Estimating Externalities to Experience in a Macro Mincer Model

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Introduction

This paper presents evidence that the age structure of the workforce matters for productivity. At first glance, this is unsurprising because standard Mincerian wage regressions show that workers with more schooling and more experience receive higher wages. If workers earn their marginal product, then the wage differential described by the Mincer evidence is a measure of the productivity difference between workers caused by different levels of schooling and experience.

However, the micro-Mincer estimations will only capture the private return to experience. It may be that there is a significant social return to experience that is not reflected in wages. Feyrer (2006) shows that the demographic structure of the workforce is related to productivity using a non-structural approach. This paper differs from this earlier work by explicitly aggregating the Mincerian wage equation. This allows for a direct estimation of the social return to experience that is directly comparable to estimates of the private return from microeconomic estimates. The results suggest that the social return to experience is much larger than the private return.

1 Mincerian Wage Regressions and Productivity

The canonical Mincer wage regression takes the following form.

\[ \log(wage) = \alpha + \beta_1 \times school + \beta_2 \times experience + \beta_3 \times experience^2 + \epsilon. \]  

(1)

Bils and Klenow (2000) collect a sample of these coefficients estimated for 52 countries. Using the average coefficients from their sample suggests that the private return to education and experience is

\[ \log(wage) = \alpha + 0.096 \times school + 0.051 \times experience - 0.00071 \times experience^2. \]  

(2)

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According to these estimates, an additional year of schooling increases the wage by 9.6%. If workers earn their marginal product, then the Mincer wage regressions should inform us about productivity differences between workers. The coefficients from these regressions can then be used to look at aggregate human capital differences. The cross country growth literature has tended to focus on years of schooling as the relevant variable of interest. Since we are turning to the Mincer evidence for guidance, it seems natural to examine the role of experience. Klenow and Rodriguez-Clare (1997) and Bils and Klenow (2000) use the micro evidence to examine cross country differences in experience and find that they play a relatively minor role.

According to the micro evidence, worker productivity rises with age up to about age fifty then falls somewhat. The Mincer evidence implies that there is about a 60% difference between the productivity of twenty years old workers and fifty year old workers. For the aggregate data, this implies that an economy with a large cohort of young workers will have lower productivity than an economy with an large cohort of older workers. This paper will see whether the aggregate effect is larger that the private effect on which these estimations are based.

\section{Estimating with the macro Mincer form}

This section will describe a cross country regression that is analogous to the Mincer regressions discussed in the previous section. The macro-Mincer specification implies that a worker will have log productivity level

\[\log(A_{i,j,t}) = \alpha_i + \alpha_t + \beta_0 \text{school}_{i,t} + \beta_1 \text{exp}_{i,j,t} + \beta_2 \text{exp}^2_{i,j,t} + \epsilon_{i,j,t}\]  

where \(A_{i,j,t}\) is the productivity level, \(\alpha_i\) and \(\alpha_t\) are time and country specific intercepts, \(\text{school}_{i,t}\) is the average years of schooling in country \(i\) at time \(t\), and \(\text{exp}_{i,j,t}\) is the average years of experience for person (or group) \(j\) in country \(i\) at time \(t\). The coefficients \(\beta_0\), \(\beta_1\) and \(\beta_2\) are equivalent to the coefficients from the micro mincer model.

Aggregate productivity in country \(i\) at time \(t\) is an average of the productivity levels over all the age groups weighted by the relative size of each age category.

\[A_{i,t} = \sum_j P_{i,j,t} A_{i,j,t} = \sum_j P_{i,j,t} e^{\alpha_i + \alpha_t + \beta_0 \text{school}_{i,t} + \beta_1 \text{exp}_{i,j,t} + \beta_2 \text{exp}^2_{i,j,t}}\]  

\[= e^{\alpha_i} e^{\alpha_t} e^{\beta_0 \text{school}_{i,t}} \sum_j P_{i,j,t} e^{\beta_1 \text{exp}_{i,j,t} + \beta_2 \text{exp}^2_{i,j,t}}\]  

\[\log A_{i,t} = \alpha_i + \alpha_t + \beta_0 \text{school}_{i,t} + \log \left( \sum_j P_{i,j,t} e^{\beta_1 \text{exp}_{i,j,t} + \beta_2 \text{exp}^2_{i,j,t}} \right) + \epsilon_{i,t}\]  

where \(P_{i,j,t}\) is the proportion of workers in age group \(j\) in country \(i\) at time \(t\). The coefficients from equation (6) can be estimated using non-linear least squares.

\footnote{While there is cross country variation in the coefficient estimates, the range of variation is relatively small. Bils and Klenow (2000) find coefficients on schooling as high as 0.28 (Jamaica) and as low as 0.024 (Poland). The majority of coefficients, however, fall between 0.05 and 0.15.}

\footnote{Klenow and Rodriguez-Clare (1997) conclude that schooling differences, when viewed through the lens of the Mincer evidence, cannot explain the majority of cross country income differences.}
3 Data

The data on workforce composition are from two sources. The International Labor Organization (ILO) has compiled cross country data on the labor force participation rates of workers by five year age groups. These participation rates are combined with data on population from the UN in order to produce worker counts by age group. The underlying population data are available at 5 year intervals. The participation rates (available at only ten year intervals) are interpolated to 5 year intervals and combined with the population counts to generate worker counts by age group at 5 year intervals. These counts are normalized by population and workforce size to produce workforce proportions by age group. The average experience for each group will be approximated by taking the average age in the group minus the average years of schooling for the country minus five.

These workforce demographics represent a product of population demographics and age specific labor participation rates. Age specific participation rates are potentially endogenous as they may be affected by aggregate economic conditions (overall participation rates do not enter the analysis). The population data provides a check for bias from this source. Population can be assumed to be predetermined in this analysis. By running the regressions on population data, we can confirm that this is not biasing the results.

Productivity is calculated as a Solow residual. I assume a Cobb-Douglas production function taking physical capital, human capital from schooling, and productivity as inputs.

\[ y_{i,t} = k_{i,t}^{\alpha} (A_{i,t} h_{i,t})^{1-\alpha} \quad (7) \]

where \( y_{i,t} \) is output, \( k_{i,t} \) is capital per worker, \( h_{i,t} \) is human capital per worker, and \( A_{i,t} \) represents productivity. Capital’s share of output, \( \alpha \) is assumed to be 1/3.\(^3\) The human capital production function is assumed to have a Mincer form

\[ h_{i,t} = e^{\phi(s_{i,t})} \quad (8) \]

where \( s_{i,t} \) is the average years of schooling in country \( i \) at time \( t \) and \( \phi(s) \) is an increasing function that is assumed to be piecewise linear with decreasing returns to scale. The coefficients are taken from Psacharopoulos (1994), which surveys the literature on returns to schooling.\(^4\) The production function can be solved for the productivity term.

Data for output are from the Penn World Tables version 6.0. Following Hall and Jones (1999), output data are adjusted to exclude income from mining and oil.\(^5\) Data for capital per worker are from Easterly and Levine (2001).\(^6\) The schooling data used to calculate human capital stocks are from Barro and Lee.

\(^3\)Gollin (2002) shows that capital’s share is roughly equal across counties.
\(^4\)The choice of coefficients follows Hall and Jones (1999). For the first four years of schooling the return to schooling in sub-Saharan Africa, 13.4 percent, is used. For schooling from four to eight years the world average return to schooling, 10.1 percent, is used. For schooling beyond 8 years the OECD return to schooling, 6.8 percent, is used. The precise method of calculating human capital from schooling is unimportant for the results.
\(^5\)This correction is taken from UN national accounts data, as collected in Aiyar and Feyrer (2002). Because the regressions in this paper exclude oil exporting countries, the corrections are quite minor and have very little impact on the results.
\(^6\)Their calculations, in turn, are based on the Penn World Tables 5.6. Both are available from the World Bank website (http://www.worldbank.org/research/growth).
Two different samples are used, an 87 country sample that includes all countries for which complete data exists, excluding oil exporters. The second sample is limited to 19 countries in the OECD. The data for each sample make up a panel at five year intervals from 1960 to 1990.

4 Results

The model will be estimated in two ways depending on the method of calculating the Solow residual. In columns which exclude the total years of schooling variable the Solow residual is calculated in the manner described above, accounting for differences in schooling as well as differences in capital per worker. In columns which include years of schooling, the Solow residual only accounts for differences in capital per worker. The two different forms are included to check for bias due to the inclusion of total years of schooling in calculating experience.

The results are reported in Table 1. Coefficients from microeconomic Mincer studies are also presented for comparative purposes in columns (1) and (2). The results resemble the microeconomic evidence in the shape of the function and the location of the peak of the quadratic. The coefficients on schooling are also similar to the micro evidence. However, the magnitude of the experience coefficients is dramatically larger than microeconomic studies suggest. Glaeser, Sacerdote and Scheinkman (2003) describe the ratio of coefficients obtained at different levels of aggregation as the “social multiplier.” This ratio summarizes the differences between the private return and the social return. In this case the value of the social multiplier for experience is roughly ten.

The results are highly significant for the non-oil sample. The OECD results are consistent with the full sample results, though the individual coefficients are only significant at the 10% level. The magnitude of the effects are quite large, but are roughly consistent with the results of Feyrer (2006) where a much less structural estimation is performed. Regressions using the population proportions rather than the work force proportions are virtually identical, suggesting that endogeneity of participation rates is not biasing the results.

Also interesting is the lack of evidence of large externalities to schooling. For the non-oil sample, the returns to schooling are somewhat higher than the private returns (14.3% versus 9.6%), but the method of estimation likely overstates the effect of schooling due to missing variable bias. For the OECD, the estimated effect of schooling is actually lower than the private return, though the confidence interval encompasses the private figure.

5 Conclusion

The topic of externalities to human capital in the form of schooling is much studied. Externalities to human capital in the form of experience by contrast have been relatively ignored. This note suggests that there are significant and large externalities to experience

\[ \text{The difference between forms one and two is roughly equivalent to restricting the coefficient } \beta_0 \text{ to be equal to the value from micro studies.} \]

\[ \text{The comparison numbers are averages of coefficients compiled in Bils and Klenow (2000).} \]

\[ \text{In a much better identified studied focused more squarely on education, Acemoglu and Angrist (2000) cannot reject the hypothesis that private and social returns to education are equal.} \]
across countries. The aggregate results suggest that the social return to experience is an order of magnitude larger than the private return. This is an important results for several reasons. First, poor countries tend to be much younger, on average, than rich countries. These results can therefore explain some portion of cross country income differences. Second, many of the rich countries are aging rapidly. The results presented here can help us understand how this aging will affect productivity growth.

References


Table 1: The Effect of Experience on Productivity – Mincer Functional Form

<table>
<thead>
<tr>
<th>Sample Regressors</th>
<th>Microeconomic Estimates</th>
<th>Aggregate Productivity NLLS</th>
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<tbody>
<tr>
<td></td>
<td>(1) Nonoil Work</td>
<td>(3) Nonoil Work</td>
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<tr>
<td></td>
<td>(2) OECD Work</td>
<td>(4) Nonoil Work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5) Nonoil Pop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6) Nonoil Pop</td>
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<td></td>
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<td>(7) OECD Work</td>
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<td></td>
<td></td>
<td>(8) OECD Work</td>
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<td>0.575 (0.043)**</td>
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<td>school</td>
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<tr>
<td></td>
<td>0.066</td>
<td>0.154 (0.001)**</td>
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<td>Quadratic Peak</td>
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<td>30.5 (2.2)</td>
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<td>33.2 (2.8)</td>
<td>38.0 (3.5)</td>
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<td>37.6 (1.2)</td>
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<td>Countries</td>
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Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%