Productivity in Colombia: Looking at the Main Stylized Facts and Some New Hypotheses[1]

Mauricio Santa María S.[2]
Jesús Orlando Gracia F.[3]

Abstract

Total factor productivity (TFP) is thought to include the most important sources of growth for a country. TFP in Latin America and Colombia declined during the 1980s and 1990s, accounting for the poor performance in terms of GDP growth during that period. This paper surveys the studies that explain the causes behind this outcome and presents new evidence related to the effects of labor market variables and innovation activities on TFP. Using time series the paper shows that a reduction in firing and hiring costs may have had positive impact on TFP growth. With a four digits ISIC panel data set of manufacturing sectors, the paper also shows that increasing worker benefits weaken incentives to innovate. Other determinants are also analyzed, including violence related indicators and human capital variables.

Resumen

La productividad total de los factores (PTF) es la fuente más importante de crecimiento para un país. La PTF en América Latina y en Colombia se redujo en las décadas de los años 80s y 90s, lo cual explica el pobre desempeño en materia de crecimiento económico de la región. Este documento revisa los estudios que explican las causas de esto y presenta evidencia nueva relacionada con los efectos del mercado de trabajo y las actividades de innovación en el comportamiento de la PTF para el caso colombiano. Con base en series de tiempo, este documento muestra que una reducción en los costos de contratación y despido tuvo un impacto positivo en la PTF. Finalmente, utilizando un ejercicio de panel data con información sectorial de la manufactura se encuentra que los crecientes beneficios laborales debilitan los incentivos para innovar. Otros determinantes de la PTF también son analizados, incluyendo violencia y capital humano.

Keywords: Total Factor Productivity, Labor Productivity, Economic Growth, Labor Reform, Latin America, Colombia, Manufacturing.
Palabras clave: Productividad total de los factores, Productividad del trabajo, Crecimiento económico, Reforma laboral, América Latina, Colombia, Manufactura.
Clasificación JEL: E31, E32, E52, F43.

Primera versión recibida en junio de 2007; versión final aceptada en julio de 2007.
Coyuntura Económica volumen XXXVII, No. 1, primer semestre de 2007, pp. 91-120. Fedesarrollo, Bogotá - Colombia.

---

[1] We would like to thank participants of the workshop on labor market and competitiveness in Bogotá (sponsored by the World Bank in September 2004) for useful comments. We are also grateful with the Directions of Economic Studies and Entrepreneurial Development of the Colombian National Planning Department for providing the data, and for comments on previous versions of this paper. All errors and omissions are our own responsibility. Also many thanks to Natalia Salazar and Carlos Prada for use ful comments and other help.

[2] Subdirector de Fedesarrollo.

[3] Universidad del Rosario.

I. INTRODUCTION

It is widely known that total factor productivity (TFP) is an important determinant of economic growth and, thus, of welfare for any country. It is thought to encompass many unobservable (or unmeasured) determinants of growth. However, the techniques used to estimate this exogenous "factor" have faced wide controversy. The first source of disagreement comes from measurement errors for the estimates of production inputs (capital stock and labor). Given that TFP is the part of GDP growth not explained by investment on capital or employment growth, it is usually considered as "the measure of our ignorance". At the same time, it has been claimed that, even if inputs are precisely measured, productivity numbers are biased downwards because gains in product quality are not taken into account. From the environmental point of view, the bias is upwards since the unmeasured environmental cost of economic growth is not included in the estimations. But despite its flaws and inaccuracies, the residual (TFP) has provided a simple and internally consistent framework for organizing data on economic growth and for understanding growth determinants and differences across countries.

This paper surveys and summarizes both the theoretical approach and the applied results, for the Colombian case, related to the estimation of the evolution of TFP and makes an effort to estimate some of its determinants. For this last task, the paper analyzes some of the variables that have been mentioned in the literature as key for productivity, but also tests new hypotheses, particularly related to labor market variables and innovation. To accomplish these goals, the paper is divided in five sections after this introduction. The first presents the recent evolution of both TFP and labor productivity for Latin America and Colombia. The second contains a revision of applied work carried out recently and is intended to be a somewhat formal discussion of what can be expected from the exercise. The third section inquires about the determinants of TFP growth, emphasizing the role of the labor market. In the fourth section, a four digit ISIC panel data for the manufacturing sector is used to test the main hypotheses. Finally, some conclusions are presented in the fifth part.

The results show that TFP growth decreased sharply since the 1980s (the data used in the paper cover until 2000 or so). This outcome is robust across methodologies and data samples. At the same time, the analyses of determinants of TFP show that variables related to the 1990s reforms have a strong impact. In particular, measures intended to reduce hiring and firing costs in the labor market, as well as trade liberalization improved TFP growth. Adverse external shocks, on the other hand, such as violence and poor management of public finances, reflected in increasing deficits until 1998, did not allow the country to grow faster due to their impact on TFP. At the sectoral level, the paper finds a negative impact on TFP of payroll taxes, even when controlling for education, export orientation and industrial concentration.

II. STYLIZED FACTS FOR COLOMBIA AND LATIN AMERICA

It is well known that Latin American countries experienced a variety of crises during the eighties and nineties. They were reflected, among other things, on lower growth rates than expected after the market-oriented reforms were implemented (end of the 1980s - beginning of the 1990s). Loayza, Fajnzylber and Calderón (LFC, 2002), analyze growth performance for the region in the period 1960-99, describing the main stylized facts using a growth accounting approach and producing forecasts based on regression analyses of the determinants of growth. Their results are presented below along with our estimates.

The main stylized facts for the region and a sample of other countries are obtained decomposing per capita GDP series, to obtain trends and cyclical components[4]. For Latin America, growth rate of the trend of per capita GDP declined since 1960s, although slightly recovering in the 1990s. Cyclical volatility[5] has decreased since the seventies across all regions of the world. For Latin American countries volatility declined during the nineties after experiencing some years of high GDP volatility in the eighties. The only exception is Colombia, where the standard deviation of the cyclical component of per capita GDP increased during the nineties as result of the market oriented reforms of the period 1989-1994, especially the independence of the central bank (see Echeverry, Escobar and Santa María, 2002 for more on this).

Another important indicator from the series is the cyclical persistence, obtained from a AR(1) regression. The coefficient measures the time required for the deviations from the trend to return to equilibrium. The estimates show that cyclical fluctuations are not persistent for the whole sample, but those findings differ across regions. Indeed, output per-capita seems to be more persistent in industrial countries than in developing ones. In the case of Latin American countries persistence in output per capita fluctuations increased in the nineties relative to the eighties. From these facts, it is safe to conclude that the recovery of growth rates observed in the 1990s cannot be attributed completely to cyclical factors, as the trend components of per capita GDP increased. Additionally, it seems that volatility was reduced for Latin American countries, but increased in the case of Colombia.

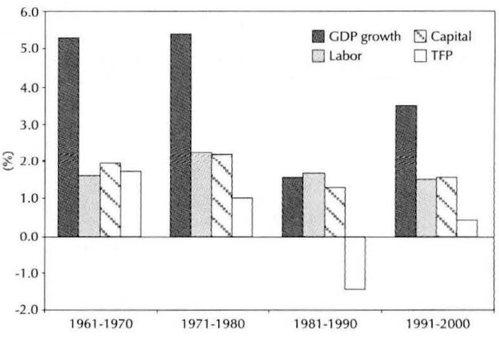
LFC (2002) find that, in Latin America, the contribution of TFP growth declined from the 1960s to the 1980s and experienced a strong recovery during the 1990s (See Table 1 and Figure 1). However, Colombia's figures score worse than the median Latin American country, with a decrease of 0,3% per year during the 90s. Correcting by human capital and factor utilization, most of the results remain for the region. However, these corrections reinforce the fact the decrease in growth rates is attributable to

Table 1. TOTAL FACTOR PRODUCTIVITY FOR SELECTED LATIN AMERICAN COUNTRIES (Average yearly rate)

	1961-1970	1971-1980	1981-1990	1991-2000
Argentina	0.96	0.24	-2.43	3.05
Brazil	1.88	3.11	-1.43	0.41
Chile	1.24	1.09	1.62	2.81
Colombia	1.77	1.68	0.02	-0.29
Mexico	1.66	1.25	-1.84	0.42
Paraguay	1.9	5.27	-0.5	-1.12
Peru	1.72	0.04	-3.42	1.55
Uruguay	0.79	1.75	-0.54	1.85
Venezuela	1.97	-2.64	-1.58	-0.18
Mean	1.54	1.31	-1.12	0.94

Source: Loayza. Fajnzylber. Calderon (2002).

Figure 1. SIMPLE GROWTH DECOMPOSITION USING MEDIAN COUNTRY BY DECADE



Source: Graph taken from LFC (2002). The median country for 1961-1970 is Peru, for 1971-1980 is Honduras, for 1981-1990 is Brazil and for 1991-2000 is Mexico.

[4] LFC (2002) use a band pass filter to characterize these issues.

[5] Measured as the standard deviation of a band pass filtered logarithm of per capita GDP.

the evolution of TFP[6]. Colombian GDP and TFP growth trend was similar to that observed for the median Latin American country until the eighties. Indeed, Colombia experienced a drastic "structural change" during the eighties (downwards), which persisted in the 1990s (see Table 2 and Grahp 2). During the period 1961-1990, TFP growth rates were higher in Colombia than in the mean country of those included in the sample, while in the 1990s Colombia began to perform worse than the mean, and worse than most of the countries. In fact, the only countries that perform worse than Colombia in the 1990s are Paraguay and Venezuela.

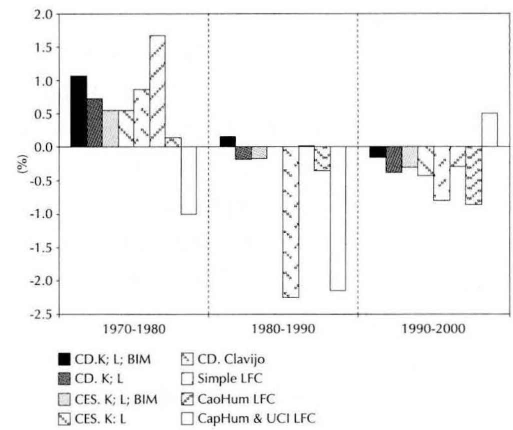
Although a complete explanation of that behavior is beyond the purpose of this paper, some explanations have been advanced by other authors. There are two types of answers in the literature. First, a standard macro explanation highlights the role of the debt crisis and the reduction in foreign capital inflows to the region during the 1980s and the effects of fiscal mismanagement during the 1990s (which resulted in high interest rates and an appreciated exchange rate). This last explanation, as we will see, was crucial in the Colombian case. Second, there is a more structural interpretation that attributes poor economic performance to either the implementation

Table 2. REAL GDP GROWTH

Annual Average	Latin America	Colombia	Chile
1950-1966	5.2	4.6	4.1
1967-1974	6.4	6.3	2.1
1975-1980	5.2	4.7	4.4
1981-1989	1.2	3.7	3.2
1990-2002	2.4	2.6	5.3

Source: Clavijo (2003).

Figure 2. COLOMBIAN TFP GROWTH (1970-2000)



Source: Own estimations, LFC (2002) and Clavijo (2003).

of the 'Washington Consensus' (especially trade liberalization and central bank independence), or, alternatively, to the lack of additional reforms that are necessary for the package to deliver better results, particularly in the institutional and fiscal fronts.

Cárdenas (2002) gives a partial explanation for this puzzle using cross-country data and aggregate time series. He finds that crime and illegal drug trafficking are the culprits for the poor productivity results during the 1980's and 1990's. Decomposing the dynamics of GDP growth into human and physical capital components, he finds that a fall in total productivity explains most of the structural change in the annual GDP growth since 1979. Before this year productivity was adding to growth, while afterwards human and physical capital accumulation were the main factors behind positive growth rates (see Figure 2). In explaining the reversal of productivity growth, the author argues that the surge in crime rates, the expansion of drug-trafficking activities and the strengthening of the insurgent movements are its main determinants.

[6] See appendix 1 for a summary of the methodological aspects of these results.

In Figure 2 we compare a set of TFP estimates for Colombia made by Clavijo (2003), LFC (2002) and our own calculations. The names in the legends stand for the methodological approach used to obtain the estimates: CD.K;L;BMI and CES.K;L;BMI are TFP obtained from the estimation of Cobb-Douglas and CES production functions with capital, labor and imports of intermediate goods. CD.K;L and CES.K;L are estimations using the same type of production functions, but without using imports of intermediate goods. CD.Clavijo is obtained from Clavijo's (2003) data and the three versions of LFC (2002) are TFP estimations from growth accounting equations using three versions of the productive factors (simple LFC, Human Capital LFC and Humand Capital & capacity utilization LFC)[7].

All the estimations show the same striking pattern: an expansion in the TFP for the 1970-1980 decade, zero or negative growth during the eighties and a clear contraction for the nineties (although smaller for some estimates than the one observed in the 1980s). These patterns match those observed for Latin American countries for the seventies and eighties but are quite below the region's average for the nineties (see Figure 1). The figure also shows that when the inputs are corrected by including the effect of human capital accumulation (CapHum) and capacity utilization (UCI) the story is different for the 1970s and 1999[8]. Indeed, the inclusion of these factors shows TFP growth after the reforms are implemented but an important contraction for the seventies and eighties. These results undoubtedly show that in the 1980s, with an economic policy, brought since the 1960s, based on closing the economy to international competition, financial repression and persistent two digit inflation, among the most important characteristics, had dried as a source of dynamic growth. TFP as result stagnated and the economy grew as a result only of growing factors of production. Also, these results show that in the 1990s the country was able to reap the benefits of the huge investments made in education in the 1970s and 1980s (*i.e.* in the 1990s the country had a more educated labor force).

But if the TFP productivity trends were disappointing in the 1990s, labor productivity results were even more so. Colombian labor productivity growth was low over the 90s, and is even farther away from the 1980's levels. Table 3 and Figure 3 compare labor productivity growth for some Latin American countries along with Korea, Singapore, US and Canada for 1990-1996 and 1990-1999 using annual data from the World Development Indicators of the World Bank. Colombia is the only country displaying an

Table 3. LABOR PRODUCTIVITY GROWTH DURING THE 90s*

	Aggregate (%)		Industrial (%)	
	1990-1996	1990-1999	1990-1996	1990-1999
Singapore	5.60	4.50	8.60	7.50
Korea	5.00	4.60	7.10	7.80
Chile	5.10	4.40	4.00	4.20
Argentina	4.40	3.20	8.00	5.40
Uruguay	2.70	2.40	3.00	3.10
Colombia	-2.10	-1.40	0.40	1.80
Peru	0.60	0.40	4.50	4.60
Brasil	0.20	0.30	2.00	1.50
Mexico	-0.30	0.60	2.80	2.00
U.S.			4.70	5.80
Canada			1.60	1.70
Mean-all	2.60	1.90	4.20	4.00
Mean-LA	1.80	1.60	3.50	3.20

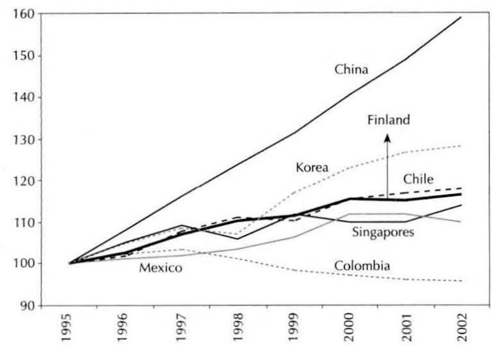
* GDP Constant prices local unit currency over employment figures from ILO.

Source: World Bank's world development indicators-WDI and U.S. Department of Labor.

7 We also used estimates from Rodriguez, JI, Perilla, J.R. and Reyes, J.D, (2004). See appendix 1 and next section for an explanation of each estimate.

8 In the appendix we present the data sources and methodology used to obtain our estimates.

Figure 3. LABOR PRODUCTIVITY (1995 = 100)



Source: For these data is WDI and GRECO for Colombia.

aggregate labor productivity slump and the lowest rate of industrial labor productivity growth for the entire selected sample. Industrial labor productivity grew 0,4% per year in Colombia, while the average for Latin American countries was 3,2%.

We argue that the observed behavior of labor productivity has contributed to the negative performance of the country in terms of TFP growth. This is a source of concern for a number of reasons, including: i) it encourages informality to the extent that it makes the opportunity cost of being formal too low; ii) it negatively impacts earnings growth; iii) it hampers competitiveness, therefore jeopardizing the ability of the country to take advantage of the globalization process; and iv) it slows down economic growth and thus welfare.

Below we present the evolution of quarterly labor productivity, measured as the ratio of GDP to employment in the seven main cities of Colombia[9]. The evidence shown differs from that presented in Figure 3 by the source and scope of the data. While Figure 3 uses aggregate annual data for employment, we present employment estimates for the seven main cities included in the national employment survey[10]. Two main conclusions can be drawn looking at the available data (See Figure 4, Figure 5 and Figure 6). First, labor productivity at the end of the data remains below its 1984 level and second, after a long period of stagnation, the 1990's witnessed an important recuperation of labor productivity, but the index is still far away from the level recorded since the 1980's first quarter.

Indeed, in Figure 4(a) we can clearly differentiate four periods[11]. In the first one, that goes from 1982 to 1988 and corresponds to the end of the 1982 economic crisis, labor productivity falls sharply. Then from the first quarter of 1988 to the third quarter of 1992, labor productivity stagnates, and finally during 1992-1998 an important improvement of labor productivity indicators is observed (which can be observed in Figure 3 as well), but only to place the index in its 1984's level. The last period shows a new drop in labor productivity caused (among other things) by a new and more severe economic crisis. It is important to notice that the improvement after 1992 is coincident with the structural reforms of 1990-1991, which included trade, financial, capital markets and labor, among the most important.

Looking at the different sectors, it is easy to observe a similar pattern for construction and commerce, which are labor intensive sectors and represent an important portion of GDP. However, the drop in

9 The source for data used in this section is DANE and DNP-DEE.

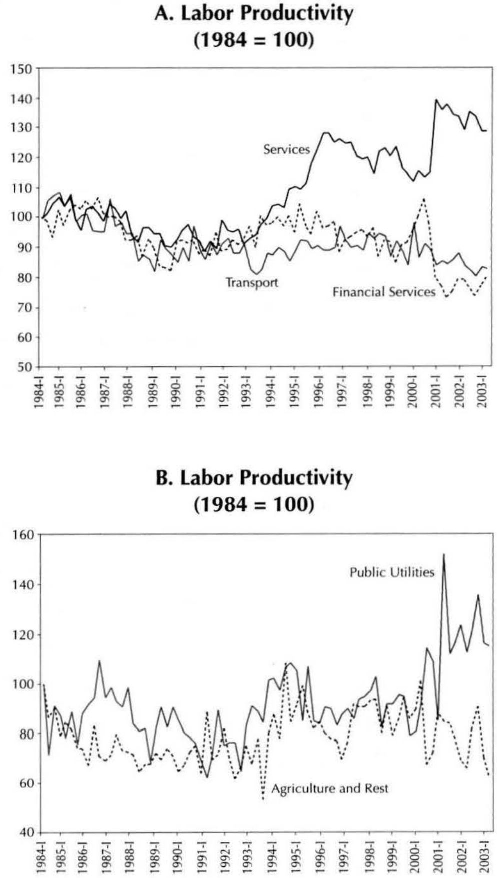
10 Encuesta Nacional de Hogares. The seven cities are Barranquilla, Bogotá, Cali, Medellín, Bucaramanga, Manizales and Pasto.

11 It is important to notice that the big jump observed in the first quarter of 2001 can be explained by the change in the methodology of the employment survey.

Figure 4. LABOR PRODUCTIVITY

Source: Own estimations.

Figure 5. LABOR PRODUCTIVITY



Source: Own estimations.

productivity is higher than the aggregate, given than these sectors were badly hit by the 1999's crisis. At the end of the data, labor productivity represents approximately 70% of the level observed in 1984. Manufacturing, public utilities and services[12], on the other hand, display labor productivities above the average and with an increasing trend during the 1990s, except for the latest period, where, in any case, the drop is smaller in manufacturing than in any other sector. It is also important to note that the services sector shows productivity growth rates higher than any other sector since 1992. To shed additional light on these issues, the evolution of labor costs and labor productivity for the manufacturing sector were also estimated and are available upon request. In the majority of sectors labor costs increase sharply after 1993-4, reflecting the enforcement of the social security reform (Ley 100 de 1993) that increased sharply contributions to the health and pensions systems. These costs decrease after 1999 in every industry due to the recession. Thus, even

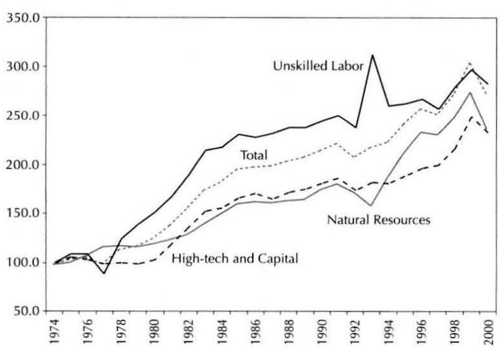
[12] Health, education, recreation and government services.

after massive employment reductions (which, for example, shot the unemployment rate from less than 10% to 20% in urban areas), productivity fell indicating the severity of the fall in output. There are sectors in which the evolution of productivity was positive and should be studied in more detail, such as apparel, chemicals, plastic, pottery, iron and leather. There are also sectors in which the evolution of productivity was especially negative. They include footwear, wood, other chemicals, petroleum, rubber and non-metallic products. In general, the same periods that could be distinguished for the aggregate case are not observed in the sectors.

Figure 6 portrays the evolution of the capital-labor ratio. These data show two important facts. Increasing manufacturing labor productivity was driven by factor substitution, and less productive workers were absorbed by activities with a larger share of informal activities. This is shown, among other things, by the fact that the capital labor ratio grew in low-skilled labor sectors more than in any other type of sectors until 1993.

Summarizing, Colombian TFP and labor productivity decreased sharply in the 1980s and 1990s at the aggregate level, although some successful sectoral trends call for some degree of optimism. We now present the explanations found in the literature and use our aggregate and sectoral TFP estimates to study what factors lie behind these results in order to shed some additional light and generate policy recommendations.

Figure 6. CAPITAL-LABOR RATIO IN MANUFACTURING BY FACTOR INTENSITY (1974 = 100)



Source: Own calculations.

III. LESSONS FROM APPLIED RESEARCH

In the last section, the available data showed that Colombian competitiveness has decrease in recent years. This section presents a benchmark to think about TFP estimates and puts forward some hypotheses to explain the behavior of TFP and productivity in Colombia. Appendix 1 has detailed description of the data and the estimation results. Then, a summary of the empirical research is discussed. These considerations will be the building blocks of our estimations in section three and four.

To obtain TFP estimates we start with an aggregate production function that typically is specified as

$$Y(t) = F(K(t), L(t), t) \qquad (1)$$

Where Y is output, K and L are capital and labor inputs and t indicates time. Although highly simple and restricted, this function allows the derivation of some conclusions about the sources of growth. Differentiating the logarithm of *(1)* with respect to time we obtain

$$\frac{\dot{Y}}{Y} = \frac{\partial K}{\partial K}\frac{K}{F}\frac{\dot{K}}{K} + \frac{\partial F}{\partial F}\frac{L}{F}\frac{\dot{L}}{L} + \frac{\partial F}{\partial t}\frac{1}{F} \qquad (2)$$

where $\dot{X} = dX/dt$ is the time derivative of the respective variable. *(1)* can be expressed in Hicks neutral form as

$$Y(t) = A(t)F(K(t), L(t)) \qquad (3)$$

Where $A(t)$[13] is TFP. It measures the shift in the production function at given levels of capital and labor. As before, taking the log derivatives of *(3)* with respect to time yields

$$\frac{\dot{Y}}{Y} = \frac{\partial F}{\partial K}\frac{K}{F}\frac{\dot{K}}{K} + \frac{\partial F}{\partial L}\frac{L}{F}\frac{\dot{L}}{L} + \frac{\dot{A}}{A} \qquad (4)$$

Where the last term represents TFP and can be rewritten as

$$\begin{bmatrix}\text{growth rate}\\ \text{of GDP}\end{bmatrix} = \varepsilon_k \begin{bmatrix}\text{growth}\\ \text{rate of } K\end{bmatrix} + \varepsilon_L \begin{bmatrix}\text{growth}\\ \text{rate of } L\end{bmatrix} + \begin{bmatrix}\text{growth}\\ \text{rate of TFP}\end{bmatrix} \quad (5)$$

In (5) ε_K and ε_L stand for the elasticity of output with respect to capital and labor, respectively. Since most of the data in equation *(5)* is easy to find from national accounts, obtaining TFP estimates is a matter of subtracting from GDP growth the weighted sum of the growth rates of inputs. However, this procedure requires valid values for the weights (the output elasticities).

There are two ways to find estimates for these parameters. One is calculating them directly and another is estimating them econometrically. In the first case, if we assume perfectly competitive factor markets, in equilibrium, income shares of capital and labor (ν_L and ν_K) are equal to the elasticities of output.

That is, let r and w be the wage and capital rates, defined as $r = A \cdot \partial F/\partial K$ and $w = A \cdot \partial F/\partial L$. From the definition of elasticities in *(4)* $\varepsilon_K = (\partial F/\partial K)\ (K/F) = rK/Y = \nu_K$ and $\varepsilon_L = (\partial F/\partial L)\ (L/F) = wL/Y = \nu_L$. Also, under constant returns to scale technology $\varepsilon_K + \varepsilon_L = \nu_L + \nu_K = 1$. This result is known as the "Solow residual". The second approach assumes a particular parametric functional form for *(1)* and the estimates for those parameters are the elasticities. TFP is then found as a residual, as mentioned above. Variations of this setup are the usual building blocks of the papers for the Colombian case.

However, as the research on this topic has shown, growth in conventional inputs explains little of the observed output growth[14]. Usually, most of this growth comes from improvements in the quality of labor and capital (including infrastructure), from formal and informal R&D investment made by governments and firms, and, in general, from technological advance in the production process. Although technological change is important in understanding growth, its determinants have not been completely understood. One of the most important insights to find out how technological change affects growth was made in Paul Roemer (1986), who formalized the following relationship between ideas and growth:

Ideas→ Nonrivalry → Increasing returns →Imperfect competition

His main point was that ideas differ from other goods because, unlike other factors of production, they are nonrivalrous. In other words, once an idea appears, it can be used by many people at no additional cost. This feature differentiates the way ideas are produced and priced. Because the appearance of an idea implies high fixed costs, usually ideas are produced with an increasing returns to scale technology. This implies that even with low costs of producing one additio-

[13] Although this is many times interpreted as technical change, it is important to make a clarification. A is a parameter that measures only a shift in output due to costless improvements in the way L and K are used. R&D is not captured by A unless it is previously taken away from the measurement of inputs.

[14] See NBER books like, Adam B. Jaffe, Josh Lerner and Scott Stern (2002), *Innovation Policy and the Economy, Volume 2*, The MIT Press. Zvi Griliches (1998), *R&D and Productivity*, University of Chicago Press.

nal unit, prices must be fixed above marginal cost. Otherwise, no firm will engage in the production of ideas. Thus, it entails a framework of positive profits, which places this activity away from perfect competition. In this context, patent law enforcement is vital when analyzing the production of ideas. That is, the incentives to make ideas depend on the inventor's expected profits rather than on the social benefit generated. This feature has created a necessity for institutions that close the gap between social and private benefits generated by inventions. The empirical production function of ideas is made mainly of one input, the amounts of money expend in R&D and one output, patents registered. In this research project we will not investigate how these features have influenced total factor productivity performance in Colombia[15]. Although these theoretical advances are irrefutable, most of them are hard to test for most developing countries given the lack of appropriate data.

For these reasons the relevance of the TFP exercise relies on the definition and structure of $A(t)$. Starting from a Cobb-Douglas constant returns to scale production function[16]

$$Y_t = A_t K_t^{\beta} L_t^{1-\beta} \qquad (6)$$

where all the variables have the same meaning as before, and defining A_t as

$$A_t = A_0 e^{\lambda t} \qquad (7)$$

that is, technology grows at a constant exponential rate λ, we could gather some data and estimate the output elasticities and λ using the following

$$\ln Y_t = \ln A_0 + \lambda_t + \beta \ln K_t + (1 - \beta) \ln L_t \qquad (8)$$

in this context, λ can be understood as a disembodied, exogenous and Hicks-neutral technological change, *i.e.*, the contribution of technological change to output growth. This implies that any technological change embodied in inputs must be correctly measured and taken into account.

Hicks-neutral technological change has the effect of increasing the efficiency of both capital and labor to the same extent. On the other hand, Harrod-neutral technological change is labor-augmenting and Solow-neutral technological change is capital-augmenting. These qualifications show that *(7)* is a narrow concept of technological change. Even if λ is small, the role of technology could have been important because embodied technological change might have been significant. Alternatively, λ may be small because the production function is not specified correctly, failing to take into consideration the endogenous aspect of technological change and alternative forms of neutrality. Conversely, a large λ may be due to large economies of scale and to resource reallocation. Another possible source of bias comes from missing variables in the production function. Intermediate inputs, energy, education and R&D have been considered as inputs that should be explicitly included.

The restrictive assumptions made to link the residual with technological change call to be cautious because there are sources of bias when obtaining TFP estimates. First, constant returns to scale must be assumed. Second, marginal cost pricing (perfect competition) also should be assumed, which could lead to a biased estimation of the Hicksian shift parameter and third, this formulation makes sense only if innovation improves the marginal productivity of all factors equally. After all these considerations are made, we present

---

15 It is important to note that in the case of a developing economy imitation activities are usually more important.

16 We also obtain estimates using a CES function.

the results from the applied research for the Colombian case at the sectoral and firm levels. For the link between labor market reform and TFP we present some evidence from the developed world.

A. Empirical Studies

In 1996 a group of Colombian economists produced a report about the evolution of productivity before and after the liberalization reforms of the 1990's[17]. The building blocks of this study were macroeconomic and sectoral, using as a connecting methodology three aspects of the problem: i) a measurement of productivity; ii) an analysis of their determinants; and iii) a diagnosis of the competitive problems either at aggregate or at each specific sector level.

The macroeconomic side of the document characterizes three phases in what has to do with GDP growth: i) high growth until 1974; ii) stagnation until mid 1980s; and iii) partial but unstable recuperation until the mid 1990s. Using this time line, they argue that during the first phase two factors contributed to increasing productivity. In the first place, the intensification of the substitution of imports and the expansion of exports that took place between 1967 to 1974. At the same time, macroeconomic stability and the favorable exchange of the period are in contrast with the crisis and volatility observed in the 1980s and 1990s. Using data from the early post-reform years they found that factors such as the business cycle and the revaluation of the exchange rate are the main macroeconomic elements to explain poor TFP performance. The manufacturing results can be summarized as follows: i) the business cycle is important, even correcting by capacity utilization; ii) labor saving restructuring seems to be important during the period before the reforms; and iii) investment plans emphasize modernization process as a preamble to technical change investment.

[17] DNP-COLCIENCIAS-FONADE (1996), National Study about the Determinants of Productivity Growth coordinated by Ricardo Chica.

In the agricultural sector, it is important to mention the specialization in crops with a comparative advantage and the intensive use of the resources. In services, the Study shows an institutional change created by the reforms, *i.e.*, modernization, decrease in prices and growth in product variety, combined with deregulation in the transport services. However, they point out the need for more public investment in education and infrastructure in order to foster foreign investment.

B. Plant Level Evidence

In order to evaluate some of the former hypotheses, a couple of plant level studies have been made. Meléndez, Seim and Medina (2003) analyze the effect of trade reforms and tax structure on manufacturing TFP. Given that their data set covers a long period (1977-99), they are able to analyze the effect of the reforms on the rate of firm's entry and exit and its relation with TFP. The empirical strategy follows Olley and Pakes (1996) and Leviston and Petrin (2002), where a Cobb-Douglas production function is the constraint of the firm's intertemporal maximization problem.

TFP estimation is made using the firm's demand for intermediate inputs that results form the maximization of profits. With these estimates, they are able to decompose productivity dynamics across sectors and firms. Total factor productivity is then related with variables that indicate the degree of trade openness and the structure of corporate tax. Although the results are in line with those presented in the last section, they are more robust given the nature of the data and the estimation procedures. Indeed, trade liberalization policies that took place in Colombia from 1985 to 1995 increased manufacturing total factor productivity because of reallocation of resources from less productive to more productive plants. The evidence from this study also shows that most of the gains from resource allocations were reversed by 1999.

Trade policy is evaluated trough effective tariffs. The econometric exercise shows that TFP increases with the exposure of firms to international competition. However, trade policy has not been able to counteract the general trend of observed productivity stagnation observed in the data. Moreover, tax exemptions do not affect positively the level and growth of total factor productivity, indicating that these instruments have failed in allocating investment to more productive activities.

Eslava, Haltiwanger, Kugler and Kugler (2003) use the same data set to evaluate the evolution of TFP and the nature of market selection in Colombia. Their focus is different from that of the previous work, in that they are interested in the role of demand and a broader definition of economic reform. In line with previous work for the Colombian case[18], they show that entering firms are more productive and exiting firms are less productive than incumbents. Additionally, they find that not only productivity, but also demand is the explanation for exiting firms. Economic reform seems to strengthen these findings.

C. Productivity, Innovation, Technology Adoption and the Role of the Labor Market

The starting hypothesis is that inflexible and burdensome labor legislation, especially in the contracting stage, may hinder productivity growth because it makes very difficult for the firm to adopt (or develop) new technologies. The effect of labor market regulations on productivity growth has received little attention, and almost no empirical testing. There are a number of channels through which labor market regulations can affect productivity (labor and total). Among the most important channels, one can think, for example, of the difficulties that strict hiring and firing regulations impose on the efficient use of the labor input along the business cycle, the lack of incentives to be productive that those regulations introduce for workers, and the fact that they are usually thought to discourage training. Thus, it appears that labor regulations, especially at the contracting stage, may be an important determinant of productivity, and thus of economic growth.

The review of the scarce specialized literature that rigorously analyzes the relationship between labor regulations and productivity starts with Hopenhayn and Rogerson (1993-HR). They find, using a general equilibrium model for job creation and destruction, that policies that interfere with the natural process of job creation/destruction at the firm level are quite costly in terms of average productivity and, more generally, in terms of aggregate welfare. One of such policies is the imposition of legislated costs to dismissals through severance payments (tax on dismissals). In effect, HR find that a tax on dismissals equal to one year's wages reduces average productivity by 2%. Consumption, on the other hand, is reduced by about 2.5% (these are long run-equilibrium effects). They find that the tax on job destruction creates a distortion that encourages firms to use resources less efficiently, with the result that productivity drops and fewer resources are devoted to the market sector of the economy.

Being more specific, HR find that the channel through which this effect occurs relates to the fact that when

18 Lui and Tybout (1996).

no dismissal costs are present, firms make their employment decisions based solely on the value of the marginal product of labor and the size and sign of the idiosyncratic shocks faced by the firm. However, when such costs are introduced, firms also base their employment decisions on the amount of labor used on previous periods, distorting such decision and making the aggregate marginal product of labor deviate from its equilibrium value. An important point is that in these base calculations, in which the tax on dismissals is set at 20% of the wage, the total costs of such tax are small (about 5% of the payroll), and even then the productivity effects are large. Thus, the authors stress the importance of these distortions and claim that focusing only on their employment effects is a mistake.

Scarpetta and Tressel (2004) show evidence for OECD countries about the link between labor market performance, TFP and economic growth. For this sample of countries, labor productivity growth accounts for at least half of GDP growth during the last two decades. Moreover, differences in labor productivity, and thus growth, have been shaped by a deepening in capital formation and increasing TFP. However, this pattern was not uniform between industries. Increasing productivity was driven mainly by high-tech industries for the case of United States, and by intermediate to low in the case of the EU15. Additionally, cross-country and cross-industry variance is explained by institutions and country-specific regulations via its impact on the incentives to innovate and to adopt new technologies.

Although it is inappropriate to judge institutions and labor market regulations by their ability to improve economic growth and labor productivity, it is also true that through their influence on the firm's cost structure, they can have an important effect on innovation. There are at least three channels to see the influence of legislation on innovation: i) the system of industrial relations; ii) the cost of hiring and firing workers; and(iii) the possible interactions between industry-specific technological characteristics and employment protection legislation, which lead to different human resources strategies.

The first channel can be seen through the wage bargaining regimes. In decentralized wage-bargaining regimes, incentives to innovate and adopt new technologies depend on the bargaining power of workers. That is, innovation is determined by the amount of rents and profits shared by employees. The second channel may affect the firm's ability to innovate, if innovation depends on the pool of labor force, but might be neutral if innovation is made through training programs or on-the-job learning. Finally, employment protection legislation has a differentiated effect depending on the industry, type, i.e., low-tech firms might be more affected by high firing and hiring cost than high-tech firms[19].

These hypotheses are tested empirically by Scarpetta and Tressel (2004) using data for OECD countries. Starting from the traditional production function for each country and industry (a function like *(1)* and specified in a *translog* form), they test an empirical model in which the conventional TFP measures are extended to account for industry and country specific characteristic, as well as technological and organizational transfer from the technology leader country. In this context, TFP growth in the frontier country leads to faster TFP growth in the followers by widening the production possibility set[20].

[19] A corollary of this effect is that high firing cost may lead to innovation in process or in the production cost rather than innovation in new goods that rely on the availability of new production factors like skilled labor. Labor market legislation is biding in the second case.

Capelli (2000) and Hobjin and Jovanovic (2001-HJ) also show that stringent hiring and firing restrictions raise the cost of labor adjustments, which is often required after innovation occurs. That is, those regulations negatively affect processes of technological upgrade because they tend to increase the often unavoidable cost of adjusting the labor force once, for example, a new technology is adopted in the production process.

Finally, Montes and Santa María (2006) show a negative relationship between non wage costs and TFP growth at a sectoral level for México. Although, at the conceptual level, the relationship between non wage costs and productivity is not so clear as the one between firing costs and productivity, there exist some channels through which such costs may affect productivity growth. Paramount among these is the fact that high non wage costs may prevent firms from growing and registering (i.e. be informal), preventing them from achieving economies of scale and making more difficult access to some very important services accessible to formal firms, such as credit.

Furthermore, at the aggregate level (national TFP), our results show that the substantial reduction of firing costs that occurred in 1990 in Colombia had a positive effect on the evolution of productivity growth.

IV. AGGREGATE TFP DETERMINANTS

After describing the main stylized facts for the region and the country of interest and after performing several calculations of the TFP, the next task is to inquire about its determinants. We follow the spirit of Loayza, Fajnzylber and Calderón (2002) in order to choose the variables to be included. That is, TFP must capture variables that explain economic reforms, indicators for infrastructure and human capital development, GDP cycle and, in the Colombian case, conflict and crime. Below we present a list of variables grouped in three main categories: structural reforms, stabilization policies and conflict. The division is arbitrary but helps us to identify the trends and roles of policies, institutions and indicators that affect TFP in the long run and that also account for cyclical fluctuations.

Structural Policies and Institutions have been recognized as a vital source of growth and development, not only in the theoretical literature but in the applied growth research. Although the disappointing nineties have risen a disagreement on which policies are the most beneficial to growth or the sequence in which policy changes must be made, there is no doubt that government actions do influence long-run growth. Following the spirit of most applied research, we consider a broad collection of policies and institutional determinants of TFP[21] such as trade openness, education, and infrastructure.

Trade openness can affect TFP in several ways. First, trade generates specialization and increases in TFP by allowing countries to benefit from their comparative advantage; second, by expanding potential markets, increasing exports creates economies of scale that have a positive effect on TFP; third, imports and exports speed up the entry and exit rate of firms with a direct increase in productivity, as shown above when referring to the paper by Eslava and others; finally, trade accelerates the rate of technology adoption by rising foreign direct investment. We use several indicators for trade openness, the ratio of exports to

[20] This is achieved by specifying an autoregressive distributed lag model of the A term in *(3)* for each country and industry. In this model the level of efficiency of a given industry or country is co-integrated with that of the leader.

[21] See LFC (2002).

GDP (xgdp), imports to GDP (mgdp), Foreign Direct Investment-FDI to GDP (fdigdp), an index for trade openness (tradeopen)[22], the real exchange index, and Exports plus Imports to GDP (xmgdp).

As important as trade, education can affect TFP through its neutralizing effects against diminishing returns in other factors of production[23]. Education is a complementary factor to physical and natural resources by smoothing technological adoption and imitation. We use the enrollment rates in primary (cobprim), secondary (cobsup) and university education (cobsup) as proxies of the effect of education over TFP.

Financial depth is also associated with expansion in TFP and hence growth. Financial markets facilitate risk diversification, identify profitable investment projects and mobilize resources to make them a reality. We use credit to GDP ratio (credgdp) as a measure of these ideas.

Another important area of policy involves the availability of public services and infrastructure. Even if they are treated as classic public goods, public services and infrastructure can affect growth by entering directly as inputs of the production function, by serving to improve total factor productivity, and by encouraging private investment as they help protect property rights. We include a series of indicators like installed telephones (teledenssity) lines per 100 thousand people, kilometers of roads (roads) and capacity of electricity generation (electricity).

As we have seen, governments play a crucial role in promoting growth, but also can become a burden to development if they collect taxes to finance inefficient and socially unprofitable projects or if they crowd out private resources to feed excessive bureaucracies. But even if most of the revenues are used in sound and thought programs, government burden can distort decisions through taxation. We use government income tax revenues to GDP (txgdp) and central government's operational and interest expenditure to GDP (cgexptogdp) as proxies to these effects.

Although the former list of variables is important to analyze TFP and growth, stabilization policies proxies were used in order to capture how a stable macroeconomic environment can contribute to growth by avoiding unexpected shocks such as financial and balance-of-payments crisis. Indeed, by reducing uncertainty, this set of variables capture how macroeconomic stability allow economic agents to concentrate on productive activities, rather than trying to manage high risk and ways to redistribute rents from uncertain outcomes such as high inflation or financial crises. We used the central government deficit/superavit (defgc), the public sector deficit, i.e. central plus regional government, public enterprises, excluding public banks (defspnf) and inflation to capture this environment.

In Colombia, the conflict may have played a role in hampering economic growth by reducing the prosperity of legal activities and by increasing the profitability of illegal crops and drug trafficking. Additionally, a huge amount of private and public resources has to be dedicated to defense and security, reducing the pool of funds that could be committed with the development of more profitable projects. We analyze the impact of the conflict by its effect on the rate of crime. We use homicides per 100 thousand people (thom), as an index that measure the intensity of the conflict and the number of offenses to life, liberty, property reported by the National Police[24].

---

[22] The index measure imports liberalization, that is, the percentage if imports that are in the list of goods and services free of restriction or quotas. Clavijo (2003).

[23] Lucas (1988).

Total factor productivity is also affected by the economic cycle. We include three types of indicators for this concept, the index of capacity utilization (uci), the labor force growth rate (gl) and the GDP gap (gdpgap). The GDP gap was obtained in the usual fashion, as the difference between the GDP and the Hodrick/Presscot filter trend. Finally, to measure the labor reform, one of the most important reforms of the nineties, we included the index of firing cost (firingcost). This index scores 11% before 1990 and 7% afterwards[25].

A. Results

The set of variables described above were regressed against TFP, testing both the validity of each linear specification and the stationarity of the series (see Appendix 2). As for stationarity, we found that most of the variables have a unit root in levels, but are stationary in growth rates. For the specification of the model, we present the results of a Leamer test for extreme limits in order to identify the variables that are statistically significant and with the correct sign after including and excluding different sets of independent variables. We found that at least one variable for each subset presented above are non fragile to the specification of the model (see Appendix 2 for the results of the test).

The determinants of TFP are identified using both levels and growth rates of the variables described above. Each variable was selected as a covariate after testing its robustness with the model's specification test. Even though most of these covariates exhibit a unit root, we used them as determinants in the explanation of TFP without providing a test for a long term relationship. Two reasons explain our procedure. First, our sample is too small to obtain a consistent test for co-integration as it is supposed to be a long term relationship and, second, most of the variables included in these regressions are not fragile to the change of specification reported in the Leamer test.

The results for the regressions in levels are reported in Table 4. The parameters in these tables are the contribution of each variable to TFP growth. In particular, variables that are computed as a ratio to GDP indicate that a change in one percentage point of that ratio would change TFP level by a number equal to each parameter. Index numbers must be understood in a similar way. In Table 5 we report the results using the growth rates of both the TFP and the variables of interest. In this case, the coefficients must be interpreted as the contribution of each variable to the growth rate of TFP. As mentioned before, these regressions capture the effect of structural and stabilization policies, the conflict and the business cycle.

Trade openness. As a series of studies have shown[26], trade openness seems to be important to explain the aggregate TFP contribution to growth. In Table 4 we show the coefficients for trade openness index (tradeopen), foreign direct investment to GDP (fdigd), the real exchange index (itcr) and the sum of exports plus imports to GDP (xmgdp). The sign of exports plus

---

27 We also include a weighted average of the three types of crimes.

25 We used Heckman and Pages methodology where the index is, $I = \sum \beta^t \delta^{t-1}(1 - g) \frac{y_t}{12t}$. Here y_t is severance payment, number of wages, when a worker is dismissed with out justified reason. *T* is the highest time expend in the company by an employee. β is the discount factor and δ the probability of remain employed in the plant.

26 Perilla, Castro and Gracia (2004); Núñez J., Rodríguez J. and Sánchez F. (1996); Clavijo (2003) and Cárdenas (2002).

Table 4. REGRESSION RESULTS (Levels, dependent vatiable: TFP)

	1	2	3	4	5	6	7	8
Exports plus imports to GDP					-0,1264			
					[0.1415]			
FDI to GDP						0,3787	0.6118 *	0,3108
						[0.3361]	[0.3071]	[0.2379]
Trade openness index							0.0630 *	
							[0.0226]	
Real exchange index								-0.0761 ***
								[0.01555]
Attainment rate university education	0,0037		0.0069 ***	0,0037	0,0063			
	[0.0041]		[0.0021]	[0.0041]	[0.0050]			
Attainment rate secundary education		0.0023 ***						
		[0.0006]						
Telephone lines per 100 thousand people						0.5685 ***	0.4311 **	1.0426 ***
						[0.1779]	[0.1641]	[0.1586]
Central goverment expenditure to GDP	-0,2958	-0.8018 ***	-0.7575 **	-0,2958	-0,4075	-0.5327 **	-0.5602 **	-0.6377 **
	[0.3593]	[0.2631]	[0.2759]	[0.3593]	[0.3819]	[0.2538]	[0.2234]	[0.1806]
GDP Gap	0.5268 ***	0.4621 ***	0.4795 ***	0.5268 ***	0.5227 ***	0.6370 ***	0.5398 ***	0.6280 ***
	[0.1336]	[0.1412]	[0.1460]	[0.1336]	[0.1342]	[0.1336]	[0.1225]	[0.0944]
Labor force growth rate	-0.3131 **			-0.3131 **	-0.2863 **	-0.2880 **	-0.2668 **	-0.2520 ***
	[0.1194]			[0.1194]	[0.1238]	[0.1105]	[0.0975]	[0.0784]
Credit to GDP	0,3386			0,3386	0,1991			
	[0.4556]			[0.4556]	[0.4836]			
Manufacturing value added to GDP	1.2793			1.2793	1.0936	0.7658 *	0.7594 *	1.4075 ***
	[0.8978]			[0.8978]	[0.9254]	[0.4292]	[0.3774]	[0.3303]
Firing cost	-0.7230 **	-0.4427	-0.4595	-0.7230 **	-0.8354 **	-0.6128 **	0.0632	-0.4752 **
	[0.2738]	[0.3029]	[0.3137]	[0.2738]	[0.3024]	[0.2554]	[0.3307]	[0.1827]
Homicides	-0,0002	-0.0006 **	-0.0002	-0.0002	-0,0002	-0,0001	-0,0002	0.0003 *
	[0.0002]	[0.0002]	[0.0002]	[0.0002]	[0.0002]	[0.0002]	[0.0001]	[0.0001]
Constant	0.8156 **	1.0530 ***	1.0691 ***	0.8156 ***	0.8961 ***	0.9417 ***	0.8497 ***	0.8484 ***
	[0.2095]	[0.0449]	[0.0468]	[0.2095]	[0.2289]	[0.0878]	[0.0840]	[0.0649]
Observations	32	33	33	32	32	32	32	32
R-squared	0,8	0,68	0,65	0,8	0,81	0,81	0,86	0,91

*significant at 10%; **significant at 5%; ***significant at 1%.
Standard errors in brackets.

imports to GDP is not the expected but the parameter is not statistically significant when using the variable in levels, however when the growth rates are used (Table 5) the coefficient is significant.

Education and infrastructure. An increase in the enrollment rate in secondary or tertiary education contributes to the TFP index with a positive sign. These set of variables were the most robust to many specifications in terms of sign and statistic value. The number of telephone lines per person is also very important to explain the TFP index. However, this variable was strong only when we correct by the labor force growth and when used in levels. The change in the infrastructure levels was neither significant nor stable in the specification[27].

Financial depth and industrialization. As mentioned before, well-functioning financial systems promote long-run growth and an increasing manufacturing share in the GDP is often related with the capacity to supply high quality jobs and with country's competitiveness with respect to others of similar size. These variables were significant and important only when correcting by the labor force growth.

Regulation and government burden. Firing costs and central government operational and interest payments are related to these concepts. Lowering

[27] The KM of roads was not statistically significant in any specification. This series has a drastic change starting 1995 when most of the projects were developed by private consortiums.

Table 5. REGRESSION RESULTS (Growth rate, dependent variable: TFP)

Growth rate of	1	2	3	4	5	6	7
Exports plus imports to GDP	0,0422	0.0659 **	0.0657***	0.0694 **	0.0657 **	0.0581 **	0.0463 *
	[0.0302]	[0.0237]	[0.0240]	[0.0236]	[0.0240]	[0.0274]	[0.0260]
Attainment rate secundary education	0,0702	0.1002					
	[0.0905]	[0.0759]					
Attainment rate university education			0,0553		0,0553	0.1221**	0.08030 *
			[0.0473]		[0.0473]	[0.0458]	[0.0474]
Central goverment expenditure to GDP	-0,0378						
	[0.0274]						
Income tax revenues to GDP		-0.0386 *	-0.0387 *	-0.0365 *	-0.0387 *	-0.0585**	-0.0585 **
		[0.0213]	[0.0215]	[0.0212]	[0.0215]	[0.0233]	[0.0217]
GDP gap(a)	0.2383 **	0.2992 ***	0.2899 **	0.2795 **	0.2899 **		
	[0.1098]	[0.1024]	[0.1095]	[0.1087]	[0.1095]		
Crimes against liberty		-0.0333 ***	-0.0311**	-0.0313 **	-0.0311 **	-0.0240 *	-0.0284 **
		[0.0114]	[0.0115]	[0.0115]	[0.0116]	[0.0128]	[0.0124]
Homicides per 100 thousand people	-0,0185						
	[0.0227]						
Capacity utilization (a)							0.1685 *
							[0.0945]
Manufacturing value added to GDP							0,0907
							[0.0798]
Constant	0,0008	-0.001	-0.0003	-0,0011	-0.0003	-0.0076 *	-0.1243 *
	[0.0056]	[0.0046]	[0.0045]	[0.0046]	[0.0045]	[0.0041]	[0.0661]
Observations	32	31	31	31	31	31	31
R-squared	0,4	0,59	0,59	0,59	0,59	0,47	0,55

*significant at 10%; **significant at 5%; ***significant at 1%.
Standard errors in brackets.

the burden for firing and hiring workers was found to be robust and important to explain TFP. It seems that both a smaller government and public debt promote growth by a high magnitude. In Table 5 the growth rate of income taxes to GDP resulted robust to any specification and with the expected sign.

Violence and Crime. These set of variables resulted to have a small effect when explaining the level of TFP, but an important role when using the growth rates. In particular, crimes against liberty have a negative effect on the TFP growth. The Cycle, GDP gap and the level of capacity utilization help to explain the TFP outcomes.

Summarizing, trade openness, measured as the growth rate of imports plus exports, increases in education attainment, especially university, the change in income taxes to GDP and the growth rate of crimes against liberty were robust to explain changes in TFP and growth. These findings help to explain the decreasing trend in TFP growth, i.e., the gains obtained by trade openness and human capital has been offset by the increasing rates of crime and the government burden. This also helps in explaining the behavior in past decades. During the 80s, the high degree of isolation from world markets, combined to high levels of financial repression and not much macroeconomic stability (approximated for example by two digit inflation rates) caused TFP and GDP growth to plummet as shown in the first section. An important finding is that overly strict labor regulations hinder productivity growth and thus negatively affect welfare. This is true for an unstable macroeconomic environment. However, most of the variation in total factor productivity has been explained by cyclical factors.

Although the former exercise helped to understand some features of recent aggregate TFP trends, evidence shown in the next section demonstrates that there have been some gains in TFP at the sectoral level. In particular, plant level estimates for the manufacturing sector show a gradual improvement in TFP explained by trade reform. In the next section we calculate and present three concepts of TFP using the yearly manufacturing survey at four ISIC digits, then with these data we analyze the determinants for the results.

V. TFP AT THE MANUFACTURING LEVEL

In this section we follow the same steps described at the beginning of section 3, that is, first we obtain the TFP estimates, and then we explain the rationale behind the choice of variables for explaining the determinants. In Appendix 3 TFP estimates (Table 1) confirm an increasing trend after 1995, *i.e.*, after the consolidation of trade reforms, and a reversal with the 1999's crisis. Indeed, TFP drops sharply in 1980, after that period crisis; stagnates for a decade and recuperate vigorously in 1995. This result is robust to the three ways of obtaining the TFP estimates (see Appendix 3). Although some plant level evidence has explained this stylized facts, we revisited the determinants of TFP in order to test the rsole of labor market institutions, innovation activities and trade openness variables.

The baseline specification models the rate of productivity growth as a function of certain covariates. As in Bernard and Jones (1996a), we include the maximum rate of growth by year as a separate covariate, which allows us to control for technological transfers from the leading industry to the rest of the manufacturing sector. We use several specifications in order to test the validity of our hypotheses.

Export and import orientation. We include several indicators for this concept: i) exports and imports by four ISIC digits to production (xprod and mprod); ii) import penetration coefficient (mpc) defined as imports /(prodution+imports-exports); and iii) imports and exports to total sales (xsales and msales). Data for exports and imports are obtained from the National Department of Statistics (DANE); because these data is not calculated from the establishment survey (EAM) it represents the direct competition for the national production in the case of imports.

Technology adoption. As we mentioned earlier, productivity is a key variable for understanding technological capacities. Since technology is embodied in capital goods (machinery and equipment), their acquisition may be the cause of productivity changes. An interesting question that arises at this point is the following: are industries which invested the most also the ones with more productivity growth? In general, the ratio of new machinery to total production (imeprod) was used to indicate the weight of adoption of capital goods to the importance of the sector. Easy as it seems, it is not a trivial question, since investment is clearly endogenous to productivity growth. That is, a simple regression would produce negative results simply by the fact that capital is a component in the construction of TFP. In order overcome this obstacle, we construct the average of the mentioned ratio by industry, and we use the mean values as a proxy for INVK/Y.

Economies of scale have also been recognized as an important source of TFP growth. We include the proportion of the production made by large firms as a proxy (sharebigpb). This indicator is taken from the EAM, which consider as big firms those with 200 or more employees.

Labor costs. Traditionally, it has been established that high cost of workforce adjustment has a negative impact on the level of employment. For instance, Heckman and Pagés (2000) found that the effects on employment levels are negative and substantial. Moreover, a lower level of employment reduces the marginal product of capital and the incentives to save and invest, which in turn, affect negatively economic growth.

Labor market regulations and institutions also play an important role in the determination of productivity growth. By shifting the optimal level of employment, adoption of technologies is also altered. However, no clear consensus has emerged about the impact of these institutions on lp and TFP growth. On one hand, Scarpetta and Tressel (2004) argue that incentives for innovation are reduced when no inter or intra industry mechanisms to offset hiring and firing cost exists. On the other hand, substitution of labor toward outsourcing and/or capital intensive technologies may have a positive impact on productivity. Overall, at this stage of analysis, empirical evidence may be very important for guiding future research in the topic. We use the information provided by the EAM to construct a variable that will be a proxy for labor costs. We consider the ratio of non-wage cost to total remuneration (sharebenefits) as a measure of the weight labor costs other than wages.

Using the technological innovation survey (EIT) for 1996, we also include a variable for *innovation* that represents the proportion of firms that innovate in each sector. We then use the same proportion for the entire sample in order to create a specific sector characteristic indicator for this concept.

Given that some comments to previous versions of this paper argued that labor costs are endogenous to TFP, we use as instrumental variables the average years of education from household surveys (ENH) and the level concentration by sector, *i.e.*, the estimations to correct for this problem. The estimation results may be found below (Table 6).

The table clearly shows that i) the burden of non wage costs has a negative impact on TFP; ii) innovation, as defined in this paper, positively affects the evolution of TFP; iii) the ratio of new machinery to total production, as a proxy of adoption of new technologies in the production process has a very large impact on TFP, in the direction of improving it; and iv) surprisingly, the variables that try to account for the degree of openness do not seem to affect the evolution of TFP at the sectoral level.

VI. FINAL COMMENTS

The main findings of this paper in terms of evolution of TFP and labor productivity can be summarized as follows:

- Total factor productivity suffered a downwards "structural break" starting in 1980. In effect, TFP was growing rapidly in the 1960s and 1970s but since 1980 it started to grow slower, trend that lasted until the end of the 1990s.

- This pattern was observed in Latin American countries as well. The main difference was that the majority of these countries showed renewed growth of TFP in the 1990s, fact that was not true for Colombia.

- The behavior of labor productivity was very similar, but even more disappointing, particularly during the 1990s.

- At the sectoral level, it was possible to find some heterogeneity in the results. Manufacturing productivity (both TFP and labor) in general displayed better performance than other sectors and, within manufacturing (at 4 digits), there were sectors that performed very well during the whole period such as apparel, while others saw their productivity

Table 6. TFP GROWTH FROM A SOLOW RESIDUAL[a]

	1	2	3	4	5
sharebenefits	-0.0418 **	-0.0485 **	-0.0420 **	-0.0485 **	-0.0429 *
	[0.0243]	[0.0250]	[0.0242]	[0.0250]	[0.0243]
innovation	0.0351 *	0.037 *	0.0354 *	0.037 **	0.0359 *
	[0.0229]	[0.0230]	[0.0230]	[0.0230]	[0.0230]
mpc	-0,0054				
	[0.0039]				
sharebigpb	0,0028	0,0035	0,0023	0,0035	0,0027
	[0.0176]	[0.0176]	[0.0176]	[0.0176]	[0.0176]
imeprod	0.2322 *	0.2646 **	0.2302 *	0.2646 **	0.2336 *
	[0.1270]	[0.1301]	[0.1266]	[0.1301]	[0.1269]
tfp_solow_max	0.0784 ***	0.0767 ***	0.0788 ***	0.0767 ***	0.0785 ***
	[0.0118]	[0.0119]	[0.0118]	[0.0119]	[0.0118]
dle	-0.0107 ***	-0.0108 ***	-0.0107 ***	-0.0108 ***	-0.0107 ***
	[0.0010]	[0.0010]	[0.0010]	[0.0010]	[0.0010]
eoc		-0,0151			
		[0.0122]			
mprod			-0,0009		
			[0.0016]		
mplusxtoprod					-0,0011
					[0.0016]
Constant	-0,0132	-0,0085	-0,0135	-0,0085	-0,0129
	[0.0131]	[0.0138]	[0.0131]	[0.0138]	[0.0131]
xprod				-0,0151	
				[0.0122]	
Observations	2034	2035	2034	2035	2034
R-squared	0,11	0,11	0,11	0,11	0,11

* significant at 10%; ** significant at 5%; *** significant at 1%

[a] Analitical weigths average share in production by sector IV for sharebenefits: concent eduenh xprod.

Standard errors in brackets.

plummet, even when the economy was growing at sound rates.

At the aggregate level, these results were mainly explained by the following factors, which were robust to different econometric specifications and to diverse functional forms in terms of explanatory variables included.

- Trade openness, measured as the growth rate of imports plus exports, which approximated the degree of inclusion of the Colombian economy in world markets.
- Financial deepening.
- Human capital, proxied by educational attainment, especially at the university level.
- The "government burden" on the economy, measured by the ratio of income taxes to GDP.
- The rate of crimes against liberty.
- These findings help to explain the decreasing trend in TFP growth across the 1980s and 1990s. That is, in the 1980's the isolation of the country

from world markets, which lasted at least 30 years, financial repression and a somewhat heavy government burden explained the sudden slowdown in productivity trends. Since the 1990s, the gains obtained by trade openness and human capital improvement (evident in the first half of the decade), were offset by the increasing rates of crime and the government burden, which accentuated and manifested in the form of increasing fiscal deficits at all levels of government.

- A large part of the variation in total factor productivity has been explained by cyclical factors.

- One of the main findings of the paper is that an overly rigid labor market, such as the Colombian one has been detrimental for TFP growth. That is, excessive labor regulations, summarized in this paper by hiring and firing costs, have negatively influenced the evolution of TFP growth. In this sense, the change introduced by the 1990 labor reform increased the pace of TFP growth.

- At the sectoral level (for manufacturing), the paper finds a similar result. Indeed, non wage costs are found to have a negative influence on TFP, even when controlling for education, exports orientation and industrial concentration, among other variables. These two findings have potent policy implications, because they show that overly regulated or costly labor regulations not only influence employment or formality levels, as generally thought, but they also tend to reduce TFP growth, and therefore economic growth and welfare are negatively affected as well. This finding alone calls for urgent policy action.

- Innovation was found to positively impact TFP at the sectoral level in manufacturing, which also call for urgent policy action, both in terms of resources devoted to this activity and the introduction of regulation that fosters innovation and Research and development.

REFERENCES

Arango, J., Gracia, O., Hernández, G. and Ramírez, J. (1998), "Reformas comerciales, márgenes de beneficio y productividad industrial Colombiana", *Archivos de Macroeconomía*, 82.

Barrios, A., Henao, M.L., Posada, M.L., Valderrama F. M. and Vásquez D.M. (1993), "Empleo y capital en Colombia: nuevas estimaciones (1950-1992)", *Archivos de Macroeconomía*, 15.

Bonilla, G., Silva, J. and Villamil, J. (1996), "Análisis metodológico y empírico de la medición de productividad en Colombia", Documento publicado en El crecimiento de la productividad en Colombia, Departamento Nacional de Planeación-Colciencias.

Capelli, P. (2000), "Examining the Incidence of Downsizing and Its Effects on Establishment Performance". in Neumark, D. (ed.), On the Job, New York : Russell Sage Foundation.

Cárdenas, M. (2002), "Economic Growth in Colombia: A Reversal of 'Fortune'". *Archivos de Economía*, 179.

Chica, R. (1996), "El crecimiento de la productividad en Colombia", Departamento Nacional de Planeación-Colciencias.

Clavijo, S. (2003), "Crecimiento, Productividad y la 'Nueva Economía': Implicaciones para Colombia", mimeo.

Clavijo, S. (1994), "Crecimiento económico y productividad en Colombia: una perspectiva de largo plazo (1957-1994)", *Archivo de macroeconomía*, 3.

Echeverry, J.C., Escobar, A. and Santa María, M. (2002), "Ciclos, Tendencias y Distribución del Ingreso: una Crítica al Modelo de Desarrollo". In Modelos de Desarrollo. Editorial Oveja Negra. Bogotá DC. 2002.

Eslava, M., Kugler, A., Haltiwanger, J. and Kugler, M. (2004), "The Effect of Structural Reforms on Productivity and Profitability Enhancing Reallocation: Evidence from Colombia," NBER *Working Paper*, W10367.

Griliches, Z. (1998), R&D and Productivity, University of Chicago Press.

Grupo de Estudios del Crecimiento Económico-GRECO (2002), El Crecimiento Económico Colombiano en el Siglo XX, Bogotá: Banco de la República-Fondo de Cultura Económica.

Hobjin, B. and Jovanovich, B. (2001), "The Information Technology Revolution and the Stock Market: Evidence", American *Economic Review*, forthcoming.

Hopenhayn, H. and Rogerson, R. (1993), "Job Turnover and Policy Evaluation: A General Equilibrium Analysis", *Journal of Political Economy*, 101: 915- 38.

Hulten, C., (2000), "Total Factor Productivity: A Short Biography", NBER Working Paper, W7471.

Jaffe, A.B., Lerner J. and Stern, S. (2002), *Innovation Policy and the Economy*, Volume 2, The MIT Press.

Jaramillo, F. y Ramírez, M. (1996), "Los determinantes de la productividad total de los factores en la economía" en Chica, R. (ed), El crecimiento de la productividad en Colombia, Departamento Nacional de Planeación-Colciencias.

Kugler, M. (2000), "The Diffusion of Externalities from Foreign Direct Investment: The Theory ahead of measurement", Discussion Papers in Economics and Econometrics, University of Southampton.

Levine, R., y Renelt, D. (1992), "A Sensitivity of Cross-Country Growth Regressions", *American Economic Review*, 82(4).

Loayza N., Fajnzylber, P. and Calderon, C. (2002), "Economic Growth in Latin America and the Caribbean: Stylized Facts, Explanations and Forecasts", mimeo, World Bank.

Meléndez M., Seim, K., Medina, P. (2003), "Productivity Dynamics of the Colombian Manufacturing Sector", Documento CEDE, 23.

Montes, G. and Santa María, M. (2007), "The Burden of Labor Costs in Mexico". Labour. Blackwell Publishing. London. Volume 21, issue 1.

Núñez, J., Rodríguez, J. and Sánchez, F. (1996), "Evolución y Determinantes de la producción en Colombia: Un análisis global y sectorial". *Archivo de Macroeconomía*, 50.

Parente, S. and Prescott, E. (2000), Barriers to Riches, MIT Press, Cambridge.

Parente, S. and Prescott, E. (2001), "Technology Adoption and Growth". NBER *Working Paper*, 3733.

Pombo, C. (1996), "Productividad Industrial en Colombia: Una aplicación en números índices". Documento publicado por la Universidad Colegio Mayor del Rosario, Facultad de economía.

Ramírez, M, and Jaramillo, F. (1996), "Los determinantes de la productividad total de los factores en Colombia", en El Crecimiento de la productividad en Colombia, DNP-Colciencias-Fonade.

Rodriguez, J.I., Perilla, J.R. and Reyes, J.D. (2004), "Cálculo del PIB Potencial en Colombia: 1970-2003". *Archivos de Economía,* 261.

Salazar, M., Durán, X., Ibañez, R. and Vargas, M. (1998), "La innovación tecnológica en Colombia: características por tamaño y tipo de empresa", Planeación y Desarrollo, XXIX(1).

Scarpetta, S., and Tressel, T. (2004), "Boosting Productivity via Innovation and Adoption of New Technologies: Any Role for Labor Market Institutions?", *World Bank Policy Research Working Paper,* 3273.

Appendix 1. DATA AND METHODOLOGY FOR AGGREGATE TFP ESTIMATION

We reproduce the estimation procedure of Rodriguez, Perilla, and Reyes-RPR (2004). The procedure, described in section 2, starts from a production function in order to obtain inputs elasticities with respect to output. Then with these estimates TFP is obtained as a residual. In Figure A1 we present three estimates for the TFP. The following production functions are estimated,

$$ln\, Y_t = lnA_t + \alpha\, ln(K_t) + \beta\, ln(L_t) + \varepsilon_t \qquad (A1)$$

and,

$$ln\, Y_t = lnA_t - \frac{\eta}{\rho} ln\, (\alpha K_t^{\rho} + \beta\, lnL_t^{\rho} + (1 - \alpha - \beta)\, BMI_t^{-\rho}) + \varepsilon_t \qquad (A2)$$

The variables in *(A1)* and *(A2)* are expressed in constant prices of 1994 and stand for GDP *(Y)*, capital stock *(K)*, labor force *(L)* and intermediate goods imports *(BMI)*. The GDP series for 1970 to 1994 is calculated by the Group of Growth Studies (GRECO) at the Central Bank in Colombia. We complete the series using data from the Department of National Statistics (DANE) from 1994 to 2002. The base year is 1994.

The Capital Stock estimates are obtained using the perpetual inventory methodology. In order to obtain the investment figure we used two sources. Data for investment (Gross Formation of Fixed Capital) for the period 1925 to 1990 and DANE's National accounts for 1990 to 2002 at 1994's prices. We obtain these estimates for investment in machinery and equipment, transport equipment and buildings. Applying a depreciation rate of 20%, 8% and 2% respectively, we obtain the aggregate capital stock.

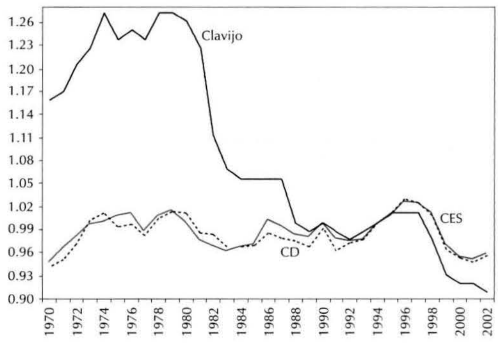
For the BMI we used millions of dollars of intermediate imports from the Balance of Payments Accounts. Data in Colombian 1994's pesos is obtained using the average nominal exchange rate and the whole sales price index for imported goods.

Finally, the employment data is obtained from Barrios *et. al.* (1993) for 1970 to 1991. From that point we use the annual employment growth rate from the National Employment Survey (ENH).

While Clavijo (2003) uses an equation similar to *(A1)*, the sample period is longer and the time series used have different mean growth rates compared with our calculations. Loayza, Fajnzylber and Calderon-LFC (2002) present three estimations from growth accounting.

In Figure 2, *simpleLFC* is obtained from a growth accounting equation *TPF = GDPgrowth* - s_k*CapGrowth* - (1 - s_k) *LabGrowth* with s_k the share of capital in income. In *CapHumLFC* we report the calculations obtained after LFC (2002) adjust by the quality of labor associated with the increases in human capital. They start from a production function where human capital is combined with labor and represents an index of the quality of the labor force. That is, they calculate the TFP after *TPF = GDPgrowth* - s_k*CapGrowth* - (1 - s_k) *(LabGrowth + SchoolGrowth)*, where school growth is an index that reflects school attainment. Finally, in *CapHum&UCILFC* they control by the rate of utilization of capital and labor, *TPF = GDPgrowth* - s_k*CapGrowthAdj* - (1 - s_k) *(LabGrowthAdj + School-Growth)*, where *CapGrowthAdj* is the utilization-adjusted growth rate of capital, and *LaborGrowthAdj* is the employment- and hours-adjusted growth rate of labor.

Figure A1
TFP ESTIMATES
(1994 = 100)



Appendix 2. LEAMER TEST FOR EXTREME LIMITS

Results presented in section 4 are highly sensitive to changes in the specification of the model. Here we present the results of a Leamer test for extreme limits[1] in order to identify the variables that are statistically significant and with the correct sign after including and excluding different sets of independent variables[1].

This test attempts to establish how the independent covariates are influenced by the set of available information. Starting from OLS estimation:

$$TFP = \beta_i I + \beta_m M + \beta_z Z + u \quad (A3)$$

The TFP is regressed against a set *I*, *M* and *Z* variables of interest. The set of *I* variables are always included in the regression (the GDP gap and the rate of credit to GDP). *M* variables are grouped according to the policy or development indicator that represent and the set *Z* (maximum 4) are variables that do not belong to *M* but are complementary to them.

The set of *M* variables are grouped in seven subsets that represent indicators of trade openness (-8-), education (-3-), infrastructure (-4-), government burden and macroeconomic stability (-6-), violence and insecurity (-6-), size of the manufacturing sector and labor reform. *Z* is a set of variables not included in *M* that represent indicators of cyclical fluctuations of the GDP.

1 Levine y Renelt (1992) and Chica (1996).

2 The exercise is performed for the rate of growth of the variables.

The procedure works following the next steps: i) an OLS regression of TFP including *I* and *M* produce a "basic" coefficient -*Bm*-; ii) TFP is OLS regressed against *M*, *I*, and all the possible combinations of 5 variables from *Z*. For all these regressions an estimate of the superior (inferior) extreme is calculated as -*Bm*- plus (less) twice the standard deviation of each coefficient; iii) The procedure reports the maximum superior extreme, the minimum inferior extreme and the base coefficient; iv) If after several iterations between *I*, *M* and *Z* the coefficients of the variables included in *M* are not statistically significant or change the signs after all possible combinations are tested, we say that those variables are fragile to changes in the specification of the model. The t-statistic of the extreme limits is obtained as,

$$t_{lim} = \frac{\beta \pm 2\sigma}{\sigma} \quad (A4)$$

Results in table 5 show that at least five variables are not fragile to changes in the specification of the model following three conditions: i) the percentage of combinations where the variable is statistically significant is greater than 25% (see % sig in table 5), ii) the coefficient shows the expected sign (B(+/-)2stder) and iii) the p-value is less than 0.10.

Table 1. LEAMER TEST EXTREME LIMITS, DEPENDENT VARIABLE TFP FROM COBB DOUGLAS PRODUCTION FUNCTION

Variable	% sig	B(+/-)2stder	stder	t-stat	p-value Adj	p-value	R^2	No Fragile/ Fragile
Trade Openness 1								
	high	0,099	0,021	2,745	0,000	0,010	0,493	
GX	4% base	0.022	0.020	1.058	0.299	0.299	0.238	Fragile
	low	-0.118	0.028	-2.230	0.000	0.034	0.582	
	high	0.145	0.023	4.195	0.000	0.000	0.578	
GM	44% base	0.047	0.023	2.063	0.048	0.048	0.312	Not Fragile
	low	0.001	0.021	2.049	0.961	0.050	0.531	
	high	1.238	0.141	6.803	0.000	0.000	0.757	
GFDI	14% base	0.002	0.004	0.488	0.629	0.629	0.214	Fragile
	low	0.000	0.004	2.053	0.958	0.050	0.485	
	high	0.202	0.033	4.161	0.000	0.000	0.606	
GITCR	13% base	0.047	0.032	1.454	0.157	0.157	0.263	Fragile
	low	0.002	0.031	2.049	0.962	0.050	0.484	
Trade Openness 2								
	high	1.161	0.264	2.394	0.000	0.024	0.629	
GXM	57% base	0.063	0.029	2.186	0.037	0.037	0.323	Not Fragile
	low	0.001	0.028	2.050	0.960	0.050	0.520	
	high	0.291	0.070	2.162	0.000	0.039	0.393	
GXMGDP	19% base	0.048	0.034	1.412	0.169	0.169	0.260	Fragile
	low	-1.250	0.242	-3.170	0.000	0.004	0.639	
	high	0.057	0.013	2.288	0.000	0.030	0.521	
TRADEOPEN	0% base	-0.001	0.012	-0.126	0.900	0.900	0.208	Fragile
	low	-0.048	0.012	-2.052	0.000	0.050	0.540	
	high	0.020	0.004	2.759	0.000	0.010	0.594	
GFDIGDP	14% base	0.002	0.005	0.408	0.686	0.686	0.212	Fragile
	low	-1.283	0.146	-6.785	0.000	0.000	0.757	
Education								
	high	1.075	0.234	2.588	0000	0.015	0.524	
CGOBPRIM	1% base	0.107	0.230	0.468	0.644	0.644	0.214	Fragile
	low	0.010	0.199	2.051	0.960	0.050	0.585	
	high	0.401	0.092	2.345	0.000	0.026	0.541	
CGOBSEC	0% base	0.087	0.098	0.891	0.381	0.381	0.229	Fragile
	low	0.005	0.097	2.049	0.961	0.05	0.500	
	high	0.280	0.060	2.673	0.000	0.012	0.532	
CGOBSUP	0% base	0.074	0.063	1.188	0.245	0.245	0.245	Fragile
	low	0.003	0.040	2.071	0.944	0.048	0.756	
Infraestructure								
	high	-0.003	0.068	-2.049	0.961	0.050	0.515	
GTELINST	6% base	-0.096	0.073	-1.315	0.199	0.199	0.254	Fragile
	low	-0.408	0.089	-2.605	0.000	0.015	0.448	
	high	-0,003	0.068	-2.049	0.961	0.050	0.515	
GTELDENS	1% base	-0.051	0.071	-0.716	0.480	0.480	0.222	Fragile
	low	-0.405	0.076	-3.341	0.000	0.002	0.564	
	high	-	-	-	-	-	-	
GROADS	0% base	-0.034	0.031	-1.117	0.274	0.274	0.241	Fragile
	low	-	-	-	-	-	-	
	high	-0.003	0.040	-2.064	0.950	0.048	0.578	
GELECTRICITY	0% base	0.013	0.042	0.308	0.760	0.760	0.210	Fragile
	low	-0.186	0.039	-2.740	0.000	0.011	0.629	

Table 1. LEAMER TEST EXTREME LIMITS, DEPENDENT VARIABLE TFP FROM COBB DOUGLAS PRODUCTION FUNCTION

Variable	% sig	B(+/-)2stder	stder	t-stat	p-value Adj	p-value	R^2	No Fragile/ Fragile
Government and macro stability								
	high	-0.001	0.023	-2.050	0.960	0.050	0.536	
GTXGDP	8% base	-0.038	0.026	-1.468	0.153	0.153	0.264	Fragile
	low	-0.127	0.029	-2.337	0.000	0.027	0.508	
	high	-0.001	0.025	-2.050	0.961	0.050	0.468	
GCGEXPTOGDP	25% base	-0.055	0.026	-2.091	0.046	0.046	0.314	Not Fragile
	low	-0.166	0.033	-3.081	0.000	0.005	0.455	
	high	-	-	-	-	-	-	
GCGINVTOGDP	0% base	0.003	0.012	0.212	0.833	0.833	0.209	Fragile
	low	-	-	-	-	-	-	
	high	-	-	-	-	-	-	
GCGOVDEF	0% base	0.000	0.001	0.137	0.892	0.892	0.208	Fragile
	low	-	-	-	-	-	-	
	high	0.002	0.000	2.653	0.000	0.013	0.598	
GSPNFDEF	1% base	0.000	0.000	0.031	0.976	0.976	0.207	Fragile
	low	0.000	0.000	2.050	0.960	0.050	0.642	
	high	-0.003	0.052	-2.051	0.960	0.050	0.575	
INFLATION	4% base	-0.039	0.056	-0.689	0.497	0.497	0.221	Fragile
	low	-0.303	0.064	-2.736	0.000	0.011	0.495	
Violence and Insecurity								
	high	-0.001	0.023	-2.055	0.957	0.049	0.582	
GTHOM	4% base	-0.026	0.027	-0.949	0.351	0.351	0.232	Fragile
	low	-0.135	0.029	-2.732	0.000	0.011	0.484	
	high	0.000	0.001	-2.049	0.961	0.05	0.531	
GTKIDNAP	1% base	-0.001	0.001	-0.788	0.437	0.437	0.225	Fragile
	low	-0.003	0.001	-2.569	0.000	0.016	0.487	
	high	0.000	0.003	-2.137	0.892	0.041	0.971	
GLIBERTY	54% base	-0.028	0.014	-2.004	0.055	0.055	0.307	Not Fragile
	low	-0.086	0.016	-3.279	0.000	0.003	0.506	
	high	-	-	-	-	-	-	
GLIFE	0% base	0.007	0.048	0.136	0.892	0.892	0.208	Fragile
	low	-	-	-	-	-	-	
	high	0.126	0.026	2.855	0.000	0.008	0.546	
GPROPERTY	4% base	0.031	0.028	1.119	0.273	0.273	0.241	Fragile
	low	0.001	0.023	2.049	0.961	0.050	0.592	
	high	0.102	0.022	2.546	0.000	0.017	0.496	
GCRIMEAVG	4% base	0.023	0.023	1.004	0.324	0.324	0.235	Fragile
	low	0.001	0.019	2.053	0.958	0.050	0.583	
Labor and others								
	high	0.252	0.052	2.796	0.000	0.009	0.450	
GFIRINGCOST	2% base	0.078	0.047	1.673	0.106	0.106	0.279	Fragile
	low	0.002	0.041	2.049	0.962	0.050	0.558	
	high	0.731	0.136	3.372	0.000	0.002	0.492	
GMANGDP	32% base	0.209	0.101	2.065	0.048	0.048	0.312	Not Fragile
	low	0.004	0.086	2.049	0.961	0.050	0.577	

%sig: number of combinations where the variable is statistically significant.
B(+/-)2stder: Max and Min extremes-Coefficient (+/-) standard deviation-.
stder: standars deviation estimated coefficient.
p-value Adj: Significance of the extreme limit.
p-value: statistical significance of the estimated coefficient used to calculate the extreme limit.

Table 2. DESCRIPTIVE STATISTICS

Variable	Obs	Mean	Std. Dev	Min	Max
cobprim	33	69,679	9,362	56,800	84,200
cobsec	33	37,352	15,766	18,000	63,400
cobsup	33	7,433	4,310	2,800	15,400
tel_installed	33	3,211,417	2,727,079	601,040	9,026,070
teledensity	33	0.073	0,049	0.024	0.175
roads	33	21,473,850	4,248,799	13,319,000	25,966,000
electricity	33	7039,602	3,651,835	2078,000	13,469,000
thom	33	45,848	19,089	21,000	78,000
credgdp	33	0.128	0.039	0.088	0.218
fdigdp	33	0.013	0.012	0.002	0.054
mgdp	33	0.099	0.028	0.072	0.153
xgdp	33	0.103	0.027	0.056	0.167
xmgdp	33	0.202	0.050	0.136	0.311
uci	33	0.715	0.030	0.637	0.750
mangdp	33	0.172	0.020	0.134	0.198
invtogdp	33	0.192	0.026	0.141	0.240
txgdp	33	0.035	0.008	0.021	0.051
defgc	33	-0.010	0.015	-0.043	0.018
defspnf	33	-0.028	0.023	-0.076	0.003
cgexptogdp	33	0.100	0.040	0.046	0.189
cginvtogdp	33	0.037	0.014	0.014	0.066

Table 3. DESCRPTION OF VARIABLES AND SOURCES

Variable	Name	Source
cobprim	Primary Schooling %	DNP
cobsec	Secondary Schooling %	DNP
cobsup	University Schooling %	DNP
tel_installed	Telephone Lines Installed	DNP
teledensity	Telephone per capita	DNP
roads	Kms of roads	DNP
roadpc	Kms of roads pc	DNP
electricity	Electricity Generation Cap	DNP
thom	Homicides per 100 thousand	DNP
credgdp	Credit to GDP	DNP-Banco de la República
fdigdp	FDI to GDP	DNP-Banco de la República
xgdp	Exports to GDP	DNP
xmgdp	Exports + Imports to GDP	DNP
txgdp	Income taxes revenues to GDP	DNP
uci	Capacity Utilization	Fedesarrollo
gdpcapdnp	GDP per capita	DNP
mgdp	Imports to GDP	DNP
mangdp	Manufacturing VA to GDP	DNP
defgc	Central Gov Deficit	DNP
defspnf	Public Sector Deficit	DNP
invtogdp	Total investment to GDP	DNP
cgexptogdp	Central Gov expenditure to GDP	DNP
cginvtogdp	Central Gov Investment to GDP	DNP
tradeopen	Imports openness index	Clavijo (2003)
itrc	Real Exchange rate index	DNP-Banco de la República

Appendix 3

TFP estimates at four digits ISIC for the manufacturing sector are obtained from the following production function,

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \varepsilon_{it} \qquad (A5)$$

Variables are in logarithms and represent production *(y)*, labor *(l)*, capital stock *(k)*, materials *(m)* and a productivity shock (ε), for sector i and time t. Estimates for parameters in *(A5)* are reported in Table 10 and TFP is obtained as,

$$TFP_{it} = y_{it} - \hat{\beta}_0 - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it} \qquad (A6)$$

Corrections for capacity utilization are obtained as,

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_e e + \varepsilon_{it} \qquad (A7)$$

$$TFP_{it} = y_{it} - \hat{\beta}_0 - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_e e_{it} \qquad (A8)$$

Table 1. RESULTS

	1	2
l	0.0466 ***	0.0485 ***
	[0.0068]	[0.0068]
m	0.8469 ***	0.8390 ***
	[0.0078]	[0.0078]
k	0.1132 ***	0.0919 ***
	[0.0076]	[0.0082]
e		0.0094 ***
		[0.0015]
Constant	0.8335 ***	0.9507 ***
	[0.0750]	[0.0765]
Observations	2403	2403
number of isic	89	89
R-squared	0,91	0,91

*significant at 10%; **significant at 5%; ***significant at 1%.
Standard errors in brackets.