HUMAN CAPITAL, THE STRUCTURE OF PRODUCTION, AND GROWTH

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D-2005-07

October 2005

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Abstract

Do high levels of human capital foster economic growth by facilitating technology adoption? If so, countries with more human capital should have adopted more rapidly the skilled-labor augmenting technologies becoming available since the 1970's. These countries should therefore have experienced faster growth in more compared to less human-capital-intensive industries in the 1980's. We also examine whether human capital accumulation was associated with faster growth in human-capital-intensive industries. Our empirical analysis yields robust support for such human capital level and accumulation effects using industry-level production and employment data in manufacturing for a large sample of countries.

1 Introduction

Following Barro (1991) and Mankiw, Romer, and Weil (1992), there has been an upsurge of empirical research on the effects of human capital on economic growth. The main issues analyzed are whether higher levels of education or greater improvements in education are associated with faster output growth. Overall, the cross-country evidence is mixed on both counts (notwithstanding the emphasis on human capital in new growth theories and recent neoclassical growth theories).[1] This could be because of difficulties when specifying cross-country growth regressions (Temple, 1999; Durlauf, Johnson, and Temple, 2005). For example, the limited number of countries forces researchers to use parsimonious specifications to avoid the degrees of freedom problem. Another reason could be attenuation bias due to mismeasured schooling data (Krueger and Lindahl, 2001; Cohen and Soto, 2001; de la Fuente and Domenech, 2001, 2005). Such attenuation bias could be magnified by multicollinearity, often present in cross-country growth regressions, as high-growth countries tend to have higher rates of human capital accumulation, deeper financial markets, stronger property rights protection, higher savings and investment rates etc. (Mankiw, 1995; Rajan and Zingales, 1998). Mixed results could also be due to schooling indicators used in empirical work often missing cross-country differences in educational quality (Hanushek and Kimko, 2000; Barro, 2001). In any case, a significantly positive correlation between schooling and output growth does not imply that schooling affects growth. Instead, both schooling and output growth could be driven by an omitted variable, total-factor-productivity growth for example (Bils and Klenow, 2000).

One way to progress in our understanding of the effects of human capital on growth is to focus on channels through which such effects could work. It is often argued that high levels of human capital facilitate technology adoption (e.g. Nelson and Phelps, 1966; Barro, 1991; Benhabib and Spiegel, 2002; Acemoglu, 2003a; Caselli and Coleman, 2005). There is a consensus that new technologies becoming available since the 1970's tended to be more

[1] The empirical studies of Romer (1990a), Barro (1991), and Benhabib and Spiegel (1994) find a significantly positive effect of schooling levels on output growth, while Cohen and Soto (2001) find no link. Temple (1999), Cohen and Soto (2001), and de la Fuente and Domenech (2001, 2005) find a significantly positive correlation between improvements in education and growth, while Benhabib and Spiegel (1994), Barro and Sala-i-Martin (1995), Caselli, Esquivel, and Lefort (1996), and Pritchett (1997) find no effect of schooling improvements on growth. Topel (1999) and Krueger and Lindahl (2001) find both education level and improvement effects on growth. Examples of endogenous growth theories emphasizing human capital are Lucas (1988) and Romer (1990b). Mankiw, Romer, and Weil (1992) incorporate human capital into a neoclassical growth model.

skilled-labor augmenting than the technologies of the 1950's and 1960's (e.g. Autor, Katz, and Krueger, 1998; Berman, Bound, and Machin, 1998; Berman and Machin, 2000; Caselli and Coleman, 2002). The defining characteristic of skilled-labor augmenting technologies is that they increase the productive efficiency of skilled relative to unskilled workers. Skilled-labor augmenting technologies therefore result in fast total-factor-productivity (TFP) growth in human-capital-intensive industries (e.g. Kahn and Lim, 1998; Klenow, 1998). As a result, countries adopting new technologies quickly should experience fast output growth in human-capital-intensive industries, once country and industry-specific growth factors are controlled for. If high levels of human capital facilitate technology adoption, output growth in human-capital-intensive industries should be faster in economies with high levels of human capital. We therefore test whether countries with higher education levels experienced faster growth in more compared to less schooling-intensive industries in the 1980's. Theories of international specialization point to human capital accumulation as another important determinant of rapid growth in human-capital-intensive industries (e.g. Ventura, 1997, 2005; Romalis, 2004). Hence, we also examine the link between country-level improvements in education and growth in schooling-intensive industries.

We investigate such human capital level and accumulation effects using data for 37 manufacturing industries in around 40 countries. Our empirical analysis builds on the framework and database of Rajan and Zingales (1998) and subsequent contributions to the finance and industry growth literature (e.g. Claessens and Laeven, 2003; Fisman and Love, 2003, 2004). We follow this literature in using U.S. data to obtain the industry-characteristics necessary for the empirical analysis. In particular, we use detailed 1980 U.S. Census data to calculate indicators of cross-industry differences in human capital intensity. These indicators allow us to test whether greater human capital levels and faster human capital accumulation were associated with faster growth in human-capital-intensive industries.

Our data yields statistically robust and economically significant support for the human capital level effect. To get a sense for the size of this effect, consider the annual output growth differential between an industry with a schooling intensity at the 75th percentile (Chemicals) and an industry at the 25th percentile (Pottery). When we measure the level of human capital using schooling quality indicators, our estimates imply that this growth differential is around $1.3\% - 2.1\%$ higher in a country with schooling quality at the 75th percentile (e.g. Malaysia) compared to a country with schooling quality at the 25th percentile (e.g. Philippines). For comparison, the average growth rate of value added in our sample is

3.4% and the median growth rate is 2.9%. When we proxy human capital levels using average years of schooling, the implied annual Chemicals-Pottery growth differential is $1.1\% - 1.8\%$ greater in countries with average schooling in 1980 at the 75th percentile (e.g. Japan with 8.2 years of schooling) than countries with average schooling at the 25th percentile (e.g. Portugal with 3.3 years). In line with recent findings in the cross-country growth literature (Hanushek and Kimko, 2000; Barro, 2001; Hanushek, 2004), schooling quantity levels often become only marginally significant or insignificant when labor force quality is accounted for.

We also find statistically robust and economically significant support for the human capital accumulation effect. For example, our estimates imply that the annual Chemicals-Pottery growth differential is $1\% - 1.2\%$ greater in countries with improvements in average schooling over the 1970-1990 period at the 75th percentile (e.g. the Philippines with an improvement of 2.3 years) than countries with increases at the 25th percentile (e.g. Sri Lanka with 1.1 years).

Our estimates of the impact of human capital on growth in human-capital-intensive industries control for country-specific and industry-specific effects. Industry effects capture movements in prices and technological innovation at the industry level. Country effects capture growth at the country level related to difficult-to-measure factors like economic policy, institutions, and social norms for example. Such factors are likely to also impact human capital accumulation. For example, economic reform may combine measures that stimulate economic growth with policies that foster education. Moreover, as shown by Bils and Klenow (2000), all factors causing rapid country-level TFP growth raise the return to human capital accumulation and will therefore lead to education investments. Omitting such country-level growth factors may therefore result in upward biased estimates of the effect of human capital on growth.

Our empirical analysis jointly considers the growth effects of human capital and those of financial markets and property rights protection emphasized in the literature. This allows us to check the robustness of industry growth effects of financial development and property rights protection to controls for human capital (and vice versa). We find that financial development and property rights protection continue to have disproportionate growth effects in industries that depend on finance (Rajan and Zingales, 1998) and use intangible assets intensively (Claessens and Laeven, 2003) respectively, even when human capital is taken into account. The magnitude of such effects drops by $15\% - 40\%$ however. In contrast, industry growth effects of financial development working through inter-industry resource reallocation and dependence on trade credit (Fisman and Love, 2003, 2004) remain nearly unchanged.

The international specialization implication of the human capital-technology adoption connection that we test is: high human capital –> rapid (skilled-labor augmenting) technology adoption –> fast output growth in schooling-intensive industries. Fast growth in schooling-intensive industries should coincide with the reallocation of production factors. To test for such factor-reallocation effects, we add industry-level employment statistics to the finance and industry growth database. We find significant and robust support for employment shifting to schooling-intensive industries in countries with high levels of education. The employment growth data also supports the hypothesis that improvements in education lead to the reallocation of employment to schooling-intensive industries.

While economies open to international trade can specialize in production, specialization is impossible in closed economies. We therefore examine the effect of high human capital levels and rapid human capital accumulation on growth in human-capital-intensive industries separately in countries with low and countries with high tariffs. In economies with low tariffs, we find positive and highly significant effects of education levels and improvements on output growth in schooling-intensive industries. In economies with high tariffs, we usually find such effects to be statistically insignificant. Protectionist trade policies therefore appear to break the link between country-level human capital and specialization in human-capital-intensive industries. These results complement those of Romalis (2004). He shows that U.S. imports from countries that accumulated human capital rapidly grew especially fast in human-capital-intensive industries. As pointed out by Ventura (1997), it is such shifts in the production and trade structure that allow open economies to avoid falling returns to human capital.

The remainder of the paper is structured as follows. Section 2 presents a model that illustrates the effects of human capital on growth in more compared to less human-capital-intensive industries. Section 3 explains the sources and main features of our data. Section 4 presents our main empirical results. Section 5 presents additional evidence. In Section 6 we perform sensitivity checks. Section 7 concludes.

2 Theoretical Framework

We now explain how a country's capacity to adopt world technologies, which following Nelson and Phelps (1966) we assume depends on its human capital, may affect production in human-capital-intensive industries. Our theoretical framework links human capital and industry production both in steady-state and during the transition to a new steady state triggered by an acceleration of skilled-labor augmenting technical change. This allows us to illustrate the positive effect of initial human capital on output growth in human-capital-intensive industries during such a transition.

The world consists of many open economies, indexed by $c \in C$, that can produce in two industries, indexed by $s = 0, 1$. There are two types of labor, high and low human capital, and we denote their supply by M_c and L_c respectively. The efficiency levels A^L and A^M of the two types of labor evolve over time and depend on each country's capacity to adopt world technologies. Following Nelson and Phelps (1966), we assume efficiency growth $\hat{A}^f_{c,t} = \left(\partial A^f_{c,t}/\partial t\right)/A^f_{c,t}$ of labor of type $f = L, M$ (hats indicate growth rates) to be increasing in the gap between country efficiency $A^f_{c,t}$ and world-frontier efficiency $A^{f,W}_t$ (W indicates the world frontier),

$$\hat{A}^f_{c,t} = \phi^f\left(H_c\right)\left(\frac{A^{f,W}_t - A^f_{c,t}}{A^f_{c,t}}\right) \tag{1}$$

where $\phi^f\left(H_c\right)$ captures the country's capacity of technology adoption, which is increasing in its human capital $H_c = M_c/L_c$. The only difference between this framework and that of Nelson and Phelps is that we distinguish between technologies augmenting the efficiency of high and low human capital workers, as in the literature on skill-biased/directed technical change (e.g. Acemoglu, 1998, 2003a; Acemoglu and Zilibotti, 2001; Caselli and Coleman, 2002, 2005).[2]

Output $X_{s,c}$ in industry s and country c is produced according to $X_{s,c} = D_c E_s (A^L_c L_c)^{1-s}(A^M_c M_c)^s$. D captures country-level efficiency and E industry-specific technology (both of which may change over time). Hence, industry 1 uses only high human capital labor, while industry 0 uses only low human capital labor. This extreme assumption on factor intensities simplifies our analysis, but is not necessary for the implications that follow.

[2] Acemoglu (2003b) discusses the relationship between the Nelson and Phelps model and the literature on directed technical change.

To examine how steady-state production levels depend on a country's capacity to adopt technologies we suppose constant efficiency growth at the world- frontier, $\hat{A}_t^{L,W} = g^L$ and $\hat{A}_t^{M,W} = g^M$. Each country's human capital H_c, and hence its capacity to adopt technologies (ϕ_c^L and ϕ_c^M), are assumed to be constant in time. In steady-state, efficiency in each country grows at the same rate as at the world-frontier. Equation (1) therefore implies that the steady-state level of efficiency of labor of type $f = L, M$ in country c is $A_{c,t}^{f*} = \frac{\phi_c^f}{g^f + \phi_c^f} A_t^{f,W}$ ($*$ denotes steady-state values). Hence, the greater the capacity of countries to adopt technologies, the closer their steady-state efficiency level to the world-frontier. It is now immediate to determine output in sector s in country c as

$$X_{s,c,t}^* = D_{ct} E_{st} L_{ct} \left(\frac{\phi_c^L}{g^L + \phi_c^L} A_t^{L,W} \right)^{1-s} \left(\frac{\phi_c^M}{g^M + \phi_c^M} A_t^{M,W} H_c \right)^s . \tag{2}$$

Steady-state production in the high as compared to the low human capital industry, $Z_{c,t}^* = X_{1,c,t}^* / X_{0,c,t}^*$, between countries c and q is therefore

$$\frac{Z_c^*}{Z_q^*} = \left[\frac{H_c}{H_q} \right] \left[\frac{\left(\phi_c^M / \phi_c^L \right) \left(\frac{g^L + \phi_c^L}{g^M + \phi_c^M} \right)}{\left(\phi_q^M / \phi_q^L \right) \left(\frac{g^L + \phi_q^L}{g^M + \phi_q^M} \right)} \right] . \tag{3}$$

This expression does not depend on country-level efficiency because we are comparing two industries within each country; it does not depend on industry-level technology because we are comparing the same industries in different countries.

Equation (3) implies that country c's human capital H_c has a factor supply effect and a technology adoption effect on its steady-state production structure as compared to country q. The factor supply effect (captured by the first bracket) is straightforward. An increase in human capital means an increase in the relative supply of the factor used by the human-capital-intensive industry and therefore relatively greater human-capital-intensive production. The focus of our theoretical framework is on the technology adoption effect (captured by the second bracket). This effect can reinforce the factor supply effect or work in the opposite direction, depending on whether it is skilled or unskilled-labor-augmenting technology that is progressing faster at the world frontier. For example, consider the case where human capital has the same impact on the capacity to adopt skilled and unskilled-labor augmenting technologies, $\phi^M(H) = \phi^L(H)$ for all H. Suppose first that skilled-labor augmenting technical progress at the world frontier exceeds unskilled-labor augmenting technical progress,

$g^M > g^L$. In this case, a higher level of human capital H_c will translate into more human-capital-intensive production in the long run through the technology adoption effect. This is because human capital facilitates the adoption of all technologies equally and it is skill-augmenting technology that is advancing more rapidly at the frontier. Now suppose instead that $g^L > g^M$. In this scenario, it is unskilled-labor augmenting technology that is progressing faster at the frontier. The technology adoption effect of higher human capital levels will therefore shift production towards the low human capital industry.

We now suppose that skilled-labor augmenting efficiency growth g^M at the world frontier increases at some time T.[3] Equation (3) implies that this acceleration of skilled-labor augmenting technical change translates into an increase in Z_c^*/Z_q^* if and only if $H_c > H_q$. Countries with high levels of human capital will therefore experience an increase in steady-state production levels in the human-capital-intensive industry. As a result, they will see relatively faster growth in the human-capital-intensive industry during the transition to the new steady-state.[4] Formally, using lower-case variables to denote logs of upper-case variables,

$$\text{(4)} \qquad \Delta z_c - \Delta z_q = [z_{c,t} - z_{c,T}] - [z_{q,t} - z_{q,T}] = g(\underset{+}{h_{c,T}}) - g(\underset{+}{h_{q,T}})$$

for $t > T$, where $g(h)$ is strictly increasing in h. Combined with (3), this implies that growth of value added $Y_{s,c,t} \equiv P_{s,t}X_{s,c,t}$ in industry s and country c is

$$\text{(5)} \qquad \Delta y_{s,c} = y_{s,c,t} - y_{s,c,T} = \underbrace{[\Delta d_c + \Delta l_c]}_{\lambda_c} + \underbrace{[\Delta p_s + \Delta e_s]}_{\mu_s} + g(\underset{+}{h_{c,T}})s.$$

The country-specific growth effect λ_c captures country-level labor-force growth and total-factor-productivity growth, while the industry-specific growth effect μ_s is the sum of price changes and industry-specific technical progress.

According to (5), the impact of initial human capital on industry output growth is greater

[3] For evidence that there was such an acceleration sometime around the early 1970's, see Autor, Katz, and Krueger (1998), Berman, Bound, and Machin (1998), Berman and Machin (2000), and Caselli and Coleman (2002). We take this acceleration to be exogenous. See Acemoglu (1998, 2002) and Acemoglu and Zilibotti (2001) for models that endogenize the rate of directed technical change at the technology frontier.

[4] This is because they adopt new skill-augmenting technologies more rapidly. Many of the new technologies becoming available since the 1970's were embodied in computers. Faster technology adoption in countries with high human capital levels should therefore be accompanied by greater computer imports. This is what Caselli and Coleman (2001) find for the 1970-1990 period.

in the human-capital-intensive industry.[5] This is what we refer to as the human capital level effect on output growth in human-capital-intensive industries.

So far we have assumed that human capital in each country is constant in time. As a result, human capital affects industry output growth only through technology adoption in (5). When human capital levels increase in time there is also a factor supply effect on output growth in human-capital-intensive industries.[6] As industries are assumed to be at opposite extremes in terms of their human capital intensity, this effect takes a particularly simple form in our framework. A one percent increase in human capital leads to a one-point output growth differential between the high and the low human capital industry. With non-extreme factor intensities, the implied output growth differential would be larger (e.g. Ventura, 1997). This is because an increase in human capital would lead to labor moving from the less to the more human capital intensive industry (assuming the economy is not fully specialized). We refer to the effect of factor supply on output growth in human-capital-intensive industries as the human capital accumulation effect.

The factor supply effect linking human capital and relative production levels in the human-capital-intensive industry in (3) does not carry through to single industry pairs in a neoclassical multi-industry model. It can be shown, however, that human capital abundant countries will still specialize in human-capital-intensive industries on average (e.g. Deardorff, 1982; Forstner, 1985). Furthermore, as shown by Romalis (2004), the positive effect of human capital abundance on relative production levels in human-capital-intensive industries re-emerges for single industry pairs once monopolistic competition and transport costs are incorporated into an otherwise standard neoclassical multi-industry model.[7]

[5] During the transition, the TFP growth differential between the high and the low human capital industry is greater in a country with high as compared to a country with low human capital. Our framework does not make predictions about whether this TFP growth differential is positive or negative. The evidence on the link between human capital intensity and TFP growth across U.S. industries is mixed. While there appears to be a positive link in the late 1970's and early 1980's (Kahn and Lim, 1998), there is no such relationship over long periods (Klenow, 1998).

[6] In principle, increases in human capital could also affect industry output growth through technology adoption. Such effects are likely to be small in our application, however, because it takes time for additional human capital to translate into new technologies.

[7] Romalis (2004) integrates the Dornbusch, Fischer, and Samuelson (1980) two-factor multi-industry Heckscher-Ohlin model with Krugman's (1980) trade model with monopolistic competition and trade costs. He shows that this yields cogent theoretical foundation for cross-country cross-industry comparisons.

3 Data

Data on real growth in value added during the 1980's at the country-industry level ($GROWTH_{s,c}$) are taken from the finance and industry growth literature (e.g. Rajan and Zingales, 1998; Claessens and Laeven, 2003; Fisman and Love, 2003, 2004) and have originally been put together by Rajan and Zingales (henceforth RZ) using the United Nations General Industrial Statistics Database. The data refer to 37 industries in 44 countries.[8] We match this data with country-industry employment growth during the 1980's ($EMPGR_{s,c}$) using the latest update of the UNIDO industrial statistics database (UNIDO, 2004).[9]

The finance and growth literature is also the source of the industry-level data needed to account for the effects of financial development and property rights protection on growth. RZ argue that financial development should matter most for finance-dependent industries. To test this hypothesis they develop an industry-level measure of "external-finance dependence" ($EXTFIN$) using COMPUSTAT financial statement data for U.S. firms in the 1980's. Claessens and Laeven (2003) use the same data source to obtain a measure of the intangible asset intensity of industries ($INTANG$) and show that intangible-asset-intensive industries grow faster in countries with better property rights protection. Additional industry characteristics will be discussed as we use them.

Our industry-level measures of human capital intensity are also based on U.S. data. The main reason is the detail and quality of U.S. industry statistics. Another reason is that U.S. labor markets are less regulated than those of other high-income countries for which some industry data are available (Djankov *et al.*, 2004). Observed differences in human capital intensities across industries are therefore likely to better reflect underlying technological characteristics of industries. Moreover, as we examine the role of human capital for industry growth jointly with that of finance and property rights, it is natural to maintain the same benchmark country for industry-level measures as the finance and growth literature. Using U.S. data to proxy for differences in human capital intensities across industries in all other countries does have drawbacks. Most importantly, it could lead us to reject our hypotheses linking country-level human capital to growth in human-capital-intensive industries not

[8] The Data Appendix lists the countries in the sample. The country-industry data is reported at the 3 and 4-digit industry level. RZ do not include the U.S. in their sample because all necessary industry characteristics are obtained using U.S. data.

[9] Employment growth refers to the 1981-1990 period (while the output growth data refers to the 1980-1989 period), because the UNIDO database does not contain much employment data before 1980.

because they are false but because U.S. data does not yield good proxies for cross-industry differences in human capital intensities in other countries. What matters for avoiding such false negatives (Type I error) is that differences in the human capital intensity across U.S. industries reflect inter-industry differences in human capital intensities in other countries. It is not necessary for industries to use human capital with the same intensity in different countries.

The data source for our industry-level measure of human capital intensity is the 1980 Integrated Public Use Microdata Series. This database contains individual-level data on hours worked by 4-digit industry classifications and years of education. This allows us to calculate average years of employee schooling ($HCINT$) for all industries in the RZ sample.[10] Table I reports the schooling intensity for all industries. The two most schooling-intensive industries are Drugs and Computing and the two least schooling-intensive are Leather and Apparel.[11] Table II, Panel A gives the correlation between $HCINT$ and the industry-level rankings used in studies on finance and industry growth. The correlation between schooling intensity and external finance dependence is positive (0.56) and significant. Hence, controlling for $HCINT$ may be important to precisely quantify the differential growth effect of finance on finance-dependent industries.

Average years of schooling at the country level (SCH) is taken from the Barro and Lee (2001) database. For completeness and to address issues related to measurement error we also employ the schooling dataset of Cohen and Soto (2001). Starting with Hanushek and Kimko (2000), recent work (e.g. Barro, 2001; Bosworth and Collins, 2003) has found that schooling quality is at least as important as years of schooling for explaining economic growth. Hanushek and Kimko collect data on the results of internationally administered tests in mathematics and sciences. They process the data to make them comparable across years and countries and extend the resulting measure of schooling quality to additional countries by estimating a model of schooling-quality determination. We use their schooling quality measure as extended and updated by Bosworth and Collins (2003). Following Hanushek and Kimko, we refer to this measure as labor-force quality ($LFQUAL$).

[10] We also calculate the share of employees with at least 12 years of education (necessary for completing secondary school) and at least 16 years of education (necessary for completing college), $HCINT(SEC)$ and $HCINT(COLL)$ respectively. Table II, Panel A shows that the correlations with average schooling are above 0.92.

[11] The share of non-production workers in total employment ($NONPROD$) has often been used to measure industry human capital intensity (e.g. Romalis, 2004). Table II, Panel A shows that the correlation between $NONPROD$ and our schooling-based measures of human capital intensity is quite high.

Country-level financial development measured as private credit over GDP ($PRIV$) and the country-level indicator of property rights protection ($PROP$) are taken from Fisman and Love (2003) and Claessens and Laeven (2003) respectively.[12] Table II, Panel B gives the correlation between the main country-level variables. The correlation between education and financial development is significantly positive (0.42), as is the correlation between education and property rights protection (0.61). Hence, controlling for education may be important to precisely quantify the channels through which financial development and property rights impact industry growth. Other country-level variables come from standard sources. The Data Appendix provides detailed definitions and sources for all variables.

4 Main Results

We start by examining whether countries with higher levels of human capital experienced faster growth in more compared to less human-capital-intensive industries in the 1980's. Then we turn to the hypothesis that growth in human-capital-intensive industries was positively related to human capital accumulation. We conclude this section by examining the two hypotheses jointly.

4.1 Human Capital Level and Industry Growth

We test for the effect of human capital levels on growth in human-capital-intensive industries using the following estimating equation:

$$(6) \qquad \Delta y_{s,c,1990-1980} = \lambda_c + \mu_s + \delta\left(h_{c,1980} * HCINT_s\right) + OtherControls$$

where the dependent variable is real valued added growth in industry s in country c ($GROWTHs, c$). $HCINT$ captures the human capital intensity of industries and h the initial level of human capital of countries. λ and μ are vectors of country and industry-specific growth effects respectively (that capture the effects of all variables determining growth at the country and industry level). $OtherControls$ stands for interactions between industry and country-characteristics used to capture the differential industry growth effects of finance and property

[12] We also experiment with other measures of financial development, such as stock market capitalization to GDP (e.g. Rajan and Zingales, 1998) and domestic credit to GDP (e.g. Fisman and Love, 2003). All our results are robust to using these indicators instead of private credit to GDP.

rights protection in the literature. It also includes the share of industry s in total manufacturing value added of country c at the beginning of the sample ($FRACT_{s,c}$), which RZ and subsequent contributions to the finance and industry growth literature use to account for initial conditions. There is a human capital level effect on growth in human-capital-intensive industries if $\delta > 0$.

The results are reported in Table III. t-statistics adjusted for heteroskedasticity are reported in parentheses and italics below the point estimates. In columns (1)-(4) human capital levels are proxied by Barro-Lee average years of schooling (SCH) in 1980. The estimate of δ in column (1) is 0.0034 and highly statistically significant. This coefficient implies an annual growth differential of 1.77% between the industry at the 75th percentile (Chemicals) and the 25th percentile (Pottery) of human capital intensity in a country with average schooling years at the 75th percentile (e.g. Japan) compared to a country at the 25th percentile (e.g. Portugal). This implied growth differential is tabulated for all specifications in the bottom row of the Table. The education level effect is somewhat larger in magnitude than the (analogously calculated) unconditional effect of financial development on growth in finance-dependent industries documented by RZ (0.9%-1.3%). It is also somewhat larger than Claessens and Laeven's (2003) unconditional effect of property rights protection on growth in industries that use intangible assets intensively (1%-1.4%).

In columns (2)-(4) we estimate the effect of high levels of schooling on growth in schooling-intensive industries controlling for the role of financial development and property rights protection for growth in finance-dependent and intangible-asset-intensive industries respectively. The positive impact of human capital levels on growth in human-capital-intensive industries is robust to the inclusion of the RZ finance interaction ($PRIV_c * EXTFIN_s$) in column (2) and the inclusion of the Claessens and Laeven (2003) property rights interaction ($PROP_c * INTANG_s$) in column (3). When we control for both the finance and the property rights interactions in column (4), however, the human capital level effect drops by a third and becomes (marginally) insignificant.

To investigate the link between the effect of human capital levels on industry growth and industry human capital intensity in a more flexible way we implement the following two-step approach. In the first step we estimate the marginal effect of average years of schooling in 1980 on industry output growth separately for each industry. This is done by replacing $\delta h_c * HCINT_s$ in (6) with $\sum_i \delta_i h_c * I[i = s]$ where $I[i = s]$ is an indicator variable that is unity when i equals s and zero otherwise. In the second step we plot the estimated industry-specific marginal growth effects δ_s against industry schooling intensity ($HCINT_s$). The positive correlation between the two is evident in Figure 1a. Moreover, this correlation does not appear to be driven by a few industries only. Higher education levels are therefore relatively more important for the growth of industries that employ schooling more intensively. The correlation is, however, weaker in Figure 1b where we use estimates of marginal growth effects δ_s that control for the differential industry growth effects of financial development and property rights protection.

In columns (5)-(8), we proxy human capital levels by schooling quality. Columns (5) and (6) show that the schooling quality interaction with industry human capital intensity ($LFQUAL_c * HCINT_s$) enters positively and significantly at the 1% level, whether or not the differential industry growth effect of finance and property rights are accounted for. Hence, countries with a high quality labor force experienced relatively faster growth in human-capital-intensive industries. According to the estimate in column (6), the annual output-growth differential between an industry with a human capital intensity at the 75th percentile (e.g. Chemicals) and an industry with a human capital intensity at the 25th percentile (e.g. Pottery) is around 2% higher in a country with educational quality at the 75th percentile (e.g. Malaysia) than a country with educational quality at the 25th percentile (e.g. the Philippines). Columns (7) and (8) show that the schooling quantity interaction becomes insignificant when human capital quality is taken into account. Our cross-country cross-industry growth results therefore add to the micro and cross-country evidence on the importance of human capital quality (e.g. Hanushek, 2004).

To examine the link between the marginal growth effect of schooling quality and industry schooling intensity in a more flexible way we return to the two-step approach. We first estimate the effect of schooling quality on industry output growth allowing for different effects in each industry. In the second step we plot the estimated industry-specific effects against industry human capital intensity. The strong positive correlation between the two is evident in Figure 2a as well as Figure 2b, where we also control for the differential industry growth effects of financial development and property rights protection. Hence, schooling quality matters more for growth in industries that use schooling intensively. Moreover, the link does not seem to be driven by a few industries only.

4.2 Human Capital Accumulation and Industry Growth

To examine the effect of human capital accumulation on growth in human-capital-intensive industries, we use an appropriately modified version of the two-step approach. We first estimate

$$(7) \qquad \Delta y_{s,c,t} = \lambda_c + \mu_s + \sum_i \theta_i \Delta h_{c,1970-1990} * I[i = s] + OtherControls$$

where $\Delta h_{c,1970-1990}$ stands for the increase in average years of schooling at the country level between 1970 and 1990 and $I[i = s]$ takes the value one when i equals s and zero otherwise.[13] This estimating equation yields the effect of schooling improvements on growth for each industry (θ_s).[14] These effects can then be compared to the schooling intensity of industries to examine whether there is a relationship.

In Figure 3a, we plot each industry's human capital intensity ($HCINT_s$) against our estimates of the effect of improvements in country-level schooling on output growth in that industry. Figure 3b repeats the exercise using estimates of θ_s that control for the differential role of financial development and property rights protection for finance-dependent and intangible-asset-intensive industries respectively. Both figures show a clear positive correlation between the effect of human capital accumulation on output growth in an industry and that industry's human capital intensity. For example, relatively rapid human capital accumulation had a large positive growth effect in schooling-intensive industries like Computing (ISIC=3825) and Professional Goods (ISIC=385) and a much smaller impact in low $HCINT$ industries like Footwear (ISIC=324) and Wood Products (ISIC=311). Moreover, this correlation does not seem to be driven by a few industries only.

To test the hypothesis of a positive link between human capital accumulation and growth in human-capital-intensive industries we estimate:

$$(8) \qquad \Delta y_{s,c,t} = \lambda_c + \mu_s + \theta \left(\Delta h_{c,1970-1990} * HCINT_s\right) + OtherControls.$$

[13] We use schooling improvements over the 1970-1990 period because of the evidence indicating that measurement error increases as shorter time-intervals are considered (e.g. Krueger and Lindahl, 2001). We present results for the 1980-1990 period when examining the robustness of our results.

[14] For a survey of work estimating such unconstrained industry growth effects for several production factors see Harrigan (2001).

Table IV reports the results for different sets of controls. The positive and highly statistically significant estimate of θ in columns (1)-(4) indicates that schooling-intensive industries grew faster in countries with greater improvements in education. To get a sense for the size of this effect, consider the comparison between a country with an improvement in schooling over the 1970-1990 period at the 75th percentile (e.g. the Philippines with an improvement of 2.3 years) and a country at the 25th percentile (e.g. Sri Lanka with an improvement of 1.1 years). According to the estimates in column (4), the associated gap in annual output growth between Chemicals (with a schooling intensity at the 75th percentile) and Pottery (at the 25th percentile) is 1.11%. This implied growth differential is tabulated for all specifications in the bottom row of the Table.

The cross-country growth literature finds that the effect of human capital accumulation on output growth is sensitive to controlling for physical capital accumulation (e.g. Benhabib and Spiegel, 1994; Krueger and Lindahl, 2001). This has been attributed to measurement error in schooling data combined with human capital accumulation being highly positively correlated with physical capital accumulation (e.g. Mankiw, 1995; Krueger and Lindahl, 2001). We now examine whether the positive effect of human capital accumulation on growth in human-capital-intensive industries is also sensitive to controls for the impact of physical capital accumulation. Note that country-level growth effects of physical capital accumulation are captured by country fixed effects in our framework. Physical capital accumulation could still affect our findings, however, because it may interact with the physical capital requirements of industries. In columns (5) and (6), we check on this possibility by adding an interaction between industry investment intensity ($INVINT$) and the increase in physical capital per worker at the country-level between 1970 and 1990.[15] $INVINT$ is retrieved from RZ and is defined as the ratio of capital expenditure to property plant and equipment of U.S. firms in the 1980's. In column (5), $INVINT_s{*}\Delta K_c/L_c$ enters positively and statistically significantly. In column (6), however, the investment interaction is rendered statistically insignificant by the RZ financial development and the Claessens and Laeven (2003) property rights protection interactions. The results in columns (5) and (6) also show that the positive effect of schooling improvements on growth in schooling-intensive industries remains statistically significant at the 1% level and of the same magnitude as in previous specifications. This result is robust to using other measures of physical capital intensity at the industry level or using

[15] We calculate the capital stock of countries using Penn World Table data and following the perpetual inventory method as implemented by Hall and Jones (1999) and Caselli (2005). The dates are chosen to make the treatment of physical capital symmetric to that of schooling.

investment rates instead of changes in physical capital.[16] Table IV therefore supports the view that human capital accumulation is an important determinant of growth in human-capital-intensive industries.

The results in Table IV on the effect of human capital accumulation on changes in the pattern of specialization in production fit nicely with Romalis' (2004) work. Romalis' theoretical framework yields that the impact of human capital accumulation on industry output and export growth is increasing in the industry's human capital intensity (an effect he refers to as the quasi-Rybczynski prediction). He examines this prediction using data on imports to the U.S. for the 1972-1998 period and finds that imports from countries experiencing rapid human capital accumulation did in fact grow most in human-capital-intensive industries.[17]

4.3 Joint Human Capital Accumulation and Level Effects

In Table V, we present the results of estimating jointly the human capital level effect and the human capital accumulation effect using

$$(9)\quad \Delta y_{s,c,t} = \lambda_c + \mu_s + \delta\,(h_{c,1970} * HCINT_s) + \theta\,(\Delta h_{c,1970-1990} * HCINT_s) + OtherControls.$$

The results in columns (1) and (2) confirm our previous findings that growth in schooling-intensive industries is increasing in both the initial level of and improvements in average schooling.[18] The point estimates are similar to those obtained in our previous analysis (and of higher statistical significance). For example, controlling for finance and property rights, the industry at the 75th percentile of human capital intensity is predicted to grow by 1.22% faster annually than the industry at the 25th percentile in a country with schooling improvements at the 75th percentile as compared to a country at the 25th percentile. The analogously calculated growth differential for the schooling level effect is 1.27%.

In columns (3) and (4), we repeat the analysis using schooling quality ($LFQUAL$) instead

[16] In particular, we experiment with three additional measures obtained from the latest update of the NBER-CES manufacturing database (Bartelsman and Gray, 1996). Capital stock over value added, capital stock over employment, and one minus the labor share in value added.

[17] Romalis' model also yields that human capital abundant countries specialize in human-capital-intensive industries (the quasi-Heckscher-Ohlin prediction). He finds that this prediction is also supported by U.S. import data. Fitzgerald and Hallack (2004) find support for the quasi-Heckscher-Ohlin prediction using production data for 21 OECD countries in 1988.

[18] As improvements in schooling refer to the 1970-1990 period, initial years of schooling is measured in 1970.

of average schooling years to measure human capital levels. The schooling quality and the schooling improvement interactions with industry human capital intensity are both positive and statistically significant. Point estimates are again similar to those obtained previously.

In columns (5) and (6), we reexamine whether growth in human-capital-intensive industries is more closely related to years of schooling or schooling quality. The results confirm our previous finding that average years of schooling turn insignificant when schooling quality is taken into account.

In columns (7) and (8), we examine the robustness of the human capital accumulation effect to controls for the role of physical capital for industry growth. In particular, we add two interactions to capture possible differential effects of high physical capital levels and rapid physical capital accumulation on growth in investment-intensive industries. The first interaction, between the RZ industry-level investment intensity ($INVINT$) and the increase in physical capital per worker between 1970 and 1990, captures growth effects of physical capital accumulation on investment-intensive industries. The second interaction, between the RZ industry-level investment intensity and the physical capital per worker in 1970, accounts for possible industry growth effects of high initial levels of capital per worker. Both interactions are statistically insignificant. Most importantly from our point of view, the human capital accumulation and the human capital level effects retain their statistical and economic significance. This is the case both when human capital levels are proxied using schooling quantity in column (7) and when they are proxied using schooling quality in column (8).[19]

The results in Table V confirm RZ's and Claessens and Laeven's (2003) argument that deep financial markets foster growth in external-finance-dependent industries and that good property rights protection generates growth in industries using intangible assets intensively. The two corresponding interactions are always positive and significant at conventional confidence levels. But the magnitude of these effects is smaller than in the previous literature. The estimate of the RZ finance interaction in Table V implies an annual output growth differential between an industry at the 75th percentile of external-finance dependence (Shipbuilding and Repairing) and one at the 25th percentile (Beverages) that is 0.85% higher in a country with financial development at the 75th percentile (e.g. Republic of Korea) compared to one at the 25th percentile (e.g. Egypt). This effect is approximately $60\% - 65\%$ of that

[19] These results are robust to using the three alternative measures of physical capital intensity at the industry level discussed in Footnote 17.

reported by RZ and Claessens and Laeven (2003). Regarding the role of property rights protection, our estimates also imply that the difference in value added growth between an industry at the 75th percentile of intangible intensity (e.g. Professional and Scientific Equipment) and an industry at the 25th percentile (e.g. Paper Products) to be approximately $0.85\% - 0.95\%$ per year higher in a country with a property rights protection index at the 75 percentile (e.g. Chile) as compared to a country at the 25th percentile (e.g. Brazil). This growth differential is approximately $75\% - 85\%$ of that reported by Claessens and Laeven.

5 Further Evidence

We start this Section by taking into account additional channels through which financial development impacts industry growth. Then we examine the role of human capital using industry-level employment growth to measure changes in the pattern of specialization. We conclude by analyzing the effect of human capital on growth in human-capital-intensive industries separately in economies with low and economies with high tariffs.

5.1 Financial Development, Human Capital and Industry Growth

In their recent contributions to the finance and industry growth literature, Fisman and Love (2003, 2004) identify additional channels through which financial development affects growth. Fisman and Love show that in countries with underdeveloped financial markets, industries with easier access to trade credit grow relatively faster.[20] To check how trade credit affects our estimates of the human capital level and accumulation effects, we include an interaction between country-level financial development ($PRIV$) and industry-level trade-credit affinity ($TRADEINT$) among the controls in (9). Industry trade-credit affinity is taken from Fisman and Love and is defined as the ratio of accounts payable to total assets of U.S. firms for the 1980's. The results are reported in Table VI, columns (1) and (2). The effects of education levels and improvements on growth in schooling-intensive industries remain significant and of a similar magnitude as in previous specifications. This is the case whether education levels are measured using years of schooling in column (1) or schooling quality in column (2). The finance-trade credit interaction enters with a negative and statistically significant coefficient. The magnitude of the effect is very close to that documented by Fisman and Love.

[20] Theoretical work suggests that this is because trade credit and external finance are substitutes (e.g. Petersen and Rajan, 1997).

Fisman and Love (2004) show that the effect of financial development on industry growth partly works through deeper financial markets facilitating the rapid reallocation of resources to industries with good growth prospects. To check the robustness of our findings to this additional financial development channel, we add an interaction between country-level financial development and industry growth opportunities ($OPPORT$) to our regressions. The growth opportunities variable is taken from Fisman and Love and is constructed using U.S. data on industry-level sales growth. Columns (3) and (4) show that the effects of human capital levels and accumulation on growth in human-capital-intensive industries remain positive, statistically significant, and of a similar magnitude as in previous specifications. Financial development has a significant positive effect on the growth of industries with relatively good prospects. The magnitude of this effect is very close to the estimates of Fisman and Love. Columns (5) and (6) jointly account for the trade-credit and the growth-opportunities channel of financial development on industry growth. Both the human capital level and accumulation effect on growth in human-capital-intensive industries continue to be highly significant and of a similar magnitude as in previous specifications.[21]

5.2 Human Capital and Industry Employment Growth

We now examine whether faster output growth in human-capital-intensive industries due to human capital level and accumulation effects coincides with the reallocation of employment. To do so we repeat our previous empirical analysis using country-industry employment growth ($EMPGR_{s,c}$) as the dependent variable. This allows us to examine whether high levels of human capital and fast human capital accumulation are associated with rapid employment growth in human-capital-intensive industries.

There is an additional reason for checking our results using employment data to measure changes in international specialization. As shown by Krueger and Lindahl (2001), a positive effect of human capital levels on subsequent output growth in cross-country regressions could be due to a world-wide increase in the individual return to human capital (whatever its cause). Our results linking human capital levels to output growth in human-capital-intensive industries could therefore be partly driven by rising individual returns to education.[22]

[21] Following Fisman and Love (2004), we also examine the sensitivity of our results to outliers by dropping the top and bottom one percent of output growth observations and using Huber's technique. In both cases the coefficients on both the human capital level interaction and the human capital accumulation interaction remain significant at the 1% level.

[22] We are grateful to Joshua Angrist and David Weil for discussions that clarified these points.

Table VII presents the results of our country-industry employment growth regressions. Our main finding is that both education levels and improvements have positive, highly statistically significant effects on employment growth in schooling-intensive industries. This is the case whether we measure education levels using years of schooling in columns (1)-(4) or schooling quality in columns (5)-(8). The effect of human capital levels on employment growth is larger than on output growth. For example, consider the annual employment growth differential between an industry with a schooling intensity at the 75th percentile (Chemicals) and an industry at the 25th percentile (Pottery). When we measure human capital levels using average years of schooling, our estimates imply that this growth differential is around 1.7% higher in a country with schooling at the 75th percentile (e.g. Japan) compared to a country with schooling at the 25th percentile (e.g. Portugal). When we measure human capital levels using schooling quality, the implied annual Chemicals-Pottery growth differential is 2% greater in countries with schooling quality at the 75th percentile (e.g. Malaysia) than countries with schooling quality at the 25th percentile (e.g. the Philippines).[23] This compares with an average employment growth of 1% and a median very close to 0. Years of schooling and schooling quality are now both significantly positively related to growth in schooling-intensive industries when included jointly in our regressions (results not in the Table).

RZ and Fisman and Love (2004) note that the distribution of the UNIDO value added growth data has long tails. For example, annual output growth at the 1st and 99th percentile is −30% and +27% (which does not count observations exceeding ±100% excluded in the RZ dataset). As a result, the standard deviation of output growth rates is twice that of employment growth rates. One explanation for this difference is that value added data is recorded with greater error than employment. This is consistent with employment growth regressions having a markedly higher adjusted R^2 (around 43%) than output growth regressions (around 26%; see Table VI).

5.3 Openness

While economies open to international trade can specialize in production, specialization is impossible in closed economies. We therefore examine whether human capital affects output growth in human-capital-intensive industries differently in economies with low and

[23] The finance effects are usually weaker than in previous tables. This is not surprising as the finance-industry growth connection works through investment and capital deepening.

in economies with high tariffs. For completeness we use tariff data for the 1980's from the (only) two sources available: the World Bank, which reports unweighted average tariffs, and Sachs and Warner (1995), who report import-weighted tariff rates.

In Table VIII, Panel A, we split economies into those with average tariffs below and above the median. Splitting the data this way results in the same number of low and high tariff countries. Median tariffs are, however, lower than the tariff thresholds generally used to define a country as a closed economy. For example, while the median Sachs and Warner tariff is 11%, Sachs and Warner classify countries as closed if tariff rates exceed 40%. (The median World Bank tariff is 15%.) In Panel B, we therefore split economies into those with tariffs above and below 40%.

In economies with low tariffs, we find the human capital accumulation effect to be positive and statistically significant at the 1% level in all specifications. In contrast, this effect is highly insignificant in economies with tariffs above 40%. In economies with tariffs above the median, the human capital accumulation effect is insignificant at the 5% level in 3 of 4 cases. Regarding the human capital level effect, consider first the case where we use schooling quality to proxy human capital levels. In this case, the human capital level effect is highly statistically significant in economies with low tariffs in all specifications. The effect becomes insignificant in countries with high tariffs however. Using average schooling years to proxy initial human capital levels yields a similar pattern. In economies with low tariffs, the human capital level effect is statistically significant at the 10% level in 3 out of 4 cases (the weaker human capital level effect using average schooling mirrors previous findings). In economies with high tariffs, this effect is always highly insignificant. Hence, the empirical evidence indicates that high human capital levels and fast human capital accumulation lead to specialization in open economies. This is not the case in high tariff economies. We find similar results when we use employment growth to measure changes in the pattern of specialization (results not in the Table).

6 Sensitivity Analysis

First we examine the role of measurement error in schooling statistics. Then we present estimates using an alternative specification for the link between human capital and schooling. We conclude by putting our output and employment growth results through further sensitivity analysis.

6.1 Measurement Error in Schooling Statistics

Recent research has pointed to measurement error in the education data as a reason why the empirical cross-country growth literature may not have found a robust positive link between education improvements and growth (e.g. Krueger and Lindahl, 2001). We now check whether our findings are sensitive to using the Cohen and Soto (2001) instead of the Barro and Lee (2001) schooling data.[24] In addition, we check the robustness of our results to using improvements in education between 1980 and 1990 as an explanatory variable.

In Table IX, column (1), we report estimates using the Barro-Lee schooling data (as in our previous analysis), but measuring schooling improvements over the 1980-1990 period instead of the 1970-1990 period (accordingly we use years of schooling in 1980 as initial human capital). Both the human capital level and accumulation effect remain highly statistically significant. In column (2), we report the results of estimating the same specification with the Cohen-Soto data. The human capital level and accumulation effect continue to be highly significant. In column (3), we follow the instrumental-variables strategy of Krueger and Lindahl (2001) to deal with measurement error. Krueger and Lindahl propose using one mismeasured schooling series as an instrument for another mismeasured series, since this eliminates attenuation bias when measurement errors are orthogonal. In column (3), we use the Cohen-Soto schooling data as an instrument for the Barro-Lee data. The effects of education levels and improvements on growth in schooling-intensive industries are somewhat larger than in previous specifications. Our results using employment growth at the industry level as a measure of changes in specialization are also robust to using the Cohen-Soto data (results not in the Table).

6.2 Alternative Functional Form

In the cross-country growth literature there is no consensus on how aggregate schooling measures should enter empirical analysis. In empirical labor economics it has been found that a log-linear (Mincerian) earnings-schooling relationship performs well (see Card, 1999,

[24] The main differences between the Cohen-Soto and the Barro-Lee dataset are that Cohen and Soto use more census observations; that they use a different approach to extrapolate missing data; and that they modify a priori implausible values.

for a review). Several macro-econometric studies have therefore adopted a log-linear model of the aggregate output-schooling relationship (e.g. Heckman and Klenow, 1998; Krueger and Lindahl, 2001).[25] Other macro studies, however, use a log-log specification (e.g. Mankiw, Romer, and Weil, 1992; de la Fuente and Domenech, 2001). In Table VIII, columns (4)-(6), we reestimate the previous three specifications using log schooling as a measure of human capital and the change in log schooling as a measure of human capital accumulation. It can be seen that these specifications also yield support for the human capital level and accumulation effect. We find similar results when we use the log schooling specifications to explain employment growth across industries with different human capital intensities (not reported in the Table).

6.3 Further Sensitivity Checks

In Table X we undertake a series of further sensitivity checks, using both output growth (in Panel A) and employment growth (Panel B) to measure changes in the pattern of specialization.

In Panel A, column (1) and (2), we include an interaction between industry human capital intensity and the initial log level of GDP per worker (Y) in our regression to investigate whether rapid growth in human-capital-intensive industries is driven by overall levels of development rather than human capital. In interpreting the results it should be kept in mind that a key determinant of aggregate productivity is human capital (broadly defined). Human capital in turn depends on education (quantity and quality) in and out of the classroom, on-the-job-learning and training, and health (Kartini Shastry and Weil, 2003). Aggregate productivity could therefore be a better proxy for human capital than our indicators of schooling, both because of measurement error and because human capital is broader than formal schooling. For example, Manuelli and Seshadri (2005) calibrate a model linking productivity and human capital and find a closer relationship between properly measured aggregate human capital and productivity than between average schooling and productivity. Because productivity is a proxy for human capital, the interaction between industry human capital intensity and aggregate productivity ($Y_c * HCINT_s$) could absorb the human capital

[25] Our regressions so far assumed that log human capital h is linear in SCH and $LFQUAL$, which implies that Δh is proportional to ΔSCH when the time period is short enough to make changes in schooling quality negligible. Caselli (2005) uses and motivates this functional form in the (very different) context of development accounting.

level effect. The results in column (1) confirm this. The interaction between initial years of schooling and industry human capital intensity enters with a statistically insignificant coefficient, while the productivity interaction with industry human capital intensity is positive and significant. In column (2), human capital levels are proxied by schooling quality. Now the human capital level effect only drops by a third relative to the same specification without the interaction between industry human capital intensity and productivity (in column (6) of Table VI). As the estimate also becomes somewhat less precise when $Y_c * HCINT_s$ is added, the effect turns just insignificant at the 10% level.

In columns (3)-(6), we provide evidence that the results in columns (1) and (2) are partly driven by the link between productivity and human capital. Mankiw, Romer, and Weil (1992) and Klenow and Rodriguez-Clare (1997) show that the physical capital-output ratio isolates the role of investment for long-run productivity from that of TFP and human capital. Hence, we can use physical capital-output ratios to capture high productivity because of investment. In columns (3) and (4), we therefore include in our regression a log physical capital-output ratio interaction with industry human capital intensity ($K_c/Y_c * HCINT_s$). The interaction between years of schooling and industry schooling intensity in column (3) continues to be statistically insignificant. However, while $Y_c * HCINT_s$ was highly significant in the analogous specification in column (1), $K_c/Y_c * HCINT$ is now only marginally significant. Most importantly, when human capital levels are measured using schooling quality in column (4), $K_c/Y_c * HCINT$ turns insignificant, while the schooling quality interaction with industry schooling intensity is significant at the 5% level. The results in columns (3) and (4) therefore indicate that it is not the link between investment and productivity that leads to the prominence of the productivity interaction with industry schooling intensity in columns (1) and (2). Moreover, it is schooling quality, rather than physical capital, that is associated with fast output growth in schooling-intensive industries.

Starting with Hall and Jones (1999) and Acemoglu, Johnson, and Robinson (2001), recent work has shown that one of the key factors determining TFP and output per worker is property rights protection. In columns (5) and (6), we therefore include an interaction between property rights and industry human capital intensity ($PROP_c * HCINT_s$) in our regression. This allows us to check whether it is the link between property rights protection, TFP, and productivity that drives the significance of the interaction between aggregate productivity and industry human capital intensity in columns (1) and (2). When we proxy human capital with average schooling years in column (5), both the property rights and the human capital level interaction with industry human capital intensity are insignificant.[26] However, when human capital levels are measured using schooling quality in column (6), the human capital level effect is significant at the 1% level, while $PROP_c * HCINT_s$ remains insignificant. Hence, it is not the link between property rights protection and productivity that leads to the prominence of the productivity interaction with industry schooling intensity in columns (1) and (2). Moreover, it is schooling quality, rather than property rights protection, that is associated with fast output growth in schooling-intensive industries.

Columns (1)-(6) confirm that human capital accumulation has a highly significant effect on output growth in human-capital-intensive industries. The effect of education improvements on growth in schooling-intensive industries is very stable across specifications and similar to that reported earlier. This effect could, however, be capturing that countries experiencing fast aggregate growth demand human-capital-intensive goods. It could also be capturing that rapid productivity growth always leads to shifts towards human-capital-intensive industries because rapidly growing countries are "modernizers". In columns (7) and (8), we therefore add an interaction between aggregate productivity growth and industry human capital intensity ($GROWTH_c * HCINT_s$). It can be seen that the effect of education improvements on growth in schooling-intensive industries remains significant at the 1% confidence level. Hence, there is no evidence that the human capital accumulation effect captures a link between rapid productivity growth and shifts towards human-capital-intensive industries.

Panel B reports specifications analogous to Panel A, but using employment growth to capture changes in the pattern of specialization. The employment growth regressions continue to display a better fit (with an adjusted R^2 around 44%) than the output growth regressions (with an adjusted R^2 around 26%). In columns (1) and (2), we include the interaction between aggregate productivity and industry human capital intensity in the regression. The effect of high human capital levels on growth in human-capital-intensive industries remains statistically significant. This is the case whether human capital levels are measured as av-

[26] Average years of schooling is the country-level variable most strongly correlated with property rights protection in our dataset. This is not surprising as good property rights protection increases the incentives for (human) capital accumulation (Hall and Jones, 1999; Acemoglu, Johnson, and Robinson, 2001) and high human capital levels lead to institutional improvements (Glaeser *et al.*, 2004). Note that both property rights protection and human capital levels are significant when interacted with industry intangible asset intensity and human capital intensity respectively (Table V column (2)). This is an example of how focusing on possible theoretical channels can help in advancing our understanding of the growth effects of highly correlated country characteristics (Rajan and Zingales, 1998).

erage schooling in column (1) or schooling quality in column (2). In columns (3) and (4), we include the interaction between the initial physical capital-output ratio and industry human capital intensity. The interaction between human capital levels and industry human capital intensity remains statistically significant, no matter which of the two human capital measures we employ. The same holds in columns (5) and (6), where we add the interaction between property rights protection and industry human capital intensity. All specifications also confirm the significance of the human capital accumulation effect on employment growth in human-capital-intensive industries. Moreover, as shown in columns (7) and (8), the effect of education improvements on growth in schooling-intensive industries continues to be robust to the inclusion of an interaction between aggregate productivity growth and industry human capital intensity. The results in Table X therefore confirm the positive link between high human capital levels and rapid human capital accumulation and growth in human-capital-intensive industries.

7 Conclusion

One way to progress in our understanding of the effects of human capital on growth is to examine channels through which such effects could work. If high levels of human capital facilitate technology adoption, better-educated countries should have adopted more rapidly the skilled-labor augmenting technologies becoming available in the 1970's. These countries should therefore have experienced faster output growth in more compared to less schooling-intensive industries in the 1980's. Theories of international specialization point to human capital accumulation as another important determinant of growth in human-capital-intensive industries. We therefore use data for 37 manufacturing industries in around 40 countries to examine whether higher levels of education and greater improvements in education were associated with faster output growth in schooling-intensive industries in the 1980's.

We find that output growth in schooling-intensive industries was significantly faster in economies with higher education levels and greater education improvements. These results are robust to controlling for the growth effects of well-functioning financial markets and good property rights protection in finance-dependent and intangible-asset-intensive industries respectively (Rajan and Zingales, 1998; Claessens and Laeven, 2003). They are also robust to controlling for additional channels through which domestic capital markets affect industry growth (Fisman and Love, 2003, 2004). The magnitude of the differential industry growth effect of education levels and improvements is similar or larger than the differential growth effect of financial development and property rights protection. Furthermore when we examine the differential industry growth effects of human capital using employment data, we find even stronger evidence for positive effects of education levels and improvements on growth in schooling-intensive industries. We also analyze the differential industry growth effects of human capital separately in countries with low and with high tariffs. In countries with low tariffs, we find highly significant positive effects of education levels and improvements on growth in schooling-intensive industries. In countries with high tariffs, such effects usually turn statistically insignificant. Protectionist trade policies therefore appear to break the link between human capital and growth in human-capital-intensive industries.

A Appendix

A.1 Country Sample

Australia (AUS), Austria (AUT), Bangladesh (BGD), Belgium (BEL), Brazil (BRA), Canada (CAN), Chile (CHL), Colombia (COL), Costa Rica (CRI), Denmark (DNK), Egypt, Arab Rep. (EGY), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), India (IND), Indonesia (IDN), Israel (ISR), Italy (ITA), Japan (JPN), Jordan (JOR), Kenya (KEN), Korea, Rep. (KOR), Malaysia (MYS), Mexico (MEX), Morocco (MAR), Netherlands (NLD), New Zealand (NZL), Nigeria (NGA), Norway (NOR), Pakistan (PAK), Peru (PER), Philippines (PHL), Portugal (PRT), Singapore (SGP), South Africa (ZAF), Spain (ESP), Sri Lanka (LKA), Sweden (SWE), Turkey (TUR), United Kingdom (GBR), Venezuela, RB (VEN), Zimbabwe (ZWE)

A.2 Variable Definitions and Sources

Country-Industry Specific

- $GROWTH_{s,c}$: Annual growth rate of real value added in industry s in country c over the 1980-1989 period. No data is available for Indonesia and Jamaica. Source: Rajan and Zingales (1998). Original source: United Nations Industrial Development Organization Industrial Statistics (UNIDO), 1993 edition.
- $FRACT_{s,c}$: Share of industry s in total value added in manufacturing in country c in 1980. Source: Rajan and Zingales (1998). Original source: UNIDO Industrial Statistics.
- $EMPGR_{s,c}$: Annual growth rate of employment in industry s in country c over the 1981-1990 period. No data is available for Costa Rica, Jamaica, and Nigeria. Source: UNIDO Industrial Statistics.

Industry-Specific

- $HCINT$: Average years of schooling at the industry level. This variable is based on data from the 1980 Integrated Public Use Microdata Series. We extract two series: $i)$ hours worked by industry and years of education; *ii*) number of employees by industry and education. Our calculations are based on eight groups of educational attainment: *i*) 0 years of schooling; *ii*) 1-4 years of schooling; *iii*) 5-8 years of schooling; *iv*) 9-11 years of schooling; *v*) 12 years of schooling; *vi*) 13-15 years of schooling; *vii*) 16 years of schooling; *viii*) more than 16 years of schooling. Average years of schooling in each industry is obtained by multiplying the share of employees in each educational attainment group by 0, 1, 6, 10, 12, 14, 16 and 18 respectively (changing these weights within the bounds of the group does not affect our results). We also calculate two additional industry-level human capital intensity indicators. $HCINT(SEC)$ is estimated as the ratio of hours worked by employees with at least 12 years of schooling (completed secondary education) to total hours worked by all employees in each industry. $HCINT(COLL)$ is estimated as the ratio of hours worked by employees with at least 16 years of education (completed college studies) to total hours worked in each industry. Source: Integrated Public Use Microdata Series.

- $EXTFIN$: Industry dependence on external financing. This variable is estimated as the industry-level median of the ratio of capital expenditure minus cash Fisman and Loveow over capital expenditure for U.S. firms averaged over the 1980-1989 period. This variable measures the portion of capital expenditure not financed by internally generated cash. Source: Rajan and Zingales (1998). Original source: COMPUSTAT.

- $OPPORT$: Industry growth opportunities. This variable is estimated as the industry-level median growth rate of sales for U.S. firms averaged over the 1980-1990 period. Source: Fisman and Love (2004). Original source: COMPUSTAT.

- $TRADEINT$: Industry dependence on trade credit. This variable is calculated as the industry-median of ratio of accounts payable over total assets for U.S. firms averaged over the 1980-1989 period. Source: Fisman and Love (2003). Original source: COMPUSTAT.

- $INTANG$: Industry dependence on intangible assets. This variable is estimated as the industry-median of the ratio of intangible assets to net fixed assets for U.S. firms averaged over the 1980-1989 period. Source: Claessens and Laeven (2003). Original source: COMPUSTAT.

- $INVINT$: Industry intensity on physical capital investment. It is defined as the ratio of capital expenditure to property plant and equipment for U.S. firms averaged over the 1980-1989 period. Source: Rajan and Zingales (1998). Original source: COMPUSTAT. We also use three additional measures of industry physical capital intensity. (1) One minus the share of wages in value added; (2) Capital stock over value added; (3) Capital stock over employment, all in 1980. Source: NBER-CES Manufacturing Industry Database (Bartelsman and Gray, 1996).

- $NONPROD$: Ratio of non-production workers to total employment in U.S. manufacturing industries in 1980. Source: NBER-CES Manufacturing Industry Database (Bartelsman and Gray, 1996).

Country-Specific:

- $PRIV$: Private credit to GDP. Private credit is defined as the ratio of private domestic credit held by monetary authorities and depositary institutions (excluding interbank deposit) scaled by GDP in 1980. No data is available for Nigeria. Source: Fisman and Love (2003). Original source: IMF International Financial Statistics.

- $PROP$: Index of property rights protection on a scale from 1 to 5; higher values indicate higher protection. The index equals the median rating for the 1995-1999 period. Source: Claessens and Laeven (2003). Original source: The Index of Economic Freedom (The Heritage Foundation).

- K/Y : Log physical capital-GDP ratio. Physical capital stock is calculated using the perpetual inventory method as implemented by Hall and Jones (1999) and Caselli (2005). Source: Penn World Tables, 5.6 (downloadable from: http://pwt.econ.upenn.edu).

- SCH^{BL} : Average years of schooling of the population aged 25 and over. No data is available for Nigeria and Morocco and for Egypt before 1980. Source: Barro and Lee (2001).

- SCH^{CS} : Average years of schooling of the population aged 25 and over. No data is available for Sri Lanka, Israel and Pakistan. Source: Cohen and Soto (2001).

- Y : Log of real GDP per worker. Source: Penn World Tables 5.6.

- $GROWTH$: Logarithmic growth rate of real GDP per worker. Source: Penn World Tables 5.6.

- $LFQUAL$: Labor force quality index on a 0-100 scale. The index is based on test results in mathematics and science that are administrated by the International Association for the Evaluation of Educational Achievement and by the International Assessment of Educational Progress. The data was originally collected and processed to ensure international and intertemporal comparability by Hanushek and Kimko (2000). Hanushek and Kimko have direct observations on test results for 39 countries between 1965 and 1991. They impute data for additional countries based on a model of test score determination. This model is based on 31 countries due to data unavailability for some explanatory variables. Bosworth and Collins (2003) follow the Hanushek and Kimko approach but use updated and additional primary data to impute test scores. As a result, labor force quality indicators are available for all countries in our sample. Source: Hanushek and Kimko (2000); Bosworth and Collins (2003).

- TAR^{SW} : Average import-weighted tariff rate over the 1980's on intermediates and capital goods. Source: Sachs and Warner (1995). Original source: UNCTAD.

- TAR^{WB} : Average unweighted tariff rate over the 1980's for all goods. Source: World Bank (http://siteresources.worldbank.org/INTRANETTRADE/Resources/tar2002.xls),

References

[ ]

Acemoglu, Daron. "Why Do New Technologies Complement Skills? Directed Technical Change and Wage Inequality." *Quarterly Journal of Economics*, November 1998, *113*(4), pp. 1055-1090.

Acemoglu, Daron. "Directed Technical Change." *Review of Economic Studies*, October 2002, *69*(4), pp. 781-810.

Acemoglu, Daron. "Patterns of Skill Premia." *Review of Economic Studies*, April 2003a, *70*(1), pp. 199-230.

Acemoglu, Daron. "Factor Prices and Technical Change: from Induced Innovations to Recent Debates." In Philippe Aghion (ed.) *Knowledge, Information and Expectations in Modern Macroeconomics: In Honor of Edmund Phelps*, Princeton, NJ: Princeton University Press, 2003b.

Acemoglu, Daron; Johnson, Simon and Robinson, James A. "The Colonial Origins of Comparative Development: An Empirical Investigation." *American Economic Review*, December 2001, *91*(5), pp. 1369-1401.

Acemoglu, Daron and Zilibotti, Fabrizio. "Productivity Differences." *Quarterly Journal of Economics*, May 2001, *116*(2), pp. 1055-1090.

Autor, David; Katz, Lawrence F., and Krueger, Alan B. "Computing Inequality: Have Computers Changed the Labor Market?" *Quarterly Journal of Economics*, November 1998, *113* (4), pp. 1169-1214.

Barro, Robert J. "Economic Growth in a Cross-Section of Countries." *Quarterly Journal of Economics*, May 1991, *106*(2), pp. 407-443.

Barro, Robert J. "Human Capital and Growth." *American Economic Review Papers and Proceedings*, May 2001, *113*(2), pp. 12-17.

Barro, Robert J. and Lee, Jong-Wha. "International Data on Educational Attainment: Updates and Implications." *Oxford Economic Papers*, 2001*, 3*(3), pp. 541-563.

Barro, Robert J. and Sala-i-Martin, Xavier. *Economic Growth.* Cambridge, MA: MIT Press, 1995.

Bartelsman, Eric J and Gray, Wayne. The NBER Productivity Manufacturing Database. National Bureau of Economic Research (Cambridge, MA) Technical Working Paper No. 205, October 1996. (Downloadable from http://www.nber.org/nberces/nbprod96.htm.)

Benhabib, Jess and Spiegel, Mark M. "The Role of Human Capital in Economic Development." *Journal of Monetary Economics*, October 1994, *34*(2), pp. 143-174.

Benhabib, Jess and Spiegel, Mark M. "Human Capital and Technology Diffusion." December 2002. Forthcoming in Philippe Aghion and Steven Durlauf (eds.) *The Handbook of Economic Growth,* Amsterdam, The Netherlands: North-Holland, 2005

Berman, Eli; Bound, John, and Machin, Stephen. "Implications of Skill-Biased Technical Change: International Evidence." *Quarterly Journal of Economics*, November 1998, *113*(4), pp. 1245-1279.

Berman Eli and Machin, Stephen. "Skilled-Biased Technology Transfer: Evidence of Factor Biased technical Change in Developing Countries." *Oxford Review of Economic Policy*, Fall 2000, *16*(3), pp. .

Bils, Mark and Klenow Peter J. "Does Schooling Cause Growth?" *American Economic Review*, December 2000, *90*(5), pp. 1160-1183.

Bosworth, Barry P. and Susan M. Collins. "The Empirics of Growth: An Update." *Brookings Papers on Economic Activity*, September 2003, 2, pp. 114-206.

Card, David. "The Causal Effect of Schooling on Earnings." In Orley Ashenfelter and David Card (eds.) *Handbook of Labor Economics.* Amsterdam, Netherlands: North Holland, 1999.

Caselli, Francesco. "Accounting for Cross-Country Income Differences." Mimeo, London School Economics, May 2005. Forthcoming in Philippe Aghion and Steven Durlauf (eds.) *The Handbook of Economic Growth*, North Holland, Amsterdam: 2005.

Caselli, Francesco and Coleman, John Wilbur II. "Cross-Country Technology Diffusion: The Case of Computers." *American Economic Review Papers and Proceedings*, May 2001, *91*(2), pp. 328-335.

Caselli, Francesco and Coleman, John Wilbur II. "The US Technology Frontier." *American Economic Review Papers and Proceedings*, May 2002, *92*(2), pp. 148-152.

Caselli, Francesco and Coleman, John Wilbur II. "The World Technology Frontier." June 2005, *American Economic Review,* forthcoming.

Caselli, Francesco; Esquivel, Gerard, and Lefort, Fernando. "Reopening the Convergence Debate: A New Look at Cross-Country Empirics." *Journal of Economic Growth*, September 1996, *1*(3), pp. 363-389.

Claessens, Stijn and Laeven, Luc. "Financial Development, Property Rights, and Growth." *Journal of Finance*, December 2003, *58*(6), pp. 2401-2436.

Cohen, Daniel and Soto, Marcelo. "Growth and Human capital: Good Data, Good Results." Centre for Economic Policy Research (London), Discussion Paper No. 3025. October 2001.

Deardorff, Alan. "The General Validity of the Heckscher-Ohlin Theorem." *American Economic Review*, September 1982, *72*(4), pp. 683–694.

de la Fuente, Angel and Domenech, Rafael. "Schooling Data, Technical Diffusion, and the Neoclassical Model." *American Economic Review Papers and Proceedings*, May 2001, *90*(5), pp. 323-327.

de la Fuente, Angel and Domenech, Rafael. "Human Capital in Growth Regressions: How Much Difference Does Data Quality Make." June 2005, *Journal of the European Economic Association*, forthcoming.

Djankov, Simeon; La Porta, Rafael; López-de-Silanes, Fisman and Loveorencio; Shleifer, Andrei and Botero, Juan. "The Regulation of Labor." *Quarterly Journal of Economics*, November 2004, *119*(4), pp. 1339 - 1382.

Dornbusch, Rudiger; Fischer, Stanley and Samuelson, Paul A. "Heckscher-Ohlin Trade Theory with a Continuum of Goods." *Quarterly Journal of Economics*, September 1980, *95*(2), pp. 203-224.

Durlauf, Steven N.; Johnson Paul A., and Temple, Jonathan. "Growth Econometrics." Forthcoming in Philippe Aghion and Steven Durlauf (eds.) *The Handbook of Economic Growth*, Amsterdam, The Netherlands: North-Holland, 2005.

Fisman, Raymond and Love, Inessa. "Trade Credit, Financial Intermediary Development, and Industry Growth." *Journal of Finance*, February 2003, *58*(1), pp. 353-374.

Fisman, Raymond and Love, Inessa. "Financial Development and Growth in the Short and Long Run." National Bureau of Economic Research (Cambridge, MA), Working Paper No. 10236, January 2004.

Fitzgerald, Doireann and Hallak, Juan Carlos. "Specialization, Factor Accumulation and Development." *Journal of International Economics*, December 2004, *64*(2), pp. 277-302.

Forstner, Helmut. "A Note on the General Validity of the Heckscher-Ohlin Theorem." *American Economic Review*, September 1985, *75*(4), pp. 844-849.

Glaeser, Edward L.; La Porta, Rafael; Lopez-de-Silanes, Fisman and Loveorencio and Shleifer, Andrei. "Do Institutions Cause Growth?" *Journal of Economic Growth*, February 2004, *9*(1), pp. 271-303.

Hall, Robert E., and Jones, Charles I.. "Why Do Some Countries Produce So Much More Output per Worker Than Others?" *Quarterly Journal of Economics*, February 1999, *114*(1), pp. 83-116.

Hanushek, Eric A. "Some Simple Analytics of School Quality." National Bureau of Economic Research (Cambridge, MA), Working Paper No. 10229, January 2004.

Hanushek, Eric A. and Kimko, Dennis D. "Schooling, Labor-Force Quality, and the Growth of Nations." *American Economic Review*. December 2000, *90*(5), pp. 1184-1208.

Harrigan, James. "Specialization and the Volume of Trade: Do the Data Obey the Laws?" National Bureau of Economic Research (Cambridge, MA), Working Paper No. 8675, August 2001.

Heckman, James and Klenow, Peter J. "Human Capital Policy". In Michael Boskin (ed.) *Policies to Promote Capital Formation*. Stanford, CA: Hoover Institution, 1998.

Kahn, James A. and Lim, Jong-Soo. "Skilled Labor-Augmenting Technical Progress in U.S. Manufacturing." *Quarterly Journal of Economics*, November 1998, *113*(4), pp. 1281-1308.

Kartini Shastry, Gauri and Weil, David N. "How Much of Cross-Country Income Variation is Explained by Health." *Journal of the European Economic Association*, April-May, 2003, *1*(2-3), pp. 387-396.

Klenow, Peter J. "Ideas Versus Rival Human Capital: Industry Evidence on Growth Models." *Journal of Monetary Economics*, June 1998, *42*(1), pp. 3-23.

Klenow, Peter J. and Rodriguez-Clare Andres. "The Neoclassical Rival in Growth Economics: Has It Gone Too Far?" In Ben Bernake and Julio Rotemberg (eds.) *NBER Macroeconomics Annual* 1997, Cambridge, MA: MIT Press, 1997.

Krueger, Alan B. and Lindahl, Mikael. "Education for Growth: Why and For Whom?" *Journal of Economic Literature*, December 2001, *39*(4), pp. 1101-1136.

Krugman, Paul R. "Scale Economies, Product Differentiation, and the Pattern of Trade." *American Economic Review,* December 1980, *70*(5), pp. 950-959.

Lucas, Robert. "On the Mechanisms of Economic Development." *Journal of Monetary Economics*, July 1988, *22*(1), pp.3-42.

Mankiw, Gregory. "The Growth of Nations." *Brookings Papers on Economic Activity*, *1995*(1), pp. 275-326.

Mankiw, N. Gregory; Romer, David, and Weil, David N. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics*, May 1992, *107*(2), pp. 407-437.

Manuelli, Rodolfo and Seshadri, Ananth. "Human Capital and the Wealth of Nations." Mimeo, University of Wisconsin-Madison, May 2005.

Nelson, Richard R. and Phelps Edmund S. "Investment in Humans, Technical Diffusion, and Economic Growth." *American Economic Review*, March 1966, *56*(1/2), pp. 69-75.

Petersen, Mitchell A. and Rajan, Raghuram G. "Trade Credit: Theories and Evidence." *Review of Financial Studies*, Fall 1997, *10*(3), pp. 661-691.

Pritchett, Lant. "Where Has All the Education Gone?" *World Bank Economic Review*, 2001, *15*(3), pp. 367-391.

Rajan, Raghuram G. and Zingales, Luigi. "Financial Dependence and Growth." *American Economic Review*, June 1998, *88*(3), pp. 559-586.

Romalis, John. "Factor Proportions and the Structure of Commodity Trade." *American Economic Review*, March 2004, *94*(1), pp. 67-97.

Romer, Paul. "Human Capital and Growth: Theory and Evidence." *Carnegie-Rochester Conference Series on Public Policy*, 1990a, 32, pp. 251-286.

Romer, Paul. "Endogenous Technical Change." *Journal of Political Economy*, October 1990b, *98*(5), pp. S71-S102.

Sachs, Jeffrey D. and Warner, Andrew M. "Economic Reform and the Process of Global Integration." *Brookings Paper on Economic Activity*, 1995, *1995*(1), pp. 1-118.

Temple, Jonathan. "The New Growth Evidence." *Journal of Economic Literature*, March 1999, *37*(1), pp. 112-156.

Topel, Robert. "Labor Markets and Economic Growth." in Orley Ashenfelter and David Card (eds.). *The Handbook of Labor Economics*. Amsterdam, The Netherlands: North Holland, 1999.

Ventura, Jaume. "Growth and Interdependence." *Quarterly Journal of Economics*, February 1997, *112*(1), pp. 57-84.

Ventura, Jaume. "A Global View of Economic Growth." Centre for Economic Policy Research (London), Discussion Paper No. 5059, May 2005. Forthcoming in Philippe Aghion and Steven Durlauf (eds.) *The Handbook of Economic Growth*, North Holland, Amsterdam: 2005.

United Nations Industrial Development Organization. *Industrial Statistics Yearbook*. New York, NY, 2004.

Figure 1: Estimated Industry-Specific Coefficient on Schooling Years and Human Capital Intensity in the U.S.

Figure 1a

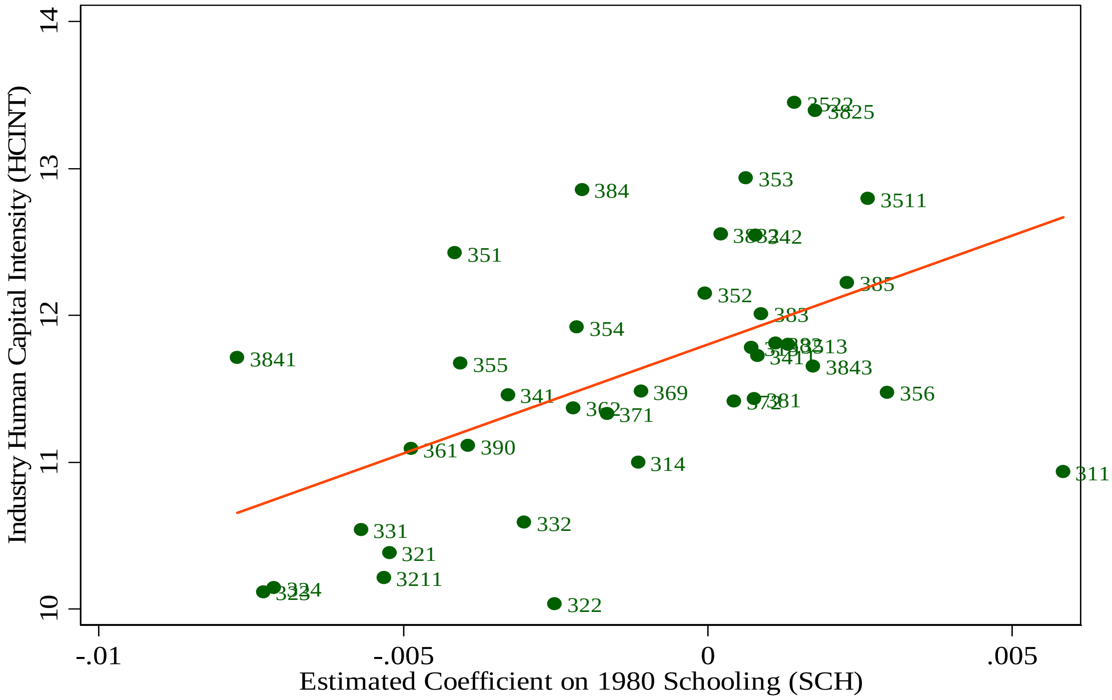
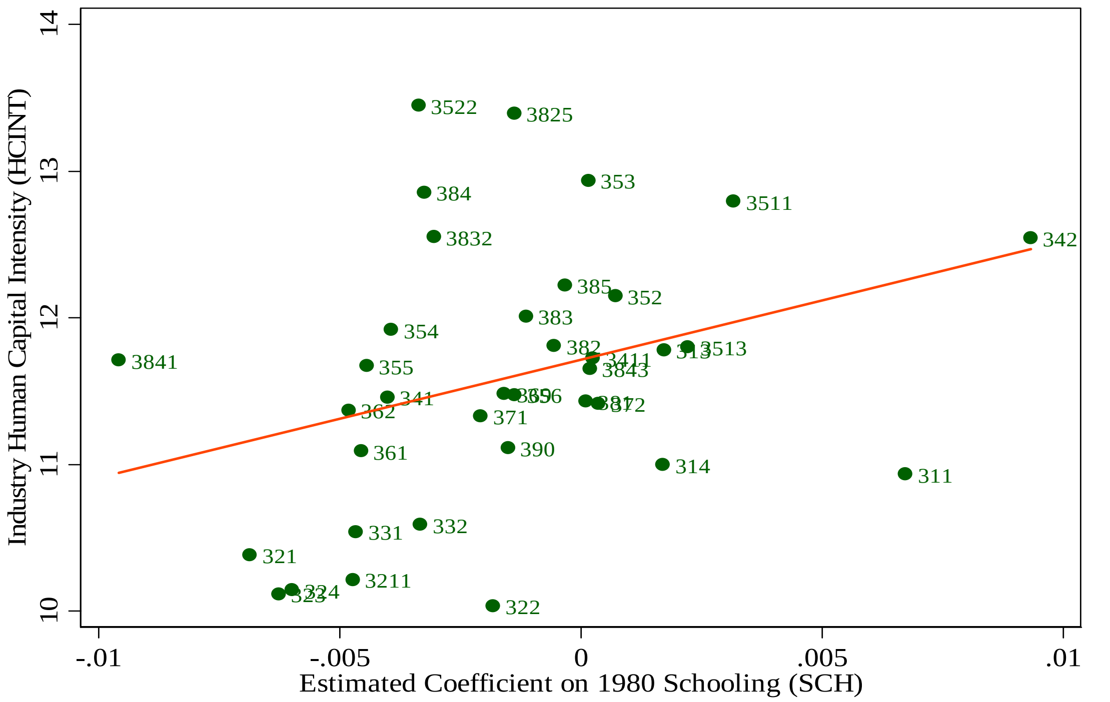


Figure 1b



Figures 1a and 1b plot our estimates of the effect of country-level schooling in 1980 on 1980-1989 industry output growth (on the horizontal axis) against industry human capital intensity (*HCINT*; on the vertical axis). The two figures differ in that the estimates in Figure 1b account for the role of financial development and property rights protection for growth in finance-dependent and intangible-assets-intensive industries respectively.

Figure 2: Estimated Industry-Specific Coefficient on Schooling Quality and Human Capital Intensity in the U.S.

Figure 2a

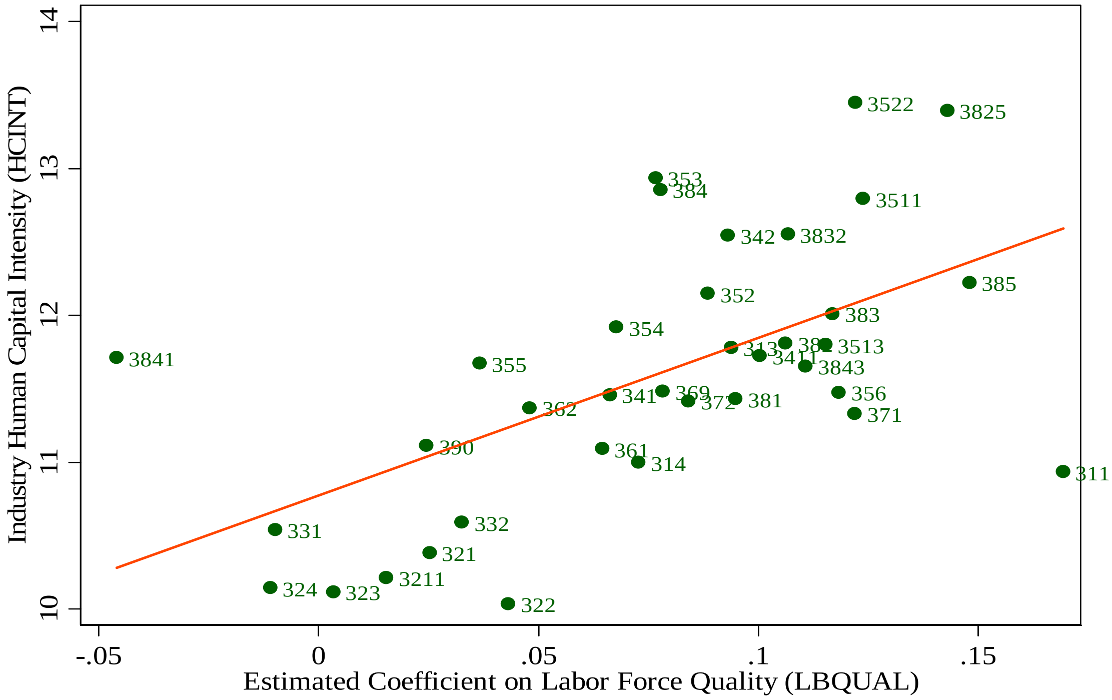
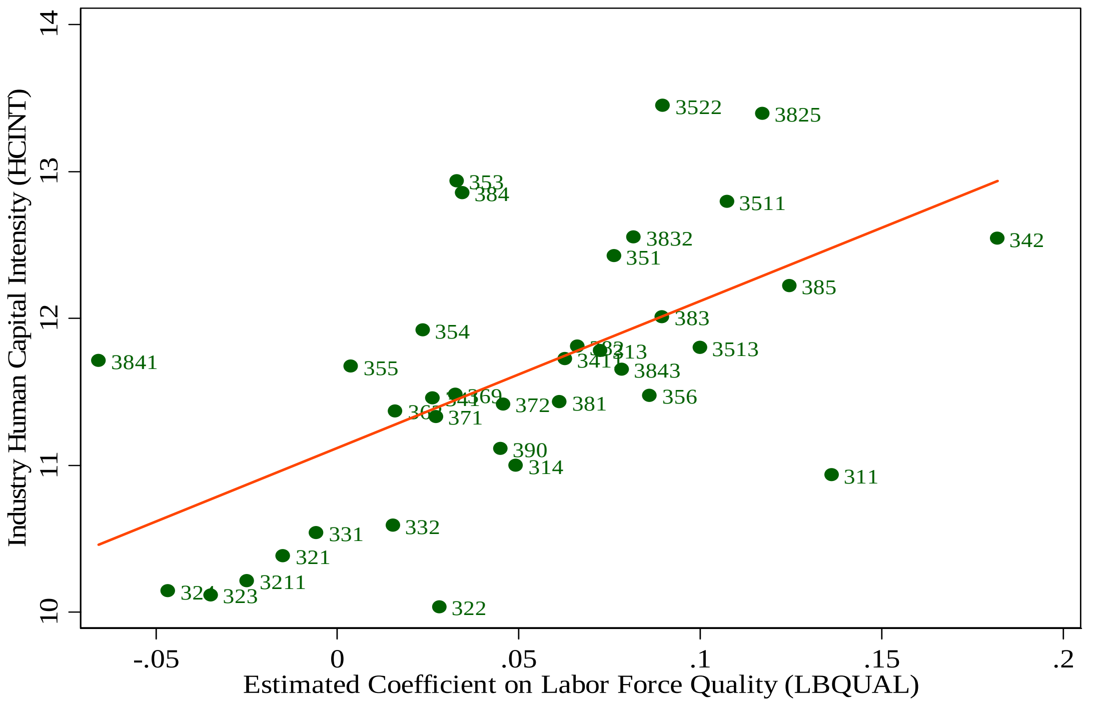


Figure 2b



Figures 2a and 2b plot our estimates of the effect of country-level labor-force quality on 1980-1989 industry output growth (on the horizontal axis) against industry human capital intensity (*HCINT*; on the vertical axis). The two figures differ in that the estimates in Figure 2b account for the role of financial development and property rights protection for growth in finance-dependent and intangible-assets-intensive industries respectively.

Figure 3: Estimated Industry-Specific Coefficient on Changes in Schooling and Human Capital Intensity in the U.S.

Figure 3a

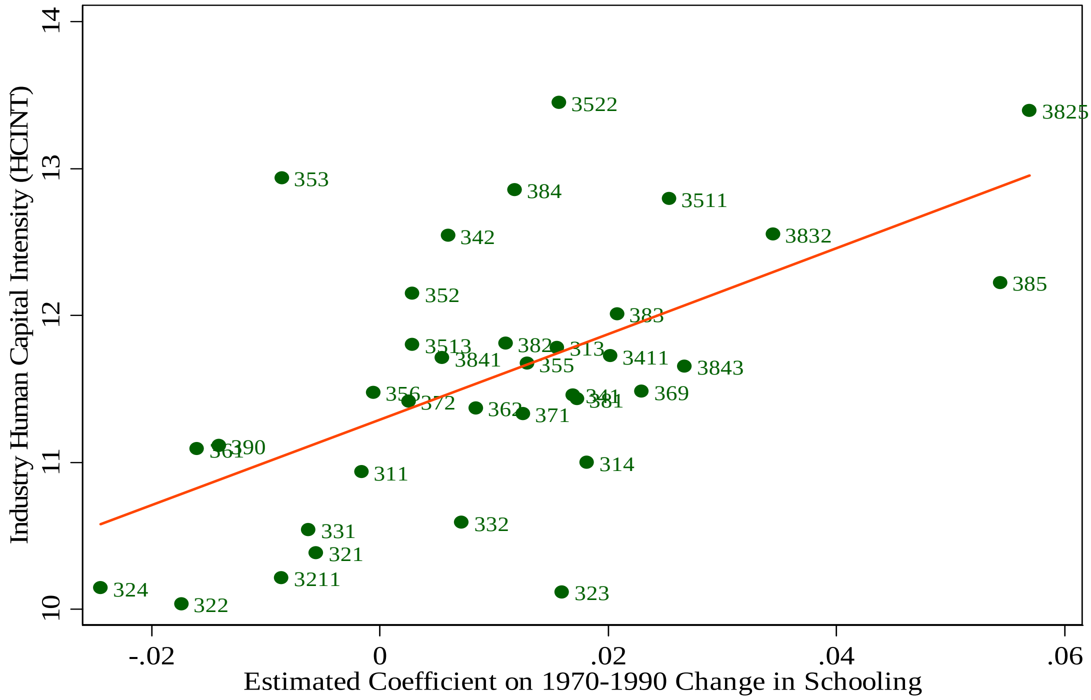
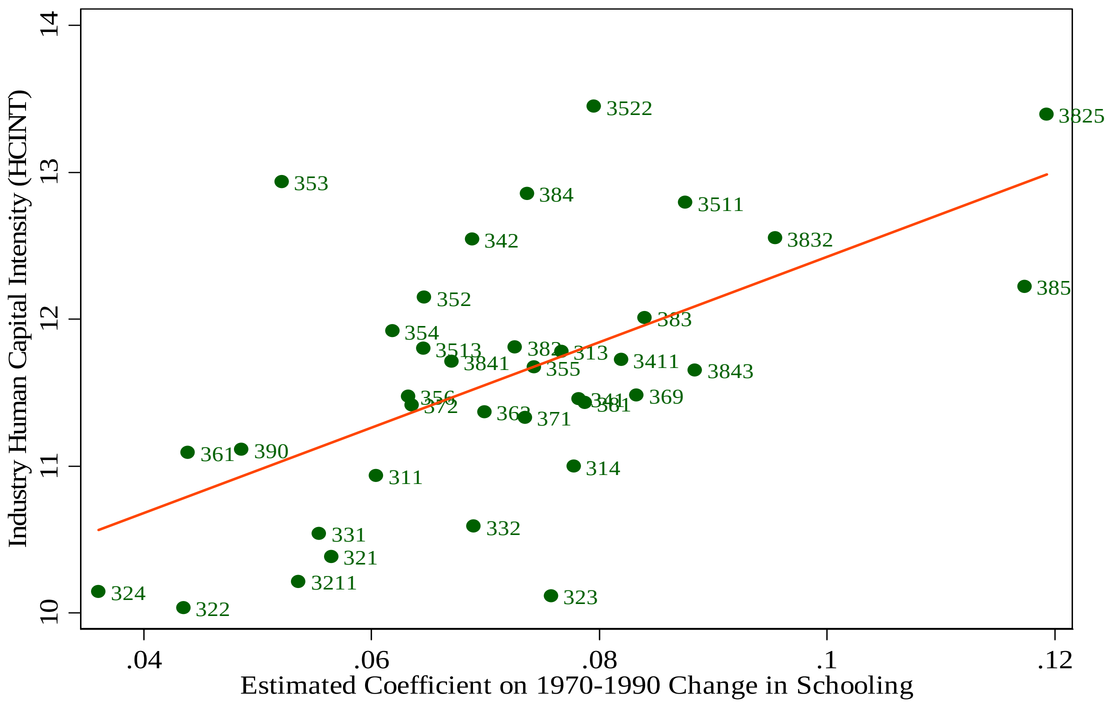


Figure 3b



Figures 3a and 3b plot our estimates of the effect of 1970-1990 country-level increases in schooling on 1980-1989 industry output growth (on the horizontal axis) against industry human capital intensity (*HCINT*; on the vertical axis). The two figures differ in that the estimates in Figure 3b account for the role of financial development and property rights protection for growth in finance-dependent and intangible-assets-intensive industries respectively.

Table I -- Industry Measures of Human Capital Intensity (Dependence)

ISIC Code	Industry Name	*HCINT*	*HCINT(SEC)*	*HCINT(COLL)*
3522	Drugs	13.45	87.22%	35.14%
3825	Office, computing	13.40	90.01%	29.29%
353	Petroleum refineries	12.94	87.26%	25.05%
384	Transportation equipment	12.86	84.20%	23.42%
3511	Basic chemicals excl. fertilizers	12.79	84.06%	24.54%
3832	Radio	12.55	83.29%	18.79%
342	Printing and Publishing	12.54	83.89%	19.97%
351	Industrial chemicals	12.42	81.60%	20.03%
385	Professional goods	12.22	79.31%	18.50%
352	Chemicals	12.15	77.08%	18.96%
383	Electric machinery	12.01	76.08%	15.29%
354	Petroleum and coal products	11.92	69.06%	14.08%
382	Machinery	11.81	76.23%	10.23%
3513	Synthetic resins	11.80	75.21%	15.14%
313	Beverages	11.78	73.81%	13.09%
3411	Pulp, paper	11.72	75.23%	10.68%
3841	Ship building and repairing	11.71	74.78%	9.99%
355	Rubber products	11.67	74.39%	10.26%
3843	Motor vehicle	11.65	73.46%	10.95%
369	Non-metal products	11.48	67.80%	14.20%
356	Plastic products	11.48	71.50%	10.19%
341	Paper and Products	11.46	70.51%	11.05%
381	Metal products	11.43	69.87%	9.71%
372	Non-ferrous metals	11.42	70.31%	9.66%
362	Glass	11.37	69.13%	8.68%
371	Iron & Steel	11.33	69.61%	8.32%
390	Other ind.	11.11	65.12%	11.92%
361	Pottery	11.09	65.01%	9.87%
314	Tobacco	11.00	66.04%	10.99%
311	Food products	10.93	65.55%	9.74%
332	Furniture	10.59	58.31%	7.09%
331	Wood Products	10.54	59.29%	7.06%
321	Textile	10.38	53.83%	6.94%
3211	Spinning	10.21	49.76%	5.49%
324	Footwear	10.14	52.07%	3.69%
323	Leather	10.12	50.69%	7.06%
322	Apparel	10.04	51.09%	5.07%
	Mean	11.61	71.13%	13.52%
	Standard Deviation	0.90	10.87%	7.12%
	Median	11.65	71.50%	10.95%
	0.25 Percentile	11.09	65.55%	9.66%
	0.75 Percentile	12.15	77.08%	18.50%

Table I reports average years of schooling of employees (HCINT) for all industries in our sample calculated using U.S. data. We also report two additional measures of industry-level human capital intensity (HCINT(SEC) and HCINT(COLL)). HCINT(SEC) is the ratio of hours worked by employees with at least 12 years of schooling (necessary for completing secondary school) to total hours worked. HCINT(COLL) is the ratio of hours worked by employees with at least 16 years of schooling (necessary for completing college) to total hours worked. The bottom rows give some descriptive statistics. The data comes from the Integrated Public Use Microdata Series and corresponds to 1980. See the Appendix for details on the construction of the three human capital intensity measures.

Table II--Correlation Structure

Panel A - Industry-level Variables

HCINT	1								
HCINT(SEC)	0.9780*	1							
HCINT(COLL)	0.9239*	0.8502*	1						
NONPROD	0.8665*	0.8193*	0.8660*	1					
EXTFIN	0.5614*	0.5200*	0.5431*	0.4885*	1				
INTANG	0.2253	0.2421	0.281	0.3741	0.1443	1			
INVINT	0.5721*	0.5654*	0.5645*	0.5808*	0.8116*	0.4038	1		
TRADEINT	-0.2018	-0.2135	-0.233	-0.2149	-0.1149	-0.1553	-0.1047	1	
OPPORT	0.3475	0.3397	0.3684	0.4213	0.6498*	0.3557	0.7666*	-0.1927	1

Panel B - Country-level Variables

SCH80(BL)	1								
SCH70(BL)	0.9698*	1							
Δ(SCH(BL)9070)	-0.015	-0.1761	1						
Δ(SCH(BL)9080)	-0.2837	-0.2424	0.6824*	1					
LFQUAL	0.6622*	0.6651*	0.1073	0.0825	1				
PRIV	0.4188*	0.4071*	0.1239	0.0987	0.5884*	1			
K/Y	0.7284*	0.7650*	0.0661	0.1389	0.7016*	0.5753*	1		
PROP	0.6123*	0.6241*	-0.054	-0.1168	0.5678*	0.3783	0.5879*	1	
Y	0.7703*	0.7881*	-0.1304	-0.1936	0.5091*	0.4251*	0.6088*	0.6342*	1

Panel A reports correlations between the main industry-level variables. The correlations are based on either 36 or 37 industry observations, depending on the variables considered. Panel B reports correlations between the main country-level variables. These correlations are based on 39 to 43 country observations, depending on the variables considered. The Data Appendix gives detailed variable definitions and sources. * denotes that the correlation is significant at the 1% confidence level.

Table III--Human Capital Level (Quantity & Quality) and Industry Growth

	Average Years of Schooling (*SCH*)				Labor Force Quality (*LFQUAL*)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FRACTs,c	-0.8817	-0.9402	-0.9052	-0.9631	-1.0199	-0.9757	-0.9367	-0.9994
	(3.48)	*(3.73)*	*(3.55)*	*(3.80)*	*(3.95)*	*(3.75)*	*(3.56)*	*(3.80)*
Human Capital Quantity Interaction	*0.0034*	0.0024	0.0030	0.0021			-0.0008	-0.0015
[*SCH80 X HCINT*]	*(2.55)*	*(1.87)*	*(2.24)*	*(1.56)*			*(0.56)*	*(1.09)*
Human Capital Quality Interaction					0.0869	0.0715	0.0931	0.0865
[*LFQUAL X HCINT*]					*(3.50)*	*(2.82)*	*(3.13)*	*(2.96)*
Finance Interaction		0.1015		0.1004		0.0734		0.0753
[*PRIV X EXTFIN*]		*(2.77)*		*(2.76)*		*(2.15)*		*(2.18)*
Property Rights Interaction			0.0069	0.0068		0.0057		0.0060
[*PROP X INTANG*]			*(2.48)*	*(2.47)*		*(2.07)*		*(2.11)*
Adjusted R2	0.222	0.245	0.224	0.247	0.216	0.257	0.233	0.257
Obs	1240	1207	1240	1207	1277	1217	1240	1217
Countries	40	40	40	40	42	41	40	41
Industry-Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Differential in Real Growth (75%-25%)	0.0177	0.0128	0.0156	0.0109	0.0220	0.0181	0.0236	0.0219

The dependent variable is the annual real growth rate of value added at the industry-country level for the period 1980-1989 (GROWTHs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. The human capital quantity (years of schooling) interaction is the product of industry-level human capital intensity (HCINT) and country-level average years of schooling in 1980 (SCH80). The human capital quality (schooling quality) interaction is the product of HCINT and an indicator of the country-level quality of the labor force (LFQUAL). The finance interaction is the product of industry-level dependence on external finance (EXTFIN) and country-level financial development in 1980 (PRIV). The property rights interaction is the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP).

The last row reports on the magnitude of the human capital level effect. We calculate how much faster an industry at the 75th percentile of human capital intensity is predicted to grow relative to an industry at the 25th percentile, when comparing a country with a level of human capital at the 75th percentile to a country at the 25th percentile. The Data Appendix gives more detailed variable definitions and the sources of the data. All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenthesis and italics below the coefficients.

Table IV--Human Capital Accumulation and Industry Growth

	(1)	(2)	(3)	(4)	(5)	(6)
FRACTs,c	-0.8274	-0.9017	*-0.8603*	-0.9303	-0.9090	-0.9350
	(3.18)	*(3.46)*	*(3.27)*	*(3.53)*	*(3.46)*	*(3.56)*
Human Capital Accumulation Interactic	*0.0087*	0.0108	*0.0086*	0.0108	0.0103	0.0107
[*Δ(SCH9070) X HCINT*]	*(2.37)*	*(3.44)*	*(2.36)*	*(3.44)*	*(3.26)*	*(3.30)*
Finance Interaction		0.1081		0.1042		0.0965
[*PRIV X EXTFIN*]		*(2.87)*		*(2.82)*		*(2.05)*
Property Rights Interaction			0.0084	0.0078		0.0074
[*PROP X INTANG*]			*(2.92)*	*(2.81)*		*(2.45)*
Investment Interaction					0.0001	0.0000
[*ΔK/L9070 X INVINT*]					*(3.11)*	*(0.37)*
Adjusted R2	0.263	0.241	0.267	0.245	0.238	0.244
Obs	1203	1171	1203	1171	1171	1171
Countries	39	39	39	39	39	39
Industry-Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes
Differential in Real Growth (75%-25%)	0.0090	0.0112	0.0089	0.0112	0.0107	0.0111

The dependent variable is the annual real growth rate of value added at the industry-country level for the period 1980-1989 (GROWTHs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. The human capital accumulation interaction is the product of industry-level human capital intensity (HCINT) and the country-level change in average years of schooling over the 1970-1990 period (ΔSCH). The finance interaction is the product of industry-level dependence on external finance (EXTFIN) and country-level financial development in 1980 (PRIV). The property rights interaction is the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP).

The investment interaction is the product of the country-level change in capital per worker over the 1970-1990 period (ΔK/L) and the Rajan and Zingales (1998) industry-level investment intensity (INVINT). The last row reports on the magnitude of the human capital accumulation effect. We calculate how much faster an industry at the 75th percentile of human capital intensity is predicted to grow relative to an industry at the 25th percentile, when comparing a country with a rate of human capital accumulation over the 1970-1990 period at the 75th percentile to a country at the 25th percentile. The Data Appendix gives more detailed variable definitions and the sources of the data. All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenthesis and italics below the coefficients.

Table V--Capital Accumulation, Human Capital Level and Industry Growth

	Schooling Years (*SCH*)		Labor Force Quality (LFQUAL)		Both *SCH* & *LFQUA* L		Physical Capital	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FRACTs,c	-0.8657	-0.9424	-0.9076	-0.9681	-0.9075	-0.9689	-0.9356	-0.9578
	(3.23)	*(3.50)*	*(3.31)*	*(3.52)*	*(3.30)*	*(3.52)*	*(3.46)*	*(3.47)*
Human Capital Accumulation Interaction	0.0107	*0.0123*	0.0067	0.0093	0.0068	0.0089	0.0117	0.0087
[*Δ(SCH9070) X HCINT*]	*(2.77)*	*(3.71)*	*(1.88)*	*(3.03)*	*(1.84)*	*(2.83)*	*(3.48)*	*(2.90)*
Human Capital Quantity Interaction	0.0038	0.0026			0.0001	-0.0004	0.0032	
[*SCH70 X HCINT*]	*(2.59)*	*(1.78)*			*(0.08)*	*(0.32)*	*(2.01)*	
Human Capital Quality Interaction			0.0770	0.0621	0.0759	0.0668		0.0675
[*LFQUAL X HCINT*]			*(2.99)*	*(2.35)*	*(2.54)*	*(2.26)*		*(2.32)*
Finance Interaction		0.0887		0.0707		0.0709	0.0864	0.0798
[*PRIV X EXTFIN*]		*(2.47)*		*(2.02)*		*(2.02)*	*(1.90)*	*(1.83)*
Property Rights Interaction		0.0065		0.0061		0.0061	0.0070	0.0070
[*PROP X INTANG*]		*(2.25)*		*(2.07)*		*(2.07)*	*(2.28)*	*(2.26)*
Investment Interaction							0.0109	-0.0040
[*ΔK/L9070) X INVINT*]							*(0.48)*	*(0.16)*
Physical Capital Level Interaction							-0.0211	-0.0154
[*K/L70 X INVINT*]							*(1.51)*	*(1.17)*
Adjusted R2	0.220	0.248	0.271	0.253	0.226	0.253	0.248	0.253
Obs	1203	1171	1203	1171	1203	1171	1171	1171
Countries	39	39	39	39	39	39	39	39
Industry-Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable is the annual real growth rate of value added at the industry-country level for the period 1980-1989 (GROWTHs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. The human capital accumulation interaction is the product of industry-level human capital intensity (HCINT) and the country-level change in average years of schooling over the 1970-1990 period (ΔSCH). The human capital quantity (years of schooling) interaction is the product of industry-level human capital intensity (HCINT) and country-level average years of schooling in 1970 (SCH70). The human capital quality (schooling quality) interaction is the product of HCINT and an indicator of the country-level quality of the labor force (LFQUAL).
The finance interaction is the product of industry-level dependence on external finance (EXTFIN) and country-level financial development in 1980 (PRIV). The property rights interaction is the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP).
The investment interaction is the product of industry-level investment intensity (INVINT) and the country-level change in capital per worker over the 1970-1990 period (ΔK/L). The physical capital level interaction is the product of INVINT and capital per worker in 1970 (K/L). The Data Appendix gives more detailed variable definitions and the sources of the data. All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenthesis and italics below the coefficients.

Table VI - Financial Development, Human Capital and Industry Growth

	(1)	(2)	(3)	(4)	(5)	(6)
FRACTs,c	-0.9469	-0.9743	-0.9448	-0.9713	-0.9332	-0.9676
	(3.52)	*(3.53)*	*(3.52)*	*(3.54)*	*(3.47)*	*(3.52)*
Human Capital Accumulation Interaction	0.0126	0.0094	0.0124	0.0094	0.0129	0.0094
[*Δ(SCH9070)* X *HCINT*]	*(3.81)*	*(3.06)*	*(3.78)*	*(3.06)*	*(3.84)*	*(3.08)*
Human Capital Quantity Interaction	0.0028		0.0027		0.0031	
[*SCH70* X *HCINT(SCH)*]	*(1.93)*		*(1.87)*		*(2.09)*	
Human Capital Quality Interaction		0.0660		0.0641		0.0698
[*LFQUAL* X *HCINT(SCH)*]		*(2.53)*		*(2.45)*		*(2.66)*
Finance Interaction	0.0819	0.0626	0.0344	0.0139		
[*PRIV X EXTFIN*]	*(2.34)*	*(1.84)*	*(0.81)*	*(0.34)*		
Property Rights Interaction	0.0058	0.0053	0.0051	0.0046	0.0047	0.0043
[*PROP X INTANG*]	*(2.02)*	*(1.82)*	*(1.90)*	*(1.69)*	*(1.73)*	*(1.58)*
Finance-Trade Credit Interaction	-0.8580	-0.9060			-0.5672	-0.6580
[*PRIV* X *TRADEINT*]	*(2.85)*	*(2.91)*			*(1.82)*	*(2.05)*
Finance-Growth Opportunities Interaction			1.1524	1.1968	1.1560	0.9699
[*PRIV* X *OPPORT*]			*(1.71)*	*(1.77)*	*(1.98)*	*(1.66)*
Adjusted R2	0.252	0.258	0.251	0.256	0.252	0.259
Obs	1171	1171	1171	1171	1171	1171
Countries	39	39	39	39	39	39
Industry-Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable is the annual real growth rate of value added at the industry-country level for the period 1980-1989 (GROWTHs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. The human capital accumulation interaction is the product of industry-level human capital intensity (HCINT) and the country-level change in average years of schooling over the 1970-1990 period (ΔSCH). The human capital quantity (years of schooling) interaction is the product of industry-level human capital intensity (HCINT) and country-level average years of schooling in 1970 (SCH70). The human capital quality (schooling quality) interaction is the product of HCINT and an indicator of the country-level quality of the labor force (LFQUAL). The finance interaction is the product of industry-level dependence on external finance (EXTFIN) and country-level financial development in 1980 (PRIV).

The property rights interaction is the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP). The finance trade credit interaction is the product of an industry-level measure of trade credit dependence (TRADEINT) and the country-level financial development (PRIV) in 1980. The finance growth opportunities interaction is the product of an industry-level measure of global industry growth opportunities (OPPORT) and country-level financial development in 1980. The Data Appendix gives more detailed variable definitions and the sources of the data. All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenthesis and italics below the coefficients.

Table VII : Human Capital Accumulation, Human Capital Level and Employment Growth

	Average Schooling Years (*SCH*)				Labor Force Quality (*LBQUAL*)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FRACTs,c	-0.1222	-0.1437	-0.1433	-0.1404	-0.1472	-0.1659	-0.1659	-0.1643
	(1.16)	*(1.36)*	*(1.36)*	*(1.33)*	*(1.35)*	*(1.52)*	*(1.52)*	*(1.51)*
Human Capital Accumulation Interaction	0.0083	0.0087	0.0087	0.0088	0.0045	0.0050	0.0050	0.0050
[*Δ(SCH9070)* X *HCINT*]	*(4.61)*	*(4.81)*	*(4.79)*	*(4.81)*	*(2.71)*	*(2.99)*	*(2.98)*	*(3.00)*
Human Capital Quantity Interaction	0.0041	0.0040	0.0040	0.0041				
[*SCH70* X *HCINT(SCH)*]	*(5.15)*	*(4.85)*	*(4.78)*	*(4.80)*				
Human Capital Quality Interaction					0.0680	0.0666	0.0666	0.0671
[*LFQUAL* X *HCINT(SCH)*]					*(4.29)*	*(4.02)*	*(3.93)*	*(3.96)*
Finance Interaction		0.0217	0.0218			0.0161	0.0161	
[*PRIV X EXTFIN*]		*(1.57)*	*(1.58)*			*(1.21)*	*(1.21)*	
Property Rights Interaction		0.0005	0.0006	0.0003		0.0008	0.0008	0.0006
[*PROP X INTANG*]		*(0.41)*	*(0.46)*	*(0.22)*		*(0.62)*	*(0.61)*	*(0.43)*
Finance-Trade Credit Interaction			0.0821	0.1847			0.0001	0.0806
[*PRIV* X *TRADEINT*]			*(0.54)*	*(1.17)*			*(0.00)*	*(0.48)*
Finance-Growth Opportunities Interaction				0.3308				0.2614
[*PRIV* X *OPPORT*]				*(1.64)*				*(1.29)*
Adjusted R2	0.428	0.437	0.437	0.437	0.431	0.440	0.439	0.439
Obs	1124	1094	1094	1094	1124	1094	1094	1094
Countries	39	39	39	39	39	39	39	39
Industry-Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable is the annual growth rate of employment at the industry-country level for the period 1981-1990 (EMPGRs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. The human capital accumulation interaction is the product of industry-level human capital intensity (HCINT) and the country-level change in average years of schooling over the 1970-1990 period (ΔSCH). The human capital quantity (years of schooling) interaction is the product of industry-level human capital intensity (HCINT) and country-level average years of schooling in 1970 (SCH70). The human capital quality (schooling quality) interaction is the product of HCINT and an indicator of the country-level quality of the labor force (LFQUAL). The finance interaction is the product of industry-level dependence on external finance (EXTFIN) and country-level financial development in 1980 (PRIV).

The property rights interaction is the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP). The finance trade credit interaction is the product of an industry-level measure of trade credit dependence (TRADEINT) and the country-level financial development in 1980 (PRIV). The finance growth opportunities interaction is the product of an industry-level measure of global industry growth opportunities (OPPORT) and country-level financial development in 1980. The Data Appendix gives more detailed variable definitions and the sources of the data. All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenth and italics below the coefficients.

Table VIII - Tariff Protection, Human Capital and Industry Growth

	Median tariff rate threshold				40% tariff rate threshold			
	World Bank		Sachs-Warner		World Bank		Sachs-Warner	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FRACTs,c	-0.9774	-0.9365	-0.9984	-0.9812	-0.9841	-0.9523	-1.0241	-0.9886
	(3.54)	*(3.51)*	*(3.50)*	*(3.57)*	*(3.37)*	*(3.36)*	*(3.43)*	*(3.42)*
HC Accumulation - HC Intensity in "Low Tariff"	0.0049	0.0114	0.0118	0.0149	0.0100	0.0122	0.0094	0.0121
[*Δ(SCH9070)* X *HCINT* X *LOW*]	*(2.05)*	*(3.29)*	*(3.03)*	*(3.97)*	*(3.32)*	*(3.88)*	*(2.55)*	*(3.35)*
HC Accumulation - HC Intensity in "High Tariff"	0.0125	0.0166	0.0029	0.0116	-0.0268	-0.0250	-0.0272	-0.0277
[*Δ(SCH9070)* X *HCINT X HIGH*]	*(1.72)*	*(2.39)*	*(0.32)*	*(1.76)*	*(1.06)*	*(0.89)*	*(0.81)*	*(0.88)*
HC Quality - HC Intensity in "Low Tariff"	0.0938		0.0563		0.0498		0.0689	
[*LFQUAL* X *HCINT* X *LOW*]	*(3.20)*		*(1.93)*		*(2.43)*		*(2.77)*	
HC Quality - HC Intensity in "High Tariff"	0.0848		0.0952		0.2518		0.4629	
[*LFQUAL* X *HCINT* X *HIGH*]	*(1.39)*		*(1.42)*		*(1.48)*		*(1.34)*	
HC Quantity - HC Intensity in "Low Tariff"		0.0032		0.0024		0.0021		0.0023
[*SCH70* X *HCINT* X *LOW*]		*(2.06)*		*(1.48)*		*(1.69)*		*(1.72)*
HC Quantity - HC Intensity in "High Tariff"		0.0000		0.0010		0.0181		0.0228
[*SCH70* X *HCINT* X *HIGH*]		*(0.01)*		*(0.26)*		*(0.89)*		*(1.19)*
Other Controls	Financial Development X Growth Opportunities [*PRIV X OPPORT*]; Financial Development X Trade Affinity *PRIV X TRADEINT*]; Property Rights Protection X Intangibility Intensity [*PROP X INTANG*]							
Adjusted R2	0.260	0.251	0.263	0.257	0.265	0.257	0.268	0.261
Obs	1171	1171	1078	1078	1171	1171	1078	1078
Countries	39	39	35	35	39	39	35	35
Industry-Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable is the annual real growth rate of value added at the industry-country level for the period 1980-1989 (GROWTHs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. HIGH and LOW are indicator variables that equal one if a country has relatively high and relatively low tariff rates respectively and zero otherwise. In columns (1)-(4) we use the median value of tariffs in our sample as a threshold between HIGH and LOW. In columns (5)-(8) we use a 40% threshold. Tariff data is taken from the World Bank in columns (1), (2), (5), and (6). In columns (3), (4), (7) and (8) we use tariff data from Sachs and Warner (1995). The human capital accumulation interactions (for HIGH and LOW tariff countries) equal the product of industry-level human capital intensity (HCINT) and the country-level change in average years of schooling over the 1970-1990 period (ΔSCH).

The human capital quantity (years of schooling) interactions (for HIGH and LOW tariff countries) equal the product of industry-level human capital intensity (HCINT) and country-level average years of schooling in 1970 (SCH70). The human capital quality (schooling quality) interactions (for HIGH and LOW tariff countries) equal the product of HCINT and an indicator of the country-level quality of the labor force (LFQUAL). All specifications also include (coefficients not reported): A finance trade credit interaction, defined as the product of an industry-level measure of trade credit dependence (TRADEINT) and the country-level financial development in 1980 (PRIV); a finance growth opportunities interaction, defined as the product of an industry-level measure of global industry growth opportunities (OPPORT) and country-level financial development in 1980 (PRIV); and a property rights interaction, defined as the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP). The Data Appendix gives more detailed variable definitions and the sources of the data.

All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenthesis and italics below the coefficients.

Table IX - Measurement Error and Logarithmic Specifications

	Change (1990-1980) in schooling and initial (1980) level of schooling measured as					
	Average Schooling Years			Logarithm of Average Schooling Years		
	Barro-Lee (1)	*Cohen-Soto* (2)	*IV Barro-Lee* (3)	*Barro-Lee* (4)	*Cohen-Soto* (5)	*IV Barro-Lee* (6)
FRACTs,c	-0.9808	-0.9972	-1.0176	-0.9929	-1.0112	-1.0273
	(3.78)	*(3.50)*	*(3.52)*	*(3.71)*	*(3.51)*	*(3.48)*
Human Capital Accumulation Interaction	0.0193	0.0203	0.0294	0.1505	0.0850	0.1404
[*Δ(SCH9080)* X *HCINT*]	*(3.76)*	*(2.46)*	*(2.39)*	*(3.50)*	*(2.00)*	*(1.91)*
Human Capital Quantity Interaction	0.0036	0.0026	0.0039	0.0466	0.0332	0.0455
[*SCH80* X *HCINT*]	*(2.70)*	*(2.43)*	*(2.60)*	*(3.89)*	*(2.63)*	*(2.44)*
Finance Interaction	0.0583	0.0486	0.0507	0.0473	0.0444	0.0434
[*PRIV X EXTFIN*]	*(1.32)*	*(1.09)*	*(1.13)*	*(1.12)*	*(1.01)*	*(1.01)*
Property Rights Interaction	0.0043	0.0050	0.0044	0.0036	0.0047	0.0041
[*PROP X INTANG*]	*(1.63)*	*(1.85)*	*(1.57)*	*(1.35)*	*(1.71)*	*(1.45)*
Finance-Trade Credit Interaction	-0.6370	-0.5810	-0.6062	-0.6928	-0.5894	-0.6272
[*PRIV* X *TRADEINT*]	*(1.90)*	*(1.67)*	*(1.66)*	*(2.05)*	*(1.68)*	*(1.74)*
Finance-Growth Opportunities Interaction	0.6672	0.6950	0.6779	0.6797	0.6944	0.6931
[*PRIV* X *OPPORT*]	*(0.92)*	*(0.91)*	*(0.89)*	*(0.94)*	*(0.91)*	*(0.92)*
Adjusted R2	0.265	0.273	0.317	0.274	0.272	0.3303
Obs	1207	1131	1121	1207	1131	1121
Countries	40	38	37	40	38	37
Industry-Country Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable is the annual real growth rate of value added at the industry-country level for the period 1980-1989 (GROWTHs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. The human capital accumulation interaction is the product of industry-level human capital intensity (HCINT) and the country-level change in average years of schooling over the 1970-1980 period (ΔSCH). The human capital quantity (years of schooling) interaction is the product of industry-level human capital intensity (HCINT) and country-level average years of schooling in 1980 (SCH80). In columns (1) and (4) we use schooling data from Barro and Lee (2001). In columns (2) and (5) we use schooling data from Cohen and Soto (2002). Columns (3) and (6) report instrumental-variables estimates using Cohen-Soto changes in schooling and the initial schooling level as instruments for the corresponding Barro-Lee variables. The models estimated in colu (4)-(6) rely on the logarithmic change in schooling and the log level of schooling in 1980. The finance interaction is the product of industry-level dependence on external finance (EXTFIN) and country-level financial development in 1980 (PRIV).

The property rights interaction is the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP). The finance trade credit interaction is the product of an industry-level measure of trade credit dependence (TRADEINT) and the country-level financial development in 1980 (PRIV). The finance growth opportunities interaction is the product of an industry-level measure of global industry growth opportunities (OPPORT) and country-level financial development in 1980. The Data Appendix gives more detailed variable definitions and the sources of the data. All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenthesis and italics below the coefficients.

Table X-Further Robustness Checks

Panel A: Dependent Variable: Value Added Growth

	GDP Level		Physical Capital		Property Rights		GDP Growth	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FRACTs,c	-0.9656	-0.9826	-0.9542	-0.9723	-0.9517	-0.9749	-0.9330	-0.9759
	(3.65)	*(3.61)*	*(3.45)*	*(3.49)*	*(3.51)*	*(3.54)*	*(3.47)*	*(3.55)*
Human Capital Accumulation Interaction	0.0135	0.0117	0.0126	*0.0107*	0.0118	0.0094	0.0130	0.0117
[*Δ(SCH9070) X HCINT*]	*(4.13)*	*(3.76)*	(3.92)	*(3.55)*	*(3.68)*	*(3.04)*	*(3.91)*	*(3.77)*
Human Capital Quantity Interaction	-0.0011		0.0004		0.0016		0.0031	
[*SCH70 X HCINT*]	*(0.57)*		*(0.32)*		*(0.95)*		*(2.09)*	
Human Capital Quality Interaction		0.0452		0.0477		0.0708		0.0838
[*LFQUAL X HCINT*]		*(1.62)*		*(2.21)*		*(2.88)*		*(2.94)*
GDP Level - Human Capital Intensity Interaction	0.0183	0.0104						
[*Y70 X HCINT*]	*(3.66)*	*(2.85)*						
Physical Capital/Output - Human Capital Intensity			0.0246	0.0139				
[*K70/Y70) X HCINT*]			*(1.69)*	*(1.08)*				
Property Rights - Human Capital Intensity Interaction					0.0047	-0.0013		
[*PROP X HCINT*]					*(0.69)*	*(0.26)*		
GDP growth - Human Capital Intensity							-0.0235	-0.3956
[*GROWTH9070 X HCINT*]							*(0.12)*	*(1.90)*
Other Controls	Financial Development X Growth Opportunities [PRIV *X OPPORT*]; Financial Development X Trade Affinity [PRIV *X TRADEINT*]; Property Rights Protection X Intangibility Intensity [*PROP X INTANG*]							
Adjusted R2	0.259	0.262	0.257	0.260	0.252	0.258	0.251	0.261
Obs	1171	1171	1171	1171	1171	1171	1171	1171
Countries	39	39	39	39	39	39	39	39
Industry-Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table X-Further Robustness Checks (cont.)

Panel B: Dependent Variable: Employment Growth

	GDP Level		Physical Capital		Property Rights		GDP Growth	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FRACTs,c	-0.1507	-0.1746	-0.1619	-0.1748	-0.1434	-0.1650	-0.1408	-0.1745
	(1.45)	*(1.63)*	*(1.46)*	*(1.55)*	*(1.34)*	*(1.50)*	*(1.34)*	*(1.61)*
Human Capital Accumulation Interaction	0.0088	0.0063	0.0080	0.0062	0.0083	0.0049	0.0094	0.0072
[*Δ(SCH9070) X HCINT*]	*(4.89)*	*(3.85)*	*(4.64)*	*(3.91)*	*(4.88)*	*(2.98)*	*(5.31)*	*(4.38)*
Human Capital Quantity Interaction	0.0028		0.0018		0.0035		0.0040	
[*SCH70 X HCINT*]	*(2.31)*		*(2.25)*		*(3.35)*		*(4.59)*	
Human Capital Quality Interaction		0.0487		0.0355		0.0572		0.0765
[*LFQUAL X HCINT*]		*(2.63)*		*(2.39)*		*(3.68)*		*(4.39)*
GDP Level - Human Capital Intensity Interaction	0.0052	0.0068						
[*Y70 X HCINT*]	*(1.63)*	*(2.91)*						
Physical Capital/Output - Human Capital Intensity			0.0196	0.0185				
[*K70/Y70) X HCINT*]			*(2.53)*	*(2.86)*				
Property Rights - Human Capital Intensity Interaction					0.0021	0.0027		
[*PROP X HCINT*]					*(0.46)*	*(0.94)*		
GDP growth - Human Capital Intensity							-0.0949	-0.3900
[*GROWTH9070 X HCINT*]							*(0.83)*	*(3.64)*
Other Controls	Financial Development X Growth Opportunities [PRIV *X OPPORT*]; Financial Development X Trade Affinity [PRIV *X TRADEINT*]; Property Rights Protection X Intangibility Intensity [*PROP X INTANG*]							
Adjusted R2	0.438	0.444	0.448	0.450	0.437	0.439	0.437	0.447
Obs	1094	1094	1094	1094	1094	1094	1094	1094
Countries	39	39	39	39	39	39	39	39
Industry-Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes to Table X

In Panel A the dependent variable is the annual growth rate of real value added for the period 1980-1989 (GROWTHs,c). In Panel B the dependent variable is the annual growth rate of employment for the period 1981-1990 (EMPGRs,c). FRACTs,c indicates the industry share in total value added in manufacturing in 1980. The human capital accumulation interaction is the product of industry-level human capital intensity (HCINT) and the country-level change in average years of schooling over the 1970-1990 period (ΔSCH). The human capital quantity (years of schooling) interaction is the product of HCINT and country-level average years of schooling in 1970 (SCH70). The human capital quality (schooling quality) interaction is the product of HCINT and an indicator of the country-level quality of the labor force (LFQUAL). The interaction between productivity level and industry human capital intensity is the product of the logarithm of GDP per worker (Y) in 1970 and industry-level human capital intensity (HCINT). The interaction between the physical capital-output ratio and industry human capital intensity is the product of the logarithm of the physical capital to GDP ratio (K/Y) in 1970 and industry human capital intensity (HCINT).

The interaction between property rights and industry human capital intensity is the product of property rights protection (PROP) and the industry human capital intensity (HCINT). The interaction between productivity growth and industry human capital intensity is the product of the logarithmic growth rate of GDP per worker (GROWTH) over the 1970-1990 period and industry human capital intensity (HCINT). All specifications also include (coefficients not reported): A finance trade credit interaction, defined as the product of an industry-level measure of trade credit dependence (TRADEINT) and the country-level financial development in 1980 (PRIV); a finance growth opportunities interaction, defined as the product of an industry-level measure of global industry growth opportunities (OPPORT) and country-level financial development in 1980 (PRIV); and a property rights interaction, defined as the product of industry dependence on intangible assets (INTANG) and a country-level measure of property rights protection (PROP).

The Data Appendix gives more detailed variable definitions and the sources of the data. All specifications include country and industry fixed effects. Absolute values of t-statistics based on robust standard errors are reported in parenthesis and italics below the coefficients.