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David Mayer & Andrew Foster

SCALE, TECHNOLOGICAL CHANGE AND HUMAN CAPITAL: MANUFACTURING AND DEVELOPMENT IN MEXICO

Abstract

We estimate changes in aggregate manufacturing productivity in Mexican municipios for the period 1988-1993 in terms of changes in physical and human capital inputs, and changes in their returns. These estimates are fully interacted with the average municipal manufacturing scale, defined as workers per firm, and its rate of change, instrumented by industrial composition variables. We find that increases in the returns to human capital are correlated with increases in productivity, and that this correlation is higher where scale increased. Scale and its rate of change interact strongly with productivity change, but by other mechanisms than increasing returns to scale. It may be, for example, that new technologies demand higher scales. Average productivity, wages and capital intensity are higher where scale is higher. A descriptive study also shows that average municipal manufacturing scale, by deciles, is monotonically related to achievements in alphabetization, primary, secondary and higher education, accumulated migration and indigenous population, and almost monotonically to marginalization and public expenditure, as an expression of the continuing rural to urban transition. The positive externalities surrounding scale could form the basis for an integral policy addressing migration, education and productivity.

Resumen

Se estiman cambios en la productividad manufacturera agregada de los municipios para el periodo 1988-1993, en función de cambios en los insumos de capital físico y humano, así como de cambios en sus retornos. Estas estimaciones son interactuadas completamente con el promedio de la escala manufacturera municipal, definida como el número de trabajadores por empresa, y con su tasa de cambio, ambas instrumentadas por variables de composición industrial. Encontramos que los incrementos en los retornos al capital humano están correlacionados con incrementos en la productividad, y que ésta correlación se incrementa cuando la escala es mayor. La escala y su tasa de cambio interactúan fuertemente con el cambio en la productividad, pero a través de mecanismos *diferentes* de los retornos crecientes a escala. Puede ser, por ejemplo, que nuevas tecnologías demanden escalas de producción más altas, que lleven la productividad promedio, los salarios y la intensidad del capital a niveles mayores en donde las escalas sean superiores. Un estudio descriptivo muestra que el promedio de la escala manufacturera municipal, por deciles, esta monotónicamente relacionada con logros en alfabetización, primaria, secundaria, educación superior, migración acumulada y población indígena; y casi monotónicamente con la marginalización y el gasto público. Estas correlaciones son expresiones de la transición rural-urbana que sigue llevándose a cabo. Las externalidades positivas de la escala podrían sustentar una política integral que abarque migración, educación y productividad.

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Introduction

Moving beyond the neoclassical theory of economic growth, which focuses on capital accumulation (Harrod, 1939; Domar, 1946; Solow, 1956; Swan, 1956), recent empirical work has underlined the importance of productivity differences between countries in determining income levels and growth rates (Knight, Loayza and Villanueva, 1993; Islam, 1995; Caselli, Esquivel and Lefort, 1996; Klenow and Rodriguez Clare, 1997; Hall and Jones, 1999; Easterly and Levine, 2000). Parente and Prescott (2000) argue that differentials in total factor productivity result in amplified income differentials. Dollar and Wolff (1994) show that technological convergence rather than factor accumulation, was behind the catch up of the OECD countries to the US Martin and Mitra (2001) show for the period 1967-1992 that TFP in both agriculture and manufacturing grew more rapidly in developed than in less developed countries. Theoretical work also emphasizes the role of technological change for growth. Aghion-Howitt (1992, 1998) model the complementary roles of capital accumulation and innovation in economic growth through creative destruction. Howitt's (2000) multi-country model shows that convergence and growth could be driven by the diffusion and spillover of ideas. However, in practice R&D is limited to just a few countries. Howitt and Mayer (2001) extend the Schumpeterian approach to differentiate between R&D and technological implementation. They show that convergence clubs of countries characterized by R&D, or trapped in innovation or stagnation, can exist even in an open economy. Productivity levels can be quite different and may be influenced by a series of country-specific and policy parameters. Their model explains the divergence in per-capita income that took place between countries during the 20th Century (Pritchett, 1997), as well as the convergence that took place between the richest countries during the second half of the century.

During the last two decades, the main economic policies applied at the international level to promote development originate from neoclassical thought. These include policies to promote macroeconomic stability, trade, investment, privatization and globalization. Notwithstanding these free market policies, income divergence between groups of countries have continued in the period 1960-1995, especially since the 80's (Mayer, 2002a). Much less growth has been achieved than is needed to emerge from poverty, let alone to begin to bridge the productivity gap. The dynamics of technological change, particularly in the case of less developed countries, are not well understood and there is a search for alternative and complementary policies to promote total factor productivity. In this respect, human capital may have an important role to play as a link to productivity. Microeconomic research has shown that virtuous interaction can exist between technological change and human capital accumulation (Foster and Rosenzweig, 1996). The question arises, does this virtuous interaction between technological change and human capital accumulation apply more generally? Does it exist in manufacturing?

Empirical research on technological change and innovation in the developed countries has centered on the effects of scale since Schumpeter (1934) stressed the importance of the contribution of large firms. It has been found, however, that although it is much more probable for large firms to undertake R&D, R&D intensity is approximately proportional to size. Even so, appropriability conditions, ownership of 'downstream' assets such as manufacturing or marketing channels, and the possibilities of output growth are all correlated with size. Similarly, searching for the correlates characterizing regional development and technological change in Mexico and their relation to human capital, the scale of production emerged as a pivotal parameter. This finding is also supported in some parallel case studies (Mayer, 2002b). We seek to suggest that recognizing the importance of urban and industrial scale may be an organizing principle for development policy on migration, education, and the achievement of productivity. It may also be an important factor influencing trade and foreign investment.

Technological change has emerged as a specific policy concern in developed countries in the last two decades. Most industrial countries now implement policies supporting R&D and technological adoption and diffusion, and seek to involve the educational system and universities with this process, moving beyond a science policy. Technological levels are recognized as determinants of competitive advantage. It is also recognized that the social returns to investments in technological change are often larger than the private returns. Technological change faces specific circumstances in the case of developed countries. First, there is less likely to be R&D; instead, most technologies are implemented. Second, the local knowledge sector is usually weak and knowledge flows must be sought from abroad. Third, rents from knowledge and technology usually flow abroad and do not result in further domestic economic activity. Finally, especially in the context of liberalization, domestic industry competes with developed counterparts having important advantages in knowledge, technology and scale. Thus technological change in developed countries is characterized by specific types of change facing specific disadvantages.

We complete the introduction by outlining the theoretical relation between skills, knowledge, trade and technological change in developing countries, focusing on the role of scale, and by describing economic change from the municipal point of view in Mexico over the period 1988-1993.

Skills, Knowledge, Scale, Trade and Technological Change

Scale and technological change

Scale has been one of the quintessential features of manufacturing since its origins. As soon as Solow (1957) established the importance of technological change, Stigler (1961) pointed out that scale is a related phenomenon of similar magnitude, something which Solow (1961) accepted. Economies of scale have been confirmed in some empirical studies, For example, Bougrine (1994) finds evidence of substantial economies of scale in manufacturing in the six Canadian regions. Reporting on 119 Brazilian industries, Willmore (1989) finds that concentration ratios depend significantly on ownership type (foreign, state or domestic private), exports, tariff protection, minimum efficient scale, capital intensity, advertising, and geographic concentration. Felli (1981) also finds that productivity, returns to scale and capital accumulation interact in manufacturing in Italy for the period 1954-1978. MacDonald and Ollinger (2000) find evidence for increasing returns to scale and increasing concentration for hog slaughter in the United States. Mayer (2002b) shows that the evolution of the poultry industry in Mexico is characterized by a process of successive concentration involving technological and commercial development. We show below that technological change may involve changes in the scale of operation not requiring the presence of increasing returns to scale.

In spite of its importance in manufacturing, there is no well-accepted theory of the endogenous relation between scale and technological change. Scale receives only passing references in such classics as Endogenous Growth Theory (Aghion and Howitt, 1988) and The Theory of Industrial Organization (Tirole, 1988). The theory is at an incipient stage. For example Scazzieri (1993) develops a theory of production addressing the choices over issues of scale and technology involved in technical practice.

For our purposes, we shall adopt the following view. As industries grow, some of the opportunities for cost reduction involve increases in the scale of operation. To achieve these increases, it is first of all necessary to have a sufficiently large demand for the product or an opportunity for the consolidation of production. Next, it will usually be necessary to either develop a new technology or to implement one from the available pool. This may require, in turn, the availability of human capital, either for carrying out the new investment or as input for the new process. Thus, as the scale of operation rises, industries move from one production function to another, rather than benefiting directly from returns to scale within the same production function or technology. This implies that scale may be related to technological change *even in the absence of increasing returns to scale.*

This point of view implies that each industry will have a well defined range of scales for which efficient production is viable, depending somewhat on local conditions. Scale will also have positive local externalities because industries will find it easier to buy and sell ever more specialized inputs and outputs where other industries have located. These propositions find strong empirical backing below, with high R-squares for scale and its rate of change regressed on industrial composition variables, and very significant coefficients obtained by interaction terms between these, including a variable counting the number of branches producing locally, both a reflection of local externalities.

The fact that product demand is one of the motivations for increases in scale makes models of the impact of market size on technological change relevant. In the Howitt and Mayer (2000) convergence club model, physical and human capital accumulation increase the incentives for innovation through the increasing profits available in a larger market. In turn, innovation through R&D or implementation lead to higher savings in human capital because of the increased level of production per capita. Thus positive market size externalities compound the possibility of a low-technology trap. A higher demand for human capital at higher scales of operation is a further compounding factor.

Scale as an indicator of development

We find for Mexico that there is also a strikingly strong relation between the scale of manufacturing (average workers per firm) and the main development indicators including education, accumulated migration, ethnicity and population growth. This is not surprising. The long-term process of development includes the formation of cities and rural to urban migration, driven by industrialization (Lewis, 1954; Harris and Todaro, 1970), and also by the technification of agriculture and the provision of services. The externality to concentration adds to the forces leading to urbanization. The process of rural to urban migration is still underway in the less developed world, except that now manufacturing demands not only unskilled but also skilled labor as inputs for production and for technological change. We show that scale and its changes are correlated with technological change, and that changes in the scale of manufacturing are positively correlated with rises in the returns to human capital.

Trade and technological change

The relationship between technological change, trade and scale is a complex one. On the one hand free trade makes it possible to implement or develop technologies operating at higher levels of scale. On the other, it increases competition. From the point of view of developing countries, this may pose the formidable problem of competing with industries at higher levels of scale, which may also be R&D leaders rather than simply implementing technology. In any case, competition has an ambiguous relation with innovation, which may be inhibited if there is to little or too much competition (Aghion et al, 2002). Thus without free trade, market size limitations and too little competition may inhibit technological growth (and therefore human capital formation), while with free trade competition might be too high, leading to the disappearance of whole industries. In the more positive case in which competition enhances productivity growth under free trade, it is quite likely that whole industrial sectors will go through a process of consolidation and integration – meaning also that some proportion of the firms in each productive sector will fail, in a process of accelerated creative destruction (Schumpeter, 1934). Additional problems may arise with regards to income distribution, since successful market concentration will have several effects. A higher scale of operation will tend to produce more wealth and higher paying jobs demanding human capital. On the other hand, wealth will concentrate towards the ownership of the firms with market power.

Thus, developing countries face the following alternative: to be doomed to a small market that will inhibit growth or, opening to trade and foreign investment, to face a process of change with winners and losers and uncertain productivity outcomes.

It is well known that under these kinds of conditions free markets are not usually efficient. Devising the policies that may produce the best outcomes, however, is not simple. Nevertheless, there is plenty of room for promoting the adoption of technology and for facilitating manufacturing at higher levels of scale by detecting viable industries and providing the appropriate infrastructure, economic setting and incentives. Targeting certain industries for growth in participating underdeveloped countries is especially important when trade treaties are implemented, to make sure that these countries will retain *all* of their viable domestic industrial base, given that they are already at a disadvantage.

Technological change from the municipal point of view in Mexico

In our study on Mexico, we use a municipal data base (equivalent to counties in the US, and giving complete coverage for the country) with the latest available economic indicators for the manufacturing sector, which correspond to 1989 and 1993. During this period, Mexico was emerging from a deep economic crisis that began with a devaluation in 1982. This was followed by a long period of unemployment, inflation and high interest rates that peaked in 1987 at 159% and 96% respectively. Stabilization policies finally reduced inflation from 51.67% in 1988 to 8.01% in 1993, and nominal interest rates from 69.53% to 14.99%. During this period the peso devalued at an average rate of 6.3% a year. Unemployment remained approximately steady.

As one of its policies for structural change, Mexico joined GATT in 1986, beginning to open to trade. In manufacturing, the opening of trade affected mainly exports. These had stagnated between 1981 and 1985, decreasing at an average rate of 0.2%, but grew 1.88% between 1986 and 1993 and 1.18% between 1994 and 2001. Thus exports in manufacturing grew more after GATT than after NAFTA. The rate of growth of imports kept to an annual average of about 3.75% throughout the period 1981-2001, with highs of 6.69% and lows of 1.36%. In this period of trade liberalization one can think that Mexico received a positive technology shock, in addition to the usual rate of technological innovation. We seek to establish whether there was a virtuous interaction between technological change and the formation of human capital.

Our study has an antecedent in Foster and Rosenzweig's (1996) on the green revolution in India. In this study, it was possible to find a one-dimensional correlate of technological change (corresponding to the use of new agricultural techniques) that yielded a measure of technological change that could be related to education. However, Mexico's macroeconomic crisis and trade liberalization induced a period of intense economic adjustment. Change was quite multidimensional. Mexico has many regions with very diverse levels and combinations of education, geography, population density, migration patterns, urban concentration, as well as human capital employment and physical capital intensity in manufacturing. None of these variables, nor regional classification (into North, Center and South and sub-regions) that have been defined in other studies (Unger and Saldaña, 1999), serves as a good proxy for indexing the propensity for technological change as it actually occurred. Figure 1 shows the results of applying a clustering method jointly grouping municipios according to the levels and rates of change of per capita productivity and human capital in manufacturing.[1] Although the similar clustering pattern show correlation between productivity and human capital, rates of change varied wildly. It is apparent that a multiplicity of phenomena took place across the range of productivity and human capital employment.

Scale and its rate of change are natural technological indexes in manufacturing. One of our main findings is that the scale of production (defined as average number of workers per manufacturing firm in each municipio), and its rate of change, are highly interrelated, not only with industrial composition and with technological change, but also with the main demographic, educational and ethnic variables, most likely as a mutual determinant.[2] To begin with, the scale of production is very closely related to the per capita inputs and outputs in manufacturing (Figure 2). The intensity of adjustment occurring in Mexico during this period can be appreciated in Figure 2.4, which plots the rate of change of scale against scale. Adjustment occurred at all scale levels, though at higher levels of scale there was a tendency for scale to decrease. It is possible that newer, more efficient manufacturing firms, especially in municipios averaging more than ten workers per firm were smaller than their predecessors. More recent lines of goods may require a smaller scale of production. It must be understood that increases and decreases in scale also represent firm creation and destruction.

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[1] Consider the joint R^2 for equations describing levels and rates of change of these variables, (linearly in time and with constants respectively), estimated separately for each group of municipios. The algorithm maximizes this R^2 among such subdivisions into ten groups.

[2] The correlation of scale with several 1990 municipal indicators is the following: change of scale -0.28; alphabetism 0.48; primary 0.34, secondary 0.50 and higher education 0.40; indigenous language -0.24; born in state -0.38; population growth 0.26 (including migration).

The strong relation that exists between manufacturing scale and important development indicators can be appreciated by plotting their averages by scale deciles. Alphabetization, primary, secondary and higher schooling, accumulated migration (as measured by the proportion of the population born in the state of residence), indigenous population, CONAPO's marginalization index, population density (all for 1990), accumulated municipal public expenditure (1988-1993), and population growth (1990-1995, including migration) are almost monotonic with scale deciles (Figure 3).

The variety of growth experiences of our 10 clusters of municipios (Figure 1) is also clarified by the introduction of scale. Figure 4 shows scatter plots for the average levels and rates of change of scale and productivity for these ten groups of municipios. Productivity rises with scale as before (Figure 4.1). However there is no clear relation between levels and changes of productivity, as would be suggested by capital accumulation theory (Figure 4.2), or between scale and its rate of change (Figure 4.3). Instead, a relation between change of scale and change of productivity is apparent (Figure 4.4). Where scale rose, so did productivity. Where scale decreased strongly, productivity decreased. For intermediate decreases in scale, both rises and falls in average productivity can be observed, corresponding to increases in new but smaller firms or to the disappearance of firms.

We estimate productivity change to obtain the *returns* to physical and human capital, the *rates of change of the returns* to physical and human capital, and how these interacted with scale and its rate of change. We also allow for direct returns and changes in the returns to scale.

The scale of operation, and its rate of change, present a problem of endogeneity. This was dealt with by instrumenting these variables with industrial composition indicators, which modeled them quite closely. Our main findings are the following. As predicted by our view that changes of scale occur though changes in technology, the direct returns to scale, and their changes, are insignificant. Instead, what we observed was that productivity change was higher where scale and its rate of change were higher, and that these variables parameterize the returns and changes in the returns to physical and human capital. The average returns to human capital were higher where scale increased, as expected.

We also estimate reduced form equations for schooling and school attendance of 12 to 18 year olds obtained from an urban employment survey ENEU in 2000. We find that manufacturing scale during the period 1988-1993 is positively correlated with both educational indicators.

Finally, we estimate reduced form equations for schooling and school attendance of 12 to 18 year olds obtained from Progresa data in 1997. We find that manufacturing scale during the period 1988-1993 significantly affects the schooling and school attendance of different age groups in different ways, probably due to the different working opportunities these have.

In the next sections we give our data sources, develop the methodology to estimate productivity change, and show the corresponding results; discuss the results for schooling and school attendance; and give our conclusions.

The Productivity Change Estimate

Data

We use municipal data for the manufacturing sector from the 1988 and 1993 economic censuses including number of firms (and their type for 1993), their gross income, fixed assets, salary bill, number of workers employed, value added and gross capital formation. Other municipal data available from SIMBAD at INEGI contains demographic and socioeconomic data from the 1990 Population Census and the 1995 Population Count, including education, data on municipal public finances, and other contextual variables.

Methodology

To estimate technological change across municipios, a log-linear approximation of the per capita value added function in municipio i at time t, given by

$$y_{it} = \theta_t + \alpha_t k_{it} + \beta_t h_{it} + \gamma_t s_{it} + \delta_t f_{it} + \mu_i + \eta_t \varepsilon_{it} \tag{1}$$

where y_{it} is log value added, θ_t is the technological level, k_{it} are log fixed assets, h_{it} are log stocks of human capital as measured by payments to labor deflated by the municipio-specific minimum wage, s_{it} is the log of workers per firm, so that γ_t measures the excess over constant returns to scale, f_{it} denotes infrastructure such as roads, μ_i are municipio-specific fixed effects, and $\eta_t \varepsilon_{it}$ are disturbances correlated with technological change.

Exact first differences of equation (1) can be written

$$\begin{aligned} \Delta y_{it} &= \Delta\theta_t + \bar{\alpha}_t \Delta k_{it} + \bar{\beta}_t \Delta h_{it} + \bar{\gamma}_t \Delta s_{it} + \bar{\delta}_t \Delta f_{it} \\ &+ \Delta\alpha_t \bar{k}_{it} + \Delta\beta_t \bar{h}_{it} + \Delta\gamma_t \bar{s}_{it} + \Delta\delta_t \bar{f}_{it} + \bar{\eta}_t \Delta\varepsilon_{it} + \Delta\eta_t \bar{\varepsilon}_{it}, \end{aligned} \tag{2}$$

where $\Delta x_t = x_{t+1} - x_t$ and $\bar{x}_t = \frac{1}{2}(x_t + x_{t+1})$ for any variable x_t. (Observe that, using the stated notation, $a_{t+1}b_{t+1} - a_t b_t = \Delta a_t \bar{b}_t + \bar{a}_t \Delta b_t$.) In the estimation, the coefficients $\bar{\alpha}_t, \bar{\beta}_t, \bar{\gamma}_t, \bar{\delta}_t$ represent the average returns to physical and human capital through the period $[t, t+1]$, excess over constant returns to scale, and returns to infrastructure. The coefficients $\Delta\alpha_t, \Delta\beta_t, \Delta\gamma_t, \Delta\delta_t$ represent average rates of change in each of these returns, and $\Delta\theta_t$ represents the rate of technological change.

We model endogenous technological change by supposing that it depends on the level of physical and human capital inputs used. We suppose

$$\Delta\theta_t = \chi_t + \chi_t^k \bar{k}_{it} + \chi_t^h \bar{h}_{it} . \tag{3}$$

Thus we finally obtain the regression

$$\begin{aligned}\Delta y_{it} &= \chi_t + \bar{\alpha}_t \Delta k_{it} + \bar{\beta}_t \Delta h_{it} + \bar{\gamma}_t \Delta s_{it} + \bar{\delta}_t \Delta f_{it} \\ &\quad + \alpha_t' \bar{k}_{it} + \beta_t' \bar{h}_{it} + \gamma_t' \bar{s}_{it} + \delta_t' \bar{f}_{it} + \xi_{it} ,\end{aligned} \tag{4}$$

The best available variable to measure infrastructure was public expenditure. Since however data for accumulated public expenditure was not available, the terms in f, measuring the change in returns to public expenditure, were not included, and only the Δf term was included. The disturbance term has the form

$$\xi_{it} = \bar{\eta}_t \Delta\varepsilon_{it} + \Delta\eta_t \bar{\varepsilon}_{it} . \tag{5}$$

Following Foster and Rosenzweig (1996), we use non-linear least squares with the White correction for heteroskedasticity. In our main estimates we use $\bar{s}_{it}$ and Δs_{it} to index the municipios, and therefore we model each of the coefficients linearly in $\bar{s}_{it}$ and Δs_{it}, e.g. $\bar{\alpha} = \alpha_0 + \alpha_1 \bar{s}_{it} + \alpha_2 \Delta s_{it}$, thus in effect stratifying the estimate of each coefficient in these two variables. We show by means of F-tests that the stratification is significant in both variables.

Modeling coefficients in terms of $\bar{s}_{it}$ and Δs_{it}, including the constant term χ_t, allows some of the convergence or divergence effects that may be present in the data to be expressed.

Instrumentation

The scale variables $\bar{s}_{it}$ and Δs_{it} on which the coefficients of the productivity estimate are being modeled present a problem of endogeneity. For this reason we instrumented this variables with 1993 industrial composition data (the only period for which it is available). The industrial composition indicators we use are: number of industrial branches present in the municipio (out of a total of 54); proportion of value added in the following divisions (out of a total of 9): chemicals and petroleum, carbon rubber and plastic derivatives; basic metals; metallic products; and machinery; and proportion of value added in the following branches: bakeries, tortillas and tortilla dough, textiles, furniture (wood), paper and derivatives, artificial fibers, glass, furniture (metal), and electronic equipment. These branches and subdivisions were chosen for their significance in trial regressions and yield an R-squared of 0.540. Also included are all the quadratic combinations of these variables (raising the R-squared to 0.675) and state dummies to account for geographical characteristics (yielding a final 0.713). The estimates for Δs_{it} obtained an R-squared of 0.19, which is high for a rate of change variable. We refer to the instrumented scale and change of scale variables, estimated by industrial composition, as S_{it} and ΔS_{it}.

The surprisingly high R-squares that are obtained in these regressions support the view that 1) each industry has a well defined distribution of scale that may depend on the locality, 2) there are positive externalities to industrial concentration, 3) the possibilities for change in scale are also importantly determined by industry-specific conditions. The results obtained, by instrumenting on industrial composition were so good for scale and its rate of change, that we also estimated regression (4) by two stage least squares, instrumenting all variables on the same set of industrial composition variables, including their interaction terms and state dummies (See Table 1).[3] The results indicate that both physical and human capital had positive returns, and that productivity change was associated with a coefficient for the rise in the returns to human capital of about 0.10 for every unit increase in log productivity and a coefficient for the decrease in the returns to physical capital of about 0.05. They also appear to give evidence that any increasing returns to scale, as well as the change in these returns, were insignificant. As we shall see below, though, the regression is mis-specified, as the significance obtained by modeling the coefficients in terms of $\tilde{S}_{it}$ and ΔS_{it} reveals.

Before turning to the full estimation, we note that a simple model of capital accumulation under a credit restriction suggests that measures of stocks in period t will be correlated with period $t-1$ productivity. Thus it is possible that the investment variables Δk, Δh, can present a problem of endogeneity. However, none of the variables in our data, including human and physical capital for the commercial sectors, provided suitable instruments according to the over-identification tests we carried out. In any case, part of the possible endogeneity problem is reduced by including the scale variable s, since the credit restrictions may be negatively correlated with the scale variable s.

We now go over the main results of our estimates (Table 2.1). The table shows four estimates, according to 1) whether the coefficients are estimated using only S as a stratifying variable, or both S and dS, and 2) whether scale was included or not in the production function from which the regression estimate was derived (see equation 1).

The F-tests comparing these estimates show that stratifying by both S and dS was consistently more significant, and that the variables needed to include scale in the production function were not found to be jointly significant in this case (see Table 3.1).[4] Thus the second regression in Table 2.1, stratifying by both S and dS but

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[3] The infrastructure variable was omitted because it yielded systematically insignificant results.

[4] They were only marginally significant when only S was used to stratifying the coefficients, but then this equation was mis-specified for not including dS in the stratification.

not including S in the production function dominates the other three. We conclude from it that:

a) Productivity change that occurred independently of the inputs (the constant, S and dS terms) increased more where scale was higher and where scale increased, implying a technological divergence effect.
b) The average returns to physical capital where consistently positive and significant, and were higher where scale increased.
c) The average returns to human capital where consistently positive and significant.
d) The returns to physical capital decreased where scale was higher or scale increased. The mean change was only somewhat positive, as can be seen in Figure 5.1, which shows the distribution of changes in the returns across municipios as predicted by the instrumented variables S and dS, restricted to those municipios where productivity increased.
e) The returns to human capital where higher where scale increased and somewhat higher where scale was lower. The mean change was positive, as can be seen in Figure 5.2, which shows the distribution of changes in the returns across municipios as predicted by the instrumented variables S and dS, restricted to those municipios where productivity increased.

Changes in scale were thus associated with increases in the returns to human capital that were accompanied on average with decreases in the returns to physical capital. This is consistent with the idea that human capital is necessary for technological change that is associated with increases in the scale of operation, and that this is profitable even when the returns to physical capital may decrease.

Scale itself was associated with decreases in the returns to both physical and human capital. Since scale is associated with industrial composition, this may imply that technological change occurred in industries not operating at the highest scale levels.

Let us consider what changes were apparent when scale was considered as an input.

a) The returns to scale decreased were scale was higher.
b) The returns to human capital were higher where scale was higher.
c) The estimated returns to human capital were lower than when scale was not included in the production function.
d) Changes in the returns to human capital were insignificant.

The main implication is that the dS terms accounting for the returns to scale interact with both the dh and h terms accounting for the returns and changes in the returns to human capital, which may proxy for scale. This is additional evidence that scale and human capital interact. However, measuring human capital through the wage bill may neglect some human capital inputs that occur through investment or in consulting and are usually not reported as wages, especially in larger firms. Thus, better data then we have available would be needed to more fully account for the relation between scale, human capital and technological change.

How are Tables 1 and 2 related? The coefficient of *S* in Table 1 probably obtains an insignificant coefficient because of the opposite signs that *S* obtains in its interaction with physical and human capital which are very much in the data. The insignificance of the *dS* coefficient is consistent with the joint insignificance of the terms representing scale in the production (obtained in the F-test comparing regressions 2 and 4).

To find out if there are any additional convergence effects that accrue to firms with low productivity, we regressed the residuals of the productivity change estimates against the mean log productivity over the period, together with dummies for the North and the South of Mexico for all four regressions. While the convergence coefficient was about -0.014, the R-squares obtained were very low, around 0.017. When dummies for the ten clubs mentioned above were included, the R-squared rose to 0.33, the North and the South dummies were significant at -0.02 and 0.02 respectively, but the convergence coefficient was insignificant. If productivity change rather than the residuals are regressed on the same variables, the R-squared is 0.64. We conclude that our productivity change estimates explain about half of the variation implicit in the club structure in terms of returns and changes to the returns of capital and human capital, stratified by scale and change of scale, while the remaining half is mostly not explained by North-South differences in Mexico or to convergence effects.

We replicated the set of regressions using the residuals *RS* and *dRS* that were obtained in the estimates for scale and change of scale in terms of the industrial composition variables, instead of the estimated *S* and *dS*. These residuals represent the average levels of scale and change of scale *above* those expected for each municipio by industrial composition variables. We also conducted F-Tests to compare the four regressions. The results are in Tables 2.2 and 2.3.

The results are the following. As can be seen in Table 2.2, residual scale *RS* and dRS play no significant role in stratifying the returns and changes in the returns to factors in technological change. However, the results may be insignificant because the residual may reflect other factors. For example, localities with low wages may result in higher scales, yielding decreasing human capital returns associated with increasing scale, the opposite sign relation to that obtained for the instrumented dS (increasing human capital returns associated with increasing scale), and therefore result in insignificant coefficients. That human capital returns rose where productivity rose is corroborated, with a coefficient of about 0.04. Table 3.2 shows that the best regression is number 4, which is more significant because of the inclusion of the terms representing direct returns to scale (rather than returns to technological change associated with changes in scale). These are all significant and imply:

a) The returns to scale higher than expected by industrial composition were significantly higher where it was higher (coefficient for *RS2*).
b) Where scale increased more than expected by industrial composition, it enjoyed significant returns (coefficient for *dRS2*).
c) The sum of the increase in returns to residual scale and the returns to residual scale where residual scale was higher (coefficient for *RSdRS*) was positive and significant.

Of course, an increase in residual scale need not represent a within industry comparison, but may also represent new, higher scale industries. Residual scale and its changes are associated with above linear returns to scale. Only the scale that is associated with industrial composition stratifies technological change. This means that technological change occurs through a process associated with changes in scale, and that the relevant scale measure is itself associated with industrial composition. This is consistent with our verbal model of how technological change may require changes in scale and with the idea that in each industry there is a well defined range of viable scales of operation, that may have some local variation. Residual scale measures that local variation, and is associated with returns to scale that may occur within or across industries.

The Urban Schooling and School Attendance Estimates

For the schooling and school attendance estimates we use data from the National Urban Employment Survey (ENEU) survey for the second trimester of 2000, which contains information on housing that can proxy for wealth, as well as on household income, schooling and income of household head, and employment. Our sample includes all 12 to 18 year olds.

Taking a long-term point of view of the role of the scale of production in the dynamics of development, we can think of schooling as an autoregressive process across generations, of the form

$$\mathrm{SCH}_t = \alpha_t\, g(\mathrm{SCH}_{t-1}) + \beta_t\, \mathrm{SCALE}_t + \varepsilon_t \qquad (6)$$

where SCH_{t+1} is schooling (or school attendance) of the young, SCH_t is parental schooling, and SCALE_t is a proxy for local wealth and incentives for schooling, where g is a concave function. Table 4, shows the results of this approach, which gives instrumented scale a positive coefficient significant at the 5% level.

A more microeconomic perspective is to estimate schooling and school attendance using a reduce form equation in which the independent variables are age, gender, wealth proxies including parental income and schooling and household composition. The database we use also contains the size of the firm in which the household head works. Therefore the additional municipal scale and change of scale variables exclude this direct effect. Especially the change of scale *dS* was found to parameterize the increase in the returns to human capital correlated with technological change. Since dS is included in the regressions, S is also included as a control. We found that age interacted significantly with these variables. Because there is subjectivity in reporting time spent working or studying, we run an estimate on the sum and on the proportion of this sum spent studying. The results are in Table 5. The coefficients for the change of scale variables were significant at the 1% level for schooling. Together with scale, they were also significant at the 1% level for the proportion of time spent studying. The total time spent studying and working had significant negative coefficients when the interaction with age was not included. The results indicate that in regions with higher or increasing average manufacturing scale, children over 12 study more than their counterparts with similar household characteristics in other regions. This effect decreases with age. The correlation of dS with schooling or proportion of time spent in school crosses the intercept at ages 15.4 and 15.5 respectively. Above this age more of the time is spent working where there is more industry.

The Rural Schooling and School Attendance Estimates

We conduct analogous estimates in the rural context. We use the data set on which Parker, Rubalcava and Teruel (2002) base their analysis of schooling inequality and language barriers for the indigenous population in Mexico. They use 1997 data from ENCASE, on the socio-economic condition of rural households, and from the Ministry of Education (SEP) on school characteristics. We add our estimated scale and change of scale variables for the period 1988-1993 to their regressions, interacted with age groups. Because these variables are at the community level, we cannot include community fixed effects, so to control for fixed effects that may be correlated with the proportion of indigenous population we also include the proportion of children speaking indigenous languages in each community as an indicator, also interacted with age. This was necessary to reproduce the signs obtained by the original authors for the dummies representing speaking an indigenous language and only speaking an indigenous language. The results are in Table 6. Scale and change of scale contribute positively to the school attendance of 6 to 8 year olds, but this effect reverts in the 9 to 11 age group, after which it is negative. It can be interpreted that more work opportunities result in less schooling. This is consistent with the signs obtained for different age groups by the proportion of children speaking indigenous languages variable. With respect to schooling, change of scale obtains similar results, but with the critical age at 12 to 14. The results for scale are the opposite, for reasons that are not clear. Since this is an accumulated, lagged variable, perhaps it is correlated with the availability of schools, especially for intermediate education.

Conclusions

Human capital returns mostly rose with technological change, and this rise was positively correlated with increases in the scale of production (Figure 5.2). There was evidence of additional interaction of scale and human capital that need to be investigated further and suggest that the two phenomena are closely related and that human capital variables may often proxy for scale.

Scale was found to significantly contribute and interact with technological change, without significant evidence of increasing returns to scale in the data. This is consistent with the idea that technological change often involves raises in the scale of operation. In addition, scale is closely associated with many indicators of development, including accumulated migration, population growth and educational levels. According to our microeconomic regressions, it is also a determinant of schooling and school attendance in urban and rural areas, where it also appears to increase the opportunities for work.

The pivotal relation of scale with migration, education and productivity is not surprising. People migrate to working opportunities, and opt for more education when it offers better jobs. Thus the installation of larger and more productive enterprises will attract workers and skills. In turn, population, skill and industrial concentration will attract further and more specialized, advanced industry. The natural positive feedback that exists between migration, education and productivity suggest that an integral policy addressing these three issues is possible, by rewarding local economic growth with public support in the form of infrastructure for the inflowing population, including education, and infrastructure for industry.

Such support would *go with the flow* of the rural to urban transition dictated by long-term economic forces in industry, agriculture and services, and would afford the opportunity to intervene in the design of the future net of cities to be in Mexico. It also provides the opportunity to lessen rural migration to Mexico City, which is already overgrown, and to the United States, by providing an alternative set of destinations where the basis for a higher standard of living can be established. This kind of policy will also tend to weaken the low-technology traps that can arise from the competition between technological implementators and R&D leaders in the world markets, and to make the long-term transition more orderly.

The fact that the changes in the scale of operation mediate the virtuous circle between productivity change and human capital returns is important. It indicates that, as is usually the case, the process of technological change involves mechanisms that the market does not coordinate efficiently. These must be addressed by public policies that may be able to generate and benefit from the positive externalities and virtuous circles mentioned above. The effects of scale must also receive attention in the formulation of trade and foreign investment policies, which should include amongst its objectives the success of all internationally viable domestic industry, as it is introduced to the competition of its developed counterparts.

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Figure 1. Groups of Municipios with Similar Human Capital and Productivity Trajectories

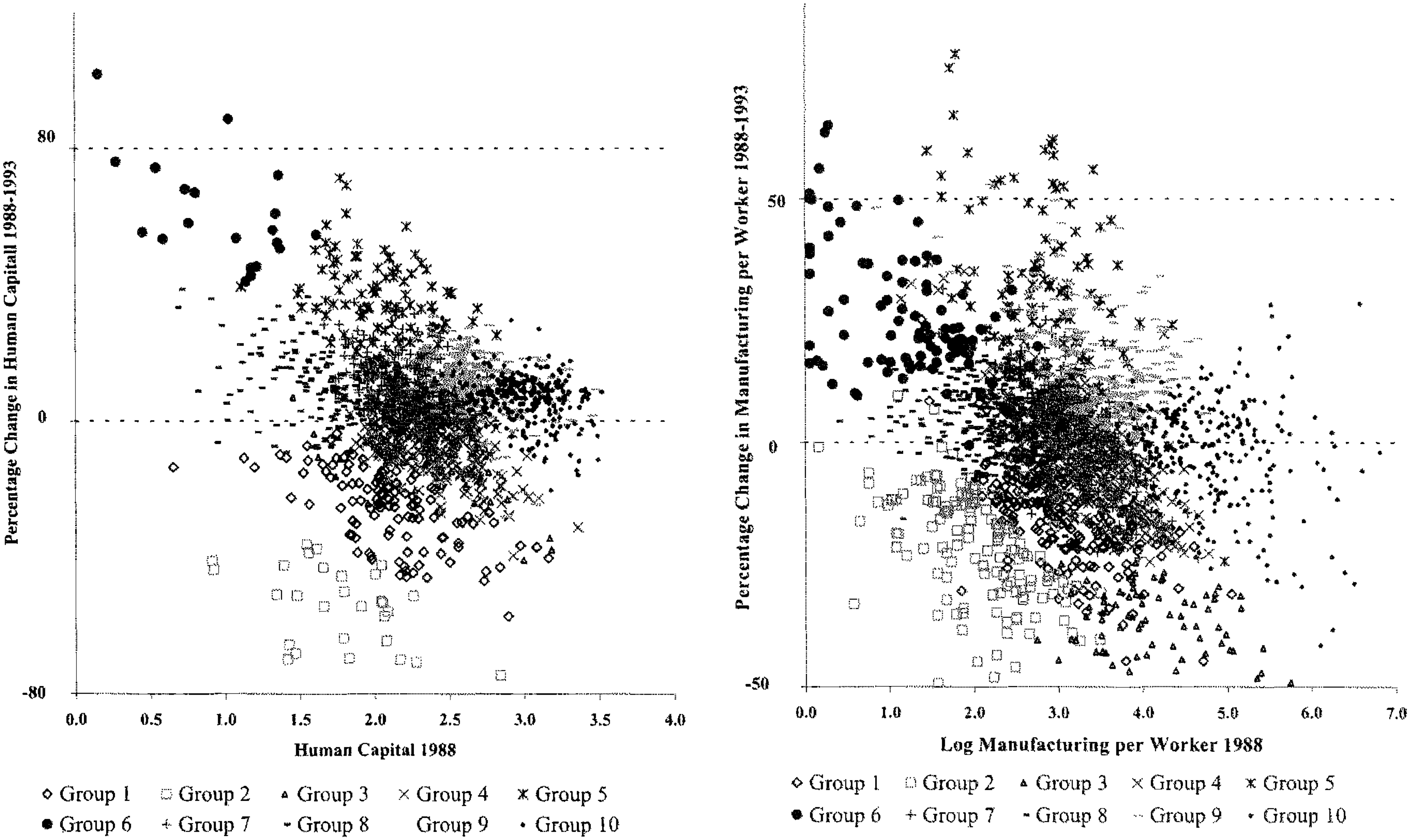


Figure 2. Relation of Scale of Operation with Inputs and Outputs per Worker

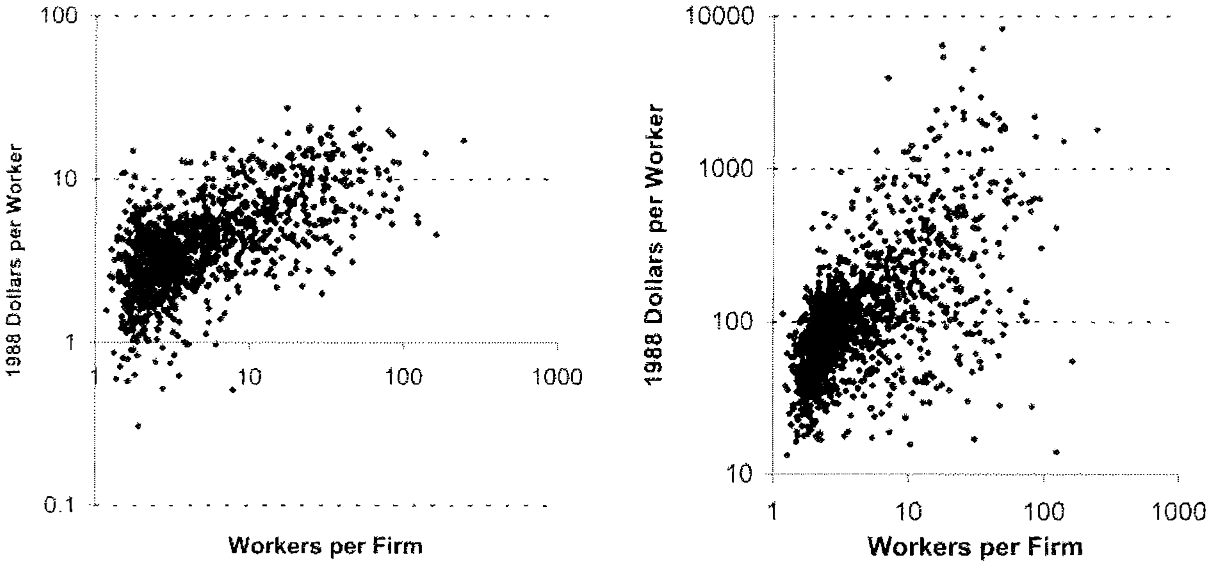


Figure 2.1 Remuneration per Worker

Figure 2.2 Fixed Assets per Worker


Figure 2.3 Value Added per Worker

Figure 2.4 Rate of Change of Workers per Firm

Figure 3 Educational, Demographic and other Municipal Indicators by Manufacturing Scale Deciles

Figure 3.1

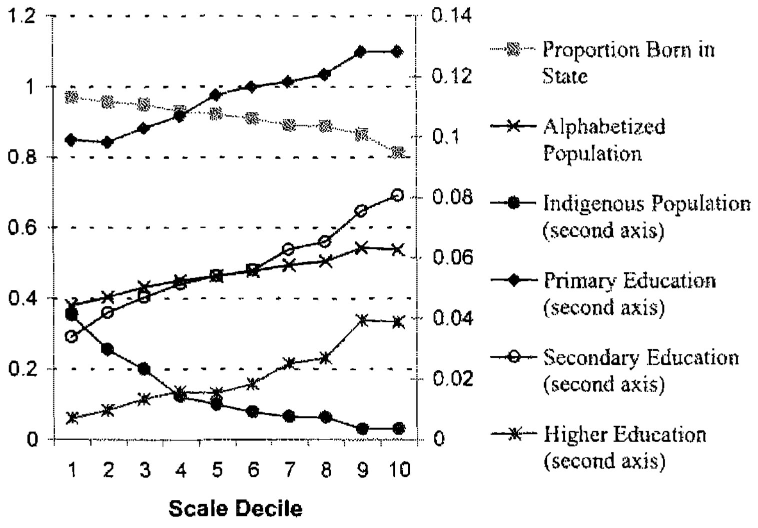


Figure 3.2

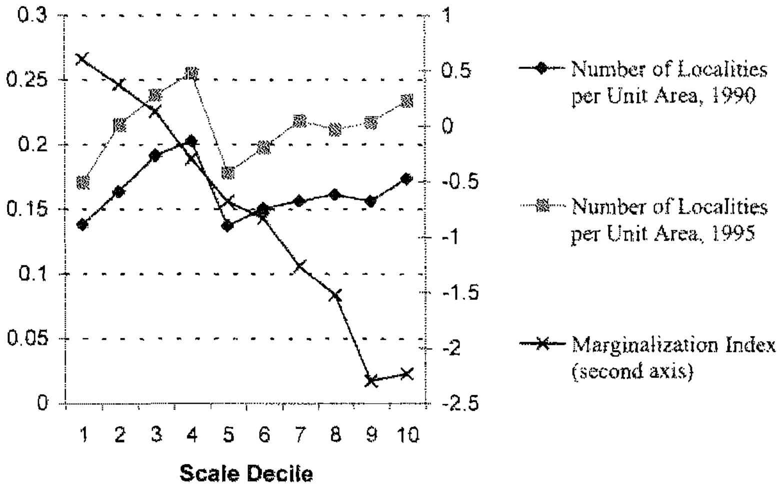


Figure 3.3

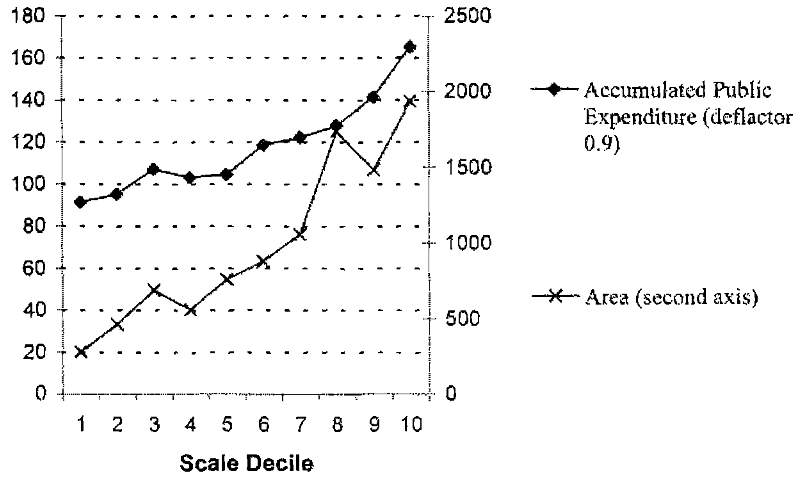


Figure 3.4

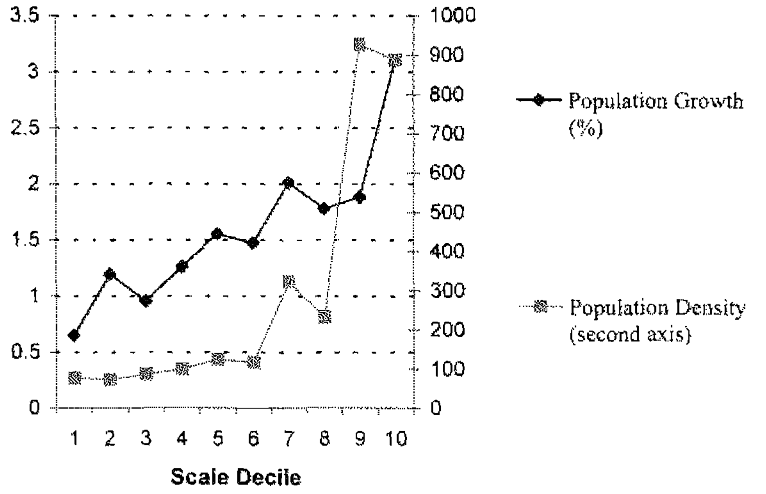


Figure 4. Relation Between Productivity, Scale and their Rates of Change Across the 10 Groups of Municipios

Figure 4.1 Productivity versus Scale

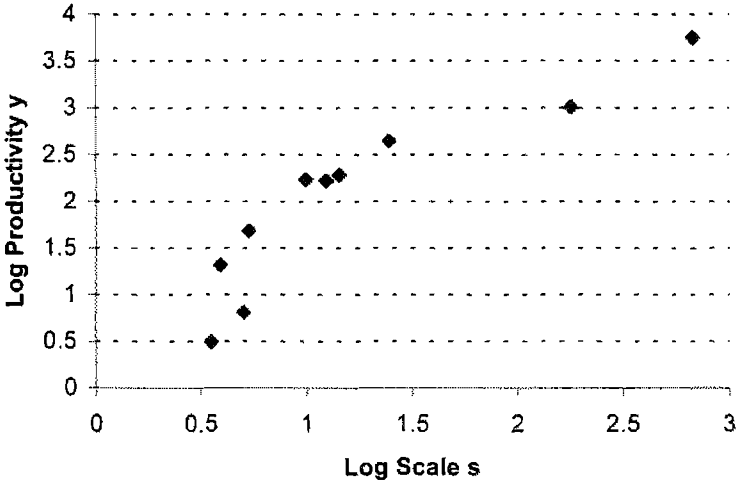


Figure 4.2 Change of Productivity versus Productivity

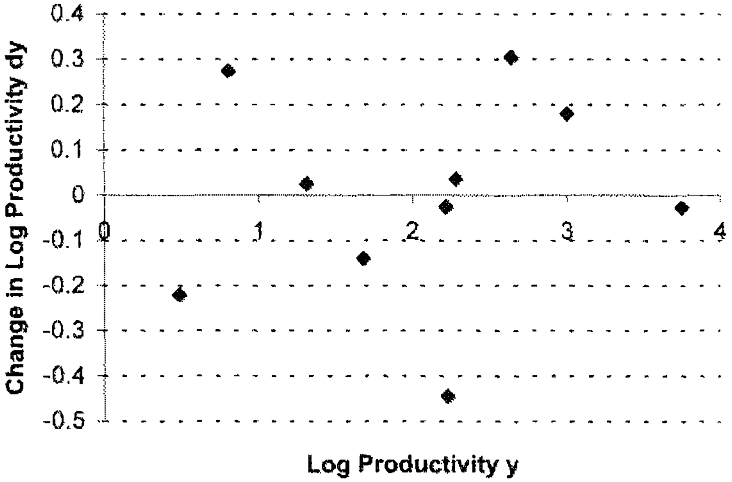


Figure 4.3 Change of Scale versus Scale

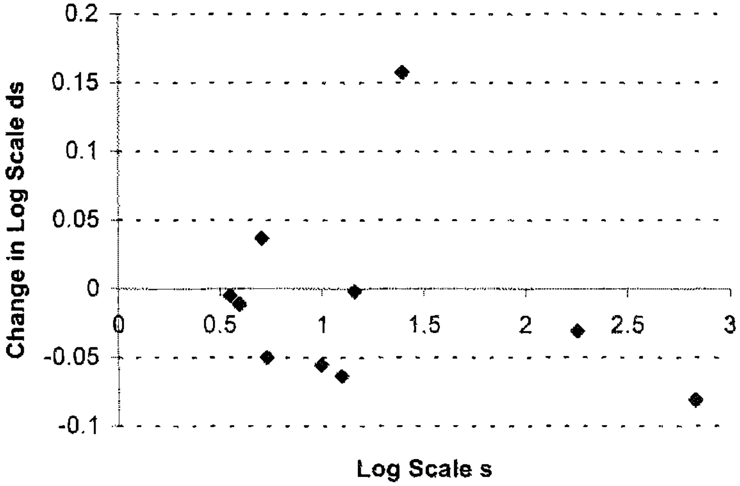


Figure 4.4 Change of Productivity versus Change of Scale

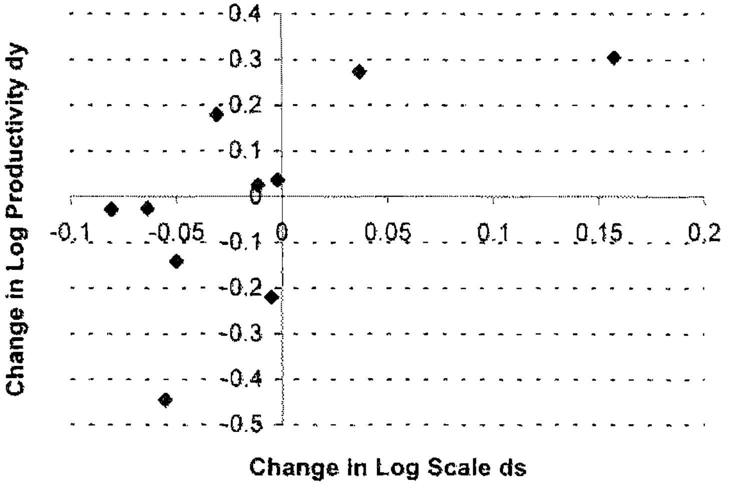
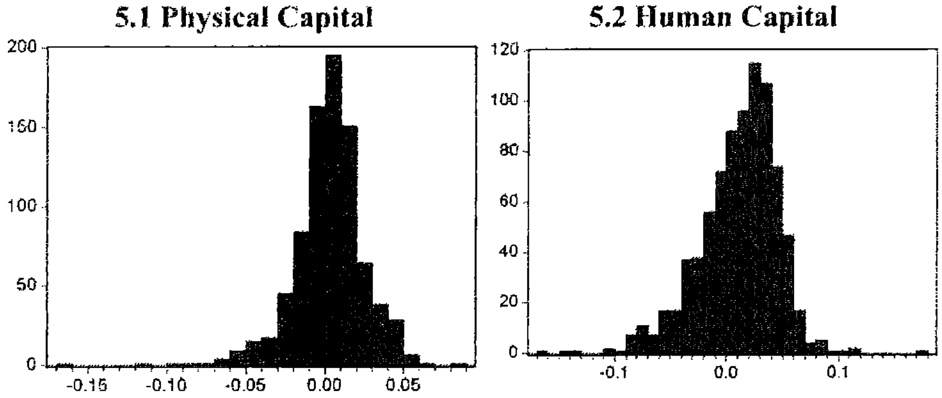


Figure 5. Municipal Histograms for the Coefficients of the Changes in the Returns to Capital (Regression 2, Table 4) Restricted to Municipios where Productivity Increased.



5.1 Physical Capital

5.2 Human Capital

Note: The graph obtained for human capital without the restriction to municipios where productivity increased is very similar, although it is very slightly shifted to the left. In the case of physical capital the two graphs are almost identical.

Table 1. Productivity Change Estimate Instrumented by Industrial Composition Indicators

	TSLS (all variables instrumented)	**TSLS (k, h, s instrumented)**	**R-squared in Instrumenting Estimate**
c	**0.176**	**0.168**	
	(0.001)	**(0.002)**	
dk	*0.172*	**0.12**	
	(0.052)	**(0)**	0.14
dh	**0.668**	**0.517**	
	(0)	**(0)**	0.22
ds	-0.197	0	
	(0.15)	(0.999)	0.19
k	**-0.056**	**-0.048**	
	(0)	**(0.001)**	0.58
h	**0.105**	**0.112**	
	(0)	**(0)**	0.47
s	0.002	0.004	
	(0.852)	(0.707)	0.72
Observations	1335	1335	
R-squared	0.17255466	0.202098536	
F statistic	36.15720119	73.58207379	

(p-value in parenthesis)

Better than 5% significance in bold
Better than 10% significance in italics

Table 2.1 Regressions for Productivity Change in Manufacturing (Continuous stratification)

Regression	**1**	**2**	**3**	**4**
Stratifying variables	**S**	**S, dS**	**S**	**S, dS**
Production Function	**Excludes Scale**		**Includes Scale**	
c	*-0.083*	-0.071	**-0.13**	**-0.109**
	(0.086)	(0.138)	**(0.015)**	**(0.04)**
S	*0.042*	**0.06**	**0.105**	**0.111**
	(0.092)	**(0.017)**	**(0.005)**	**(0.003)**
dS		**1.357**	0.063	*1.217*
		(0.014)	(0.755)	*(0.07)*
S2			**-0.016**	*-0.013*
			(0.015)	*(0.052)*
SdS			-0.081	0.021
			(0.341)	(0.867)
dS2				-0.689
				(0.164)
dk	**0.203**	**0.248**	**0.206**	**0.254**
	(0.003)	**(0)**	**(0.003)**	**(0)**
Sdk	-0.043	-0.049	-0.048	-0.054
	(0.227)	(0.16)	(0.185)	(0.126)
dSdk		**1.212**		**1.311**
		(0.028)		**(0.02)**
dh	**0.236**	**0.246**	**0.163**	**0.191**
	(0.001)	**(0.001)**	**(0.038)**	**(0.021)**
Sdh	0.081	0.076	**0.131**	*0.11*
	(0.105)	(0.138)	**(0.02)**	*(0.053)*
dSdh		0.361		0.387
		(0.619)		(0.655)
k	0.015	0.012	0.013	0.008
	(0.322)	(0.375)	(0.356)	(0.579)
Sk	-0.006	*-0.012*	-0.007	*-0.011*
	(0.41)	*(0.068)*	(0.272)	*(0.091)*
dSk		**-0.389**		**-0.385**
		(0.001)		**(0.001)**
h	**0.054**	**0.062**	0.025	0.035
	(0.009)	**(0.003)**	(0.343)	(0.185)
Sh	**-0.026**	*-0.023*	-0.008	-0.007
	(0.034)	*(0.056)*	(0.621)	(0.659)
dSh		**0.487**		0.442
		(0.03)		(0.119)
dpub	0.049	0.039	0.047	0.047
	(0.311)	(0.426)	(0.333)	(0.327)
Sdpub	-0.025	-0.023	-0.025	-0.029
	(0.419)	(0.458)	(0.415)	(0.349)
dSdpub		-0.335		-0.215
		(0.597)		(0.733)
R-squared	0.252	0.270	0.256	0.273
F-statistic	37.25	26.32	29.89	22.67
Prob (F)	0.000	0.000	0.000	0.000
Log likel.	663.450	678.396	667.130	681.020

(p-value in parenthesis)

Better than 5% significance in bold
Better than 10% significance in italics

Table 2.2 Regressions for Productivity Change in Manufacturing

(Continuous stratification by residual scale)

	1	2	3	4
Stratifying variables	**RS**	**RS, dRS**	**RS**	**RS, dRS**
Production Function	**Excludes Scale**		**Includes Scale**	
c	0.001	0.003	-0.008	-0.008
	(0.965)	(0.9)	(0.757)	(0.782)
RS	-0.044	-0.052	-0.056	-0.057
	(0.392)	(0.346)	(0.275)	(0.283)
dRS		-0.019	*-0.101*	0.029
		(0.948)	*(0.09)*	(0.915)
RS2			**0.022**	**0.028**
			(0.021)	**(0.003)**
RSdRS			0.05	**0.247**
			(0.524)	**(0.017)**
dRS2				**0.733**
				(0.012)
dk	**0.152**	**0.16**	**0.153**	**0.161**
	(0)	**(0)**	**(0)**	**(0)**
RSdk	-0.055	-0.015	*-0.071*	-0.036
	(0.141)	(0.72)	*(0.052)*	(0.396)
dRSdk		*0.441*		0.362
		(0.072)		(0.128)
dh	**0.379**	**0.398**	**0.389**	**0.388**
	(0)	**(0)**	**(0)**	**(0)**
RSdh	0.025	0.019	0.027	-0.042
	(0.712)	(0.809)	(0.712)	(0.593)
dRSdh		-0.195		*-0.532*
		(0.486)		*(0.087)*
k	-0.001	-0.002	0.001	-0.001
	(0.941)	(0.727)	(0.881)	(0.868)
RSk	0.003	0.004	0.002	0.005
	(0.787)	(0.778)	(0.869)	(0.698)
dRSk		-0.01		-0.006
		(0.894)		(0.934)
h	**0.043**	**0.041**	**0.039**	**0.041**
	(0)	**(0)**	**(0)**	**(0)**
RSh	-0.004	-0.018	-0.017	-0.024
	(0.839)	(0.431)	(0.406)	(0.281)
dRSh		-0.108		-0.062
		(0.319)		(0.537)
dpub	0.017	0.017	0.015	0.019
	(0.533)	(0.526)	(0.581)	(0.475)
RSdpub	0.004	-0.012	-0.003	-0.03
	(0.944)	(0.859)	(0.954)	(0.659)
dRSdpub		-0.208		-0.325
		(0.523)		(0.323)
R-squared	0.243	0.252	0.249	0.260
F-statistic	35.54	23.99	28.82	21.31
Prob (F)	0.000	0.000	0.000	0.000
Log likel.	656.326	663.495	661.455	670.809

(p-value in parenthesis)

Better than 5% significance in bold
Better than 10% significance in italics

Table 3.3 F Tests Comparing Productivity Change Estimations

Regression	2	3	4	4
Reduced to Regression	1	1	2	3
Prob (F)	0.0280	0.0174	0.0024	0.0053

If the F Tests are considered as a preference ordering, then regression 4 is preferred

Table 4. Impact of Manufacturing Scale on Schooling and School Attendance

	Schooling (Robust least squares)	**School attendance (Robust logit)**
age*sex (male = 1)	**0.036**	**0.249**
	(0)	**(0)**
age 13	**2.066**	**-0.237**
	(0)	**(0)**
age 14	**4.14**	**-0.639**
	(0)	**(0)**
age 15	**4.764**	**-1.232**
	(0)	**(0)**
age 16	**5.542**	**-1.891**
	(0)	**(0)**
age 17	**5.93**	**-2.457**
	(0)	**(0)**
sex	**-0.429**	**-1.982**
	(0)	**(0)**
schooling of household head	**1.334**	**0.498**
	(0)	**(0)**
schooling of household head squared	**-0.046**	**-0.015**
	(0)	**(0)**
manufacturing scale	**0.032**	*0.037*
	(0.044)	*(0.055)*
constant	**-8.323**	**-2**
	(0)	**(0)**
Number of obs	35806	35806
F or Wald	6310.65	8325.25
Prob	0	0
R-squared or Pseudo R-squared	0.5463	0.3517

(p-values in parenthesis)

Better than 5% significance in bold
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Table 5. Impact of Manufacturing Scale on Schooling, Time Spent Studying or Working, and Proportion Spent Studying of 12 to 18 Year Olds

	Schooling	Time studying or working	Proportion spent studying
constant	**-5.927**	**3.601**	**0.966**
	(0)	**(0.058)**	**(0)**
employee dummy	**-0.062**	0.264	**-0.018**
	(0.177)	(0.474)	**(0.005)**
S (manufacturing scale instrumented by industrial composition)	-0.043	-1.687	**0.099**
	(0.76)	(0.144)	**(0)**
dS (change in manufacturing scale instrumented by industrial composition)	**8.413**	-20.835	**0.885**
	(0)	(0.148)	**(0)**
S*age	0.007	0.031	**-0.006**
	(0.45)	(0.707)	**(0)**
dS*age	**-0.546**	0.538	**-0.057**
	(0)	(0.6)	**(0.002)**
age*sex (male = 1)	**0.039**	**0.799**	**0.024**
	(0)	**(0)**	**(0)**
age 13	**1.881**	**0.556**	**-0.031**
	(0)	**(0.115)**	**(0)**
age 14	**3.849**	**2.028**	**-0.099**
	(0)	**(0)**	**(0)**
age 15	**4.368**	**2.845**	**-0.198**
	(0)	**(0)**	**(0)**
age 16	**5.169**	**4.779**	**-0.359**
	(0)	**(0)**	**(0)**
age 17	**5.431**	**6.15**	**-0.459**
	(0)	**(0)**	**(0)**
age 18			
sex	**-0.418**	**-0.987**	**-0.252**
	(0)	**(0)**	**(0)**
schooling of household head	**1.349**	**0.359**	**0.076**
	(0)	**(0.076)**	**(0)**
schooling of household head squared	**-0.049**	**-0.032**	**-0.002**
	(0)	**(0)**	**(0)**
log income of household head	**-0.167**	**3.542**	**-0.071**
	(0)	**(0)**	**(0)**
household head employed last week	**-0.094**	**1.522**	**0.02**
	(0.022)	**(0)**	**(0.002)**
sex of household head	**0.086**	**-2.687**	**0.038**
	(0.024)	**(0)**	**(0)**
hours worked by household head	0.001	0	0
	(0.111)	(0.993)	(0.837)
people in household aged 0-5	**-0.144**	*-0.205*	**-0.027**
	(0)	*(0.148)*	**(0)**
people in household aged 6-11	*-0.03*	**0.391**	**-0.007**
	(0.075)	**(0.003)**	**(0.004)**
people in household aged 12-15	**-0.179**	**-1.494**	**-0.071**
	(0)	**(0)**	**(0)**

(p-values in parenthesis)

Better than 5% significance in bold
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Table 5 (continued)

people in household aged 19-22	**-0.322**	**-1.388**	**-0.021**
	(0)	**(0)**	**(0)**
people in household aged 23-30	**-0.145**	**-1.183**	**0.006**
	(0)	**(0)**	**(0.034)**
size of firm where household head works	**0.016**	**-0.265**	**0.008**
	(0.014)	**(0)**	**(0)**
Housing characteristics			
private bathroom	0.068	**-1.604**	**0.028**
	(0.298)	**(0.003)**	**(0.003)**
Walls: brick excluded			
wood	*-0.147*	-0.235	**0.021**
	(0.043)	(0.689)	**(0.043)**
adobe	0.061	**1.824**	-0.009
	(0.538)	**(0.033)**	(0.533)
corrugated materials	0.008	-0.41	0.03
	(0.949)	(0.702)	(0.11)
cardboard	**0.087**	-0.99	-0.02
	(0.565)	(0.447)	(0.381)
other	-0.236	-2.361	*-0.034*
	(0.517)	(0.371)	*(0.479)*
Roofing: concrete excluded			
thatching and similar	**-0.284**	**-1.234**	0.004
	(0)	**(0.013)**	(0.691)
corrugated materials	**-0.194**	-0.7	0.002
	(0)	(0.073)	(0.762)
cardboard	**-0.313**	0.46	-0.004
	(0)	(0.511)	(0.747)
other	-0.082	*4.557*	**0.061**
	(0.839)	*(0.074)*	**(0.139)**
Floors: proper coverings excluded			
cement	**-0.068**	0.224	**-0.022**
	(0.02)	(0.342)	**(0)**
earth	**-0.289**	-0.162	**-0.064**
	(0.001)	(0.812)	**(0)**
Services: electricity excluded			
water	-0.088	0.262	**0.027**
	(0.229)	(0.674)	**(0.009)**
drainage	0.042	0.21	0.005
	(0.529)	(0.702)	(0.604)
telephone	**0.28**	**-0.887**	**0.034**
	(0)	**(0)**	**(0)**
other	0.046	*-0.177*	**0.017**
	(0.237)	*(0.563)*	**(0.002)**
Number of obs	33889	33889	27921
F or Wald	1311	100.64	700.75
Prob	0	0	0
R-squared or Pseudo R-squared	0.5271	0.1115	0.4566

(p-values in parenthesis)

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Table 6. Impact of Scale and its Change in Rural Schooling and School Attendance in 1997

Independent variable	**Schooling**		**School attendance**			
Additional control varaible	**None**	**Proportion Indigenous**	**None**	**Proportion Indigenous**	**None**	**Proportion Indigenous**
Instrumented Scale Variables for 1988-1993						
S*Age 6 to 8 dummy	**-0.1** **(0)**	**-0.059** **(0)**	**0.575** **(0.008)**	**0.784** **(0)**	0.107 (0.618)	**0.592** **(0.007)**
S*Age 9 to 11 dummy	**-0.023** **(0.024)**	-0.009 (0.378)	-0.138 (0.441)	-0.001 (0.996)	*-0.296* *(0.098)*	-0.031 (0.863)
S*Age 12 to 14 dummy	**0.058** **(0)**	**0.048** **(0)**	**-1.358** **(0)**	**-1.27** **(0)**	**-1.295** **(0)**	**-1.219** **(0)**
S*Age 15 to 18 dummy	**0.132** **(0)**	**0.092** **(0)**	**-2.07** **(0)**	**-2.039** **(0)**	**-1.954** **(0)**	**-2.115** **(0)**
dS*Age 6 to 8 dummy	**0.796** **(0)**	**0.979** **(0)**	*-5.084* *(0.078)*	-3.806 (0.19)	-4.697 (0.101)	-1.825 (0.527)
dS*Age 9 to 11 dummy	**0.843** **(0)**	**0.902** **(0)**	-0.782 (0.752)	-0.006 (0.998)	-0.029 (0.991)	1.498 (0.542)
dS*Age 12 to 14 dummy	-0.192 (0.281)	-0.239 (0.18)	**-35.57** **(0)**	**-35.194** **(0)**	**-34.438** **(0)**	**-34.048** **(0)**
dS*Age 15 to 18 dummy	**-2.233** **(0)**	**-2.41** **(0)**	**-64.745** **(0)**	**-64.677** **(0)**	**-63.2** **(0)**	**-63.931** **(0)**
Indicator of Local Indigenous Population						
Proportion of Indigenous Children		**0.626** **(0)**		**6.204** **(0)**		**12.535** **(0)**
Proportion of Indigenous Children*Age		**-0.056** **(0)**		-0.091 (0.201)		**-0.436** **(0)**
Child Characteristics						
Child is indigenous	**-0.218** **(0)**	**-0.195** **(0)**	**1.19** **(0)**	**-3.065** **(0)**		
Only speaks indigenous language					**-11.943** **(0)**	**-19.254** **(0)**
Speaks indigenous & Spanish					**3.503** **(0)**	**-2.434** **(0)**
Gender (Boy=1)	*-0.016* *(0.074)*	*-0.015* *(0.087)*	**3.234** **(0)**	**3.233** **(0)**	**3.154** **(0)**	**3.15** **(0)**
Age 9 to 11	**2.129** **(0)**	**2.195** **(0)**	**6.416** **(0)**	**6.585** **(0)**	**5.665** **(0)**	**6.209** **(0)**
Age 12 to 14	**4.025** **(0)**	**4.153** **(0)**	**-13.262** **(0)**	**-12.97** **(0)**	**-14.489** **(0)**	**-13.466** **(0)**
Age 15 to 18	**4.974** **(0)**	**5.174** **(0)**	**-56.356** **(0)**	**-55.928** **(0)**	**-57.702** **(0)**	**-56.098** **(0)**

(p-values in parenthesis)

Better than 5% significance in bold
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Table 6. (Continued)

Independent variable	**Schooling**		**School attendance**			
Additional control varaible	**None**	**Proportion Indigenous**	**None**	**Proportion Indigenous**	**None**	**Proportion Indigenous**
Parental Characteristics						
Father's age	**0.006** **(0)**	**0.006** **(0)**	**0.038** **(0.008)**	**0.041** **(0.005)**	**0.033** **(0.022)**	**0.037** **(0.012)**
Father's edu 1 to 5 years	**0.404** **(0)**	**0.404** **(0)**	**4.939** **(0)**	**4.942** **(0)**	**4.617** **(0)**	**4.597** **(0)**
Father's edu 6 + years	**0.651** **(0)**	**0.652** **(0)**	**9.271** **(0)**	**9.233** **(0)**	**8.896** **(0)**	**8.812** **(0)**
Mother's age	**0.01** **(0)**	**0.01** **(0)**	0.002 (0.895)	0.004 (0.816)	-0.007 (0.67)	-0.005 (0.75)
Mother's edu 1 to 5 years	**0.477** **(0)**	**0.476** **(0)**	**6.16** **(0)**	**6.241** **(0)**	**5.675** **(0)**	**5.748** **(0)**
Mother's edu 6 + years	**0.745** **(0)**	**0.749** **(0)**	**10.948** **(0)**	**11.023** **(0)**	**10.39** **(0)**	**10.472** **(0)**
Assets						
Cement Floor	**0.304** **(0)**	**0.305** **(0)**	**2.751** **(0)**	**2.785** **(0)**	**2.697** **(0)**	**2.745** **(0)**
Hhold has water and electricity	**0.296** **(0)**	**0.295** **(0)**	**3.227** **(0)**	**3.211** **(0)**	**3.212** **(0)**	**3.182** **(0)**
Hhold owns agric. land	**0.043** **(0)**	**0.041** **(0)**	**1.491** **(0)**	**1.407** **(0)**	**1.622** **(0)**	**1.498** **(0)**
Hhold has refrig. and stove	**0.453** **(0)**	**0.45** **(0)**	**5.448** **(0)**	**5.526** **(0)**	**5.559** **(0)**	**5.666** **(0)**
constant	**-0.406** **(0)**	**-0.513** **(0)**	**70.654** **(0)**	**69.936** **(0)**	**72.845** **(0)**	**71.399** **(0)**
observations	177103	177103	177578	177578	177578	177578
F	11483.35	10771.7	3811.01	3563.64	3761.52	3544.75
P	0	0	0	0	0	0
R-squared	0.5642	0.5648	0.3506	0.3508	0.3534	0.354

(p-values in parenthesis)

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