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Quality management system and firm performance in an emerging economy: The case of Colombian manufacturing industries - prepared for the Institutions for Development Department

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Inter-American Development Bank
Institutions for Development Sector

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Abstract*

Over one million firms around the world have adopted a Quality Management System (QMS) that conforms to ISO 9001 certification in 2015 and recent figures show that certifications have rapidly increased in emerging economies. ISO 9001 is considered a signal of high quality for products or services in markets with large imported competition or firms competing in international markets. However, implementing ISO 9001 certification entails large costs to companies for documentation of operating procedures, training, internal auditing, and corrective action. The impact of QMS on firm performance is unknown in developing economies and is still under-researched for more developed countries. This paper takes advantage of unique data on the status of certified and non-certified manufacturing firms in Colombia (an emerging economy) and matches it with firm performance. In 2006, the Colombian government launched policies to reduce the cost of adopting certification. We use this change to implement a difference-in-differences specification on panel data of certified and non-certified firms by matching samples at the year 2003, three years before the policy change. This is the most comparable data possible. Our findings suggest that firms that adopt ISO 9001 certification increase labor productivity (measured as added value over labor) by 12 percent, and sales per employee and wages by 8 percent. The effect is larger for firms that adopted certifications two years after the new policies compared with firms that adopted them immediately. The potential mechanism to explain gains in firm performance is human capital because, prior to the changes, firms with more temporary workers could not take advantage of certification.

JEL codes: L15, D22, O31
Key words: ISO 9001, emerging economies, innovation, productivity, quality certification

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1. Introduction

A Quality Management System (QMS) that conforms to ISO 9001 certification has been adopted by many firms around the world and recent figures show that certification has rapidly increased in emerging economies. In 2015, over one million organizations had ISO 9001 certifications, of which 4.8 percent were adopted in Central and South America, a remarkable share increase compared to 1.9 percent in 2003 (ISO, 2015). This recent trend might be explained by the need for domestic firms in those economies to signal the high quality of their products or services. However, implementing ISO 9001 certifications entails large costs to companies for documentation of operating procedures, training, initial assessment, internal or external certification auditing, and corrective action. Firms incurring those costs must expect higher profits after certification. Consequently, several governments in emerging economies are implementing policies to support efficient national Quality Infrastructure (QI) systems with lower administrative costs to increase both firm productivity and aggregate productivity. In particular, several Latin American governments, such as Brazil, Colombia, Costa Rica, and Chile, promoted institutional reforms to improve or create their national QI system (Guasch, Racine, Sánchez, et al., 2007).

There is an open debate about the expected positive impact of QI, in particular QMS certification like ISO 9001, on firm performance, managerial decisions, and organizational decisions. Evidence from developed economies is still inconclusive and, for developing countries, evidence is almost non-existent. Some scholars have associated certifications, in particular those related to ISO 9001, with larger reductions in product costs (Corbett, Montes-Sancho, and Kirsck, 2005); better financial performance (Sharma, 2005); and higher rates of corporate survival as well as increasing sales, employment, and wages (Levine and Toffel, 2010). Moreover, literature has shown that certification increases revenues because quality certification allows firms to access new markets and customers (Singh, Power, and Chuong, 2011), has positive impacts on innovative behavior (Manders, de Vries, and Blind, 2016), or improves the capabilities of human capital (Lo, Wiengarten, Humphreys, et al., 2013). Contrary to these positive impacts, other studies for developed economies found that QMS certifications do not necessarily increase financial performance. Naveh and Marcus (2004) found that ISO 9001 certified electronics manufacturers did not outperform their non-certified counterparts in firm performance or regarding innovation behavior and Wayhan, Kirche, and Khumawala (2002) found no impact of ISO certification on financial performance.

Perhaps the evidence in emerging economies is scant because the high adoption of certification is relatively new and firm-level data to measure potential impacts on firm performance and behavior is still under construction. This paper is the first to show evidence of the positive impact of ISO certification on firm performance and wages in emerging economies. We take advantage of unique data available in Colombia that links the status of certified and non-certified firms with several indicators of firm performance. Colombia's manufacturing industry is an interesting case to analyze because, in the mid-2000s, the Colombian government reformed policy to create a well-functioning and integrated QI system.[1] The objective of the policy was to support enterprises operating at the national level to become more competitive in a more open economic environment.[2,3] Consequently, there was a rapid and steady increase in ISO certifications of Colombian firms that resulted in Colombia ranking in the top 15 countries around the world in 2014, with more than 14,000 ISO 9001 certifications obtained.

This explosion in adoption provides a potential source of variation to estimate the causal impact of QMS on firm performance in Colombian manufacturing firms. Taking the changes in policy that ease the costs to obtain certifications and remove obstacles to firms in obtaining them, we can claim a causal impact of those certifications on performance. We implemented a difference-in-differences specification on fixed effect panel data of a sample of certified and non-certified firms by matching comparable groups before the policy was implemented. Our empirical strategy reduced any differences in observable characteristics in the matching process before policy implementation and controlled for parallel trends in main outcomes before the large increase in adoptions of QMS certifications. Controlling for parallel trends was very important since it helped control for non-observable characteristics before policy implementation that might explain both the adoption of ISO 9001 certifications and a firm's higher performance.

We found that, on average, firms that adopted certifications in process increased labor productivity (measured as added value over labor) by 12 percent, sales per employee by around 8 percent, and wages by 8 percent, which was higher than non-

[1] The government issued CONPES 3446, a policy framework to document the general policies on QI under which different governmental institutions must implement their initiatives.
[2] Gallego and Gutiérrez (2016) present the case study of the recent QI system evolution in Colombia as a part of a research program on QI, productivity, and innovation funded by the Inter-American Development Bank to analyze the quality infrastructure in four Latin America countries: Colombia, Argentina, Costa Rica, and Chile.
[3] The national standardization body, ICONTEC, already functioned well and few changes were implemented. However, ISO certification only makes sense when organizations have access to good accreditation bodies and are confident in the assessments and auditing firms. Those pillars were very weak or lacking.

certified firms. The effects are significant and show the relevance of the government policies created to promote an institutional environment for a well-functioning QI in an emerging economy more involved in open markets. The effects are differentiated by the time the certification was achieved, with firms that certified at the end of the period (2009 and 2010) being more affected by QMS than earlier adopters (2007 and 2008). There is no evidence of any effect of technological intensity by industry or by size of firm. We found evidence that the capabilities of human capital may amplify the impact of certification on labor productivity. Firms with a larger share of temporary workers in their workforce might not receive the productivity advantage of certification, which is compatible with the idea that the organizational changes that an ISO certification demands requires a more stable workforce.

The rest of the paper is organized as follows: Section 2 presents the Colombian context. Section 3 presents the theoretical framework and the hypothesis for analysis. Section 4 presents the data used in this study and the empirical design of the matching procedure. Section 5 details the identification strategy. Section 6 presents the main econometric results. Section 7 concludes.

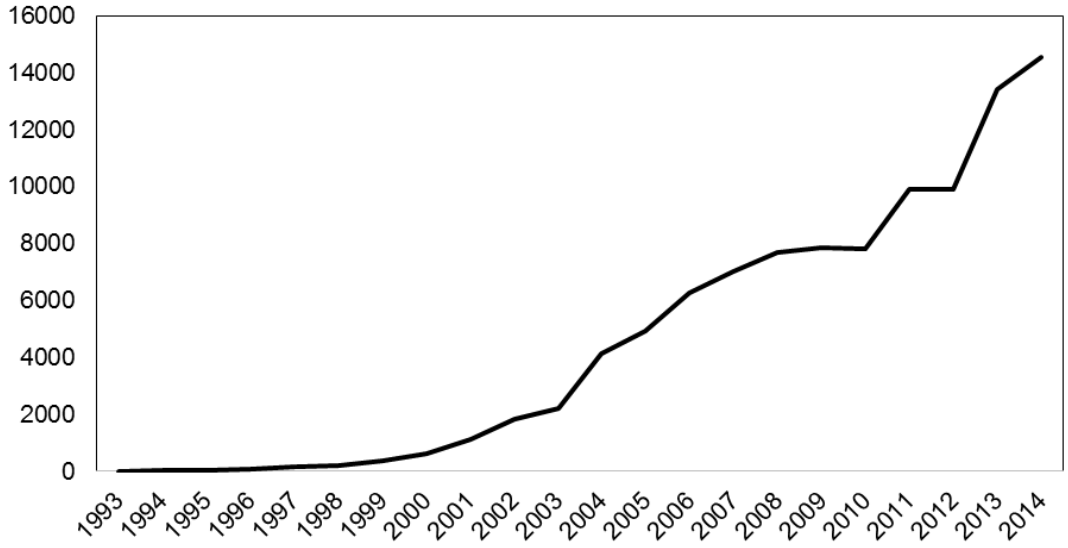
2. The Colombian Quality System: A Brief Account

For long periods, historical and political events led many developing economies to implement high import tariffs and to impose non-trade barriers, which created markets for goods and services that were protected from external competition. Within these protected markets, little attention was paid to the quality of products and services. By the 1990s, some governments in Latin America, including Colombia, started to open their economies to the international flow of goods and services (Ocampo and Ros, 2011). In most countries, those decisions were later accompanied with the signing of bilateral trade agreements. Governments in the region were aware that the infrastructure for quality was (very) poor and thus put in motion plans for reforms (Guasch, et al., 2007). The private sector was also aware that it would have to pay attention to quality issues in producing goods and began demanding quality services.

Colombia was one of the countries that lacked good infrastructure for quality. By 1993, there was no national accreditation body recognized internationally, and the metrology side of QI, although it existed, was confined within an institution that did not have enough technical capabilities. The openness of markets, the so-called *apertura económica*, started in 1991, and some bilateral and multilateral trade agreements were

signed in the 1990s and others in the 2000s (Attanasio, Goldberg, and Pavcnik, 2004). It was not until the middle of the 2000s, however, that the Colombian government launched a coherent public policy oriented toward improving the national quality system. The public policy formalized in the CONPES 3446 of 2006 set the guidelines to modernize Colombia's QI and, in our view, it has been the main signal of the government's commitment to quality. Figure 1 shows the trend in ISO 9001 certifications. There is a clear upward trend in certifications in the 2000s.

Figure 1: ISO 9001 Certifications by Colombian Organizations



Source: ISO (2015).

The launching of the new policy and the availability of data on firm certification presents a unique opportunity to test two objectives. First, from the point of view of the public policy, is whether implementing public policy to improve the country's QI is worth imitating. Second, from the perspective of private firms, is whether it pays off to be certified. In the following sections, we will try to show readers that the answer to both questions is yes. Governments should maintain their (continuous) efforts to improve their country's QI, and firms must opt to get ISO certifications.

3. Theoretical Framework and Hypotheses

Why do firms want to become certified? The International Organization for Standardization (ISO) notes that, "Certification can be a useful tool to add credibility by demonstrating that your product or service meets the expectations of your customers." To accomplish those objectives, firms must spend non-monetary resources, like time, design, and thoughts, on

the process and costs, such as contracting a registrar, incurring internal costs, and hiring external experts. The ISO website provides information about the different range of costs associated with implementing an ISO certification. The cost depends, among other things, on firm characteristics like size, and whether the firm has already implemented a quality system. The greatest cost is hiring a consultant. Costs range between US$3,600 for small firms that have a quality system to US$57,000 for large firms that do not yet have a quality system. Costs could increase depending on employee hours spent.

But, what are the benefits of being certified?

There are incentives for firms to obtain certifications. First and perhaps foremost is that being certified is a signal to the public that the firm's products or services meet expectations. Second, certification signals the organization's attitude toward quality to all of its stakeholders, particularly its workforce (Rao, Ragu-Nathan, and Solis, 1997; Arauz and Suzuki, 2004). Further, some research has found that consumers like to know that the products they buy have a signal of quality. Indeed, ISO certification can enhance brand image, which in turn influences the positive attitude of consumers, brand preference, and purchase intention (Wu and Jang, 2014). Overall, a firm will learn during the certification process, leading to better quality, lower costs and, hence, greater sales and productivity.

The conjunction of a better consumer image of a firm's product and a better process resulting from ISO 9001 certification can lead to better production arrangements that will be reflected in firm performance. Some research for developed countries has found evidence that certified firms are more successful than non-certified firms in terms of financial measures like return on assets (Corbett, Montes, Kirsch, et al., 2002; Corbett, et al., 2005; Heras, Dick, and Casadesús, 2002; Heras, Molina, and Gavin, 2011). The benefits of being certified also extend to non-financial performance indicators like growth in volume of production and productivity. Indeed, certified firms have been found to grow faster in terms of sales, productivity, employment, and wages (Terlaak and King, 2006; Levine and Toffel, 2010; Tzelepis, Tsekouras, Skuras, et al., 2006). The positive effects of firms obtaining certifications has also been researched and documented for developing countries. These have been cross-sectional studies and the main results are that having an ISO certification can contribute to larger sales (Starke, Eunni, Martins, et al., 2012) or increase a firm's propensity to export and to export on a large scale (Goedhuys and Sleuwaegen, 2016; Volpe, Castresana, and Castagnino, 2010). Furthermore, Ulla, Wei, and Xie (2014) discovered that Latin American and Caribbean firms that adopted ISO

standards found that it helped reduce their financial constraints and increase labor productivity. These findings prompted us to propose two hypotheses:

- **H1:** Labor productivity at certified firms will be higher than at non-certified firms.
- **H2:** Certified firms will have higher sales per employee.

However, the impact of certification on a firm goes beyond enhancing financial or production performance. It has also proved to impact employee careers and potentially employee remuneration. ISO 9001 is part of the more global concept of total quality management (TQM) and as such deals with organizational issues. It is widely recognized that ISO 9001 certification involves having a qualified workforce to implement all organizational changes. Research has found that, firms had to choose the types of training needed to implement ISO 9001 in the organization (Quazi and Jacobs, 2004). Therefore, a better, focused, and trained workforce is to be remunerated accordingly. In addition, implementation of TQM practices could support or strengthen employees' efforts to change work practices and, in some cases, work practices that transfer power to employees, such as high-performance work practices. One effect of being certified is being a driver of better earnings for workers (Hunter and Lafkas, 2003). For instance, Cappelli and Neumark (2001) found evidence that management practices like TQM were positively associated with employee wages. Forth and Millward (2004) also found that employees who participated or were involved in managing the workplace obtained an average premium of 8 percent over those that were not involved. More recently, Levine and Toffel (2010) also confirmed a positive causal effect of adopting ISO 9001. Specifically, they found that "annual wages grew to be about 7.5 percent higher at ISO firms than at their matches; supporting the hypothesis that adoption leads to higher wages" (p. 990). If, as some research has found, ISO 9001 implementation entails training the workforce, allowing organizational changes (i.e., new management practices) that confer power to employees, we posit the following hypothesis:

- **H3:** Obtaining an ISO certification will enhance human capital, which could positively affect wages.

4. Data

4.1. *Sample*

We constructed a unique dataset by merging two sources of information. First the Innovation Survey for Manufacturing Firms (*Encuesta de Desarrollo e Innovación Technologica*, EDIT) measures innovation behavior, innovation investments, and other

variables related to firm efforts to carry out innovation activities, as well as the core variable for this study: whether a firm has obtained a QMS certification such as ISO 9001. EDIT is a mandatory survey for firms with 10 or more employees that is done every two years. We used four surveys that span 2005 to 2010. The self-response to the question of whether the firm obtained an ISO certification is the dummy variable that proxies *ISO adoption*. In the manufacturing industry, we observed a rate of firms with ISO certification for the period 2005–10 of around 17 percent. The percentage of Colombian manufacturing firms that adopted an ISO certification is still relatively low, but increasing in recent years.

The second source—the Annual Manufacturing Survey (*Encuesta Anual Manufacturera*, EAM)—provides information on sales, added value, year of constitution (age), region where the firm is located, industry, exporter status, and workforce characteristics, among key variables. EAM data has been used extensively in research on firm productivity and exports (Roberts and Tybout, 1997; Clerides, Lach, and Tybout, 1998; Das, Roberts, and Tybout, 2007; Kugler and Verhoogen, 2012). Colombia's National Administrative Department of Statistics (*Departamento Administrativo Nacional de Estadística*, DANE) implements both surveys with manufacturing firms that have 10 or more employees. The EAM is a yearly survey that collects information from roughly 8,000 firms per year, while the EDIT is a biannual survey that collects information at the firm level for almost the same universe of manufacturing companies. All firms in both data sources have the same identifier, and we were available to merge the EDIT with the yearly data from the EAM.

After merging the two datasets, we had an unbalanced panel of 62,300 firm-year observations for 2003–10. Those firms represent around the 85 percent of the EAM and 90 percent of the EDIT observations for the period. We thus had a large enough sample to be representative of the industry for the econometric exercise and enough firms to implement the matching approach for the period before the large increase in firm certifications.

4.2. *Main Indicators*

Table 1 presents the distribution of certified and non-certified firms for 2005 to 2010. We ended with a sample of 6,125 year-firm observations with ISO certifications and 35,454 with no certification, representing an incidence of 17.3 percent. The percentage of certified firms grew from 13 percent in 2005 and 2006 to 20 percent for the years after the government started to implement the change in policy about QI, a large change in the number of adopters related with the explosion in ISO certification shown in Figure 1. To

capture the impact of ISO certification on firm performance, we considered a firm certified if it adopted certification in any year between 2007 and 2010, which are the years after implementation of the policy. Thus, our variable of interest is each firm's certification status.

Table 1: Number of ISO 9001 Certified and Non-certified Firms by Year

	Certified	Non-certified	Ratio (%)
Total	**6,125**	**35,454**	**17.3**
2010	1,255	6,454	19.4
2009	1,253	6,563	19.1
2008	1,181	5,794	20.4
2007	1,081	5,013	21.6
2006	677	5,000	13.5
2005	674	4,990	13.5

Source: EDIT-DANE.
Note: Total equals number of year-firm observations during the period.

The main outcome variables we used in the empirical exercise are value added per employee, sales per employee, and average wages. *Value added per employee* is a standard proxy for firm productivity. For each firm year, we calculated the value added per employee as the amount of real value added divided by the number of employees. To reduce the effect of potential outliers and since the sample of firms is composed mainly of small and medium firms, we took the log of this value. *Sales per employee* captures effects not directly related to firm productivity, like consumer perception about product quality. For each firm year, we calculated sales per employee as the total amount of real sales divided by the number of employees. As for value added per employee, we took the log of sales per employee to account for differences in firm size. Finally, for each firm year, we calculated *average wages* as the total real paid wages divided by the number of employees.

Table 2 presents the definitions of variables used in our analysis and their sample characteristics. The rate of adoption for the period 2005–10 was around 17 percent for the whole sample. The average firm age was 22 years, 16 percent of firms exported at least one year in the period, and 7 percent of firms had foreign capital. For the exercises, we used the initial value at the year 2000 and the average growth of rate for the period 2000 to 2003, the period before the change in policies.

Table 2: Description and Summary Statistics of Variables

Variable	Description	Mean	SD	Min	Max
Main Variables					
Adopts certification	Dummy = 1 if the firm adopted a certification this year and 0 otherwise	0.17	0.35	0	1
Added value	Total amount of value added in Colombian pesos in the year (log)	9.87	1.33	−7.36	17.0
Sales	Total amount of sales (log) in Colombian pesos in the year	10.8	1.21	1	19.44
Wages	Total average amount paid to workers as salaries and wages (log) in Colombian pesos in the year	8.2	1.94	0.2	12.86
Control Variables					
Firm size	Total number of employees in the year	82.73	220.6	10	7712
Initial firm size	Total number of employees in the first year (2000)	78.9	209.2	10	5496
Initial added value per employees	Total amount of firm's value added (log) in Colombian pesos in the first year (2000)	9.78	0.99	−0.11	14.66
Growth rate in added value per employee	% growth rate in firm's value added in Colombian pesos in the years before implementation of policy reform (2000 to 2003)	0.22	0.81	−0.99	9.6
Initial sales per employees	Total amount of firm's sales (log) in Colombian pesos in the first year (2000)	10.7	3.08	1	16.45
Growth rate in sales per employee	% growth rate in firm's sales in Colombian pesos in the years before implementation of policy reform (2000 to 2003)	0.04	0.66	−1	9.9
Initial wages	Total amount paid to workers as salaries and wages (log) in Colombian pesos in the first year (2000)	8.5	0.9	0.1	11.91
Growth rate in average wages	% growth rate in average wages paid by the firm in Colombian pesos in the years before implementation of policy reform (2000 to 2003)	0.01	0.27	−1	9.7
Age	Number of years since the firm was established	22.01	14.7	0	120
Export	Total amount of firm's export sales (log) in Colombian pesos	5.6	6.7	0	19.44
Initial export	Total amount of firm's export sales (log) in Colombian pesos in the first year (2000)	0.16	5.5	0	16.30
Growth rate in average exports	% growth rate in firm's export sales in Colombian pesos in the years before implementation of policy reform (2000 to 2003)	0.23	1.38	0	9.6
Market share	% market share the firm had in the year	0.001	0.006	0	0.49
Initial market share	% market share the firm had in the first year (2000)	0.002	0.014	0	1
Investment	Amount of investment undertaken divided by the number of employees in the year (log)	3.78	4.84	0	15.33
Initial investment	Amount of investment per employee (log) undertaken in the first year (2000)	3.27	4.73	0	13.31
Share of temporary employees	% of employees who were hired temporarily at the year	0.31	0.37	0	1
Initial share of temporary employees	% of employees who were hired temporarily in the first year (2000)	0.23	0.34	0	1
Growth rate in temporary employees	% growth rate in % of temporary employees	0.098	0.99	−1	9.90
Share of white-collar employees	% of employees who were white collar in the year	0.30	0.21	0	1
Foreign capital	Dummy = 1 if firm had foreign capital in the year	0.07	0.25	0	1

Source: EDIT-EAM DANE.

5. Identification Strategy

We performed a difference-in-differences exercise to compare the changes in valued added per employee, sales per employee, and average wages among ISO certified firms and non-certified firms. First we had to match a control group of non-certified firms.

5.1. *The Matching Sample*

Matching analysis requires a control group that shares similar characteristics to those of the treatment group. For this purpose, we needed to find non-certified firms with similar pre-adoption value added per employee, sales per employee, average wages, and other observable factors similar to firms that later certified. Certifications like ISO 9001 could correlate with our main variables of interest because of unobservable firm characteristics that might affect certification adoption as well as performance and average remunerations. For example, if firms with good management practices or good leaders are more likely to adopt ISO 9001 certifications and to implement activities that increase productivity, a linear regression model would capture a correlation better than a causal effect. If the certified status is not randomly assigned, the pool of non-certified firms is not necessarily comparable to the group of firms that obtained a certification, and we must deal with potential problems of self-selection.

The Colombian manufacturing dataset has two important advantages for our matching procedure. First, the large number of firms increases the probability of finding non-certified firms with the same characteristics as firms with ISO 9001 certifications. Second, the availability of several years of information before implementation of the reform to the quality system in Colombia (2000 to 2003) allowed us to provide evidence in favor of the main assumptions of our identification strategy in which observable characteristics can be controlled for.

We developed propensity scores by estimating a probit model for the adoption status of firms between 2007 and 2010.[4] We implemented the matching process at the year 2003, three years before implementation of the policy reform (2006). In this probit model, we included values for the three outcome variables as controls: *value added per employee*, *sales per employee*, and *average wages.* We also included initial values (at year 2000) and their growth rate for the period 2000–03. We complemented the exercise

[4] We used the Epanechnikov kernel estimator to calculate the propensity score. We implemented other matching estimators as a robustness check.

by including other important determinants like *firm size,* age, *age squared*, an *export* dummy, a dummy for *foreign capital*, an indicator of *human capital* (the white collar to blue collar ratio), the *share of temporary workers*, the value of *capital stock* (or investment), and *market share* (see Table 2 for the descriptions, sources of variables, and main statistics). Furthermore, we added 6 dummies to control for *region* and 22 for the international standard industrial classification (*ISIC*). The results of the probit are presented in column 1 of Table A1 in the Appendix, and Table 3 reports the balance test for the treatment support for ISO adoption.

The first three columns of Table 3 show that certified firms are different from non-certified firms prior to the launch of the policy reform on quality in Colombia. For all but three variables, the null hypothesis of equality of means is rejected. The results strongly support the insight that firms self-selected into the certification process. Clearly, these firms were larger, measured by the number of employees, the mean sales per employee, or the mean value added per employee; were older; were more likely to export; paid higher wages; and had larger market shares than firms that did not eventually adopt certification. Surprisingly, adopters did not have higher growth rates than non-adopters and had lower human capital. The last three columns of Table 3 show that all variables are balanced after matching and, therefore, we are confident that treated and control firms share the same characteristics—including the initial values of the main outcomes and control variables and the trends for the years before 2003—at the moment we implemented the matching procedure and three years before the CONPES reforming the quality system in Colombia was launched.

Other results in Table 3 are worth highlighting. First, the pseudo R-squared of a probit model of adopters versus non-adopters of certifications is 0.24 in the full sample, meaning that observable variables account for the adoption. The likelihood ratio test rejects the null hypothesis that the model cannot explain adoption with a p-value of zero. When we estimated the same model in the sample of matched firms, the pseudo R-squared is barely 0.007, and the test cannot reject the null hypothesis that the model does not explain certification. Overall, the findings reassure us that treated firms (i.e., certified) and control firms (non-certified) in the matched samples were very similar at the year 2003 before the Colombian government launched the policy reform of the quality system in 2006. Remaining differences can be attributed to firm adoption of certifications.

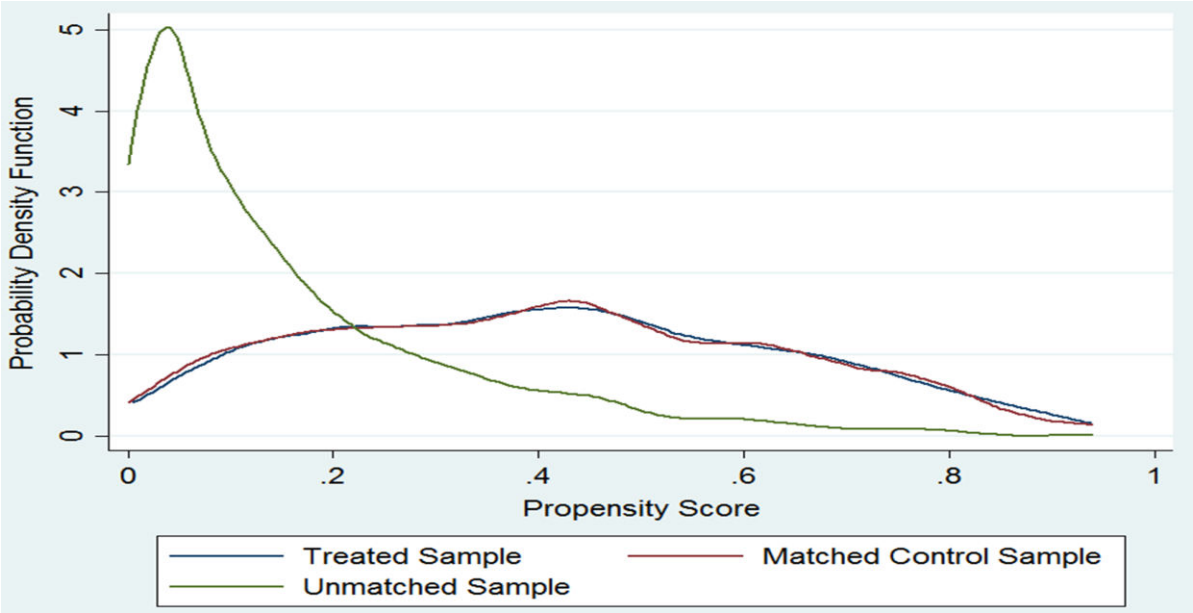
Table 3: Balance Test, Support for ISO Adoption 2007–10

	Unmatched			Matched		
Variable	**Treated**	**Control**	**Diff**	**Treated**	**Control**	**Diff**
(log) initial added value per employee	10.374	9.7073	0.667***	10.354	10.366	−0.012
(log) initial sales per employee	11.448	10.531	0.917***	11.688	11.706	−0.018
(log) initial firm size	4.1867	3.1582	1.029***	4.1633	4.1279	0.035
(log) initial wages	8.7821	8.3976	0.385***	8.7991	8.7652	0.034
Export (dummy = 1 if firm exported in the first year)	0.48331	0.20889	0.274***	0.49254	0.48293	0.01
(log) initial investment	5.9498	3.0503	2.9***	5.9114	5.9344	−0.023
Initial share of temporary employees	0.23434	0.25148	−0.017	0.23238	0.236	−0.004
Initial market share	0.00485	0.00126	0.004***	0.00481	0.00428	0.0005
Growth rate of added value before	0.18038	0.23159	−0.051**	0.17442	0.21111	−0.037
Growth rate of sales before	0.04552	0.05019	−0.005	0.04777	0.0595	−0.012
Growth rate of wages before	0.01786	0.01722	0.0006	0.00982	0.0291	−0.019
Temporary employment share before	0.09505	0.06948	0.026**	0.10457	0.11592	−0.011
(log) firm age	3.0747	2.9074	0.168***	3.0793	3.0472	0.032
(log) firm age^2	6.0458	5.6719	0.374***	6.0385	5.969	0.069
(log) firm size	4.3537	3.1603	1.193***	4.3598	4.3482	0.012
(log) firm size^2	8.7074	6.3207	2.387***	8.7197	8.6964	0.023
Export (dummy = 1 if firm exported)	0.3897	0.17188	0.218***	0.39502	0.38423	0.011
Share of white-collar employees	0.28707	0.30779	−0.021***	0.28675	0.29346	−0.007
Market share by industry	0.00335	0.00076	0.003***	0.00328	0.003	0
(log) investment per employee	6.3157	2.9353	3.38***	6.2893	6.2371	0.052
Foreign capital (dummy = 1 if FC > 0)	0.20682	0.05666	0.15***	0.19502	0.1916	0.003
Number of observations						
Pseudo R^2	0.249			0.007		
LR Chi^2	1222.9			18.12		
P > Chi^2	0.000			1.000		

Source: Authors.
Notes: *** p < 0.01; ** p < 0.05; * p < 0.1.

Figure 2 shows the propensity score distribution for 2007–10. Clearly, the distribution of the propensity scores for certified firms are (almost) equal to the distribution for non-certified firms, which indicates that the matching successfully found firms with similar propensity scores.

Figure 2: Propensity Score Matching Distribution for Certified and Non-certified Firms



Source: Authors.

5.2. *The Difference-in-Differences Treatment Effects*

To identify causal effects of certification adoption on firm performance and average wages, we assessed differences in post-policy reform trends using a difference-in-differences methodology for the full sample and for matched comparable samples. Since we used panel structure data, we were able to control for unobservable sources of bias to avoid selection problems. In this sense, we implemented a fixed-effect firm model that allowed us to control for all unobservable variables, as long as they did not vary with time. The equation is as follows:

$$Y_{it} = \alpha_i + \delta_t + \beta \cdot ISO_adoption_i + \gamma Period(2006+) + \rho DiD + \theta X_{it} + \varepsilon_{it} \quad (1)$$

where Y_{it} is the outcome of firm *i* in year *t*, α_i captures all time-constant factors that affect the outcome and are firm-specific, δ_t explains yearly shocks that affect all firms, $ISO_adoption_i$ is a dummy variable that takes the value 1 if the firm is certified (our treatment variable), $Period\ (2006+)$ is a dummy for the period 2007–10, X_{it} is a vector of time-varying control variables, DiD is the difference-in-differences estimator with ρ as our parameter of interest that measures the impact of ISO 9001 on the firm's performance and wages, and ε_{it} is the error term, which is assumed to be orthogonal to certification ($ISO_adoption_i$). The estimation of a model as posited in Equation 1 for the full sample

should control for all unobservable factors, as long as they do not vary with time. Then, the validity of the fixed-effect model rests on the assumption that trends in the outcomes would have been equal in the absence of the certification of a firm. The same specification for the matched sample allowed us to control for unobservable factors over comparable firms, making our specification strategy more credible. The X vector includes all the variables used in the matching process that varied on time.

6. Main Results

Results for the difference-in-differences evaluation of the value added per employee, sales per employee, and average wages are presented in Table 4. The table consists of three pairs of columns, each showing the impacts of firm certification on the three outcome indicators. Following the approach in the balance tests, Table 4 presents the results for 2007–10. Estimates of the difference-in-differences are lower on the matched sample than on the fixed-effect model for the three outcome variables, showing that the selection is positive if we do not control for observables on comparable samples.

Table 4: Difference-in-Differences Evaluation of Policy Reform of the National System of Quality

	Added Value (log)		Sales (log)		Wages (log)	
	FE	M	FE	M	FE	M
ISO 9001×After 2006	0.157***	0.126***	0.174***	0.0782*	0.209***	0.0792*
	(0.0203)	(0.0287)	(0.0374)	(0.0402)	(0.0335)	(0.0416)
Observations	78,111	44,294	78,111	44,294	78,111	44,294
R-squared	0.026	0.036	0.069	0.106	0.017	0.010
Number of Firms	12,076	4,578	12,076	4,578	12,076	4,578

Source: Authors.
Notes: FE: Fixed effect over the total sample. M: Fixed effect over the matching sample.
Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

Value added per employee was about 12.6 percent higher for firms that became certified than for their non-certified counterparts. Besides being statistically significant at 1 percent, the economic effect is a clear-cut message to managers and policymakers that being certified pays off and that promoting quality programs in public policy is worth doing. Regarding the impact of being certified on *sales per employee*, the result is also remarkable since it shows that certified firms had, on average, 7.8 percent higher sales than non-certified firms. Lastly, the certification process seemed to have incentivized firms to pay higher *average wages* to their employees. Table 4 shows that certified firms paid on average about 8 percent higher wages than non-certified firms.

One implication of these results is the potential link among them. Two effects are in play. On one hand, being more productive and efficient can lead to lower costs and then to potentially lower prices in more competitive environments. A certified firm can get better labor productivity measured by value added per employee. On the other hand, previous case study research has shown that consumers will pay for quality even for non-differentiated products. When consumers find out that a product has a quality seal such as an ISO certification, they are more willing to buy the product and to pay more for it. Certified firms are aware of this and can demand a higher price than their rivals. Sales can also increase. The link between firms being more productive and having lower costs, and consumers wanting quality products is unclear, and thus more research is warranted.

Certified firms pay higher wages than comparable non-certified firms. This is supported by previous research. For a developing economy that is more aggressively entering international markets, higher wages can be viewed as negative for competitiveness. However, there are also factors that together offset the cost of higher wages. First, since local and foreign consumers willingly pay more for products made by certified firms, demand for such products remain high (or at least stable). Second, in this case, Colombian firms gain some competitive advantage not only locally but also internationally. Third, firms that want to be certified have to invest in their human capital. What is recovered in terms of enhanced quality, their workers put into their day-to-day tasks. In the end, being certified pays off in terms of productivity, sales, and human capital.

6.1. *Heterogeneous Effect*

The positive and significant effects observed in Table 4 raise some questions about the time it takes for effects to result from certification. To account for those concerns, we present some heterogeneous effects on time. Although the time span after the reform was initiated is short, we split the sample into two-year pairs: 2007–08 and 2009–10. The changes associated with implementing the CONPES 3446 would likely take time to have an effect. For instance, metrology and accreditation are closely related to firm certification, and the Colombian institutions responsible for these tasks were weak or non-existent at that time. Therefore, the effects of certification in the first pair of years (2007–08) should be lower than for the next pair (2009–10). Table 5 presents the results only for the matched sample of firms. As expected, for the three outcome indicators, the effect was higher for 2009–10 than for 2007–08, in particular for sales per employee and average wages. Sales per employee were almost 12 percent higher for 2009–10 compared to 8 percent for 2007–08.

Table 5: Heterogeneous Effect by Period of Adoption

	2007–08			2009–10		
Variables	**Added Value**	**Sales**	**Wages**	**Added Value**	**Sales**	**Wages**
ISO 9001×After 2006	0.105***	0.0806***	0.0747*	0.106***	0.118***	0.0843***
	(0.0251)	(0.0297)	(0.0402)	(0.0269)	(0.0300)	(0.0306)
Observations	44,519	44,519	44,519	44,438	44,438	44,438
R-squared	0.041	0.096	0.010	0.037	0.126	0.013
Number of Firms	4,598	4,598	4,598	4,591	4,591	4,591

Source: Authors.
Notes: Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

We were also interested in seeing the potential heterogeneous effect of high- versus low-tech sector and certification on the three outcome variables. To that purpose, we divided the sample between high- and low-tech firms[5] for 2007–08 and 2009–10. The thinking was that firms manufacturing technologically demanding products would be keener to become certified since certification entails putting in practice changes to enhance quality. Table 6 presents the results. Surprisingly, we did not find any effect. The coefficients that interact treated effects with technological intensity (TECH) were not significant for either of the two periods. Thus, adoption of ISO type standards is undertaken irrespective of technological intensity. However, more research is warranted.

Table 6: Heterogeneous Effect by Technological Intensity and Size

	Added Value	**Sales**	**Wages**	**Added Value**	**Sales**	**Wages**
ISO 9001×After 2006	0.144***	0.0886**	0.110**			
	(0.0318)	(0.0415)	(0.0438)			
ISO 9001×After 2006×TECH	−0.0808	0.0786	−0.120			
	(0.0566)	(0.0808)	(0.0837)			
ISO 9001×After 2006				0.118***	0.121***	0.130***
				(0.0314)	(0.0312)	(0.0392)
ISO 9001×After 2006×Size (cont.)				−7.33e−05	−9.36e−06	−0.000209**
				(5.71e−05)	(6.65e−05)	(0.000103)
Observations	44,448	44,448	44,448	44,438	44,438	44,438
R-squared	0.036	0.103	0.011	0.038	0.127	0.016
Number of Firms	4,592	4,592	4,592	4,591	4,591	4,591

Source: Authors.
Notes: Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

[5] Eurostat groups 2-digit ISIC sectors into three broad categories based on their technological intensity: high-, medium-, and low-tech. To simplify, we used two groups: high and low technological intensity.

6.2. *Potential Mechanisms*

In this section, we explore mechanisms that may explain adoption of ISO type standards, in the direction of amplifying the impact of being certified over our outcome variables. First, we looked at firms that had exported, had innovated, or had had some share of temporary workers. The first two were not significant, but the ratio of temporary workers to total firm employees was statistically significant in differentiating the impact of being certified over firm's performance. To account for this mechanism, we regressed an interaction between the difference-in-differences estimator and the ratio of temporary workers to total workforce (see Table 7). Permanent workers are part of firm capabilities (Teece, Pisano, and Shuen, 1997; Helfat, 1997) in the sense that firm knowledge is stored in the minds of its employees. This is a cumulative dynamic process. A firm's human capital is made up of its employees, who usually have a formal and to some extent tacit long-term relationship. Clearly, firms will only invest in permanent employees. Temporary workers are generally hired to complete a specific task or to temporarily replace workers that are on leave (sick leave, vacation, etc.). There is no incentive to train temporary workers or to spend resources on them. Therefore, firms with a lower share of temporary workers would be expected to see a greater impact of being certified.

Table 7: Permanent Workers as Amplifier

	Added Value	Sales	Wages
ISO 9001×After 2006	0.192***	0.173***	0.0621**
	(0.0340)	(0.0408)	(0.0273)
ISO 9001×After 2006×TEMPO	−0.239***	−0.185**	0.0867
	(0.0700)	(0.0823)	(0.136)
Observations	44,448	44,448	44,448
R-squared	0.038	0.103	0.071
Number of Firms	4,592	4,592	4,592

Source: Authors.
Notes: Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

Table 7 shows the coefficient of the interaction term ISO 9001×TEMPO is negative, as expected. This means that firms with more temporary workers underperformed firms with a lower share of such workers. The effect is greater for productivity than for sales. The effect on wages was positive but not significant. Our conjecture is that this can be explained by the type of contract that characterizes this labor relationship, with most temporary workers being hired through a third party.

6.3. *Robustness Check*

The first concern is that some firms could have adopted ISO certifications before the Colombian reform was implemented. In fact, we observed some certified firms for the years 2005 and 2006 (see Table 1). Therefore, we ran the same specification of Equation 1 but with the treatment firms being those that were certified in 2005 and 2006. We also used a matched sample using the propensity to be a certified firm in 2005 or 2006 for the year 2003 (the probit model result is presented in the last column of Table A1 in the Appendix). The idea was to assess the causal effect of the reform. Table 8 presents the results and, for each of the main outcomes, the fixed-effect model on the full sample and on the matched sample. As expected, certification adoption is positive and significant for the full sample, which is consistent with the idea that there are non-observable firm characteristics that might explain both adoption and firm performance. However, with regressions on the model on the matched sample for comparable firms (certification and excluding firms certified after 2006) the effect disappears. Those results strongly support our evidence that the reform implemented after 2006, to promote ISO certification, increased firm performance and wages.

Table 8: Robustness of Certified Firms at 2005 and 2006

	Added Value (log)		**Sales (log)**		**Wages (log)**	
	FE	**M**	**FE**	**M**	**FE**	**M**
ISO 9001×before2006	0.143***	0.0499	0.106	-0.0865	0.258***	0.145*
	(0.0443)	(0.0573)	(0.0811)	(0.0835)	(0.0618)	(0.0859)
Observations	62,219	32,560	62,219	32,560	62,219	32,560
R-squared	0.031	0.049	0.070	0.125	0.021	0.018
Number of Firms	10,326	3,482	10,326	3,482	10,326	3,482

Source: Authors.
Notes: FE: Fixed effect over the total sample. M: Fixed effect over the matching sample.
Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

We implemented different matching estimators as a robustness check of the matching process. We changed the matching procedure to a Mahalanobis specification and k-nearest neighborhood matching. Table 9 shows that our main results are consistent with different specifications of matching estimators for the same period as the basic results.

Table 9: Robustness with Different Matching Estimators

	Mahalanobis			Neighborhood		
	Added Value (log)	Sales (log)	Wages (log)	Added Value (log)	Sales (log)	Wages (log)
ISO 9001×After 2006	0.130***	0.136***	0.0800*	0.0948***	0.136***	0.0616
	(0.0351)	(0.0350)	(0.0411)	(0.0305)	(0.0339)	(0.0400)
Observations	16,649	16,649	16,649	19,502	19,502	19,502
R-squared	0.040	0.104	0.011	0.042	0.117	0.013
Number of Firms	1,582	1,582	1,582	1,903	1,903	1,903

Source: Authors.
Notes: Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

7. Conclusions

We argue that government policy related to quality reached a turning point in 2007 when CONPES 3446 of 2006 was issued. The CONPES commanded that the changes be made but, in our view, this was just a starting point that put in motion the gear assembly of the whole Colombian quality system.

Based on two very rich datasets, we used whether a manufacturing firm had obtained a process certification as a (perhaps noisy) measure of firm quality. We used this information in a series of econometric tests and applied panel data techniques commonly used in this kind of exercise. We also used propensity score matching techniques to build comparable samples of control and treatment groups, where firms share unobservable features. Our difference-in-differences exercise showed that certified firms increase their value added per employee about 12.6 percent compared to non-certified firms. Furthermore, we found that sales per employee (a measure that we argue captures both firm and consumer perception of product quality) also grew more for certified than for non-certified firms around 7.8 percent. Additionally, certified firms paid better average wages than non-certified firms (7.9 percent).

These results verified our three hypotheses and are in accordance with findings in related research. For instance, Levine and Toffel (2010) found that, after certification, certified firms experienced annual growth in sales of about 9 percent more than non-certified firms and on average paid about 7.5 percent more annually to their employees.

Our finding that firms that adopt certifications obtain valuable benefits both in value added and sales give support to the efforts Latin American governments have recently put into strengthening their national system of quality. It is true that the more common beneficiaries of implementing reform are initially large firms, since they have the internal

capabilities to undertake investments and projects. However, the gains those large organizations obtain from implementing an ISO or other certification can be expanded to small and medium companies. For that to happen, more government support projects should be devised and implemented.

Moreover, Levine and Toffel (2010) found a very positive impact of ISO adoption. ISO and TQM programs tend to be vilified for producing benefits only for employers, with no gains for workers. We found that average wages post-reform increased in certified firms compared to non-certified firms. The improvement in remuneration seems to be a result of the (continuous) training firms that adopt certification must undertake to make the whole process successful.

As Latin American economies, in particular Colombia, strive to enter new and more demanding external markets, government support for the efforts of all kinds of organizations to carry out or implement TQM-related projects must be maintained.

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Appendix

Table A1: Probit Results of Propensity Scores

Dependent Variables: Adoption of ISO Certification in the Year

Variable	2007–10	2007–08	2009–10	2005–06
(log) initial added value per employees	0.114***	0.103**	0.0650	0.0591
	(0.0416)	(0.0443)	(0.0468)	(0.0542)
(log) initial sales per employees	0.0396**	0.0385*	0.0574**	0.0408
	(0.0198)	(0.0210)	(0.0248)	(0.0273)
(log) initial firm size	−0.219***	−0.191***	−0.0672	−0.0654
	(0.0666)	(0.0702)	(0.0719)	(0.0824)
(log) initial wages	0.181***	0.196***	0.187**	0.318***
	(0.0667)	(0.0713)	(0.0765)	(0.0901)
Export (dummy = 1 if firm exported at first year)	0.101	0.0372	0.103	0.0556
	(0.0683)	(0.0719)	(0.0842)	(0.0932)
(log) initial investment	0.0156**	0.0130*	0.00980	0.0138
	(0.00641)	(0.00694)	(0.00760)	(0.00930)
Initial share of temporary employees	0.0914	0.146*	0.0965	0.319***
	(0.0798)	(0.0849)	(0.0898)	(0.102)
Initial market share	−9.710	−4.982	−1.680	11.61
	(6.544)	(6.440)	(8.023)	(8.975)
Growth rate of added value before	0.0448	0.0206	0.0329	0.0129
	(0.0355)	(0.0392)	(0.0380)	(0.0460)
Growth rate of sales before	0.118***	0.115***	0.118***	0.109**
	(0.0373)	(0.0398)	(0.0406)	(0.0462)
Growth rate of wages before	0.267**	0.253**	0.211	−0.252
	(0.106)	(0.113)	(0.157)	(0.234)
Growth rate of temporary employment share before	−0.166*	−0.0962	0.123	0.0418
	(0.0903)	(0.0905)	(0.0810)	(0.0928)
(log) firm age	−1.717*	−1.365	0.172	0.784
	(0.912)	(0.954)	(0.735)	(0.881)
(log) firm age squared	0.823*	0.649	−0.0697	−0.305
	(0.423)	(0.443)	(0.336)	(0.404)
(log) firm size squared	0.263***	0.242***	0.177***	0.185***
	(0.0325)	(0.0345)	(0.0353)	(0.0408)
Export (dummy = 1 if firm exported)	0.0834	0.0747	0.111	0.146
	(0.0680)	(0.0708)	(0.0831)	(0.0928)
Share of white-collar employees	−0.177	−0.0915	−0.0754	−0.00468
	(0.131)	(0.141)	(0.147)	(0.172)
Market share by industry	21.50**	8.539	1.668	−17.10
	(9.942)	(9.728)	(12.59)	(14.38)
(log) investment per employee	0.0335***	0.0337***	0.0312***	0.0377***
	(0.00635)	(0.00698)	(0.00798)	(0.0101)
Foreign capital (dummy = 1 if FC > 0)	−0.118	−0.163*	−0.0861	−0.193**
	(0.0844)	(0.0859)	(0.0902)	(0.0970)
Observations	4,748	4,728	4,598	4,567

Source: Authors.
Notes: Standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.