Education and Consumption: The Effects of Education in the Household Compared to the Marketplace

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1. Introduction

Since the first systematic studies about 50 years ago of the monetary returns to education, thousands of estimates have been prepared for a large number of countries. Typically, sizeable rates of returns of the order of 7-15 % have been found, with magnitudes dependent on country, level of education, and time period. Adjustments for various measures of ability, family background, and still other factors have failed to reduce these estimates by much, if at all, and some adjustments, such as for errors in reporting school years, have raised the estimated returns.

Many fewer studies have concentrated on benefits from education other than earnings, such as in health, child rearing, marriage, and consumption of new goods, even though studies of outcomes in these areas show apparently large effects of education on such "consumption" activities. To correct this imbalance in emphasis, our study concentrates mainly on consumption benefits of education, and only discusses earnings to draw differences between the effects of education in the work place and household sectors.

In order to highlight what we think are the key differences between the household and market sectors we examine a model in which the fundamental production structure is the same in the two sectors. In particular, we assume that both sectors produce a wide range of goods that require individuals to perform a large number of distinct tasks. We believe that a model with the same underlying production characteristics is useful for at least two reasons. First, a wide range of "outputs" are produced in both sectors. In the market sector firms produce food, housing, transportation, health care etc. while in the household individuals do finances, make investment decisions, prepare meals, provide health care etc. Second, both sectors have changed in similar ways over time. In both sectors technological change has transformed production with capital goods replacing human effort in the preparation of life necessities and increasing complex technologies providing a range of new services.

Instead of focusing on technological differences our analysis focuses on differences in the way production is organized in the two sectors. In particular, we assume that (1) the division of labor is much less extensive in the household – households consist of a relatively small number of individuals each of which is responsible for many activities and (2) individuals work together (cooperate) in the marketplace to produce output for sale versus produce for their own consumption in the household. As a result of these differences in organization, individuals typically perform a relatively small range of tasks in the market and are paid based on marginal productivity, but perform a wide range of tasks in the household and collect the full product of their household production. For purposes of our analysis, we take these differences in organizational structure as given, though in principle one could attempt to derive this difference from a more primitive theory based on agency costs, a desire for privacy, or other factors that determine household organization. Our goal in this paper is to flesh out some of the implications of these differences in organizational structure between households and the marketplace.

One key aspect of our model is that individuals invest in skills including education to enhance their productivity. We allow individuals to invest in both general skills that raise productivity on all tasks and specific skills that raise productivity on a single task. We show that there are strong gains from investing in specific skills in the market sector due to the ability to specialize. This agrees well with observed behavior where individuals typically specialize to produce a small range of products and even then often perform only a subset of the tasks required to produce that limited range of products. The marketplace allows these individuals to benefit from the enhanced productivity associated with this specialization and benefit still further from the specialized skills of others through trade.

In contrast, given that individuals must perform a large number of tasks in equilibrium in the household, an individual's benefit from household production will depend on that individual's productivity on the full range of tasks. In addition, in the household sector, any one individual does not benefit from the enhanced productivity of others on other tasks (aside from other household members such as spouses and parents).

In our model individuals are "self-sufficient" in the household sector. As a result of these differences in organization, individuals benefit from increasing their productivity at the full range of household tasks rather than focusing on a narrow range of tasks as they would in the market sector. As such, general skills are much more important in the household than in the marketplace.

There are other important differences between the two sectors. In the market sector, individuals combine their skills with other inputs and the resulting output is sold in the marketplace. In such a setting, an individual's compensation for time worked will be determined by the market value of his marginal product. As such, individual compensation is determined by the individual's skill at his chosen task (as opposed to all tasks) and the value received depends on the market supply of complementary and substitute factors. In contrast, compensation for time worked in the household depends on the average rather than marginal productivity of the individual's time. In addition, since individuals do not combine their time with that of others, individual benefits from household production do not depend on the supply of complementary and substitute labor factors in other households.

While, the differences in the degree of specialization and cooperation between the market and household sectors have a wide range of implications (many of which we explore below) the effect of technological progress that augments the productivity of skilled workers highlights the contrast. Changes which made highly educated workers more productive at all tasks (such as educated labor augmenting technical progress on all tasks) would unambiguously raise the household productivity of educated workers and would not have any significant effect on the productivity of less educated workers who work in their own households. In contrast, making all educated workers more productive through labor augmenting progress in the marketplace would make less educated workers better off to the extent that they are complementary with educated workers or specialize at different tasks than educated workers. Such productivity increases could make more educated workers worse off if the demand for their services was inelastic.

The focus on how changes in the economic environment such as technological change affect the market and household sectors is of particular interest given the evolution of the market sector over the past several decades. As has been well documented, returns to education have increased substantially in the United States and other developed economies (see Katz & Murphy 1989). The fact that returns to education have risen in spite of rapid growth in the relative supply of more educated workers means that other economic factors have shifted demand in favor of educated workers even faster than the growth in supply (Katz & Murphy 1989, Murphy and Welch 1989). Many of the commonly recognized factors behind this shift, (1) skill-biased technological change associated with computerization and the expansion of labor saving technologies, (2) the falling price of capital goods combined with capital-skill complementarity (Krussel et al. (1997)), and (3) the shift of product demand toward high skill intensive sectors also appear to have occurred in the household as well. As the example of technological change cited above suggests and as we show in greater detail below, differences in the degree of specialization and cooperation between the market and household sectors would likely make the impact of such changes even greater in the household sector than what has been seen in the market sector.

Formally, our basic model of specialization in the market sector by different education groups among a continuum of goods is closely related to Ricardian models of trade between countries with a continuum of goods (see Dornbush, Fischer, Samuelson, 1977). Some of our comparative static results have a close correspondence with the results of these models on the gains from trade. For example, the effects on lower educated groups of an increased supply of higher educated groups in our paper are closely related to the results by Dornbush, et al. on the effects of an increased size of the rest of the world on the welfare of a particular country.

However, our focus is different because ours is on the effects of technological progress, changes in the number of persons with different amounts of education, and other variables on the gains from education in households compared to those in the market sector. Some of our result in these comparisons have not been derived, or at least not emphasized, in this trade literature. Yet these results are crucial to our conclusions about why the gains from education are different in the market sector and in households.

The paper is organized as follows. Section 2 lays out our basic model of production and contrasts the rewards of educated and less educated workers in the household and marketplace for given an exogenous difference in skill levels across education groups. Section 3 examines the differences in incentives to invest in skills between the market and household sectors and demonstrates the strong gain to specialized skills in the market and correspondingly weak gains in the household. Section 4 contrasts the impact of changes in technology and other factors between the market and household sectors. We show that many of the forces that mute the impact of such changes in the market sector either don't operate or operate in very different ways in the household sectors. In particular, to the extent that the same types of underlying changes have occurred in the household that have driven the evolution of market outcomes we show how they would generate even more pronounced changes in the household sector. Section 5 extends our model to allow for limited specialization within the household through marriage and parent-child interactions. It shows why returns to education in the household sector may be higher for individuals from less educated households even though returns to education in the market sector may be lower for these same individuals.

2. Production in the Market and Household Sectors

We begin our analysis with a simple model of production that we will use for both the market and household sectors. We assume that there is a continuum of tasks that must be performed in each sector. For simplicity, we associate each of these tasks with the production of a specific consumption good, and assume that an individual's output on a given task is simply his skill at that task multiplied by the time devoted to the task. Hence, an individual with skill level $S(x)$ on task x who spends $t(x)$ units of time working on task x will produce $Y(x) = t(x)*S(x)$ units of output.

To keep things simple we assume that individuals have additively separable preferences over these goods of the form

$$(1) U = \left[\int A(x) Y(x)^{1-1/\sigma} \, dx \right]^{\sigma/(\sigma-1)},$$

where x indexes the different tasks, σ measures the degree of substitutability between the outputs of the different tasks, and A(x) measures the level of demand for the output of task x. We assume ∫ A(x) dx = 1, so that A(x) measures the distribution of demand across tasks.

Throughout our analysis we consider two levels of education which we denote as high school and college. For now we assume that all individuals within a given education level have identical skills, and that educated workers are more productive at all tasks but have a comparative advantage at some tasks relative to others. In particular, we order the tasks according to the degree of comparative advantage of the more educated workers so that the educated workers, have a comparative advantage at the higher index tasks. Therefore, the comparative advantage of college graduates $R(x) = S_{COL}(x)/S_{HS}(x)$ is increasing in x with $R(x) \geq 1$ for all tasks.

Equilibrium in the Market Sector

Given the structure described above, the allocation of workers will be determined by comparative advantage. College and high school graduates will specialize at different tasks with college graduates performing the higher index tasks and high school graduates performing the lower index tasks. We denote the equilibrium cutoff level of tasks that separates the tasks performed by college and high school graduates by x*, and the corresponding cutoff level of comparative advantage R* = R(x*). Since all individuals are identical within a given education level, all must earn the same amount regardless of which tasks they perform in equilibrium. The output per hour produced by college graduates working at task x is $S_{COL}(x)$, so that the price of good x will be $P(x) = W_{COL}/S_{COL}(x)$ for $x \geq x^*$, where W_{COL} is the equilibrium wage of college graduates. Similarly, for $x < x^*$ prices will be $P(x) = W_{HS}/S_{HS}(x)$.

Since the utility function given in equation (1) is homothetic we can act as if there is a single representative consumer. The utility function specified above implies that for this representative consumer

$$(2)\ A(x)Y(x)^{-1/\sigma} = \lambda P(x),$$

where λ is the representative consumer's marginal utility of income. This implies that equilibrium consumption of good Y(x) will satisfy

$$(3)\ Y(x) = \lambda^{-\sigma} A(x)^{\sigma} P(x)^{-\sigma}.$$

Given our assumptions on technology we must have $P(x) = W_{HS}/S_{HS}(x)$ for $x<x^*$ and $P(x) = W_{COL}/S_{COL}$ for $x>x^*$. Of course, this implies that $W_{COL}/W_{HS} = R(x^*)$. This implies that

$$
\begin{aligned}
(4)\quad P(x) &= W_{HS}/S_{HS}(x) \quad for\ x<x^* \\
&= W_{HS}/S_{HS}(x) * R(x^*)/R(x) \quad for\ x>x^*
\end{aligned}
$$

The gains to specialization are immediately evident in equation (4). The prices of products produced by high school graduates are the same as they would be without specialization by education level. However, the prices of products produced by college graduates are lower by the factor $R(x^*)/R(x)$ for $x>x^*$. This reflects the comparative advantage of college graduates at those tasks and the gains from trade received by high school graduates.

Solving for the equilibrium quantities, prices and time allocations is relatively straight forward. If we denote the time devoted to the production of good x by t(x), output on task x will be $Y(x) = t(x)\ S_{HS}(x)$ for $x<x^*$ and $Y(x) = t(x)\ S_{COL}(x) = t(x)\ R(x)\ S_{HS}(x)$ for $x>x^*$. In order to pin down prices we need to chose units for measuring prices. One convenient set of units is to use the wage of high school graduates as the numeraire. Then equilibrium prices, production and time allocations will satisfy

$$(5a)\quad P(x) = 1/S_{HS}(x) \;\; for\; x < x^*$$
$$= 1/S_{HS}(x)^* R(x^*)/R(x) \;\; for\; x > x^*$$

$$(5b)\quad Y(x) = \lambda^{-\sigma} A(x)^{\sigma} S_{HS}^{\sigma}(x) \;\; for\; x < x^*$$
$$= \lambda^{-\sigma} A(x)^{\sigma} S_{HS}^{\sigma}(x)^*(R(x)/R(x^*)^{\sigma} \;\; for\; x > x^*$$

$$(5c)\quad t(x) = \lambda^{-\sigma} A(x)^{\sigma} S_{HS}^{\sigma-1}(x) \;\; for\; x < x^*$$
$$= \lambda^{-\sigma} A(x)^{\sigma} S_{HS}^{\sigma-1}(x)^* R(x)^{\sigma-1}/R(x^*)^{\sigma} \;\; for\; x > x^*$$

To solve the full equilibrium we need to bring in the two supply constraints, that the total time demanded of college and high school graduates is equal to their corresponding supplies. Mathematically

$$(6a)\quad T_{HS} = \lambda^{-\sigma} \int_{x<x^*} A(x)^{\sigma} S_{HS}^{\sigma-1}(x)\,dx$$

$$(6b)\quad T_{Col} = \lambda^{-\sigma} \int_{x\geq x^*}^{1} A(x)^{\sigma} S_{HS}^{\sigma-1}(x)\,R(x)^{\sigma-1}/R(x^*)^{\sigma}\,dx\;,$$

where T_{HS} and T_{COL} are the total time of high school and college graduates available in the marketplace. The equilibrium cutoff, x*, can be determined form the ratio of these two conditions equating relative demands and relative supplies:

$$(7)\quad \frac{T_{Col}}{T_{HS}} = \frac{\int_{x\geq x^*} A(x)^{\sigma} S_{HS}^{\sigma-1}(x)\,R(x)^{\sigma-1}/R(x^*)^{\sigma}\,dx}{\int_{x<x^*} A(x)^{\sigma} S_{HS}^{\sigma-1}(x)\,dx}$$

There is a unique x* that solves this equation since the denominator (the demand for high school labor) is monotonically increasing in x* and the numerator (the demand for college labor) is monotonically falling in x*.[1] As can be seen from the right hand side, as x* increases, relative demand shifts as the allocation of tasks changes (the extensive margin) and the relative price of goods produced with college labor increases. The aggregate degree of substitutability between college and high school labor is a

[1] Once we have determined x*, the remaining parameter, λ, can be determined from either equation (6a) or equation (6b) which can then be used to determine the absolute amounts of outputs and inputs. We omit this final step in our analysis since we are interested in relative quantities and prices.

combination of the substitutability of task outputs, σ, and the easy of switching tasks on the margin, determined by the distribution of comparative advantage.

Several aspects of this equilibrium are worth noting. First, the equilibrium return to education is determined by the productivity differential on the marginal task x*. Holding this marginal productivity differential fixed, changes in relative productivities such as increasing R(x) for x>x* will have differential effects based on the magnitude of σ. For σ>1, increasing R(x) for some range of x's above x* will increase the relative demand for college graduates and raise the earnings differential by pushing up x*. In contrast, when σ<1, raising the raising R(x) for x>x* lowers the educational wage differential. Second, when college graduates have a strong advantage at some tasks R(x)>>R(x*), high school graduates gain significantly since they buy these goods for a small fraction, R(x*)/R(x), of what it would costs them to produce the goods themselves.

In our model the supply of college and high school labor is perfectly elastic across tasks. As a result, the surplus over what high school graduates would be willing to pay for the infra-marginal goods above x* is competed away by producers (college graduates) and generates consumer surplus for the buyers (high school graduates).

One particularly simple case is the case where σ=1 (Cobb-Douglas) in which case the allocation of resources across tasks is independent of productivity, and only depends on the demand for the task A(x) and the type of worker assigned to the tasks. In particular, tasks performed by college graduates are assigned equivalent time measured in market based efficiency units but less physical time by the equilibrium relative price R(x*). This case will be particularly useful for our comparison of the market and household sectors which we consider next.

Equilibrium in the Household Sector

When we consider production in the household sector rather than the market sector much of the analysis remains the same except that both college and high school graduates must produce the full range of goods for their own consumption. In particular, from the perspective of high school graduates, the price of consumption for goods x>x* would rise by a factor R(x)/R(x*) relative to the market case. That is, prices would increase the most to high school graduates for the goods where college graduates have the biggest comparative advantage (the highest x goods). Similarly, from the perspective of college graduates, the price of goods for x<x* would rise by the factor R(x*)/R(x), with the largest rise for the lowest index goods. Clearly, both groups would be worse off due to the lack of specialization. This is what Wesley Mitchell referred to a century ago as the "backward art of spending money" where households are less efficient than firms due to the lack of specialization.[2]

Formally, high school graduates in the household sector solve the same utility maximization problem as in the market sector with the exception that $P(x) = 1/S_{HS}(x)$ for all x. The first order conditions are then the same as in equations (2) and (3) above so that the optimal allocation of time satisfies:

$$7.1\ t(x) = \frac{T\, A(x)^{\sigma}\, S(x)^{\sigma-1}}{\int A(z)^{\sigma}\, S(z)^{\sigma-1} dz}.$$

The utility level received by a high school graduate in the household sector will then be

$$7.2\ U_{HS} = T\left[\int A(x)^{\sigma}\, S_{HS}(x)^{\sigma-1} dx\right]^{1/(\sigma-1)}.$$

Similarly, the utility level received by a college graduate will be

$$7.3\ U_{COL} = T\left[\int A(x)^{\sigma}\, S_{COL}(x)^{\sigma-1} dx\right]^{1/(\sigma-1)}.$$

The education premium in the household (which can be interpreted as the ratio of effective incomes) will then be

$$7.4\quad R^{HH} = \left[\frac{\int A(x)^{\sigma}\, S_{HS}(x)^{\sigma-1} R(x)^{\sigma-1} dx}{\int A(x)^{\sigma}\, S_{HS}(x)^{\sigma-1} dx}\right]^{1/(\sigma-1)}$$

Equation 7.4 expresses the effective income ratio of college graduates relative to high school graduates as a non-linear weighted average (weighted by the expression A(x)σ

[2] As we will see in section 3 below, this loss of the gains from specialization across education levels is only part, and maybe only a small part, of the efficiency loss from the lack of specialization in the household sector.

SHS(x)σ-1) where the average is a convex function of R(x) when σ>1 and concave in R(x) when σ<1.

In response to the change in prices, the household allocation of resources across tasks will in general be different from that found in the market. The direction in which resources flow will be determined by the degree of substitutability across tasks. When substitution across task outputs is relatively poor, σ<1, households will shift resources toward the sectors where productivity falls (i.e. sectors where prices rise). When σ>1 the allocation of resources will shift in the opposite direction. The case where σ=1 provides a convenient benchmark case since the allocation of resources across sectors will not change. High school graduate households, college graduate households, and the market will all allocate resources across sectors in the same proportions. In terms of consumption, high school graduates will simply scale down their consumption of all goods with x>x* by the factor R(x*)/R(x) relative to the market sector outcome, and maintain the same level of consumption for goods with x<x*. For college graduates we should see exactly the reverse, consumption of goods with x>x* would remain fixed relative to the market sector and consumption of goods with x<x* would be reduced by the factor R(x)/R(x*) in the household sector. The calculations for the Cobb-Douglas (σ=1) case are useful even in the case where σ≠1 since they would still represent a first order approximation to the loss in these other cases since substitution has a second order effect on welfare. Exact calculations using the indirect utility functions given in equations (7.2) and (7.3) above can also be made for cases where σ≠1.

Most importantly for our purposes, the overall comparative advantage of college graduates will change between the market and non-market sectors. In the market sector high school graduates buy output x at a price of $1/S_{HS}(x)$ for x<x*, and at a price of $1/S_{HS}(x)*R(X*)/R(x)$ for x>x*. This is equivalent to having productivity $S_{HS}(x)$ for x<x* and $S_{COL}/R(x*) > S_{HS}(x)$ for x>x*. For college graduates, we have the reverse story, with equivalent productivities $S_{HS}*R(x*) > S_{COL}(x)$ for x<x*, and $S_{COL}(x)$ for x>x*. Comparing the market and household sectors, the relative advantage of college graduates in the household will be greater due to the fact that their effective relative productivity rises for all tasks with x>x*, but fall due to the fact that their effective relative productivity falls for $x<x^*$. Essentially, college graduates gain less in the household than the market to the extent that they have to spend considerable time performing tasks at which they have little comparative advantage (low x tasks) but gain more relative to the market to the extent that they now get the full advantage of their comparative advantage for tasks with $x>x^*$.

Any comparison of returns to college in the market and household sectors will come down to assessing the relative importance of these two categories of tasks, and the degree of consumer surplus generated in the market on those tasks (i.e. the extent to which $R(x)/R(x^*) > 1$ for $x>x^*$, and $R(x^*)/R(x)>1$ for $x<x^*$). Given our assumption that college graduates have an absolute advantage at all tasks, this second effect is bounded above by $R(x^*) = W_{COL}/W_{HS}$. In contrast, the gains to high school graduates from trading in the market compared to the household could be very large on some tasks (i.e. we could have $R(x)>>R(x^*)$ for some tasks).

Figure 1 illustrates these ideas by plotting the price of goods in the market and household sectors for both college and high school graduates (expressed in units of high school graduate time in the market sector). In these units high school graduates are allocated with 1 unit of income, and college graduates are allocated with $R(x^*)$ units of income in either the market or household sectors. Since the units of x are arbitrary, we let x represent the comparative advantage of college graduates so that $R(x) = x$. The figure shows the prices faced by both groups in the market sector, and by each of the two groups in the household sector. The equilibrium price function in the market sector is the lower envelope of the two lines. The price function in the household sector for college graduates lies above the market price line to the left of x^*, and the household price function for high school graduates lies above the market price function to the right of x^*. The two shaded regions in the figure represent the losses for college and high school graduates in the household relative to the market. The advantage of college graduates relative to high school graduates in the household sector versus the market sector will then be determined by the relative sizes of these two areas (weighted by the distribution of inputs across tasks).

In the case where σ=1 this comparison is aided by the fact that the allocation of resources across tasks is the same in the market and household sectors. In that case the amount of mass to the left and right of x* will then be equal to the relative supplies of college and high school graduates. We will return to this in section 4 below.

3. Investments in Skills

Our analysis of the returns to education in the market and household sectors outlined in the previous section took the distribution of comparative advantage across tasks generated by education as fixed. This section discusses some aspects of skill investment, with an eye toward contrasting the household and market sectors. The most striking difference between the two sectors is in terms of the relative value of specific and general education. The model described in the previous section is easily augmented to allow for specialized education in addition to general education. For this extension we interpret the skill levels $S_{HS}(x)$ and $S_{COL}(x)$ as the productivity on each of the tasks generated by general training. We then allow individual's to engage in specific training for a given task, x, by investing time, I(x), to increase their productivity at that task. We assume that productivity on a given task, x, in which the individual has invested I(x) units of time in specific training is given by S(x) F(I(x)) with F(0)=1, F'()>0, F''<0. In this formulation, specific training will augment general training. The cost of this investment is the loss of time available for production, and the gain is in terms of enhanced productivity on the remaining time devoted to that task. In particular, given a the total time allocated to a given task T(x), the individual will choose I(x) to maximize

$$(8)\,(T(x)-I(x))\,F(I(x))\,.$$

The solution to this problem will have

$$(9)\,I(x)=0 \;\; if \;\; T(x)<1/F'(0)$$

$$F'(I(x))=F(I(x))/(T(x)-I(x)) \quad otherwise.$$

The elasticity of output on the task with respect to total time devoted to that task will be T(x)/(T(x)-I(x)) > 1. Since task output increases more than proportionately with time devoted to the task, individuals will fully specialize in the market sector and will devote all of their time to a single task (see Becker and Murphy 1992). This would be true for both college and high school graduates, so that productivity on each task would then be (T – I*)/T F(I*) S(x) on all tasks performed in equilibrium, where I* maximizes equation (8). This specialization investment makes college and high school labor more productive at all tasks performed in the market sector.

We can extend the model further to allow endogenous investment in both general and specific training, where S(x) is now a function of the time invested in general training, g, as in $S(x) = S_0(x)\, G(g)$. Note that g does not depend on x since by assumption it is general training and raises productivity at all tasks. Since, the returns on a task are convex in T(x), individuals will again specialize completely in the market sector and perform only a single task in equilibrium. With complete specialization at task x, the maximization for someone with T units of time to devote to general training, specific training and working at task x will then be

(10) $(T - g - I(x))\, G(g)\, F(I(x))$.

In this case the individual will allocate time between general and specific training so as to equate the marginal products of time in terms of task x productivity between the two. Hence, even though individuals gain productivity at all other tasks with general training, only productivity on this single task matters. The ability to specialize implies that both general and specific training are evaluated only on their ability to raise task x productivity. While this basic result can be muted by introducing other factors, such as individual level or aggregate uncertainty, or even predictable variability in productivity across tasks, the basic incentives remain: the incentive to increase task productivity is proportional to the time expected to be spent on that task – there is no reason to direct investment to increasing productivity on other tasks that will not be performed in equilibrium. In the pure market sector case with complete specialization, the possession of general skills would only be a byproduct of the effort to be as productive as possible on a single task.

The incentives to invest in general training in the case of the household production are very different. Since individuals in the household sector perform a wide range of tasks, the time devoted to any one task is small (literally zero in our example with a continuum of tasks). In this case, pure task specific investment would have essentially zero value so that the condition $T(x) < 1/F'(0)$ would be met. Then it will not pay to invest in task specific skills. In contrast, general skills would still have their full value since they raise productivity by the same proportion on all tasks. As a result, someone investing in general and specific skills would invest more in general skills, and less (actually zero) in specific skills for work in the household sector versus the market sector. This prediction fits very well with the observed differences between women and men in terms of the types of education received. Historically women have been more likely to invest in general as opposed to specific training and have allocated relatively more of their time to the household.

Since in actuality individuals allocate time to both the market and household sectors, the investment problem they face is a combination of the household and market problems described above [TO BE CONTINUED]

4. The Evolution of Education Premiums in the Household and Market Sectors

This section explores further implications of our model. In particular, we will address how changes in technology, factor supplies, and other elements affect outcomes in the market and household sectors. For simplicity we use our model from section 2, though the analysis can be extended in a straight forward way to the case of specialized investments outlined in section 3.

Our analysis assumes that technical and other changes in the market and household sectors have proceeded in roughly parallel directions. We think this fits well with the changes observed in the two sectors. In particular, both sectors have been characterized by three major events. First, both sectors have seen a substantial decline in the demand for raw human labor. In the market sector this has shown up in terms of a decline in the demand for laborers, operatives etc (see Katz and Murphy 1989 or Murphy & Welch (198x, 199x)). In the household sector, this has shown up in the reduced household time devoted to meal preparation, laundry, and other activities that previously occupied substantial household time (see Greenwood et al.). Secondly, both sectors have seen the introduction of more sophisticated technologies such as computers, advanced electronics, more sophisticated medical care, and the growing importance of information and communications. Finally, both sectors have seen declines in the real cost and increased use, of capital goods: physical capital in the market sector and household durables in the household sector. Our basic thesis is that these changes have shifted comparative advantages in the two sectors in roughly similar ways, but that the impact of these changes has differed due to the differences in market organization described above. In this section we explore the implications of this thesis.

The effects of changes in factor supplies represent the most striking difference between the market and household sectors. Starting from an equilibrium in the market as depicted in figure 1, an increase in market supply of college (high school) graduates would shift the college effective productivity down (up), so that college graduates would lose (gain) in the market sector, and high school graduates would gain (lose). In the household sector, factors supplies would have no effect on either group since all individuals perform the same mix of tasks in equilibrium regardless of factor supplies. While this difference is obvious given the distinction in the way production is organized in the two sectors, our model highlights its importance given the substantial growth in the supply of educated labor in the market sector over time.

The difference between the supply effects can be seen clearly in the case where growth in the demand for college labor, captured in our model by a rightward shift in the distribution of demand across tasks, is offset by growth in the supply of college graduates, so that the market premium for educated labor stays fixed. In that case, we can think of the productivity curves in Figure 1 staying fixed, with a shift in the distribution of demand to the more skill intensive tasks. The bottom line would be no change in the relative real income of college and high school graduates in the market since there is no change in nominal relative incomes, and preferences are homothetic. But there would be a substantial rise in the welfare of college graduates relative to high school graduates in the household sector due to an increase in the tasks at which college graduates have a comparative advantage. Thus, to the extent that we have corresponding shifts in task demands in the two sectors and growth in supply of college graduates that prevents college relative wages from rising, we would expect college graduates to have gained relatively in the household even though relative wages stayed constant in the market.[3]

What we have observed in the market over the past several decades (and to some extent over the 20th century) is a combination of the relative supply effect and the demand story. In particular, the history of the market sector has been characterized by substantial growth in the relative supply and demand for college graduates (see Katz and Murphy 1989, Murphy & Welch 2003). Over recent decades, the growth in demand has outstripped the growth in supply, generating a rising premium for college graduates. Over the longer term, the growth in supply and demand have been more in balance, with periods of rising premiums offset by periods of declining premiums.

To examine the change in the relative welfare of college and high school graduates we consider the simple case where σ=1, so that the allocation of time across sectors is the same in the college and high school sectors. We can compare outcomes in the household and market sectors for both college and high school graduates by the income premium the consumer would require to compensate for the higher prices faced in the household sector. In the case of σ=1 consumption of good x is simply M*A(x)/P(x), where M is income. The individual's utility is then

$$(11)\ \ln(U) = \int_1^\infty A(x)\ln(M / P(x))\,dx \quad = \ln(M) - \int_1^\infty A(x)\ln(P(x))\,dx$$

The percentage change in income required to compensate the consumer for changing prices from P(x) to P'(x) is then simply

[3] The one possible effect running the in opposite direction would be if the infra-marginal demands shifted in the reverse direction (toward less college intensive tasks). As long as the shift was uniform in the sense that A'(x)/A(x) was increasing in x, where A'(x) and A(x) are the new and old demand distributions this will not happen.

$$(12)\ Comp = \int_{1}^{\infty} A(x)[\ln(P'(x)) - \ln(P(x)]\,dx$$

College graduates face the same prices in the two sectors for x>x*, and face higher prices in the household sector for x<x*. For x<x*, prices in the household sector are higher by the ratio R(x*)/R(x). Hence the compensating difference for college graduates is simply

$$(13)\ Comp_{COL} = \int_{1}^{x^*} A(x)[\ln(R(x^*)) - \ln(R(x)]dx\,.$$

Similarly, the compensating change in income for high school graduates would be

$$(14)\ Comp_{HS} = \int_{x^*}^{\infty} A(x)[\ln(R(x)) - \ln(R(x^*)]dx\,.$$

The advantage of college graduates in the household environment relative to the market environment is then given by

$$(14)\ ADV = \int_{x^*}^{\infty} A(x)[\ln(R(x)) - \ln(R(x^*)]dx - \int_{1}^{x^*} A(x)[\ln(R(x^*)) - \ln(R(x)]dx\,.$$

These correspond to the two shaded regions in figure 1. As such the total equivalent income advantage for college graduates in the household sector can be written as

$$(15)\ \ln(Y_{COL}/Y_{HS}) = \ln(R(x^*)) + \int_{x^*}^{\infty} A(x)[\ln(R(x)) - \ln(R(x^*)]dx - \int_{1}^{x^*} A(x)[\ln(R(x^*)) - \ln(R(x)]dx$$

We can use equation (15) to measure the gain for college graduates in the household sector in terms of the return in the market sector, ln(R(x*)), and infra-marginal advantages and disadvantages of college graduates relative to high school graduates in the household sector (the second two terms). Based on outcomes in the market sector we know that R(x*) has risen over time. We also know that the mass of activities of comparative gain for college graduates (x>x*) has increased and the mass of activities where college graduates have an infra-marginal disadvantage has decreased. Notably, both of these last two occurred in spite of the increase in x*. As many have observed, based on outcomes in the market sector, this implies that demand has shifted in favor of college graduates (see Katz and Murphy 1989 for example). In our model, this would mean that A(x) has shifted toward high values of x since both the relative price and relative quantity of college graduates have increased.

The second two terms in equation (15) represent surplus terms and can be thought of in terms of the resources (measured by time in the household or value of inputs in the market sector) times the average difference between comparative advantage on those tasks and the marginal market task, x*.

Based on the framework presented by Katz and Murphy we can begin to analyze the components of equation (15). The first term in equation (15) depends only on the market premium for college graduates relative to high school graduates. The second two terms cannot be measured directly, but the mass of resources devoted to the two components (i.e. time spent on the two sets of infra-marginal tasks) is simply measured by the fraction of market income going to high school and college graduates. Table 1 examines the relative prices and quantities underlying equation (15) for 1967 and 2003 based on Current Population Survey (CPS) data.

Table 1. College-Plus and High School Quantity and Price Data

		1967		2003
Relative Wage		1.51		1.95
College Share		.24		.58
High School Share		.76		.42

Under the assumption that σ=1, the interpretation of these data together with the view that the evolution of technology has been the same in the household and market sectors would be that in 1967, 76% of the tasks performed were tasks where college graduates had a comparative advantage of 1.51 to 1 or less. In 1967, only on 24% of tasks did college graduates have a comparative advantage of 1.51 to 1 or more. In contrast, by 2003 the fraction of tasks where college graduates had a comparative advantage of 1.95 or more (a much higher threshold) was 58%. As such, in 1967, college graduates had a comparative advantage less than the market premium in roughly ¾ of the tasks whereas in 2003 college graduates had an advantage less than the market premium in only 2/5 of the tasks. Unless the average differentials above and/or below the market threshold moved very strongly in the other direction it would seem that the returns to education in the household increased much more than the tremendous rise we saw in the market sector over this same period.

Figures 2a and 2b illustrate the change in terms of our earlier graph (Figure 1). Figure 2a depicts the situation in 1967 when ¾ of the household the have educational advantages below the market advantage. Figure 2b shows 2003 when more than half of the tasks performed in the household have an educational advantage greater than that seen in the market sector.

The key to this contrast is the effect of supply and the distribution of comparative advantage across tasks. This can be seen by considering the extreme case where college labor's share is very low. When the supply of college graduate labor is very low, college graduates will only perform the market tasks where they have the greatest comparative advantage. As such the market premium will exceed their productivity advantage in almost all tasks. Their market compensation will then be the same as if they had that large of a comparative advantage at all tasks. If gradually over time we switched to the other extreme where college graduate labor accounts for almost all of the market supply then the reverse would hold. College graduates would now perform all tasks except those where they have the smallest comparative advantage. Their market compensation would now reflect their comparative advantage on the tasks where they have the least comparative advantage and the market premium will be less than their productivity advantage on almost all tasks. Since the premium in the household is based on an average level of comparative advantage (see equation 15) rather than the supply and demand determined marginal task, college graduates gain much more over time in the household compared to the market under these conditions.

While over the recent period the college premium has risen substantially, over the longer term education returns in the market have shown less of a trend, while quantity changes have been even more dramatic. Thus, in the longer term returns are likely to be even more skewed toward rising in the household compared to the market sector given the larger increase in tasks for which college graduates have a comparative advantage and the fact that the growth in demand has been completely offset by supply growth in the market sector.

The model outlined here and existing evidence from the market sector can help us understand the source of this growing premium. We discuss several factors in turn.

Technical Change

In our model, changes in technology can be thought of in terms of shifts in the productivity functions $S_{HS}(x)$ and $S_{COL}(x)$ for a fixed definition of tasks. Educationally neutral changes in productivity would be captured by equal proportional shifts in these two schedules, and would hold comparative advantage, R(x), fixed. For the case where $\sigma=1$, when these changes are infra-marginal, they will have equal effects on the welfare of college and high school graduates in both the household and the market. The reason is shares devoted to the different goods are the same for the two groups and the same in the household and in the market.

When $\sigma>1$ and the change is infra-marginal, the group specializing in the tasks where productivity increased will gain the most in the market sector, as the demand for their services will rise and relative wages will tilt in their favor. How much they gain in relative terms will depend on how much the cutoff level must move to equate supply and demand. In the household sector, both groups will gain an amount based on how much resources are allocated to that task. With $\sigma>1$, groups will devote relatively more time to the tasks at which they have the greatest comparative advantage, and the relative gains will tend to follow the same direction but will not necessarily be of the same magnitudes as in the market sector.

When $\sigma<1$, the contrast between changes in the two sectors is more extreme. In this case, the relative wage of the group specializing in the tasks where productivity increased falls as the cutoff must move against them in order to clear the market. If that move is sufficiently large they will be worse off, while the group not specializing in those tasks always gains more than them, and always gains in absolute terms. In the household sector, both groups gain from education neutral technical advance with the group allocating relatively more time to that sector gaining more.

The distinctions between the market and household sectors for technical changes that are education specific are even greater. In the case where the change is infra-marginal, and in the favor of the group not specialized in a given task the change has no effect on the market sector equilibrium but will clearly benefit that group in the household. In the case where $\sigma<1$, the contrast will be even more extreme since then the less productive group will devote more rather than less resources to the activities for which they have a comparative disadvantage. This is much like the impact of general training in our discussion of investment in section 3. Increases in productivity on tasks not performed in equilibrium have no value in the market sector but since all tasks are performed in the household, increases in productivity is valued on all tasks. Hence, increases in productivity on tasks with a comparative disadvantage will be disproportionately valued in the household when $\sigma<1$.

When the increase in productivity is education specific and occurs for the group specialized at that activity, the effect in the market sector is the same as when productivity increases for both groups. Hence education biased and education neutral technical change would have the same effect on market outcomes in this case. When $\sigma=1$, both groups gain equally in the market sector case even though the productivity gain occurred for only one group. When $\sigma>1$, the group experiencing the productivity gain will gain more than the group with no productivity gain since relative wages will shift in their favor, while in the case where $\sigma<1$ the group experiencing no productivity improvement will actually gain more. In the household of course only the group experiencing the productivity gain will be affected.

Induced Technical Change

As has been emphasized by Acemoglu and others, an increase in the relative supply of educated workers could induce technical change that favors those workers due to the induced greater payoff to such innovations induced by the greater supply. In the market sector, the induced change may offset, or even more than offset, the loss in relative earnings generated by the imperfect substitutability of educated and less educated workers. However, given the evidence is that substitution between education levels is relatively low (Katz and Murphy and others estimate the elasticity of substitution to be roughly 1.4[4]) this induced demand effect would need to be very large to offset the negative price effect directly caused by the supply change with a fixed technology. If the induced technical progress effect is not quite strong, it will only mute rather than offset the downward effect on educational premiums of greater supply.

In our opinion, induced technical change would be more likely to be important in the household sector. Industry level and other economies of scale that operate through the market size effect are likely to be found for household goods as well as production methods. With a more educated consumer population, products will be tailored to more educated consumers. Since there is no compensating imperfect substitution force to offset in the household case, the induced change effect is the only force that will operate. As a result, with induced technical change, growth in the supply of educated workers will actually increase the education premium in the household even if the induced technical change effect is relatively weak.

Changes in the Demand for Tasks

Changes in the demand for tasks, shifts in the A(x) function in our model, will have substantial effects in both the market and household sectors. In the market sector, the major effect happens when demand shifts between tasks performed by different groups. Shifts within tasks performed by a single group that hold overall demand fixed have no effect. For example, shifts in demand from tasks where college graduates have a modest relative advantage compared to the market premium (i.e. R(x) close to R(x*)) to

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[4] In fact their estimate should already account for some of the induced demand effect to the extent it operates over the frequency used in their empirical analysis.

tasks where they have a great advantage ($R(x) >> R(x^*)$) would have a neutral effect on college and high school graduates. In the household sector of course, such a shift would benefit college graduates relative to high school graduates since the tasks where the college graduates have the greatest comparative advantage have become more important.

Changes in the relative demand between tasks performed by one group and the other will affect the market return to education by shifting demand in favor of one of the two groups. Hence, shifts in demand from less skilled tasks to more skilled tasks will have an effect to the extent it shifts demand from tasks below x^* to tasks above x^*. However, given that prices are determined by relative advantage on the marginal task, this effect will be the same regardless of whether the shift is from tasks slightly below x^* to slightly above x^* or from well below x^* to well above x^*. In the household the effect of a shift toward higher x tasks will not depend particularly on the level of x^*.

Changes in the composition of demand across tasks over time can be generated by many forces including differential income elasticities across goods, or changes in the prices of complementary or substitutable inputs (which we do not explicitly model but could be added in a straight forward way).

Capital-Skill Complementarity

One force that has operated in both the market and household sectors is the declining cost of capital goods relative to both labor inputs and consumption goods. The decline in the relative costs of capital goods has caused growth in the capital-labor ratio in the market, and growth in consumer durables in the household. One key effect of the declining relative price of capital goods and rising capital inputs works through capital-skill complementarity where capital goods serve as substitutes for low skilled labor and complements to high skilled labor. It is important to realize that this force works on both margins. It works to reduce the demand for less skilled labor by allowing capital goods to perform activities previously requiring less skilled workers. It also serves to enhance the demand for high skilled workers by generating new tasks to design, operate and control more sophisticated devices. The role of capital-skill complementarity in generating growth in the relative demand for more skilled labor, and thereby raising the return to education, has been explored for the market sector by Krusell et al. (1997).

We believe that these same forces have been important in the household. In the household, consumer durables have reduced the time required for menial household tasks such as laundry, cleaning, etc. (see Greenwood et al.). These types of tasks are the tasks that less skilled workers perform in the market sector, and therefore are the tasks at which college graduates have the least comparative advantage. As the time devoted to these tasks in the household sector declines, college graduates gain more than high school graduates since college graduates earn a smaller return on these types of tasks. The large time devoted to menial tasks in the past served as a "tax" on education since they required educated workers to spend more time on tasks at which they had less comparative advantage.

At the same time, the influx of more sophisticated technologies in the household, such as computers and the Internet, has enhanced the demand for skilled workers in the household just as it has in the marketplace. Based on evidence from the market sector we know that such new technologies benefit educated workers more than less educated workers, particularly when they are first introduced. This advantage may then fall somewhat over time as new devices mature and become simplified and easier to use.

Discussion

[MORE TO BE ADDED]

5. Multi-Person Households and Interactions with the Market

Up until this point, we have acted as if household consist of a single individual that must perform all tasks, and as if the market and household sectors exist in isolation. While this framework is useful for illustrating the key contrasts between the sectors, some additional insights can be gained by allowing for multi-person households, and interactions between the two sectors.

Several straight-forward results follow from considering multi-person households. The same gains that motivate specialization in the market generate gains to specialization across individuals in the household. In this case, individuals would like to partition tasks, and invest in productivities relatively specific to the subset of tasks they perform in equilibrium. In our model, this would generate an incentive to form household with heterogeneous members. Since we tend to see strong positive sorting across spouses in terms of the level of education, there must be other forces that work against this such as joint consumption and limits on the transfers that can take place within a household (see Becker and Murphy 2000). In addition, even though there has been strong sorting by education level, men and women still specialize at different tasks, and the areas of study in college have historically differed substantially between men and women.

This same force explains why household returns to education may be higher for individuals from less educated backgrounds while market returns to education may be lower for these same individuals. In terms of market returns, all workers sell there services in the same marketplace. As such, the market returns to education will differ by family background, when family background is an important complementary input to producing skills through education. Since, schooling is a highly education intensive activity in the market sector (historically it has employed the highest fraction of educated workers in the economy) educated parents are likely to have a strong comparative advantage at educating their children. As such, it would not be surprising that earnings rise faster with education for children raised in more educated households.

In contrast, non-market returns will differ not just according to differences in the ability to produce educated children but in the value of the output produced since output prices are not equalized across households. More educated individuals that come from less educated households may get a large gain due to the fact that there are few substitutes for these skills in household production. In the context of our model, they can specialize in performing the household tasks requiring the most education. Just as supply matters in the market sector and more educated workers do better when there are fewer educated workers, supply matters in the multi-person household, but in this case it is relative supply within the household rather than relative supply in the market as a whole. This can help explain why Elias (2005) finds that the effect of education on non-market outcomes is higher for those from poor family backgrounds.

6. Conclusion

[TO BE ADDED]

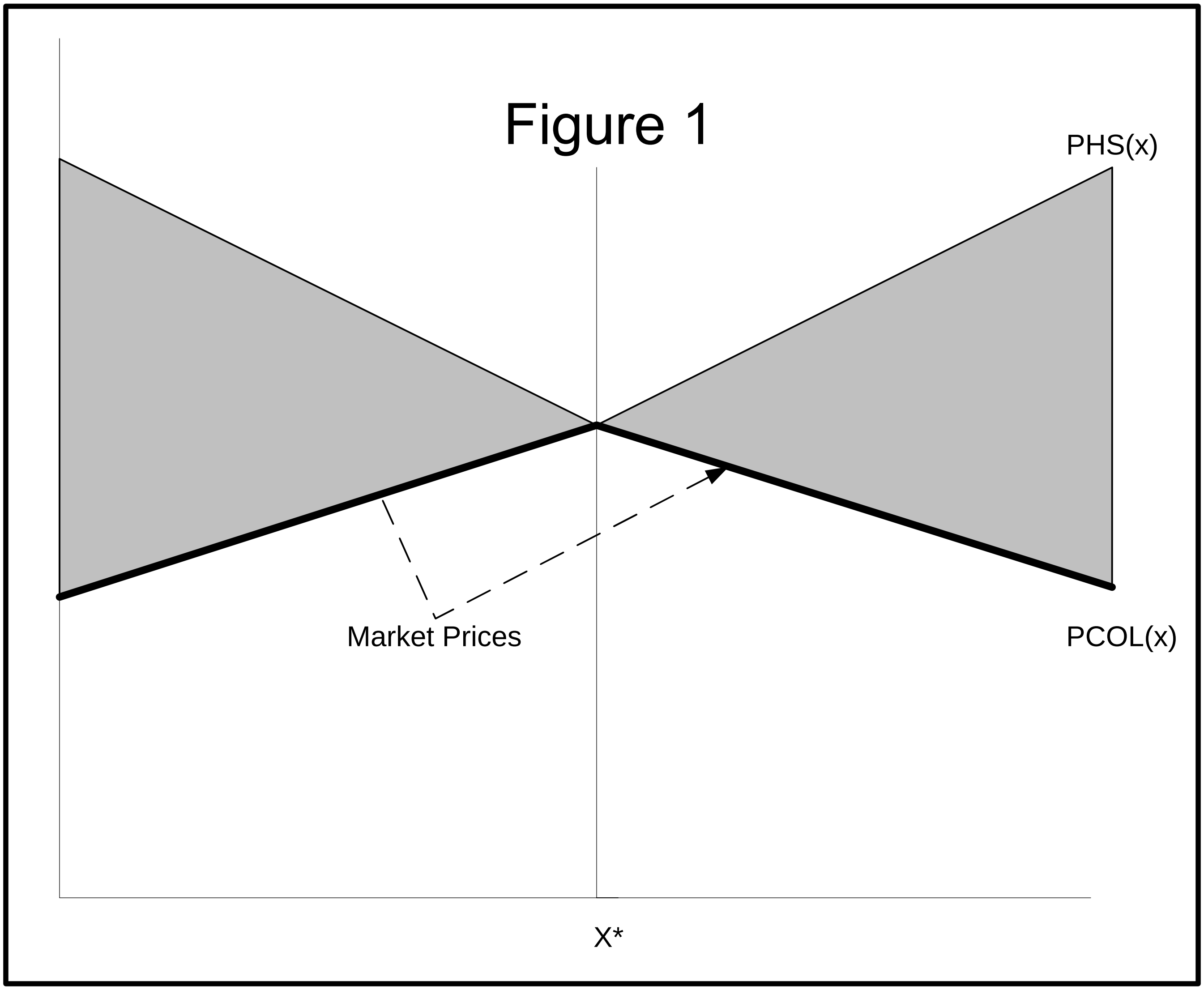

Figure 1

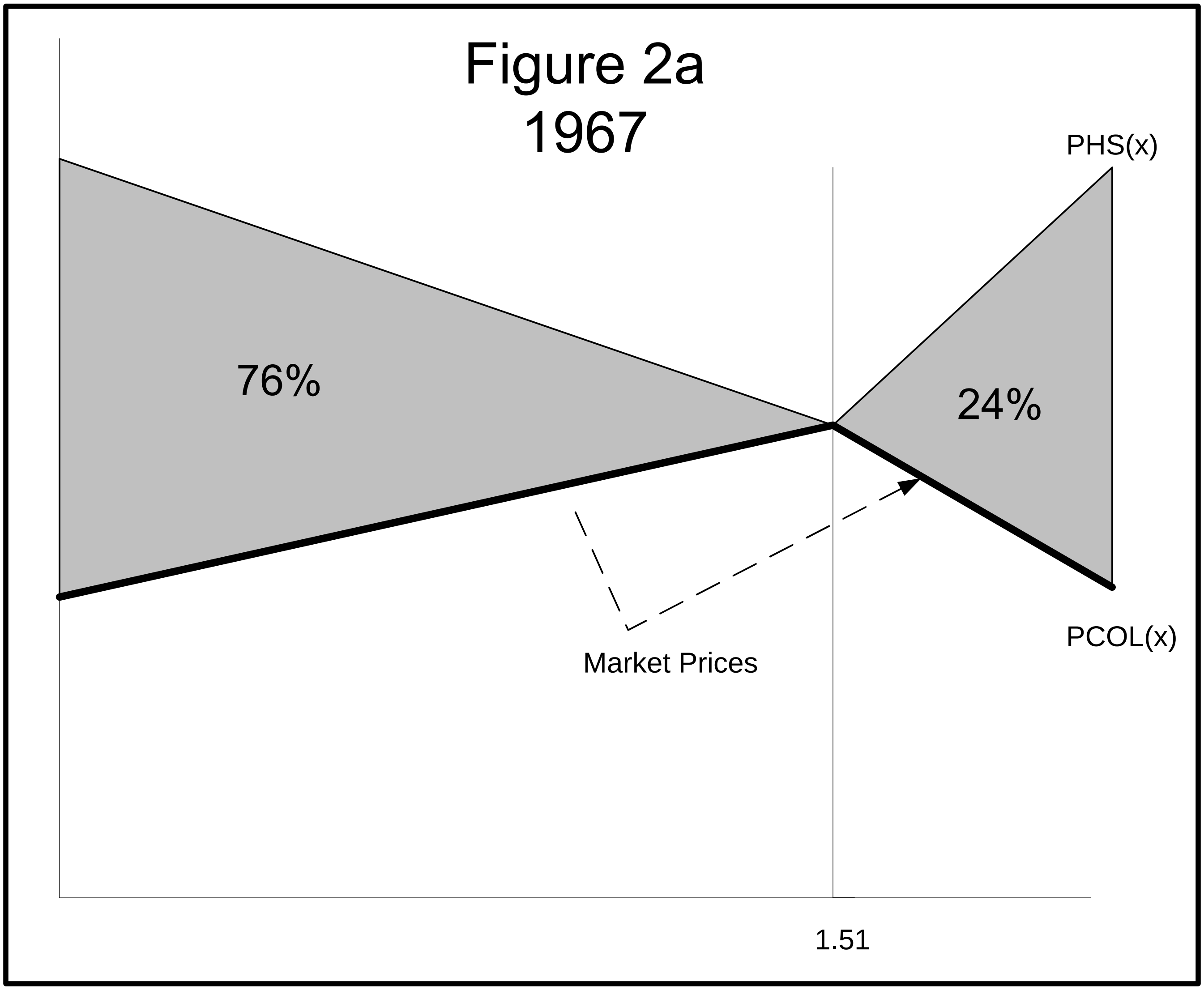

Figure 2a
1967

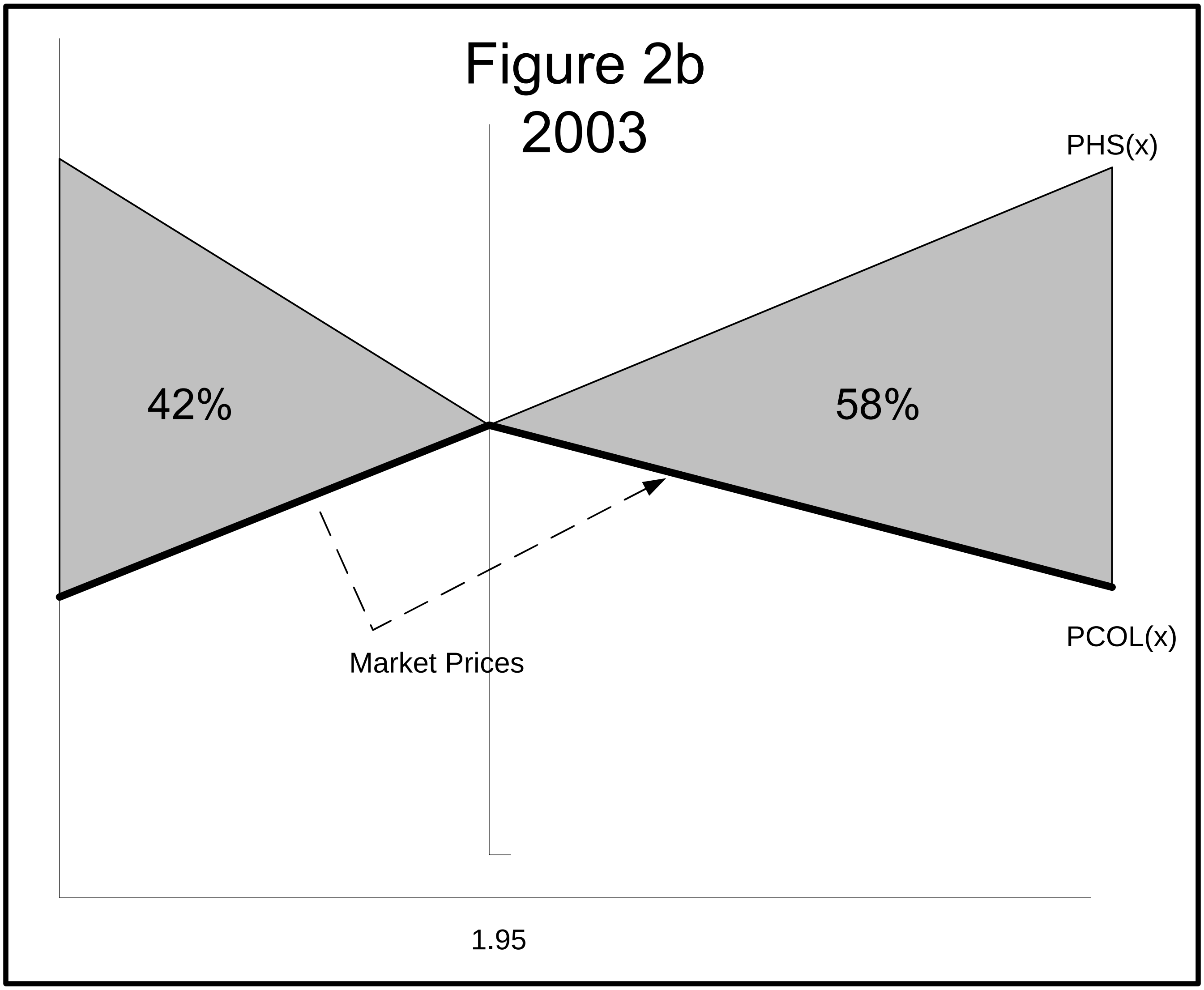
Figure 2b
2003
PHS(x)
42%
58%
PCOL(x)
Market Prices
1.95