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Economic Structure, Productivity, and Infrastructure Quality in Southern Mexico

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Abstract

There are large and sustained differences in the economic performance of sub-national regions in most countries. Deichmann, Fay, Koo, and Lall examine the economic structure and productivity in Southern Mexico and compare it with the rest of the country. The authors use firm level data from Mexican manufacturing to test the relative importance of firm level characteristics (such as human capital and technology adoption) compared with external characteristics (such as infrastructure quality and regulatory environment) in explaining productivity differentials.

The authors find that the economic structure of Southern Mexico is considerably different from the rest of the country, with the economic landscape dominated by micro enterprises and a relative specialization in low productivity activities. This, coupled with low skill levels and fewer skill upgrading opportunities, reduces the performance of Southern firms. Productivity differentials between Southern firms and others, however, only exist for micro enterprises. The econometric analysis shows that while employee training and technology adoption enhance productivity, access to markets by improving transport infrastructure that link urban areas also have important productivity effects.

This paper—a joint product of Infrastructure and Environment, Development Research Group, and the Finance, Private Sector, and Infrastructure Unit, Latin America and the Caribbean Region—is part of a larger effort in the Bank to understand the role of economic geography and urbanization in the development process. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Yasmin D'Souza, room MC2-622, telephone 202-473-1449, fax 202-522-3230, email address ydsouza@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at udeichmann@worldbank.org, mfay@worldbank.org, or slall1@worldbank.org. October 2002. (29 pages)

Economic Structure, Productivity, and Infrastructure Quality in Southern Mexico[1]

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Economic Structure, Productivity, and Infrastructure Quality in Southern Mexico

1. Introduction

The effects of external factors on the performance of the manufacturing sector are of major interest to policy makers concerned with facilitating economic activities in all regions of a country. How should publicly provided social and physical investment be targeted to yield the highest return as measured in increased productivity and employment? And what factors are critical in helping lagging regions catch up with more dynamic areas of the country? The intellectual underpinnings of these investigations are found in the 'New Growth Theory' and 'New Economic Geography' literature with an emphasis on increasing returns, externalities and imperfect competition. New Growth Theory proponents such as Romer (1986; 1990 a, b) and Lucas (1988) stress the role of technology adoption, rents from innovation, human capital, and government policy in influencing the performance of firms. The public sector can provide or enhance some of these enabling factors. The point of departure from neo classical models (Solow 1956, Swan 1956) is therefore that *public policy matters* – publicly provided skills training or education programs and public investment in technology development and innovation, among other things, enhance economic performance and can help reduce imbalances in regional economic performance. Complementing these non-spatial growth theories, models in the 'New Economic Geography' literature (Krugman 1991) emphasize the importance of transport costs and therefore location in the spatial concentration of economic activity. This leads the way to examining the potential benefits of transport infrastructure by connecting remote regions to major urban areas, and thereby offsetting some of the inherent disadvantages of remote location (see Henderson et al. 2001).

There are large and sustained differences in the economic performance of sub national regions in most countries. Well documented examples of 'lagging regions' in industrialized countries where productivity and incomes are unusually low by national standards are the Applachian states in the United States and the Southern part of Italy. Similar situations of low incomes and productivity exist in developing countries. Examples are the rural areas of the Southwest and the Northwest of China, outer islands of Indonesia, parts of Northeastern India, Northwestern and Southern parts of Bangladesh, much of northern Nigeria, the rural Savannah of Ghana, northeast Malaysia, and the northeast of Brazil (Ravallion 1998). Differentials in regional economic performance in developing countries tend to be more severe due to much lower investment overall and a concentration of investment in one or a few growth centers. Lagging regions in countries such as China or Brazil are not just characterized by lower relative incomes and standards of living, but may in fact be home to significant poverty. The local population may be stuck in so-called *spatial poverty traps*, in which poor infrastructure and resource endowments lead to limited access to educational, social and economic opportunities (Jalan and Ravallion 1997). Out-migration alone is unlikely to solve this problem. Governments therefore need to consider public investment in those areas to stimulate private sector growth and increase productivity and employment.

While there has been considerable work on identifying proximate sources of firm level productivity (see Tybout 1998), there is limited empirical evidence on why firms in some regions prosper and on which location based amenities have the largest impact on firm level productivity. Some of the reasons are methodological. Due to the idiosyncratic evolution of agglomeration and dispersion factors, it is more complicated to develop general explanations concerning spatial variations in productivity than to explain general factors contributing to productivity differentials. The benefits of agglomeration economies from scale, density and scope advantages lead to spatial concentration of economic activity and productivity, whereas high friction costs from poor transport connectivity would lead to dispersion (Button and Pentecost 1999). Other reasons for the paucity of studies of regional differences in firm productivity are empirical. Micro-level firm data at a sufficiently disaggregated level of sectoral and spatial aggregation are rarely available, especially in developing countries. Furthermore, new tools for modeling spatial and locational parameters explicitly have only recently been adopted in economic research.

In this paper we examine the determinants of firm level productivity in Mexican industry and their relation to differentials in economic performance in the Southern states of Mexico in comparison with the rest of the country. [2] We are particularly interested in examining the following questions:

1. Are there significant productivity differences between firms in the South and other firms?
2. Is the industrial structure of the lagging South considerably different from the rest of the country?
3. Do factors beyond the internal production process influence productivity?
4. In particular, do the availability of reliable transport infrastructure and the state level regulatory environment influence productivity?

The rest of the paper is organized as follows. In Section 2, we provide an overview on productivity distribution and firm level characteristics in Mexican manufacturing establishments. In Section 3 we discuss the determinants of productivity including the role of infrastructure and business regulation. The econometric specification and results are presented in Section 4 and 5 respectively. Section 6 concludes.

2. Productivity differentials in Mexican industry

We use data from the National Survey of Employment, Salaries, Technology, and Training (ENESTYC) to examine productivity differentials across manufacturing establishments in Mexico. This survey program is implemented by the National Institute for Statistics, Geography and Informatics (INEGI). ENESTYC is designed to provide rich information on employment, worker characteristics, training, and use of technology in

[2] The eight Southern states are: Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatán.

Mexico's manufacturing firms. Firms in the ENESTYC can be identified at the level of the country's 3000 municipios, which allows us to conduct spatially disaggregated analysis of transport infrastructure and plant level productivity. The ENESTYC surveys have been conducted in 1992, 1995, and 1999. However, each survey uses a different sampling frame and methodology, which prevents us from creating a panel of firms for analysis. We use the 1999 data which includes data from 7,429 plants. Firms in the ENESTYC are grouped into four size categories: micro (1-15 workers), small (16-100), medium (101-250), and large (more than 250). A major advantage of using the ENESTYC database is that it is representative across firm size and industry sectors. For the analysis, we supplement ENESTYC firm level data with detailed information on the availability and quality of infrastructure (INEGI 2000), as well as municipio level estimates of GDP per capita (CONAPO 2000).

Average labor productivity in the South, measured as output per worker, is about 53% of the national average. Plant level productivity is nationally estimated to be 254,300 Pesos per worker in 1999 compared to 134,300 Pesos per worker in the Southern states (Table 1). Figure 1 shows a comparative distribution of productivity for Southern firms and those located in other regions. We see that firms in the South have a somewhat bimodal distribution with a lower mean value and larger productivity dispersion than firms in other states. Productivity levels in other regions are largely normally distributed.

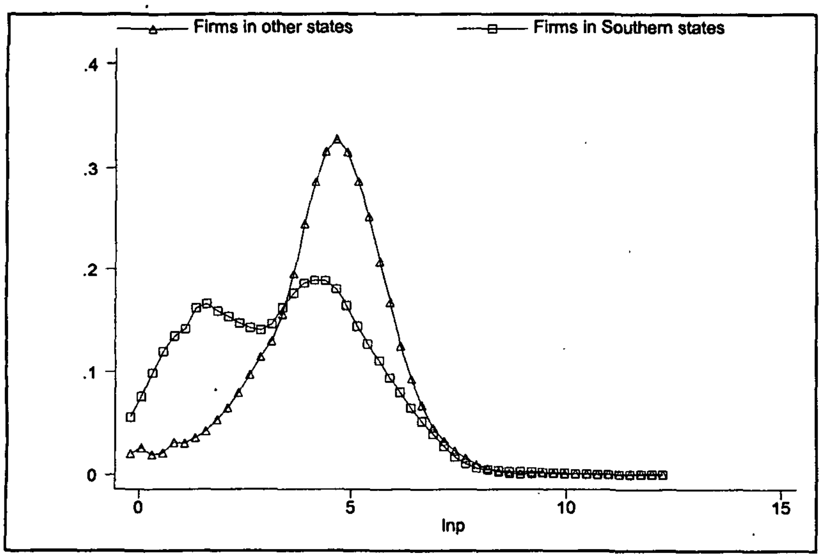
Table 1: Firm size and productivity

	Southern Region			Other Regions			Nation		
Size	No. of Firms	Share of Firms (%)	Avg. productivity ('000 peso)	No. of Firms	Share of Firms (%)	Avg. productivity ('000 peso)	No. of Firms	Share of Firms (%)	Avg. productivity ('000 peso)
Micro	386	55.1	25.9	1525	22.7	191.1	1911	25.7	157.7
Small	82	11.7	367.5	1129	16.8	352.4	1211	16.3	353.4
Medium	112	16.0	222.7	1882	28.0	281.6	1994	26.8	278.3
Large	121	17.3	240.1	2192	32.6	263.0	2313	31.1	261.8
Total	701	100.0	134.3	6728	100.0	266.88	7429	100.0	254.3

Source: ENESTYC (INEGI 1999)

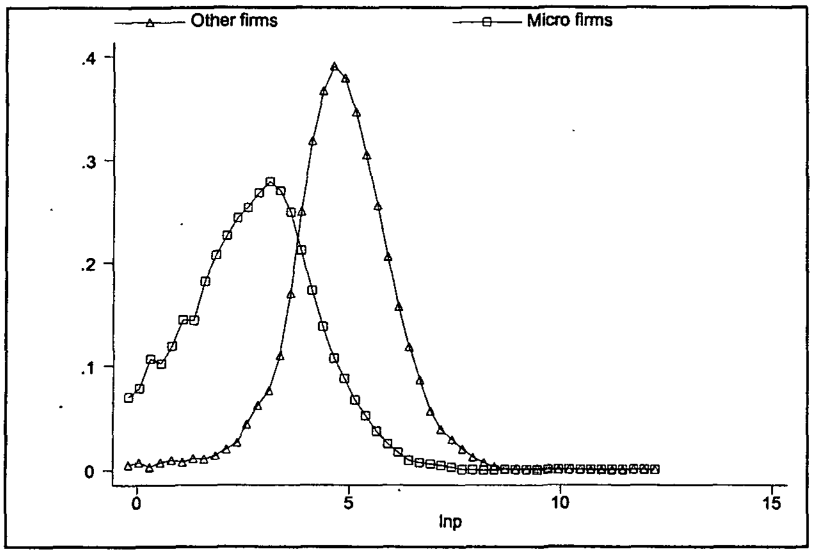
There is considerable heterogeneity in productivity across firm size. Average productivity in micro size firms is 157,700 Pesos/worker compared to 353,400 Pesos/worker for small firms, 278,300 Pesos/worker for medium sized firms, and 261,800 Pesos/worker for large firms. Labor productivity of micro firms is thus only about 55% of non-micro firms. Figure 2 shows the distribution of productivity for micro and other firms. The distribution of micro firms is centered to the left of the distribution of other firms. Average productivity is lower and dispersion is higher for micro firms. Productivity differentials for micro versus larger firms are even more pronounced in the South, where micro-firms represent about 55% of all manufacturing activity in the Southern states. This is more than double the national representation of micro-firms. The dominance of micro firms in the South reflects a production structure dominated by activities that cannot exploit scale economies. Micro firms in the Southern states are only 10% as productive as larger firms in that region. In the rest of the country micro firms achieve 66% of the productivity of larger firms. Across regions, productivity of micro-firms in the South is only 26,000 Pesos/worker, which is about 14% of micro-firm productivity in non-Southern locations.

Figure 1: Labor productivity in Southern and other firms[3]



[3] The log of productivity is used to show productivity distribution

Figure 2: Distribution of labor productivity for micro and other firms



In addition to the dominance of micro firms in the South, the economic base of this region is also considerably different from the rest of the country. Approximately two thirds of manufacturing units in the South are either in the Food, Beverages and Tobacco or in the Textiles, Clothing and Leather industries. In contrast, nationwide representation of these two industry sectors is about 41%. Even with disproportionately high representation in these two sectors, average labor productivity is considerably lower than national standards. For example, in the Food, Beverages and Tobacco industries, average nationwide labor productivity is 399,000 Pesos/worker but is only 266,000 Pesos/worker in the Southern region. Similarly in the Textiles, Clothing and Leather industries, average nationwide labor productivity is 101,000 Pesos/worker compared to 16,500 Pesos/worker in the South. Relatively high value sectors such as Metal products and machinery industries represent 24.4% of the national firm distribution but only account for 7.3% of Southern firms.

3. Determinants of productivity

Firm level characteristics

Two of the most important factors affecting a firm's productivity level are human capital and the degree to which the company employs improved technologies. In both categories, firms in the Southern states lag behind their peers in the rest of the country. About 64% of employees in Southern firms are unskilled workers compared to 52% in other parts of the country. On the job training is also significantly lower in Southern firms (Table 2). Only 41% of firms in the South have employee training programs compared to 70% in the rest of the country. Technology adoption rates are also quite low – adoption of generic technologies in the South is 52% compared to 77% in other regions; adoption of automated equipment is 19.7% compared to 34.3% in non Southern states; and adoption of computerized numeric control (CNC) machines is 5.6% in the South compared to 10.2% in other parts of the country.

Table 2: Firm Level Attributes

				Technology adoption					
		Employee training		Any Type		Automated equipment		CNC	
	Total no. of firms	No. of firms	Share of firms (%)	No. of firms	Share of firms (%)	No. of firms	Share of firms (%)	No. of firms	Share of firms (%)
Southern Region									
Micro	386	24	6.2	98	25.4	14	3.6	-	0.0
Small	82	56	68.3	60	73.2	17	20.7	3	3.7
Medium	112	94	83.9	97	86.6	49	43.8	19	17.0
Large	121	112	92.6	109	90.0	58	47.9	17	14.0
All firms	701	286	40.1	364	51.9	138	19.7	39	5.6
Other Regions									
Micro	1,525	195	12.8	634	41.6	126	8.3	8	0.5
Small	1,129	767	67.9	888	78.7	332	29.4	67	5.9
Medium	1,882	1,656	88.0	1,647	87.5	777	41.3	249	13.2
Large	2,192	2,096	95.6	2,028	92.5	1,075	49.0	359	16.4
All firms	6728	4714	70.0	5197	77.2	2310	34.3	683	10.1
Nation									
Micro	1,911	219	11.5	732	38.3	140	7.3	8	0.4
Small	1,211	823	68.0	948	78.3	349	28.8	70	5.8
Medium	1,994	1,750	87.8	1,744	87.5	826	41.4	268	13.4
Large	2,313	2,208	95.5	2,137	92.4	1,133	49.0	376	16.3
All firms	7429	5000	67.3	5561	74.8	2448	32.9	722	9.7

Source: ENESTYC (INEGI 1999)

Endogenous growth models predict that both foreign capital and foreign investment are important productivity enhancing factors. Grossman and Helpman (1991) show that foreign trade and investment contributes to economic growth through increased quality inputs for manufacturing firms, knowledge spillovers from foreign firms to domestic firms, and competitive pressures from global markets. Coe and Hoffmaister (1995) showed that trading is an important source of productivity growth in general and particularly for firms in developing countries as they can embody foreign knowledge from developed countries. Empirical work by Blomstrom (1986) for Mexican industry shows that the presence of foreign subsidiaries positively contributes to structural efficiency. Similarly Iscan (1998) finds that TFP in Mexican manufacturing firms improved in parallel with increasing exports after NAFTA.

The final destination of finished products varies considerably between firms in the South and other parts of the country. From the ENESTYC questionnaire we can identify firms with more than 50% of their sales in foreign markets. Findings from trade models (Grosman and Helpman 1991, Coe and Helpman 1995) suggest that export oriented firms are likely to have higher rates of technology adoption and will function close to the domestic best practice efficiency frontier. As a consequence, productivity should be higher for these firms. In the ENESTYC sample, 15.4% of all firms have export market orientation. In comparison, export orientation for Southern firms is about half the national average (8.3%). Disaggregating by firm size, for the South we find that only 1.2% of micro firms and in comparison 20.1% of non-micro firms produce mainly for foreign markets. We also look at the source of investment and find that about 13.6% of all firms in the country have more than half of their investment from foreign sources. Compared to the nationwide average of 13.6%, only 3.3% of Southern firms have majority foreign investment. Disaggregating by firm size we find that almost all foreign investment is in non-micro firms.

Transport Infrastructure and Market Access

High quality transport infrastructure creates opportunities for interaction among firms and customers—regardless whether these customers are other firms or households. Firms that are located in areas with better infrastructure will be more integrated into the regional, national and global market system. This reduces the cost of obtaining inputs from suppliers and shipping finished goods to customers. Firms that are located in highly accessible areas are also more exposed to competition and are thus forced to improve productivity.

Quantitative information on regional or local market integration is scarce. Summary statistics such as the total road length in a state/province or straight-line distance to ports or urban agglomerations are poor proxies for the complexity inherent in a national or regional transportation network. We therefore use a digital geographic representation of Mexico's transport network to compute an index of accessibility for each municipio as a simple measure of accessibility and potential market integration (see Lall et al. 2001). The index summarizes the size of the potential market that can be reached from a particular point given the density and quality of the transport network within that region. The definition of the access measure is conceptually straightforward. For any given point in the country, the accessibility indicator is the sum of the population of urban centers surrounding that point, inversely weighted by the travel time required to reach that center. Several small urban centers in close proximity may thus have a similar contribution to the access measure as a single larger urban center that is further away. Formally, the access indicator is calculated as:

$$A_i = \sum_j P_j * f(d_{ij})$$

where A_i is the accessibility indicator for location i, P_j is the population of city j, and d_{ij} is the distance or travel time between location i and city j. The function applied to the distance or travel time measure is selected so that cities further away contribute relatively less to the overall index. In the classical gravity model that is frequently used in the analysis of trade flows, this function is the inverse of the squared distance. Alternatively, the negative exponential decay function that we applied to travel times in our analysis yields a more gradual diminishing of the influence of urban centers. We computed the access measure using an up-to-date digital map of transportation infrastructure (INEGI 2001).[4] For each road segment, the database indicates the number of lanes and whether it is paved or unpaved. For railroad lines, the number of tracks is indicated. For each category of road or rail we determined an estimated average travel speed which allowed us to calculate how long it will take to traverse each segment in the transport network.[5] For urban population, we use an INEGI database of the location and population size of approximately 700 cities and agglomerations in Mexico.[6] These urban centers account for approximately 68 million of Mexico's 97 million people in 2000. We computed the accessibility index for a very large number of points distributed across Mexico. The distance weight is the travel time along the shortest path in the network from the given point to each urban center. The municipio level indicator used in our econometric analysis is the average of the accessibility indicator of all points that fall into that municipio. Figure 3 shows the resulting market access surface for Mexico.

A limitation of the market access indicators used here is that it only estimates domestic market access. This indicator does not take into account potential market size effects across national boundaries. For example, we potentially bias the true market integration downwards for the northern regions of Mexico because many firms located there have buyer-supplier linkages with border cities in the United States. A logical extension of our work would thus be to test the effect of cross-boundary market accessibility on the productivity of firms near border areas (see Clement et al. 2002).

We calculated a second, related indicator based on a measure of local wealth rather than population. For firms it matters not only how many people reside within the vicinity of a given point, but also what their purchasing power is. Since we do not have information on personal income, we used available data on municipio level GDP. The local market potential

[4] The digital road and rail network includes 171,000 km of roads, of which 84,000 km are paved roads, 51,000 are unpaved, and 36,000 are paths and breaches. The rail network has an estimated total length of 14,000 km. These values are GIS calculated from 1:1million scale digital maps and may not necessarily match official statistics.

[5] Using travel time on a transport network provides a more accurate measure of accessibility compared to the computationally much simpler straight-line distance as employed, for example, by Hanson (1998).

[6] See http://sedac.ciesin.org/plue.

index is defined as the total GDP that can be accessed through the transport network within two hours travel time. In this case we do not discount GDP that is located further away, so the results can be expressed in monetary units. The index is calculated using the Consejo Nacional de Población's (CONAPO) estimates of municipio per capita gross product. Within each municipio we first computed the total GDP for urban centers based on their population. We then distributed the residual GDP evenly over all other points in that municipio.[7] The GDP-based market potential index is then the sum of the estimated GDP that is generated at all points in the network that can be reached within the specified travel time. The point with the maximum estimated market potential is in Cuauhtemoc municipio in the Federal District. According to our estimates, a quarter of the total national GDP is generated within two hours travel time from this point.

Regulation and Investment Climate

The regulatory framework in México is complex and cumbersome despite efforts to improve it. In an effort to assist these reforms, the *Consejo Coordinator Empresarial* (CCE), a trade group has published an annual report since 1998 on the quality of the regulatory framework. The assessment is based on an analysis of improvement brought to the states' regulatory framework (examining legal, administrative and institutional instruments in place) and on an annual survey of entrepreneurs which asks them (i) their views of the quality of the regulatory framework, and (ii) the number of days requires in their experience to open a business.

Figure 4 and Figure 5 show state level variations in selected business regulation indicators from CCE (2001). As the maps show there are no clear difference between the Southern States and the rest of the country. In fact there are significant variations among the Southern States and across indicators.

[7] A necessary simplifying assumption is that urban and rural GDP are identical.

4. Econometric Analysis

Specification

We estimate two models to test the impacts of technology adoption, worker training, infrastructure and business regulations on plant level productivity. The first model is estimated only with plant-level characteristics and the second model with both plant-level and plant invariant regional characteristics. The results from separate models facilitate examination of the relative importance of each attribute with respect to productivity and make it easier to identify productivity differentials between the Southern states and the rest of the country.

We use the following two models:

$$\begin{aligned}\ln(P_i) = \beta_0 + \beta_1 TR_i + \beta_2 AGE_i + \beta_3 SW_i + \beta_4 FC_i + \beta_5 LOC_i + \\ \textstyle\sum_{j=1}^{3} \gamma_j TA_{ij} + \sum_{k=1}^{3} \lambda_k SZ_{ik} + \sum_{l=1}^{8} \omega_l IND_l + \varepsilon_i\end{aligned} \quad (1)$$

$$\begin{aligned}\ln(P_i) = \beta_0 + \beta_1 TR_i + \beta_2 AGE_i + \beta_3 SW_i + \beta_4 FC_i + \beta_5 LOC_i + \beta_6 ACC_m \\ \textstyle\sum_{j=1}^{3} \gamma_j TA_{ij} + \sum_{k=1}^{3} \lambda_k SZ_{ik} + \sum_{l=1}^{8} \omega_l IND_l + \sum_{r=1}^{2} \delta_r RG_{sr} + \sum_{r=1}^{2} \eta_r RG_{sr} LOC_i + \varepsilon_i\end{aligned} \quad (2)$$

where P is firm labor productivity measured in Pesos per worker, TR is worker training, AGE is plant age, SW is the share of skilled workers, FC is a foreign capital dummy indicating whether foreign investment accounts for more than 50% of total investment, LOC is a dummy for the Southern states, ACC is the municipio-level market access indicator, TAs are technology adoption indicators discussed below, SZs are firm size dummies, INDs are industry dummies, and RGs are measures of state-level business regulations.

Given the large productivity differences between micro and other sized firms, we decided to perform the analysis in three parts. First, with the entire sample of firms, next with micro firms, and finally with non micro firms. As micro firms make up more than 50% of manufacturing activity in the Southern states, a better understanding of factors influencing these firms will help examine the economic base of this region. We also believe that the needs of micro firms and larger firms are different. Micro firms are also more likely to be influenced by the local regulatory environment and regional milieu due to their small size. Due to their small size, most of these firms need to develop good working relationships with ancillary firms for business services and other activities which could typically be part of a larger firm. As a result, the workings of all related firms and links with credit markets and lenders are important for the survival of micro enterprises.

Predictions from endogenous growth models attribute the sustainable growth of productivity to the accumulation of human capital and knowledge. Worker training and the adoption of new technology tend to be productivity-enhancing factors. In our models, worker training is a dummy variable specifying whether or not a plant provides any kind of training program for its employees. We consider varying degrees of sophistication in new technologies by including three technology adoption variables for (a) computerized numeric control (CNC) machines, (b) automated equipment, and (c) any kinds of general manufacturing technologies. Following INEGI's definition, we group the sample into four size categories: micro, small, medium, and large. Eight industry dummy variables are included to capture industry-specific fixed effects.

In the second model, we introduce state business regulations and transport infrastructure (the market access indicator). The number of days required to open a business and a measure of regulatory improvement measure the business regulatory environment for each state. The latter is the rank of the state according to an index of regulatory improvement from 1 (state with most improvement) to 32 (state with least improvement). As noted in Section 3 these data are taken from CCE's study "*Calidad del Marco Regulatorio en Las Entidades Federativas Mexicanas: Estudio Comparativo*" done in 1999.

As to the market access measure, its development and introduction in productivity analysis is perhaps the major innovation of this study. Transportation is a central element of the so-called new economic geography (Krugman 1991, Fujita et. al. 1999). Availability of reliable infrastructure reduces transportation costs of inputs and outputs, thereby leading to productivity enhancements. We also include a Southern states dummy to compare firm level productivity in the Southern states and the rest of the country. Mexico provides an interesting case study because firms in the Southern states are believed to have much lower productivity due to the lack of skilled labor and the relatively low levels of technology use. Under the assumption that the regulatory environments are more important in less-developed Southern states than others, we also included interaction terms between the Southern states dummy and business regulation variables.

A problem with the ENESTYC dataset is that data for some variables are missing for some observations. Many firms do not report their location or production attributes. Missing observations can introduce bias in the parameter estimates, if the dropped observations are not completely random. As it turns out with the ENESTYC data, the missing observations show a clear pattern. Most of the missing data for production value (i.e. firm level output) are for small firms located in the Southern states. On the other hand most of the missing location attributes are for medium and large size firms. The easiest and probably the most frequently used methods to handle the missing data problem is casewise data deletion and mean substitution. If a case (i.e., a firm) has any missing values, the entire record is deleted or missing data are substituted by average values. However, Roth (1994) compares various commonly used approaches in empirical research and concludes that casewise data deletion and mean substitution are inferior to maximum likelihood based methods such as multiple imputation (Rubin 1978, 1987, among others). Multiple imputation usually generates five to ten complete data sets by filling in gaps in existing data with proper raw values. Raw values are drawn at random from their predicted distribution based on the observed data. Then each complete data set can be analyzed by common statistical methods such as regression analysis. After conducting the identical analysis multiple times using different imputed data sets, results from all regressions are combined into one summary set of parameters.

Advantages of the multiple imputation technique are well-documented. First, it is robust to violations of the assumption that variables are normally distributed. Second, it generates complete multiple raw data matrices that can be analyzed by virtually any statistical package. Third, statistical inferences (standard errors and p-value) are valid because multiple imputation incorporates uncertainly introduced by missing values. Lastly, in principle, the imputation process does not change any underlying data structure while it increases the number of observations usable for analysis (Schafer, 1997).

5. Results from Econometric Analysis

We estimated equations (1) and (2) using standard OLS techniques for all firms, only with micro firms, and with all other firms (excluding micro). Findings are summarized in Tables 5, 6 and 7. Table 5 provides results for all firms, Table 6 for micro firms and Table 7 for other medium and large size firms. We discuss the results in three main parts (1) firm characteristics, (2) location attributes, and (3) state regulations.

Firm Characteristics

We find that firm level characteristics such as employee training, firm age, share of skilled workers, and technology adoption influence productivity. As noted previously, productivity is measured as output per worker, which in fact represents labor productivity.

Employee Training: Using all firms in the ENESTYC sample, we find that employee-training programs have a positive effect on labor productivity. The coefficient reported in Table 1 is 0.268, which means that firms with employee training programs are 31% more productive than other firms. Translating this into Pesos, an employee-training program increases labor productivity by about 78,000 pesos per worker. The positive contribution of employee training is significant even when we parse the sample into micro and other firms. However the benefits of employee training are more pronounced for micro firms. The coefficient for micro firms is 0.586 (Table 6), which translates into an 80% productivity increase or 125,000 Pesos/worker. In comparison, the coefficient for other firms is 0.131, which is about a 14 % increase in productivity or 40,000 pesos per worker. The benefits of training are important, but to a lesser extent for non-micro enterprises.

Firm Age: The effects of firm age vary between micro and other firms. In general we find that firm age has a positive effect on productivity. Using the entire ENESTYC sample, we estimate the coefficient on Age as 0.004, which means that firms increase productivity by about 0.37% or 930 Pesos/worker with each additional year in business. The coefficient for non-micro firms is 0.006, which means that these firms increase productivity by 0.62% or 1,770 Pesos/worker for each additional year in business. In contrast, Age has a negative effect on the productivity of micro enterprises. The coefficient for Age is –0.007, which means that productivity of micro enterprises decreases by 0.66% or 1,040 Pesos/worker every year.

Share of Skilled Workers: The skill level of workers influences productivity. The coefficient for this variable for all firms is 0.005 which means that a 1-percent increase in the share of skilled workers increases productivity by 0.5% or by 1,270 Pesos/worker. The benefits of skilled labor are higher for non-micro firms with productivity estimated to increase by 1,630 Pesos/worker with a 1% increase in the share of skilled labor. In comparison, the benefits for micro firms are estimated to be 400 Pesos/worker.

Technology Adoption: Technology adoption is measured by three variables – adoption of generic technologies, (2) adoption of automated equipment, and (3) adoption of CNC technology. We find that technology adoption has a positive effect on productivity. The coefficients for all three types of technology adoption variables are positive and significant when we use the entire sample. For example, the coefficient for the use of any type of generic technology is 0.378, which translates into a 46% or 117,000 Pesos/worker increase in productivity. Similarly technology adoption increases productivity by 50% (79,000 Pesos/worker) for micro firms and about 21% (61,000 Pesos/worker) for other firms.

While the adoption of generic technologies has considerable benefits for all firms, micro firms appear to benefit the most from adoption of CNC technologies. Using CNC machines is estimated to increase micro firm productivity by 126.52% which is about 200,000 Pesos/worker. Of course, these results do not reflect the costs associated with adopting these technologies and their utilization potential by micro enterprises.

Firm Size: Firm size increases productivity – larger firms are more productive than other firms. Using the entire sample we find that small, medium and large firms are more productive than micro firms, and the benefits of scale increase with firm size.

Source of Investment: Foreign investment matters. In general, we find that firms who have majority investment from foreign sources are more productive than other firms. Using the entire sample, we find that firms with majority foreign investment are about 40% more productive than other firms. This translates into a productivity differential of about 100,000 Pesos/worker between firms with majority foreign investment and other firms in the sample. As there are almost no micro firms in the sample that have substantial foreign investment, findings here are only relevant to non-micro (mostly medium and large) firms. When we remove micro firms from the sample, the estimate for other firms is 0.049, which means that average productivity in firms with majority foreign investment is about 50% higher than productivity for other non micro firms.

Location Attributes

Southern Location: To examine productivity differential between Southern and other firms, we introduced a firm invariant fixed effect, which is 1 for firms in the South and 0 for firms located in other parts of the country. The coefficient of –1.137 for all firms means that firms in the South are in general about 68% less productive than firms located in other parts of Mexico. However, the location disadvantage only applies for micro-firms. The coefficient of – 1.90 for these firms means that micro firms in the South are about 85 % less productive than other micro firms. On the other hand, the coefficient for firm location in the Southern states is not significant for non-micro firms. This means that there are no significant productivity differentials between non-micro firms in the South and other parts of the country.

Market Access: One of our main questions of interest is to examine the importance of market access as measured by the indicators described in Section 3. Since the two alternative access indicators (potential market integration based on urban population and the amount of GDP generated within a two hour travel time) yielded almost identical results. We therefore only discuss the results using the former. This indicator provides an index measure of the size of the potential market that can be reached from a particular point, conditional on the density and quality of the transport network within that region. Using the entire ENESTYC sample, we estimate the coefficient for the market access indicator to be 0.006. The coefficient is statistically significant and suggests that a 10% increase in market access will increase labor productivity by 6%. In productivity terms this means that, in general, a percentage increase in market access will enhance productivity by 1,530 Pesos/worker.

The importance of domestic market access varies between micro and non-micro firms. For micro firms, we find that market access is a significant determinant of labor productivity. Our estimate of 0.01 means that a 10 % increase in access to markets will enhance productivity by 13 %. This translates into a productivity gain of 1,630 Pesos/worker with 1 percent increase in the market access indicator. On the other hand, market access is not a significant determinant of productivity for non-micro firms. As in the case of Southern location, we do not find evidence to support the importance of domestic market access for non-micro firms in Mexico.

The estimates of the impact of improvements in market access mentioned here are largely illustrative. A given percentage increase in market access cannot easily be translated into a policy relevant variable such as a certain amount of required infrastructure investment in Pesos. This is because the market access indicator is essentially "unit-less", and infrastructure investment is location-specific and will have different effects in different places. However, GIS techniques could be used to assess the potential effect of alternative infrastructure projects on market access which can in turn be converted into an estimate of productivity gain.

State Regulations

As discussed in section 3, we use (1) number of days to open a business and (2) ranking of states by regulatory improvement programs. Both measures have the expected impact on productivity. Using the entire sample, the coefficient for number of days to open a business is –0.002, which means that each additional day added by bureaucratic red-tape reduces productivity by 0.17 % or by 4,200 Pesos/worker. In comparison, firms located in states who have made regulatory improvements are likely to perform better. Our analysis suggests that a unit improvement in regulation or business climate will enhance productivity by 0.8% or by 2,120 Pesos/worker.

We find that the state level business environment largely affects micro firms. The coefficient for 'number of days' is –0.007 which means that a unit increase in the number of days required to start a business decreases labor productivity by 0.67% or by 1,050 Pesos/worker among micro firms. The coefficient for state level regulatory improvements is –0.012, which means that a unit improvement in state regulations will increase productivity by –1.24% or by 1,950 Pesos/worker. In comparison, only the regulatory improvement variable is significant for non micro firms. The coefficient of –0.005 means that a unit improvement in the regulation ranking will improve productivity by 0.54%.

6. Conclusions

In this paper we examine the determinants of firm level productivity in Mexican industry and their relation to differentials in economic performance in the Southern states of Mexico in comparison with the rest of the country. Using firm level data from the National Survey of Employment, Salaries, Technology, and Training (ENESTYC) we examine four related hypotheses on economic structure and productivity.

The first hypothesis is that there are considerable productivity differences between firms in the South and other firms. Using the ENESTYC data we find that average labor productivity in the South is about 53% of the national average. Central to the findings of low productivity is the dominance of micro enterprises in the economic base of the South. These firms account for as much as 55% of all economic activity in the region, with average productivity being much lower than firms of other size categories. Results from our econometric analysis show that significant productivity differentials do not exist across all size categories but are only limited to micro firms. Average labor productivity for micro enterprises is 25,000 Pesos per worked in the South compared to 157,700 Pesos per worker nationwide.

The second hypothesis is that the industrial structure of the South is considerably different from the rest of the country. We find evidence to support this hypothesis as over two-thirds of Southern industrial activity is either in Food, Beverages, and Tobacco and in Textiles, Clothing, and Leather industries. In contrast, these industries represent only 41% of economic activities nationally. The main concern with this specialization is that average labor productivity for these two industry sectors in the South is considerably lower than national standards.

The third and fourth hypotheses relate to determinants of firm level productivity. Our empirical analysis shows that labor force skill levels, employee training programs and technology adoption have positive effects on firm level productivity. These findings support predictions from the New Growth Theory where accumulation of knowledge capital is a crucial factor for productivity growth, and the heterogeneity in its sources (i.e., worker skill, investment for new technology, and trade) will create significant difference in firm performance, or collectively, regional performance. As the economic landscape of the South is dominated by micro firms, it will be important to assess the relative costs associated with various types of skill upgrading and technology adoption programs as well as link these to absorption capacity at the firm level.

In addition to firm level characteristics, regional endowments and characteristics also influence productivity. We find that access to markets has important productivity effects. Given the low levels of transport connectivity in the Southern states, improvements in the quality and density of the network are likely to enhance productivity. However, we find that improved market access only matters for the micro enterprises and are not significant for medium and large size firms. One explanation for this is that a considerable share of medium and large size firms produce for foreign markets compared to most micro firms which produce for the "local" domestic market. As our indicator of market access only covers domestic markets, it is likely that the benefits of connectivity to trans-border markets as in the United States are not captured in the analysis. However, these results must be examined in a larger context. As most micro enterprises in the South with their low productivity levels operate much below the domestic best practice efficiency frontier, any improvements to the external environment must be accompanied by improvements at the firm level. The benefits of infrastructure access can only be fully realized if the internal allocation at the firm level is efficient and there is a reduction in internal X-inefficiency (Leibenstein 1966). In this context, infrastructure improvements are a necessary but not sufficient condition.

Beyond the impacts on firm level productivity, poor transport infrastructure translates into escalating logistics costs for firms located in the Southern regions. Guasch (2002) estimates logistics costs in Mexico's Southern States to be around 29% of GDP, which is considerably higher than the national average of 18% which by itself is twice the level of OECD countries. Transport and transshipment costs represent about one-third of total logistics costs. The poor condition of the road networks is also affecting the efficiency and the reliability of trucking services, by increasing truck operating costs by 10% to 30% on deteriorated highways, and by affecting delivery schedules. While investments in inter regional infrastructure and regulatory reform are necessary conditions for enhancing productivity, they are definitely not sufficient. Recent work by Lall and Rodrigo (2001) on Indian industry points to the existence of significant plant level technical inefficiencies, which range from 50 - 60 percent of the domestic best practice standards. Productivity gains from improvements in transport infrastructure will be limited without improvements in firm level efficiency.

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Figure 3: Market Access Indicator Using Travel Times

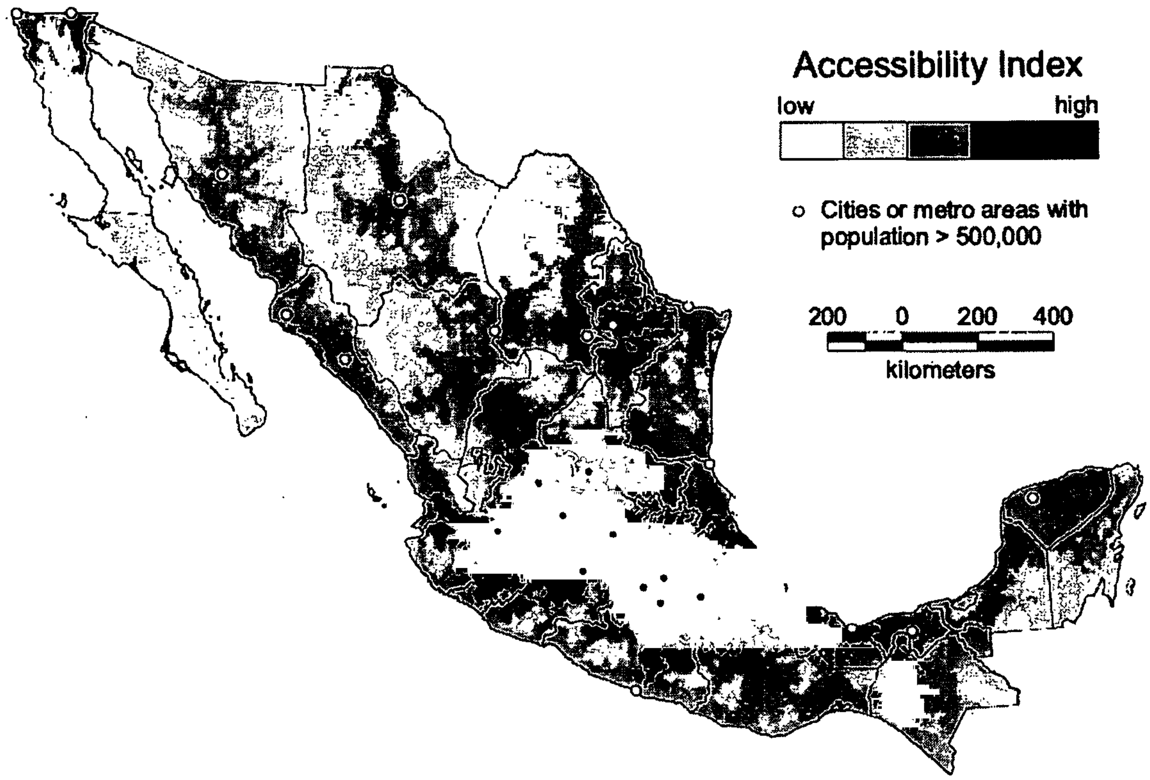

Figure 4: Average Number of Days to Open a Business (Source: CCE 2001)

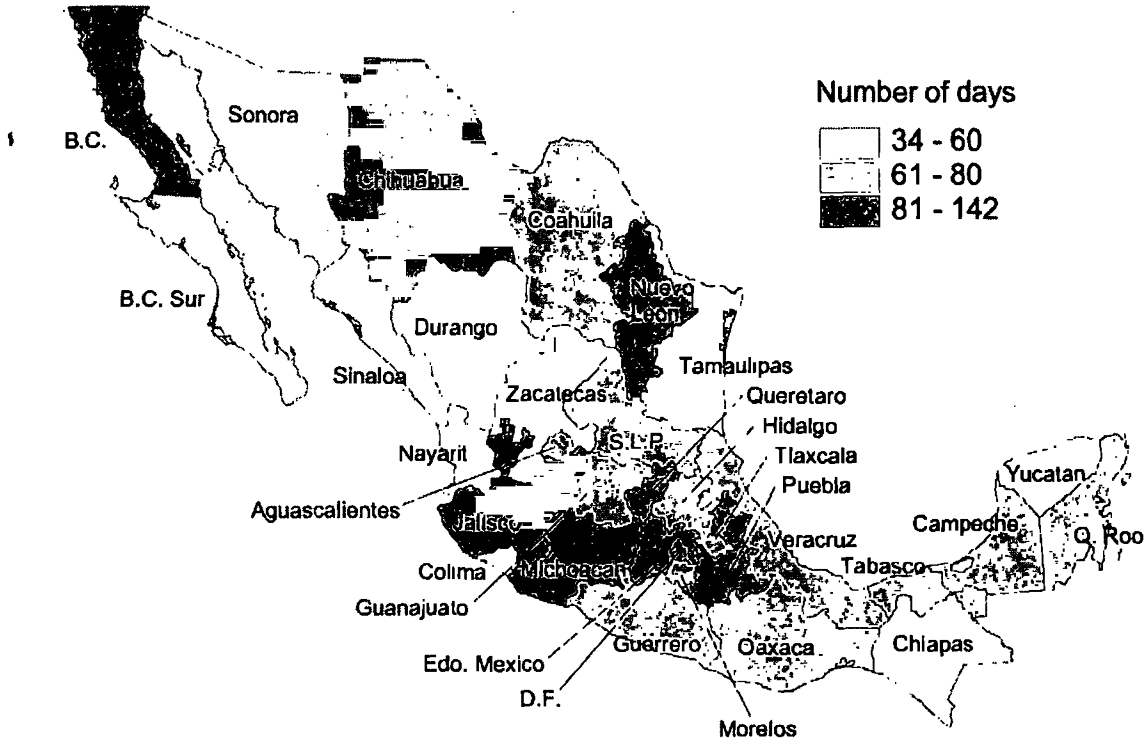

Figure 5: Ranking of States' Programs of Regulatory Improvement (Source: CCE 2001)

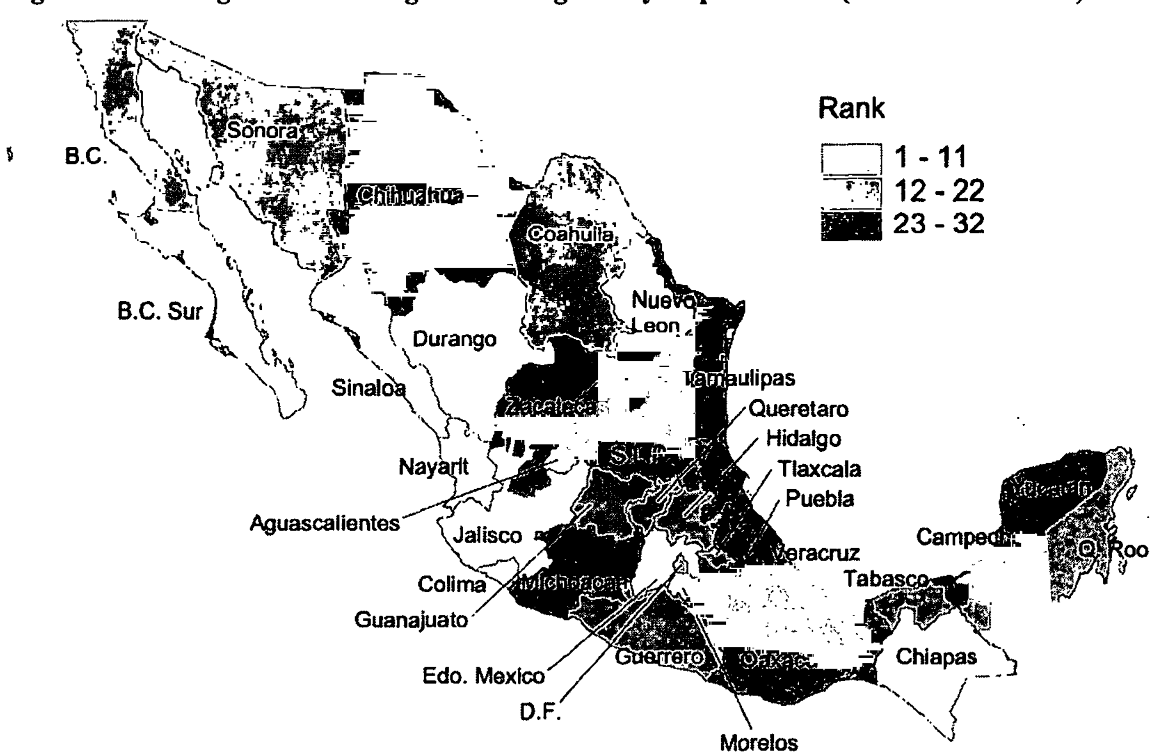

Table 5: Estimates for all firms

Variable	Estimate	Standard Error	Pr > |t|	Estimate	Standard Error	Pr > |t|	Marginal Effect (%)	Marginal Effect in 000 peso
		Model 1			Model 2			
Firm Characteristics								
Employee Training (0, no; 1, yes)	0.280	0.044	0.000	0.268	0.044	0.000	30.74	78.21
Firm Age	0.004	0.001	0.000	0.004	0.001	0.000	0.37	0.93
% of Skilled Workers	0.005	0.000	0.000	0.005	0.000	0.000	0.50	1.27
Adoption of Any Types Technology	0.377	0.041	0.000	0.378	0.041	0.000	45.94	116.87
Adoption of Automated Equipment	0.187	0.037	0.000	0.178	0.038	0.000	19.50	49.60
Adoption of CNC	0.234	0.056	0.000	0.225	0.055	0.000	25.28	64.32
Foreign Capital (1, if foreign investment>50%)	0.303	0.049	0.000	0.333	0.050	0.000	39.49	100.46
Firm Size								0.00
Small	1.040	0.055	0.000	1.037	0.055	0.000	182.18	463.48
Medium	1.301	0.056	0.000	1.301	0.056	0.000	267.33	680.08
Large	1.300	0.059	0.000	1.305	0.059	0.000	268.69	683.54
Location								0.00
South Region Dummy (0, others; 1, South)	-0.390	0.050	0.000	-1.137	0.268	0.000	-67.91	-172.76
Market Access				0.006	0.002	0.014	0.60	1.53
State Regulation								
No. of Days to Open a Business				-0.002	0.001	0.051	-0.17	-0.42
Regulatory Improvement (1, good -- 32, bad)				-0.008	0.002	0.000	-0.83	-2.12
South Dummy*No of Days				0.003	0.004	0.409	0.34	0.85
South Dummy*Regulatory Improvement				0.029	0.006	0.000	2.94	7.48
Industry Fixed Effects								0.00
Textile, clothing and leather	-0.804	0.050	0.000	-0.802	0.050	0.000	-55.14	-140.28
Wood and wood products	-0.477	0.066	0.000	-0.466	0.066	0.000	-37.23	-94.70
Paper and paper products	-0.192	0.064	0.003	-0.176	0.065	0.007	-16.12	-41.01
Chemical products	0.082	0.050	0.105	0.071	0.052	0.173	7.35	18.70
No metal mineral products	-0.504	0.061	0.000	-0.495	0.062	0.000	-39.03	-99.29
Basic metal industries	0.530	0.099	0.000	0.499	0.102	0.000	64.64	164.46
Metal products, machinery and equipment	-0.291	0.045	0.000	-0.293	0.046	0.000	-25.43	-64.69
Other manufacturing	-0.666	0.099	0.000	-0.636	0.100	0.000	-47.05	-119.70
Adj R-Sq	0.45			0.45				

Table 6: Estimates for micro firms

Variable	Estimate	Standard Error	Pr > |t|	Estimate	Standard Error	Pr > |t|	Marginal Effect	Marginal Effect in 000 peso
		Model 1			Model 2			
Firm Characteristics								
Employee Training (0, no; 1, yes)	0.591	0.098	0.000	0.586	0.098	0.000	79.67%	125.64
Firm Age	-0.008	0.003	0.002	-0.007	0.003	0.016	-0.66%	-1.04
% of Skilled Workers	0.003	0.001	0.000	0.003	0.001	0.002	0.25%	0.40
Adoption of Any Types Technology	0.427	0.071	0.000	0.409	0.070	0.000	50.50%	79.64
Adoption of Automated Equipment	0.273	0.124	0.027	0.300	0.123	0.015	34.94%	55.10
Adoption of CNC	0.765	0.458	0.095	0.818	0.455	0.072	126.52%	199.53
Foreign Capital (1, if foreign investment>50%)	-1.511	1.282	0.239	-1.825	1.274	0.152	-83.88%	-132.28
Location								
South Region Dummy (0, others; 1, South)	-0.467	0.076	0.000	-1.903	0.407	0.000	-85.09%	-134.18
Market Access				0.010	0.005	0.032	1.03%	1.63
State Regulation								
No. of Days to Open a Business				-0.007	0.002	0.000	-0.67%	-1.05
Regulatory Improvement (1, good -- 32, bad)				-0.012	0.004	0.000	-1.24%	-1.95
South Dummy*No of Days				0.012	0.006	0.042	1.25%	1.98
South Dummy*Regulatory Improvement				0.031	0.010	0.002	3.14%	4.96
Industry Fixed Effects								
Textile, clothing and leather	-0.916	0.095	0.000	-0.871	0.095	0.000	-58.17%	-91.73
Wood and wood products	-0.359	0.106	0.001	-0.331	0.106	0.002	-28.21%	-44.49
Paper and paper products	0.185	0.174	0.288	0.288	0.173	0.097	33.41%	52.68
Chemical products	0.717	0.159	0.000	0.776	0.158	0.000	117.24%	184.89
No metal mineral products	-0.569	0.100	0.000	-0.503	0.101	0.000	-39.50%	-62.30
Basic metal industries	0.680	0.315	0.035	0.721	0.302	0.018	105.56%	166.46
Metal products, machinery and equipment	-0.086	0.098	0.381	-0.039	0.098	0.693	-3.79%	-5.98
Other manufacturing	-0.595	0.164	0.000	-0.498	0.165	0.003	-39.20%	-61.82
Adj R-Sq	0.25			0.26				

Table 7: Estimates for all other firms

Variable	Estimate	Standard Error	Pr > |t|	Estimate	Standard Error	Pr > |t|	Marginal Effect	Marginal Effect in 000 peso
		Model 1			Model 2			
Firm Characteristics								
Employee Training (0, no; 1, yes)	0.136	0.048	0.005	0.131	0.049	0.007	13.96%	40.18
Firm Age	0.007	0.001	0.000	0.006	0.001	0.000	0.62%	1.77
% of Skilled Workers	0.006	0.001	0.000	0.006	0.001	0.000	0.57%	1.63
Adoption of Any Types Technology	0.191	0.054	0.001	0.193	0.055	0.001	21.34%	61.43
Adoption of Automated Equipment	0.212	0.038	0.000	0.202	0.039	0.000	22.33%	64.28
Adoption of CNC	0.270	0.054	0.000	0.261	0.054	0.000	29.82%	85.85
Foreign Capital (1, if foreign investment>50%)	0.376	0.047	0.000	0.403	0.049	0.000	49.66%	142.98
Firm Size								
Medium	0.274	0.043	0.000	0.278	0.043	0.000	32.07%	92.33
Large	0.267	0.044	0.000	0.274	0.045	0.000	31.57%	90.90
Location								
South Region Dummy (0, others; 1, South)	-0.196	0.070	0.005	-0.645	0.376	0.087	-47.55%	-136.90
Market Access				0.0003	0.003	0.927	0.03%	0.07
State Regulation								
No. of Days to Open a Business				0.001	0.001	0.313	0.10%	0.30
Regulatory Improvement (1, good -- 32, bad)				-0.005	0.002	0.003	-0.54%	-1.56
South Dummy*No of Days				0.002	0.006	0.668	0.24%	0.70
South Dummy*Regulatory Improvement				0.017	0.009	0.064	1.70%	4.91
Industry Fixed Effects								
Textile, clothing and leather	-0.676	0.056	0.000	-0.685	0.057	0.000	-49.60%	-142.81
Wood and wood products	-0.522	0.089	0.000	-0.530	0.090	0.000	-41.12%	-118.38
Paper and paper products	-0.279	0.067	0.000	-0.288	0.069	0.000	-25.04%	-72.08
Chemical products	0.027	0.052	0.611	-0.001	0.055	0.980	-0.14%	-0.40
No metal mineral products	-0.398	0.080	0.000	-0.408	0.081	0.000	-33.47%	-96.37
Basic metal industries	0.496	0.105	0.000	0.448	0.108	0.000	56.58%	162.89
Metal products, machinery and equipment	-0.313	0.050	0.000	-0.335	0.051	0.000	-28.46%	-81.93
Other manufacturing	-0.675	0.125	0.000	-0.691	0.127	0.000	-49.91%	-143.68
Adj R-Sq	0.17			0.17				

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