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Robust Investment Climate Effects on Alternative Firm-Level Productivity Measures[1]

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[1] This paper is an updated and revised version of Escribano and Guasch (2004, 2005, 2008) based on a selection of the recent results obtained in the background working papers written for the investment climate assessments (ICA) of the World Bank on 42 developing countries. The list of countries includes Eritrea, Ethiopia, Madagascar, Malawi, Niger, Tanzania, Zambia, Burkina Faso, Uganda, Mali, Kenya, Senegal, Mauritania, Bangladesh, Honduras, Pakistan, Cameroon, India, Bolivia, Guatemala, Honduras, Nicaragua, Philippines, Morocco, Indonesia, Ecuador, El Salvador, Egypt, Namibia, Turkey, Algeria, Colombia, Brazil, Mexico, Botswana, Costa Rica, South Africa, Swaziland, Croatia, Chile, Mauritius, Pakistan and Peru. The robustness of the TFP results that we present here are maintained in all these countries. We are indebted to Jorge Pena, Heisnam Singh and Rodolfo Stucchi for their excellent research assistance and to D. Ackerberg, A. Pakes and J. Levinsohn for the suggestions given on the previous versions of this paper. We have also benefited from the suggestions of Paulo Correa, Luke Haggarty, Danny Leipziger, Eduardo Ley, Marialisa Motta, Jose Guillherme Reis, Isabel Sánchez and Stefka Slavova, from participants of the American Association meetings in Chicago, January 2006, from seminars and courses given by A. Escribano at the World Bank from 2007 to 2010, the Ministry of Economic Affairs of Turkey and Egypt, at CORE (UCL, Belgium) and from the participants of the summer courses given at the University Carlos III de Madrid during years 2009, 2010.

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Abstract

Developing countries are increasingly concerned about improving country competitiveness and productivity, as they face the increasing pressures of globalization and attempt to improve economic growth and reduce poverty. Among such countries, Investment Climate surveys (ICs) at the firm level, have become the standard way for the World Bank to identify key obstacles to country competitiveness, in order to prioritize policy reforms for enhancing competitiveness. Given the surveys objectives and the nature and limitations of the data collected, this paper discusses the advantages and disadvantages of using different total factor productivity (TFP) measures. The main objective is to develop a methodology to generate robust investment climate impacts (elasticities) on TFP under alternative measures. The paper applies it to the data collected for ICs in four developing countries: Costa Rica, Guatemala, Honduras and Nicaragua. Observations on logarithms of the production function variables are pooled across three countries (Guatemala, Honduras and Nicaragua). Endogeneity of the production function inputs and of the investment climate variables is addressed by using observable firm level information, a variant of the control function approach, considering IC variables as proxy and also by aggregating certain investment climate variables by industry and region. It is shown that by using this methodology it is possible to get robust IC “elasticities” on TFP for more than ten different TFP measures. The robust IC elasticity estimates for the five countries show how relevant the investment climate variables are to explain the average productivity of each country. IC variables in several categories (red tape, corruption and crime, infrastructure and, quality and innovation) account for over 30 percent of average productivity. The policy implications are clear: investment climate matters and the relative impact of the various investment climate variables helps indentifying where reform efforts should be directed in each country. It is argued that this robust methodology can be used as a benchmark to assess cross-country productivity effects in other IC surveys. This is important since similar firm-level IC surveys on several sectors (manufacturing, services, etc.) are now available at the World Bank for more than 65 developing countries.

1 Introduction

As developing countries face the pressures and impacts of globalization, they are seeking ways to stimulate growth and employment within this context of increased openness. With most of these countries having secured a reasonable level of macroeconomic stability, they are now focusing on issues of competitiveness and productivity through microeconomic reform programs. From South East Asia to Latin America, countries are reformulating their strategies and making increased competitiveness a key priority of government programs.

A significant component of country competitiveness is having a good investment climate or business environment. The investment climate, as defined in the World Development Report, see World Bank (2005), is "the set of location-specific factors shaping the opportunities and incentives for firms to invest productively, create jobs and expand." It is now well accepted and documented, conceptually and empirically, that the scope and nature of regulations on economic activity and factor markets - the so-called investment climate and business environment - can significantly and adversely impact productivity, growth and economic activity (see Bosworth and Collins, 2003; Rodrik and Subramanian, 2004; McMillan, 1998 and 2004; OECD, 2001; Wilkinson, 2001; Alexander et al., 2004; Djankov et al., 2002; Haltiwanger, 2002; He et al., 2003; Dethier et al (2008), World Bank, 2003; and World Bank, 2004 a,b). Prescott (1998) argues that to understand large international income differences, it is necessary to explain differences in productivity (TFP). His main candidate to explain those gaps is the resistance to the adoption of new technologies and to the efficient use of current operating technologies, which in turn are conditioned by the institutional and policy arrangements a society employs (the investment climate for us). Cole et al. (2004) also have argued that Latin America has not replicated Western economic success due to the productivity (TFP) gap. They point to competitive barriers (investment climate variables in our analysis) as the promising channels for understanding the low productivity observed in Latin American countries.

Figures 1a to 1c plot the evolution of the GDP-per capita, of labor productivity and labor force participation in Costa Rica, Guatemala, Honduras and Nicaragua, relative to the values of the US. Since the relative labor force participation of each country is stable since 1975, the decline in GDP per capita is mainly due to the observed decline in labor productivity, indicating that the gap in both series, relative to the US, is increasing through time (divergence). Therefore, these countries show serious productivity problems. In this paper we want to study how the investment climate factors of those three Caribbean countries can help us identifying the main bottlenecks for productivity growth in important areas; infrastructure, red tape, corruption and crime, finance and corporate governance and, quality, innovation and labor skills.

Government policies and behavior exert a strong influence on the investment climate through their impact on costs, risks and barriers to competition. Key factors affecting the investment climate through their impact on costs are: corruption, taxes, the regulatory burden and extent of red tape in general, input markets regulation (labor and capital), the quality of infrastructure, technological and innovation support, and the availability and cost of finance.

For example, Kasper (2002) shows that poorly understood "state paternalism" has usually created unjustified barriers to entrepreneurial activity, resulting in poor growth and a stifling environment. Kerr (2002), shows that a quagmire of regulation which is all too common, is a massive deterrent to investment and economic growth. As a case in point, McMillan (1998) argues that obtrusive government regulation before 1984 was the key issue in New Zealand's slide in the world per-capita income rankings. De Soto (2002) describes one key adverse effect of business regulation is to have weak property rights; with costly firm regulations, fewer firms choose to register and more firms become informal. Also, if there are high transaction costs involved in registering property, assets are less likely to be officially recorded, and therefore cannot be used as collateral to obtain loans, thereby becoming "dead" capital.

Likewise, poor infrastructure and limited transport and trade services increase logistics costs, rendering otherwise competitive products uncompetitive, as well as limiting rural production and people's access to markets, which adversely affects poverty and economic activity (Guasch, 2004).

The pursuit of greater competitiveness and a better investment climate is leading countries -often assisted by multilaterals such as the World Bank - to undertake their own studies to identify the principal bottlenecks in terms of competitiveness and the investment climate, and to evaluate the impact these have, to set priorities for intervention and reform. The most common instrument used has been firm-level surveys, known as Investment Climate surveys (ICs), from which both subjective evaluations of obstacles and objective hard-data numbers with direct links to costs and productivity are elicited and imputed. Such surveys collect data at firm level on the following themes: infrastructure, bureaucracy and corruption, technology and quality, human capital, corporate governance, crime and security, and financial services.

While the ICs are quite useful in identifying major issues and bottlenecks as perceived by firms, the data collected is also meant to provide a quantitative assessment of the impact or contribution of the investment climate (IC) variables on productivity. In turn, that quantified impact is used in the advocacy for, and design of, investment-climate reform. Yet providing reliable and robust estimates of productivity estimates of the IC variables from the surveys is not a straightforward task. First, ICs do not provide balance panel-type data on all the variables. Second, the production function is not observed; and third, there is an identification issue separating Total Factor Productivity (TFP) from the production function inputs. When any of the production function inputs is influenced by common causes affecting productivity, like IC variables or other plant characteristics, there is a simultaneous equation problem. In general, one should expect the productivity to be correlated with the production function inputs and, therefore, inputs should be treated as endogenous regressors when estimating production functions. This demands special care in the econometric specification for estimating those productivity effects and in the choice of the most appropriate way of measuring productivity.

There is an extensive literature discussing the advantages and disadvantages of using different statistical estimation techniques and/or growth accounting (index number) techniques to estimate productivity or Total Factor Productivity in levels (TFP) or in rates of growth (TFPG). For overviews of different productivity concepts and aggregation alternatives see Solow (1957), Jorgenson, Gollop and Fraumeni (1987), Hall (1990), Olley and Pakes (1996), Foster, Haltiwanger and Krizan (1998), Batelsman and Doms (2000), Hulten (2001), Diewert and Nakamura (2002), Jorgenson (2001) and Barro and Sala-i-Martin (2004).

In this paper we discuss the applicability of some of these techniques to the problem at hand and present adaptations and adjustments that provide a best fit for the described objective: estimating robust productivity impact of IC variables collected through firm-level surveys across countries; investment climate surveys (ICS).

The development of a robust econometric methodology, to be used in most developing countries as a benchmark for evaluating the impact of IC variables on productivity at the firm level, is the main objective of this paper. To illustrate its applicability and usefulness, the methodology is used to assess the productivity impact in four different countries, Costa Rica, Guatemala, Honduras, and Nicaragua, with the ICs data collected for 2001 and 2002 (Guatemala, Honduras, and Nicaragua) and 2002, 2003 and 2004 (Costa Rica).

Using a common productivity methodology is essential for benchmarking and for cross-country comparisons of the empirical TFP results. This methodology is intended to give robust empirical results and aims at encompassing and explaining the reasons why different research groups addressing common issues related to infrastructure and finance effects on TFP, were reaching opposite conclusions even if they were using the same data set coming from the same ICs. Are the results contingent on the particular TFP measure used? One group was using the Cobb-Douglas production function with 2SLS, other where using Olley and Pakes (1996), other groups the Translog or GMM, others were first estimating TFP and then identifying the IC effect on TFP in a second step, etc. What is the best way to proceed to evaluate the IC effects on TFP? The answer given in this paper is that it does not matter what particular TFP measure is used or what particular estimation procedure is considered, as long as we are controlling or conditioning on the relevant firm level investment climate information (avoiding having omitted IC variables and unobservable fixed effects). In support of diversity and cross fertilization, having alternative econometric approaches should help identifying the limitations, advantages or disadvantages of each of the TFP measures. Those TFP results that are robust to different approaches should play a key role in the formulation of policy recommendations. Our robust econometric approach to different environments can be justified in econometric terms statistical sensitivity analysis.

In particular, this paper is structured as follows. Section 2 introduces the concepts of productivity (TFP) and discusses general productivity measures based on levels versus differences. We conclude that, given the fixed effect nature of IC variables obtained form ICs, it is better to analyze productivity in levels (or log-levels) rather than rates of growth of productivity. This section also introduces a consistent econometric methodology for the selection of IC and firm explanatory variables for different productivity (TFP) measures. This econometric strategy is applied to study the investment climate determinants of TFP in Costa Rica, Guatemala, Honduras and Nicaragua. Section 3, describes in detail the estimation issues and presents the empirical results. This section also suggests evaluating the country specific contribution of IC variables to average productivity, if we have estimated common elasticities by pooling the data from several countries. Section 4 compares our empirical results with the results form using other methods suggested in the literature to estimate production functions. Finally, section 5 presents a summary of the econometric methodology and of the main conclusions. All the Figures and Tables with the definitions of the variables used and with the panel data estimation results are included in the Appendix.

2 Alternative Total Factor Productivity (TFP) Measures to Estimate the Impact of the Investment Climate (IC) on TFP

The econometric methodologies discussed in this paper are applied to study the productivity determinants of variables collected at the firm level. In particular, we consider the impact of investment climate (IC) variables and other firm control variables (C) on several productivity measures. We classify the IC variables into four broad categories: i) infrastructure, ii) red tape, corruption and crime, iii) finance and corporate governance and iv) quality, innovation and labor skills; see Tables 3a to 3d of the appendix.

Total factor productivity (TFP), or multifactor productivity, refers to the effects of any variable different from the inputs --labor (L), intermediate materials (M) and capital services (K)--, affecting the production (sales) process. To be more specific, consider that the production function Q=F(L,M,K,α) and the productivity (TFP_{it}) equation of the firm (i) at period (t) are given by:

$$Y_{it} = F(L_{it}, M_{it}, K_{it}, \alpha_{F,it})\, TFP_{it} \qquad (1a)$$

$$TFP_{it} = G(IC_{it}, C_{it}, \alpha_{IC.it}) \exp(u_{it}) \qquad (1b)$$

where u_{it} is a random error term with properties that will be specified later on. The individual firms are indicated by the sub-index i = 1, 2, ..., N, where N is the total number of firms in the sample and by the sub-index time t = 1, 2, ..., T, where T is the total number of years in the sample. In the IC surveys, N is large and T is small.

When any of the input variables (L, M and K) is influenced by common causes affecting productivity, like IC variables or other firm characteristic variables (C), we have a simultaneous equation problem. (See Marschak and Andews, 1944, and Griliches and Mairesse, 1997). In general, we should expect productivity to be correlated with the inputs L, M and K, and therefore the inputs must be treated as endogenous regressors when estimating production functions. Blundell and Bond (2000) discuss a solution, System-GMM, to this endogenous regressors problem based on a generalized method of moments (GMM) approach, applied to persistent panel data. Olley and Pakes (1996), Levinsohn and Petrin (2003) and Akerberg, Caves and Frazer (2006) suggest structural approaches to estimate production functions.

A specific solution to this endogeneity problem of the inputs L, M and K in (1a) will be presented in section 2.2 when estimation issues of production functions are discussed.

Taking logarithms in (1a) and (1b), where *lower case letters indicate variables in logs*,

$$y_{it} = q_{it} + tfp_{it} \quad (2a)$$

$$tfp_{it} = \log G(IC_{it}, C_{it}) + u_{it} \quad (2b)$$

where log(TFP) = tfp is the "residual" from equation (2a) and q = log F(L,M,K). That is, the log of TFP is the difference between the logarithm of output (Log Y=y) and the logarithm of aggregate input (log Q=q) formed by the inputs L, M and K. Differentiating (2a) and (2b) we get similar expressions for the rates of growth:

$$dy_{it} = dq_{it} + dtfp_{it} \quad (3a)$$

$$dtfp_{it} = d\log G(IC_{it}, C_{it}) + du_{it}\ . \quad (3b)$$

From equations (3a) and (3b) it is clear that we would like to be able to assign to $dtfp_{it}$ all those changes different than L_{it}, M_{it} and K_{it}, that shift the production function of firm i in period t, while associating the movements along the production function with changes in the aggregate input[3], dq_{it}.

The next step is to discuss the advantages and disadvantages of using alternative measures of productivity for the evaluation of the impact of IC variables on productivity. From the above discussion is clear that we have two general approaches to measure TFP: a) based on the rate of growth of productivity or b) based on the level (or logs) of productivity.

From equations (3a) and (3b) and the comment of footnote 3 we can write (2a) and (2b) in term of their rates of growth[4] as:

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[3] Consider the extended production function $Y_{it} = F(L_{it},M_{it},K_{it}, TFP_{it})$, where TFP_{it} is an aggregate productivity index which incorporates technological changes, recent innovations, etc., in the production of Y_{it}. In this general specification, any improvement in TFP_{it} , perhaps due to improvements in IC conditions, represents a movement along the production function as well as a shift of the production function.

$$d\log Y_{it} = \frac{\partial \log F_{it}}{\partial L_{it}} dL_{it} + \frac{\partial \log F_{it}}{\partial M_{it}} dM_{it} + \frac{\partial \log F_{it}}{\partial K_{it}} dK_{it} + \frac{\partial \log F_{it}}{\partial TFP_{it}} dTFP_{it}\ .$$

If the "residual" or weighted rate of growth of TFP_{it} , which is $\frac{\partial \log F_{it}}{\partial TFP_{it}} dTFP_{it} = \alpha_{P,it} d\log TFP_{it}$, has elasticity $\alpha_{P,it}=1$ then TFP reflects to the actual Total Factor Productivity. However, when the separability conditions (Hicks neutral technical, etc.) are not satisfied, see Jorgenson, Gollop and Fraumeni (1987), what we are measuring by the "residual" is the rate of growth of productivity as a time varying weighted rate of growth of TFP_{it} and this might not be equal to actual the rate of growth of the real total factor productivity. As we will see in the empirical section, those conditions are difficult to satisfy in most developing countries. However for simplicity of the presentation, from now one we call the "residual" TFP. This productivity (TFP) concept is sometimes called *multifactor productivity (MFP).*

[4] Notice that we are assuming that IC and C variables are scalar and not vectors. At this point this is done to simplify the notation. Later on and also in the empirical application we will consider both as vectors.

$$dy_{it} = \alpha_{L,it} dl_{it} + \alpha_{M,it} dm_{it} + \alpha_{K,it} dk_{it} + dtfp_{it} \quad (4a)$$

$$dtfp_{it} = \alpha_{IC,it} \text{d}\log IC_{it} + \alpha_{C,it} \text{d}\log C_{it} + du_{it} \quad (4b)$$

where the coefficients of equation[5] (4a) $\alpha_{j,it}$ are the heterogeneous and time varying j-input-elasticities of the aggregate input Q, j = L, M, and K, of firm (i) in period (t).

Which of the two approaches, a) or b), is more convenient to evaluate the impact of IC variables on productivity based on IC surveys?

At first glance, the procedure based on TFP growth seems to be more general and more convenient because it does not require us to specify any particular functional form of the production function F(L,M,K). However, it has serious drawbacks arising from the quality of the data (measurement errors and missing firm observations from one year to the next).

The most common drawbacks of estimating equation in rates of growth are:

(i) Measurement errors are enhanced by taking first differences,

(ii) When the inputs are not strictly exogenous (or "exogenous") the standard simultaneous equation problems imply and least square estimators are inconsistent and biased. The most common solution requires the use of generalized method of moments (GMM) estimators or instrumental variable (IV) estimators. However, equations with variables in differences suffer from the weak instruments problem which produces very poor parameter estimates (Griliches and Mairesse, 1997). Recently, Blundell and Bond (2000) have proposed an alternative GMM estimator for variables that are slow mean reverting (persistent).

(iii) We only have information on IC variables for a single year. Therefore, if we compute rates of growth we lose all the unobservable fixed effects but we also lose all the observable fixed effects related to the investment climate (IC_i) which is the main objective of these IC surveys.

In any case, before estimating TFP growth based on equation (4a) we have to take two important decisions:

First. We have to approximate the continuous transformation of the variables, say $\text{dlog}(Y_{it})=dy_{it}$, by a discrete approximation based on first differences, say $\Delta\log(Y_{it})$ =

[5] The coefficients of (4b) are also elasticities and are defined in a similar way.

$\log(Y_{i,t})-\log(Y_{i,t-1})=y_{it}-y_{it-1}$. This last approximation requires transforming (4a,) using the Tornqvist[6] (1936) index:

$$\Delta y_{it} = \bar{\alpha}_{L,it}\Delta l_{it} + \bar{\alpha}_{M,it}\Delta m_{it} + \bar{\alpha}_{K,it}\Delta k_{it} + \Delta tfp_{it} \qquad (5)$$

where $\bar{\alpha}_{j,i,t} = \frac{1}{2}(\alpha_{j,i,t} + \alpha_{j,i,t-1})$ is average input-output elasticity of input j of firm i during the last two years (t and t-1) where j = L, M and K.

Second. Since the heterogeneous and time varying input-output elasticities $\alpha_{j,it}$ are unknown they can be measured by nonparametric procedures, index number techniques (Solow 1957, Diewert and Nakamura 2002) or estimated by regression techniques, assuming that the input-output elasticity parameters are constant in some sense. In this paper, we will consider two possibilities: a) the *unrestricted case* where constant input-output elasticities are considered at the *industry level* pooling and not pooling across countries, and b) the *restricted case* where constant elasticity parameters are considered at the *aggregate level*, pooling and not pooling countries.

To understand why the characteristics of World Bank´s investment climate surveys (ICs) favor the productivity analysis in levels (or logs), we describe in the next section the main ICs properties of these four Central Latin America countries.

2.1 Investment Climate Surveys (ICs)

To measure TFP at the firm level we use data from investment climate surveys (ICs) which are stratified random samples of *manufacturing firms*, with stratification variables being usually industry, region and size. The sampling processes are done in close partnership with regional statistical agencies which provided the necessary information on the total census of manufacturing firms in each country. In order to ensure enough number of large establishments in the sample of manufacturing firms, a sampling approach which oversampled large firms was applied. The basic structure and questions of each investment climate survey is common across all developing countries.

Our data base of each developing country is a short unbalanced panel with temporal observations of production function variables for two or three years; in particular 2001 and 2002 (T=2) for Guatemala Honduras, and Nicaragua and three years 2002, 2003 and 2004 (T=3) for Costa Rica. However, for the investment climate information, which is listed in Tables 3a to 3d of the appendix, the questions were made only for one of the

[6] Jorgenson and Griliches (1967), among others, suggested to use *this Tornqvist* index as an approximation to the continuous *Divisia* index.

years (the last one) of each survey; year 2002 in the case of Guatemala, Honduras, and Nicaragua and year 2004 for Costa Rica.

This raises the first question: should we only use cross-section data (say only for 2002 for the pool of three countries and only 2004 for Costa Rica) or, should we also make use of the recall data from the previous one or two years of data on the production function variables (Y, L, M and K)? We assume that, unless there are important structural breaks, the IC variables at the firm level should not change much from one year to the next within a short period of two or three years. For example, the *number of power outages* suffered by a firm should be similar or constant (fixed effect) within a short period of time, two or three years, since that the quality of the electricity system (an in general the whole investment climate) is stable in the short run. Therefore, for each i-firm we repeat the values observed of each IC_i variable for the corresponding two or three years creating a vector of observable fixed effects[7].

We are interested in keeping as many observations as possible to benefit from the law of large numbers and the central limit theorems. Hence, when the number of firm observations is small, we suggest pooling observations across Guatemala, Honduras, and Nicaragua while treating separately Costa Rica[8] since we have more firm observations for it. This is important because firm observations in developing countries are very unevenly distributed through time and across firms, precluding us from doing separate country analyses of each industry or sector. (See Table 4 of the appendix). For example, if we conduct an industry analysis country by country, we will end up having in the textile sector of Honduras only 9 observations, while if we pool the observations across the three countries we have at least 38 observations, providing therefore more reliable statistical results from the pool.

In 2001, after pooling the observations across the three countries, we only have 440 observations while for 2002 we have 1,020 observations (very unbalanced panel). Therefore, if we measure productivity in rates of growth we will end up with at most 440 firms, which is a very small sample size to study differences by industry and by country. However, doing the analysis in levels or logs we get 1,460 observations in

[7] We were suggested by J. Levinsohn to compare our results with those obtained using only cross section data, without repeating the values of the IC values during few years. Almost identical but less efficient parameter estimates were obtained when using only cross section data instead of recall data (results are available upon request).

[8] Some other World Bank studies take alternative approaches; see Dethier et al (2008) for a very complete and updated survey on IC analysis. For example some of them select a very large pool of countries (say 30 countries) and estimate only a cross section. However, by doing that cross country analysis at the firm level, we generally loose a lot of firms from the sample because and we end up having only few IC variables (omitted variables problems) for very different countries. This approach could suffer from important sample representation problems and is therefore subject to sample selection biases. We believe that by selecting only a small group of countries with similar number of firm responses to the questions of the IC surveys increases not only the representativeness of the sample, but also the number of IC variables and the total number of observations.

total. From Table 4 of the appendix it is clear that the three countries have similar number of observations for the two-year period: Guatemala has 468 firms, Honduras 472 and Nicaragua 521.

In all the regressions we use several productivity measures, 11 dummy variables (D_r , r = 1, 2, ..., 11) and a constant term (intercept). That is, we control for an industry effect of the nine industries (apparel, beverages, chemicals/rubber, food/tobacco, furniture/wood, leather/shoes, nonmetallic minerals, textiles, metal), by including only eight dummy variables, leaving out apparel to avoid having perfect multicolinearity with the constant term. Similarly, we add only one year dummy variable leaving out the corresponding dummy for the year 2001. Finally when we pool countries, to control for a constant country effect, we include two dummies, one for Honduras and the other for Nicaragua, with Guatemala omitted. In the case of Costa Rica we have enough observations to avoid pooling the ICs with the other three Caribbean countries but we also make use 9 control dummies; seven industry dummies and two dummies out of three years.

2.2 Alternative Measures of Firm-Level TFP

To estimate TFP in levels (logs) we first have to specify the functional form of the production function. If the functional form F(L,M,K) is Cobb-Douglas, estimating productivity in levels requires estimation of the following well known equation,

$$y_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + tfp_{it} \,. \qquad (6)$$

Least squares estimation of the input-output elasticities of equation (6) are inconsistent and biases since the inputs are endogenous and therefore correlated with tfp.

One of the usual alternatives, also considered in this paper, is to use a nonparametric or index number approach based on cost-shares from Hall (1990) to obtain the Solow´s residual in levels (logs)

$$tfp_{it} = y_{it} - \bar{s}_L l_{it} - \bar{s}_M m_{it} - \bar{s}_K k_{it} \qquad (7)$$

where $\overline{s}_j$ is the constant aggregate *average cost shares* from the last two years[9] given by $\overline{s}_j = \frac{1}{2}(s_{j,t} + s_{j,t-1})$ for j = L, M and K. The advantage of the Solow residuals, Solow(1957), is that it does not require the inputs (L, M, K) to be exogenous nor the input-output elasticities to be constant. The drawback is that it requires having constant returns to scale (CRS) and at least competitive input markets.

Measuring TFP in levels (or in logs) it is less demanding in terms of:

(i) data quality (since it allows us to treat unbalanced panel without loosing many observations),

(ii) measurement errors, and

(iii) allow us to estimate the effect on TFP of fixed effect IC_i (observable fixed effects).

We also estimate production functions considering *structural techniques* based on Olley and Pakes (1996), Levinshon and Petrin (2003) and Ackerberg, Caves, and Frazer (2006) and Wooldridge (2005).

The production function using a structural approach can be written in logs as (8)-(9);

$$y_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + tfp_{it} \qquad (8)$$

$$tfp_{it} = \upsilon_{it} + e_{it} \ , \qquad (9)$$

where the unobserved tfp_{it} sequence is formed by the sum of two components; the unobserved productivity component { υ_{it} *: t=1, 2,…, t* which includes a constant the term say α_p } and the sequence of *i.i.d* unanticipated shocks {e_{it}*: t=1, 2,…, t*}. From (8) and (9) we get the following extended production function with unobserved TFP variables (υ_{it}),

$$y_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \upsilon_{it} + e_{it} \ . \qquad (10)$$

The endogeneity of the inputs (l, m and k) of equation (8) comes from the fact that,

$$E\left[tfp_{it} / l_{it}, m_{it}, k_{it}\right] = E\left[\upsilon_{it} / l_{it}, m_{it}, k_{it}\right] + E\left[e_{it} / l_{it}, m_{it}, k_{it}\right] = E\left[\upsilon_{it} / l_{it}, m_{it}, k_{it}\right] \neq 0.$$

[9] When there is only firm information about a single year we take the average cost share of the firms of that year.

The Olley and Pakes (1996), O&P, structural model, consider that optimal investment in fixed assets (i_{it}) is a function of firm's productivity and firm's the capital stock, i.e., $i_{it} = h_t(\upsilon_{it}, k_{it})$. They show that when i_{it} is strictly monotonic in υ_{it}, it can be invert it out obtaining the productivity component $\upsilon_{it} = h_t^{-1}(i_t, k_t)$. Substituting this expression into (11) they obtained the following extended production function where, y_{it} measure value added instead of output,

$$y_{it} = \alpha_L l_{it} + \alpha_K k_{it} + \upsilon_{it} + e_{it} = \alpha_L l_{it} + \alpha_K k_{it} + h_t^{-1}(i_{it}, k_{it}) + e_{it} \ . \tag{11}$$

The unobserved productivity component υ_{it} is here "proxy" by $\upsilon_{it} = h_t^{-1}(i_{it}, k_{it})$ and since the function $h^{-1}(.)$ is of unknown form it is usually approximated by low order (3rd order) polynomial and estimated by OLS giving the following parameter estimates of equation (11),

$$y_{it} = \hat{\alpha}_L l_{it} + \hat{\alpha}_K k_{it} + \hat{h}_t^{-1}(i_{it}, k_{it}) + \hat{e}_{it} = \hat{\alpha}_L l_{it} + \hat{\Phi}(i_{it}, k_{it}) + \hat{e}_{it} \ . \tag{12}$$

From (12) O&P get in the *first step* the parameter ($\hat{\alpha}_L$) of the labor input (l_{it}) and suggest to get an estimate of α_K in a *second step* based on the estimated values of $\hat{\Phi}(i_{it}, k_{it})$ since $\upsilon_{it}(\alpha_k) = \hat{h}_t^{-1}(i_{it}, k_{it}) = \hat{\Phi}(i_{it}, k_{it}) - \alpha_K k_{it}$ where α_K is used as an initial estimate of α_K. The final optimal value of α_K is obtained from the following GMM orthogonality condition $E\left[\xi_{it} / k_{it}\right] = 0$ where the innovation or martingale difference sequence of productivity ξ_{it} is given by $\xi_{it} = \upsilon_{it} - E\left[\upsilon_{it} / I_{it-1}\right] = \upsilon_{it} - E\left[\upsilon_{it} / \upsilon_{it-1}\right] = \upsilon_{it} - \Psi\left[\upsilon_{it-1}\right]$ and ξ_{it} it is orthogonal to k_{it} (identification of α_K) since the optimal decision on k_{it} is taken at time t-1 based on all the information available at that time. Let $\xi_{it}(\alpha_k) = \upsilon_{it}(\alpha_k) - \hat{\Psi}\left[\upsilon_{it-1}(\alpha_k)\right]$ where $\hat{\Psi}\left[\upsilon_{it-1}(\alpha_k)\right]$ are the predicted values from a nonparametric regression, including a constant term. Then, the optimal value of α_K is finally obtained from the sample analogue of $E\left[\xi_{it}(\alpha_k) / k_{it}\right] = 0$.

Key assumptions for the O&P estimation procedure are the following: a) productivity υ_{it} follows a first order Markov process, b) labour is a non-dynamic input (perfectly variable) while capital is a dynamic input depending on the investment process, c) investment is strictly monotonic in productivity υ_{it}, d) productivity is the only (scalar) unobservable entering the investment process, *e)* require at least two years of firm level data on investment. However, as was pointed out before, in practice we lose many firms from our sample when we can only consider those firms that we track for more than one year. Panel data based on IC surveys of developing countries are usually very unbalanced forcing us to drop many firms from the sample (all those firms that have zeros in the firm's investment variable). This last requirement is one of the main drawbacks applying the O&P estimation procedure for developing countries; the investment in fixed capital variable usually takes many zero values, creating a loss of efficiency using O&P.

To overcome the problem of zeros observed in the investments in fixed capital variable, Levinshon and Petrin (2003), L&P, suggested using intermediate inputs (m_{it}) as "proxy" for the unobserved productivity (υ_{it}) instead of investment (i_{it}), since the IC surveys have much higher response rates in questions related to intermediate inputs. That is,

$$m_{it} = f_t(\upsilon_{it}, k_{it}) \tag{13}$$

where f(.) is strict monotonic in υ_{it} then this expression can be inverted to get υ_{it} as a function of m_{it} and k_{it}. By replacing υ_{it} in equation (10) the resulting production function becomes,

$$y_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \upsilon_{it} + e_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + f_t^{-1}(m_{it}, k_{it}) + e_{it} \tag{14}$$

where the unobserved productivity component υ_{it}, which is correlated with the endogenous inputs (l, m and k), is now "proxy" by $\upsilon_{it} = f_t^{-1}(m_{it}, k_{it})$. The function $f^{-1}(.)$ is of unknown form and therefore it is as in O&P approximated by a low order (3rd order) polynomial and it is estimated by OLS giving the following parameter estimates of equation (14),

$$y_{it} = \hat{\alpha}_L l_{it} + \hat{\alpha}_M m_{it} + \hat{\alpha}_K k_{it} + \hat{h}_t^{-1}(m_{it}, k_{it}) + \hat{e}_{it} = \hat{\alpha}_L l_{it} + \hat{\Phi}(m_{it}, k_{it}) + \hat{e}_{it} \ . \tag{15}$$

From (15) L&P get in the *first step* the parameter ($\hat{\alpha}_L$) of the labor input (l_{it}). To get an estimate of α_M and α_K they suggest to use the following *second step* procedure based on the estimated values of $\hat{\Phi}(m_{it}, k_{it})$. From (15) we have that

$\upsilon_{it}(\alpha_M,\alpha_k)=\hat{h}_t^{-1}(m_{it},k_{it})=\hat{\Phi}(m_{it},k_{it})-\alpha_M m_{it}-\alpha_K k_{it}$ where α_M and α_K are initial estimates. The final optimal values of α_M and α_K are obtained from the following GMM orthogonality conditions $E\left[\xi_{it}/\begin{bmatrix}k_{it}\\ m_{it-1}\end{bmatrix}\right]=0$ where the innovation or martingale difference sequence of productivity ζ_{it} is given by $\xi_{it}=\upsilon_{it}-E[\upsilon_{it}/I_{it-1}]=\upsilon_{it}-E[\upsilon_{it}/\upsilon_{it-1}]=\upsilon_{it}-\Psi[\upsilon_{it-1}]$ and ξ_{it} is orthogonal to m_{it-1} and k_{it} (identification of α_M and α_K). Let $\xi_{it}(\alpha_M,\alpha_k)=\upsilon_{it}(\alpha_M,\alpha_K)-\hat{\Psi}[\upsilon_{it-1}(\alpha_M,\alpha_K)]$ where $\hat{\Psi}[\upsilon_{it-1}(\alpha_M,\alpha_K)]$ are the predicted values from the nonparametric regression of $\upsilon_{it}(\alpha_M,\alpha_K)$ on $\upsilon_{it-1}(\alpha_M,\alpha_K)$ and a constant term for any parameter values of α_M and α_K. Then, the optimal values of α_M and α_K are finally obtained as those values that makes the sample analogues of $E\left[\xi_{it}(\alpha_M,\alpha_K)/\begin{bmatrix}k_{it}\\ m_{it-1}\end{bmatrix}\right]$ as close to zero as possible.

Key assumptions for the L&P estimation procedure are the following: a) productivity υ_{it} is following a first order Markov process, b) labour and intermediate inputs are a non-dynamic inputs (perfectly variable inputs) while capital is a dynamic input, c) the intermediate input is strictly monotonic in productivity υ_{it} and d) productivity is the only (scalar) unobservable entering the intermediate input process.

Ackerberg, Caves, and Frazer (2006), AC&F point out that the labour coefficient cannot be identified in equations (11) and (14), since the labour input l_{it} is *collinear* with the corresponding two nonparametric terms; $\alpha_M m_{it}+\alpha_K k_{it}+h_t^{-1}(i_{it},k_{it})$ in (11) and $\alpha_K k_{it}+\alpha_M m_{it}+f_t^{-1}(m_{it},k_{it})$ in (14).

AC&F propose to use the following extended production function where y_{it} measures value added instead of output,

$$y_{it}=\alpha_L l_{it}+\alpha_K k_{it}+\upsilon_{it}+e_{it}=\alpha_L l_{it}+\alpha_K k_{it}+f_t^{-1}(m_{it},k_{it},l_{it})+e_{it}\ . \tag{16}$$

The unobserved productivity component υ_{it} is here "proxy" by $\upsilon_{it}=f_t^{-1}(m_{it},k_{it},l_{it})$ and since the function $f^{-1}(.)$ is of unknown form it is usually approximated by low order (3^{rd} order) polynomial and estimated by OLS giving the following parameter estimates of equation (16),

$$y_{it}=\hat{\alpha}_L l_{it}+\hat{\alpha}_K k_{it}+\hat{f}_t^{-1}(m_{it},k_{it},l_{it})+\hat{e}_{it}=\hat{\Phi}(m_{it},k_{it},l_{it})+\hat{e}_{it}\ . \tag{17}$$

From (17) AC&F estimates $\hat{\Phi}(m_{it}, k_{it}, l_{it})$ in the first step and then use the following *second step* procedure based on the estimated values of $\hat{\Phi}(m_{it}, k_{it}, l_{it})$. From (11)-(12) we have that $\upsilon_{it}(\alpha_L, \alpha_K) = \hat{h}_t^{-1}(m_{it}, k_{it}, l_{it}) = \hat{\Phi}(m_{it}, k_{it}, l_{it}) - \alpha_L l_{it} - \alpha_K k_{it}$ where α_L and α_K are any initial parameter values. Let $\xi_{it}(\alpha_M, \alpha_k) = \upsilon_{it}(\alpha_L, \alpha_K) - \hat{\Psi}\left[\upsilon_{it-1}(\alpha_L, \alpha_K)\right]$ where $\hat{\Psi}\left[\upsilon_{it-1}(\alpha_L, \alpha_K)\right]$ are the predicted values from the nonparametric regression of $\upsilon_{it}(\alpha_L, \alpha_K)$ on $\upsilon_{it-1}(\alpha_L, \alpha_K)$ and a constant term, for any values of α_L and α_K. The final optimal GMM values of α_L and α_K are obtained from the sample analogue of the following two orthogonality conditions $E\left[\xi_{it}(\alpha_L, \alpha_K) / \begin{bmatrix} k_{it} \\ l_{it-1} \end{bmatrix}\right] = 0$.

Finally, Wooldridge (2005) proposed a computational simple GMM estimation procedure that could be used in all three structural procedures; OP, LP and ACF. In the empirical application we will only follow Wooldridge when estimating ACF.

Hall and Jones (1999) argue that to explain differences in levels of long-run economic success across countries, one is forced to focus on more basic determinants: like infrastructure and persistent barriers that make technology and capital not moving fast across borders ... and continue saying that *"long-run determinants of economic success are factors that are changing slowly over time"*. For us, those basic firm level determinants are associated here with fixed effects related to the investment climate (IC). That is, firm level determinants based on information on infrastructure, red tape, finance, innovation, labor skills, etc., see Tables 3a to 3d of the appendix. This is in line with our preference for the TFP approach in levels, instead of in differences since they get rid of fixed effects (all the investment climate variables). Notice that none of the previous structural TFP estimation procedures allow us to consider fixed effect components in equation (10).

Our TFP estimation procedures can be justified from the following simplified *structural simultaneous equations model* which includes the following equations: a production function (Cobb-Douglas in this case), a TFP equation, and determinants of the unobserved firm specific time-fixed effects and we could include the inputs demands of L, M and K. For simplicity, we do not write the usual demands equations of the inputs L, M and K but we should have in mind that they are all affected by certain common causes related to IC variables (observable fixed effects) which for us are the main sources of endogeneity of the inputs in (18a)-(18d),

$$y_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + tfp_{it} \quad (18a)$$

$$tfp_{it} = \upsilon_{it} + e_{it} \tag{18b}$$

$$\upsilon_{it} = a_i + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P \tag{18c}$$

$$a_i = \alpha'_{IC} IC_{P,i} + \alpha'_C C_{P,i} \ \ + \varepsilon_i \tag{18d}$$

where IC_i and C_i of equation (18d) are firm level fixed effect vectors of investment climate variables and other control variables, while D_j and D_t of (18c) are vectors of industry (j) dummies and year (t) dummies, respectively. Notice that the time dummies (D_t) capture part of the momentum that productivity has and that is usually captured by allowing a first order autocorrelation process (first order Markov condition in the structural model) with high persistence[10].

The usually unobserved fixed effects (a_i) of the TFP equation (18c) are here proxy by the set of observed fixed values of IC, and C variables of (18d) and a remaining unobserved random effect term (ε_i). The two random error terms of the system, ε_i and e_{it}, of the following *extended production function* are assumed to be conditionally uncorrelated with the explanatory L, M, K, IC, C and dummy variables[11]

$$y_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \alpha'_{IC} IC_{P,i} + \alpha'_C C_{P,i} \ \ + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P + \varepsilon_i + e_{it} \tag{19}$$

Therefore, the extended production function (19) represents the *conditional expectation* with a composite error term equal to $\varepsilon_i + e_{it}$; a random effect term (ε_i) and the unpredictable productivity shocks (e_{it}). That is,

$$\begin{aligned} &E(y_{it} / l_{it}, m_{it}, k_{it}, IC_{P,i}, C_{P,i}, D_j, D_t, \varepsilon_i, \theta) = \\ &\quad = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \alpha'_{IC} IC_{P,i} + \alpha'_C C_{P,i} \ \ + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P + \varepsilon_i \end{aligned} \tag{20}$$

where we assume that equation (19) satisfy *standard assumptions* of random effects (RE) in conditional models,

$$E\left[e_{it} / l_{it}, m_{it}, k_{it}, IC_{P,i}, C_{P,i}, D_j, D_t, \varepsilon_i \right] = 0 \tag{21a}$$

$$E\left[\varepsilon_i / l_{it}, m_{it}, k_{it}, IC_{P,i}, C_{P,i}, D_j, D_t \right] = 0 \tag{21b}$$

$$and \quad Var\left[\varepsilon_i / l_{it}, m_{it}, k_{it}, IC_{P,i}, C_{P,i}, D_j, D_t \right] = \sigma_\varepsilon^{\ 2} . \tag{21c}$$

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[10] We could do that but since most ICs of developing countries are very unbalanced, we prefer not to lose many observations (firms) when allowing for the AR(1) version of TFP. However, we plan to do that in the near future when having access to balanced panel based on investment climate surveys.

[11] Under conditions (20a) to (20c) the OLS estimator with robust standard errors of the productivity (TFP) equation (18) is consistent, although a more efficient estimator (say GLS) is given by the random effects (RE) estimator that takes into consideration the particular covariance structure of the error term, $\varepsilon_i + e_{it}$, which introduces certain type of heteroskedasticity in the regression errors of (19).

Notice that we need to condition on the observable fixed effects (IC_i) and (C_i) and on certain industry (D_j) and time dummies (D_t) to get the orthogonally condition of the inputs L, M and K. That is, without conditioning in IC and C variables, $E\left[e_{it} / l_{it}, m_{it}, k_{it}, D_j, D_t, \varepsilon_i\right] \neq 0$ and also $E\left[a_i / l_{it}, m_{it}, k_{it}, D_j, D_t, \varepsilon_i\right] \neq 0$ and therefore there is correlation between the unobserved effects ($\varepsilon_i + e_{it}$) and the inputs (L, M and K) coming from the *common causes* generated by the observable fixed IC and C effects.

To clarify the difference between our approach and the structural approach of AC&F we specify our model (without the random effect component) in terms of value added measures of y_{it},

$$y_{it} = \alpha_L l_{it} + \alpha_K k_{it} + \upsilon_{it} + e_{it} \quad (22a)$$

$$\upsilon_{it} = a_i + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P + \xi_{it} \quad (22b)$$

$$a_i = \alpha'_{IC} IC_{P,i} + \alpha'_C C_{P,i} \quad . \quad (22c)$$

The structural model of AC&F can be written in this case as,

$$y_{it} = \alpha_L l_{it} + \alpha_K k_{it} + \upsilon_{it} + e_{it} \quad (23a)$$

$$\upsilon_{it} = \Psi\left[\upsilon_{it-1}\right] + \alpha_P + \xi_{it} \quad (23b)$$

$$\upsilon_{it} = f_t^{-1}(m_{it}, k_{it}, l_{it}) \quad . \quad (23c)$$

The unobserved productivity (υ_{it}) corresponding to both production functions, (22a) and (23a), is "proxy" by two different approaches based on two different information sets, (22b-22c) and (23b-23c). While AC&F requires having certain types of dynamic panel[12] structure, our approach can be used in simple cross sections or in dynamic panels with trending data but with uncorrelated errors. The two corresponding extended production functions are;

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[12] The corresponding equation (22b), in the traditional *dynamic panel literature* of Chamberlain (1982), Anderson and Hsiao (1982), Arellano and Bond (1991) and Blundell and Bond (1998, 2000), is the following; $\upsilon_{it} = a_i + \alpha'_{Ds} D_j + \omega_{it} + \alpha_P + \xi_{it}$ where ω_{it} follows an AR(1) process, $\omega_{it} = \rho\omega_{it-1} + \varsigma_{it}$ where the AR(1) coefficient (ρ) is high and close to one (persistent productivity shocks) . In our approach this high AR(1) is proxy by a flexible deterministic trend with changing coefficients given by $\alpha'_{DT} D_t$. We hope that The World Bank will create soon balanced dynamic panel of ICS so that we could evaluate the robustness of our empirical results.

$$y_{it} = \alpha_L l_{it} + \alpha_K k_{it} + \alpha'_{IC} IC_{P,i} + \alpha'_C C_{P,i} \;\; + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P + \xi_{it} + e_{it} \qquad (24)$$

$$y_{it} = \alpha_L l_{it} + \alpha_K k_{it} + \Psi\left[f_{t-1}^{-1}(m_{it-1}, k_{it-1}, l_{it-1})\right] + \alpha_P + \xi_{it} + e_{it} \qquad (25)$$

Under condition $E\left[\xi_{it} + e_{it} \,/\, l_{it}, m_{it}, k_{it}, IC_{P,i}, C_{P,i}, D_j, D_t, \varepsilon_i\right] = 0$ OLS in one step in (24) is a consistent and unbiased estimator in just one step. However, following AC&F, equation (25) requires a two step approach; first and estimate of $f^{-1}(.)$ and Ψ, using equations (23a) and (23c), and second a final estimate of the α_L and α_K from equation (23b) and from the sample analogue of the following two orthogonality conditions $E\left[\xi_{it}(\alpha_L, \alpha_K) / \begin{bmatrix} k_{it} \\ l_{it-1} \end{bmatrix}\right] = 0$.

Equation (24) has the usual form of a familiar Cobb-Douglas extended production function, but it is obvious that the previous argument of controlling for observables fixed effects (IC_i and C_i variables) apply to other functional forms. For example for the TRANSLOG production function;

$$\begin{aligned} y_{it} = {} & \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \frac{1}{2}\alpha_{LL}(l_{it})^2 + \frac{1}{2}\alpha_{MM}(m_{it})^2 + \frac{1}{2}\alpha_{KK}(k_{it})^2 + \\ & + \alpha_{LM}(l_{it})(m_{it}) + \alpha_{LK}(l_{it})(k_{it}) + \alpha_{MK}(m_{it})(k_{it}) + \\ & + \alpha'_{IC} IC_{P,i} + \alpha'_C C_{P,i} \;\; + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P + \xi_{it} + e_{it}. \end{aligned} \qquad (26)$$

The Translog is only a “local approximation” to an unknown function and therefore might not give very reliable globally parameter estimates, but at least allows us to test if the technology (at the aggregate level or at the industry level) is Cobb-Douglas and also, from equation (25,) give us a closer approximation to AC&F structural model without the cubic terms and the lags of the inputs (l, m and k) but adding elements like the IC and C effects.

With both parametric specifications of our extended production functions, (24) and (26), we can also test the constant returns to scale[13] (CRS) condition behind Solow´s residuals (tfp_{it}) of equation (7).

The second equations (18b) or (22b) of both alternative system of equations, provide the usual TFP equations of firm i in year t of most structural models. However notice that

[13] For example, under CRS the coefficients of the inputs (L, M, and K) of the Cobb-Douglas specification of the production function add up to one. Similar but more complicated coefficient restrictions apply for a CRS Translog production function. Tables 8, 9 and 10 show the results for the pool of countries and for Costa Rica.

now TFP in (18b) depends on the unobserved firm specific effects, a_i, a vector of firm investment climate (IC_i) and other firm level control variables (C_i), industry, country and year dummies (D_r) and unpredictable shocks (ξ_{it}) which are assumed to be conditionally uncorrelated with the inputs (L, M and K) and the rest of variables of the extended production function.

The main advantages of investment climate surveys (ICs) is that the usually unobserved firm specific fixed effects (a_i) are now observed (see equations (18d) or (22c)) at the micro level due to the detailed firm specific information obtained from the IC surveys. In equation (18d) we add an extra firm specific random effect (RE) term (ε_i) which is the part of the unobserved firm effects conditionally uncorrelated with the investment climate variables (IC_i) and the control variables (C_i). Notice, that since the number of observable firm specific fixed effects (IC_i and C_i) is very large in our data sets (we used more than 100 observable firms fixed effects) it is reasonable to assume that errors e_{it}'s are uncorrelated with the inputs (L,M and K) after conditioning on all the investment climate information of the firms.

From our simple simultaneous equation model, it is clear that a standard 2-step estimation approach, where we first estimate (by OLS) the single equation (18a) to get a measure of productivity (TFP) and second use this estimated productivity (TFP) measure to evaluate the impact of IC variables on TFP, will render the least square estimator of those elasticities inconsistent and biased. The created measurement error problem of the estimated dependent variable (tfp_{it}) of equation (18b) is clearly transmitted to rest of the parameters of the production function equation (18a). The reason is clear; the measurement error term of the dependent variable (tfp) of equation (18b) is correlated with the inputs (labor, capital, etc.) at least through the common IC variables that affect optimal input firm's decisions. Therefore, our solution to address the endogeneity of the inputs is to estimate an *extended production function* after incorporating all the IC variables that are driving endogeneity of the inputs. By joint estimation of the input-output elasticities and the rest of the parameters of the system (IC and C variables), the IC variables are used as *proxies* for the unobserved firm productivity fixed effects (a_i) as well as the usually unobserved productivity effects (υ_{it}). OLS, with robust standard errors on the extended production function (19), is also consistent although less efficient than random effects (RE). In (27) the error term $u_{it} = \varepsilon_i + e_{it}$ is conditionally uncorrelated with the explanatory variables,

$$y_{it} = \alpha_L l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \alpha'_{IC} IC_{P,i} + \alpha'_C C_{P,i} + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P + u_{it} \,. \qquad (27)$$

The standard two step approach to estimate IC elasticities could be used if the corresponding TFP measure is obtained from the nonparametric Solow´s residuals (tfp from equation (7)) that use accounting techniques but should not be used from the OLS residuals of (18a). Therefore, under standard regularity conditions consistent estimates of the IC elasticities and semi-elasticities on TFP, can be obtained from the following second step based on the Solow´s tfp_{it} measures from (7);

$$tfp_{it} = \alpha'_{IC} IC_{P,i} + \alpha'_{C} C_{P,i} + \alpha'_{Ds} D_j + \alpha'_{DT} D_t + \alpha_P + u_{it}. \qquad (28)$$

Otherwise, we can consistently estimate in none step the input-output elasticities as well as the IC effects on tfp based on the extended production function (27).

Since there is no single salient measure of TFP_{it}, any empirical evaluation on the productivity (TFP) impact of IC variables might critically depend on the way productivity is measured. Therefore, to get reliable empirical IC effects to do policy analysis, we suggest looking for robust empirical results using several productivity measures. This is the approach we will follow in the rest of the paper. Ackerberg et al (2006) also conclude saying "*Finding that production function parameters are consistent across multiple techniques with different assumptions is surely more convincing than only using one*". For this purpose, we use at least 12 productivity measures (see section 3) that best fit with the characteristics of our data set: two levels of aggregation (country level and industry level), with two parametric production functions (Cobb-Douglas and the Translog), with the Solow residuals for the two aggregation levels and applying L&P and AC&F structural estimators. That is, we can run OLS from a one-step regression[14] based on the *extended production function* (27). In the empirical applications we allow the errors (u_{it}) from (27) and (28) to be heteroskedastic and therefore we will be using pooling OLS with robust standard errors (also using cluster standard errors) and allowing for random effects (RE) estimators (GLS).

2.3 Endogeneity of the IC Variables

An econometric problem that we have to face in estimating (27) and (28) is the possible *endogeneity* of IC variables and some C variables. The traditional dynamic (with lags)

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[14] Alternatively, we could have used an equivalent two-step control function approach (Blundell and Powell, 2003) where we first estimate by OLS a regression of each of the inputs on all the IC and C variables (partialling out) and then include the residuals of each estimated input equation, instead of the observed inputs, in the original production function.

instrumental variables (IV) cannot be used in this context, given that we only have information on IC variables for one year.

Therefore, to control for the endogeneity of certain IC variables, we use alternative IV based on the *region-industry average* of the plant level investment climate variables ($\overline{IC}$) instead of the original IC variables. This is simple solution frequently used in empirical panel data studies at the firm level. In particular, for the pool of countries we have in total 13 regions for the three countries and 9 industries for each country (see Table 1 for details). In Costa Rica, we have 7 regions and 8 industries (see Table 2). Taking region and industry averages instead of the individual IC variables, is also useful to avoid dropping firms with missing IC information and also to avoid having important omitted IC variables when several firms have missing values in relevant IC variables. Addressing the missing values problem is a key issue in most IC surveys as will become clear in the empirical applications. Another possible interpretation of our results follows Chalak and White (2008) since we are using many IC explanatory variables that might be endogenous those cannot be considered proper instruments since they are endogenous (extended instrumental variables; EIV) however they could identify and estimate causal effects. Not all regression coefficients need to have signs and magnitudes that make causal sense. For instance Chalak and White (2008) argue; "In order to properly understand what effects one is estimating, with a given regressions including or excluding causally relevant variables, it is necessary to have a clear understanding of the underlying causal relations … we consider identification of causal effects given causal structures specified a priori". In our approach we do not specify a priori the causal structure. However, when the TFP specification controls for the relevant firm-level information related to the investment climate, then the empirical results on the signs and magnitude of the IC regression coefficients are robust and with the expected signs. Whether the results are causal or not, could be confirmed when having richer data sets based on balanced dynamic IC panels and we could check that in the near future when new ICS are available for these countries.

2.4 Strategy for IC Variables' Selection

The econometric methodology applied for the selection of the IC and C variables goes from the general to the specific. Once we have a parsimonious model with only significant variables, we test for omitted variables to make sure that we did not deleted relevant IC variables due to the strong multicolinearity of the initial general model.

The *omitted variables* problem that we encounter, starting from a too simple model generates biased and inconsistent parameter estimates. On the contrary, adding *irrelevant variables* (meaning starting from a very general model with some variables that are irrelevant) might suffer multicolinearity among IC variables providing unbiased and consistent but inefficient estimates. Therefore, we start from a general model, such as equations (24) and (26) with most for the IC variables of Tables 3a to 3d included at once, and we reduce this general model to a simpler one with only relevant (significant) variables[15]. Note that the final estimated model is efficiently estimated once we have deleted insignificant or irrelevant variables.

Going from general-to-specific is usually recommended to avoid having omitted variable biases and spurious correlations, see Hendry and Nielsen (2007). Consider a regression with **n** irrelevant variables. Then the average number of variables found significant by chance at the α significant level is **nα**. Say α=0.05 and n=40 then nα=2. That is, on average, 2 irrelevant variables are included and 38 variables are correctly excluded if *repeated t-test* are used. If α is reduced to α=0.01, as it is sometimes suggested when doing repeated t-testing, and n=40 then average number of variables found significant is reduced to nα=0.4**.** However, the main problem of reducing the significance level **α**, is that we are also reducing the power of the t-test, making the detection of relevant variables difficult (which is a misspecification with crucial implications in terms of spurious correlations). Monte Carlo evidence shows from Hoover and Perez (1999) and Hendry and Krolzig (2001, 2005) that general-to-specific modeling has a small search cos**t**; that is a small additional cost in terms of size and power that arise by doing *repeated testing with multiple path selection algorithms* starting in a general unrestricted model (GUM) that is not the true local DGP.

In the reduction process we do not delete all insignificant variables at once, since due to multicolinearity, if we drop one variable that is highly correlated with others, some of the insignificant variables might become significant. An informative statistic for this purpose is the variation of the R^2 of the regression (or the variation in the standard error of the regression). The R^2 of the final simplified models, with only significant or relevant variables, are included in Table 7 for Guatemala, Honduras and Nicaragua and Table 8 for Costa Rica. Those R^2 of the reduced models are smaller but very close to the R^2 of the most general regression model we started with. We applied this iterative procedure, eliminating the least significant variables leaving, for interpretive purposes,

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[15] Sometimes, in the final regression model, we leave IC variables that are not individually significant but are relevant for the model either because they are jointly significant, affect the significance of other variables or are significant in other TFP measures. When this happens it could be due to the presence of multicolinearity among some of the explanatory variables of the production function (Translog case specially) or among other IC variables.

at least one IC variable from each broad IC category (infrastructure, bureaucracy/corruption, crime, technology and quality, human capital, corporate governance, etc.). Once we have a reasonable parsimonious model we start testing for omitted IC variables block by block, to see if due to the multicolinearity among IC variables we deleted a relevant IC variable in the reduction process. Notice, that most automatic modeling process does not consider this steps going from the specific to the general step. The reason is that they are based on orthogonal regressors and therefore multicollinearity problems are not an issue.

The final TFP estimated coefficients of IC variables reported in Tables 7 and 8 of the Appendix were obtained using this modeling selection strategy in all the countries. We include in those Tables 7 and 8 the set of IC variables that were *significant in at least one of the twelve TFP specifications.* It is important to notice that these empirical estimates are *robust*; all the IC coefficients of the TFP equations have equal signs and vary within a small range of parameter values. The detailed empirical results are discussed in the next sections.

3 Robustness of the Estimated Productivity-IC Elasticities and Semi-elasticities

As we said before, for policy implications we would like the estimated *elasticities, or semi-elasticities* of IC variables to be robust among: 1) different functional forms of the production functions; 2) different consistent estimation procedures; 3) different productivity measures; and 4) different aggregation levels (industry, country, pooling across countries, etc).

As mentioned in section 2, to reduce the simultaneous equation bias and the risk of getting reverse causality problems of endogenous IC_i variables, we use their corresponding region-industry average ($\overline{IC}_j$). The coefficients of investment climate ($\overline{IC}_i$) variables and other plant-specific control variables (C_{it}) are maintained constant for all the firms in Costa Rica and for all the firms in the pool of countries. However, we allow the production function elasticities, and therefore the productivity measures, to change for each functional form (Cobb-Douglas and Translog) and for each different aggregation levels (industry and countries). We consider two levels of aggregation: (i) restricted estimation (imposing equal input-output elasticities among industries for the three countries) and (ii) unrestricted estimation (allowing different input-output elasticities for each industry). Moreover, we consider two different estimators (pooling OLS and random effects, RE) for each productivity measure.

BOX 1: Summary of Productivity (TFP) Measures and Estimated Investment Climate (IC) Elasticities				
			1.1.a OLS	
1. Solow´s Residual	**Two Step**	**1.1 Restricted Coef**	**1.1.b RE**	**2 (TFP_{it}) measures**
	Estimation		**1.2.a OLS**	**4 (IC) elasticities**
		1.2 Unrestricted Coef	**1.2.b RE**	
			2.1.a OLS	
2. Cobb-Douglas	**Single**	**2.1 Restricted Coef**	**2.1.b RE**	**4 (TFP_{it}) measures**
	Estimation		**2.2.a OLS**	**4 (IC) elasticities**
		2.2 Unrestricted Coef	**2.2.b RE**	
			3.1.a OLS	
3. Translog	**Single Step**	**3.1 Restricted Coef**	**3.1.b RE**	**4 (TFP_{it}) measures**
	Estimation		**3.2.a OLS**	**4 (IC) elasticities**
		3.2 Unrestricted Coef	**3.2.b RE**	
				10 (TFP_{it}) measures
			Total	**12 (IC) elasticities**

Restricted Coef.= Equal input-output elasticities in all industries of the three countries
Unrestricted Coef.= Different input output elasticities by industry of the three countries
OLS = Pooling Ordinary Least Squares estimation (with robust standard errors)
RE = Random Effects estimation

Box1 summarizes the productivity measures and the corresponding IC elasticities that we estimate for the pool of Latin American countries and for Costa Rica. For Costa Rica, we also add the results obtained from other structural estimation approaches based on L&P and AC&F procedures.

Thus we obtain at least 10 different productivity measures (TFP_{it}) and we evaluate the impact of IC variables on each of them based on at least two estimation procedures pooling OLS and RE. If the sign of the impact of certain IC variables on productivity differ depending on the particular productivity (TFP) measure used, those results are not robust and therefore are not reliable for making policy recommendations[16]. However, as we will see later on it is possible to get robust IC elasticities and semi-elasticities on TFP even when the correlations between the alternative TFP measures are low (or even negative). We estimated the correlations between the pairs of TFP measures (in logs) obtained from the four single-step production function and from the two Solow residuals. The correlations between the Solow residuals and the TFP from restricted

[16] This was the case with the initial analysis done at the World Bank among different units (Infrastructure, Finance, etc.) working with this data set of LAC countries. As we will see our approach is able to encompass previous contradictory results and is able to explain the lack of robustness of IC elasticities on TFP when they do not control for the relevant firm-level information (unobservable fixed effects, omitted variables, etc.).

production functions are high, ranging from 0.87 to 0.98. However, for the unrestricted input-output elasticities across industries (unrestricted production functions) the correlations are much lower; ranging from 0.69 in the Cobb-Douglas case to 0.11 in the Translog case.

Figure 2 and Figure 3 of the Appendix, shows the kernel density of the 1og TFP measures for the pool of LAC countries and for Costa Rica, correspondingly. We observe that mainly the location of the different TFP measures is different, especially for the unrestricted industry input-output elasticities, see parts I of Figures 2 and 3. Therefore, we might expect the IC elasticities on TFP to change (not robust) depending on the particular TFP measure used. However, as we will see soon, this is not necessarily the case. It is possible to get robust estimates for any of the TFP measures considered as long as we control for the important aspects of the firm´s investment climate (observable fixed effects). The shapes of the alternative TFP measures are easily compared using demeaned TFP (without a constant term), see parts II of Figures 2 and 3. In the case of Costa Rica, we can also compute L&P and ACF procedures and the results are similar to the ones obtained from Solow´s residuals. In summary, if the goal is to get robust IC elasticities on TFP, see section 3.3, it is not so important which particular TFP measure is used.

3.1 Restricted Coefficient Estimates (equal input-output elasticities)

3.1.1 Solow´s Residual (two-step restricted estimation)

We first obtain the Solow residuals (TFP_{it}) from equation (7) using nonparametric measures (cost shares) and second we estimate the impact of IC variables on TFP_{it} through regression techniques. This two-step approach clearly overcomes the endogeneity problem for the inputs in the first step.

Table 6 shows that the cost share of labor is 0.36 in the pool of countries and 0.33 in Costa Rica. The cost shares of intermediate materials are 0.53 and 0.56, respectively, and the ones on the capital stock are 0.11 and 0.11. The cost shares add up to one because we are imposing constant returns to scale (CRS) following Solow´s suggestion.

The empirical estimates in the second step obtained from equation (24), by pooling the observations from the three countries and running OLS and random effects (RE), are in Table 7. Table 8 shows the similar estimates for Costa Rica. We will comment these results in section 3.3.

3.1.2 Cobb-Douglas and Translog Productivities (Single-step restricted estimation)

In this case, we consider that the elasticities of the three inputs (L, M, K) of the Cobb-Douglas (24) and Translog (26) extended production functions are constant for the aggregate manufacturing sector. Each of the two equations is estimated in a single step, meaning that the parameters of the production function are estimated jointly with the parameters of the IC, C and D variables. However, to make the empirical results easily readable we present them in separate tables. Table 6 shows the input-output elasticities and Tables 7 and 8 show the corresponding elasticities and semi-elasticities of the IC variables on TFP.

In the pool of countries, see Table 6, the estimated labor elasticity of the Cobb-Douglas production function is 0.43 (OLS) and 0.48 (RE), the intermediate materials elasticity is 0.52 (OLS) and 0.45 (RE). Finally, the elasticity of capital is 0.07 for both OLS and RE. With both estimation procedures, we can not reject the constant returns to scale (CRS) hypothesis.

In the case of Costa Rica, the estimated input elasticities are as follows: (i) labor, 0.31 by OLS and 0.29 by RE, (ii) intermediate materials, 0.53 by OLS and 0.47 by RE, and (iii) capital, 0.12 by OLS and RE. In this case, the CRS hypothesis is rejected at any reasonable significance value in the case of RE and at 10% in the case of OLS (the p-value is 0.0649).

The empirical input-output elasticities for Translog production functions are also in Table 6. The Translog specification allows us to test if the production function is Cobb-Douglas. The Cobb-Douglas specification is rejected with a p-value of 0.0 both for the pool of LAC countries and for Costa Rica separately. The CRS is not rejected at any reasonable significance level for the pool of countries and is rejected at any significance level for Costa Rica.

3.2 Unrestricted Production Function Coefficients (by industry)

In this case, we allow the input-output elasticities of (L, M and K) of the production function to vary industry by industry. Table 1 shows the definition of the industries for the pool of LAC countries and Table 2 for Costa Rica.

3.2.1 Solow´s Residuals (Two-step unrestricted estimation)

First, we observe that there is certain homogeneity among the 9 industries. Intermediate materials (M) always has the highest share around 0.50, followed by the cost share of labor nearly 0.40 and finally the share of the capital stock at around 0.10[17].

Second, the empirical results from the OLS and the random effects (RE) estimates of equation (24) are included in Table 7 (pool of countries) and Table 8 (Costa Rica).

3.2.2 Cobb-Douglas and Translog Productivities (Single-step unrestricted estimation by industry)

In this case, the extended production function specifications of equations (24) and (26) become the production functions for each of the nine industries (j), where j=1,2 ,...,9. Each equation is estimated by OLS and by random effects (RE). Once again, we separate the information on the production function elasticities from the information on the IC elasticities to make the tables more readable although all the parameters were jointly estimated in one step.

A summary of the results is the following, see Escribano and Guasch (2008) for more details; estimating the unrestricted Cobb-Douglas specification in the pool of countries the constant returns to scale (CRS) condition is not rejected in six out of nine sectors (Apparel, Food and Tobacco, Furniture and Wood, Nonmetallic minerals, Textiles and Metal Products). In the industry of Chemical and Rubber the hypothesis is strongly rejected and in the other sector the evidence is mixed. For other sectors like leather/shoes, the estimated input-output elasticities are very different from the values obtained from the cost shares given by the two-step procedure with Solow residuals, meaning that the industries have certain heterogeneity in their input-output elasticities. Therefore, the corresponding productivity measures should differ in a significant way as showed in Figures 2 and 3.

With the Translog specification, the CRS hypothesis is only rejected in the Apparel sector. The evidence in the other industries is mixed in the sense that is rejected in the OLS and not rejected in the RE estimation.

In the case of Costa Rica the CRS hypothesis is not rejected when estimating a Cobb-Douglas specification in three out of eight industries and rejected two.

The empirical results of the Translog production function parameters are included the following; the CRS hypothesis is rejected in 5 industries and not rejected in one. The Cobb-Douglas specification is rejected in six out of eight sectors it was rejected. The industries that failed to reject the Cobb-Douglas specification also failed to reject CRS.

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[17] For space limitations the estimation input-output elasticities at the industry level are not reported in the Tables of the Appendix, but are available in the Appendix of Escribano and Guasch (2008). Similarly with the correlation matrices of the alternative TFP measures discussed before.

It is clear from this section that the results on the input-output elasticities are not robust to the functional form of the production function or to the heterogeneity sector by sector.

The conclusion we obtain from this section is the following; testing parameter restrictions on input-output elasticities is informative about technological aspects of the firms (returns to scale, functional forms of production functions, etc.) but this information might not be relevant if the objective is to obtain robust estimates of the IC effects on TFP. Therefore, the important question for us is; does it matter what TFP measure is used in order to get robust IC elasticities on TFP? The answer is NO, under certain conditions, as we will see in the next section.

3.3 Empirical Results: The impact of the IC variables on firms' productivity

The economic interpretation of each investment climate coefficient is contingent on the units of measurement of each IC variable and on the transformations performed on them (logs, fractions, percentages, qualitative constructions, etc.). Since all the productivity (TFP) measures considered here are always in logs, when the IC variable is also expressed in logs the estimated coefficient measures the constant *IC elasticity on TFP*. When the IC variable is not expressed in logs and is not a binary variable, the estimated coefficient is usually described as the *IC semi-elasticity*[18] *on TFP*. The constant IC elasticity on TFP measures the percentage change in TFP induced by a percentage change in the IC variable and the semi-elasticity coefficient multiplied by 100, measures the percentage change in TFP induced by a unitary change in the IC variable. For interpretation purposes, a detailed explanation of the units of measurement of each variable is given Table 3 and Tables 7 and 8.

The question of interest here is whether alternative productivity (TFP) measures yield similar elasticity and semi-elasticity estimates for the IC effects on TFP. The large set of Investment Climate (IC) variables are classified into five broad groups or blocks: (a) Red Tape, Corruption and Crime, (b) Infrastructure, (c) Quality, Innovation and Labor Skills, (d) Finance and Corporate Governance, and (e) Other control variables.

[18] While it is sometimes natural to express an IC variable in log form, for some types of IC variables it is more appropriate not to do so. For example, when an IC variables is a fraction or a percentage number with some data equal to 0 or close to 0. Notice however that expressing IC variables in fractions allow us to interpret also their coefficients as constant elasticities and not as semi-elasticities.

The results reported in Tables 7 and 8 shows that within each investment climate group, all the individual IC variables have the expected signs and the small numerical variability obtained in the IC elasticities or semi-elasticities for the 10 productivity measures is always within a reasonable range of values. As expected, in absolute terms, the highest IC elasticity corresponds to the Solow residual or to the Cobb-Douglas specification, while the lowest usually correspond to the Translog production function. That is, we observe a trade-off between the role played by inputs (labor, intermediate materials and capital) and the role played by the IC variables and other control variables. The robustness of these empirical results across TFP measures allows us to obtain *robust economic evaluations* of the IC effects of productivity which was the main purpose of this paper.

The Translog results on the empirical estimates of the IC elasticities are the same in terms of signs but fewer IC coefficients are significant, see Tables 7 and 8. The reason is clear; the Translog specification includes many nonlinear terms of the inputs variables of each sector and they compete with the explanatory power of IC variables. The important result is that all the signs of the coefficients of the IC and C variables are invariant to the TFP measure used[19]. Therefore, the results on the impact of IC variables on productivity are robust to different productivity measures, suggesting that we can use the signs and the range of estimated elasticities for policy analysis[20].

We present a summary of the individual estimates of the elasticities or semi-elasticities of IC variables on productivity (TFP) in Figures 4 and 5 of the Appendix. Both Figures show the similarity and homogeneity (robustness) obtained among the twelve IC coefficients obtained from different TFP measures and also from different estimation procedures. To make feasible these firm-level IC estimations across a large number of developing countries comparisons we would like to concentrate on only one of the TFP measures. For simplicity, our selected TFP measure is the Solow residual. Figure 4 and 5 shows that the Solow´s residuals give IC parameter values very close to the average and also to the median of the twelve IC elasticities obtained for the pool of LAC countries and Costa Rica[21].

As was discussed before the key issue for this robustness is to control for the relevant IC firm-level information. Even if the analyst is only interested on the effects of say infrastructure on TFP, we have to control for the IC information we have on the other

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[19] We also considered the possibility of having nonlinear impacts of IC variables on productivity in equations (24) and (26) by including linear terms as well as the square and cubic terms of the IC and C variables that appear in those equations but they were not significant.

[20] Those elasticity and semi-elasticity parameter were also estimated *for small and large* firms as well as for *young and old firms*. The results are reported in Escribano and Guasch (2005).

[21] These results are also observed in all the background papers written for the World Bank investment climate assessment (ICA) of developing countries and are available upon request.

IC blocks (red tape, corruptions and crime, finance, quality, innovation and labour skills, etc.)[22]. For example Table 9 of the Appendix shows that the *shipment losses IC variable* is also significant but changes the sign if we only analyze the IC effects of Infrastructure variables on TFP, without controlling for the other IC blocks of variables. Similar and even more unstable results are obtained with say *the number of criminal attempts* suffered by the firm, see Table 9. Similar unstable results are obtain for Costa Rica in Table 10 where for example we highlight the IC variable *dummy variable indicating the payments to obtain a contract with the government* that becomes insignificant when we only consider IC variables from the block of red tape, corruption and crime, without controlling for the information of the other IC blocks.

3.4 Further evidence on the robustness of the IC effects on TFP

Table 6 in middle of panel B, shows the estimates of the input elasticities for the Ackerberg, Caves, and Frazer (2006), ACF from now on, and for Levinsohn and Petrin (2003), LP from now on. ACF and LP procedures discussed in section 2 are applied here for the case of Costa Rica. We did not apply Olley and Pakes (1996) procedure in this case due to the low quality of the data (many missing values, etc.) on firm-level investment. We apply these procedures only to Costa Rica because the panels of Guatemala, Honduras and Nicaragua are very unbalanced and these procedures require the use the lag of the inputs. For the procedure of ACF we use the Wooldridge (2005) GMM procedure with heteroskedastic standard errors. We use a polynomial of degree 3 to approximate equation (23), i.e., Q = 3, and a polynomial of degree 1 to approximate function *f*(.), i.e. G=1. As expected, in Table 6 panel B, the input-output elasticity of capital obtained by L&P or by ACF are too low, 0.08 and 0.09 respectively. This is not solved by estimating equation (10) by fixed effects (FE), without controlling for IC variables since the estimated elasticity of capital is 0.07. However, remember that when controlling for IC variables a simple OLS with robust standard errors, or a random effects estimators, provide an elasticity of capital equal to 0.12, see Table 6, panel B. A question of interest that we leave for future research is how to extend O&P, L&P and ACF procedures to control for IC variables.

Notice that the previous robustness results of IC elasticities in TFP are also preserved estimating by these more advance procedures, see Table 11. With the estimated input elasticities from O&P, L&P and ACF we estimate firms' productivity (TFP) first and in

[22] This was the reason why different units of the World Bank working with the same data set were obtaining different signs and magnitudes on common IC coefficients.

a second step we evaluated the impact of the investment climate variables on TFP. For comparative purpose, the first column of Table 11 shows the results obtained using Solow residual. As can be seen, the IC results on TFP are still robust. None of the IC variables change signs and the magnitudes of the coefficients are similar.

4 Conclusions

There is no single salient measure of productivity. However, for the evaluation of the investment climate (IC) effects on TFP this is not an important issue, as long as we control for the relevant firm-level IC information. By *productivity* we mean the part of the production of goods (sales) that is not explained by the main inputs (labor, intermediate materials and capital). This productivity concept is usually called total factor productivity (TFP) or multifactor productivity (MFP).

The empirical analysis at the firm-level was undertaken without transforming the variables into rates of growth. There are good reasons explaining this decision: (a) the firm-level IC variables are available for only one year; (b) the panel data for Guatemala, Honduras and Nicaragua is very unbalanced with many more observations in 2002 than in 2001. Hence computing rates of growth for the production function variables implies loosing many observations; and finally (c) measurement errors are enhanced by taking first differences. Therefore, variables in levels are used after applying the logarithmic (logs) transformations of output, labor, intermediate materials and capital.

Apart from the Solow´s residual, L&P, and ACF, TFP is estimated here as the regression residuals of production functions after controlling for the firm-level IC information. We suggest a single-step least squares estimation procedure where the parameters of the production function (input-output elasticities) are jointly estimated with the coefficients of the IC determinants of productivity. To get consistent least squares estimates of the input-output elasticities it is necessary that all inputs (L, M, and K) are uncorrelated with TFP. But this is almost never the case since the investment climate (IC) variables affect the inputs as well as TFP. This property invalidates most two-step least squares procedures where TFP is estimated first and then its investment climate determinants are estimated on the TFP equation.

However, a valid two-step approach is also used when the input-output elasticities are obtained, following Solow (1957), from the cost-shares, since there is no exogeneity requirement on the inputs with this nonparametric procedure. Once TFP is measured as the Solow´s residual in levels, the IC effects on productivity can be consistently estimated in a second step.

We show how to get *robust* estimates (elasticities) of investment climate determinants on TFP independently on the particular TFP measured used. In this context, a minimum set of requirements for making economic policy prescriptions based on IC estimates on TFP is that they are robust among: 1) *different functional forms* of the production functions, 2) *different consistent estimators*, 3) *different productivity (TFP) measures* and 4) *different levels of aggregation* of the *input-output elasticities* (industry, country, pool of countries, etc.). We have showed this is possible; we get all the expected signs on all IC coefficients from 12 different TFP measures. Obviously, the numerical values of those elasticities parameters slightly vary within a small range of values from one TFP measure to the next. We also showed that the kernel densities estimates of TFP obtained based on the Solow´s residuals are similar in shape to the ones obtained with other TFP measures, after demeaned. In fact, the mean and the median of the 12 different IC elasticities on TFP are similar to the IC elasticities on TFP based on Solow´s residual. Therefore, when comparing IC elasticities on TFP across a large set of developing countries, we can concentrate only on the evaluation of the IC effects on the Solow´s residuals[23].

Four important categories of investment climate (IC) variables are identified: (a) Infrastructure, (b) Read Tape, Corruption and Crime, (c) Finance and Corporate Governance and (d) Quality, Innovation and Labor Skills. Within each IC group, all the estimated individual IC coefficients always have the expected signs and the estimated elasticities or semi-elasticities are always within a reasonable value range for the 12 different TFP measures considered. In absolute terms, the higher values of the IC elasticities correspond to the Solow residual or to the Cobb-Douglas specification, while the lowest usually correspond to the Translog production function. Therefore, as expected there is a trade-off between the role played by the inputs (labor, intermediate materials and capital) and the role played by the IC variables and other firm-level control variables. In summary, even if we are only interested in the effects of say infrastructure on TFP, we have showed that for robustness the key issue is to control for the relevant IC information we have on the other IC blocks (red tape, corruptions and crime, finance, quality, innovation and labour skills, etc.).

This robustness across 12 different productivity measures from 42 developing countries allows us to provide reliable country and sector empirical estimates on the IC effects on TFP. Overall, IC variables account for over 30 percent of average productivity in those LAC countries. Therefore, the investment climate matters for TFP and the robust

[23] A different question is how to make cross-country comparisons based on TFP measures without comparing apples and oranges? We are addressing this question now based on alterative demeaned concepts of TFP but it is out of the scope of this paper.

relative size of the impact of the various investment climate variables on TFP indicate where the efforts of reforms (IC bottlenecks) should be placed.

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Appendix: Tables and Figures

Table 1: General information at plant level and production function variables: Guatemala, Honduras and Nicaragua

General Information at Plant Level	Industrial classification	Apparel, beverages, chemical/rubber, food/tobacco, leather/shoes, nonmetallic minerals, textiles, metal products.
	Regional classification	Guatemala: Guatemala city, Metropolitan area close to Guatemala city, Metropolitan area far from Guatemala city, Altiplano region, Coast region, Northwest region. Honduras: Western region, Center-South region, Olancho region, North cost region. Nicaragua: Managua region, Pacific region.
Production Function Variables	Sales	Used as the measure of output for the production function estimation. For all countries, it is converted into USD using IMF average exchange rates.
	Employment	Total number of workers.
	Materials	Total costs of intermediate and raw materials used in production (excluding fuel). For all countries, it is converted into USD using IMF average exchange rates.
	Capital stock	Net book value of all fixed assets.
	Labor cost	Total expenditures on personnel.

Table 2: General information at plant level and production function variables: Costa Rica

General Information at Plant Level	Industrial classification	Food and beverages; textiles; apparels; wood and furniture; paper and edition; chemicals rubber and plastics; non-metallic products; machinery and equipment-metallic products.
	Regional classification	San José; Alajuela; Cartago; Heredia; Guanacaste; Puntarenas; Provincia Limón. Additional classification used in figures: Great Urban, Rest of Central Valley, Rest of the Country.
Production Function Variables	Sales	Used as the measure of output for the production function estimation. Sales are defined as total sales plus the changes in the inventories of finished goods. The series are deflated by using the Industrial Production Price Index, base 1999.
	Employment	Total number of permanent and temporal workers (full or part time).
	Total hours worked per year	Total number of employees multiplied by the average hours worked per year.
	Materials	Total costs of intermediate and raw materials used in production (excluding fuel). The series are deflated by using the Industrial Production Price Index, base 1999.
	Capital stock	Net book value of all fixed assets (log). The series are deflated by using the Industrial Production Price Index, base 1999.
	User cost of capital	The user cost of capital is defined in terms of the opportunity cost of using capital; it is defined as the long term interest rate in Costa Rica (more than 5 years) plus a depreciation rate of 20% minus the rate of growth of the consumption price index.
	Labor cost	Total expenditures on personnel, deflated by using the Industrial Production Price Index, base 1999.

Table 3: Investment climate (IC) variable

Name of the variable	Definition	Country
A. Infrastructure		
Average duration of power outages Hours per day (logs) (AV)	Average duration of power outages suffered by the plant in hours during last fiscal year.	GUA, HON, NIC, CR
Average number of days to clear customs for imports (logs) (AV)	Average number of days needed to clear customs for export during last fiscal year	GUA, HON, NIC
Average no. of days to clear customs for exports (logs) (AV)	Average number of days needed to clear customs for imports during last fiscal year.	CR
Shipment Losses (Fraction of total sales) (AV)	Fraction of the value of the plant’s average cargo consignment that was lost while in transit due to breakage, theft, spoilage or other deficiencies of the transport means used.	GUA, HON, NIC
Dummy for Internet Access (0 or 1)	Dummy variable that takes value 1 if the firm use regularly the internet to communicate with its clients and suppliers.	GUA, HON, NIC
Total number of water outages (logs) (AV)	Total number of water outages suffered by the plant during last fiscal year.	CR
Average days waiting for an electricity supply (logs) (AV)	Number of days waiting for a public electric supply since the moment of the application to the day the service was received (number of days)	CR
B. Red tape, corruption and crime		
Number of days spent in Inspection and Regulation related work Days (logs) (AV)	In the last year, total number of inspections regarding with taxes, employment, health control, municipal inspectors, etc.	GUA, HON, NIC, CR
Fraction of sales declared to IRS for tax purposes (Fraction of total sales) (AV)	Percentage of plant's total sales declared to taxes.	GUA, HON, NIC, CR
Number of criminal attempts suffered (Number) (AV)	Total number of criminal attempts suffered by the plant during the last year.	GUA, HON, NIC
Dummy for payments to obtain a contract with the government (0 or 1) (AV)	Dummy that takes value 1 if firms in the main sector occasionally need to give gifts or make informal payments in order to get a contract with the government.	CR
Percentage of sales never repaid (% of total sales) (AV)	Percentage of monthly total sales to private customers that were never repaid.	CR
Number of days lost due to absenteeism (logs)	Days of production lost due to employeers absenteeism during last year.	CR
C. Finance and corporate governance		
Dummy for external audit of financial statements (0 or 1)	Dummy variable that takes value 1 if firm's annual statements are engaged in a process of external auditory.	GUA, HON, NIC
Dummy for firm belonging to a trade assoc. (0 or 1) (AV)	Dummy variable taking value 1 if the firm belongs to a trade association or trade chamber.	CR
Dummy for credit line (0 or 1)	Dummy variable that takes value 1 if the plant reports that it has a credit line.	CR
Dummy for debts with creditors (0 or 1) (AV)	Dummy variable that takes value 1 if the firm has any debt with suppliers.	CR
Firm's profits after taxes as a percentage of total sales (% of total sales) (AV)	Firm's profits after taxes as a percentage of total sales.	CR
Dummy for firm owning almost all the lands in which the plant operates (0 or 1)	Dummy variable that takes value 1 if the firm is the owner of almost all its lands.	CR

Table 4 (continued): Investment climate (IC) variable

D. Quality, innovation and labor skills		
Fraction computer-controlled machinery of total machinery (Fraction of total machinery)	Fraction computer-controlled machinery of total machinery (Fraction of total machinery)	GUA, HON, NIC, CR
Fraction of total staff engaged in R & D (Fraction of total staff)	Fraction of total staff engaged in R & D (Fraction of total staff)	GUA, HON, NIC
Dummy for ISO quality certif. (0 or 1)	Dummy variable taking value 1 if the firm has any kind of ISO quality certification.	GUA, HON, NIC, CR
Fraction of total staff with secondary education or more (Fraction of total staff)	Fraction of total staff with secondary education or more (Fraction of total staff)	GUA, HON, NIC
Dummy for training provided beyond "on the job" (0 or 1)	Dummy variable taking value 1 if the firm provides 'beyond of the job' training, either internal or external.	GUA, HON, NIC
Dummy for new technological license (0 or 1) (AV)	Dummy variable that takes value 1 if the firm has acquired any new technology with important implications in the production process.	CR
Number of plant's employees dealing with	Number of plant's employees dealing with engineering and design (logs)	CR
Percentage of immigrant workers (% of total staff) (AV)	Percentage of immigrant workers (% of total staff) (AV)	CR
Percentage of unskilled workers receiving training (% of unskilled workers) (AV)	Percentage of unskilled workers receiving training (% of unskilled workers) (AV)	CR
Percentage of staff using computer at job (% of total staff)	Percentage of staff using computer at job (% of total staff)	CR
E. Other control variables		
Dummy for Incorporated Company (0 or 1)	Dummy variable taking value 1 if the firm is constituted as a incorporated company.	GUA, HON, NIC
Age of the firm years (logs)	Age of the firm years (logs)	GUA, HON, NIC
Share of Imported inputs (Fraction of total inputs)	Share of Imported inputs (Fraction of total inputs)	GUA, HON, NIC
Dummy for foreign direct investment (0 or 1)	Dummy variable taking value 1 if any percentage of firm's share belongs to	CR
Number of competitors in plant's main market	Number of competitors in plant's main market (logs) (AV)	CR
Dummy for benefit from free trade agreements	Dummy for benefit from free trade agreements with signed by the	CR
Percentage of capacity utilization (percentage)	Percentage of capacity used by the plant in average during last year.	CR
Dummy for importer firm (0 or 1)	Dummy variable taking value one if the firm imports any share of its	CR

Table 5: Total number of observations used in the IC regressions by country and industry

	Pool			Total Pool	Costa Rica
	Guatemala	Honduras	Nicaragua		
Apparel	129	70	64	**263**	111
Food/ Tobacco	102	134	68	**304**	0
Beverages	8	19	17	**44**	0
Food and beverages	0	0	0	**0**	132
Chemical/Rubber	61	35	67	**163**	148
Furniture/ Wood	56	126	127	**309**	145
Leather/ Shoes	6	0	45	**51**	0
Nonmetallic minerals	36	44	69	**149**	104
Textiles	22	9	7	**38**	0
Metal Products	48	35	57	**140**	64
Paper & edition	0	0	0	**0**	128
Machinery & Equipment	0	0	0	**0**	162
Total	**468**	**472**	**521**	**1461**	**994**

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.

Table 6: Total number of observations used in the IC regressions by year and industry

A. Guatemala, Honduras and Nicaragua

	2001	2002	Total
Apparel	71	191	262
Food/ Tobacco	12	32	44
Beverages	52	111	163
Chemical/Rubber	103	201	304
Furniture/ Wood	90	219	309
Leather/ Shoes	15	36	51
Nonmetallic minerals	44	105	149
Textiles	8	30	38
Metal Products	45	95	140
Total	440	1020	1460

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.

B. Costa Rica

	2002	2003	2004	Total
Food & beverages	43	44	45	**132**
Textiles	21	21	22	**64**
Apparels	35	38	38	**111**
Wood & furniture	47	48	50	**145**
Paper & edition	42	43	43	**128**
Chemicals, rubber & plastics	49	49	50	**148**
Non-metallic products	34	34	36	**104**
Machinery & Equipment-Metallic products	52	54	56	**162**
Total	**323**	**331**	**340**	**994**

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.

Table 6: Production Function Parameters from the Restricted Estimation

A. Guatemala, Honduras and Nicaragua

	Labor (L)	**Materials (M)**	**Capital (K)**	**L2**	**M2**	**K2**	**L*M**	**L*K**	**M*K**
Cost-shares	0.36	0.53	0.11						
Cobb-Douglas controlling for IC variables									
Pool OLS	0.43***	0.52***	0.07***	-	-	-	-	-	-
RE	0.48***	0.45***	0.07***	-	-	-	-	-	-
Test for CRS		OLS	Prob > F = 0.316		RE	Prob > chi2 = 0.636			
Translog controlling for IC variables									
Pool OLS	1.21**	0.05	-0.09	0.06**	0.04***	0.02***	-0.10***	-0.01	-0.02
RE	1.18***	0.07	-0.19**	-0.04***	0.03***	0.02***	-0.07***	-0.02	-0.00
Test for CRS		OLS	Prob > F = 0.619		RE	Prob > F = 0.543			
Test for Cobb-Douglas		OLS	Prob > chi2 = 0.012		RE	Prob > chi2 = 0.000			

B. Costa Rica

	Labor (L)	**Materials (M)**	**Capital (K)**	**L2**	**M2**	**K2**	**L*M**	**L*K**	**M*K**
Cost-shares	0.33	0.56	0.11						
Cobb-Douglas									
Controlling for IC variables:									
Pool OLS	0.31***	0.53***	0.12***	-	-	-	-	-	-
RE	0.29***	0.47***	0.12***	-	-	-	-	-	-
Test for CRS		OLS	Prob > F = 0.0649		RE	Prob > chi2 = 0.0001			
Other estimation methods without controlling for IC variables:									
FE[(a)]	0.10***	0.33***	0.07***	-	-	-	-	-	-
A.C.F.[(b)]	0.29***	0.67***	0.09***	-	-	-	-	-	-
LP[(c)]	0.26***	0.32***	0.08***						
Translog controlling for IC variables									
Pool OLS	0.45**	0.92***	-0.30***	-0.02	0.06***	0.02***	-0.06**	0.09***	-0.09***
RE	0.37	0.70***	-0.23	-0.02	0.05***	0.02**	-0.05	0.07**	-0.08***
Test for CRS		OLS	Prob > F = 0.0001		RE	Prob > F = 0.0001			
Test for Cobb-Douglas		OLS	Prob > chi2 = 0.000		RE	Prob > chi2 = 0.0000			

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.
NOTES:
(a) Fixed effect estimation.
(b) Ackerberg, Caves and Frazer's (2007) procedure using the GMM estimation method of Wooldridge (2005) without IC variables.
(c) Levinsohn and Petrin's (2003) estimation procedure.

(1) Significance is given by robust standard errors.* significant at 10%; ** significant at 5%; *** significant at 1%.
(2) The cost shares of labor, materials and capital are calculated as average (excluding outliers) of the plant-level cost shares of labor, materials and capital across all plants in years 2001 and 2002 (Guatemala, Honduras, and Nicaragua) and 2002, 2003 and 2004 (Costa Rica).
(3) The sample generating the sets of production function coefficients is constituted by all plants (excluding outliers) in years 2001 and 2002 (Guatemala, Honduras, and Nicaragua) and 2002, 2003, and 2004 (Costa Rica).

Table 7: Estimation of IC elasticities and semi-elasticities on productivity controlling for observable fixed effects: Guatemala, Honduras, and Nicaragua

Block of IC variables	Explanatory IC variables	Restricted estimation						Unrestricted by industry estimation					
		Two steps		Single step				Two steps		Single step			
		Solow residual		Cobb-Douglas		Translog		Solow residual		Cobb-Douglas		Translog	
		OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E
Infrastructures	Average duration of power outages Hours per day (logs) (AV)	-0.078*	-0.066	-0.079*	-0.087	-0.073*	-0.07	-0.082*	-0.071	-0.055	-0.059	-0.026	-0.03
	Average number of days to clear customs for imports (logs) (AV)	-0.101***	-0.099***	-0.103***	-0.093**	-0.114***	-0.111***	-0.098***	-0.096**	-0.100**	-0.095**	-0.096***	-0.096**
	Shipment Losses (Fraction of total sales) (AV)	-1.588**	-1.15	-1.766**	-0.981	-1.289*	-0.565	-1.553*	-1.107	-2.078**	-1.513	-1.934**	-1.296
	Dummy for Internet Access (0 or 1)	0.145***	0.136***	0.147***	0.187***	0.121***	0.163***	0.153***	0.144***	0.130***	0.178***	0.112***	0.144***
Red tape, corruption and crime	Number of days spent in Inspection and Regulation related work Days (logs) (AV)	-0.131***	-0.133***	-0.135***	-0.139***	-0.099***	-0.114***	-0.131***	-0.132***	-0.123***	-0.137***	-0.078**	-0.091**
	Fraction of sales declared to IRS for tax purposes (Fraction of total sales) (AV)	-0.302	-0.305	-0.268	-0.404	-0.324	-0.486*	-0.249	-0.246	-0.38	-0.404	-0.417*	-0.417
	Number of criminal attempts suffered (Number) (AV)	-0.026**	-0.027**	-0.024**	-0.025*	-0.01	-0.012	-0.024**	-0.026**	-0.024**	-0.02	-0.001	-0.005
Finance and corp. gov.	Dummy for external audit of financial statements (0 or 1)	0.177***	0.168***	0.164***	0.193***	0.126***	0.145***	0.176***	0.168***	0.153***	0.181***	0.086**	0.099**
Quality, innovation and labor skills	Fraction computer-controlled machinery of total machinery (Fraction of total machinery)	0.136*	0.169*	0.147*	0.220**	0.145*	0.179*	0.139*	0.172*	0.154*	0.223**	0.138*	0.168*
	Fraction of total staff engaged in R & D (Fraction of total staff)	0.534*	0.473*	0.620**	0.591*	0.545**	0.603**	0.537*	0.479*	0.551**	0.506	0.468*	0.484*
	Dummy for ISO quality certif. (0 or 1)	0.136	0.166*	0.158	0.196*	0.016	0.053	0.149	0.176*	0.17	0.192*	0.068	0.054
	Fraction of total staff with secondary education or more (Fraction of total staff)	0.05	0.085	0.068	0.129*	0.053	0.117*	0.054	0.088	0.069	0.134*	0.076	0.142**
	Dummy for training provided beyond "on the job" (0 or 1)	0.117***	0.116***	0.105***	0.136***	0.087***	0.112***	0.119***	0.117***	0.109***	0.133***	0.102***	0.118***
Other control variables	Dummy for Incorporated Company (0 or 1)	0.121***	0.124***	0.112***	0.142***	0.093**	0.120***	0.124***	0.127***	0.103***	0.119**	0.100***	0.109**
	Age of the firm years (logs)	0.038**	0.040*	0.035*	0.044*	0.035**	0.041*	0.037*	0.039*	0.030*	0.033	0.030*	0.037*
	Share of Imported inputs (Fraction of total inputs)	0.105**	0.108**	0.093*	0.129**	0.086*	0.116**	0.108**	0.110**	0.068	0.099*	0.067	0.076
	Observations	1461	1461	1461	1461	1461	1461	1461	1461	1461	1461	1461	1461
	R-squared	0.25	0.25	0.92	0.92	0.93	0.93	0.19	0.19	0.92	0.92	0.94	0.94

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.
NOTES: (AV) means that the variable enters the regression in form of industry-region average. Significance is given by robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%. The regressions include a constant, industry dummies and year dummies.

Table 8: Estimation of IC elasticities and semi-elasticities on productivity controlling for observable fixed effects: Costa Rica

Block of IC variables	**Explanatory ICA variables**	**Restricted**						**Unrestricted by industry**					
		Two steps estimation		**Single step estimation**				**Two steps estimation**		**Single step estimation**			
		Solow residual		**Cobb-Douglas**		**Translog**		**Solow residual**		**Cobb-Douglas**		**Translog**	
		OLS	**R.E**	**OLS**	**R.E**	**OLS**	**R.E**	**OLS**	**R.E**	**OLS**	**R.E**	**OLS**	**R.E**
Infrastructures	Average no. of days to clear customs for exports (logs) (AV)	-0.077**	-0.083	-0.076**	-0.066	-0.072**	-0.059	-0.089**	-0.095*	-0.076*	-0.072	-0.044	-0.048
	Average duration of power outages. Hrs. per day (logs) (AV)	-0.027***	-0.026	-0.029***	-0.032*	-0.017**	-0.019	-0.027***	-0.026	-0.030***	-0.031*	-0.022**	-0.033*
	Total number of water outages (logs) (AV)	-0.233***	-0.244*	-0.217***	-0.181	-0.121**	-0.113	-0.237**	-0.247	-0.207***	-0.181	-0.220***	-0.204**
	Average days waiting for an electricity supply (logs) (AV)	-0.130***	-0.135***	-0.128***	-0.134***	-0.089***	-0.094**	-0.118***	-0.124***	-0.106***	-0.120**	-0.054*	-0.055
Red tape, corruption and crime	Percentage of sales declared to IRS for tax purposes (% of total sales) (AV)	0.011***	0.011**	0.010***	0.008**	0.005***	0.004*	0.010***	0.010**	0.010***	0.009***	0.006***	0.005**
	Number of days spent in Inspection and Regulation related work Days (logs)	-0.337***	-0.340***	-0.326***	-0.301***	-0.198***	-0.195**	-0.346***	-0.346***	-0.326***	-0.346***	-0.281***	-0.311***
	Dummy for payments to obtain a contract with the government (0 or 1) (AV)	0.393***	0.427*	0.394***	0.447*	0.177*	0.222	0.419***	0.455*	0.240*	0.292	-0.118	0.041
	Percentage of sales never repaid (% of total sales) (AV)	-0.015***	-0.015**	-0.016***	-0.019***	-0.007*	-0.011*	-0.016***	-0.016*	-0.014***	-0.018***	-0.002	-0.004
	Number of days lost due to absenteeism (logs)	-0.042**	-0.037	-0.042**	-0.038	-0.034**	-0.032	-0.046***	-0.04	-0.023	-0.021	-0.021	-0.027
Finance and corporate governance	Dummy for firm belonging to a trade assoc. (0 or 1) (AV)	0.446***	0.468***	0.447***	0.455***	0.412***	0.373**	0.403***	0.418**	0.568***	0.560***	0.480***	0.409**
	Dummy for credit line (0 or 1)	0.052	0.047	0.070*	0.098	0.038	0.063	0.054	0.05	0.039	0.024	0.035	0.029
	Dummy for debts with creditors (0 or 1) (AV)	0.317*	0.377	0.276	0.294	0.032	0.119	0.276	0.338	0.330*	0.412	0.142	0.058
	Firm's profits after taxes as a percentage of total sales (% of total sales) (AV)	0.019***	0.019**	0.018***	0.016*	0.009**	0.007	0.018***	0.018*	0.014***	0.013*	0.008	0.01
	Dummy for firm owning almost all the lands in which the plant operates (0 or 1)	-0.164***	-0.156**	-0.158***	-0.131*	-0.146***	-0.121**	-0.155***	-0.146**	-0.158***	-0.129**	-0.165***	-0.137**
Quality, innovation and labor skills	Dummy for ISO certification (0 or 1)	0.268***	0.267***	0.301***	0.390***	0.286***	0.310***	0.283***	0.277***	0.180***	0.217*	0.192***	0.237**
	Dummy for new technological license (0 or 1) (AV)	0.169	0.138	0.196*	0.254	0.111	0.156	0.211*	0.178	0.117	0.2	0.214*	0.380**
	Percentage computer-controlled machinery of total machinery (% of total machinery)	0.002***	0.002*	0.003***	0.004**	0.002***	0.003**	0.002**	0.002	0.002***	0.003**	0.001*	0.003**
	Number of plant's employees dealing with engineering and design (logs) (AV)	0.029***	0.029*	0.031***	0.035*	0.017	0.022	0.032***	0.032*	0.017	0.023	0.001	0.018
	Percentage of immigrant workers (% of total staff) (AV)	-0.133*	-0.125	-0.133*	-0.135	-0.069	-0.085	-0.172**	-0.163	-0.023	-0.002	-0.065	-0.105
	Percentage of unskilled workers receiving training (% of unskilled workers) (AV)	0.004	0.003	0.004	0.002	0.007**	0.005	0.004	0.003	0.007**	0.004	0.012***	0.009*
	Percentage of staff using computer at job (% of total staff)	0.002*	0.002	0.002*	0.002	0.002**	0.002	0.001	0.001	0.002**	0.002	0.003***	0.001
Other control variables	Dummy for foreign direct investment (0 or 1)	0.138*	0.141	0.156*	0.198*	0.109	0.129	0.143*	0.146	0.183**	0.263**	0.07	0.118
	Number of competitors in plant's main market (logs) (AV)	0.126***	0.117**	0.125***	0.112**	0.120***	0.109**	0.137***	0.126**	0.107***	0.088*	0.100***	0.141***
	Dummy for benefit from free trade agreements with signed by the government (0 or 1)	0.083*	0.085	0.109**	0.188**	0.083	0.143*	0.056	0.059	0.095*	0.183**	0.116**	0.152*
	Percentage of capacity utilization (percentage)	0.003***	0.003**	0.003***	0.004***	0.004***	0.004***	0.003***	0.003**	0.003***	0.004***	0.003***	0.004**
	Dummy for importer firm (0 or 1)	0.180***	0.176***	0.220***	0.315***	0.212***	0.276***	0.187***	0.184***	0.191***	0.270***	0.186***	0.234***
	Observations	985	985	985	985	985	985	985	985	985	985	985	985
	R2	0.29	0.29	0.94	0.94	0.95	0.95	0.27	0.27	0.95	0.95	0.96	0.96

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.

NOTES: (AV) means that the variable enters the regression in form of industry-region average. Significance is given by robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%. The regressions include a constant, industry dummies and year dummies.

Table 9: IC elasticities and semi-elasticities with respect to productivity WITHOUT controlling for other IC variables: Guatemala, Honduras, and Nicaragua

Blocas of IC variables	Explanatory IC variables	Restricted estimation						Unrestricted by industry estimation					
		Two steps		Single step				Two steps		Single step			
		Solow residual		Cobb-Douglas		Translog		Solow residual		Cobb-Douglas		Translog	
		OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E
Infrastructures	Average duration of power outages Hours per day (logs) (AV)	-0.084**	-0.076	-0.042	-0.071	-0.053	-0.069	-0.087**	-0.079*	-0.027	-0.047	-0.043	-0.054
	Average number of days to clear customs for imports (logs) (AV)	-0.016	-0.015	-0.037	-0.011	-0.044	-0.027	-0.012	-0.011	-0.042	-0.021	-0.028	-0.018
	Shipment Losses (Fraction of total sales) (AV)	1.759**	2.310*	1.450*	2.377*	1.682**	2.602**	1.736**	2.280*	1.357	2.033	0.983	1.782
	Dummy for Internet Access (0 or 1)	0.311***	0.302***	0.217***	0.279***	0.181***	0.232***	0.321***	0.311***	0.202***	0.265***	0.173***	0.206***
Red tape, corruption and crime	Number of days spent in Inspection and Regulation related work Days (logs) (AV)	-0.100***	-0.100***	-0.087***	-0.097***	-0.054**	-0.075**	-0.097***	-0.098***	-0.083***	-0.096***	-0.044*	-0.058*
	Fraction of sales declared to IRS for tax purposes (Fraction of total sales) (AV)	-0.759***	-0.765***	-0.441**	-0.645***	-0.505***	-0.695***	-0.725***	-0.727***	-0.540***	-0.668***	-0.621***	-0.690***
	Number of criminal attempts suffered (Number) (AV)	-0.0004	-0.001	-0.013	-0.008	0.001	0.003	0.002	0.0004	-0.012	-0.007	0.009	0.007
Fin. and Corp. Gov.	Dummy for external audit of financial statements (0 or 1)	0.287***	0.281***	0.182***	0.222***	0.128***	0.158***	0.291***	0.285***	0.180***	0.216***	0.103***	0.118***
Quality, innovation and labor skills	Fraction computer-controlled machinery of total machinery (Fraction of total machinery)	0.184**	0.242**	0.116	0.220**	0.122	0.174*	0.190**	0.250**	0.140*	0.234**	0.142*	0.187*
	Fraction of total staff engaged in R & D (Fraction of total staff)	0.421	0.356	0.774***	0.805***	0.606**	0.742***	0.429	0.364	0.696***	0.722**	0.605***	0.682**
	Dummy for ISO quality certification (0 or 1)	0.288***	0.317***	0.196**	0.269***	0.052	0.104	0.302***	0.327***	0.216**	0.268***	0.12	0.118
	Fraction of total staff with secondary education or more (Fraction of total staff)	0.167***	0.192***	0.175***	0.247***	0.141**	0.215***	0.173***	0.197***	0.164***	0.238***	0.149**	0.221***
	Dummy for training provided beyond "on the job" (0 or 1)	0.218***	0.214***	0.125***	0.169***	0.105***	0.135***	0.224***	0.219***	0.128***	0.161***	0.127***	0.146***
	Dummy for Incorporated Company (0 or 1)	0.254***	0.251***	0.132***	0.180***	0.108***	0.146***	0.262***	0.258***	0.128***	0.160***	0.114***	0.130***
Other control variables	Age of the firm years (logs)	0.031*	0.029	0.021	0.021	0.022	0.023	0.031	0.028	0.021	0.019	0.029*	0.033
	Share of Imported inputs (Fraction of total inputs)	0.280***	0.287***	0.149***	0.205***	0.119***	0.166***	0.288***	0.294***	0.135***	0.189***	0.106**	0.134***

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.
NOTES: (AV) means that the variable enters the regression in form of industry-region average. LIGHT GREY means that the variable changes in significance and magnitude with respect to the full estimation of Table 2. DARK GREY implies that it changes also the direction of the effect. Significance is given by robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%. The regressions include a constant, industry dummies and year dummies.

Table 10: IC elasticities and semi-elasticities with respect to productivity WITHOUT controlling for other IC variables: Costa Rica

Blocas of IC variables	Explanatory IC variables	Restricted estimation						Unrestricted by industry estimation					
		Two steps		Single step				Two steps		Single step			
		Solow residual		Cobb-Douglas		Translog		Solow residual		Cobb-Douglas		Translog	
		OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E	OLS	R.E
Infrastruc-tures	Average number of days to clear customs for exports (logs) (AV)	-0.06	-0.066	-0.073**	-0.071	-0.058*	-0.06	-0.080**	-0.085	-0.062	-0.074	-0.031	-0.052
	Average duration of power outages Hours per day (logs) (AV)	-0.013**	-0.012	-0.011	-0.013	-0.009	-0.013	-0.014**	-0.013	-0.018***	-0.020**	-0.014**	-0.020**
	Total number of water outages (logs) (AV)	-0.144**	-0.156	-0.131**	-0.146	-0.077**	-0.095	-0.156**	-0.167	-0.102*	-0.118	-0.068	-0.087
	Average days waiting for an electricity supply (logs) (AV)	-0.109***	-0.112**	-0.108***	-0.117**	-0.096***	-0.104**	-0.101***	-0.103**	-0.084***	-0.097**	-0.077**	-0.073*
Red tape, corruption and crime	Percentage of sales declared to IRS for tax purposes (% of total sales) (AV)	0.004**	0.004	0.004**	0.003	0.001	0.001	0.004**	0.004	0.004**	0.003	0.001	0.002
	Number of days spent in Inspection and Regulation related work Days (logs)	-0.018	-0.018	-0.070*	-0.014	-0.031	-0.005	-0.027	-0.026	-0.075*	-0.054	-0.084**	-0.086
	Dummy for payments to obtain a contract with the government (0 or 1) (AV)	0.156	0.18	0.143	0.185	0.02	0.05	0.185	0.21	0.053	0.134	-0.142	-0.044
	Percentage of sales never repaid (percentage of total sales) (AV)	-0.015***	-0.015**	-0.012**	-0.018**	-0.006	-0.012*	-0.016***	-0.016**	-0.011**	-0.015**	0.002	-0.002
	Number of days lost due to absenteeism (logs)	-0.026*	-0.022	-0.024	-0.021	-0.014	-0.015	-0.032**	-0.027	-0.007	-0.009	-0.005	-0.014
Finance and corporate governance	Dummy for firm belonging to a trade association (0 or 1) (AV)	0.351***	0.366**	0.252***	0.425**	0.265***	0.307*	0.321***	0.331*	0.251**	0.369**	0.14	0.168
	Dummy for credit line (0 or 1)	0.125***	0.117*	0.083**	0.145**	0.051	0.093	0.126***	0.118*	0.039	0.049	0.055	0.062
	Dummy for debts with creditors (0 or 1) (AV)	0.16	0.196	0.126	0.149	0.037	0.116	0.143	0.182	0.089	0.096	-0.015	-0.029
	Firm's profits after taxes as a percentage of total sales (% of total sales) (AV)	-0.006**	-0.005	-0.003	-0.006	-0.004	-0.008*	-0.007**	-0.007	-0.005	-0.008*	-0.004	-0.007
	Dummy for firm owning almost all the lands in which the plant operates (0 or 1)	-0.135***	-0.132**	-0.182***	-0.152**	-0.170***	-0.144**	-0.120***	-0.117*	-0.176***	-0.147**	-0.190***	-0.154**
Quality, innovation and labor skills	Dummy for ISO certification (0 or 1)	0.549***	0.545***	0.502***	0.707***	0.427***	0.513***	0.549***	0.542***	0.394***	0.518***	0.387***	0.423***
	Dummy for new technological license (0 or 1) (AV)	0.198**	0.184	0.039	0.218	-0.004 (a)	0.109	0.207**	0.195	-0.039 (a)	0.147	-0.079	0.069
	Percentage computer-controlled machinery of total machinery (% of total machinery)	0.005***	0.005***	0.004***	0.006***	0.004***	0.005***	0.005***	0.005***	0.004***	0.006***	0.003***	0.004***
	Number of plant's employees dealing with engineering and design (logs) (AV)	0.036***	0.036*	0.028**	0.041*	0.020**	0.029	0.038***	0.038*	0.017	0.03	0.003	0.012
	Percentage of immigrant workers (perc. of total staff) (AV)	-0.256***	-0.258**	-0.245***	-0.244**	-0.166***	-0.188*	-0.283***	-0.283**	-0.124*	-0.109	-0.109	-0.137
	Percentage of unskilled workers receiving training (perc. of unskilled workers) (AV)	-0.001 (a)	-0.002 (a)	-0.001 (a)	-0.003 (a)	0.002	0.001	-0.002 (a)	-0.002 (a)	0.001	-0.001 (a)	0.004**	0.003
	Percentage of staff using computer at job (perc. of total staff)	0.006***	0.006***	0.005***	0.006***	0.004***	0.005***	0.005***	0.005***	0.005***	0.006***	0.004***	0.004***
Other control variables	Dummy for foreign direct investment (0 or 1)	0.395***	0.387***	0.312***	0.464***	0.225***	0.297***	0.393***	0.384***	0.297***	0.467***	0.196***	0.279**
	Total number of competitors in plant's main market (logs) (AV)	0.021	0.018	0.027	0.009	0.044	0.034	0.023	0.019	0.032	-0.001	0.019	0.022
	Dummy for benefit from free trade agreements with signed by the government (0 or 1)	0.268***	0.264***	0.197***	0.337***	0.144**	0.228***	0.246***	0.242***	0.141**	0.276***	0.184***	0.239***
	Percentage of capacity utilization (percentage)	0.003***	0.003**	0.003***	0.004**	0.004***	0.004***	0.003***	0.003**	0.003***	0.004***	0.003***	0.003**
	Dummy for importer firm (0 or 1)	0.308***	0.303***	0.277***	0.445***	0.246***	0.344***	0.310***	0.304***	0.248***	0.380***	0.259***	0.317***

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.

NOTES: (AV) means that the variable enters the regression in form of industry-region average. Significance is given by robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%. The regressions include a constant, industry dummies and year dummies. LIGHT GREY means that the variable changes in significance and magnitude with respect to the full estimation of Table 2. DARK GREY implies that it changes also the direction of the effect. (a) The variable changes the direction of the effect, although statistically insignificant.

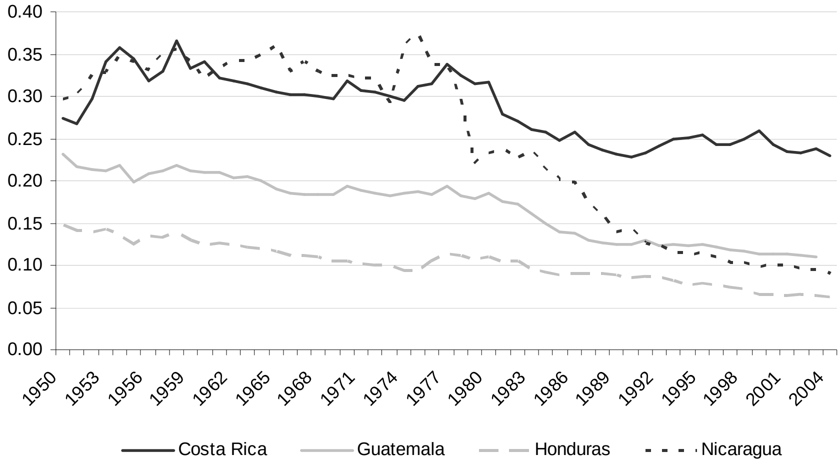
Table 11: Further Evidence on the robustness of IC elasticities and semi-elasticities on TFP: Costa Rica

Blocks of IC variables	Explanatory IC variables	Restricted Solow Residual; Cost-Shares	Levinsohn and Petrin	A.C.F (2007) (5)
Infrastructures	Average number of days to clear customs for exports (logs) (AV)	-0.077**	-0.009	-0.082*
	Average duration of power outages Hours per day (logs) (AV)	-0.027***	-0.044***	-0.023*
	Total number of water outages (logs) (AV)	-0.233***	-0.064	-0.301**
	Average days waiting for an electricity supply (logs) (AV)	-0.130***	-0.137***	-0.121***
Red tape, corruption and crime	Percentage of sales declared to IRS for tax purposes (Percentage of total sales) (AV)	0.011***	0.004	0.012***
	Number of days spent in Inspection and Regulation related work Days (logs)	-0.337***	-0.235***	-0.359***
	Dummy for payments to obtain a contract with the government (0 or 1) (AV)	0.393***	0.492***	0.342*
	Percentage of sales never repaid (percentage of total sales) (AV)	-0.015***	-0.026***	-0.011**
	Number of days lost due to absenteeism (logs)	-0.042**	-0.045**	-0.042*
Finance and corporate governance	Dummy for firm belonging to a trade association (0 or 1) (AV)	0.446***	0.403***	0.440***
	Dummy for credit line (0 or 1)	0.052	0.177***	0.024
	Dummy for debts with creditors (0 or 1) (AV)	0.317*	0.228	0.398
	Firm's profits after taxes as a percentage of total sales (perc. of total sales) (AV)	0.019***	0.012**	0.019**
	Dummy for firm owning almost all the lands in which the plant operates (0 or 1)	-0.164***	-0.063	-0.157***
Quality, innovation and labor skills	Dummy for ISO certification (0 or 1)	0.268***	0.611***	0.188**
	Dummy for new technological license (0 or 1) (AV)	0.169	0.536***	0.089
	Percentage computer-controlled machinery of total machinery (perc. of total machinery)	0.002***	0.007***	0.002*
	Number of plant's employees dealing with engineering and design (logs) (AV)	0.029***	0.044***	0.025*
	Percentage of immigrant workers (perc. of total staff) (AV)	-0.133*	-0.155	-0.149
	Percentage of unskilled workers receiving training (perc. of unskilled workers) (AV)	0.004	-0.002	0.007*
	Percentage of staff using computer at job (perc. of total staff)	0.002*	0.002	0.001
Other control variables	Dummy for foreign direct investment (0 or 1)	0.138*	0.342***	0.121
	Total number of competitors in plant's main market (logs) (AV)	0.126***	0.107**	0.135***
	Dummy for benefit from free trade agreements with signed by the government (0 or 1)	0.083*	0.411***	0.033
	Percentage of capacity utilization (percentage)	0.003***	0.004***	0.002*
	Dummy for importer firm (0 or 1)	0.180***	0.569***	0.093*
	Observations	985	985	985
	R^2	0.29	0.58	0.20

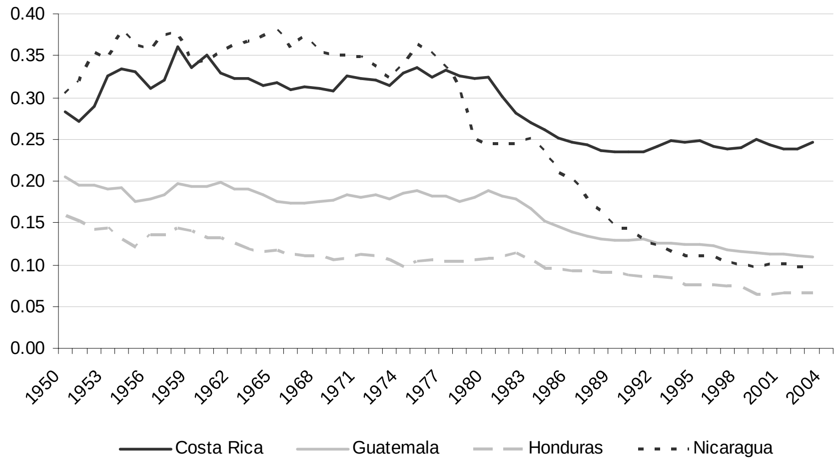
Source: Authors' elaboration with Investment Climate Surveys (ICs) data.
NOTES:
(1) (AV) means that the variable enters the regression in form of industry-region average.
(2) Significance is given by robust standard errors. * significant at 10%; ** significant at 5%; *** significant at 1%.
(3) Two steps estimation, inputs elasticities restricted by industry.
(4) The regressions include a constant, industry dummies and year dummies.
(5) Ackerberg, Caves and Frazer's (2007) GMM estimation method of Wooldridge (2005) without IC variables.

Figure 1: Decomposition of per capita income from 1950 to 2004: Guatemala, Honduras, Nicaragua, and Costa Rica. Evolution relative to the US

(a) Real Gross Domestic Product per capita (Relative to US)



(b) Real Gross Domestic Product per worker (Relative to US)



(c) Labor force participation (Relative to US)

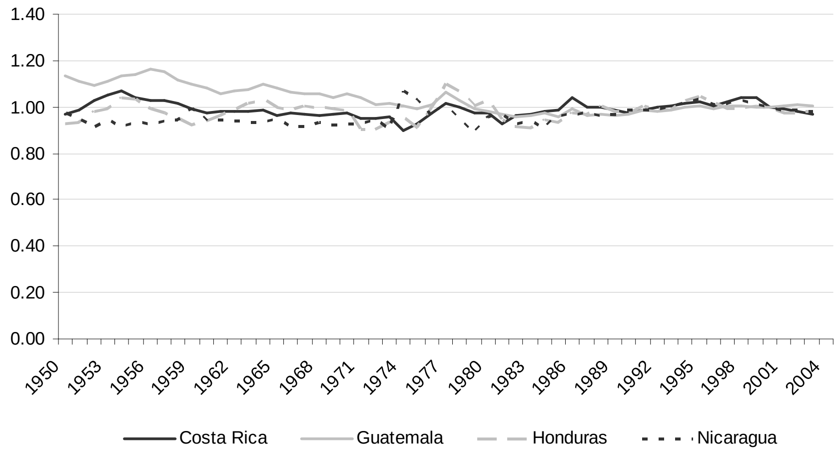
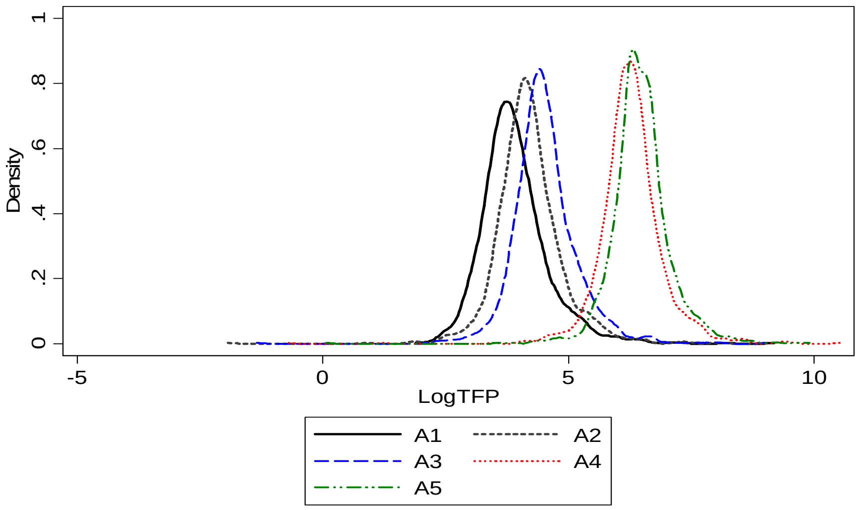
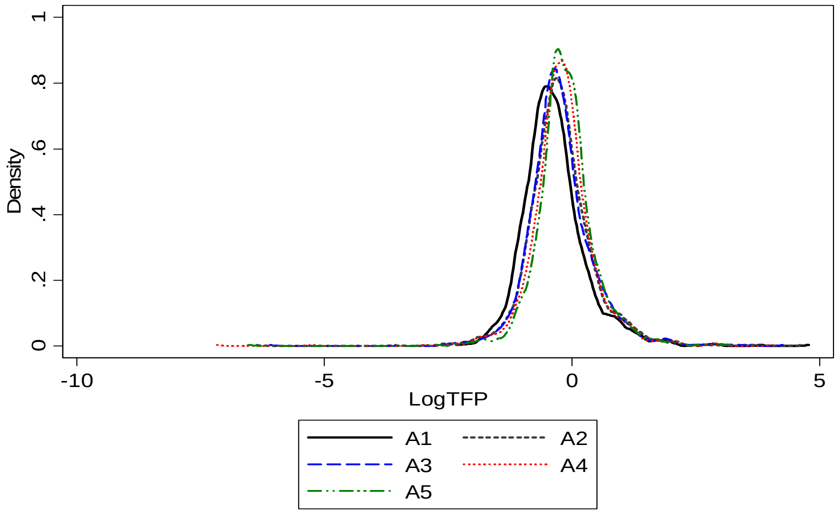


Figure 2. Kernel density estimates of alternative TFP measures: Guatemala, Honduras and Nicaragua

I. A constant term is included in each TFP measure



II. Subtracting the constant term from each TFP measure (demeaned TFP)



A1: Restricted Solow residual

A2: Single step, Cobb-Douglas, restricted (OLS)

A3: Single step, Cobb-Douglas, unrestricted (OLS)

A4: Single step, Translog, restricted (OLS)

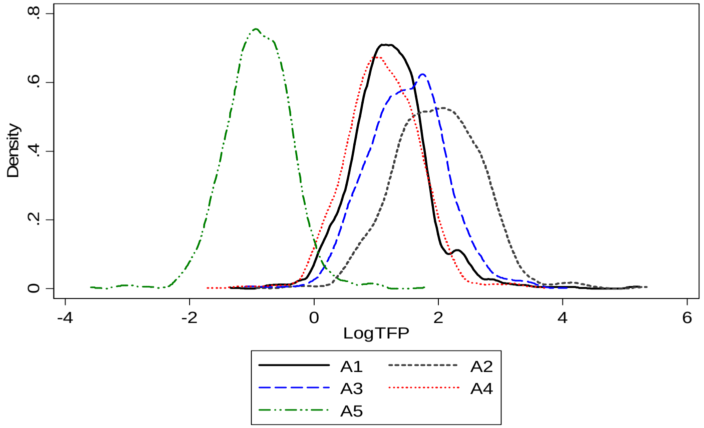
A5: Single step, Translog, unrestricted (OLS)

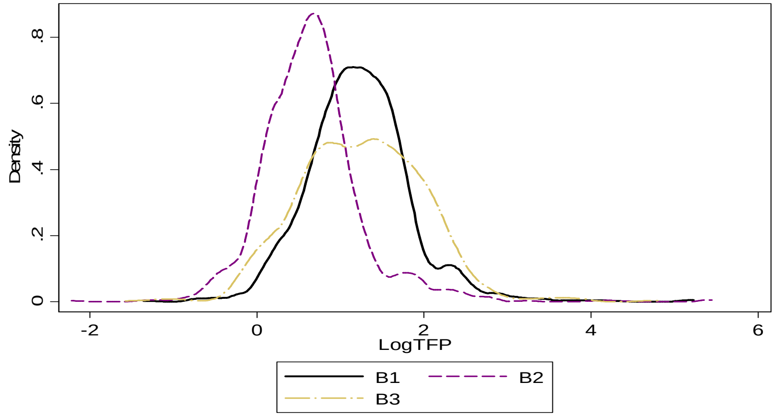
Note: Epanechnikov kernel.

Source: Authors' elaboration with Investment Climate Surveys (ICS) data.

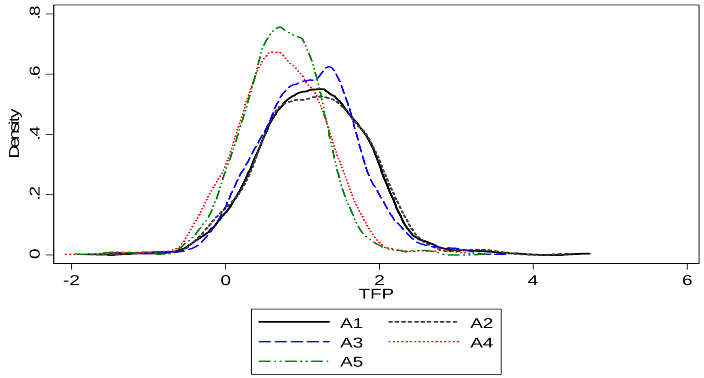
Figure 3: Kernel density of alternative productivity measures: Costa Rica

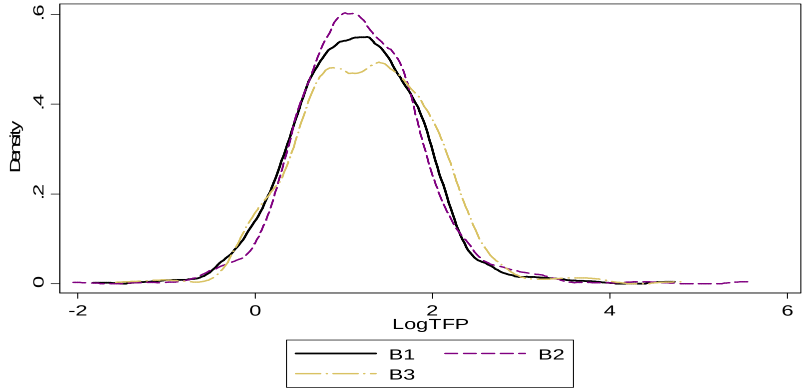
I. A constant term is included in each TFP measure





II. Subtracting the constant term from each TFP measure (demeaned TFP)

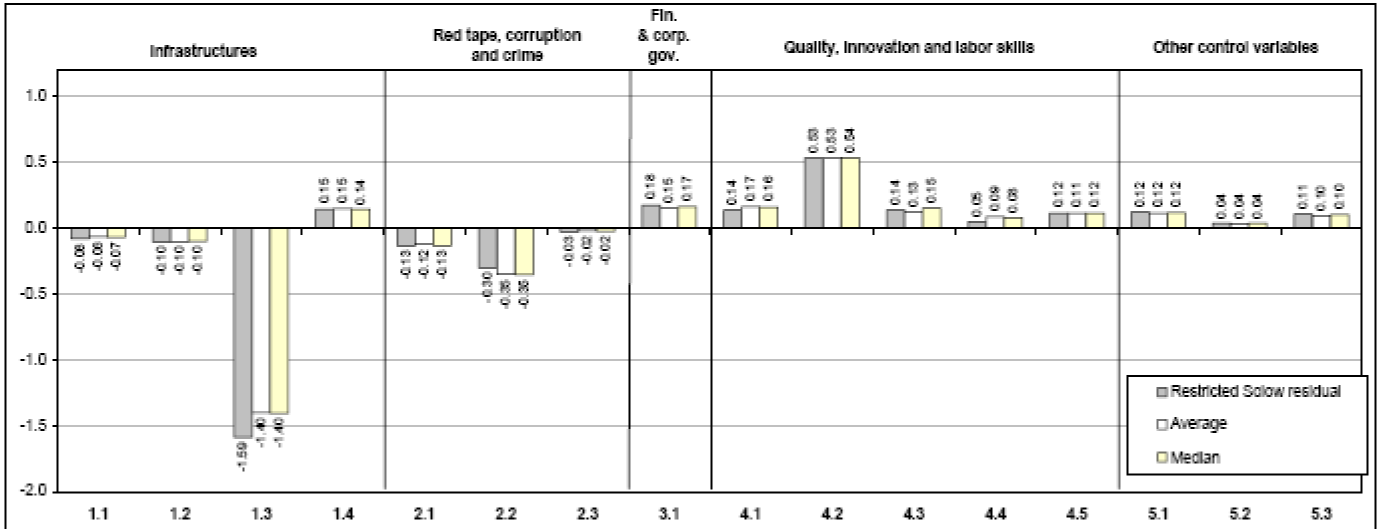




A1: Restricted Solow residual
A2: Single step, Cobb-Douglas, restricted (OLS)
A3: Single step, Cobb-Douglas, unrestricted (OLS)
A4: Single step, Translog, restricted (OLS)
A5: Single step, Translog, unrestricted (OLS)
Note: Epanechnikov kernel.
Source: Authors' elaboration with Investment Climate Surveys (ICS) data.

B1: Restricted Solow residual;
B2: Ackerberg, Caves and Fraser (GMM procedure)
B3: Levinsohn and Petrin

Figure 2: IC elasticities and semi-elasticities on productivity (TFP): Guatemala, Honduras and Nicaragua



1. Infrastructures
1.1 Average duration of power outages Hours per day (logs)
1.2 Average number of days to clear customs for imports (logs)
1.3 Shipment Losses (Fraction of total sales)
1.4 Dummy for Internet Access (0 or 1)

2. Red tape, corruption and crime
2.1 Number of days spent in Inspection and Regulation related work Days (logs)
2.2 Fraction of sales declared to IRS for tax purposes (Fraction of total sales)
2.3 Number of criminal attempts suffered (Number)

3. Finance and corporate governance
3.1 Dummy for external audit of financial statements (0 or 1)

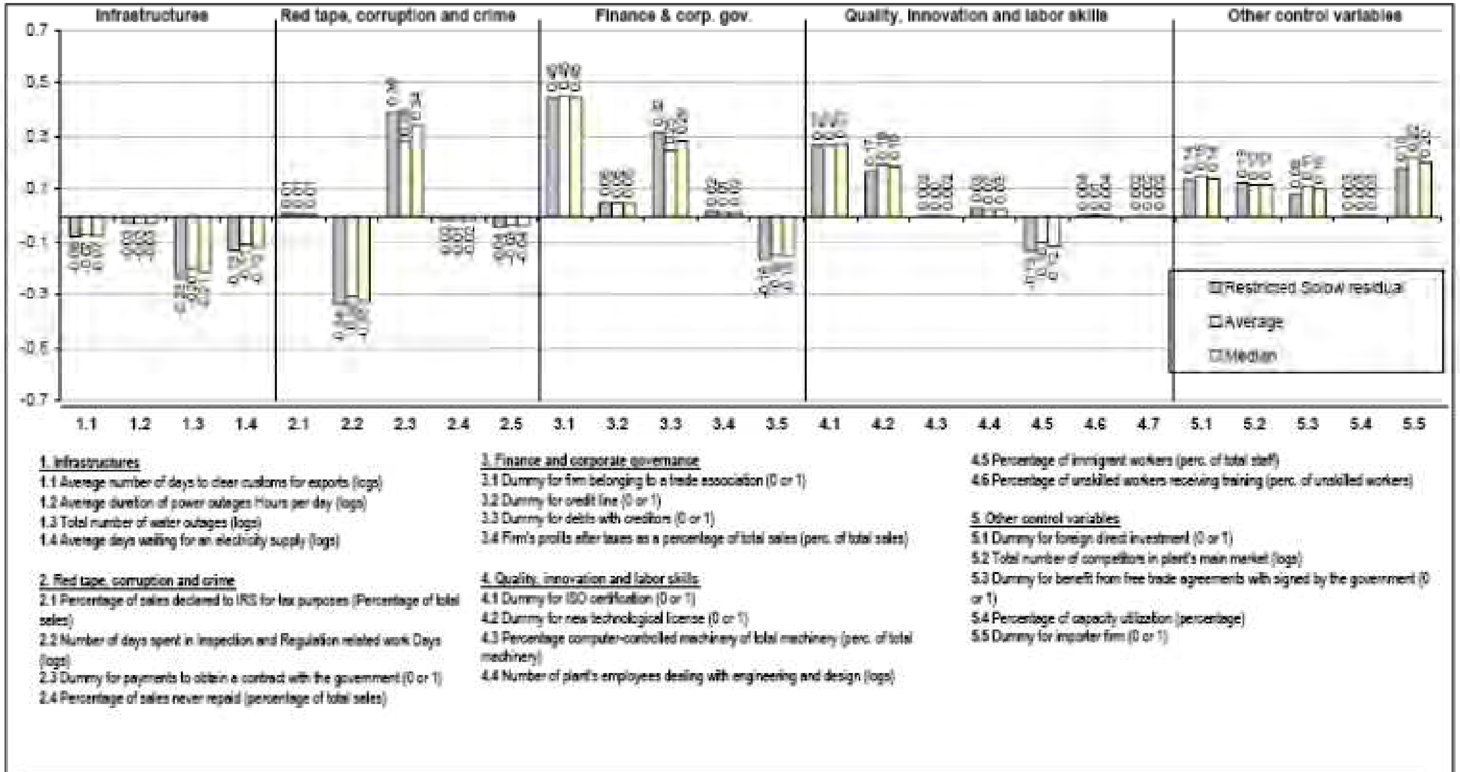
4. Quality, innovation and labor skills
4.1 Fraction computer-controlled machinery of total machinery (Fraction of total machinery)
4.2 Fraction of total staff engaged in R & D (Fraction of total staff)
4.3 Dummy for ISO quality certification (0 or 1)
4.4 Fraction of total staff with secondary education or more (Fraction of total staff)
4.5 Dummy for training provided beyond "on the job" (0 or 1)

5. Other control variables
5.1 Dummy for Incorporated Company (0 or 1)
5.2 Age of the firm years (logs)
5.3 Share of imported inputs (Fraction of total inputs)

* Grey bars correspond to elasticities and semi-elasticities from the restricted Solow residual case.
* White bars correspond to the average value of the twelve elasticities and semi-elasticities from the robust estimation. Light yellow bars correpond to the median of the twelve elasticities and semielasticities.

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.

Figure 3: IC elasticities and semi-elasticities on productivity (TFP): Costa Rica



* Grey bars correspond to elasticities and semi-elasticities from the restricted Solow residual case.
* White bars correspond to the average value of the twelve elasticities and semi-elasticities from the robust estimation. Light yellow bars correpond to the median of the twelve elasticities and semielasticities.

Source: Authors' elaboration with Investment Climate Surveys (ICs) data.