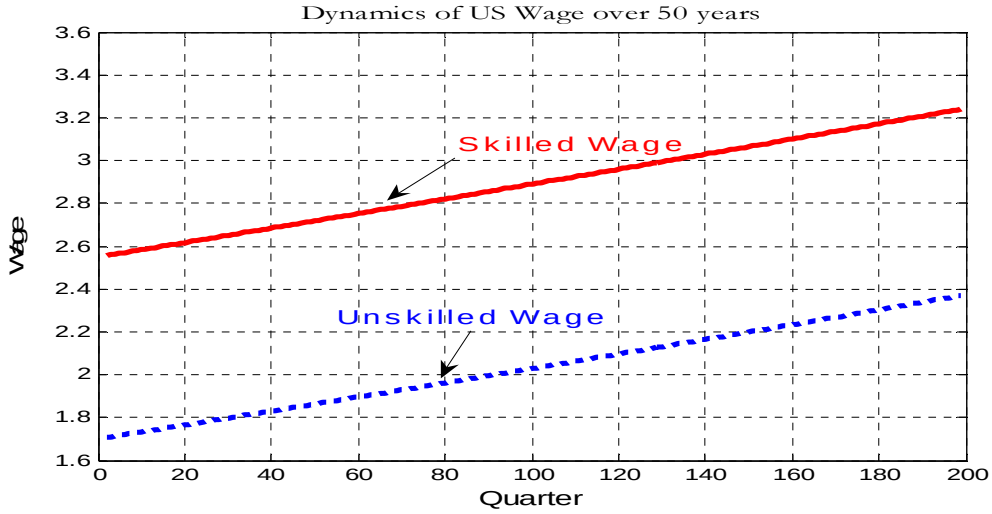
1. I trace out the dynamics over 50 years of the skill premium and other variables without exogenously manipulating the supply of skilled and unskilled, letting only the total factor productivity change over time.
2. I trace out the movement over the last 100 years to reflect the path observed in reality, with exogenous changes in the demand and elasticity parameters.
3. I forecast the path of variables over the next 25 and 50 years.

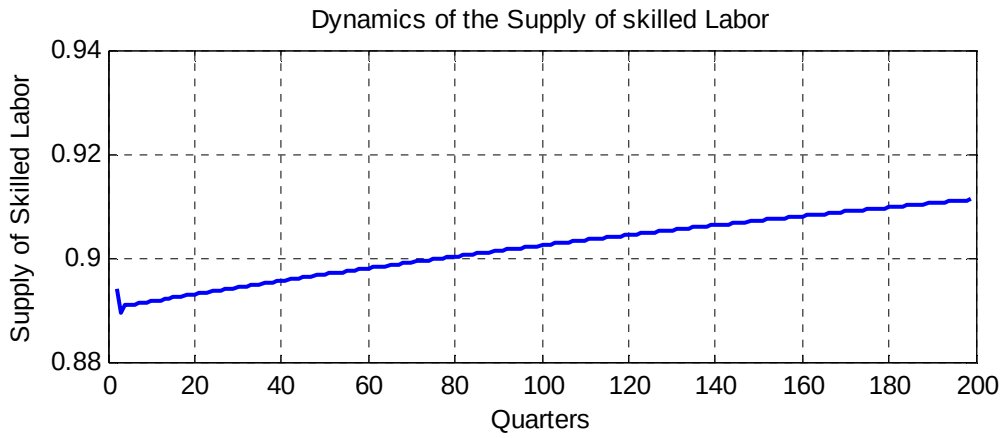
IV.1. *The Long Term path of variables as determined by the model*

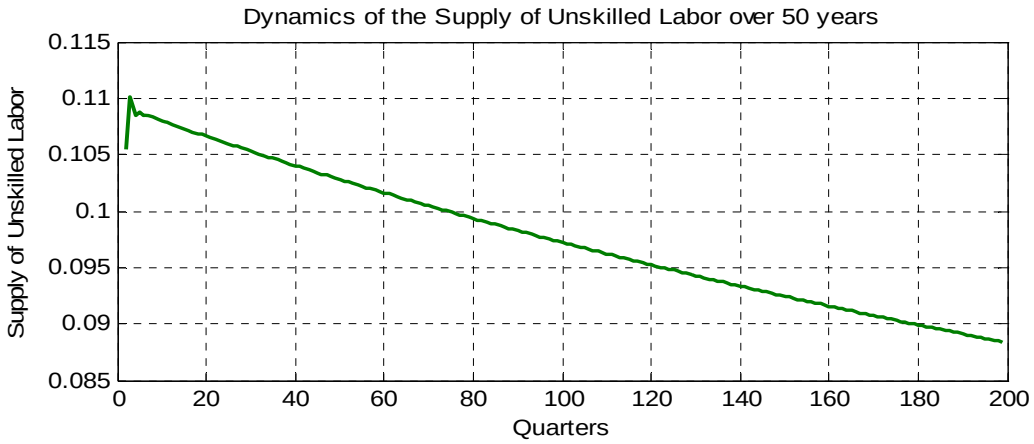
1. When only Total Factor Productivity changes over the period



With a neutral total factor productivity change over time the skilled wage rises at a slower rate than the unskilled wage, leading to a fall in the skill premium over time.



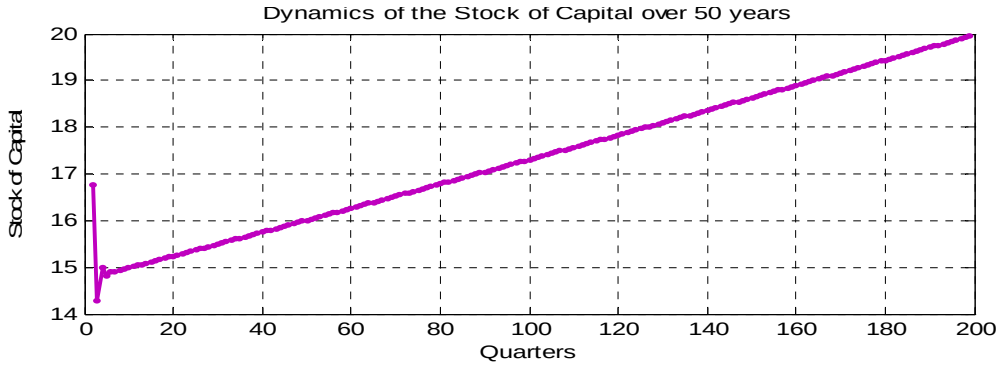




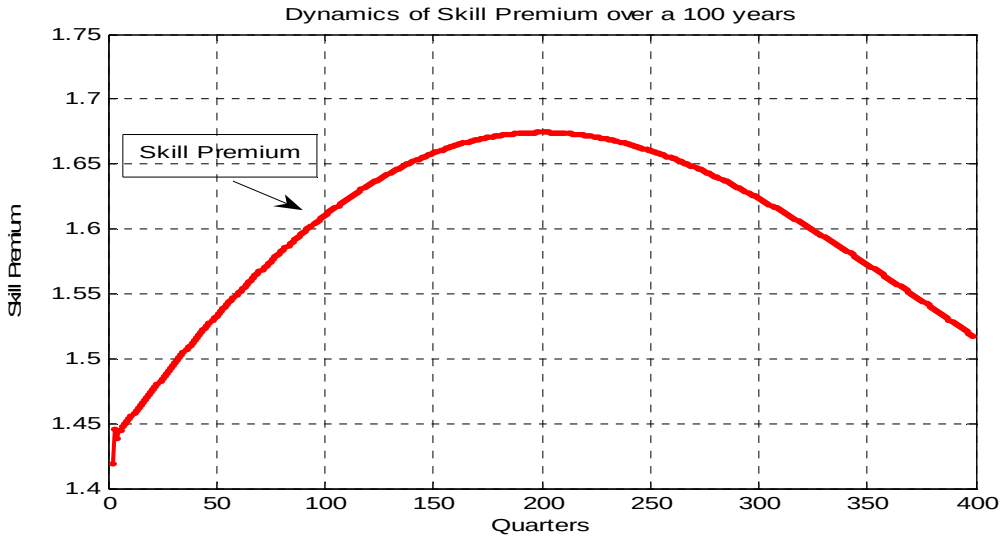
We see that the supply of skilled labor must increase over time, especially given our assumption of zero growth rate of labor. A positive growth rate of labor can be assumed to not change the dynamics in a significant manner.

Since the stock of labor is constant, the share of unskilled labor declines over time, while the share of skilled labor rises over time.

Stock of Capital shows a rising trend throughout the period. This is consistent with growing nations.

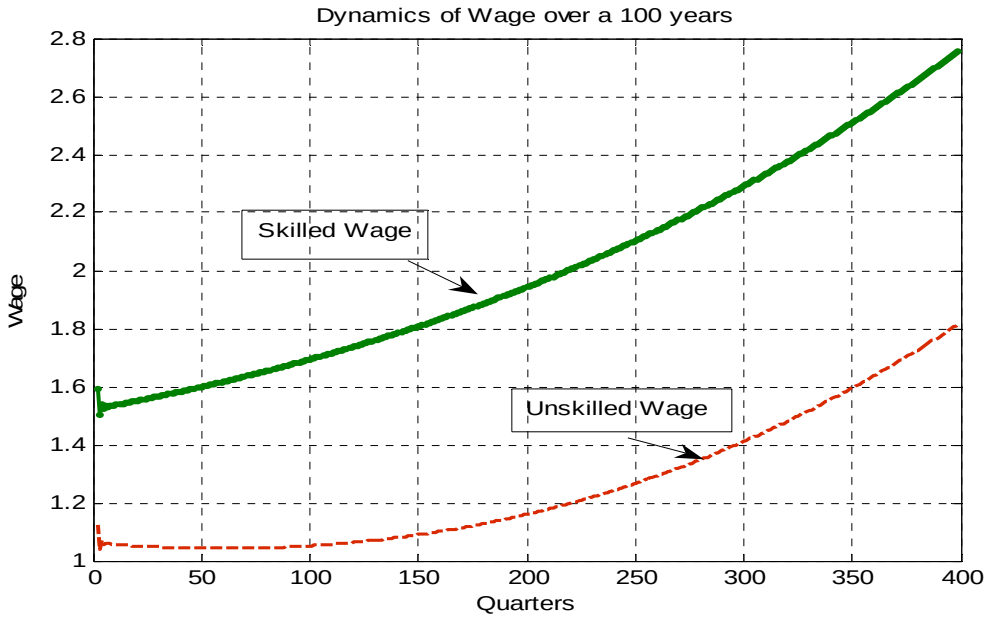


IV.2. *Dynamics of skill premium with a skill biased technological change throughout*

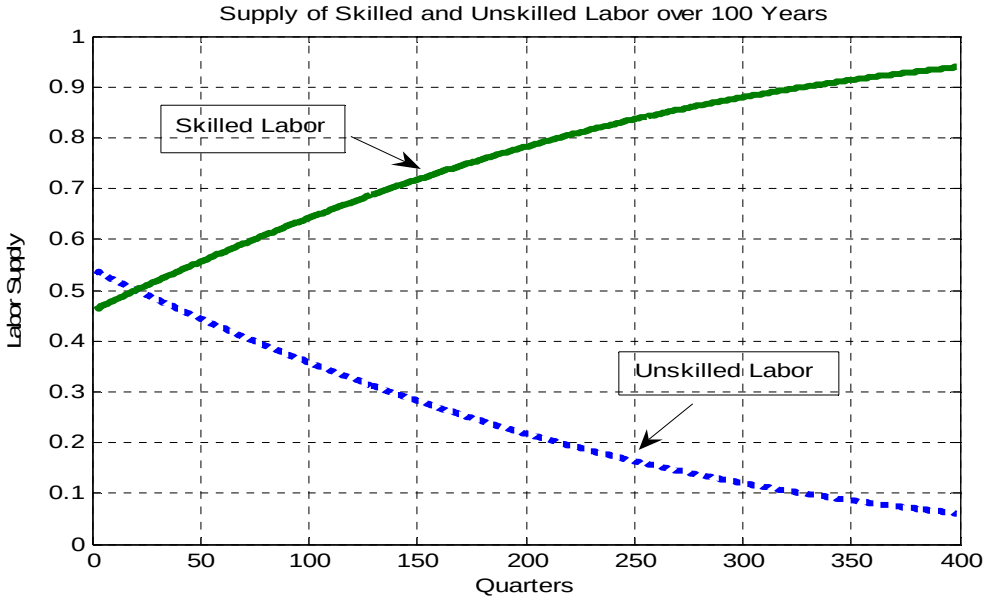


In the above figure, I slowly increase the demand for skilled labor over time. The value of ϕ is started at 0.3, and increased at an incremental 0.001 for 400 quarters. At the end, it is 0.7. We notice that non linearities in skill premium can be captured, as the skill biased technological change affects the demand for skill parameter. The Total factor productivity parameter is also increased at a constant rate over time.

The whole story can be told only after observing the trends in the other variables.



We see above that the initially the wage of the skilled worker rises faster than the unskilled worker, but after a point the unskilled workers wage rises faster than the skilled workers.



We see in the above figures that the share of skilled labor follows a concave curve. That is the curve increases at a decreasing pace over time. On the other hand, the share of unskilled labor follows a convex curve, falling but the rate of fall is at a slower pace.

Real Time Data

We know that in the USA, before1980's the skill premium rose initially and then fell. The Graph shows that given the other estimated parameters, the skill premium can rise only up to a point, after which, the supply of labor, will increase to compensate for the increase in the demand.

However after the 1980's the skill premium in the US picked up again. Hence once again the demand for high skilled workers was not kept up with the supply of skilled workers. There was an exogenous shock that manifested itself in a skilled demand increasing parameter - the information technology revolution.

The elasticity of substitution parameter also plays a part in the story. Although on one hand we would expect the Information technology revolution to make your previous skills less flexible, another feature is that with the realization that flexible skills are a must, people started going for more flexible skill acquisition over time. The burst of short term/part time/ night classes in the 1980's and 1990's are privy to the demand for more flexible skills. Since the elasticity of substitution parameter affects the demand of skilled

labor, for the demand to go up, and skilled labor to keep up with it, the elasticity of substitution must go up over time[1].

The falling and rising trends in skill premium between the 1950's and 1990's have baffled many economists. Models have generally failed to capture the non linear dynamics.

In this paper, I propose a demand supply method to incorporate the non linear dynamics observed during the 1920's to 1990's.

I make note of the following points.

1. Total Factor Productivity rose through out the period, thus the parameter is increased at a constant rate throughout

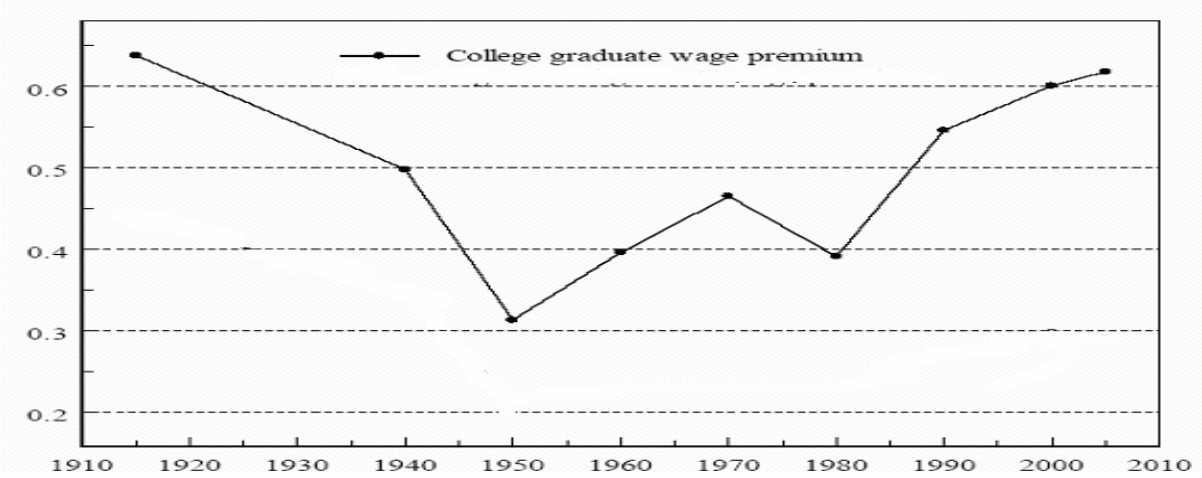
2. All other parameters are kept constant before the information technology revolution.

3. With the coming of the technology boom, demand for skilled labor increased.

4. The Elasticity of substitution is increased to keep up with the demand for skilled labor.

Accounting for these changes, I start with a demand for skilled labor at a constant rate of 40% through the 50's, 60's and 70's. During this time, skill premium is seen to experience a fall, as only productivity is increased.

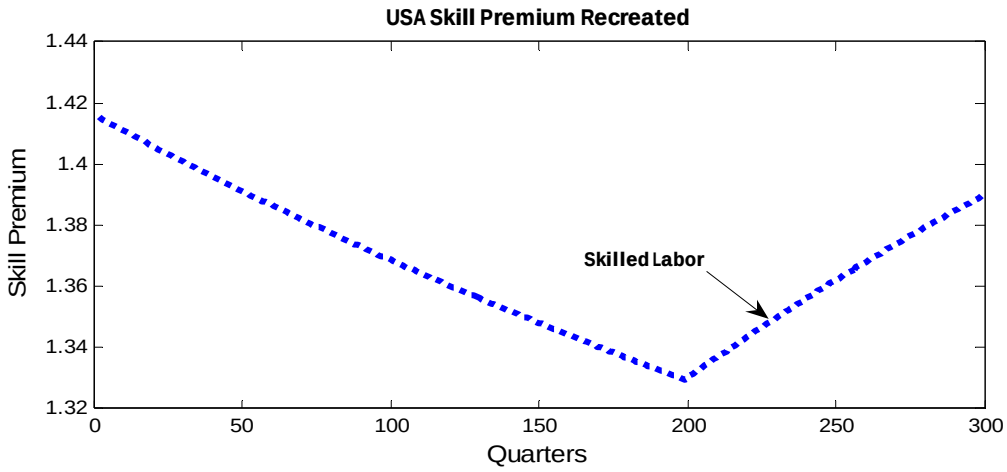
With the start of the technology boom, and the information technology revolution, a skill bias is demand increased the demand for skilled labor. Exogenously feeding in the changes in demand for skill and the elasticity of substitution, we are able to replicate the non linearity's in the skill premium.



Source: Goldin and Katz, (2007). The race between education and technology

[1] See footnote on Page 13. A variety of results with varying elasticities of substitution is show in Katz and Goldin (2007)

The fine curves cannot be captured my general model[1]. However, over all, if parameter shift are justifiably used, demand and supply shifts can explain the movement in skill premium in countries on a general basis.

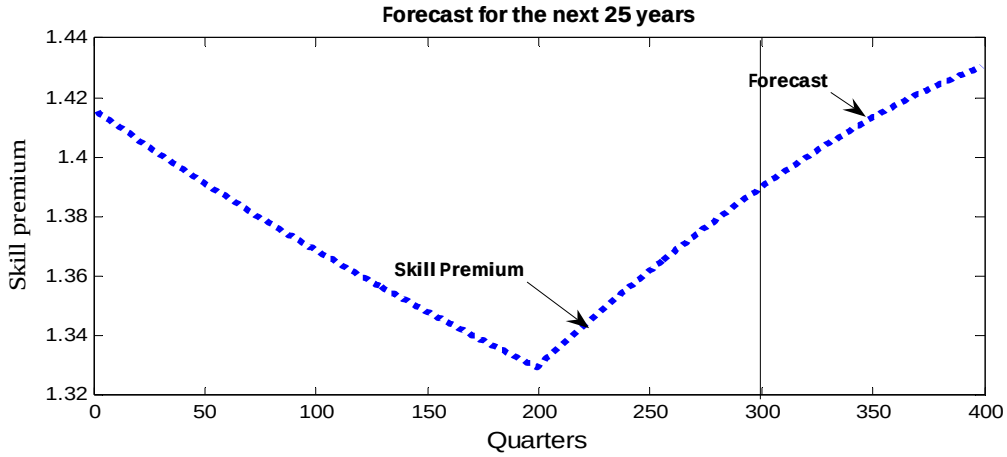


IV. 3. *Forecasts for the Next 25 years for the Skill Premium*

With Global Offshoring, especially in developed countries in the US, the skill premium can be expected to grow, unless overt measures are taken to improve the welfare of the unskilled.

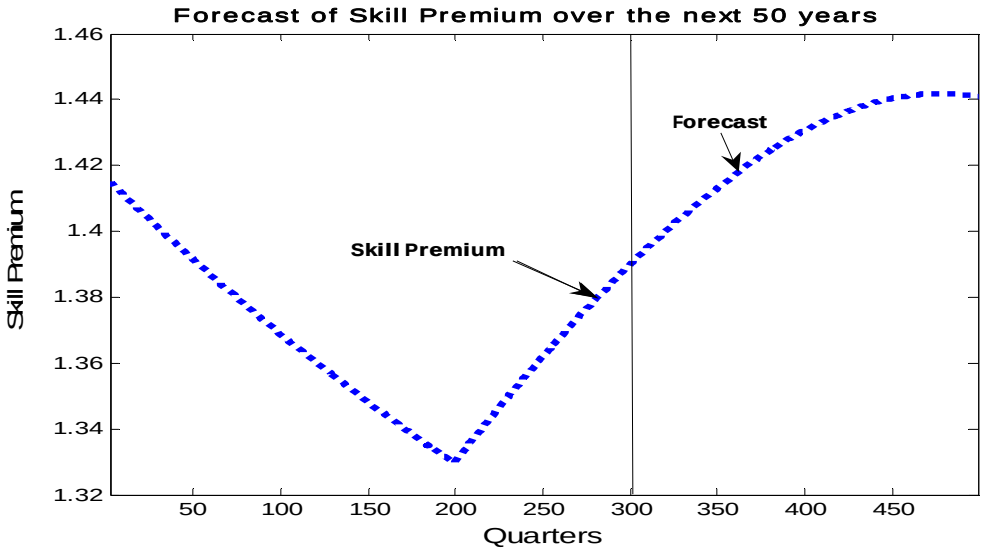
This model shows the market determined skill premium though rising, is good in a sense, since the rising gap will spur more people to go attain higher education.

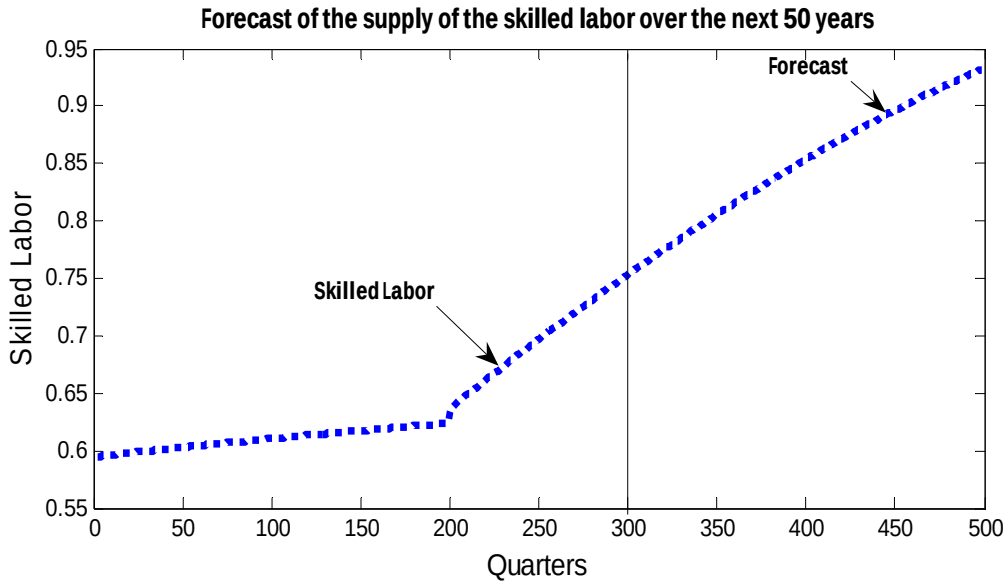
The dynamics of the skill premium and share of skilled labor are shown below for the next 25 years.



[1] The changes in early 1970's were due to changes in the total factor productivity after the oil price shocks.

IV.4. *Forecasts for the Next 50 years for the Skill Premium*





We see a comforting result.

If the supply - demand long term dynamics hold, then after some time, the supply of college graduates should rise fast enough to cause a dip in the skill premium .This is the upside of income inequality that Gary Becker and Kevin Murphy wrote about. A time will come in the future, when income inequality will fall *and* the share of educated labor will have risen considerably; all this just by the *force of the invisible hand.*

What then is to be done about those not benefiting from the above curves? This brings me to the Final section of this paper.

IV.5 *Results*

1. *Estimates the trend over a long term*.

My model can be used to predict non linearities over time which are absent in even Heckman's work. He estimates the trends for the last 30 years (late 1970's onwards), and the wage differential movement is largely uni-directional. My model can be used to explain the rise and fall of skill premium over a long enough periods.

2. *Exogenous technology shocks are captured*

The exogenous skill biased technological shocks are not captured precisely in empirical estimations; I use an exogenous trend movement in the skill bias technical change to study non linear dynamics

Yorukoglu (1997) claims that 1974 is the watershed for start of the modern technology revolution.

3. *Separate effects of specific parameter shifts*

Initially only an increase in total factor productivity is examines. This gives us an almost linearly falling trend in skill premium. However, when features of skill biased technical change and changes in elasticity of substitution are introduced, non linear dynamics are captured

4. *A confirmation of the invisible hand in skill premium dynamics*

We see that in the long run, the invisible hand force of the market, where each individual by working to maximize his own life time income within the given set of parameters, can be used to explain the broad trends seen in the markets. Accommodating for trade liberalizing policies, movements in skill premium in all countries developing and developed countries can be simulated over the long run, of course with some knowledge of future parameter shifts.

5. *Endogenous Skill Formation*

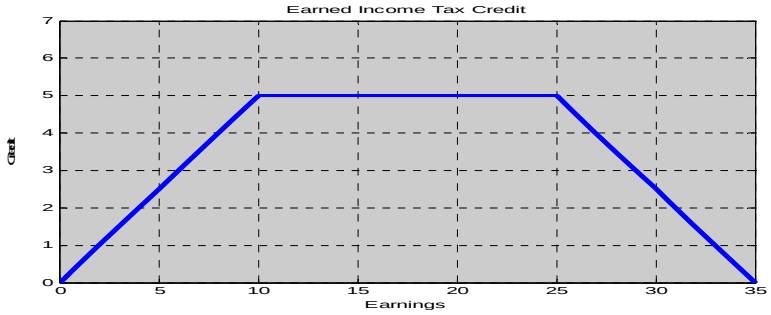
As opposed to Bound and Johnson (1992), Katz and Murphy (1992) and Krussel *et al.* (1996), there is endogenous determination of skill formation within the model. Heckman *et al.* (1998), however also makes use of this endogenous skill formation, across a variety of cohorts and cross sections. Heckman's empirical model is more precise in terms of suiting all the features of the US economy. Such preciseness can be used as an extension of the model, left to study later.

V. *Policy Experiment – Wage Subsidies to Low income workers*

Wage subsidies are used to create incentives for workers to invest in skills that will be useful in their workplace. These subsidies have been found to be more useful for those who would not otherwise work. For those who would work without a subsidy, the effect would depend on whether learning is rivalrous with working[1] or people acquire skill while working (learning by doing).

In the United States, programs like the Earned Income Tax Credit (EITC) create non-linearities in the return to work, due to the targeted nature of these programs.

The EITC supplements annual earnings for those who work. The standard graph for subsidy has the following form.



Above a certain wage level (35000, in this figure) the pre-subsidy wage and the effective wage levels are the same.

In such a case, what could the effect be on skill premium? What then are the implications for my model?

I refer to Heckman's work and specifically look at Heckman, Lochner and Cossa (2003) for their insightful analysis of '*learning by doing versus on the job training: using on variation induced by the EITC to distinguish between models of skill formation'*.

We start with the assumption that skills do not depreciate, and wages always rise. A second assumption is that investment in skill and earnings are rival goods. The opportunity cost of investing in skill the foregone earnings. Thus as the income is higher the opportunity cost of investing in skill formation is higher.

For a very low wage worker (earning less than $10000 in my diagram), the opportunity cost is of time investing in skills is raised, with the program, than without the program. This tends to reduce skill formation since, as during the payoff period, the person is more likely to be in the second segment (between $10000 and $25000). If the person is very poor, the marginal effect is at best zero, and hence there is no effect of inducing skill enhancement.

For the person in the second segment, the effect is ambiguous. If the person continues to be in the flat segment, there is no effect. If the person jumps to the third segment, the effect is to retard the skill enhancement process, as the subsidies are on a decline.

[1] Becker(1964) and Ben Porath (1967)

The third segment is the most interesting. As there is a declining subsidy, this causes investment into skill to have positive returns. Thus, even if the person leaves the segment all together, he is faced with a situation of no negative subsidies, and he is overall better off. In this case, skill acquisition is enhanced.

Thus, despite, wealth effects, labor leisure trade offs, this simple model creates an ambiguous effect on the person's desire to acquire cost. Thus the probability of a person willing to bear the cost of education is not simply a matter of moving to a high skilled region. If the wage subsidy was the same to all low income workers, then it would have an equal impact on all low income workers.

V.1*Dynamics of Skill Premium under Lump Sum Wage Subsidy*

With a lump sum wage subsidy, in my model, the supply of low and high skill worker would be changed. This is because the cost of education is lowered by the level of the wage subsidy. This would change the dynamics of the skill premium.

The new equation to maximize lifetime income would look like:

$$X_{i,t} \equiv \max(w_{h,t} - \pi_i, w_{l,i} + S)$$

where S is the wage subsidy.

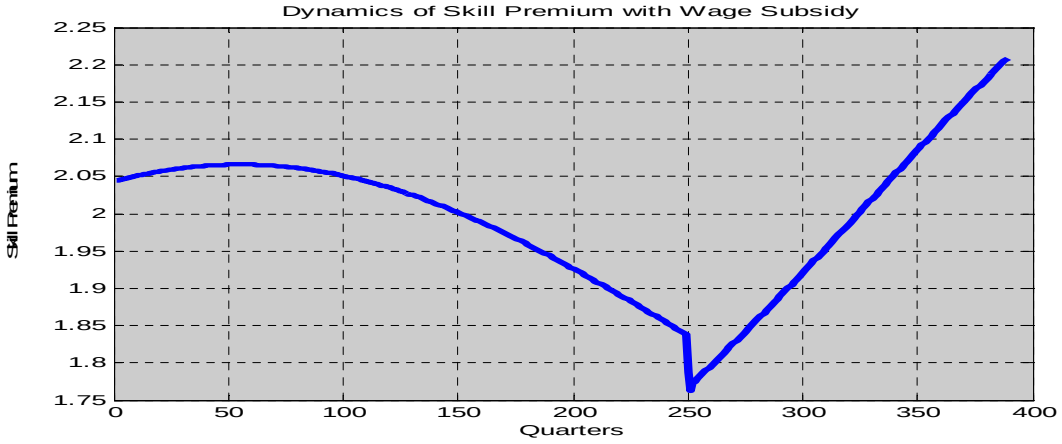
Hence the cut off point would be determined as

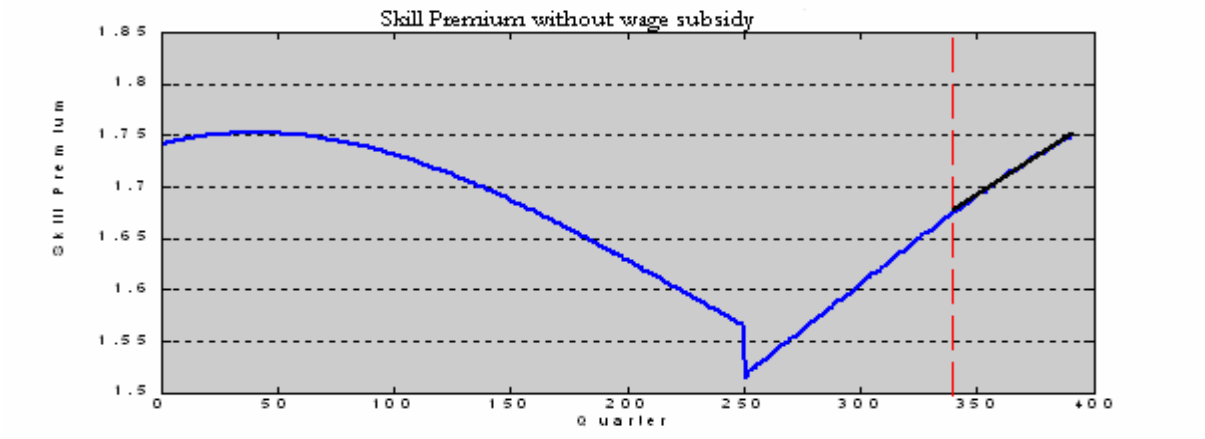
$$\pi_t^* = w_{h,t} - w_{l,t} - S$$

where $\bar{\pi} > \pi^* > \underline{\pi} > 0$

The graph for the dynamics of skill premium before and after wage subsidy is shown below:

A subsidy of 0.4 is set. The Unskilled wage is at 1.24. That is a wage subsidy of about 30% of unskilled wage level would produce the following shifts.





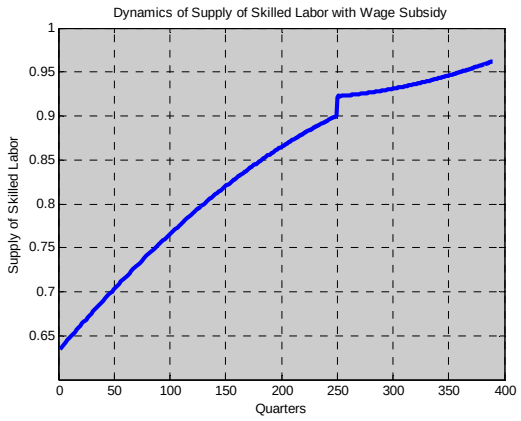
We see a distinct rise in skill premium due to wage subsidy. Thus a simple wage subsidy is infact widening the wage inequality levels.

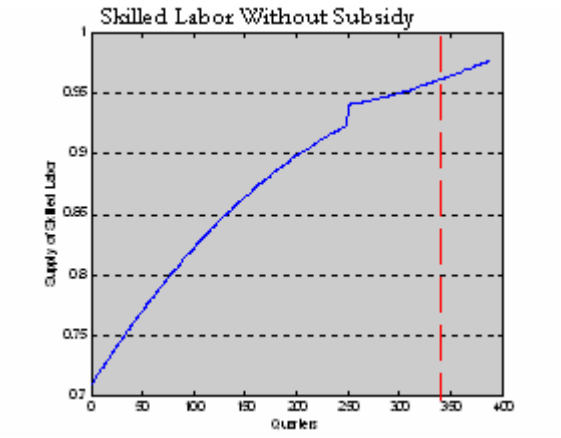
This result is obtained because, an increase in wage subsidy, provides a comfort level to the low wage workers, that prefer to remain low skilled despite a higher skill premium.

This reduces the supply of skilled workers over time and increases the supply of unskilled workers in the dynamics system.

This is the flip side lump sum wage subsidies. They keep the growth of the economy down, by reducing the desire of workers to become skilled. This has the same impact as workers in segment A and B in the diagram above. The opportunity cost of becoming skilled is higher, since the payoffs have decreased. Though the workers are temporarily better off, it is not in the long term interest of them and the economy.

A graph of the supply dynamics of skilled labor is shown below. As expected the supply of skilled laborers under the wage subsidy scheme (the figure on the right) is below the level of skilled worker in the pre subsidy time.





The effect of wealth usually serves to decline the supply of skilled labor, and considering wealth effects would further increase wage inequality and hamper the growth with equity objective. But that would also include measuring the income and substitution effects on

workers. Either way, on average, a wage subsidy effect on supply of skilled workers is negative and at best, neutral.

This model excludes the people who were not working and get induced to work due to programs like the EITC. These are the people that are most affected by programs like the EITC. A wage subsidy will "increase their hours of work and will increase their incentives to invest in work related skills"[1].

V.2 *Skills Acquired through Experience*

The 'Learning by doing' model treats investment in skill acquisition and work as Non-Rival goods. This changes the impact of a wage subsidy drastically on the supply of skilled labor and skill premium.

In this model

1. The more the supply of workers, the more the acquisition of skill taking place.
2. The more number of hours worked, the more the skill acquisition taking place.

So the effect of EITC to induce more workers to work and making workers work more hours, has a good effect on the desire for people to acquire skill. Thus the impact of workers in the three segments shown above is very different.

1. For workers in the first segment, the wage subsidy is increasing with every hour worked; hence workers tend to work more hours.
2. In the second segment the impact is neutral. And assuming leisure is valuable, these people would choose not to increase the number of hours worked, or may even decrease it.
3. In this case, clearly workers prefer to reduce the number of hours worked as the wage subsidy rises with each hour worked less.

Hence the results are in contrast to those observed in the job training case. However in both cases a wage subsidy would encourage workers who were unemployed to work and acquire skills and raises the average skill level.

V.3 *Compromise*

In the real world, the nature of skill acquisition is of both the above two types. But they can be generalized into different categories. Learning by doing is more useful to move up within a group level. That is if you are high skilled and would like to earn more, skill acquisition comes with experience. In a continuous time model with a skill levels ranging between 0 and 1, learning by doing effects are more pronounced.

In models where averages in the form of two levels are studied, such as skilled wage and unskilled wage, learning by doing effects plays a lesser role. We assume College graduates form a cut off point on average for the difference in the skill level of the

[1] Heckman et al (2003)

worker. The assumption that work and learning are rival goods is a more realistic assumption.

Thus from now on I use the Becker-Ben Porath on-the-job-training (OJT) model to study the effect on skill premium

V.4 *A Dynamic General Equilibrium OJT Model*

We first look at the period specific proportional subsidy, although the EITC is not exactly one. The standard Becker-Ben Porath model treats skill formation costs as earnings foregone. This was the assumption on which my model in based.

Assume a wage subsidy in the first period diverts people away from investment towards market work, but the next period subsidy encourages first period investment.

In the standard Ben-Porath model, human capital is produced by time investment, *I*. I will try to use the concept in my model.

Consider the following changed structure of the model.

1. *Firms*

The economy is assumed to be made up of a number of identical firms who maximize the following profit function

$$\pi = Y - C = K^{\alpha} A * [(\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{1/\rho}]^{1-\alpha} - r * K + wl * U + wh * S$$

This gives us the following first order conditions:

$$r = \alpha K^{\alpha-1} A * ((\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{1/\rho})^{1-\alpha} \quad (1)$$

$$ws = K^{\alpha} A * ((\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{(1-\alpha-\rho)/\rho} * (\rho * \phi * (S)^{(\rho-1)})) \quad (2)$$

$$wl = K^{\alpha} A * ((\phi(S)^{\rho} + (1-\phi)(U)^{\rho})^{(1-\alpha-\rho)/\rho} * ((1-\phi) * \rho * U^{(\rho-1)})) \quad (3)$$

The same full employment assumption holds,

$$S/L + U/L = 1 \quad (4)$$

2. *Households*

I once again consider an Overlapping Generation's model with individuals living over 2 periods and the total population is constant. When individuals are born, they notice the endogenously determined skill premium and decide whether they will acquire education or not. This cost is denoted by π_i >0. I assume again the uniform probability distribution of π over $[\bar{\pi}, \underline{\pi}]$ where $1 \geq \bar{\pi} > \underline{\pi} > 0$

I consider only the case a very low income worker, who initially faces an upward sloping wage subsidy scheme proportional to his wage as in segment 1 shown earlier. The low

income worker also decides to invest a proportion of his time in the first period to invest in acquiring skills. We assume that earning and skill acquisition are rivalrous.

If the person were to remain unskilled his earning would have been,
$w_{l,t} + s * w_{l,t} = (1+s)w_{l,t}$

Whereas if the person were to become skilled his earning would have been, $w_{h,t} - \pi$,
where π is the opportunity cost of getting skilled

For an individual to become skilled, he has to maximize his net income when he is young: $X_{i,t} \equiv \max(w_{h,t} - \pi_i, w_{l,i} + S)$

where S is the wage subsidy.

Hence the cut off point would be determined as
$\pi_t^* = w_{h,t} - w_{l,t} - S$

But we know that the cost is the opportunity cost of giving up earning in the unskilled period. Thus we have, $\pi_t^* = w_{l,t} * t$. This gives us the endogenously determined time that the low skilled worker spends to get skilled.

The Rest of the equations are the same
$s_t = (\beta/(1+\beta))X_t$
$c_t^y = (1/(1+\beta))X_t$
$c_{t+1}^o = (1+r_t-\delta)(\beta/(1+\beta))X_t$
The supply of skilled and unskilled labor is the same as before,

$$S_t = \phi(\pi_t^*) = \frac{\pi_t^* - \underline{\pi}}{\bar{\pi} - \underline{\pi}} \qquad (6)$$

$$U_t = 1 - \phi(\pi_t^*) = \frac{\bar{\pi} - \pi_t^*}{\bar{\pi} - \underline{\pi}}$$

3. *Dynamics*

The capital stock next period is given by
$K_{t+1} = (1+r-\delta)s_t = (1+r-\delta)(\beta/(1+\beta))(H_t w_{h,t} + L_t w_{l,t} - E_t)$ (7)

These 7 equations solve to give steady state values for $w_{l,t}, w_{h,t}, r_t, \pi_t^*, K_t, A_t, S_t, U_t$.

Skill premium is obtained as $\frac{w_{h,t}}{w_{l,t}}$

V.5 *Model accommodating the EITC scheme.*

The EITC scheme was introduced in the USA in 1975, and is a wage subsidy to low income workers in the form of a refundable tax credit. It has grown in popularity with every tax policy change and currently enjoys bipartisan support in the US. This section seeks to analyze why this is so and what are the effect of EITC on income inequality over time?

The EITC can be defined by the following function

$$S(w_{l,t}) = \begin{cases} |\, S_a w_{l,t} & w_{l,t} < a, \quad "phase-in" \\ |\, S_b & a \le w_{l,t} \le b, \quad "plateau" \\ |\, S_b - S_c(w_{l,t} - b) & b \le w_{l,t} \le c, \quad "phase-out" \\ |\, 0 & w_{l,t} \ge c \end{cases}$$

Where $S_a = S_b / a$ and $S_c = S_b/(c-b)$

According to Wikipedia, "Other countries with EITCs include Great Britain (see: working tax credit), Canada, Ireland, New Zealand, Finland, Belgium, France, the Netherlands and Denmark. In some cases, these are small (the maximum EITC in Finland is 290 Euros), but others are even larger than the US EITC (the UK EITC is worth up to 6150 Euros)"

We note that the EITC structure produces some non differential points and dynamics may be affected by these points. This paper deals only with the incentive to acquire higher education and the impact of income and other taxes are assumed not to change the non convex budget set facing the low income workers. We work with low skilled and low income workers as knowing their budget set.

The EITC is given according to family size and income, but since I consider a homogenous group of low income workers moving up the average over time, such differences do not enter my analysis.

V.6 *Dynamics of the OJT-EITC GE Model*

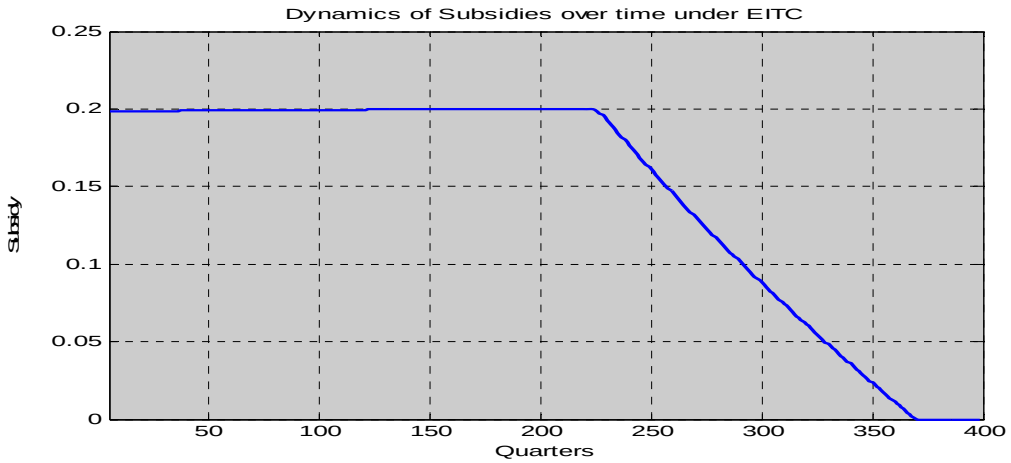
I first derive the wage schedule of the low income workers over time. I then break up the schedule into three different regions, with appropriate cut off points a, b and c.

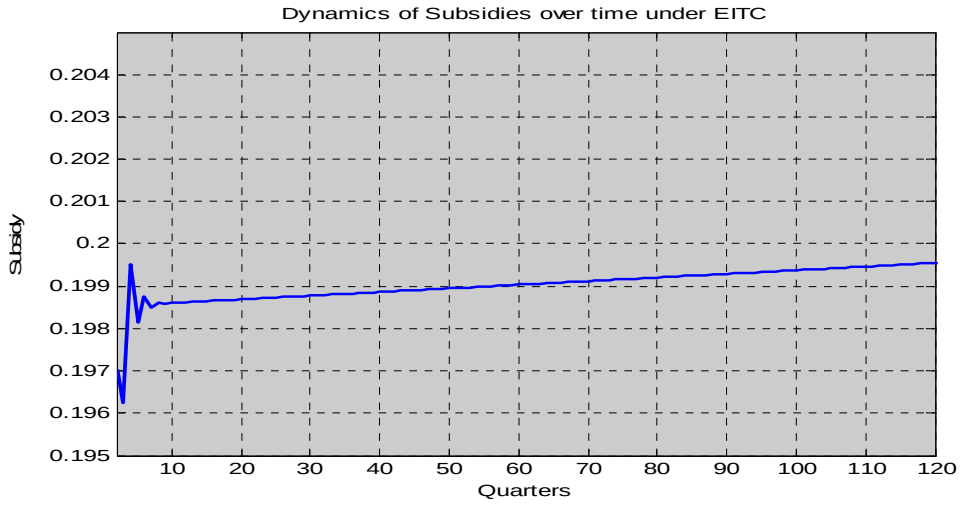
Hence in the beginning when the average wage level was less that 'a', the low skilled workers are given a rising wage subsidy. When they move over to the region between 'a' and 'b', they are given a fixed credit. When they then move to the region 'b' and 'c', the subsidy is falls as shown above. Finally when the workers reach the region above 'c', the subsidy or credit is removed.

From empirical literature, the value of credit given in the plateau is about 10-20% of the wage level in that region. I set $S_b = 0.2$ and set the other values accordingly.

Doing the required modifications in the model, we get the following results for skill premium, supply of skilled labor and the time spent in investing in education[1]

The values of a, b and c are set at intervals apart within the low wage income group. The movement of subsidy of the low skilled workers over time is recreated as shown below





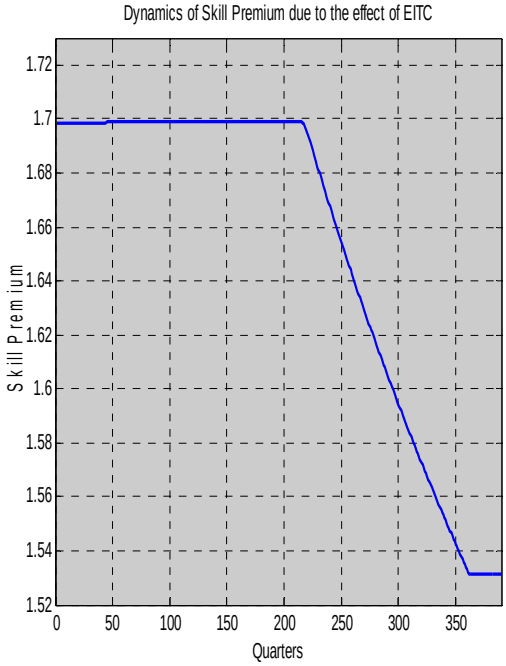
We see that initially workers receive subsidies as under segment A with the credit increasing with time. The first 120 quarters are recreated.

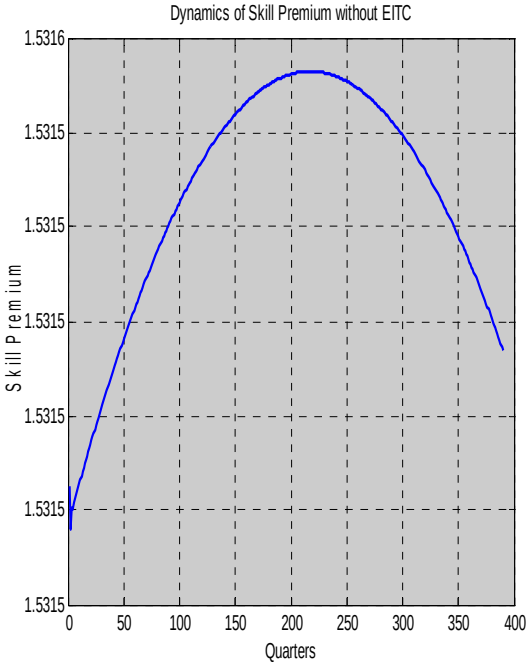
[1] Only technology is changed in this section. Recreating observed results will be done in the next section

After that, there is a flat period, with subsidy equal to 0.2 (or about 20% of the wage level) and finally a period, when as income increases, the subsidy is removed. After a certain income level, the people don't receive any subsidy.

My analysis treats people as a homogenous group growing together with time.

Their skill premium shows the following dynamics over the last 100 years.

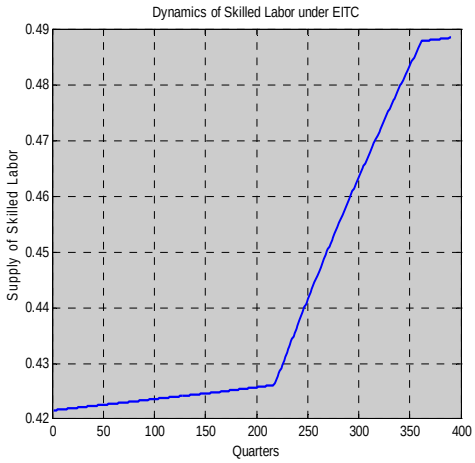


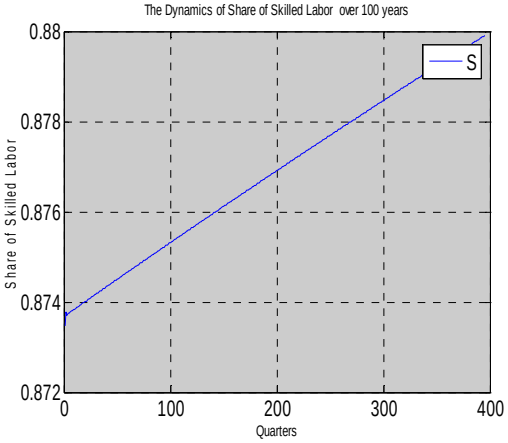


We see a fascinating result where the subsidy actually cause skill premium to rise considerably. It remains stable when EITC credit is in the second segment and then decreases as the subsidy is removed.

Without subsidy, even though the graph looks like there is a large rise in skill premium, if it is drawn to scale we see that it is very small compared to the increase in the case of wage subsidies.

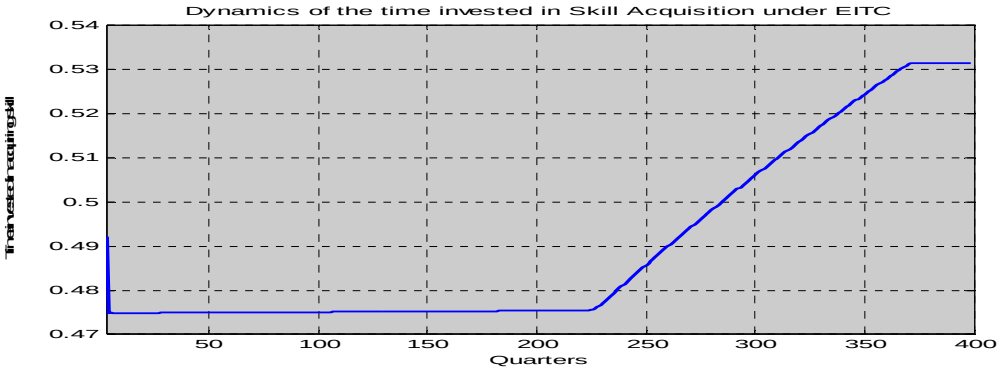
Let us now check the effect on the supply of skilled and unskilled labor:





We see that the supply of skilled labor is far less compare to the unskilled labor. And that it rises sharply as the subsidy level is decreased. The pattern in unskilled labor supply should be the opposite, as we still consider constant labor supply.

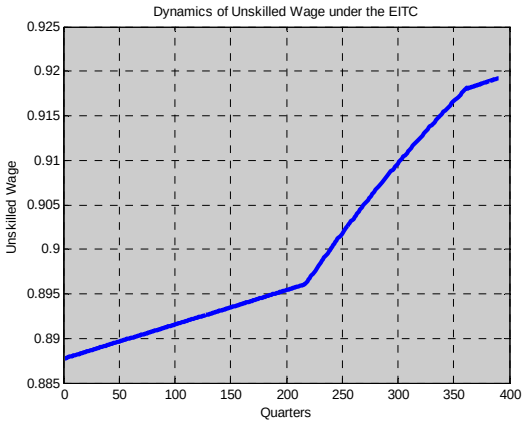
Finally let us see the time that the workers put into investing in education.

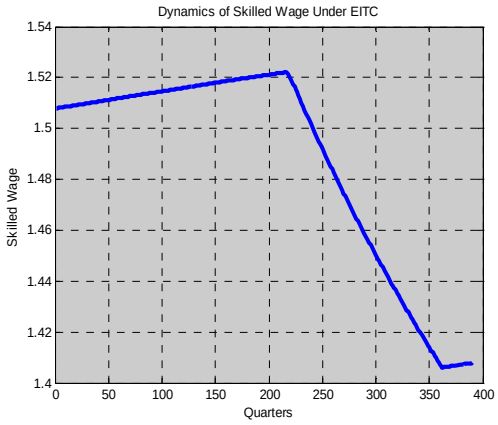


Contrary to our intuition that the time spent is acquiring skill, we see that supply of skilled labor, continues to increase, however at a very slow pace. Under a wage subsidy, people don't consider is very useful to acquire skill. Their lack of interest is offset by the increasing skill premium that induces their demand for skill.

On the other hand, when the subsidy level is going down, the skill premium shows a downward trend. However the marginal benefit of the subsidy offsets the effect of decreasing skill premium and there is an overall increase in supply is the skilled labor. This confirms the intuition we had at the beginning, that falling subsidies tend to increase incentives for people to acquire education. In addition they also serve to decrease the skill premium!

The dynamic paths of the Unskilled and Skilled wage are shown next. I then discuss empirical finding to reconcile my model's simulations to reality.





V.7 *Empirical findings of the impact of EITC*

There are three effects of EITC in theory

1. Income effect: With an increase in total lifetime wealth, it encourages consumption of leisure and discourages work. This tends to reduce the investment in skills
2. Substitution effect: This works opposite to the income effect and encourages substitution of leisure with hours worked.
3. Direct effect: In an income maximizing model, where the subsidy raises the positive marginal cost of investment in education by raising the opportunity cost of time. But this found to raise the future net wage rates and hence increases skill investment.

The findings in reality are,

1. When individuals earn less than a: The substitution effect dominates the income effect and the individual experience a larger wage growth.
2. When individual earn between a and b: the income effect dominates and individuals are discouraged from going for investment in human capital
3. For the region between b and c: For an inelastic labor supply, the lower marginal cost of investment dominates to have a positive effect of EITC of supply of skilled labor

V.8 *Simulation of the OJT-GE model with EITC*

In my model I use a representative agent's model. There is a representative agent for the unskilled workers and a representative agent for the skilled worker.

I assume that the working life of the both agents is 30 years (120 quarters).

Given the overlapping generations model, at each point in time, an agent who has to decide between investing in human capital or remaining unskilled, checks his current

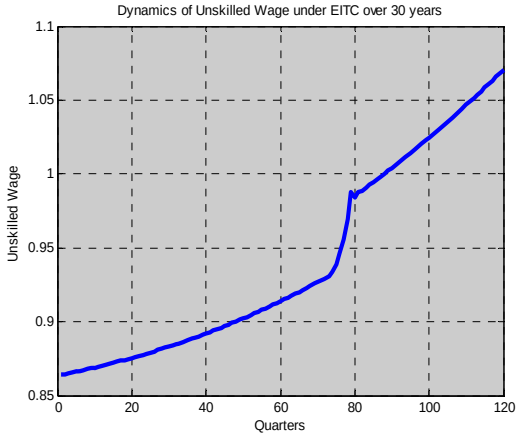
wage level (which is changing over time), and compares it with the cost of acquiring education and the high skilled wage.

I also introduce the rising demand for skilled workers (skill biased progress) over time and a falling elasticity of substitution between skilled and unskilled workers (a 0.0001 decrease per quarter). Technological progress is assumed to continue at the previous rate of 0.0001.

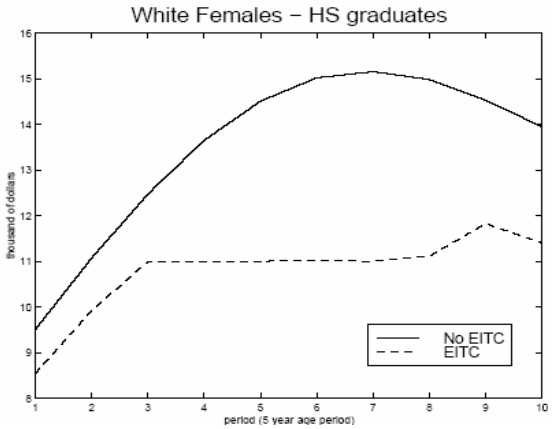
With these added dynamics exogenously specified, I generate the dynamics of the variable under study over a 30 year period (1975-2005).

Here are the results:

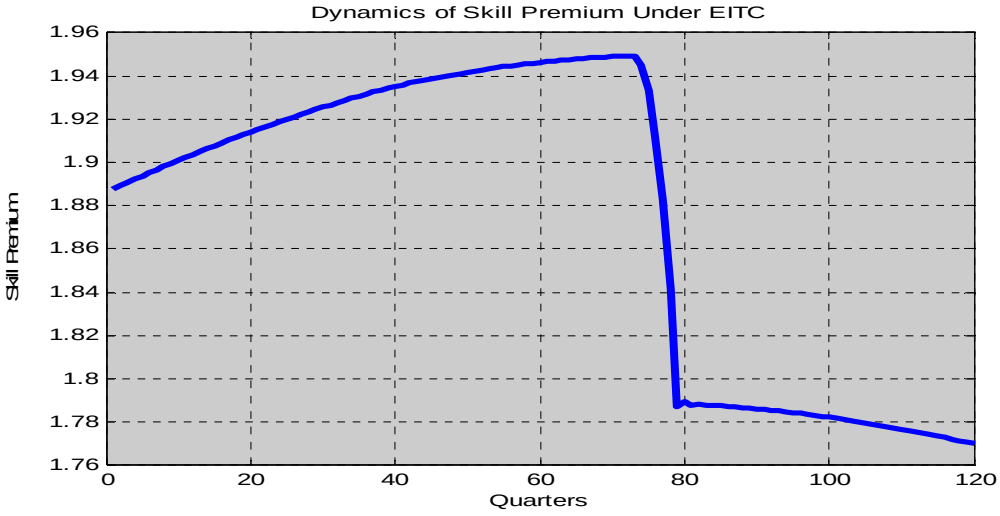
a. *Unskilled Wage, Supply of Unskilled Labor and Time invested in Human Capital*



a=0.90 b=0.93 c=0.98



Source: Heckman et al. (1998)



We see that with EITC, when wage subsidies are rising or constant, the skill premium tends to rise. This is the time that people would normally go for investing in higher education, but, due to the cushion of subsidy, they find the opportunity cost of foregoing work very high. The time spent in investing in education is lower than normal. However, when the wage subsidy falls, the opportunity cost also falls, and people find it much more useful to go for skill acquisition.

Drawbacks of this model are

1. Income tax and other tax rates are not included
2. Leisure is not included in the consumption utility function
3. Homogeneity in the skilled and unskilled workforce is assumed. This abstracts away from more realistic analysis of the topic.
4. Efficiency of the labor, as used in the Ben-Porath model, is not used.

V.9. *Lessons and Policy Recommendations*

The analysis of the effect of wage subsidies is slightly different, from Heckman's general equilibrium analysis. In his model, even after becoming high skilled and earning a high skilled wage, a rising skill premium can induce people to go for *on the job training*, to rise up the skill ladder. Since that feature cannot be included in my model, the lessons we learn are of a different nature.

The main lesson within the dynamics studied is that declining wage subsidies are the most powerful force in inducing people to invest is more training/higher education. The increase in the supply is so high that for that period there is a fall in the skill premium.

Not only is the effect felt during the decreasing wage subsidy period, but even after, due to the high supply of skilled labor, the skill premium continues to decline.

This dynamic feature of skill premium dynamics can be applied to a cross section at any period of time. Policy makers can simulate results to determine at which cut off point, the increase in supply of skilled workers is at the highest level, given the expenditure constraints.

Seeing the impact of EITC on a homogenous group helps policy makers specifically target the low skilled workers to increase their demand for higher skills. My model gives a sample simulation of the results.

However there are many drawbacks in this model, which are incorporated in Heckman *et al.* Thus more empirically sound features can be used as an extension of this simple model, and is left now for further work.

Conclusion

This paper has made a reasonable to cover the broad issues of skill premium facing the world in a simple general equilibrium model.

The Cross sectional analysis gives the steady state values of skill premium for a number of model economies. These model economies are made to match with real economies going through different stages of economic development. The skill premiums results are not in concert with income inequality, but the two concepts are very different.

On the long run analysis front, this paper has shown a method that can reasonably explain the long run non linearities in US skill premium that were not explained in any other paper. It makes the forecast, that skill premium will start showing a declining trend in a few decades, unless some other exogenous shock, changes the parameter values entirely.

In the policy experiment examining the impact of wage subsidies on skill premium, showed that declining wage subsidies are the strongest force for reducing skill premium.

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APPENDIX

Appendix 6

II *Countries - Gini Coefficient and Education Attainment*

Table 6

Education and Inequality information about Japan, China and India

	Japan			China			India		
	Gini	Secondary Enrolment (%Gross)	Tertiary Enrolment (%Gross)	Gini	Secondary Enrolment (%Gross)	Tertiary Enrolment (%Gross)	Gini	Secondary Enrolment (%Gross)	Tertiary Enrolment (%Gross)
1980	21.9			23.4					
1981	27.8			23.9					
1982	28.4			23.2					
1983	28.1			24.6			34.1		
1984	27.8			25.8					
1985	29.1			26.4					
1986	29.8			28.8			36.8		
1987				29.2			35.6		
1988				30.1			34.8		
1989	31.2			30.0			35.6		
1990	35.0			29.4			34.0		
1991				32.5			38.0		
1992	31.1			31.4			37.4		
1993				32.0			35.5		
1994				34.0			34.3		
1995	31.6			33.9			37.2		
1996				39.0			35.5		
1997	30.3			33.0			36.0		
1998	31.9	102	44	33.0	62	6	36.5	42	..
1999		102	45	35.0	63	8	36..3	46	..
2000		102	47	39.0	65	10	36.0	48	10
2001		102	49		67	13		48	10
2002		103	51		70	15		50	11
2003		102	52	44.9	73	19		52	11
2004		102	54	0.47			0.37	54	12

Sources: WDI, and Inequality Database

Table 6.2

Education and Inequality info about Singapore, US and Democratic Republic of Korea

	Singapore	US			Korea		
Year	Gini	Gini	Secondary Enrolment (%Gross)	Tertiary Enrolment (%Gross)	Gini	Secondary Enrolment (%Gross)	Tertiary Enrolment (%Gross)
1980							
1981	0.43	39.7			36.7		
1982	0.43	40.0					
1983	0.46	40.7			35.7		
1984	0.47	40.9					
1985	0.47	41.1			35.4		
1986	0.46	41.6			36.9		
1987	0.46	42.0					
1988	0.46	42.5			32.0		
1989	0.46	42.6					
1990	0.47	43.1					
1991	0.47	42.7					
1992	0.47	42.8			34.7		
1993	0.47	43.2			32.4		
1994	0.47	45.1					
1995	0.4875	45.3			32.6		
1996	0.4924	44.8			32.6		
1997	0.4929	45.0			31.6		
1998	0.444	45.5			36.9	102	68
1999	0.446		96	71		100	66
2000	0.467		95	73		98	73
2001			94	69		94	78
2002			94	70		91	83
2003			93	81		90	87
2004			95	83		91	89

Sources: WDI and World Inequality Database

Table 6.3

Information about educational attainment in Asia

Table 8. Selected Asian Countries: Gross Education Enrolment Ratios, 1980s

	Primary	*Secondary*	*Tertiary*
Thailand (1990)	95	29	10
South Korea	104	87	37
Singapore	111	69	12
Hong Kong	106	74	13
Indonesia	119	48	7
Malaysia	102	57	7
Philippines	110	71	28

Sources: Pasuk and Isra, 2000: Table 11; Myers and Chalongphob, 1991:14.

We see, Singapore supply of tertiary educated is far less than South Korea's.

Table 6.5

Table 6. Educational Enrolment in Selected Economies, 1970-1993

Economy	*% of age group enrolled in educational institutions*					
	Primary		*Secondary*		*Tertiary*	
	1970	*1995*	*1970*	*1995*	*1970*	*1993*
South Korea	103	99	42	96	16	48
Malaysia	87	91	34	58*	4	7
Thailand	83	98*	17	38*	13	19
Indonesia	80	97	16	42	4	10
United Kingdom	104	100	73	92	20	37
France	117	99	74	88	26	50
Japan	99	100	86	96	31	30

Note: * 1993

Source: World Bank (1995, 217; 1997, 226-7; 1998, 200-1).

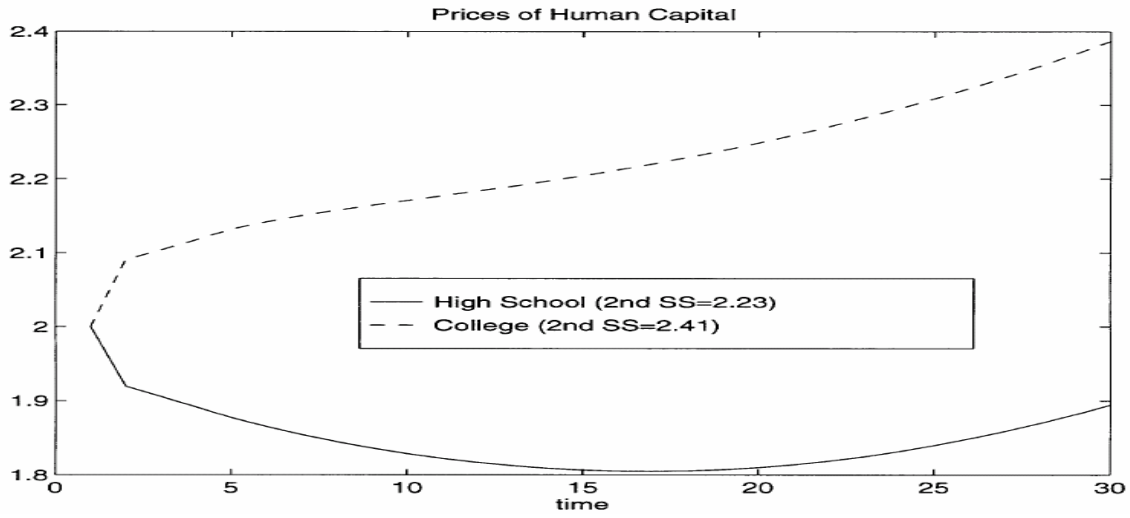
We see that South Korea's supply of tertiary educated is greater than Japan.

Appendix 8

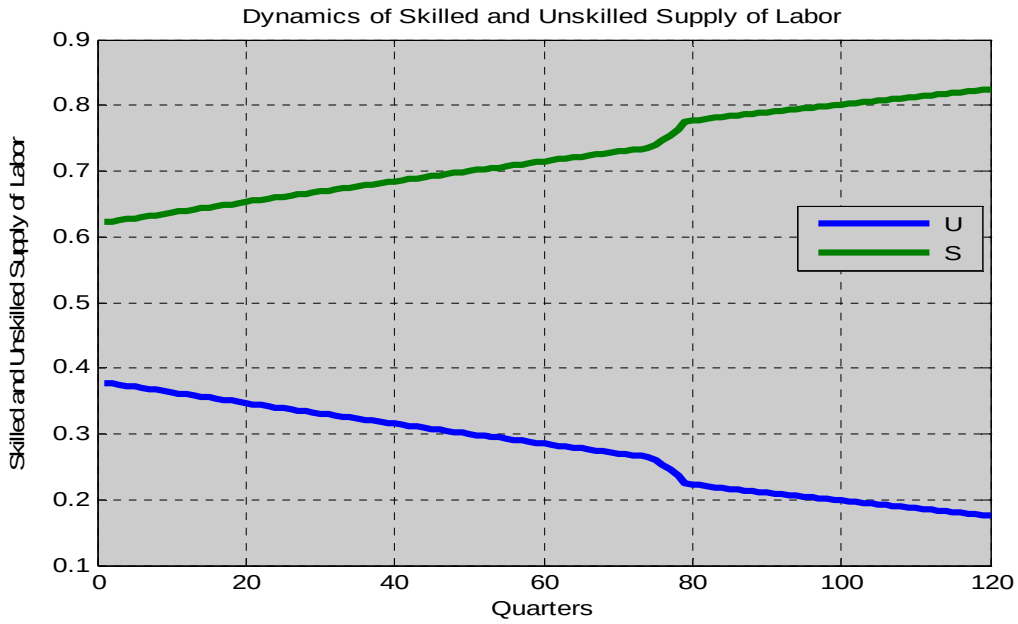
a. *Long term dynamics as shown in Heckman et al. (1998) versus my model*

a1. *Price of Human Capital*

Heckman et al. (1998)

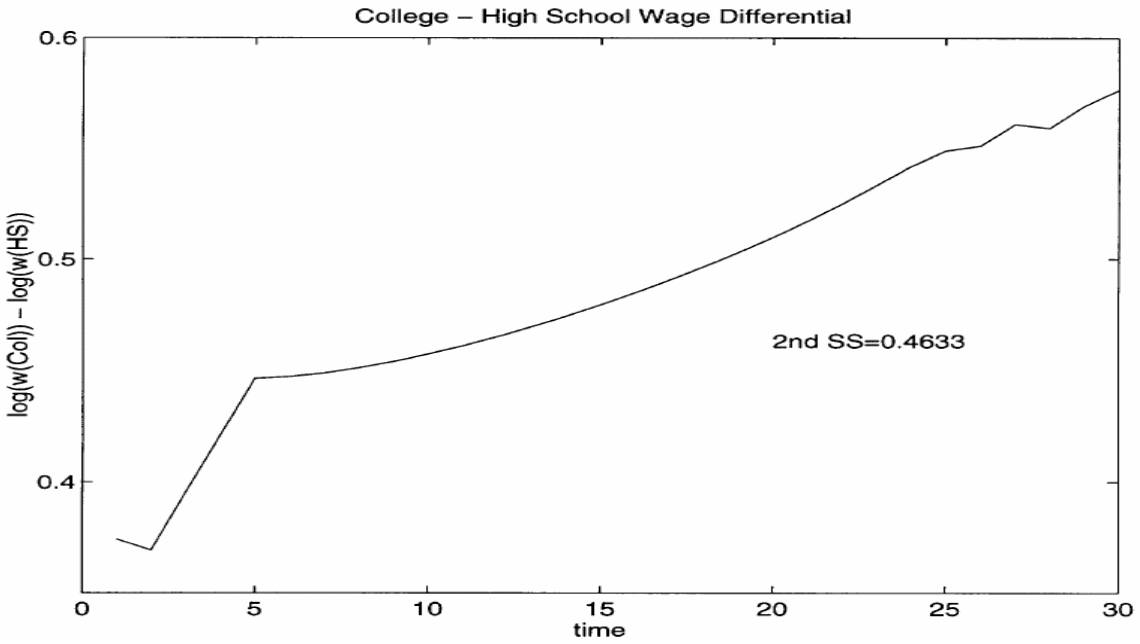


My OJT-DE model

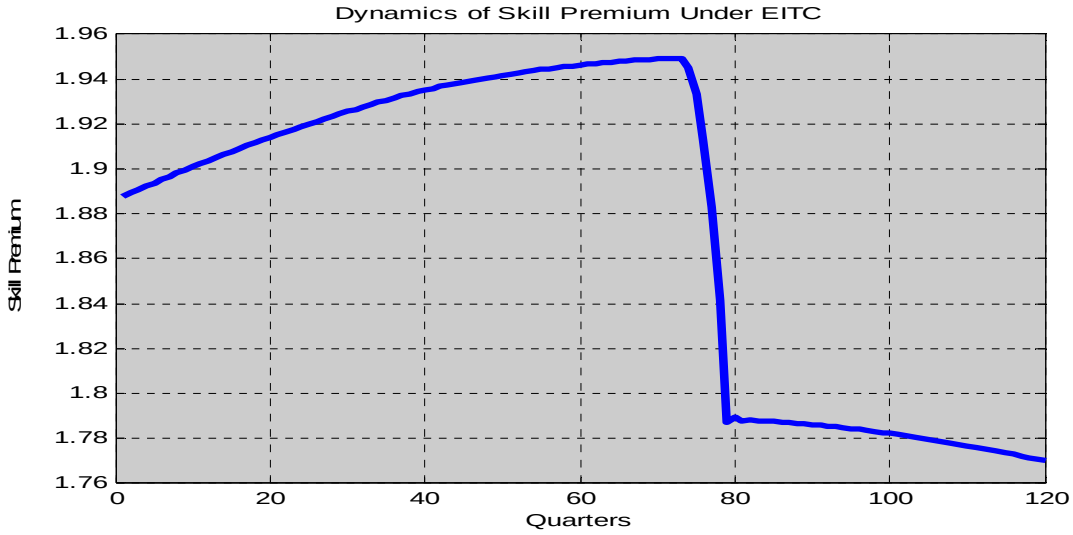


a2. *Skill Premium*

Heckman et al. (1998)

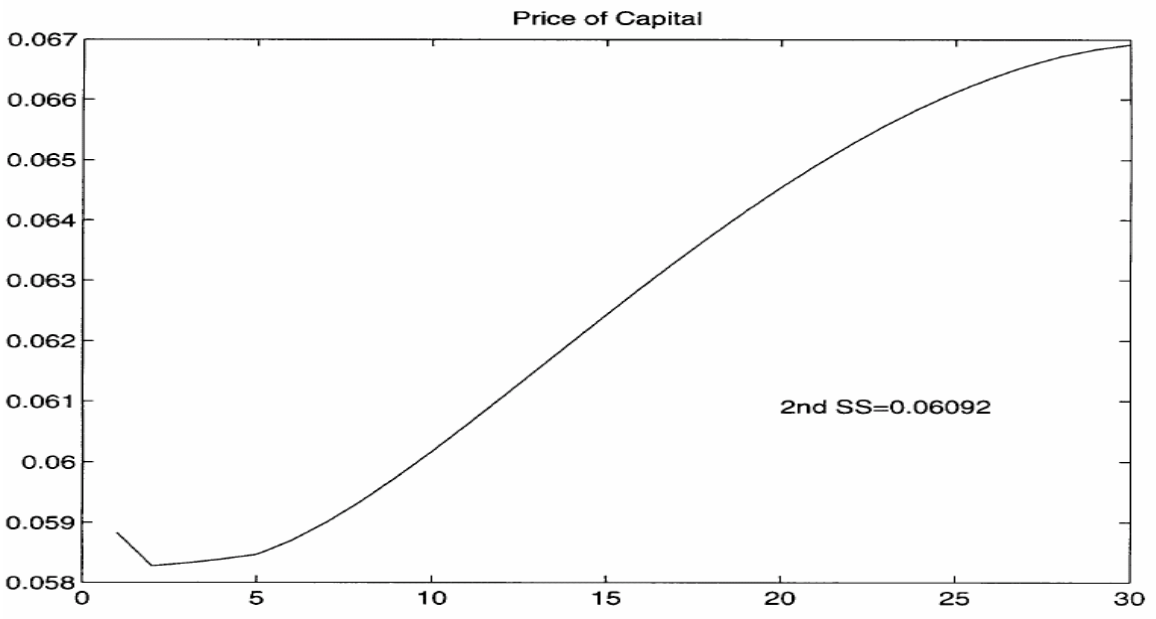


My OJT-DGE model

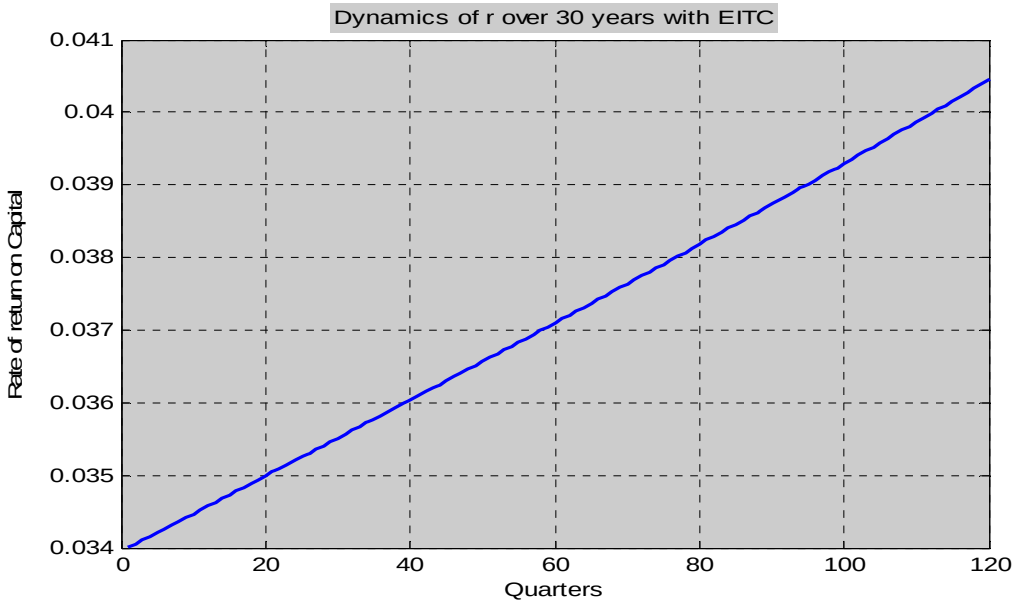


a3. *Price of Capital*

Heckman et al. (1998)

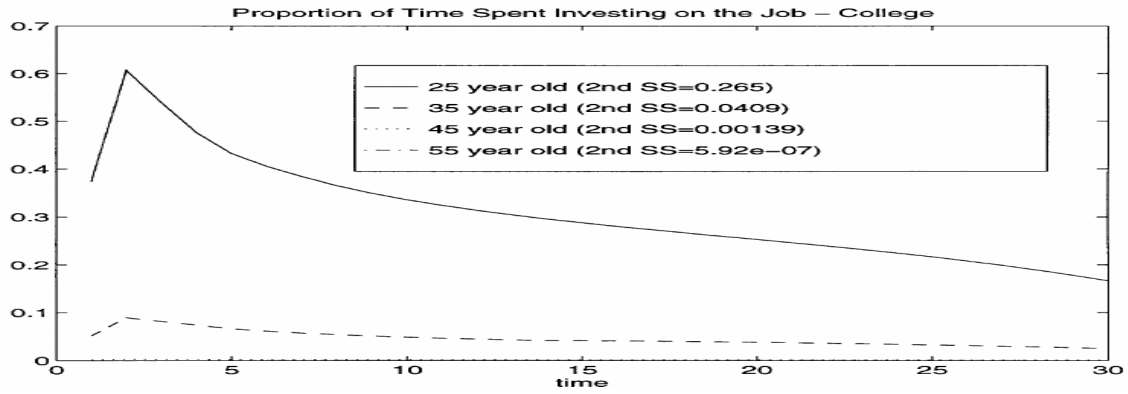


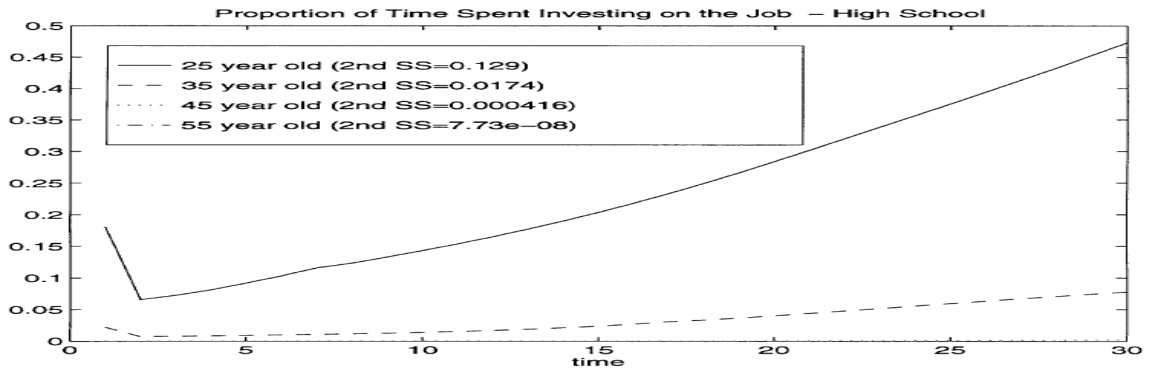
My OJT-DGE model



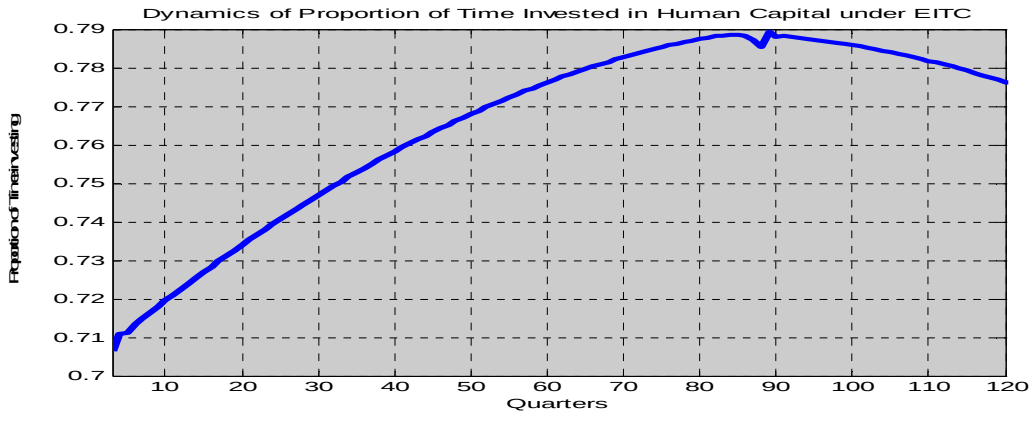
a4. *Proportion of time spend investing on the job-College*

Heckman et al. (1998)





My OJT-DGE Model



The crucial difference in the graphs arises from the difference in assumptions
In my model, job training is taken as a substitute of education and is invested in before the job starts. In Heckman et al. job training is under taken at different stages of their career.