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S&P 500 UNDER A STRUCTURAL MACRO-FINANCIAL MODEL*

S&P 500 BAJO UN MODELO MACROFINANCIERO ESTRUCTURAL

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Abstract

In this paper, we propose a macro-financial model that combines a semi-structural, medium-term macroeconomic model with the Dynamic Gordon Model or DGM (Campbell and Shiller, 1988). The proposed framework allows us to analyze the relationship between the output gap, inflation, short-term interest rate, and stock market indicators: price, dividend, and volatility. We estimate the model for the US economy using Bayesian techniques on quarterly data from 1984 to 2020. The decomposition of the unconditional variance of the variables shows that (i) demand shocks are relevant for most macroeconomic variables and stock prices; (ii) supply shocks affect inflation mainly; (iii) shocks to the price-dividend ratio account for around 12%, 5% and 16% of the variability of the output gap, inflation, and interest rates, respectively; and (iv) the DGM mechanism helps to cushion the effects of an interest rate shock and increases the speed of convergence of all macroeconomic variables after an inflation shock, compared to a standard, semi-structural model, reflecting in this manner the importance of stock prices on the dynamics of macroeconomic variables.

* We thank the helpful comments of participants at an internal seminar at the Financial Stability Area of the Central Bank of Chile, as well as two anonymous referees. The opinions expressed herein are those of the authors and do not necessarily represent the views of the Central Bank of Chile or its Board members. All remaining errors are our own.

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JEL Classification: *C11, E12, E17, G12.*

Resumen

En este artículo proponemos un modelo macrofinanciero que combina un modelo macroeconómico semiestructural de mediano plazo con el Modelo Dinámico de Gordon o MDG (Campbell y Shiller, 1988). El marco propuesto permite analizar la relación entre la brecha de producto, inflación, tasa de interés de corto plazo, e indicadores del mercado de valores como precio, dividendos, y volatilidad. Estimamos el modelo utilizando técnicas bayesianas con datos trimestrales de EE.UU. desde 1984 a 2020. La descomposición de la varianza incondicional de las variables revela que (i) shocks *de demanda son relevantes para la mayoría de las variables macroeconómicas y el precio de las acciones; (ii)* shocks *de oferta afectan principalmente a la inflación; (iii)* shocks *al ratio precio-dividendo representan cerca de 12%, 5% y 16% de la variabilidad de la brecha de producto, inflación y tasas de interés, respectivamente; y (iv) el mecanismo MDG ayuda a amortiguar los efectos de* shocks *a la tasa de interés e incrementa la velocidad de convergencia de todas las variables macroeconómicas luego de un* shock *de inflación, respecto de un modelo semiestructural estándar, lo que refleja la importancia del precio de las acciones respecto de la dinámica de variables macroeconómicas.*

Palabras clave: *Modelo neokeynesiano, valoración de activos, estimación bayesiana, ciclos económicos.*

JEL Clasificación: *C11, E12, E17, G12.*

I. INTRODUCTION

Gordon (1962) model is widely used for evaluating stock prices. The static version of this model provides a closed-form solution for the intrinsic value of a stock, which is determined by three key elements, namely future dividend payments, the dividend growth rate, and the relevant interest rate. However, the assumptions required for achieving the static version of the model are not realistic, neither useful for proper dynamic analysis. In this sense, Campbell and Shiller (1988) provide an alternative version, which is based on a first-order approximation of the log stock return. This alternative is known as Dynamic Gordon growth Model (DGM), and it

has been applied to the US stock market to decompose the impact of dividend growth and interest rates over stock returns (Campbell and Ammer, 1993), or to analyze the impact of changes in monetary policy on equity prices (Rigobon and Sack, 2003; Bernanke and Kuttner, 2005), among other empirical applications. Nevertheless, the DGM lacks key macroeconomic variables such as output growth or inflation rate. In that sense, Blanchard (1981) provides a theoretical model in which output gap, stock prices, and interest rates are included. It extends a standard IS-LM model by adding long-term interest rate and equity; however, risk premium is zero.

In this article, we propose to enrich the DGM with a rational expectations New-Keynesian macroeconomic model composed by an aggregate demand equation (or IS curve), an aggregate supply equation (or Phillips curve), and an equation that describes the dynamics of the short-term interest rate. Extending a structural macroeconomic model with asset pricing component is in line with others efforts documented in the literature. For example, Berkaert, Cho and Moreno (2010) extend a standard New Keynesian model with a non-arbitrage Affine Term Structure model; meanwhile Gray *et al.* (2010) introduce financial risk indicators into a structural macroeconomic model.

Based on data for the US economy, we estimate our model's parameters using quarterly data from 1984 to the third quarter of 2020. The estimation poses some challenges that we discuss in detail. In particular, the close-to-non-stationary dynamic of the price-dividend ratio suggests that results based solely on empirical approaches, such as VAR, should be taken with caution and given that we use Bayesian techniques. Overall, the estimated model provides a good representation of crucial variables' dynamics, although some sample moments related to the inflation rate are over-estimated. The decomposition of the variables' unconditional variance in the proposed model shows that demand shocks are relevant for both the output gap and interest rates, explaining 48% to 82% of the total variance, respectively. Meanwhile, supply shocks affect inflation mainly. Finally, shocks to the price-dividend ratio account for roughly 12%, 5%, and 16% of the fluctuations in the output gap, inflation, and interest rates, respectively. The impulse-response analysis shows that, relative to an otherwise standard semi-structural macroeconomic model, the DGM mechanism helps to cushion the effects of an interest rate shock and increases the speed of convergence of all macroeconomic variables after an inflation shock. Hence, these results highlight the importance of stock prices on the dynamics of macroeconomic variables.

The article is organized as follows. Section II presents the model, and Section III introduces the US aggregate variables used in the estimation of our model. Section IV shows estimation results under a Bayesian approach, and Section V concludes.

II. MODEL SETUP

The model consists of a set of four equations that we describe in detail in this section. The first three equations describe macroeconomic variables such as output

gap, inflation, and the short- term interest rate. The last equation, on its part, defines the stock price dynamics. For simplicity, we assume that all variables are expressed as linear approximations around their long-run trends. Thus, they are all demeaned or de-trended.

The first equation is aggregate demand, or IS curve, establishes that output gap (y_t) is a function of a mixed backward-forward specification, which allows for both inter-temporal optimization and some degree of inertia. The short-term real interest rate (r_t) has a negative impact on output gap through the investment channel, whereas the log P-D ratio (z_t) captures the positive impact of investment opportunities on y_t. Thus,

$$y_t = \lambda_0 y_{t-1} + (1-\lambda_0) E_t(y_{t+1}) - \lambda_1 r_t + \lambda_2 z_t + u_{1t} \quad (1)$$

where u_{1t} is a structural aggregate demand shock. The lag and lead parameters of the output gap are forced to sum up to one, which is a standard constraint applied in practice to reduce the number of parameters.

Second equation is the aggregate supply or a hybrid Phillips curve, where the inflation rate (π_t) is a rational expectations solution with inertia given by

$$\pi_t = \delta_0 \pi_{t-1} + (1-\delta_0) E_t(\pi_{t+1}) + \delta_1 y_t + u_{2t} \quad (2)$$

where u_{2t} is a structural aggregate supply shock. As in the case of equation (1), we consider the same constraint on the lag and lead parameters of π_t .

To complete the macroeconomic model, we include a third equation for the short-term interest rate (i_t). This equation relates the short-term interest rate with its own lag, the expectations about future inflation, and the output gap, as follows:

$$i_t = \kappa_0 i_{t-1} + \kappa_1 E_t(\pi_{t+1}) + \kappa_2 y_t + u_{3t} \quad (3)$$

where u_{3t} is a structural short-term interest rate shock. It should be noted that we do not impose any particular restriction on the parameters of this equation. Further, in our empirical application, we use the Wu and Xia (2016) shadow rate because, after the Global Financial Crisis of 2007-2008, short-term risk-free rates in the US were truncated at 0%, an episode known as the Zero Lower Bound period[1]. Also, the short-term real interest rate is defined as follows: $r_t \equiv i_t - E_t(\pi_{t+1})$.

Finally, we consider a dynamic pricing equation that relates stock prices with expected future dividend payments in a similar way than Campbell and Shiller (1988). We use a log-linear approximation of the log stock return (x_{t-1}), which is the

[1] As a robustness check exercise, we conducted all our estimations using an alternative short-term: high-quality corporate bond rate. The results are similar to those presented in this paper; hence they are not reported.

following: $x_{t+1} = k + \rho p_{t+1} + (1-\rho) d_{t+1} - p_t$, where p_t is the log of stock price and d_t is the log of dividend payments, both in real terms, and k and ρ are parameters of the Taylor approximation. In particular, the parameter ρ is related to the long run level of the price-dividend (P-D) ratio.

Ignoring constant terms ($k = 0$), we have the following ex-ante equation for the log of the stock price: $p_t = d_t + \rho E_t\left(p_{t+1} - d_{t+1}\right) + E_t\left(\Delta d_{t+1}\right) - E_t(x_{t+1})$. Further, we assume that dividends are related to the real economy as $E(\Delta d_t) = \theta_2 y_t$, meanwhile the log stock return is related to the short-term interest rate and to some risk premium as $E\left(x_{t+1}\right) = \theta_3 r_t + \theta_4 h_t$, where h_t is the log of VIX that characterizes the risk premium in the model. Taking these elements and $z_t = p_t - d_t$ as the log P-D ratio, we have the following equation: $z_t = \rho E_t\left(z_{t+1}\right) + \theta_2 E_t\left(y_{t+1}\right) - \theta_3 r_t - \theta_4 h_t$. However, various related studies have documented a high persistence of the P-D ratio in small samples (see Lettau and van Nieuwerburgh, 2008; Chevillon and Mavroeidis, 2018; Golinski, Madeira and Rambaccussing, 2018; among others). Thus, to incorporate some degree of inertia, we consider a hybrid version of the previous equation instead:

$$z_t = \theta_0 z_{t-1} + \theta_1 E_t\left(z_{t+1}\right) + \theta_2 E_t\left(y_{t+1}\right) - \theta_3 r_t - \theta_4 h_t + u_{4t} \tag{4}$$

where u_{4t} is a structural shock to the log P-D ratio. To complete the model, we assume that each structural shock follows an uncorrelated, zero-mean AR(1) process as

$$u_{it} = \rho_i u_{i,t-1} + \sigma_i v_{it} \tag{5}$$

for all $i = 1,\ldots 4$, and v_{it} is a zero-mean, unit-variance shock. Also, we assume that h_t follows an AR(1) process[2].

III. DATA

We consider six US aggregate variables in quarterly frequency that span the period from 1984q1 to 2020q3: output gap, annualized quarterly inflation rate, risk premium proxied by the log of the VIX, short-term shadow interest rate, stock prices, and dividends per share (Table 1). We demean all variables to be consistent with the model described previously.

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[2] The specification of our structural model implies that its reduced-form representation follows a VAR(2) process. See the Appendix for more details.

TABLE 1

DATA DESCRIPTION AND SOURCES

Variable	Description	Source	Observations
y	Output gap	FRED	HP-filtered real GDP with $\lambda = 1{,}600$
π	Inflation rate	FRED	Annualized quarterly growth of CPI
h	Risk premium	FRED	Log of VIX
i	Wu and Xia (2016) shadow rate	FRBA	Annual rate
p	Price	Robert Shiller's webpage	Log of S&P 500 index divided by CPI
d	Dividend	Robert Shiller's webpage	Log of dividends per share divided by CPI

FRED stands for to the Federal Reserve Economic Data of the Federal Reserve Bank of Saint Louis; FRBA stands for the Federal Reserve Bank of Atlanta; GDP stands for Gross Domestic Product; CPI stands for Consumer Price Index; VIX stands for Chicago Board Options Exchange Market Volatility Index.

In particular, we compute the output gap (y_t) as the difference between real GDP and its HP-filtered trend component, where the smoothing parameter was set equal to 1,600. The inflation rate (π_t) is the annualized quarterly variation of the Consumer Price Index, whereas our measure of risk premium (h_t) is the log of the VIX. Since this variable is available from 1990q1, we extended the series back to 1984q1 by estimating a GARCH(1,1) model on monthly stock returns. Then, we relate the VIX with the one-month-ahead predicted standard deviation to account for the former variable being the 30-day expected volatility of the S&P 500 returns.

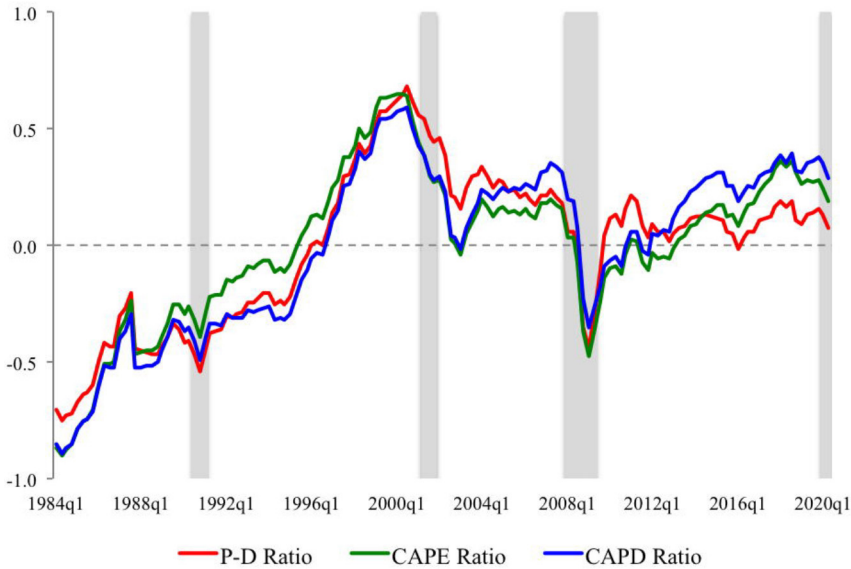
The short-term interest rate (i_t), on its part, corresponds to the shadow rate proposed by Wu and Xia (2016). Unlike the observed short-term interest rate, the shadow rate is not bounded below by 0%. In particular, it is the implicit 1-month interest rate based on a truncated Gaussian non-arbitrage affine term structure model. Moreover, when the shadow rate is positive and above 0.25%, it is equal to the Effective Federal Funds Rate.

Further, the price-dividend ratio (z_t) corresponds to the difference between the S&P 500 index and dividends per share (both in real terms and logarithms) [3]. However, it is common in the financial industry to use an alternative measures by considering the price-earnings ratio, where earnings per share are smoothed over a moving window of ten years. This alternative measure of price pressures is called the Cyclical-Adjusted Price to Earnings (CAPE) ratio. Figure 1 shows the P-D along with CAPE and the

[3] The dataset is the same as in Shiller (1989) and is available online for download.

FIGURE 1

COMPARISON OF ALTERNATIVE PRICE RATIOS



All variables are detrended. P-D, CAPE, and CAPD stand for price to dividend, cyclical-djusted price to earnings, and cyclical-adjusted price to dividend, respectively. All variables are detrended. Shaded areas correspond to recession periods, as defined by the National Bureau of Economic Research (NBER).

Cyclical-Adjusted Price to Dividend (CAPD) ratios, the latter being the traditional price-dividend ratio but with dividends per share smoothed over a moving window of ten years, all in logs. Note that, before the 2007-2008 Global Financial Crisis period, all three indicators behave similarly. However, after that event, the smoothed ratios tend to exhibit a positive trend, in sharp contrast with the P-D ratio that remains relatively stable. This result suggests that CAPE and CAPD are strongly affected by the crisis period, where both earnings and dividends per share decreased significantly.

In our sample, there is a declining trend in the short-term interest rate being below its average during the last decade (Figure 2). Although this trend reverted starting in 2014, the COVID-19 pandemic implied further decreases in the interest rate to stimulate the economy. On the other hand, the price-dividend ratio has an increasing trend before 2000, followed by some mean-reversion, and a significant drop during the Global Financial Crisis of 2007-2008. Interestingly, the P-D ratio remained relatively unchanged during the recent coronavirus pandemic, and the dividend growth rate decreased by a considerably smaller magnitude compared to its dramatic fall –around

FIGURE 2
OBSERVABLES FOR THE DYNAMIC GORDON MODEL

Shaded areas correspond to recession periods, as defined by the National Bureau of Economic Research (NBER).

30% below its historical average– during the Global Financial Crisis period. Lastly, the risk premium measure has a sharp upsurge during the Global Financial Crisis and the COVID-19 worldwide outbreak.

IV. BAYESIAN ESTIMATION

4.1. Posteriors

Several parameters of the model are standard in the monetary policy literature. Thus, we draw priors for this set of parameters from the Beta, Normal, and Inverse Gamma distributions. The prior mean was set equal to the related literature's calibrated values, and we choose the prior standard deviations to contemplate plausible ranges for the parameters. In particular, we consider the calibration used by Fuhrer (2010) to study inflation persistence in the US economy. More precisely, for the case of the IS equation, we set $\lambda_0 = \delta_0 = 0.5$, which provides a balance between backward- and forward-looking dynamics of the output gap and inflation. Also, we use $\lambda_1 = \delta_1 = 0.1$, although, in practice, it is possible to have lower magnitudes. In the case of λ_2, we assume that the P-D ratio has a similar impact on the output gap than the short-term interest rate. For the short-term interest rate equation, we use $\kappa_0 = 0.8$, $\kappa_1 = (1-0.8)\times 1.5 = 0.3$, and $\kappa_2 = (1-0.8)\times 0.5 = 0.1$. For the price-dividend equation, we consider $\theta_0 = 0.05$ and $\theta_1 = 0.8$. There is no empirical counterpart for θ_2, θ_3, and θ_4. Thus, we use 0.5. Finally, we assume for simplicity that $\rho_i = 0.5$ and $\sigma_i = 0.005$ for all structural shocks and the dynamics of h_t.

Table 2 reports the mode, the mean, and the 90% probability interval related to the posterior distribution of the model's structural parameters obtained by the Metropolis-Hastings algorithm with 10,000 replications. Several aspects are worth highlighting from this table. First, the posterior mean of the IS curve parameters is somewhat similar to the standard calibrations in semi-structural DSGE models. The mean sensitivity of the output gap to variations of the short-term interest rate is estimated to be 0.17, close to the calibrated value. In contrast, the lag parameter of this curve is about half of its prior mean, while the output gap is almost insensitive to variations of the P-D ratio. Second, the estimated parameters of the hybrid Phillips curve reveal a forward-looking behavior of inflation. Further, our results also show that the output gap has relevant effects on inflation, which is roughly 60% larger than its calibrated value. Third, the posterior mean of the parameters associated with the equation for the short-term interest rate shows an important backward-looking component consistent with the downward trend exhibited by the shadow rate during the whole sample (Figure 2). Also, the point estimate of the parameter k_1 is around 1.6 times larger than its calibrated value, implying that the short-term interest rate is very sensitive to expected inflation fluctuations. Lastly, the estimates related to the pricing equation support the idea that there exists an interaction between the output gap and the stock market. In particular, the posterior mean of θ_2 is close to 0.38, suggesting that the P-D ratio reacts to changes in the expected value of future output growth.

TABLE 2

POSTERIOR ESTIMATE OF MODEL PARAMETERS

Parameter	Prior Distribution			Posterior Distribution		
	Distrib.	Mean	Std. Dev.	Mode	Mean	90% PI
λ_0	Beta	0.500	0.100	0.214	0.229	[0.214, 0.253]
λ_1	Beta	0.100	0.050	0.170	0.156	[0.140, 0.176]
λ_2	Beta	0.100	0.050	0.017	0.018	[0.012, 0.023]
δ_0	Beta	0.500	0.100	0.130	0.111	[0.091, 0.130]
δ_1	Beta	0.100	0.050	0.164	0.162	[0.148, 0.171]
k_0	Beta	0.800	0.150	0.912	0.920	[0.903, 0.943]
k_1	Beta	0.300	0.100	0.465	0.465	[0.424, 0.499]
k_2	Beta	0.100	0.050	0.092	0.098	[0.072, 0.118]
θ_0	Beta	0.050	0.010	0.045	0.049	[0.044, 0.054]
θ_1	Beta	0.800	0.050	0.883	0.879	[0.867, 0.890]
θ_2	Normal	0.500	0.150	0.383	0.364	[0.299, 0.414]
θ_3	Normal	0.500	0.150	0.388	0.383	[0.347, 0.428]
θ_4	Normal	0.500	0.150	0.042	0.044	[0.032, 0.055]
ρ_1	Beta	0.500	0.200	0.965	0.962	[0.945, 0.978]
ρ_2	Beta	0.500	0.200	0.046	0.084	[0.056, 0.113]
ρ_3	Beta	0.500	0.200	0.448	0.461	[0.377, 0.551]
ρ_4	Beta	0.500	0.200	0.964	0.958	[0.939, 0.979]
ρ_h	Beta	0.500	0.200	0.801	0.796	[0.731, 0.855]
σ_1	Inv. Gamma	0.005	∞	0.002	0.002	[0.002, 0.003]
σ_2	Inv. Gamma	0.005	∞	0.015	0.015	[0.013, 0.018]
σ_3	Inv. Gamma	0.005	∞	0.005	0.005	[0.005, 0.006]
σ_4	Inv. Gamma	0.005	∞	0.006	0.006	[0.005, 0.008]
σ_h	Inv. Gamma	0.005	∞	0.190	0.192	[0.176, 0.214]

The posterior distribution was obtained using the Metropolis-Hastings algorithm with 10,000 replications. PI stands for probability interval.

4.2. Moment Comparison

To evaluate our proposed model's performance, we compare some key sample moment conditions of the output gap, inflation, the P-D ratio, the short-term interest rate, and the measure of risk premium, with their corresponding moments derived from the estimated model. In particular, we focus our attention on the volatility, the first-order autocorrelation, and the cross-correlation between these variables.

Table 3 shows the results of our estimations for the baseline model and a specification without the DGM mechanism[4]. Overall, we note that the model can capture several

[4] The specification without the DGM mechanism considers equations (1) to (3) plus the AR(1) process for the structural shocks only and shuts-down the z_t process in the IS curve. In other words, this specification is simply a standard, semi-structural macroeconomic model.

TABLE 3

MOMENT COMPARISON

Moment	Point Estimate	Std. Err.	Baseline		No DGM	
			Model Moment	|z|-stat	Model Moment	|z|-stat
σ_y	0.013	0.001	0.017	3.23	0.021	5.59
σ_π	0.020	0.001	0.022	4.49	0.021	3.32
σ_z	0.332	0.024	0.286	1.94		
σ_i	0.032	0.003	0.038	2.15	0.010	8.87
σ_h	0.336	0.022	0.323	0.58		
$\varphi_y(1)$	0.648	0.064	0.774	1.97	0.809	2.51
$\varphi_\pi(1)$	0.314	0.078	0.383	0.88	0.462	1.89
$\varphi_z(1)$	0.968	0.016	0.943	1.61		
$\varphi_i(1)$	0.980	0.013	0.989	0.69	0.937	3.24
$\varphi_h(1)$	0.823	0.047	0.802	0.45		
$\varphi_{y,\pi}$	0.321	0.079	0.532	2.69	0.414	1.18
$\varphi_{y,z}$	0.037	0.083	0.125	1.07		
$\varphi_{y,i}$	0.377	0.077	0.259	1.54	-0.482	11.2
$\varphi_{y,h}$	-0.155	0.082	-0.179	0.30		

σ denotes volatility, $\varphi(1)$ denotes first-order serial correlation, and $\varphi_{a,b}$ denotes the cross-correlation between variables *a* and *b*. Model moments based on the posterior mean of the estimated parameters.

univariate and multivariate dynamic behavior of the endogenous variables mentioned before. For instance, in our dataset, the price-dividend ratio is about 25 times more volatile than the output gap. In comparison, the estimated model delivers a P-D ratio that is roughly 17 times more volatile, although this difference is not statistically relevant at standard significance levels. Analogously, the sample autocorrelation of the output gap and the P-D ratio and the cross-correlation between them is close to 0.65, 0.97, and 0.04, respectively, whereas the estimated model predicts values for these statistics of around 0.77, 0.94, and 0.13. However, the model fails to replicate some moments related to the inflation rate. More concretely, the volatility of π and the correlation between y and π predicted by the estimated model are significantly above their sample counterparts.

From the previous table, we also note that incorporating the DGM mechanism into an otherwise standard, semi-structural macroeconomic model improves the overall fit to data. In particular, when this mechanism is not present, then several moments of the short-term interest rate and inflation move away from their sample counterparts. For example, the volatility of i predicted by the model without the DGM channel is about one-third of that in the data, its first-order autocorrelation becomes smaller compared to the baseline model, and the cross-correlation between this variable and output gap turns negative. In the case of inflation, the model without DGM generates

a significantly higher persistence of π. However, its volatility and cross-correlation with the output gap are closer to their sample counterparts than the proposed model.

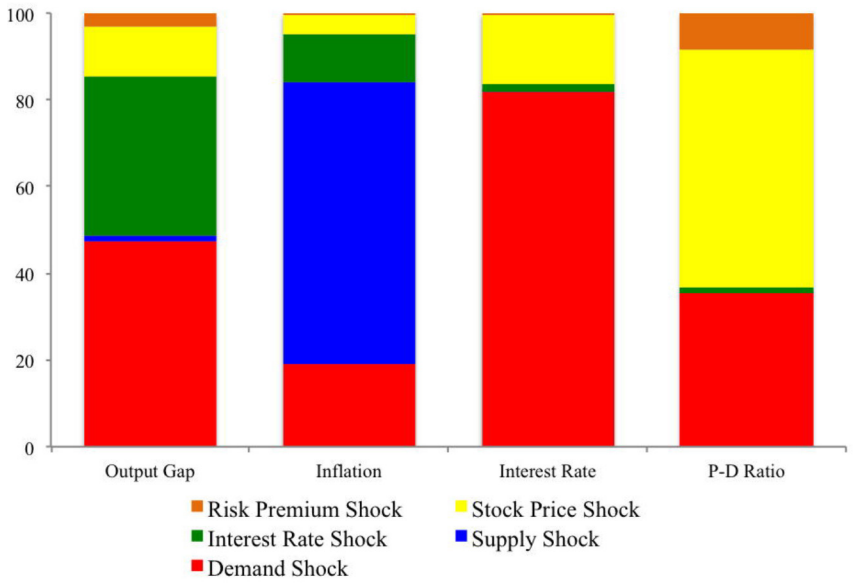
4.3. Variance Decomposition

Figure 3 shows the decomposition of the unconditional variance of the output gap, inflation, the short-term interest rate, and the price-dividend ratio based on the mean of the model posterior distribution shown in Table 2.

From this figure, we note that demand, interest rate, and stock price shocks drive the output fluctuations, thus reflecting the importance of this variable's dynamics and the importance of stock prices and interest rates on aggregate demand through consumption and investment. A similar situation occurs when decomposing movements in the shadow rate, which are propelled mainly by demand and stock price shocks and, to a lesser extent, by interest rate shocks. In the case of supply shocks, they are more relevant to inflation in general. Their incidence is about 65% of the total variance due to the instead forward-looking nature of this variable. Finally, in the case of the P-D ratio, roughly 55% of all variations are explained by stock price shocks, while demand shocks account for about 35% of the total variance. To understand this

FIGURE 3

UNCONDITIONAL VARIANCE DECOMPOSITION



result, we should look at the prior and posterior mean of θ_2. From our estimations, the sensitivity of the price-dividend ratio to changes in the expected value of future output gap is smaller than its prior value, which is in line with the fact that, previous to the Global Financial Crisis of 2007-2008, episodes of positive output gaps tend to coincide with stock market expansions.

4.4. Impulse Response Functions

Figure 4 shows the results for a set of key Impulse-Response Functions (IRFs) under our baseline model (blue lines) and under the model without the DGM mechanism (green lines).

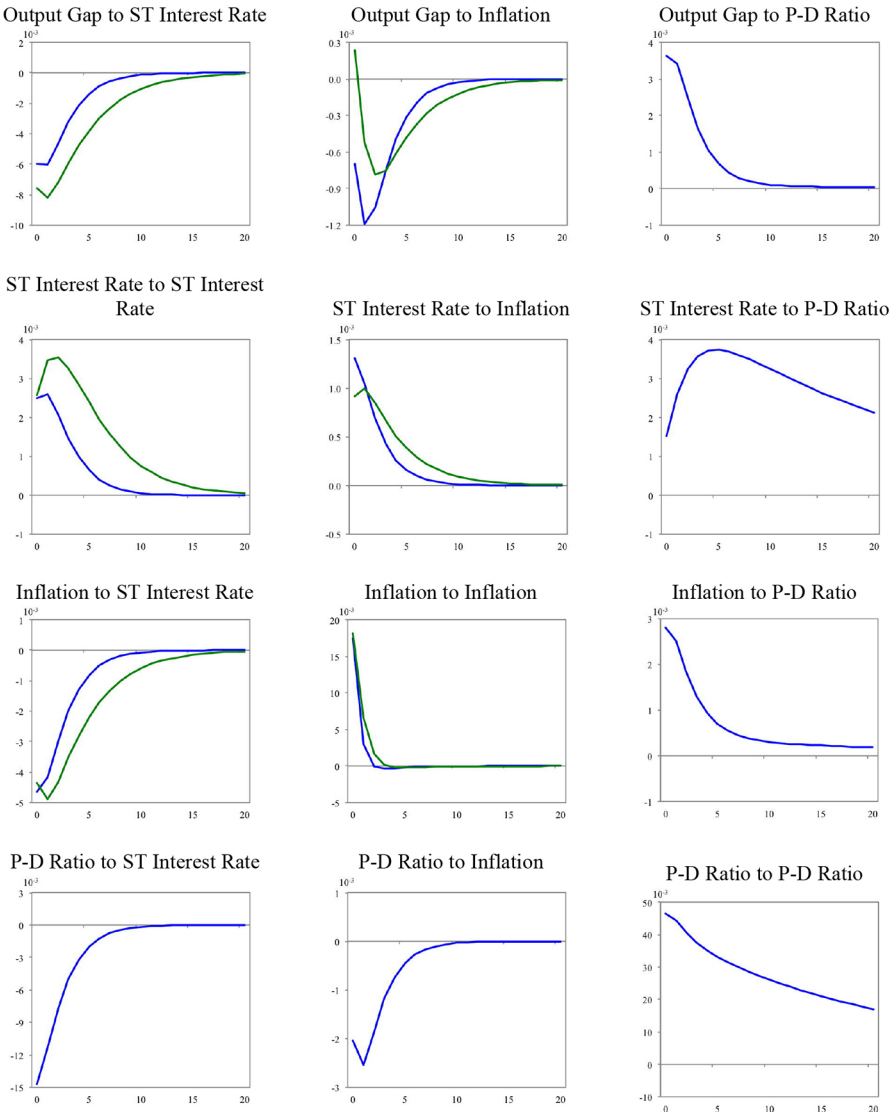
The first column of this figure shows the impact of an unanticipated increase in the short-term interest rate, reducing the output gap, inflation, and the price-dividend ratio in the short run. The impact on the stock market is driven by both the output gap effect and the discounting effect. In the former case, it is clear that the higher interest rate will deteriorate the output gap for several periods through the investment channel, which in turn will narrow the growth rate of dividends and hence the P-D ratio. In the second case, the higher short-term interest rate and lower expectations about future inflation imply a higher rate at which future dividend payments are discounted. Therefore, the price-dividend ratio will fall below its steady-state value for several periods. Further, note that the DGM mechanism tends to cushion the interest rate shock because, in the absence of this mechanism, the investment channel's magnitude (λ_1) is closer to its traditional calibration value. Hence the output gap and, ultimately, inflation reacts less to this shock.

The second column of Figure 4 shows that a positive inflation shock will worsen both the output gap and the P-D ratio. This shock can be related, for instance, to an increase in oil prices, thus implying an inverse relationship with stock prices given the predominance of the real activity channel in the short-run. However, in the medium-run, the discounting effect becomes more relevant. Thus, the price to dividend ratio will increase because the short-term real interest rate is still below its steady-state value. In this context, stock prices return to their long-run value in about ten quarters after the shock occurred. We also note that when the DGM channel is not present, the short-term interest rate's sensitivity to expected inflation is about one-third of its estimated value under the baseline model. In this way, inflation rises more than proportionally. Consequently, the short-term real interest rate falls below its steady-state value and positively stimulates the output gap in the short-run. However, the speed of convergence to the long-run equilibrium values is slower than in the baseline model because of the absence of the discounting effect that positively affects the P-D ratio and the output gap in the medium-run.

Lastly, the third column of Figure 4 reports the impact of a positive, one-standard-deviation shock in the price-dividend ratio equation. This shock can be viewed, for example, as an increase in the risk appetite of investors. The positive shock in the

FIGURE 4

IMPULSE-RESPONSE FUNCTIONS



Response of each variable to a one-standard-deviation shock under the baseline model (blue lines) and no DGM model (green lines).

P-D ratio will stimulate aggregate spending and the output gap through consumption and investment (Blanchard, 1981). Specifically, in the former case, since stock shares are part of the wealth, a higher valuation of the stock market will positively affect consumption. In the latter case, a larger price-dividend ratio will boost the value of capital in place relative to its replacement cost, hence expanding investment.

V. CONCLUSIONS

This article extends the Dynamic Gordon growth Model (DGM) with a medium-term, semi-structural macroeconomic model. Thus, the proposed four-equations framework allows us to analyze the relationship between the output gap, inflation, stock price, and interest rate. The parameters of the model are estimated using Bayesian techniques. The decomposition of the unconditional variance of the model variables, evaluated in the posterior means, shows that demand shocks are relevant for both macroeconomic variables and stock prices. Moreover, shocks to the price-dividend ratio account for around 12%, 5%, and 16% of the variability of the output gap, inflation, and interest rates, respectively. The impulse-response analysis shows that, relative to an otherwise standard semi-structural macroeconomic model, the DGM mechanism helps to cushion the effects of an interest rate shock and increases the speed of convergence of all macroeconomic variables after an inflation shock. Hence, these results highlight the importance of stock prices on the dynamics of macroeconomic variables.

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APPENDIX

A.1. Reduced-form Representation

Let $X_t = (y_t, \pi_t, i_t, z_t, h_t)'$ be the vector of all endogenous variables of the model, and $U_t = (u_{1t}, u_{2t}, u_{3t}, u_{4t}, u_{ht})'$ the vector of structural shocks. With these definitions, the model can be written in matrix form as follows:

$$AX_t = BE_t(X_{t+1}) + CX_{t-1} + U_t \tag{A.1}$$

where the matrices Λ, *B*, and *C* contain structural parameters. We can take a structural VAR (SVAR) of order one as a candidate solution for expression (A.1):

$$X_t = PX_{t-1} + QU_t \tag{A.2}$$

where *P* is assumed to have all its eigenvalues inside the unit circle. The solution for *P* and *Q* depends on the structure of U_t. In our case, we assumed that each structural shock follows an AR(1) process. Hence

$$U_t = RU_{t-1} + SV_t \tag{A.3}$$

where *R* accounts for the persistence of the shocks (ρ_i), and *S* for their variances (σ_i). Taking all all previous expressions together, we have that $E_t(X_{t+1}) = PX_t + QRU_t$, and replacing into the structural model (A.1) yields $AX_t = B(PX_t + QRU_t) + CX_{t-1} + U_t$, which is equivalent to

$$X_t = (A - BP)^{-1}CX_{t-1} + (A - BP)^{-1}(BQR + I)U_t$$

By the undetermined coefficient approach (Uhlig, 1999), matrix *P* solves $P = (A - BP)^{-1}C$, meanwhile matrix *Q* satisfies $Q = H(BQR + I)$. In the case of *P*, it requires to solve a quadratic matrix equation:

$$BP^2 - AP + C = 0 \tag{A.4}$$

Several procedures can be used to solve equation (A.4), such as a generalized eigenvalue problem, and Schur decomposition. In particular, we consider an iteration process that involves a matrix $H(P) = (A - BP)^{-1}$. Thus, the process initiates with P_0, then $H_0 = H(P_0)$, and updated with $P_{i+1} = H_iC$.

After getting *P*, matrix *Q* can be obtained using the $vec(\cdot)$ operator. By using this operator, we have that $vec(Q) = vec[(HB)QR] + vec(H)$. Noting also that $vec(ABC) = (C' \otimes A)vec(B)$, then we have the following expression for *Q*:

$$vec(Q) = [I - R' \otimes (HB)]^{-1} vec(H) \tag{A.5}$$

Given equation (A.2), we also have $X_{t-1} = PX_{t-2} + QU_{t-1}$, which can be multiplied by QRQ^{-1} as follows: $QRQ^{-1}X_{t-1} = QRQ^{-1}PX_{t-2} + QRU_{t-1}$. Subtracting the latter from (7), and replacing (8), yields the following VAR(2) model (Cho and Moreno, 2006):

$$X_t = \left(P + QRQ^{-1}\right)X_{t-1} - QRQ^{-1}PX_{t-2} + QSV_t \tag{A.6}$$

In conclusion, the reduced form of our proposed structural model corresponds to a VAR(2) process. More importantly, note that the solution relies crucially on solving expressions (A.4) and then (A.5), for getting matrices *P* and *Q*, respectively.

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EFFICIENCY IN PUBLIC HIGHER EDUCATION: A STOCHASTIC FRONTIER ANALYSIS CONSIDERING HETEROGENEITY

EFICIENCIA EN LA EDUCACION PUBLICA SUPERIOR: UN ANALISIS DE FRONTERA ESTOCASTICA CONSIDERANDO HETEROGENEIDAD

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Abstract

We aim to study technical efficiency of undergraduate teaching activity in national (public) universities in Argentina. We employ a stochastic frontier analysis (SFA) with a panel of 37 national universities over 2005-2013. We compare models that do not account for heterogeneity with heterogeneity-extended SFA models. We find from 18 percent to 25 percent of inefficiency on average in terms of lost outcomes (graduates) depending on the specification, with high dispersion among universities. Models considering heterogeneity report the highest levels of technical efficiency. Besides, the results show evidence of heterogeneity both observed and unobserved. Our estimates are robust to different specifications.

Keywords: *Universities' Teaching Efficiency, Stochastic Frontier Analysis, Heterogeneity*

JEL Classification: *I23, C23.*

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Resumen

Nuestro objetivo es estudiar la eficiencia técnica de la educación de grado en universidades nacionales (públicas) en Argentina. Empleamos un análisis de frontera estocástica (SFA) con un panel de 37 universidades nacionales durante 2005-2013. Comparamos modelos que no tienen en cuenta la heterogeneidad con modelos extendidos de SFA con heterogeneidad. Encontramos desde el 18 al 25 por ciento de ineficiencia en promedio en términos de resultados perdidos (graduados) dependiendo de la especificación, con alta dispersión entre las universidades. Los modelos que consideran heterogeneidad muestran los niveles más altos de eficiencia técnica. Además, los resultados muestran evidencia de heterogeneidad tanto observada como no observada. Nuestras estimaciones son robustas a diferentes especificaciones.

Palabras clave: *Eficiencia en la Educación Universitaria, Análisis de Frontera Estocástica, Heterogeneidad*

Clasificación JEL: *I23, C23*

1. INTRODUCTION

Higher education coverage has increased in recent years in Latin America and the Caribbean. The average gross enrollment rate in higher education (within population ages 18-24) in the region grew from 21 to 43 percent between 2000 and 2013. The expansion occurred at a time of economic growth, abundance of fiscal resources and middle class rise, and it was concentrated in the low- and middle-income segments. Completion rates in the Latin American region are close to 50 percent (compared to around 65 percent in the United States). Lower income and lower ability students are more likely to drop out. Time to degree in Latin America is 136 percent of the stipulated time (similar than the United States figure). Nevertheless, the average statutory duration of the programs is shorter in the United States than in Latin America. Student/faculty ratio is similar in Latin America to that of comparable countries of Eastern Europe or Eastern Asia, while salaries represent a higher proportion of total universities' expenses in Latin America (Ferreyra et al., 2017).

In Argentina, the public and private sector share the supply of higher education. The public institutions are mostly federal, and the private universities are non-for-profit organizations (mostly foundations). Law No. 24521 of 1995 of superior education established a National State responsibility in financial support for national universities with federal revenues. National universities have economic and financial autonomy; they manage their resources and approve their budget with considerable freedom in their administrative, planning, and academic activities.

The Argentine educational system does not include standardized exams, neither to complete high school nor to access public universities or to fulfill university degrees. Moreover, tuition is free for all undergraduate students attending public universities, regardless of their financial status and academic achievements.

The demographics of the country results in a strong concentration of students and universities in the metropolitan area of the nation. In the last thirty years, several universities have been created in the suburbs of the capital city to de-congest one of the oldest and largest universities of the country, the University of Buenos Aires (UBA).[1]

According to data of the Ministry of Education of Argentina, in 2016 there were 57 public universities, 49 private institutions (all non-for profit), 4 provincial and 1 foreign university. In 2015 there were 1.9 million undergraduate students in Argentine universities, where 1.49 million attended public universities. In that year, there were over 458 thousand new enrolling students and 125 thousand undergraduates obtained their degrees. Between 2006 and 2015, the stock of students increased 19 percent, enrollment rate grew 27 percent and 47 percent more students concluded studies. Nevertheless, only 27 percent of the students completed their studies in the stipulated time in public universities, while 37 percent dropped-out during the first year.

The heterogeneity among public universities is another characteristic of the Argentine national system. For example, over the period 2005-2013, the mean degree rate (defined as the number of graduated/(0.2*number of students)) was 0.26 for the whole country, but this indicator shows a strong dispersion within the nation. For instance, the rate goes from 0.39 in the University of Rosario (located in the central region of Argentina) to 0.07 in the University of Jujuy (that is in the northwest part of the country).

The system is characterized by high university dropout rates, long duration of the studies, low graduation rates and, in some disciplines difficulty in finding a suitable job is reported. Colomé (1996) highlights the scarce academic complementarity of institutions within the system, being the student mobility more an administrative matter than an academic issue. Among national universities located at short distances, there is overlapping in the degree programs offered.

The measurement of efficiency in higher education institutions in Argentina has gained growing interest in recent years, especially due to the expansion of the university system. This expansion has been supported by two phenomena: the creation of new public universities and, the growth in the resources that the National State allocates to education. In fact, Law No. 26075 of 2005 of Education Financing established

[1] The UBA was founded in 1820 and is the second oldest public university in the country. According to data of the Ministry of Education of Argentina, 25 percent of the students of public universities attend the UBA, while its budget represented almost 32 percent of total expenses allocated to public universities over the period 2003-2015 (*Anuarios de Estadísticas Universitarias*, available at: http://portales.educacion.gov.ar/spu/investigacion-y-estadisticas/anuarios/).

that by 2010 the resources allocated to all education levels have to be equivalent to 6 percent of the Gross Domestic Product, including higher education.

In this context, it is relevant to analyze the results of the educational process in terms of the product achieved compared to the inputs used. In particular, as public financial resources are involved in the educational process, the study of efficiency is crucial. In this sense, the educational process may be considered as the result of a production process that uses a variety of inputs to yield one or more outputs. The outcomes (or outputs) produced in a university can be split in teaching (knowledge dissemination), research (knowledge production), and extension / transfer / public / community or "third mission" services (externalities and public goods directed to varied audiences beyond campuses) (Cohn and Cooper, 2004; Johnes and Johnes, 2009).

Optimizing producers get the maximum attainable output for a given technology and level of inputs (or, equivalently, they attain given output with the minimum level of inputs). Such optimal relationship between inputs and outputs defines the production possibility frontier. The potentially sub-optimal behavior of a producer is modelled using the concept of technical efficiency. Consequently, the efficiency of a university is defined as the capacity to generate the maximum output given the quantity of inputs they use. The main approaches used for the estimation of the production frontier are the Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA).

In the case of Argentina, the combination of increasing public resources supporting public universities, the historically low completion rates observed and, the heterogeneity among universities, support the importance of studying efficiency in higher education.

The aim of this paper is to estimate technical efficiency for undergraduate teaching activity in national universities in Argentina using SFA. As detailed in Section 2, there are several papers that work with production frontier-type applications to higher education in the international literature. However, there are very few studies for Argentina.

Our paper contributes to the literature in two main aspects. First, we make the first quantitative estimation of technical efficiency in higher public education system in Argentina as a whole, using SFA. Second, we concentrate on modeling university specific observed and unobserved heterogeneity, to estimate technical efficiency more accurately, and we include a sensitivity analysis to check for the robustness of our results. If heterogeneity is not considered, it can create considerable bias in the inefficiency estimates as far as the models do not consider the specific differences among universities.

The paper is organized as follows: Section 2 accounts for the literature review on universities' efficiency; Section 3 depicts the methodology and data used; Section 4 shows the estimation results and the sensitivity checks; and finally, Section 5 presents the conclusions of the study.

2. LITERATURE REVIEW

The existent studies vary in the definitions of the variables used to reflect inputs and outputs, and in the methods they use to appraise efficiency. Most conclude that inputs can be grouped as student inputs, staff inputs and capital inputs, while outputs can be divided into teaching and research (Johnes and Yu, 2008).

Teaching is the delivering of educational services, which implies human capital accumulation, including both knowledge, competences, and skills. The main variables used in the literature to approximate the teaching activity are: (i) the number of degrees completed, which is the most precise measure even when it may underestimate the outcomes because of dropouts (Avkiran, 2001; Worthington, 2001; Salerno, 2003, Johnes, 2006b; Alberto, Carignano and Ercole , 2010; Katharaki and Katharakis, 2010; Coria, 2011; Kuah and Wong, 2011; Laureti, Secondi and Biggeri, 2014; Cantele, Guerrini and Campedelli, 2016; Quiroga-Martinez, Fernández-Vázquez and Alberto, 2018); (ii) the results in standardized exams, recalling that student´s grade is a complex function of the student´s entry-level ability, the marking standards of the university, as well as of teaching and supervision quality (Worthington, 2001; Johnes, 2006b; Kuah and Wong, 2011; Zoghbi, Rocha and Mattos, 2013; Laureti, Secondi and Biggeri, 2014); (iii) the number of students, which is in fact an indicator of the "raw material" of the process (Salerno, 2003; Cantele, Guerrini and Campedelli , 2016); (iv) courses/ hours/credits taught (Cohn and Cooper, 2004; Kuah and Wong, 2011); (v) job or remuneration attainment once graduated (Worthington, 2001; Kuah and Wong, 2011; Zoghbi, Rocha and Mattos, 2013); (vi) admission to graduate studies (Ferreyra et al., 2017) and; (vii) products, such as training to non-graduated students (Coria, 2008).

Meanwhile, research is the development and accumulation of new knowledge. This output can be approximated by: (i) published products (Salerno, 2003; Worthington and Lee, 2008; Coria, 2011; Kuah and Wong, 2011; Cantele, Guerrini and Campedelli, 2016); (ii) citation indexes (Avkiran, 2001; Kao and Hung, 2008); (iii) Ph.D. awarded (Worthington and Lee, 2008; Kuah and Wong, 2011; De Fraja and Valbonesi, 2012); (iv) patents and other intellectual property issues (Kao and Hung, 2011; Kuah and Wong, 2011); (v) grants or other funds for projects (Abbott and Douccouliagos, 2003; Salerno, 2003; Katharaki and Katharakis, 2010; Kuah and Wong, 2011; Cantele, Guerrini and Campedelli, 2016; Kao and Hung, 2016), which can be considered more properly as inputs than as outputs (Johnes and Yu, 2008).

Extension (also called Transfer / Public or Community Services or Third Mission) consists in the generation of public goods and externalities, with possible (but difficult to measure) rewards in terms of publicity and prestige, in higher tuition values or in supporting fundraising activities. Extension includes cultural and sports activities (Avkiran, 2001; Cohn and Cooper, 2004), non-formal education for the elder and other collectives (Cohn and Cooper, 2004, Worthington and Lee, 2008), informed opinion and advice on social or community issues (Avkiran, 2001; Cohn and Cooper, 2004) and the most difficult to measure, the construction of (desirable) social values and

citizenship (Avkiran, 2001; Ferreyra et al., 2017). Due to the difficulties in measuring extension activities, their effects on university efficiency have not yet been estimated in the empirical literature.

The resources (inputs) of university education can be classified as human and non-human resources. The former includes labor and "raw materials", and the latter encompasses facilities. Human resources are academic and non-academic staff (Johnes, 1996; Avkiran, 2001; Worthington, 2001; Worthington and Lee, 2003; Johnes and Yu, 2008; Coria, 2011; Kuah and Wong, 2011; Laureti, Secondi and Biggeri, 2014), while the "raw materials" of the process are the students (Coria, 2011; Laureti, Secondi and Biggeri, 2014). To address the possible substitution between teaching and research activity, it can be calculated the ratio between research teachers (or research workload) and total faculty (Johnes and Yu, 2008; Kao and Hung, 2008; Coria, 2011). Alternatively, salaries can be used to approximate human inputs (Coria, 2011). Non-human resources include capital goods and materials, which can be measured by using physical units such as square meters of laboratories or classrooms, classroom seats, computers and books in libraries (Johnes, 1996; Laureti, Secondi and Biggeri, 2014; Cantele, Guerrini and Campedelli, 2016) or by money spent on hardware (Worthington, 2001; Cao and Hung, 2008; Worthington and Lee, 2008).

Quality variables are used in some university efficiency studies. Quality can be considered either as an outcome or as an input, using ratios or dummy variables. These variables are usually indications of completion (Zogbi, Rocha and Mattos, 2013; Ferreyra et al., 2017), achievements and recognition (duration, structure and contents of the programs, time dedication and qualification of the staff). Quality can also be applied to the expenditures (Ferreyra et al., 2017). It can also be addressed by the technology in use, for example by establishing the ratio between on-line and off-line students (Wolff, Baumol and Noyes Saini, 2014). The quality of the staff input is reflected by the faculty proportion with professor status, and/or full-time on part-time professor's ratio (Kuo and Ho, 2003; Johnes and Yu, 2008; Sav, 2012). The premise underlying this variable is that the promoted/tenured faculty is more productive than the others. Nevertheless, they may have been promoted when research demands were less strict than nowadays or, once promoted, professors could be less motivated and less productive which results in an uncertain effect of the staff status (Johnes and Yu, 2008).

Finally, environmental, or contextual variables allow for unbiased comparisons among institutions and permit addressing for observable heterogeneity. They are used for separating the effect of uncontrollable inputs. It can be distinguished at least three groups of environmental variables in the literature: (i) those referred to students' intellectual, economic, and social background (Worthington, 2001; Zoghbi, Rocha and Mattos, 2013; Laureti, Secondi and Biggeri, 2014; Ferreyra et al., 2017) ; (ii) those referred to sociodemographic characteristics as poor or rich regions in term of GDP and human capital (Costa, de Sousa Ramos and Ramos de Sousa, 2011; Laureti, Secondi and Biggeri, 2014; Cantele, Guerrini and Campedelli, 2016; Ibañez Martín,

Morresi and Delbianco, 2017), ethnicity (Worthington, 2001), age (Laureti , Secondi and Biggeri, 2014), or gender (Johnes, 2006a; Laureti, Zoghbi, Rocha and Mattos, 2013; Secondi and Biggeri, 2014) and; (iii) those referred to the type of university -big or small- (Laureti, Secondi and Biggeri, 2014; Daraio, Bonaccorsi and Simar, 2015; Cantele, Guerrini and Campedelli, 2016), old or new (Johnes and Johnes, 2009), private or public (Millot 2015; Cantele, Guerrini and Campedelli, 2016), profit or non-for profit, laic or religious, specialized or generalist, specialized in "labor intensive" or in "capital intensive" disciplines (Cohn and Cooper, 2004; Horne and Ho, 2008; Johnes and Johnes, 2009; Laureti, Secondi and Biggeri, 2014; Daraio, Bonaccorsi and Simar, 2015; McGukin and Winkler, 2015; Cantele, Guerrini and Campedelli, 2016).

Previous works on this issue for Argentina are Alberto, Carignano and Ercole (2010) who rank the universities using a cross efficiency model, Coria (2011) who finds that, for all public universities, the average level of inefficiency varies from 23.2 percent to 23.9 percent, Ibañez Martín, Morresi and Delbianco (2017) who estimate inefficiency for the departments of one specific national university of Argentina and Quiroga-Martínez, Fernández-Vázquez and Alberto (2018), who find an average efficiency of 78.6 percent among the public universities of the country. Three of these studies use a non-parametric method (Data Development Analyst –DEA) to estimate efficiency in public universities, while Ibañez Martín, Morresi and Delbianco (2017) apply a parametric stochastic frontier analysis (SFA). Quiroga-Martinez, Fernández-Vázquez and Alberto (2018) estimate a two stage DEA.

3. METHODOLOGY AND DATA

3.1. Stochastic Frontier Analysis

To estimate technical efficiency, we employ one of the most used parametric techniques, namely stochastic frontier analysis (SFA).[2] In particular, we include university specific heterogeneity in the SFA to account for the potential bias in the inefficiency estimates.

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[2] The other most used frontier efficiency technique is Data Envelopment Analysis (DEA). This non-parametric method characterizes the set of efficient producers (those on the frontier) and then derives estimates of inefficiency based on how far each observation deviates from the frontier. Both methods have advantages and disadvantages. For example, SFA requires ample samples and yields the possibility of statistical tests of the results. DEA allows working with relatively small samples, but in its common formulation it does not allow testing the statistical significance of the results. SFA estimates a function, thence crucial decisions should be made with respect to the functional form that describes the phenomena and to the distribution of the error term. Those decisions are not required in the DEA analysis, nevertheless, the inefficiency scores it yields are deemed as purely inefficiency without considering randomness at all.

Prior to the estimation of the stochastic frontier (SF), we examine the empirical form of the production function, i.e., the empirical association between the number of graduates (Y_{it}) of university *i* at year *t* and the explaining variables (included in the vector D_i for dummy variables and in X_{it} for the other independent variables). We also include a time-trend variable τ to capture the technological change over time. Based on the Box Cox transformation method (Box and Cox, 1964), we perform alternative transformations to the variables in the model to capture the form of the relationship.[3] The general specification of the regression has the following form:

$$Y_{it}^{(\theta)} = \alpha + \beta X_{it}^{(\lambda)} + \delta D_i + \theta\tau + \varepsilon_{it} \qquad i = 1,\ldots,N,\ t=1\ldots T \qquad (1)$$

where $Y_{it}^{(\theta)} = \dfrac{Y_{it}^{\theta} - 1}{\theta}$ and $X_{it}^{(\lambda)} = \dfrac{X_{it}^{\lambda} - 1}{\lambda}$ are the vectors of the dependent and the independent variables subject to transformations for specific values of the parameters λ and θ if $\theta, \lambda \neq 0$, and $Y_{it}^{(\theta)} = \log(Y_{it})$, $X_{it}^{(\lambda)} = \log(X_{it})$ are the transformations when $\theta = 0$ and $\lambda = 0$, respectively.[4]

This Box Cox general functional form includes the most common model specifications as subsets, including linear, semi-log and double log. Then, using Pooled Ordinary Least Squared (POLS), we estimate Eq. (1) using the following alternative specifications: linear (θ=λ=1), log-lin (θ=0, λ=1), lin-log (θ=1, λ=0) and log-log (θ=λ=0). It is important to note that the last model produces the Cobb–Douglas production function.

Secondly, to select the most appropriate specification within the set of candidate models, we perform the Bayesian Information Criteria (BIC). The BIC is defined as: BIC = − 2logL + log(N)K, where L is the likelihood of the model, N is the number of observations in the dataset and K is the number of parameters to be estimated in the model. The BIC rewards goodness of fit (as assessed by the likelihood function) and penalizes the number of estimated parameters. The model with the minimum BIC value is considered the model that better fits the data.[5]

Thirdly, with the selected specification for Eq. (1), we estimate the stochastic production frontier. In the SFA the residual ε_{it} is defined as the difference between

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[3] The Box and Cox transformations are a family of power transformations used in statistics to correct biases in the error distribution, to correct unequal variances and mainly to correct the nonlinearity in the relationship. In this paper we focus on powers usually used to characterize production relationships.

[4] The notation $Y_{it}^{(\theta)}$ and $X_{it}^{(\lambda)}$ (with θ and λ in parentheses) indicates that the vectors of dependent and independent variables are transformed using those parameters. The specific transformations are defined as $\frac{Y_{it}^{\theta} - 1}{\theta}$ and $\frac{X_{it}^{\lambda} - 1}{\lambda}$, respectively.

[5] To make the BIC criteria comparable among the different models, we use the likelihood of log-normal distribution instead of the likelihood of the normal distribution in the BIC formula for the independent variable Y_{it}. This adjustment was performed in the models where the response variable is $\log(Y_{it})$ (see, Burnham and Anderson, 2002 p.81).

the normally distributed term v_{it}, which represents the classical random error $\left(v_{it} \sim iid\ N\left(0, \sigma_v^2\right)\right)$, and a one-sided disturbance u_{it} which represents inefficiency:

$$\varepsilon_{it} = v_{it} - u_{it} \qquad i = 1,\ldots,N,\ t=1\ldots T \tag{2}$$

It is also assumed that v_{it} and u_{it} are independent from each other and identically distributed across observations. The SFA models are estimated via maximum likelihood (ML) or simulated maximum likelihood (SML) techniques and it is usually assumed that the distribution of u_{it} is half-normal, truncated normal, exponential, or normal gamma.[6]

According to Aigner, Lovell and Schmidt (1977), technical efficiency (TE) is a measure of how well the individual transforms inputs into a set of outputs based on a given set of technology and economic factors. If TE is defined as the ratio of observed output to the stochastic frontier output, then $TE_{it} = \exp(-u_{it})$.[7] As the econometric procedure allows to estimate ε_{it} (i.e, the compound error of Eq. (1)), we use the strategy proposed by Jondrow, Lovell, Materov and Schmidt (1982), hereafter JLMS, to decompose the inefficiency term from the residual. A point estimate of the inefficiencies can be obtained using the mean:

$$E\left(u_{it} \setminus \varepsilon_{it}\right) = \frac{\sigma_*\ \phi\left(\frac{\mu_{*it}}{\sigma_*}\right)}{\Phi\left(\frac{\mu_{*it}}{\sigma_*}\right)} + \mu_{*it} \qquad i = 1,\ldots,N,\ t=1\ldots T \tag{3}$$

where $\mu_{*it} = \frac{-\sigma_u^2\ \varepsilon_{it}}{\sigma_v^2 + \sigma_u^2}$ and $\sigma_*^2 = \frac{\sigma_u^2\ \sigma_u^2}{\sigma_v^2 + \sigma_u^2}$

For the estimation of TE, we concentrate on SF models that account for universities' heterogeneity. In this case, different academic contents and/or processes, regional differences in socio-economic characteristics of the students and teachers, and geographical features that prioritize some fields over others (such as Agronomics in regions whose productive activity is more linked to agriculture) are aspects that are beyond the universities' authorities control and that could affect their productive

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6 In general, SFA is based in two sequential steps: in the first, estimates of the model parameters are obtained by maximizing the log-likelihood function. In the second step, point estimates of inefficiency can be obtained through the mean (or the mode) of the conditional distribution $f = (u_i \setminus \widehat{\varepsilon_{it}})$. For details, see Belotti et al. (2012).

7 $ET_{it} = \frac{f\left(X_{it}\beta\right)\exp(v_{it} - u_{it})}{f\left(X_{it}\beta\right)\exp(v_{it})} = \frac{1}{\exp(u_{it})} = \exp(-u_{it})$. If u_{it} equals zero, then TE equals one, and production is said to be technically efficient.

efficiency. If that heterogeneity is not accounted for, it remains in the error term, and the endogenous independent variables would be correlated with the residual violating a basic assumption of the SFA. This would result in biased parameter estimates in the production frontier, including the efficiency estimates.

In this sense, we take heterogeneity into account through the inclusion of those effects in the mean of the distribution of inefficiency (observed heterogeneity) and by randomizing some parameters of the stochastic frontier model (unobserved heterogeneity). We also estimate a combined model where we have randomized the frontier constant term and at the same time explained the mean of the inefficiency distribution by a covariate. We also estimate the "true fixed effects model" (Greene 2005a), where the unobserved heterogeneity is represented by the individual fixed effects. We next include a description of the SFA models used in the empirical strategy that deal with heterogeneity.

3.1.1. Observed heterogeneity

Random Effect models (RE and REH)

We perform the random effect (RE) model proposed by Pitt and Lee (1981) using the linear or nonlinear specification chosen in the first step of the empirical strategy. This means that, although we continue with the notation of the general specification of the production function, the parameters λ and θ take specific values at this stage of the empirical strategy. Then, the RE model is specified as:

$$Y_{it}^{(\theta)} = \alpha + \beta X_{it}^{(\lambda)} + \delta D_i + \theta\tau + \varepsilon_{it} \qquad i = 1,\ldots,\text{N},\ t=1\ldots\text{T} \tag{4}$$

$$\varepsilon_{it} = v_{it} - u_i$$

$$v_{it} \sim \text{N}(0,\sigma_v^2)$$

$$u_i \sim \text{N}^{+}(0,\sigma_u^2)$$

Or:

$$Y_{it}^{(\theta)} = \alpha_i + \beta X_{it}^{(\lambda)} + \delta D_i + \theta\tau + v_{it} \qquad i =1,\ldots,\text{N},\ t=1\ldots\text{T} \tag{5}$$

where $\alpha_i \equiv \alpha - u_i$

This model fits by ML; it assumes that technical inefficiency is half normal, and that, in proportional terms, it is constant over time. As can be seen, individual heterogeneity cannot be distinguished from inefficiency. Then, the whole time-invariant heterogeneity is confounded into inefficiency, and therefore, $\widehat{u_i}$ might be picking up heterogeneity in addition to, or even instead of, inefficiency (Greene, 2005b). Besides,

Kumbhakar and Hjalmarsson (1993) argued that the time varying component v_{it} would inappropriately capture time varying inefficiency.

This specification assumes that inefficiency is not correlated with the regressors, and this is a problem when, in the presence of heterogeneity, the inefficiency term is not independent of the frontier inputs (endogeneity). One way to deal with this issue is to introduce the exogenous variables in the location of the distribution of the inefficiency. The most common approach is to parameterize the mean of the pre-truncated inefficiency distribution.[8] This model specification, called here random effect with observed heterogeneity (REH) model can be written as:

$$
\begin{aligned}
&Y_{it}^{(\theta)} = \alpha + \beta X_{it}^{(\lambda)} + \delta D_i + \theta\tau + \varepsilon_{it} \qquad i=1,\ldots,\mathrm{N},\ t=1\ldots\mathrm{T} \qquad (6)\\
&\varepsilon_{it} = v_{it} - u_i\\
&v_{it} \sim \mathrm{N}(0,\sigma_v^2)\\
&u_i \sim \mathrm{N}^{+}(\mu_i,\sigma_u^2)\\
&\mu_i = z_0 + z_1 h_i
\end{aligned}
$$

In the case that heterogeneity also depends on time, the vector of explanatory variables associated with technical inefficiency also varies over time and so the mean of the truncated distribution of the inefficiency term.[9] One advantage of this technique is that the correlation between the variables that explain the inefficiency and the independent variables is allowed. However, although observed heterogeneity is modeled separately, unobserved heterogeneity remains in the inefficiency term. And this could result in biased parameter estimates, including the TE. To overcome these limitations, Greene (2005a) proposes the following models which deals with unobserved heterogeneity.

3.1.2. Unobserved heterogeneity

True Fixed Effects Model

To overcome the problem of the previous models where inefficiency cannot be separated from time-invariant individual effects, Greene (2005a) proposes the following model, called the true fixed effects model (TFE), where the university specific constant term is included in the stochastic frontier:

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[8] An alternative approach to analyzing the effect of exogenous variables on inefficiency is to rescale its distribution allowing observable variation in σ_{ui}^2. See for example, Caudill and Ford (1993); Caudill, Ford, and Gropper (1995), and Hadri (1999).

[9] For more details, see Batesse and Coelli (1995).

$$Y_{it}^{(\theta)} = \alpha_i + \beta X_{it}^{(\lambda)} + \delta D_i + \theta\tau + \varepsilon_{it} \qquad i=1,\ldots,N,\ t=1\ldots T \qquad (7)$$
$$\varepsilon_{it} = v_{it} - u_{it}$$
$$v_{it} \sim N(0,\sigma_v^2)$$
$$u_{it} \sim N^{+}(0,\sigma_u^2)$$

This model allows controlling for constant individual unobserved heterogeneity and assumes that inefficiency is time varying, meaning that there is not structural inefficiency that persists over the period of analysis. The model is fit by ML and the normal-half normal model is applied to the stochastic part of the regression.

True Random Effects Model

The true random effect model (TRE) proposed by Greene (2005a) is an extension of the previous RE model and has the following structure:

$$Y_{it}^{(\theta)} = \alpha + w_i + \beta X_{it}^{(\lambda)} + \delta D_i + \theta\tau + \varepsilon_{it} \qquad i=1,\ldots,N,\ t=1\ldots T \qquad (8)$$
$$\varepsilon_{it} = v_{it} - u_{it}$$
$$v_{it} \sim N(0,\sigma_v^2)$$
$$u_{it} \sim N^{+}(0,\sigma_u^2)$$

As can be seen, it is a model with a traditional random effect w_i but with the additional feature that the time varying disturbance is not normally distributed. The model is estimated by maximum simulated likelihood. It is assumed that $w_i \sim N(0,\theta^2)$, where θ represents the standard deviation of the unobserved heterogeneity and $E\left(w_i \setminus X_{jit}\right) = 0$, where j is the number of independent variables.

Compared with the Pitt and Lee (1981) model where u_i is the inefficiency, in the TRE u_{it} is the inefficiency, and it is time varying. Moreover, whereas in the RE model the inefficiency term also contains all other time invariant unmeasured sources of heterogeneity, in the TRE model these effects appear in w_i and u_{it} picks up the inefficiency.

3.1.3. Observed and unobserved heterogeneity combined

To account for observed and unobserved heterogeneity, it is possible to combine the previous RE and TRE models as follows:

$$Y_{it}^{(\theta)} = \alpha + w_i + \beta X_{it}^{(\lambda)} + \delta D_i + \theta\tau + \varepsilon_{it} \qquad i=1,\ldots,N,\ t=1\ldots T \qquad (9)$$

$$\varepsilon_{it} = v_{it} - u_{it}$$
$$v_{it} \sim \mathrm{N}(0, \sigma_v^2)$$
$$u_i \sim \mathrm{N}^+(\mu_i, \sigma_u^2)$$
$$\mu_i = z_0 + z_1 h_i$$
$$w_i \sim \mathrm{N}(0, \sigma_w^2)$$

With this specification, observed heterogeneity is included in the model by parameterizing the mean of the inefficiency distribution, and the unobserved heterogeneity (which remains in the inefficiency term in the RE model), is accounted for by introducing the specific random effects and by assuming that the inefficiency component varies across individuals and time. Once again, the heterogeneity term could also depend on time, and so, the mean of the truncated distribution of the inefficiency term.

3.2. Data

We work with the "*Anuarios de Estadísticas Universitarias"* of the Ministry of Education of Argentina. We use a balanced panel of 37 National Universities in Argentina with information over the period 2005-2013. The year of foundation was the main criterion followed to choose the Universities of the panel, together with the availability of consistent and continuous information (see Table 5). The newest Universities were not included since the time to "generate" graduates is not long enough. Two universities were not included in the date set since the information was not completed over the period under analysis.[10] The period begins in 2005, when Law No. 26075 of Education Financing was established.

In the literature review we present an exhaustive enumeration of possible variables to address outputs, inputs, quality, and environmental variables. The availability of data forces us to use certain variables and to disregard others. For example, concerning output, variables which characterize the future career of graduates or their achievements as students (such as salary or other labor market achievements, or effective length of studies by cohort, or average grades) are not available. The same happens for results of research activity, such as published papers or registered patents.

As regards inputs, some limitations arise when addressing the quality of the faculty. For example, we can distinguish positions, such as full professor –"titular"-

[10] The National Universities that were not included are: Instituto Universitario del Arte (1996), Noroeste de la Provincia de Buenos Aires (2002), Chaco Austral (2007), Río Negro (2008), José C. Paz (2009), Moreno (2009), Oeste (2009), Villa Mercedes (2009), Arturo Jauretche (2010), Avellaneda (2010) and Tierra del Fuego (2010).

or associate, but we cannot determine if they have any Ph.D.; or we can distinguish full-time from part-time professors, but we do not know if the full-time faculty devote their time to research or to administrative tasks.

The consideration of heterogeneity is important. It also allows addressing some differences among universities. For example, Medicine schools are rarely present in the newest universities. The oldest universities (those founded prior to the 1970s) offer in general more diverse and complex disciplines and they are more research oriented. In fact, Argentina has four scientists awarded with the Nobel Prize in sciences, and all of them worked at the National University of Buenos Aires (UBA).

The output variable is measured as the number of graduates. This variable is defined as the number of undergraduate students who completed all courses and other academic requirements.

The inputs that we consider are students, human resources (faculty), financial resources, and environmental variables. We include the number of students defined as enrolled undergraduates. As human resources, we take the number of teachers, considering their role (professor or assistant) and their time contractual dedication ("exclusive", "semi-exclusive" or "simple"). We calculate a professor variable (Professor_w) and an assistant variable (Assistants_w), in both cases weighting roles with time dedication. Following the Ministry of Education definition for the equivalent full-time ("exclusive") faculty position, the weights are 1 for "exclusive", 0.5 for "semi-exclusive" and 0.25 for "simple". Then, the faculty roles (professor or assistant) are converted into full-time equivalent.

Concerning financial resources, we consider total annual expenditures (i.e. costs of personnel, goods and services and monetary transfers) in constant terms (basis 2013=100).[11] Personnel expenses refer to the remuneration of all salaries, employer contributions, family allowances, extraordinary services and social benefits received by the agents, while the rest of the costs are the operating and capital expenditures.

As the local context influences the development of the educational process in universities, we include dummy variables for the country's five regions defined by the Census Bureau *INDEC* (Metropolitan Buenos Aires –GBA-, Northwest –NOA-, Northeast -NEA-, West –Cuyo-, Central –Pampeana- and Southern –Patagonia-) to capture this effect. Finally, we include a measure of efficiency in the efficiency equation, defined as the ratio number of students of university *i* in period *t* divided into the maximum number of students of university *i* over the period 2005-2013 (rprodst).

Table 1 presents a description of these variables by university. On average, the set of universities considered has 1.29 million students, 66,371 graduates per year, 25,791 full-time equivalent professors and 28,393 full time equivalent assistants. Considering a mean duration of five years for each degree, the graduation rate is 25.7 percent (66,371/258,234) on average. Each year, the financial resources employed

[11] To deflate the expenditure series, we use the ICC Index calculated by INDEC.

by the sample of universities averaged ARS 42,633 million in terms of 2013 constant prices (equivalent to 7,909 million dollars at July 1st). [12] Then, each graduate demanded on average ARS 642,000 (or USD 119,000) of financial resources. Table 2 presents the descriptive statistics of the whole sample.

TABLE 1

RESOURCES AND OUTCOMES BY UNIVERSITY (AVERAGE 2005-2013)

University	Graduates	Students	Exclusive	S-exclusive	Simple	Professors_w	Assistants_w	Expenditures	Rprodst
Buenos Aires *(1821), GBA*	16,809	322,535	2,392	2,871	18,786	3,025	5,499	13,500	0.90
Catamarca *(1972), NOA*	388	12,379	306	402	385	443	160	811	0.94
Centro PBA *(1974), Pampeana*	585	12,425	563	386	854	491	478	1,050	0.90
Chilecito *(2004), NOA*	48	3,066	44	118	161	99	44	166	0.52
Comahue *(1971), Patagonia*	957	26,997	587	748	1,348	597	701	1,440	0.87
Cuyo *(1939), Cuyo*	2,305	31,322	661	1,942	1,695	1,177	879	2,300	0.99
Córdoba *(1613), Pampeana*	6,875	106,413	1,371	3,275	4,334	1,973	2,118	4,340	0.96
Entre Ríos *(1973), Pampeana*	913	13,043	190	976	1,054	504	438	467	0.88
Formosa *(1988), NEA*	563	11,691	97	331	730	280	165	249	0.92
Gral. Sarmiento *(1993), GBA*	196	5,145	234	88	0	137	141	212	0.72
Jujuy *(1972), NOA*	184	12,864	208	499	403	275	283	510	0.87
La Matanza *(1989), GBA*	1,308	31,184	448	738	444	387	541	811	0.86
La Pampa *(1958), Pampeana*	410	8,953	261	345	1,078	334	369	435	0.97
La Plata *(1897), Pampeana*	4,953	99,699	1,507	2,138	8,911	1,833	2,971	2,760	0.89
La Rioja *(1994), NOA*	603	24,034	54	908	727	405	285	367	0.75
Lanús *(1995), GBA*	472	10,355	38	159	256	144	38	207	0.81
Litoral *(1919), Pampeana*	1,664	39,184	649	1,083	1,878	767	894	1,050	0.89
Lomas de Zamora *(1972), GBA*	2,699	34,735	104	138	2,711	504	346	408	0.93
Luján *(1972), GBA*	895	16,889	286	418	840	326	380	429	0.92
Mar del Plata *(1975), Pampeana*	1,168	23,335	673	642	2,701	706	963	769	0.92
Misiones *(1973), NEA*	686	20,733	290	457	748	379	327	553	0.89
Nordeste *(1956), NEA*	2,912	50,934	536	199	3,424	623	869	920	0.95
Patagonia Austral *(1994), Patagonia*	119	6,959	158	293	491	224	203	297	0.77
Patagonia S. J. Bosco *(1980), Patagonia*	417	13,300	227	566	1,560	472	428	556	0.92
Quilmes *(1989), GBA*	985	15,020	233	116	262	220	136	168	0.67
Rosario *(1968), Pampeana*	5,686	73,227	1,056	2,061	4,991	1,412	1,922	1,230	0.98
Río Cuarto *(1971), Pampeana*	906	16,643	764	576	330	551	584	366	0.87
Salta *(1972), NOA*	468	24,087	429	767	410	388	527	394	0.86
San Juan *(1973), Cuyo*	582	19,458	868	1,038	1,143	1,141	532	493	0.94
San Luis *(1973), Cuyo*	566	12,703	757	444	154	515	502	408	0.93
San Martín *(1992), GBA*	754	10,862	96	225	733	281	111	551	0.84
Santiago del Estero *(1973), NEA*	708	14,001	331	251	203	285	223	181	0.86

[12] The exchange rate was ARS 4.93 = USD 1 in January 2nd, ARS 5.39 in July 1st, and ARS 6.53 in December 30th, 2013. The July 1st is a reasonable mean of the whole year average Price.

University	Graduates	Students	Exclusive	S-exclusive	Simple	Professors_w	Assistants_w	Expenditures	Rprodst
Sur *(1956), Patagonia*	1,032	19,493	614	275	1,334	519	566	387	0.94
Tecnológica Nacional *(1948), Pampeana*	4,071	73,144	542	819	17,216	3,009	2,247	2,520	0.88
Tres de Febrero *(1995), GBA*	237	8,936	90	136	145	157	37	247	0.72
Tucumán *(1912), NOA*	2,096	61,418	1,315	2,191	691	1,254	1,329	1,010	0.97
Villa María *(1996), Pampeana*	152	4,004	114	285	143	135	157	71	0.66
Total	66,371	1,291,169	19,096	28,902	83,273	25,971	28,393	42,633	

Source: Own elaboration on "Anuarios de Estadísticas Universitarias".

TABLE 2

DESCRIPTIVE STATISTICS OF THE WHOLE SAMPLE OVER 2005-2013 (N=333)

Variable	Mean	Std. Dev.	Min	Max
Graduates	1,794	2,996	24	18,124
Students	34,896	54,356	1,111	358,071
Exclusive	516	503	0	2,478
Semi-exclusive	781	796	44	3,589
Simple	2,251	4,176	0	21,214
Professors	1,473	1,992	115	10,522
Assistants	2,075	3,202	2	18,636
Professors_w	702	715	53	3,224
Assistants_w	767	1,046	1	6,011
Expenditures (millions 2013 AR$)	1,140	2,790	3	30,200
GBA	0.243	0.430	0	1
NOA	0.162	0.369	0	1
NEA	0.108	0.311	0	1
Cuyo	0.081	0.273	0	1
Pampeana	0.324	0.469	0	1
Patagonia	0.081	0.273	0	1
Rprodst	0.866	0.148	0.187	1

Source: Own elaboration on "Anuarios de Estadísticas Universitarias".

4. RESULTS

First, to select the model specification for the production function, we estimate four models for the whole sample by pooled OLS. We use a linear specification and the nonlinear log-lin, lin-log and log-log (Cobb Douglas) ones. We consider Graduates as the dependent variable while the independent variables included are Students, Professors_w, Assistants_w, Expenditures, the regions GBA, NOA, NEA, Cuyo, Pampeana, the Time Trend and a Constant.

As showed in Table 3, most of the signs of the significant variables are the expected ones and are robust to all specifications. The BIC information criterion favors the log-log specification, then we employ it as our "basis model".

TABLE 3

HIGHER EDUCATION PRODUCTION FUNCTION UNDER ALTERNATIVE SPECIFICATIONS (POLS)

Variables	Model Specification			
	linear	log-lin	lin-log	log-log
Students	0.045***	0.000	1,277.341***	0.844***
	(0.005)	(0.000)	(332.880)	(0.070)
Professors_w	0.378**	0.001***	702.347	0.531***
	(0.152)	(0.000)	(430.467)	(0.101)
Assistants_w	0.156	0.000	155.768	-0.126***
	(0.265)	(0.0005)	(148.810)	(0.043)
Expenditures	0.000	0.000***	472.551***	0.003
	(0.000)	(0.000)	(146.583)	(0.022)
GBA	489.821***	0.790***	2,086.486***	0.7290***
	(83.445)	(0.172)	(491.393)	(0.090)
NOA	-206.889***	-0.078	120.593	-0.147*
	(78.983)	(0.182)	(363.263)	(0.084)
NEA	359.876***	0.995***	396.699	0.622***
	(85.177)	(0.173)	(310.857)	(0.096)
Cuyo	142.673	0.350	-690.903**	0.243**
	(114.559)	(0.214)	(333.124)	(0.117)
Pampeana	428.535***	0.649***	329.813	0.595***
	(68.716)	(0.155)	(292.896)	(0.066)
Trend	4.725	0.034**	-140.499***	0.003
	(15.366)	(0.017)	(54.065)	(0.009)
Constant	-480.780***	5.081***	25,410.432***	-4.667***
	(96.495)	(0.174)	(2,930.968)	(0.338)
Observations	323	323	323	323
R-squared	0.962	0.704	0.678	0.927
BIC	5103.149	5191.901	5792.577	4746.398

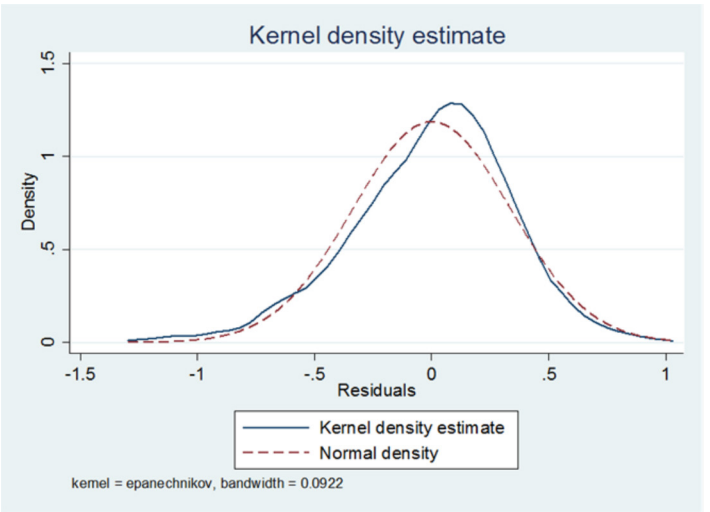
Source: Own elaboration.

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Before performing the SFA models, we test the residuals of the chosen Cobb Douglas POLS model to check for the validity of the stochastic frontier method. The idea behind the test is that for the production frontier model (with a composed error $v_{it} - u_{it}$, $u_{it} \geq 0$ and v_{it} distributed symmetrically around zero), the residuals of the corresponding OLS estimation should skew to the left. The calculated statistic for the skewness is equal to -0.475, and it is statistically significant (p-value=0.001) indicating that the distribution of the residuals, skews to the left (see Figure 1).[13]

[13] The statistic test performed is that proposed by Schmidt and Lin (1984) and is defined as: $b_1^{1/2} = \frac{m_3}{m_2 \, m_2^{1/2}}$, where m_2 and m_3 are the second and third sample moment of the OLS residuals, respectively.

FIGURE 1

DISTRIBUTION OF OLS RESIDUALS (LOG-LOG POLS MODEL)



As the residuals of the sample have the correct characteristic for the implementation of the procedure of maximum likelihood, we next estimate the SF models using the chosen Cobb Douglas (double log) form for the production function. For observed heterogeneity, we use the ratio number of students of university *i* in period *t* divided on the maximum number of students of university *i* over the period 2005-2013 ($rprodst_{it}$) as a measure of enrollment efficiency.

As can be seen in Table 4, in terms of signs and significance, results almost do not differ among specifications, except in the case of the TFE model where none of the regional dummy is statistically significant. All the significant coefficients have the expected sign and have similar magnitudes among models. The number of students has a positive effect on the determination of the stochastic production frontier, but the teachers' effects differ: the number of professors has a positive impact while the effect is negative when assistant professors are considered. This could be explained because the proportion of assistants is customarily larger in the initial years of the different programs, where the courses are more general, than in the following years, and the drop-out rates are there also the largest.

Only in the RE model the university expenditure explains the production of graduates. Then, it seems that human resources are more important for the definition of the production frontier than the budget allocated to each university. Regarding the regional variables all the models except TFE show that the geographical region explains

the number of graduates. Ceteris paribus, all universities have a positive significant differential in the number of graduates regarding the basis region (Patagonia). The time variable is in general positive, but it is never statistically significant, meaning that there is not any technological development over the period under analysis.

As it is shown in Table 4, the enrollment efficiency measure (rprodst) has the expected negative sign, but it is not significant for explaining the distribution of the mean of inefficiency in the RE model, however it is significant in the model that considers both observed and unobserved heterogeneity (TRE+REH). The estimated inefficiency variance is significant in all models, while it presents the highest value in the RE one. This means that some of the inefficiency captured in the RE model is in fact heterogeneity. Finally, the parameter θ, which characterizes the simulated standard distribution of the university specific intercept term (w_i), is statistically significant indicating the presence of heterogeneity among universities.

TABLE 4
ESTIMATION RESULTS OF THE ALTERNATIVE SFA MODELS

Variables	Alternative models				
	RE	REH	TFE	TRE	TRE+REH
ln Students	0.772***	0.888***	0.889***	0.865***	0.854***
	(0.076)	(0.062)	(0.104)	(0.067)	(0.066)
ln Professors_w	0.602***	0.500***	0.507***	0.276***	0.283***
	(0.107)	(0.093)	(0.128)	(0.095)	(0.092)
ln Assistants_w	–0.158***	0.158***	0.151***	–0.085**	–0.088**
	(0.041)	(0.034)	(0.046)	(0.036)	(0.037)
ln Expenditures	0.037*	–0.007	–0.001	0.023	0.023
	(0.020)	(0.024)	(0.019)	(0.017)	(0.017)
GBA	0.823***	0.724***	0.917	0.649***	0.658***
	(0.140)	(0.083)	(0.989)	(0.146)	(0.146)
NOA	–0.177	–0.147**	–0.243	–0.140	–0.139
	(0.139)	(0.075)	(0.857)	(0.148)	(0.149)
NEA	0.660***	0.607***	0.887	0.671***	0.679***
	(0.154)	(0.088)	(1.037)	(0.160)	(0.155)
Cuyo	0.369**	0.372***	0.454	0.323**	0.321**
	(0.162)	(0.096)	(1.036)	(0.159)	(0.158)
Pampeana	0.573***	0.544***	0.623	0.550***	0.553***
	(0.130)	(0.068)	(1.243)	(0.139)	(0.138)
Trend	–0.004	0.003	0.007	0.006	0.004
	(0.007)	(0.009)	(0.007)	(0.006)	(0.005)
Constant	–4.566***	4.238***		–3.748***	–3.666***
	(0.520)	(0.360)		(0.418)	(0.397)
Observations	323	323	323	323	323
Number of groups	37	37	37	37	37
Log-likelihood	–38.382	–95.062	44.727	–17.336	–15.724
BIC	151.873	276.789	164.763	121.336	118.113

Variables	Alternative models				
	RE	REH	TFE	TRE	TRE+REH
Mu					
Rprodst		–1.581			170.148***
		(2.627)			(0.759)
Constant		–1.129		302.097***	–106.005
		(3.100)		(10.262)	
sigma_u					
Constant	0.405***	0.941	0.213***	8.071***	7.362***
	(0.060)	(0.701)	(.0203)	(0.431)	(0.014)
sigma_v					
Constant	0.241***	0.206***	0.106***	0.114***	0.112***
	(0.010)	(0.023)	(0.015)	(0.016)	(0.012)
Theta				0.262***	0.262***
				(0.036)	(0.035)

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

Regarding the efficiency scores estimated with the alternative SFA models (see Table 5), the mean efficiency over the entire period goes from 75 percent to 82 percent depending on the model considered. This means that from 18 percent to 25 percent of the production (graduates) is lost due to inefficiency. These values are in line with previous non-parametric studies in Argentina (inefficiency from 23.2 percent to 23.9 percent in Coria, 2011, and average efficiency of 78.6 percent in Quiroga Martínez, Fernández-Vázquez and Alberto, 2018). Besides, as expected, those models that account for unobserved heterogeneity present higher values of TE while the RE model presents the lowest value. This result indicates that there is evidence of heterogeneity that overestimates inefficiency.

TABLE 5

DESCRIPTIVE STATISTICS OF THE ESTIMATED EFFICIENCY SCORES (JLMS TECHNIQUE)

Variable	Mean	Std. Dev.	Min	Max
RE	0.749	0.152	0.371	0.951
REH	0.764	0.143	0.259	0.951
TFE	0.825	0.141	0.237	0.972
TRE	0.816	0.141	0.238	0.967
TRE+REH	0.821	0.137	0.237	0.969

Source: Own elaboration.

Table 6 presents a correlation among the estimated inefficiency scores of the alternative models. As can be observed, the ranks of the RE model are highly correlated with those of the REH model, weakly correlated with the ranks of the TRE+REH specification, and not statistically correlated with the ranks of the TFE and TRE models. This means that the ranking of the technical efficiency scores differs depending on the model chosen, more specifically it depends whereas the model accounts for unobserved university-specific differences. In fact, the RE and the REH model rank the universities similarly, while the rankings of the TFE and the TRE models are highly correlated.

TABLE 6

CORRELATION OF INEFFICIENCY ESTIMATE

	RE	REH	TFE	TRE	TRE+REH
RE	1				
REH	0.721	1			
	0.000				
TFE	0.074	0.657	1		
	0.184	*0.000*			
TRE	0.082	0.657	0.984	1	
	0.141	*0.000*	*0.000*		
TRE+REH	0.137	0.703	0.989	0.987	1
	0.014	*0.000*	*0.000*	*0.000*	

Source: Own elaboration.
Note: p-value in italics.

In Table 7 we present the ranking of the public universities according to their estimated efficiency score. As expected, the ranking is similar among the TFE, the TRE and the TRE+REH models. When analyzing university by university, in these latter models the ranks of the Universities of Rosario, Entre Ríos and Lomas de Zamora decrease compared with the RE and REH rankings, while the positions of other big Universities such as the Universities of Córdoba, La Plata and Buenos Aires increase. This result indicates that there are heterogeneity factors that influence inefficiency.[14]

[14] We can advance one possible explanation since the proportion of working students varies among the universities of the sample. Using the data of the *Household Survey of INDEC* (EPH) for the period under analysis we find that those universities which substantially improve their performance are those located in urban agglomerates which present the highest rates of working students.

TABLE 7

TECHNICAL EFFICIENCY (TE) SCORES BY UNIVERSITY (AVERAGE 2005-2013)

University	RE TE score	University	REH TE score	University	TFE TE score	University	TRE TE score	University	TRE+REH TE score
Lomas de Zamora	0.9514	Cuyo	0.9028	Córdoba	0.8906	Cuyo	0.8916	Cuyo	0.8973
Rosario	0.9442	Lomas de Zamora	0.8990	Cuyo	0.8898	Nordeste	0.8858	Nordeste	0.8901
Cuyo	0.9324	Rosario	0.8958	Sur	0.8896	Córdoba	0.8836	Córdoba	0.8884
Entre Ríos	0.9311	Nordeste	0.8873	Tecnológica Nacional	0.8894	Sur	0.8830	Sur	0.8863
Tucumán	0.9285	Tucumán	0.8872	Buenos Aires	0.8887	La Plata	0.8789	Mar del Plata	0.8814
Nordeste	0.9284	Entre Ríos	0.8748	Mar del Plata	0.8879	Mar del Plata	0.8780	La Plata	0.8809
Comahue	0.9232	Córdoba	0.8722	Misiones	0.8847	Buenos Aires	0.8750	Buenos Aires	0.8801
Quilmes	0.9168	Comahue	0.8570	La Plata	0.8845	Tucumán	0.8740	Tecnológica Nacional	0.8795
La Rioja	0.8856	San Martín	0.8470	Litoral	0.8843	Tecnológica Nacional	0.8735	Tucumán	0.8791
San Martín	0.8486	Sur	0.8346	Nordeste	0.8822	Patagonia San Juan Bosco	0.8720	Patagonia San Juan Bosco	0.8754
Sur	0.8449	Luján	0.8276	Patagonia San Juan Bosco	0.8813	Litoral	0.8697	Litoral	0.8709
Catamarca	0.8329	Río Cuarto	0.8242	La Pampa	0.8751	Río Cuarto	0.8694	Río Cuarto	0.8705
San Luis	0.8319	Catamarca	0.8165	Río Cuarto	0.8744	Luján	0.8655	Luján	0.8701
Río Cuarto	0.8298	Patagonia San Juan Bosco	0.8130	Luján	0.8720	Misiones	0.8645	La Pampa	0.8669
Villa María	0.8297	Buenos Aires	0.8116	Tucumán	0.8716	San Martín	0.8621	Misiones	0.8664
Patagonia San Juan Bosco	0.8143	Mar del Plata	0.8086	San Juan	0.8712	La Pampa	0.8620	San Martín	0.8608
Santiago del Estero	0.8053	La Plata	0.8052	Centro de la PBA	0.8634	Lomas de Zamora	0.8550	Lomas de Zamora	0.8603

University	RE TE score	University	REH TE score	University	TFE TE score	University	TRE TE score	University	TRE+REH TE score
Luján	0.7952	Quilmes	0.8032	Villa María	0.8619	Centro de la PBA	0.8530	San Luis	0.8573
Córdoba	0.7727	La Rioja	0.7991	San Martín	0.8518	San Luis	0.8519	Centro de la PBA	0.8537
La Pampa	0.7459	San Luis	0.7916	San Luis	0.8513	Lanús	0.8509	Lanús	0.8495
Salta	0.7408	La Pampa	0.7718	Catamarca	0.8474	Villa María	0.8482	Catamarca	0.8478
Mar del Plata	0.7402	Santiago del Estero	0.7701	Lanús	0.8462	Catamarca	0.8442	San Juan	0.8392
Formosa	0.7108	Litoral	0.7504	Lomas de Zamora	0.8298	San Juan	0.8350	Villa María	0.8373
Tecnológica Nacional	0.6981	Centro de la PBA	0.7501	Entre Ríos	0.8276	Comahue	0.8238	Comahue	0.8253
Lanús	0.6917	Tecnológica Nacional	0.7389	Comahue	0.8201	Entre Ríos	0.8229	Entre Ríos	0.8216
Chilecito	0.6820	Villa María	0.7327	La Rioja	0.8092	La Rioja	0.8167	La Rioja	0.8090
Centro de la PBA	0.6600	Salta	0.7176	Jujuy	0.7946	Santiago del Estero	0.7782	Rosario	0.7762
La Plata	0.6546	La Matanza	0.7170	Patagonia Austral	0.7877	Rosario	0.7724	Santiago del Estero	0.7734
Litoral	0.6538	Formosa	0.7030	Santiago del Estero	0.7864	Jujuy	0.7684	Jujuy	0.7687
La Matanza	0.6346	Lanús	0.6939	Rosario	0.7600	Patagonia Austral	0.7617	Patagonia Austral	0.7557
General Sarmiento	0.6030	General Sarmiento	0.6363	La Matanza	0.7555	La Matanza	0.7560	La Matanza	0.7516
Jujuy	0.5651	Misiones	0.6221	Salta	0.7360	Salta	0.7364	Salta	0.7348
Patagonia Austral	0.5500	Chilecito	0.6194	Tres de Febrero	0.6997	General Sarmiento	0.7097	General Sarmiento	0.6972
Misiones	0.5469	Jujuy	0.5809	General Sarmiento	0.6972	Tres de Febrero	0.7052	Tres de Febrero	0.6961
Buenos Aires	0.5464	Patagonia Austral	0.5590	Quilmes	0.6818	Quilmes	0.7043	Quilmes	0.6956
Tres de Febrero	0.3847	San Juan	0.4570	Chilecito	0.6711	Chilecito	0.6771	Formosa	0.6763
San Juan	0.3707	Tres de Febrero	0.4322	Formosa	0.6625	Formosa	0.6723	Chilecito	0.6594

Source: Own elaboration.

To complete the analysis, we check for the robustness of our results. To doing so, we first choose one of the five alternative fixed/random effects SFA models (i.e. RE, REH, TFE, TRE and TRE+REH) using the Hausman test and the BIC criterion. Secondly, with the model chosen in the previous step, we perform the sensitivity analysis. The Hausman test compares the fixed effect estimator that is known to be consistent, with the random effects estimator that is efficient under the assumption being tested.[15] The statistic is distributed as χ^2 and the null hypothesis is that the random effect estimator is indeed an efficient (and consistent) estimator of the true parameters. In our case, the χ^2 statistic is negative when comparing the TFE model with the RE model ((χ^2 *(10)*=-23.03), with the TRE model (χ^2 *(9)*=-89.17) and with the TRE+ REH one (χ^2 *(10)*=-33.78). This result might be interpreted as strong evidence that we cannot reject the null hypothesis and that random effects might be appropriate for modeling the SF (Stata, 2019 p. 899). When comparing the TFE model with the REH one, the χ^2 (10)=4.89 and, therefore, we cannot reject the null hypothesis that the random model is the more appropriate. Then, among the random effects models TRE+REH specification was selected since it shows the lowest BIC value.

For the sensitivity analysis, we first separate the total expenditure into its components (i.e. personnel, consumption, goods and services and transfers). Since almost 90 percent of these expenditures are due to salaries, this type of expenditure could be reflected in the teaching variables. Then model S1 includes all the expenditures' components except those that refer to personnel.

In model S2 we tested the role of research in the production frontier. Unfortunately, the database does not include any account for publications, patents, or other quantifiable research outputs, neither does it include mention to grants or other financial resources devoted to those activities. The quantifiable variable that we include is the percentage of faculty of national universities under the program of research incentives.[16] This program was introduced in the early 1990s as a sort of supplemental compensation for public universities' faculty included in accredited research projects. The incentive program categorizes the faculty in five types of researchers. Quiroga-Martinez, Fernández-Vázquez and Alberto. (2018) chose to assign weights to the categories and to disaggregate them in two broad groups. For simplicity, we considerate all incentivized faculty in one variable. Per university, we calculate the percentage of professors and teaching assistants under the program over total faculty in each institution.

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[15] For details about this test, see Hausman (1978).

[16] The "Program of Incentives to Research in National Universities" works as a supplement on salaries of professors and teaching assistants of public Argentine universities. Candidates should apply first for a qualitative category (A, B, C, etc.) which is assigned on basis of the professorship category and research individual outcomes. The categorized educator has then to apply as a member of a project crew and claim the benefit. It is not paid synchronically with salaries. Instead, it is paid quarterly and frequently with one or two quarters of delay.

In the next two models, we use two alternative specifications to measure the teachers' effects. In model S3, we consider the teachers according to their role (professor or assistant) and we include an environmental variable defined as $exclusive\_p = \frac{exclusive}{(exclusive + 0.5\ semi + 0.25\ simple)}$ to take into account the proportion of full-time over total full-time equivalent faculty.

In model S4, we consider the number of professors according to their time dedication (exclusive, semi-exclusive or simple). This classification comprised every existing category in the national system, going from full-time professors holding a permanent chair, and from full- and part-time assistants. We also include an environmental variable defined as $professors_p = \frac{professor}{(professor + assistant)}$ to account for the proportion of professors in the regression.

Finally, in all models we include an alternative measure of enrollment efficiency in the efficiency equation (*rprodnst*) defined as the ratio number of enrollees of university *i* in period *t* divided on the maximum number of enrollees of university *i* over the period 2005-2013 (model S5).

Table 8 presents the different sensitivity models. As can be seen, the results are in line with those of the basis TRE-REH model (see Table 4). In all the specifications, the number of students has a positive and significant effect on the graduates while the teachers' effects differ depending on their role (professors show positive impact while assistants have a negative sign). When the incentives for researching are included (model S2), the variable shows a positive sign. However, it is not statistically significant for explaining the number of graduates.

An interesting finding is that, when considering total expenditures as a whole this variable is never statistically significant. However, when their different components (those different from the personnel expenditures) are explicitly accounted for, the consumption expenditure variable shows a statistically significant positive sign. This result indicates that the expenditure made on materials and supplies for the operation of the universities has a positive effect on the number of graduates. Finally, the geographical regions explain the number of graduates as in the previous basis TRE-REH model.

TABLE 8

SENSITIVITY ANALYSIS: ALTERNATIVE SPECIFICATIONS OF THE TRE-REH MODEL

Variables	S1	S2	S3	S4	S5
ln Students	0.874***	0.852***	0.891***	0.897***	0.863***
	(0.076)	(0.069)	(0.062)	(0.118)	(0.067)
ln Professors_w	0.330***	0.282***			0.274***
	(0.103)	(0.095)			(0.095)
ln Assistants_w	–0.095***	–0.088**			–0.085**
	(0.038)	(0.037)			(0.036)
Incentives		0.001			
		(0.011)			
ln Consumption	0.077**				
	(0.042)				
ln Services	–0.081				
	(0.050)				
ln Goods	–0.012				
	(0.021)				
ln Professor			0.228***		
			(0.080)		
ln Assistants			–0.095***		
			(0.036)		
ln Exclusive_p			–0.018		
			(0.046)		
ln Expenditures		0.023	0.022	0.016	0.023
		(0.017)	(0.016)	(0.012)	(0.017)
ln Exclusive				0.015	
				(0.122)	
ln Semi Exclusive				0.001	
				(0.062)	
ln Simple				0.044	
				(0.038)	
ln Professors_p				0.143	
				(0.132)	
GBA	0.749***	0.656***	0.582***	0.765*	0.650***
	(0.163)	(0.147)	(0.209)	(0.395)	(0.146)
NOA	–0.150	–0.141	–0.139	–0.103	–0.143
	(0.156)	(0.149)	(0.202)	(0.217)	(0.148)
NEA	0.583***	0.681***	0.626***	0.530	0.671***
	(0.221)	(0.155)	(0.213)	(0.351)	(0.159)
Cuyo	0.384***	0.319**	0.617**	0.597**	0.323**
	(0.174)	(0.159)	(0.255)	(0.290)	(0.159)
Pampeana	0.519***	0.552***	0.558***	0.673**	0.548***
	(0.153)	(0.139)	(0.198)	(0.313)	(0.139)
Trend	0.015***	0.004	0.005	0.007	0.005
	(0.011)	(0.006)	(0.005)	(0.009)	(0.006)
rprodst	–115.056***		171.399***	–114.876	
	(11.835)		(1.266)	(200.962)	
rprodnst					–68.068***
					(10.348)

Variables	S1	S2	S3	S4	S5
Constant	–3.309*** (0.518)	3.638*** (0.474)	–3.712*** (0.384)	–3.077 (0.000)	–3.715*** (0.407)
Observations Number of id	323 37	323 37	322 37	311 36	323 37
Log-likelihood BIC	–14.701 133.4117	–15.718 129.656	–14.637 127.442	–7.9163 107.669	–17.130 126.702

Source: Own elaboration.

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Moreover, the TE scores obtained are highly and positively correlated with those of the basis TRE-REH model (the correlation coefficients undertake values over 95 percent among specifications). This indicates that the estimated TE in the base TRE-REH regression is robust to the alternative specifications performed in the sensitivity analysis.

5. SUMMARY AND CONCLUSIONS

This paper estimates the technical efficiency in teaching activity in Argentine public universities using SFA. We compare conventional models that do not account for heterogeneity with heterogeneity-extended SFA models.

We applied the basic "random effect model", an extension of the "random effect model that includes observed heterogeneity" to the mean of the inefficiency distribution, a "true fixed effects model" and a "true random effects model" (both accounting for unobserved heterogeneity), and a combination of the "true random effect model" with the extended random effect model.

We work with data from the Ministry of Education of Argentina. Our dataset consists of a balanced panel of 37 National Universities in Argentina with information over the period 2005-2013. We find that, in terms of signs and significance, results almost do not differ among specifications, except in the case of the TFE model where none of the regional dummy is statistically significant (however, the majority of the specific dummy variables are significant).

All the significant coefficients have the expected signs and have similar magnitudes across the models. The number of students has a positive effect on the determination of the production frontier, but the teachers' effects differ by roles: the number of professors has a positive impact, while the effect is negative when assistant professors are considered. This is coherent with the observed practice of having a larger proportion of assistants working in the initial years in basic (general) courses, where drop-out rates are the largest.

Only in the RE model, the expenditures explain the production of graduates. Then, it seems that human resources are more important for the definition of the production frontier than the budget allocated to each university. This result is in line with that of the non-parametric study of Quiroga-Martinez, Fernández-Vázquez and Alberto (2018).

Only when the different components of total expenditure are considered separately, the expenditure made on materials and supplies for the operation of the universities shows a significant positive effect on the number of graduates. Regarding the regional variables, all the models show that the geographical region explains the number of graduates. Ceteris paribus, all universities have a positive significant differential in the number of graduates regarding the baseline region (Patagonia) with the exception of those located in the north-west part of the country (NOA).

The time-trend variable is in general positive, but it is never statistically significant, meaning that there is no technological progress over the period under analysis. In the same vein, the faculty incentives variable does not appear significant in the estimates.

Regarding the estimated efficiency scores, the mean efficiency over the entire period goes from 75 to 82 percent depending on the model considered. This means that from 18 to 25 percent of the production (graduates) is lost due to inefficiency. These values are similar to those found in previous studies for Argentina (Alberto, Carignano and Ercole, 2010; Coria, 2011; Quiroga-Martinez, Fernández-Vázquez and Alberto, 2018) and are also in line with the international experience, which find values of average efficiency around 80 percent (Johnes, 2006). Besides, as expected, those models that account for unobserved heterogeneity present higher values of TE while the RE model presents the lowest value. This result indicates that there is evidence of heterogeneity, and that not paying attention to this fact overestimates inefficiency. Our results are robust to different model specifications.

This study adds insight into the estimation of technical efficiency in Latin American universities. However, some limitations remain. One is the difficulty in identifying the "capital intensity" required by the different fields in each university. This information could provide more robust results. Unfortunately, our sources do not include this information. Another drawback is the lack of a better measure of research activity. Once again, the database does not include any statistics regarding publications, patents, or other quantifiable research outputs. Finally, as in all previous empirical articles on this issue, externalities are not either considered in this study due to the lack of information. In this sense, this paper could be an opportunity for the policy makers to improve the existing databases.

Although it is beyond the objective of the paper to conclude any meaningful policy recommendation, we would like to highlight some points. First, this kind of analysis calls for caution regarding measures to improve graduation results such as quality-insensitive cost cutting, relaxing effort demanded on students, and focusing only on administrative efficiency (Gates and Stone, 1997 characterize some policy suggestions). Second, higher education is a knowledge intensive industry, it requires high-quality human resources and financial resources, but if incentives are not set properly (clear aims and goals in terms of outputs), money could be spent inefficiently. Third, every effort in adequately address quality and environmental issues enriches the decision making.

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FEAR SHOCKS, SUBSIDIES AND COVID-19 IN AN INTEGRATED MARKET

GOLPES DE MIEDO, SUBSIDIOS Y COVID-19 EN UN MERCADO INTEGRADO

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Abstract

In an imperfect competition model of trade a domestic and foreign country establish a cooperative or non-cooperative subsidy schedule. The optimal subsidies are positive but different in size depending of the firm's efficiency and the magnitude of the consumer market. After setting the subsidy, a fear shock in the domestic country caused by COVID-19 affects the domestic welfare depending on the subsidy schedule and firms' efficiency. The effect of a fear shock in foreign country depends on his patter of trade. Finally, when fear shock affects negatively the welfare, the best policy response is to reduce the subsidy.

Keywords: *Fear shock, integrated markets, subsidy, COVID-19, cooperative policies, emotions, cognitive bias, consumer decision, welfare analysis, international trade.*

JEL Classification: *D43, D91, F12, H30.*

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Resumen

En un modelo de comercio de competencia imperfecta, un país doméstico y foráneo establece un esquema de subsidios cooperativos o no cooperativos. Los subsidios óptimos son positivos pero de diferente tamaño según la eficiencia de las empresas, y tamaño de mercado. Establecida la política, un shock *de miedo causado por COVID-19 afecta el bienestar del país doméstico dependiendo del esquema de subsidios, y la eficiencia de las empresas. El efecto del miedo en el país extranjero depende de su patrón comercial. Finalmente, cuando el* shock *de miedo afecta negativamente el bienestar, la mejor respuesta de política es reducir el subsidio.*

Palabras clave: *Golpes de miedo, mercados integrados, subsidios, COVID-19, políticas cooperativas, emociones, sesgo cognitivo, decisión del consumidor, análisis de bienestar, comercio internacional.*

Clasificación JEL: *D43, D91, F12, H30.*

1. INTRODUCTION

Currently, there is a global challenge: the management of an infectious disease produced by the new coronavirus SARS-Cov-2, and the disease that this virus develops COVID-19. It is naive to argue about the great consequences of COVID-19 in the world. With a high rate of infection and mortality, COVID-19 is already a global concern, a pandemic. The impact of this pandemic on the world economy is as great as its health consequences.

The economic consequences derived from this pandemic are well documented: a drop in the Gross National Product (GNP), contraction of trade and investment, high unemployment rates, etc. (Baldwin and Weder di Mauro, 2020). The SARS-Cov-2 virus infects not only the world population, but also the markets. Given the obvious concern about the COVID-19 pandemic, economists identify and estimate the economic impact of the disease (for example, Atkeson, 2020; Barro, Ursua, and Weng, 2020; Gormsen and Koijen, 2020). However, our intention is not to delve into this topic. We intend to analyze, in a stylized model, one of the causes behind the crisis of the pandemic in the economy: fear.

According to Baldwin and Werder Di Mauro (2020), the economic impact of the pandemic comes from three sources. First, the impact of COVID-19 on health, which affects the labor market. Second, the economic impact of containment measures that negatively affect value chains, productivity, trade, etc. Third, those of a psychosocial nature. The first two are tangible and measurable, the third, on which this work focuses, is intangible.

Basically, the pandemic has generated a contraction in economic activity due to the drop in consumption. On the one hand, rising unemployment reduces income, at the end consumption and economic activity too. On the other hand, since confinement measures reduce economic activity and employment, there is existential loss, anxiety and terror that is evoked by the massive unemployment caused by the COVID-19 pandemic (Blustein and Guarino, 2020). The fear that occurs due to the possible loss of employment, and the fear of contracting SARS-Cov-2 reduce people's willingness to consume.

Therefore, we can argue that consumption is reduced both by the decrease in income given by the reduction in employment, along with the increase in fear of the possible scenario of job loss and contagion. In this work, we want to focus only on the second reason. While we recognize that unemployment is a fundamental variable in the explanation of the crisis, the analysis of fear, as an intangible variable, is relevant to explain the dynamics of the COVID-19 crisis. Fear includes unemployment as a catalyst for the anxiety. Fear changes individual behavior, and it depends on beliefs and cognitive biases. We argue that fear is a cognitive bias, and a relevant factor to explain the decline in the world economy due to COVID-19.

Fear is primarily an emotion stimulated by the perception of danger or threat, which causes changes at the physical and psychological levels as well as changes in behavioral ones. Likewise, fear is modulated by the process of cognition and learning. Therefore, fear is judged as rational or appropriate, and irrational or inappropriate. Fear in its cognitive process is related to anxiety (Öhman, 2008), and in its learning process, it serves for survival by generating adequate behavioral responses in its evolution (Olsson and Phelps, 2007). Moreover, it is shaped by its social relationships and culture, which guide their understanding of when and how much fear to feel (Gill and Burrow, 2017).

Humans create specific fears as a result of learning. Fear can be learned by experiencing or seeing a terrifying traumatic event on a personal and social level (Olsson, Nearing, and Phelps, 2006). The fear of Covid-19 arises mainly from a learning process encouraged by social networks, and generally with significant negative results as presented by Goyal *et al.* (2020), Li *et al.* (2020) as well as Zhou (2020). The distorted information on the factors related to the transmission of the virus, the consequences of the disease, along with the alarm generated by COVID-19 promote insecurity and fear in the population. These uncertainties not only have negative global consequences but also physical, psychological, and social implications for the population (Ornell *et al.*, 2020).

The level of fear caused by the pandemic is measured by Ahorsu *et al.* (2020). These authors develop and validate a scale that assesses fear of coronavirus: the COVID-19 fear scale (FCV-19S). In this work, fear is directly associated with its rate of transmission (rapid and invisible), as well as with its morbidity and mortality. Unfortunately, fear can amplify the damage of the disease itself. This further leads to other psychosocial challenges such as stigma, discrimination, and loss (Pappas *et al.*,

2009). With high levels of fear, people may not think clearly and rationally about COVID-19. The psychosocial aspect is not yet fully considered. With a higher level of fear, we have larger negative consequences on welfare.

Fear can change people's behavior based on the incentives they have to optimize their resources at critical moments (Harper *et al.*, 2020). Because fear is an adaptive emotion, behavioral change in times of COVID-19 affects all human dimensions such as social and economic. Particularly in the economy, fear affects consumer decisions. The higher the level of fear, the greater the impact on consumption. The outbreak of the pandemic generates drastic consequences in daily life. It increases the fear of the population and causes great economic uncertainty (Ortmann, Pelster and Wengerek, 2020). In the case of U.S. household consumption, the pandemic reduces consumption as analyzed by Baker *et al.* (2020). It has been proved in the literature that an increase in fear may reduce consumption by changing consumer behaviors (Hutjens, 2014).

According to Chen, Qian, and Wen (2020), the great uncertainty negatively affects consumers' willingness to consume as insecurity and anxiety (in the form of fear) can trigger fearful kinds of behavior even if there is no real economic threat. These authors conclude that there is a negative impact of COVID-19 on consumption after China's outbreak in late January 2020. The reduction in consumer demand, as a direct result of fear due to the pandemic, has a restrictive effect on the world economy. As a result, demand is weakened and the economic recovery would be delayed.

In a globalized context, the consequences of the pandemic on the economy are well documented. COVID-19 negatively affects trade, supply chains, and tourism, all of which have an impact on the global economy (Ahani and Nilashi, 2020). Globalization not only spreads the disease, but also inhibits efforts to control it (McKibbin and Fernando, 2020). In integrated economies, not only is international trade reduced, but also has a relative impact on the welfare of the countries (Baldwin and Tomiura, 2020). Since COVID-19 affects the supply and demand of international trade, the fear shocks affect demand. Therefore, it affects the international trade of goods and services.

The motivation for this article comes from the relationship between fear, such as a consumer shock due to COVID-19, and trade flows between two trading partners in an integrated market. The question we intend to answer is: what is the impact of a fear shock, given by COVID-19, on the welfare of two countries with integrated markets? In the context of non-cooperative and cooperative subsidy policies carried out by the countries, this work tries to analyze the optimal response against the negative economic impact of COVID-19 on the economy. Even when the effort made by European countries in order to set some cooperative polices has been notorious (Europen Council, 2020), there is an evident absence of international cooperative strategies for the rest of the world (Brown and Susskind, 2020). However, it was expected given by the reduction of the global trade integration, and the increase in the protectionism (Gunnella and Quaglietti, 2019).

The lack of cooperative strategies worldwide is not only at a medical level, but to an economic level as well. The European Union has made diagnoses on the impact of

Covid-19 on its productive structure and has chosen a set of subsidies for the rescue of its companies. However, there is no structured long-term plan for the economic recovery of the region (European Council, 2020). But in the rest of the world there are no cooperative international economic policies, either short or long term. Even in regions with some type of economic/trade agreement, there is, at most, some type of cooperation in terms of health strategies (Brown and Susskind, 2020). There are two reasons to explain the lack of economic cooperative strategies. First, the pandemic is likely so recent that the first step is to rescue the region's economy rather than boost the economy as a whole. Second, the grueling process of the trade war and the rise of populist protectionism inhibit any cooperation initiative.

On the other hand, according to the OECD (2020), the policy aimed at containing and mitigating the economic consequences of the pandemic, either as a national policy or as an international strategy (adopted by the European Union) has been the use of fiscal policy based on the granting of subsidies and in the acquisition of foreign debt by the countries. The subsidy policy is a self-reflexive act of policy makers in times of crisis. These subsidies are presented in most cases at the national level, but there is no evidence of international cooperation in this regard. Currently, the European Union has a subsidy scheme at the regional level, it is not the product of a cooperation process between countries but of previously established agreements given the nature of the integration of the area. In this work, we focus on considering subsidies as an economic mitigation policy against COVID-19.

We present a mathematical theoretical partial equilibrium model of trade in which two-countries, two-firms, with an integrated good market; establish origin-based subsidy policies. We determine the optimal subsidy policies between both countries when these policies are cooperative and non-cooperative. This equilibrium is similar to that analyzed by Keen, Lahiri, and Raimondos-Moller (2009).

However, different from the previous work, we analyze the impact of fear shock on trade flows, and consequently on the welfare of both countries. When this fear shock affects the welfare of a country negatively, the affected country reacts by using its policy of subsidies to compensate for the loss of welfare. Our main motivation is to present a theoretical model closer to the fact of how a demand shock caused by a global event, such as COVID-19, affects trade flows along with well-being between partner countries, and how to react to this shock of fear.

Assuming a partial equilibrium model of two countries and two firms helps not only to have a simple analysis, but also allows us to isolate the phenomenon of a fear shock in a specific market. In this model we are not considering a more general approach that allows us to include, among other variables, the problem of unemployment due to the pandemic. It is well known that the impact on employment is significant in consumer decisions. A general rather than partial approach would help us to relate the problem of employment with that of fear. However, we maintain a partial equilibrium model in order to have a more defined approximation of the impact of fear on consumer decisions, since the model could be enriched with a more general approach, but it would lose focus on the problem of fear.

Having only two firms allows the impact of fear shock to be incorporated into production in a simplified way. When more countries and more firms are included, the results are intuitively similar but less clear. On the other hand, in an integrated market without tariff barriers, it is expected that a fear shock may have different effects on welfare when governments have cooperative and non-cooperative subsidy policies. The aim is to analyze whether fiscal cooperation between countries produces different results than when countries establish an independent policy. In this way, we can have some intuition about whether fiscal cooperation reduces the impact of fear shock in the integrated market.

In the initial stage of the pandemic, this theoretical model is relevant since it allows us to infer some possible scenarios and results. The empirical relevance of this model comes from allowing us to establish perspectives on the impact of a fear shock on the welfare of countries in an integrated good market. In addition to technological differences (that is a common feature of rich and poor countries). As well as to estimate the impact of a fear shock on international cooperation agreements, or even to evaluate the impact of a fear shock on trade and consumption flows. A theoretical model of this type allows us enormous flexibility of analysis in different scenarios.

The model is spelled out in the following section. In section 3, we derive the properties of the optimal subsidy in a non-cooperative and cooperative equilibrium and the impact of fear shock. In section 4 some concluding remarks are made.

2. THE MODEL

Following Keen, Lahiri, and Raimondos-Moller (2009)'s basic framework, we are considering a partial equilibrium model and imperfect competition in the market for a homogenous good. In the background, we have a numeraire second commodity traded internationally in a competitive market. Both goods are produced using a single internationally immobile factor of production under constant returns to scale. So, the price of this factor gets tied down by the zero-profit condition in the numeraire sector. In the same sense, these assumptions tied down the average variable and marginal cost of production in the imperfectly competitive sector.

There are two trading countries, 'home' and 'foreign' (the latter, and all its variables, indicated by an asterisk), as well as a single representative consumer in each. Preferences may differ between the two countries. Indirect utilities in the two countries are assumed to be of the quasi-linear form

$$U(P,\mu) = \frac{P^2}{2} - \alpha P + \mu$$

$$U\left(P^*,\mu^*\right) = \frac{P^{*2}}{2} - \alpha^* P^* + \mu^*$$

where P and P^* are the consumer prices, and, μ and μ^* are the lumps-sum income or a reserve level of income, in both countries. Additionally α, α^* are positives and large enough to avoid the irrelevance result and to simplify our model. Given that the factor of production is inelastically supplied there is not the price of a factor in the argument of the indirect utility function. We get the linear demands Using Roy's identity in both countries, which are linear in prices and no income effect:

$$D = \alpha(\varepsilon) - P \tag{1}$$

$$D^* = \alpha^* - P^* \tag{2}$$

D and D^* are home and foreign demand respectively. α is a decreasing and linear function of a variable ε which we call "fear level" such that $\alpha'(\varepsilon) < 0$ and $\alpha''(\varepsilon) = 0$. Even when fear certainly may affect the foreign country as well, we analyze fear only in the home country for simplicity reasons as set in equation (1). The case in which we analyze fear in both countries does not affect the results found in this work since we always consider the net level of fear in a specific country. If we include the impact of fear in equation (2), the result depends on whether the foreign fear is greater or less than the domestic fear. The difference between foreign and domestic fear is the net level of fear. We can consider, without loss of generality, that the level of fear in the domestic country is higher than abroad. However, assuming only fear in the domestic country is a convenient assumption for simplicity.

Fear is a negative symptomatic emotion that produces extreme levels of emotional avoidance with specific stimuli (Perin *et al.*, 2015). It is associated with a social anxiety disorder and creates alterations in rationality and behavior (Krueger *et al.*, 2018). As such, widespread public fear, caused by pandemic diseases such as COVID-19, could lead to significant levels of mental distress at the population level. This distress can lead to exacerbated forecast decisions that may reduce consumption levels.

Fear does also motivate different kinds of behavior that reduce the participation in risky kinds of behavior, and excessive consumption may be risky kinds of behavior. A higher level of fear (ε) is correlated with a lower level of consumption given by anxiety produced by uncertainty about the future. Therefore, for our model, fear is a shock affecting consumer decisions.

The market for the homogenous good is internationally integrated, so the equilibrium requires:

$$D + D^* = x + x^* \tag{3}$$

where outputs in the two countries are denoted by x and x^*. On the other hand, arbitrage then equates consumer prices across the two countries as

$$P_w = P = P^* \tag{4}$$

with P_w being the world price. This price is the same for both countries. From (1) to (4) we have the aggregate inverse demand function

$$P_w = \frac{a}{2} - \frac{(x + x^*)}{2} \tag{5}$$

Such that

$$a = \left(\alpha + \alpha^*\right) > 0$$

For simplicity, we assume a monopolistic firm in each country producing and trading a homogeneous good. Even when each firm has the average variable and the marginal cost as constant through the analysis, it may differ between firms. With arbitrage as described above, profits are

$$\pi = \left(P_w - k\right)x - F \tag{6}$$

$$\pi^* = \left(P_w - k^*\right)x^* - F^* \tag{7}$$

Where $k = c–s$, $k^* = c^*–s^*$, such that s and s^* are the subsidy per-unit of output given to home and foreign firm respectively, c and F are the marginal and fixed cost of the home firm. c^* and F^* are the marginal and fixed costs of the foreign firm. The marginal cost is the part of the unit cost that is determined by technological and factor market conditions and is taken to be constant. We consider that firms have technological differences expressed in their marginal costs such that $c \neq c^*$. When the marginal cost of one firm is greater than the cost of the other, the former is more inefficient than the latter. The technological difference between countries largely defines their economic capacity. Therefore, we can have an approximation that measures the wealth and poverty of a country. The first-order conditions of (6) and (7) are

$$d\pi = \left(P_w - k\right)dx + xdP_w \tag{8}$$

$$d\pi^* = \left(P_w - k^*\right)dx^* + x^*dP_w \tag{9}$$

From (5) we get

$$\frac{dP_w}{dx} = \frac{dP_w}{dx^*} = -\frac{1}{2} < 0 \tag{10}$$

Any increase in the output of firms unequivocally reduces the world price. Using (10) into (7) and (8) we have

$$\frac{d\pi}{dx} = \left(P_w - k\right) - \frac{x}{2} = 0$$

$$\frac{d\pi^*}{dx^*} = \left(P_w - k^*\right) - \frac{x^*}{2} = 0$$

From these expressions, we can obtain the firms' output as

$$x = 2(P_w - k) \tag{11}$$

$$x^* = 2(P_w - k^*) \tag{12}$$

Taking (11) and (12) into the aggregate inverse demand function (5) we get

$$P_w = \frac{a}{6} + \frac{k + k^*}{3} \tag{13}$$

Substituting (13) into (11) and (12), we get the optimal output as

$$x = \frac{2}{3}\left(\frac{a}{2} + k^* - 2k\right) \tag{14}$$

$$x^* = \frac{2}{3}\left(\frac{a}{2} + k - 2k^*\right) \tag{15}$$

The amount of output produced by each firm depends on their marginal cost and subsidies. Starting from zero subsidies, the more efficient firm produces more than the inefficient one. Such that

$$x - x^* = 2(c^* - c)$$

Substituting (14) and (15) in the profit functions we have

$$\pi = \frac{x^2}{2} - F \tag{16}$$

$$\pi^* = \frac{x^{*2}}{2} - F^* \tag{17}$$

Finally, it is assumed that the profit of each firm accumulates for the representative consumer of that country as a lump sum of income, as well as the subsidy expenses. Therefore, we omit any income restrictions. The utilities of the representative agent, the welfare function, in the two countries are them the sum of consumer and producer surplus plus (minus) subsidy expense:

$$W = CS + \pi - sx \tag{18}$$

$$W^* = CS^* + \pi^* - s^* x^* \tag{19}$$

Where the first, second, and third term at the right hand in (18) and (19) is the consumer surplus, producer surplus, and the cost for subsidizing each firm. Because it is a partial equilibrium model, it should be clear that welfare measures only the producer and consumer surplus of the homogeneous good. We are going to focus only on the impact of the fear shock on production, consumption and subsidy decisions in this market. From the consumer surplus we have

$$dCS = -DdP_w \tag{20}$$

$$dCS^* = -D^* dP_w \tag{21}$$

The equations (1) - (3) and (13)-(21) form the backbone for the following analysis.

3. OPTIMAL POLICY AND FEAR SHOCK

Having set the basic framework, we shall now determine the optimal subsidy policy set by both countries. This policy is an origin-based subsidy policy similar to Keen, Lahiri and Raimondos-Moller (2009), in the context of an integrated good market. We consider cooperative and non-cooperative subsidies. Later on, we analyze the impact of fear shock on welfare once a subsidy policy is set in both countries.

The optimal policy is the result of a two-stage game. At stage one, both governments set their subsidy policies to maximize welfare. At stage two, the firms behave optimally under Cournot competition. We use backward induction to solve

for the subgame perfect equilibrium. At stage two, the optimal output of firms was determined in (14) and (15).

At stage one, the governments set the optimal subsidy taking into account the subsequent reaction of the firms. To do so, we have to determine comparative statics of the effects of subsidies on the optimal output, consumer, and producer surplus.

Derivation of (14) and (15) respect to the subsidy we get

$$\frac{dx}{ds} = \frac{dx^*}{ds^*} = 4/3 > 0 \tag{22}$$

$$\frac{dx^*}{ds} = \frac{dx}{ds^*} = -2/3 < 0 \tag{23}$$

It is intuitively clear that an increase in the subsidy offered by a home (foreign) government gives a competitive advantage to the home (foreign) firm over the competing one. A subsidy increases the output of the subsidized firm and reduces the output of the other firm. This intuition applies for the producer surplus (16) and (17) such that

$$\frac{d\pi}{ds} = \frac{4}{3}x > 0 \tag{24}$$

$$\frac{d\pi^*}{ds} = -\frac{2}{3}x^* < 0 \tag{25}$$

$$\frac{d\pi^*}{ds^*} = \frac{4}{3}x^* > 0 \tag{26}$$

$$\frac{d\pi}{ds^*} = -\frac{2}{3}x < 0 \tag{27}$$

Unequivocally, a subsidy received by a firm increases its profits and reduces the profits of the competing firm. On the other hand, from (13) we get,

$$\frac{dP_w}{ds} = \frac{dP_w}{ds^*} = -\frac{1}{3} < 0$$

Any subsidy reduces the world price as more output is in the market. Consequently, from (20) and (21), we get the impact of the subsidy on consumer surplus as,

$$\frac{dCS}{ds} = \frac{dCS}{ds^*} = \frac{D}{3} > 0 \tag{28}$$

$$\frac{dCS^*}{ds^*} = \frac{dCS^*}{ds} = \frac{D^*}{3} > 0 \tag{29}$$

A subsidy, offered by any country, benefits the consumer surplus of both countries because of the reduction in the world price of the consumer good. The increase in production of the subsidized firm is greater than the decrease in the production of the other one, decreasing the world price.

On the other hand, we can derive the impact of fear shock on the welfare of both countries assuming subsidies as given. From (13), (14) and (15), we have

$$\frac{dP_w}{d\varepsilon} = \frac{\alpha'(\varepsilon)}{6} < 0 \tag{30}$$

$$\frac{dx}{d\varepsilon} = \frac{dx^*}{d\varepsilon} = \frac{\alpha'(\varepsilon)}{3} < 0 \tag{31}$$

First of all, a larger level of fear implies a reduction in consumption, and the world price goes down. The output of firms also decreases due to the reduction in consumption. Under these reasons, the profits of firms decrease as well. From (16) and (17), we have

$$\frac{d\pi}{d\varepsilon} = \frac{\alpha'(\varepsilon)}{3} x < 0 \tag{32}$$

$$\frac{d\pi^*}{d\varepsilon} = \frac{\alpha'(\varepsilon)}{3} x^* < 0 \tag{33}$$

The fall in production reduces the producer surplus. However, the reduction in the price affects the consumer surplus (20) and (21) as,

$$\frac{dCS}{d\varepsilon} = \frac{5D}{6}\alpha'(\varepsilon) < 0 \tag{34}$$

$$\frac{dCS^*}{d\varepsilon} = -\frac{D^*}{6}\alpha'(\varepsilon) > 0 \tag{35}$$

Initially, an increase in fear produces a downward shift of D as suggested (1) and decreases the world price as in (30). For the home country, the reduction in the demand is larger than the reduction in the market price such that the consumer surplus

decreases. On the other hand, for the foreign country, the quantity of goods available in the integrated economy is greater, and the price is reduced. So the consumer surplus of foreign country increases with the fear shock.

Once we have defined the comparative statics of subsidies and fear, we derive the impact of subsidies and fear on welfare. Total differentiation of (18) and (19), using (22) to (35) we get:

$$dW = A_1 ds + A_2 ds^* + A_3 d\varepsilon \tag{36}$$

$$dW^* = A_1^* ds + A_2^* ds^* + A_3^* d\varepsilon \tag{37}$$

Where

$$A_1 = \frac{D}{3} + \frac{4}{3}x - s\frac{4}{3} - x$$

$$A_2 = \frac{D}{3} - \frac{2}{3}x + s\frac{2}{3}$$

$$A_3 = \frac{\alpha'(\varepsilon)}{3}\left[x + \frac{5}{2}D - s\right]$$

$$A_1^* = \frac{D^*}{3} - \frac{2}{3}x^* + s^*\frac{2}{3}$$

$$A_2^* = \frac{D^*}{3} + \frac{4}{3}x^* - s^*\frac{4}{3} - x^*$$

$$A_3^* = \frac{\alpha'(\varepsilon)}{3}\left[x^* - \frac{D^*}{2} - s^*\right]$$

All coefficients seem ambiguous. Now, we determine the optimal subsidy policies and the impact of fear shock on welfare in two scenarios. These are the case of non-cooperative and cooperative policies.

3.1. Non-cooperative policies

In this case, both governments in each country determine the optimal pollution policy taking into account their welfare only. They do not pay attention to the other country's welfare. To determine the optimal non-cooperative policies, we set $\frac{dW}{ds} = 0$, and $\frac{dW^*}{ds^*} = 0$ such that A_1 and A_2^* in (36) and (37) should be equal to zero, and solving for each policy as

$$s^{NC} = \frac{1}{4}(D + x) > 0 \tag{38}$$

$$s^{*NC} = \frac{1}{4}\left(D^* + x^*\right) > 0 \tag{39}$$

The concavity conditions hold for both policies since

$$\frac{d^2W}{ds^2} = \frac{d^2W^{*^2}}{ds^{*^2}} = -1 < 0$$

Optimal subsidies are positive. These results are similar to those presented by Keen, Lahiri, and Raimondos-Moller (2009). The amount of subsidy depends on the efficiency of firms and the demand on each country. From (1), (2), (5), (14), (15), (38) and (39) we have

$$s^{NC} - s^{*NC} = \frac{1}{2}\left(\alpha - \alpha^*\right) + (c^* - c)$$

A larger subsidy is granted by the country with the most efficient firm, and the largest consumer market. We can formally say that

Proposition 1. *In a model of imperfect competition model of trade between two countries with an integrated market, the optimal non-cooperative subsidies established by each country are positive. However, the subsidy granted by the country with the most efficient firm, and the largest consumer market is greater than the subsidy granted by the other country.*

Intuitively speaking, subsidizing the local firm improves welfare since the increase in consumer and producer surplus is greater than the cost of financing the subsidy. On the other hand, it is intuitively clear that the country with the highest production efficiency and the largest consumer market size establishes a greater subsidy to satisfy its market and to get a competitive advantage. Each country is interested in a policy that benefits its welfare, establishing a subsidy is a policy measure that guarantees a certain level of competitiveness and provision of consumer goods.

Now, we shall consider the impact of fear shock on the welfare of each country once the optimal subsidies have been set. Substituting (38) and (39) into the coefficient A_3 and A_3^* we have

$$\left.\frac{dW}{d\varepsilon}\right|_{s = s^{NC}} = \frac{\alpha^{'}(\varepsilon)}{4}[x + 3D] < 0 \tag{40}$$

$$\left.\frac{dW^*}{d\varepsilon}\right|_{s^* = s^{NC^*}} = \frac{\alpha'(\varepsilon)}{4}\left[x^* - D^*\right] \tag{41}$$

The effect of a fear shock on the welfare of the home country is unequivocally negative. The fall in producer and consumer surplus is greater than the fall in the cost of the subsidy. On the other hand, the effect of a shock of fear on the welfare of the foreign country is determined by the commercial profile of the country. In an integrated market of two countries, one country is the exporter and the other one is the importer.

According to (41), if $x > D$ home country is the exporting country, and the foreign country becomes the importing country so that $x^* < D^*$. In the foreign country, an increase in the level of fear reduces producer surplus, increases consumer surplus, and reduces the cost of the subsidy. Therefore (41) is positive regardless of the difference in the level of efficiency of the firms. In the event that the foreign country is the exporter, the opposite analysis applies. Formally, we can say

Proposition 2. *In a model of imperfect trade competition between two countries and a non-cooperative subsidy policy, an increase in the level of fear reduces the welfare of the home country. The welfare of the foreign country depends on the pattern of trade: if the foreign country is an importer, welfare grows, but if it is an exporter, welfare is reduced.*

For example, there is a reduction in most commodity prices due to the COVID-19 pandemic according to the World Bank Group (2020). A negative impact is expected for exporting countries of these goods, but a benefit for importing countries. Of course, the outcome may seem counterintuitive as the pandemic crashes markets and erodes people's incomes.

However, from the perspective of a partial equilibrium model, in which we measure welfare in terms of the tradable good, we can consider that the surplus of this good reduces the world price. Therefore, it improves the consumer surplus of the importing country. Due to the assumption of numeraire good, we are considering that people have an income reserve that allows a minimum level of consumption. Any change in the income of the people given by, for example, income-generating employment affects the consumption of the numeraire good.

Finally, to end this sub-section, when an increase in the fear level reduces the welfare of a home country, the local government attempts to correct this negative shock by employing policy instruments available. In this case, when the local government pursues an optimal subsidy policy, in what way should the local government respond to an increase in the fear level? The best policy response to this fear shock is through the change in optimal subsidy policy. From (38), we have

$$\frac{ds^{NC}}{d\varepsilon} = \frac{7\alpha'(\varepsilon)}{24} < 0$$

The best policy response of the home country is to reduce the subsidy since a reduction in the subsidy reduces the cost for subsidizing as well as increases the producer surplus of the foreign country. This strategy tries to compensate for the negative shock on consumption by reducing the cost of subsidy. Moreover, it offers a competitive advantage to the foreign firm. It is a counterintuitive result as the local government is promoting a competitive disadvantage to the local company. However, in an integrated market the consumer surplus is expected to improve by reducing the costly subsidy to be supplied by the foreign firm. Formally, we can say

Proposition 3. *In an imperfect competition model of trade between two countries with an integrated market, the optimal response of the home country to an increase in the fear level is to reduce the subsidy paid to the home firm.*

This strategy seems contradictory in pandemic times because many governments in the world promote the subsidy as an economic recovery strategy. However, when consumption falls, subsidizing firms becomes costly, and governments prefer to import cheaper goods. For example, in Mexico, the government removed restrictions on drug imports, removing government support for Mexican drug producers to have cheaper medicines. The Mexican government's argument is that the cost of medicines is high, and the cost of supporting local firms is greater than the loss in consumer surplus. Of course, it is not a generalized strategy as this policy strategy is limited to certain integrated markets where the benefit in consumer surplus is larger than the fall in production and employment.

However, the strategy adopted by the home country may adversely affect the foreign one. From the coefficient A_1^* in (37), and taking the optimal foreign firm subsidy as given, we have

$$\left.\frac{dW^*}{ds}\right|_{s^* = s^{NC^*}} = \frac{1}{2}\left[D^* - x^*\right]$$

In the event that the foreign country is an importer $\left(D^* > x^*\right)$, the reduction of the subsidy negatively affects the foreign country since the reduction of the home subsidy makes the imported goods more expensive despite the benefit of the foreign producer's surplus. When a foreign country is an exporter $\left(D^* < x^*\right)$, a reduction in the domestic subsidy improves the welfare of the foreign country through a greater producer surplus.

If the foreign country may expect a reduction in welfare due to the reduction in subsidy, then the best policy response to this home subsidy reduction is to increase the subsidy offered by the foreign government to the foreign firm. From (39), we have

$$\frac{ds^{NC^*}}{ds} = -\frac{1}{12} < 0$$

The increase in the subsidy increases the capacity to produce and therefore to consume the good. In this way, the foreign country is less dependent on imports. However, in this work, we are not interested in analyzing the dynamic interaction between subsidy policies, but we can see that if the governments of both countries react to the other's policy changes, both countries will seek a policy that compensates for their decline in welfare.

3.2. Cooperative policies

When both countries agree to cooperate with a particular subsidy policy, the policy set by each country is going to take into account not only the impact on his welfare but also the welfare in the other country. Each country's subsidy policy affects the consumer and producer surplus and the cost of the other country's subsidy. To do so, we solve the following system,

$$dW = (A_1 + A_1^*)ds + A_3 d\varepsilon \tag{42}$$

$$dW^* = (A_2 + A_2^*)ds^* + A_3^* d\varepsilon \tag{43}$$

We set $\frac{dW}{ds} = 0$, and $\frac{dW^*}{ds^*} = 0$, such that $(A_1 + A_1^*)$ and $(A_2 + A_2^*)$ in (46) and (47) are equal to zero and solving for each policy taking into account (14) and (15) we have

$$s^c = \frac{1}{2}\left[D + D^* - x\right] = \frac{1}{2}x^* = \frac{1}{4}a - \frac{1}{2}c^* > 0 \tag{44}$$

$$s^{c^*} = \frac{1}{2}\left[D + D^* - x^*\right] = \frac{1}{2}x = \frac{1}{4}a - \frac{1}{2}c > 0 \tag{45}$$

Where

$$x = \left(\frac{1}{2}a - c\right)$$

$$x^* = \left(\frac{1}{2}a - c^*\right)$$

The concavity conditions hold for both policies since

$$\frac{d^2W}{ds^2} = \frac{d^2W^{*2}}{ds^{*2}} = -\frac{2}{3} < 0$$

As in the non-cooperative case, both subsidies are positive. However, the amount of subsidy given by each country is different. From (14), (15), (44) and (45) we get

$$s^c - s^{c^*} = \frac{1}{2}(c - c^*)$$

The country with the most inefficient firm is offering the largest subsidy. Formally, we can say

Proposition 4. *In an imperfect competition model of trade between two countries, the optimal cooperative subsidies set by each country are positive. However, the subsidy granted by the country with the most inefficient firm is larger than the subsidy granted by the other one.*

The optimal pollution policy is to set a positive subsidy in both countries since the benefits in producer and consumer surplus of both countries are larger than the cost for subsidizing firms. Countries are taking into account the cost of subsidy and the consumer and producer surplus of the other country as well, so the subsidies that they agree to establish are oriented to achieve the maximum possible production to benefit consumers in both countries.

However, in case of a cooperative subsidy, the amount of the subsidy depends only on the efficiency of the firms. This amount is higher the lower the efficiency of the firm. When the subsidy is cooperative, both countries take into account the market of the other country, and therefore, the country with the most inefficient firm compensates its competitive disadvantage with a higher subsidy to adequately supply the market of the region. The subsidy is aimed at improving the efficiency and competitiveness of firms.

Now, as in the previous case, we shall consider the impact of fear shock on the welfare of each country once the optimal subsidies have been set. Substituting (44) and (45) into the coefficient A_3 and A_3^*, we have

$$\left.\frac{dW}{d\varepsilon}\right|_{s = s^C} = \frac{\alpha'(\varepsilon)}{6}\left[x + \frac{5}{2}D - \frac{1}{2}x^*\right] \tag{46}$$

$$\left.\frac{dW^*}{d\varepsilon}\right|_{s^* = s^{*C}} = \frac{\alpha'(\varepsilon)}{6}\left[x^* - D^*\right] \tag{47}$$

From the optimal outputs x and x^* defined above, when the foreign firm is equal to or less efficient than the home firm $(c^* \geq c)$, then $x^* < x$, and (46) is negative. That is, a fear shock reduces the welfare of the home country. On the contrary, when the demand from the home country (D) is small, and the home firm is sufficiently less efficient than the foreign one $(c^* \ll c \text{ then } x^* \gg x)$, a fear shock increases the welfare of the home country.

On the other hand, the impact of the fear shock in the foreign country is the same as in the non-cooperative case regardless of the difference in the level of efficiency of the firms. Again, the effect of a fear shock on welfare could be determined by the foreign country's commercial profile. When the home country is the exporting one and the foreign country is the importing one, (47) it is positive. When the home country is the importing one and the foreign country is the exporting one, (47) is negative. Formally we can say

Proposition 5. *In a model of imperfect trade competition between two countries and a policy of cooperative subsidies, an increase in the level of fear increases the welfare of the foreign country if this country is an importer. It reduces welfare if this country is an exporter. On the other hand, if the home firm is at least as efficient as the foreign firm, an increase in the level of fear reduces the benefit of the home country. Otherwise, when the foreign firm is sufficiently more efficient than the home company, and the size of the home demand is small, then an increase in the fear level increases the welfare of the home country.*

When the firm in the home country is at least as efficient as the foreign one, the producer surplus in the home country is large. A fear shock generates a fall in producer surplus of both firms, and a fall in home consumer surplus larger than the increase in the foreign consumer surplus. The net fall on consumer and producer surplus is larger than the reduction in the cost of the subsidy. But when the firm in the home country of is very inefficient and its demand is small, it means that the producer and consumer surplus in home country are small. A fear shock improves the welfare of the home country, since the reduction in the cost of the subsidy along with the increase in foreign consumer surplus are greater than the fall in producer surplus in both firms, and the fall in home consumer surplus. The intuition behind this result is that the cooperative subsidy policy is designed to compensate for the inefficiency of firms in the face of competition. Therefore, the more inefficient the firms, the higher the subsidy cost.

As in the case of non-cooperative subsidies, if $x > D$ home country is the exporting one, and the foreign country becomes the importing one so that $x^* < D^*$. In this case, an increase in the level of fear reduces producer surplus, increases consumer surplus, and reduces the cost of the subsidy. Therefore, (47) is positive regardless of the difference in the level of efficiency of the firms. In the event that the foreign country is the exporter $(x^* > D^*)$, the opposite analysis applies. It appears that the establishment of a cooperative subsidy does not affect the impact of a fear shock on

foreign welfare. The result is explained by the fact that we assume that the foreign country has not affected its consumption decision due to the increase in fear.

When an increase in the fear level reduces the welfare of a home country, the home government attempts to correct this negative shock by employing policy instruments available. The best policy response to this fear shock is through the change in optimal subsidy policy. From (44), we have

$$\frac{ds^C}{d\varepsilon} = \frac{\alpha'(\varepsilon)}{4} < 0$$

Again, the best policy response of the home country is to reduce the subsidy. The reduction in the cost of subsidy would be larger than the loss in home producer surplus and consumer surplus of both countries. This strategy tries to compensate for the negative shock on consumption by reducing the cost of the subsidy. Formally, we can say

Proposition 6. *In an imperfect competition model of trade between two countries and cooperative subsidy policy, the optimal response of the home country to an increase in the fear level is to reduce the subsidy paid to the home firm.*

As previously mentioned, this strategy seems contradictory in times of pandemic because many governments in the world promote the subsidy as an economic recovery strategy. However, the cost of subsidizing the home firm is greater as its productivity increases. The best strategy, regardless of the other economy's concern for a cooperative policy, is to reduce the subsidy.

On the other hand, it is expected that the shock of fear, due to COVID-19, generates unilateral decisions of the negatively affected country regardless of the agreements that it has had in terms of cooperation with other countries. Cooperation agreements are fragile in pandemic times. As mentioned above, a fear shock is not a predictable situation in any trade deal. The negative effect on the economy, and the unforeseen event, makes any trade deal relatively unstable. The countries, faced with a pandemic crisis like the current one, will determine policies that best suit their own interests, breaking previously established agreements. Trade agreements are unstable in crisis contexts such as the COVID-19 pandemic.

In a cooperative policy context, any change in policy by the home government simply breaks the rules of cooperation. The foreign government does not expect any cooperative reaction, even when this government benefits or not from the change in home policy. Breaking the cooperative rule is simply going back to the non-cooperative case unless a new agreement has to be formalized again. It is not useful to analyze the reaction of the foreign government. A new cooperative agreement must be signed instead.

4. CONCLUSIONS

It is naive to say that COVID-19 has not been an economic nightmare for economies around the world. One of the consequences of the pandemic is the change in consumer behavior caused by a fear shock. Fear is a distortion of the rationality typical of an environment of uncertainty that disturbs consumption decisions. It can shake the global economy. It is our interest to analyze the impact of a fear shock on the market equilibrium of a world of two countries.

We develop a partial equilibrium model between two trading partner countries, and a firm in each of them that competes in an integrated market. Each country establishes a subsidy in a non-cooperative way (competition subsidy) or in a cooperative way. Once the subsidy scheme is established, both countries face the emergence of a pandemic that upsets the balance in trade and welfare due to a change in consumer decision caused by a fear shock that restricts consumption.

With either a cooperative or a non-cooperative subsidy scheme, optimal subsidies are positive. However, the amounts of non-cooperative subsidies depend on the difference in the efficiency of the firms, and the size of the consumer market. Since each country is only concerned with maximizing its own profit, the country with the highest production efficiency and the largest market size establishes a greater subsidy to satisfy its market and obtain a competitive advantage over the other country. In the case of a cooperative subsidy, both countries also take care of the welfare of the other, so that the subsidies are oriented to reduce the inefficiency of the companies and maximize the welfare in both countries. In this way, the subsidy is higher when the company is less efficient to help it grow and supply the market in the region.

Once optimal policies are in place, a fear shock in the home country can distort the trade balance and affect the welfare of countries. This fear shock reduces both the producer surplus in both countries and the consumer surplus in the home country. Nevertheless, it increases the consumer surplus in the foreign country due to a reduction in the world price. When the subsidy is non-cooperative (competitive), the fear shock reduces the welfare of the home country. On the other hand, the foreign country can be an importing or an exporting country. When the country is an importer, a fear shock increases consumer surplus and thus welfare due to the fall in world price. For example, falling commodity prices can increase consumer surplus in importing countries with reduced economic impact from COVID-19. Otherwise, when the country is an exporter, the fall in the consumption of the home country negatively affects the welfare of the foreign country via the fall in its exports.

On the other hand, when both countries establish a cooperative subsidy, a fear shock negatively affects the welfare of the home country if the home firm is at least as efficient as the foreign firm as expected. But when the home country has a much more inefficient firm and its consumer market is very small, then a fear shock improves welfare, since the impact of the shock is minimal and the reduction in the cost of subsidizing an inefficient firm is high. In the presence of a fear shock, the

best strategy is not to subsidize the inefficient firms because of the high cost of their rescue. Finally, the impact of the fear shock in the foreign country is the same as that presented in the non-cooperative case since this country does not experience the fear shock in its demand.

What is the best response of the home country to the fall in its welfare due to a fear shock? The optimal answer is always to reduce the subsidy, and thus reduce the cost of financing the home business. Although this is counterintuitive result, in an integrated market the benefit is obtained by improving the consumer surplus with the goods produced by the foreign firm and at a lower cost. The improvement in the consumer surplus and the reduction in the cost of the subsidy are greater than the fall in the home producer surplus. With segmented markets the political reaction would surely be different. On the other hand, this policy of reducing subsidies is not sustainable when both countries establish a cooperative subsidy scheme. In this case, the fear shock makes the agreement untenable. Therefore, both countries decide their best option even if it prejudices the other country.

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EFECTO DE LOS INDICADORES DE GOBERNANZA MUNDIAL SOBRE EL NIVEL DE CONVERGENCIA

EFFECT OF WORLD GOVERNANCE INDICATORS ON THE CONVERGENCE LEVEL

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Resumen

La investigación pretende analizar el grado de afectación de la calidad institucional respecto del nivel de convergencia en el mundo mediante un enfoque de dos pasos. Primero, identificamos clubes de convergencia utilizando la prueba log-t en 176 países durante 1996-2018. Segundo, mediante la regresión logística ordenada investigamos la probabilidad de pertenencia a determinado club, según calidad institucional. La investigación presenta dos contribuciones fundamentales. Primero, un enfoque metodológico distinto. Segundo, se hallan seis clubes y dos factores determinantes para un nivel de convergencia alto, mientras que el resto de factores incrementan la probabilidad de pertenecer a un grupo de ingresos medios.

Palabras clave: *Convergencia, crecimiento, instituciones, prueba log-t, regresión logística.*

Clasificación JEL: *B25, B52, C23.*

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Abstract

The research aims to analyze the degree of impact of institutional quality on the level of convergence in the world through a two-step approach. First, we identified convergence clubs using the log-t test in 176 countries during 1996-2018. Second, through the ordered logistic regression we investigate the probability of belonging to a certain club, according to institutional quality. The research presents two fundamental contributions. First, a different methodological approach. Second, there are six clubs and two determining factors for a high level of convergence, while the rest of the factors increase the probability of belonging to a middle-income group.

Keywords: *Convergence: growth, institutions, log-t test, logistic regression.*

JEL Classification: *B25, B52, C23.*

1. INTRODUCCION

Uno de los hallazgos más importantes en la literatura empírica respecto del crecimiento económico es que, en todos los países, las instituciones son un determinante importante del desarrollo económico a largo plazo (Hall y Jones, 1999; Acemoglu, Johnson y Robinson, 2001; Rodrik, Subramanian y Trebbi, 2004). Los países ricos generalmente gozan de instituciones de mejor calidad que los países en vías de desarrollo. Acemoglu (2009) sostiene que existe un convincente apoyo empírico a la hipótesis de que las diferencias en las instituciones económicas, más que la suerte, la geografía o la cultura, causan diferencias en los ingresos per cápita.

Si el desarrollo institucional es un factor importante del crecimiento a largo plazo, entonces comprender la naturaleza del desarrollo institucional es fundamental para tener una idea del proceso de crecimiento. Varias contribuciones a la literatura de crecimiento empírico han intentado arrojar luz sobre esto probando si la calidad institucional en los países en desarrollo converge con la de los desarrollados. Por ejemplo, Knack (1996) y Knack y Keefer (1995) encuentran que la diferencia en la calidad institucional es una razón importante por la que los países pobres no pueden converger con los países de altos ingresos. Estudios más recientes han encontrado que los países con menor calidad institucional mejoran sus capacidades institucionales más rápido que los países con mejor calidad institucional (Elert y Halvarsson, 2012). Savoia y Sen (2016) encontraron que los países con instituciones inicialmente pobres tendían a alcanzar lentamente a aquellos con alta calidad institucional, independientemente de las condiciones iniciales de las instituciones.

Una característica destacada de todas estas contribuciones es que se basan en alguna versión de las pruebas de sigma o convergencia β. Una limitación clave de estas pruebas es que se basan en la idea de la presencia de un solo estado estacionario estable

a largo plazo. Esto ignora la posibilidad de la existencia de múltiples estados estables (o convergencia de clubes) en la economía para diferentes grupos de países. Para tener en cuenta esta posibilidad, Phillips y Sul (2007) sugieren un método basado en la regresión para analizar la transición económica. Este enfoque supera las deficiencias en los enfoques anteriores y acomoda un concepto más amplio de convergencia en comparación con los estudios anteriores de Chatterji (1992) y Quah (1997). Lo más importante, este marco econométrico permite la posibilidad de convergencia absoluta o de subgrupo (club) bajo una variedad de posibles caminos de transición. En este documento hacemos la pregunta: ¿en qué medida la calidad de las instituciones medida por medio de los indicadores de gobernanza afecta el nivel al que convergen los países hacia su propio estado estacionario? Encontramos evidencia clara de convergencia en clubes y la pertenencia a un club específico está estadísticamente vinculada a la calidad observada de las instituciones de cada economía.

Desde un punto de vista teórico, se debería esperar equilibrios múltiples en la calidad institucional. Acemoglu y Robinson (2006; 2008) argumentan que puede haber persistencia de instituciones económicas extractivas como los derechos y regulaciones de propiedad inseguros, los que limitan la entrada a mercados e instituciones políticas extractivas. Estas instituciones concentran el poder en manos de unos pocos con controles y equilibrios limitados, ya que las élites políticas que se benefician de estas instituciones no tendrían ningún incentivo para cambiarlas. Del mismo modo, Blackburn *et al*. (2006) muestran que el desarrollo económico y la corrupción pueden determinarse conjuntamente, de modo que pueden existir múltiples equilibrios a largo plazo donde es difícil cambiar de un estado de alta corrupción y bajo desarrollo económico a un estado de baja corrupción y alto desarrollo económico. Esta idea está relacionada con el planteamiento de Baumol (1986) acerca de la hipótesis de convergencia en club. Según esta última, si dos países inician el proceso de convergencia económica con diferentes ingresos por trabajador, llegarán a diferentes estados estacionarios, es decir, diferentes equilibrios.

Si las instituciones son realmente vulnerables a la existencia de equilibrios múltiples, implica que algunos países están atrapados con instituciones de bajo nivel, mientras que otros convergen hacia la mayor calidad institucional de los países desarrollados. Sin embargo, este resultado lleva inmediatamente a una aparente contradicción con el consenso actual de que las instituciones tienen una relación causal con los ingresos. Por un lado, encontramos instituciones que exhiben equilibrios múltiples. Por otro lado, la literatura respecto de convergencia de ingresos parece implicar que el ingreso per cápita tiene un único equilibrio de estado estacionario a largo plazo. ¿Cómo explicamos entonces una relación causal entre una variable con equilibrios múltiples y otra que tiene un solo equilibrio? La única explicación lógica podría ser (i) que el ingreso per cápita en sí exhibe equilibrios múltiples (el ingreso en algunos países está detenido en situaciones de bajo nivel, mientras que otros convergen al nivel de los países desarrollados) en lugar de convergencia única y (ii) que la calidad de las instituciones es un determinante significativo de los niveles de ingresos. En conjunto, estos dos

resultados reforzarían nuevamente la fuerte relación causal entre las instituciones y los ingresos, pero la dinámica de esta relación sería significativamente diferente en comparación con la forma en que se prevé en la literatura actual.

En este sentido, los datos entre países proporcionan evidencia de estas posibilidades. Utilizando una regresión logística ordinal, se muestra que la calidad de las institucionales son un determinante significativo en la determinación de clubes de convergencia según su estado estacionario propio. En resumen, este artículo contribuye a la literatura de crecimiento empírico de dos maneras importantes. En primer lugar, según nuestro conocimiento, este estudio es el único intento de demostrar que, en muchos países en desarrollo, la calidad de las instituciones es capaz de explicar la convergencia al nivel de los países desarrollados. Luego, el documento establece empíricamente un fuerte vínculo entre la calidad institucional y el crecimiento, pero que es claramente diferente de la discutida en la literatura actual. Más específicamente, mostramos que no solo los países con instituciones pobres tienen ingresos más bajos, sino que una mejora de la calidad institucional no necesariamente conlleva un desplazamiento positivo en el nivel de convergencia de ingresos. Establecer esta naturaleza particular de la relación institución-ingreso constituye la contribución más relevante e importante de este documento.

El estudio comprende dos etapas. En la primera etapa, aplicamos el método de Phillips y Sul (2007) para formar los clubes de convergencia, durante el periodo 1996 hasta 2018 para 176 países. Nuestro estudio muestra que, durante este período, estos países no exhiben una convergencia absoluta hacia un único estado estacionario. Sin embargo, la mayoría de los países convergen en más de un club que emerge con el tiempo, mientras que dos países divergen de estos clubes. Además, los clubes caracterizados por un bajo nivel de ingresos no muestran ninguna tendencia a converger hacia el club superior, lo que indica que estos países están atrapados en trampas de bajos ingresos.

En el segundo paso, una regresión logística (*logit*) ordinal u *ologit* es usada para probar si la calidad de las instituciones medida por medio de los indicadores de gobernanza es un determinante causal importante de pertenecer a un determinado club. Los resultados señalan que dos factores resultan relevantes para determinar la pertenencia a clubes de mayor ingreso, estos son: efectividad del gobierno y estabilidad política.

El artículo está dividido en cinco secciones. La siguiente sección revisa la literatura relevante. La sección tres describe la metodología de Phillips y Sul (2007) que se utiliza para identificar clubes de convergencia. La sección cuatro presenta los resultados de las pruebas de convergencia utilizando el método de Phillips y Sul y los resultados obtenidos al aplicar un modelo de regresión *ologit* entre instituciones y nivel de ingresos. La sección cinco concluye el artículo.

2. REVISION DE LITERATURA

Hay dos ramas de la literatura que son relevantes para este artículo. La primera trata de estudios que se han centrado en la naturaleza del desarrollo institucional. Elert

y Halvarsson (2012) utilizan el "Índice de Libertad Económica del Mundo", para 141 países durante el período 1970-2009. El estudio encontró que los países con menor calidad institucional mejoran más rápido que los países con mayor calidad institucional. Savoia y Sen (2016) prueban la convergencia absoluta y condicional en la calidad institucional, basada en medidas de calidad legal, burocrática y administrativa, para el período 1970-2010. Para una convergencia absoluta, los autores utilizaron como variable dependiente la tasa de crecimiento anual promedio en la calidad institucional y como independiente a la calidad institucional observada al comienzo del período de la muestra. Un coeficiente negativo estimado confirmó la existencia de convergencia absoluta. El mismo ejercicio fue repetido para la convergencia condicional, donde un conjunto de variables explicativas (por ejemplo, PIB per cápita inicial, nivel inicial de educación, democracia, efectos fijos regionales, efecto geográfico, variables *dummies* de origen legal, religión, fraccionamiento étnico, etc.) que explican los determinantes a largo plazo del cambio institucional fueron incluidas en la regresión. Ambas pruebas de convergencia, es decir, absoluta y condicional, muestran claramente una correlación negativa significativa entre la medida de calidad institucional inicial y la tasa de crecimiento promedio anual en la calidad institucional. Con base en estos hallazgos, concluyen que los países con instituciones inicialmente pobres tendieron a ponerse al día lentamente con los países con alta calidad institucional, independientemente de las condiciones iniciales de las instituciones. Sin embargo, ninguno de estos dos estudios permite la posibilidad de clubes de convergencia respecto de niveles de ingreso per cápita. En este artículo se evalúa el efecto de la calidad institucional respecto del nivel de convergencia a nivel de clubes.

La segunda rama se ocupa específicamente del desarrollo metodológico de varias medidas de convergencia, lo que lleva al desarrollo de técnicas que pueden usarse para identificar clubes de convergencia. La literatura concerniente a la convergencia del producto se remonta a Baumol (1986). Sin embargo, fueron Barro y Sala-i-Martin (1992; 2004) quienes introdujeron por primera vez los conceptos de convergencia beta (β) y sigma (σ). La convergencia β implica que los países más pobres crecen más rápido que los más ricos y los alcanzan a largo plazo. La convergencia σ implica que la dispersión del ingreso disminuye con el tiempo. Posteriormente, estos enfoques transversales puros fueron criticados por no tener en cuenta las diferencias no observadas entre países (heterogeneidad transversal) y son susceptibles a errores de medición, sesgos de endogeneidad y autocorrelación espacial (Temple, 1999). Como resultado, muchos procedimientos de prueba recientes para la hipótesis de convergencia se han desarrollado utilizando series de tiempo o técnicas de datos de panel. Bernard y Durlauf (1995) y Evans y Karras (1996) señalaron la importancia de las series de tiempo y los métodos de datos de panel en lugar del enfoque transversal.

Al conceptualizar la convergencia dentro de un marco de datos de panel, Phillips y Sul (2007) proporcionan un avance importante en las pruebas de convergencia, ya que su metodología se ocupa de varias deficiencias encontradas en las pruebas anteriores descritas previamente. En primer lugar, capturan el comportamiento transversal

heterogéneo, mediante la adopción de un modelo que involucra un factor común (que representa la tendencia a largo plazo) y los efectos idiosincrásicos (que representan la heterogeneidad transversal a corto plazo). Los estudios anteriores que tenían una estructura similar se centraron en analizar las propiedades asintóticas de los factores comunes en los modelos de fijación de precios de Chamberlain y Rothschild, 1983; Connor y Korajczyk, 1986. Otros estudios han acomodado factores comunes no estacionarios y errores idiosincráticos (Bai y Ng, 2002; Moon y Perron, 2004). Phillips y Sul (2007) extienden estos modelos para capturar el comportamiento heterogéneo del agente al permitir que el elemento idiosincrásico sistemático evolucione con el tiempo. La prueba de convergencia luego se reduce a una prueba econométrica basada en regresión de si estos componentes idiosincrásicos heterogéneos que varían en el tiempo convergen con el tiempo en una constante. Este enfoque también se ocupa de otras deficiencias en la metodología anterior. A diferencia de los enfoques basados en series temporales, su prueba no necesita hacer suposiciones acerca de la estacionariedad de la variable o el factor común. Además, este es el único enfoque que permite al investigador diferenciar entre una amplia gama de posibilidades de convergencia: convergencia absoluta, divergencia de transición con convergencia a largo plazo, convergencia de club y finalmente, divergencia absoluta. Sobre la base de esta técnica, Phillips y Sul (2009) descubren que, en una gran sección transversal de las naciones, hay evidencia estadística de clubes de convergencia.

La hipótesis de la convergencia condicional implica que la convergencia real depende de las características estructurales básicas del país, pero no depende del ingreso inicial por trabajador. Sin embargo, el ingreso inicial por trabajador puede tener un efecto en la trayectoria de crecimiento económico del país. Por tanto, independientemente del hecho de que dos países podrían compartir evoluciones similares de variables fundamentales y una tasa de crecimiento a largo plazo, es posible que no converjan al mismo estado estacionario si no tienen ingresos iniciales similares por trabajador. Esto se conoce como la hipótesis de convergencia en club. Según esta última, si dos países inician el proceso de convergencia económica con diferentes ingresos por trabajador, llegarán a diferentes estados estacionarios. En otras palabras, el ingreso de un país por trabajador converge en una ruta de crecimiento a largo plazo que depende de las características estructurales básicas del país y de si su PIB inicial por trabajador está por encima o por debajo de un valor umbral específico. Por tanto, el ingreso por trabajador converge al mismo nivel en todos los países, con la condición de que los países sean estructuralmente similares y comiencen en el mismo lado de sus respectivos valores umbral. Esto no contradice el hecho de que los países con diferentes ingresos iniciales por trabajador pueden converger al mismo estado estacionario que los países más ricos, siempre y cuando las asimetrías de los países se vean reducidas por reformas estructurales. Estas reformas pueden llevar el ingreso per cápita del país por encima del umbral, y así iniciar un proceso de crecimiento que lleve al país a niveles más altos de ingresos.

Finalmente, contribuciones recientes examinan la calidad institucional en los países de bajos ingresos y su convergencia al nivel observado en los países de altos ingresos. Kar *et al.* (2019) usan la prueba *log-t* sugerida y evidencian la existencia de equilibrios múltiples en la calidad institucional, con varios países atrapados en trampas de instituciones de baja calidad. Los autores concluyen que los países analizados están atrapados en situaciones de bajo nivel de ingreso de las que es difícil escapar porque las instituciones que permiten el crecimiento son de baja calidad. Adicionalmente, Omri y Ben (2020) utilizan un enfoque de modelado de ecuaciones simultáneas para demostrar la efectividad de la buena gobernanza para reequilibrar los componentes económicos en el caso de 20 economías MENA seleccionadas para el período 1996-2014. El estudio concluye que la gobernanza política e institucional contribuye positivamente a los tres componentes del desarrollo sostenible y la mejora de la gobernanza política e institucional permite a los gobiernos de MENA moderar tanto los impactos negativos de las emisiones de carbono en el crecimiento económico y el desarrollo humano.

3. METODOLOGIA

La aplicación de un enfoque de series temporales para el estudio de la convergencia se puede encontrar en los trabajos seminales de Carlino y Mills (1993) y Bernard y Durlauf (1995). Estos autores desarrollaron el concepto de convergencia estocástica, basado en las propiedades de estacionariedad de las variables bajo análisis. Este concepto establece que dos variables no estacionarias convergen si existe una relación de cointegración entre ellas. En otras palabras, dos series no estacionarias convergen si comparten la misma tendencia estocástica.

Esta definición de convergencia puede probarse empíricamente utilizando técnicas econométricas de series temporales. Sin embargo, como señalaron Phillips y Sul (2009), las pruebas de convergencia tradicionales no son apropiadas cuando la velocidad de la convergencia varía en el tiempo. Para tener en cuenta la dimensión temporal y transitoria de las variables, Phillips y Sul (2007; 2009) introdujeron la heterogeneidad transversal y de series de tiempo en los parámetros de un modelo de crecimiento neoclásico. La heterogeneidad se formula como un modelo de factor de variación temporal no lineal que proporciona flexibilidad sobre el comportamiento idiosincrático de la variable a lo largo del tiempo y por medio del conjunto de observaciones. El modelo conserva algo en común en todo el panel, lo que significa que cuando los componentes idiosincrásicos heterogéneos que varían en el tiempo convergen hacia una constante, la convergencia del panel se mantiene. El punto de partida de la prueba *log-t* es un modelo de factor simple:

$$X_{it} = \delta_{it}\mu_t \tag{1}$$

donde δ_{it} es un coeficiente de factor variable en el tiempo y mide la distancia idiosincrásica entre algún factor común μ_t y la parte sistemática del X_{it}.

La representación econométrica en (1) se puede utilizar para analizar la convergencia al verificar si el elemento sistemático δ_{it} converge. Phillips and Sul (2007) proponen modelar los elementos de transición δ_{it} construyendo una medida relativa de los coeficientes de transición:

$$h_{it} = \frac{X_{it}}{N^{-1}\sum_{i=1}^{N} X_{it}} = \frac{\delta_{it}}{N^{-1}\sum_{i=1}^{N} \delta_{it}} \tag{2}$$

La ecuación (2) mide el componente sistemático δ_{it} en relación con el panel. La variable h_{it} es denominada ruta de transición relativa y traza una trayectoria individual para cada i relativa al promedio de panel. Entonces, h_{it} mide la desviación relativa de la región del camino de crecimiento común en estado estacionario μ_t.

Para formular una hipótesis nula de convergencia, los autores sugieren un modelo semiparamétrico para el comportamiento variable de tiempo de δ_{it} de la siguiente manera:

$$\delta_{it} = \delta_i + \frac{\sigma_i \xi_{it}}{L(t)t^{\alpha}} \tag{3}$$

Donde δ_i es fijo, $\sigma_i > 0$, ξ_{it} es i.i.d. (0,1) mediante i pero débilmente dependiente de t, L (t) es una función que varía lentamente y tiende al infinito, cuando t tiende al infinito. Siguiendo a Phillips y Sul (2007), se asume que la función L (t) es *log t*. ξ_{it} introduce componentes que varían en el tiempo y específicos del país al modelo. El tamaño de α determina el comportamiento (convergencia o divergencia) de δ_{it}. Esta formulación garantiza la convergencia del parámetro de interés para todos $\alpha \geq 0$, que es la hipótesis nula de interés ya que $\delta_{it} = \delta_i$ cuando $t \to \infty$. Además, si esta hipótesis se cumple y $\delta_i = \delta_j$ (para $i \neq j$), la especificación de la ecuación (3) todavía permite períodos de transición en los que $\delta_{it} = \delta_{jt}$, incorporando así la posibilidad interesante de heterogeneidad de transición o incluso divergencia de transición por medio de i. Por tanto, la hipótesis nula de convergencia se puede escribir como:

$$\begin{aligned} H_O &: \delta_i = \delta \quad y \quad \alpha \geq 0 \\ H_A &: \delta_i \neq \delta, \textit{ para todo } i \quad y/o \quad \alpha < 0 \end{aligned} \tag{4}$$

La hipótesis alternativa incluye divergencia, pero también puede considerar la convergencia en club. Por ejemplo, si hay dos clubes de convergencia, la alternativa es:

$$H_A : \delta_{it} \rightarrow \begin{cases} \delta_1 \quad y \quad \alpha \geq 0, \; si \; i \in G1 \\ \delta_2 \quad y \quad \alpha \geq 0, \; si \; i \in G1 \end{cases} \tag{5}$$

Donde G representa un club específico.

Phillips y Sul (2007) muestran que estas hipótesis pueden probarse estadísticamente mediante el siguiente modelo de *log t*:

$$\log\left(\frac{H_1^2}{H_t^2}\right) - 2\log \mathrm{L}(t) = c + b\log t + u_t \tag{6}$$

Donde $t = [rt], [rt]+1, \ldots, T$ con $r \in (0,1)$ y $\log\left(\frac{H_1^2}{H_t^2}\right)$ es el diferencial de transición cuadrada media en sección transversal y mide la distancia del panel desde el límite común. Phillips y Sul (2007) sugieren $r = 0.3$ basado en sus experimentos de simulación.

La prueba de regresión de convergencia en (6) se compone de cuatro pasos (Phillips y Sul, 2009). En el primer paso, los individuos se clasifican en el panel en orden decreciente de acuerdo con las observaciones en el último período. Si existe una volatilidad sustancial de series de tiempo en los datos, la clasificación puede basarse en el promedio de series de tiempo de las últimas observaciones [rT], con r = 1/2 o 1/3. El segundo paso consiste en la formación del grupo central de países k *. En este paso, se selecciona el primer subgrupo de individuos k ejecutando la regresión *log t* y calculando la estadística de prueba de convergencia t_k para este subgrupo. Una vez que se han seleccionado los primeros individuos más altos del panel, el grupo central de tamaño k * se obtiene maximizando t_k sobre k de acuerdo con el criterio

$$k^* = \arg max_k \text{ sujeto a } min \left\{t_k\right\} > -1.65 \tag{7}$$

En el tercer paso, los individuos en el panel que no están incluidos en el primer grupo central se agregan, uno a la vez, al grupo central compuesto por k* miembros y la prueba *log t* se ejecuta nuevamente. El individuo en cuestión debería incluirse en el club de convergencia si el estadístico t asociado es mayor que el valor crítico c. En el último paso, se forma un subgrupo con los individuos restantes que no cumplen con el criterio de inclusión en el paso tres. La prueba *log t* se realiza para este grupo. Si la estadística es mayor que -1.64, este subgrupo forma otro club de convergencia. De lo contrario, se repiten los pasos del 1 al 3 para ver si este segundo subgrupo puede subdividirse en grupos de convergencia más pequeños. Esto es particularmente relevante, ya que el rechazo de la hipótesis nula de convergencia no implica necesariamente divergencia; de hecho, podría indicar varios escenarios

diferentes, como puntos de equilibrio separados o caminos de crecimiento en estado estacionario, así como convergencia de clubes y regiones divergentes en el panel completo. El enfoque propuesto por Phillips y Sul (2007) presenta claros beneficios. Primero, es una prueba de convergencia relativa, ya que mide la convergencia en un promedio de sección transversal, en contraste con el concepto de convergencia de nivel analizado por Bernard y Durlauf (1996). En segundo lugar, este enfoque supera a las pruebas de raíz de unidad de panel estándar, ya que con este último $X_{it} - X_{jt}$ puede retener características no estacionarias incluso cuando la condición de convergencia se mantiene, en otras palabras, las pruebas de raíz unitaria de panel pueden clasificar la diferencia entre series de convergencia gradual como no estacionarias. Como un problema adicional, una mezcla de series estacionarias y no estacionarias en el panel puede sesgar los resultados. Por el contrario, las pruebas de Phillips y Sul (2007) no dependen de ninguna suposición particular acerca de la estacionariedad de tendencia o la no estacionariedad estocástica de las variables a probar.

Para determinar la pertenencia a un club, un modelo de regresión ordenada es empleado, tal como lo introdujeron McKelvey y Zavoina (1975). La variable a explicar, que se denota por c, representa el club al que pertenece un país. Esta variable se puede clasificar como una variable ordinal, ya que los clubes observados se pueden clasificar de acuerdo con los niveles de ingreso per cápita. Suponiendo que la membresía en cierto club está relacionada con una variable latente continua y_i^*, la que indica el nivel de ingresos de estado estacionario individual de una región, el modelo se puede escribir como:

$$y_i^* = X_i\beta + \epsilon_i \tag{8}$$

Donde Xi contiene las variables explicativas, así como un término constante, con i = 1, ..., 176 indicando el país. El vector de columna β incluye los coeficientes estructurales. Como la variable dependiente y_i^* no se observa, el modelo no puede estimarse con MCO. En cambio, se aplican técnicas de máxima verosimilitud (MV) para calcular las probabilidades de observar los valores de c dado X (modelo de regresión ordenada). Para utilizar ML, debe especificarse la distribución del término de error ϵ_i. Suponemos que los errores tienen una distribución logística con una media de cero y una varianza de $\pi^2/3$, lo que significa que se puede hacer referencia al modelo de regresión ordenada resultante como modelo *logit*. Debido a que este último no es lineal en sus resultados de probabilidad, el impacto de una variable en los resultados puede interpretarse de varias maneras. Para explorar el efecto de una sola variable en la probabilidad de pertenencia a un club específico, informamos los efectos marginales promedio respecto de las probabilidades de cada variable.

Utilizamos datos de fuentes secundarias. Para la evaluar la convergencia en clubes fue empleado el PIB per cápita, PPA (a precios constantes de 2011) obtenido de los indicadores de desarrollo mundial (2020). Se considera un panel de 176 países,

para estos las series están completas durante el periodo 1996-2018. La calidad de las instituciones es medida por los indicadores de gobernanza mundial (2020): Voz y rendición de cuentas, Estabilidad política y ausencia de violencia, Efectividad del gobierno, Calidad regulatoria, Imperio de la ley y Control de la corrupción.

Un problema que puede estar presente en este tipo de análisis es el de endogeneidad. La endogeneidad puede tener lugar como consecuencia de un error en la medición, autocorrelación de los residuos o errores, omisión de variables o simultaneidad. En este sentido, es admisible señalar lo siguiente: i) La métrica que utiliza el Banco Mundial es un sistema de escala, la que deriva de un conjunto de datos y a partir de ello se calcula cada dimensión de calidad de gobernanza y gobernabilidad. Consecuentemente, el riesgo de error de medición y variables omitidas para el cálculo de los índices resultantes y la información incorporada en este trabajo es inexistente, pues varios autores (Butkus, Mačiulytė-Šniukienė, y Matuzevičiūtė, 2020; Di Cataldo y Monastiriotis, 2018) destacan la calidad de la información que produce el Banco Mundial (World Bank Group, 2020) en lo referente a indicadores de gobernanza y además destacan que el uso de todas las dimensiones especificadas brinda un reflejo adecuado de la calidad institucional de una economía; ii) debido a que la finalidad del estudio es la estimación de una ecuación que refleje la relación entre las variables independientes y la dependiente, el problema de simultaneidad característico de sistemas de ecuaciones simultáneas puede ser descartado; iii) el estadístico de Durbin-Watson en las series de indicadores de calidad de gobernanza muestran la ausencia de autocorrelación serial hasta el cuarto rezago. Además, por construcción del procedimiento empleado, la primera etapa permite clasificar los países en clubes de convergencia en función de una variable, renta per cápita, y dicha clasificación es empleada en una segunda etapa en donde las variables de medición de la calidad de gobernanza mundial son estrictamente exógenas, con lo que los coeficientes estimados resultarían consistentes.

No obstante, se ha procedido a corroborar estos planteamientos mediante el test de Hausman (1978), siguiendo el procedimiento detallado por Gujarati y Porter (2010) utilizando como posibles instrumentos los sugeridos por Balsalobre y Álvarez (2016), los que podrían capturar el posible efecto no observado como lo establecen los autores. Las variables a saber son: Tasa de Inflación, Ratio de Dependencia, Población Urbana (como porcentaje del total de habitantes), y fueron obtenidos del Banco Mundial (2020). Los resultados señalaron que no existe evidencia empírica de omisión de variables. Consecuentemente el modelo *ologit* se estimó por máxima verosimilitud utilizando el *software* STATA®.

4. RESULTADOS Y DISCUSION

4.1. Clubes de convergencia

Cuando la prueba *log t* se aplica al PIB per cápita en 176 economías a nivel mundial durante el período 1996–2018, la hipótesis de convergencia general se rechaza al nivel de significancia del 5%. Por tanto, podemos concluir que los países no convergieron al mismo equilibrio de estado estacionario en términos de PIB per cápita. Luego aplicamos el procedimiento de prueba del mecanismo de agrupamiento, donde identificamos doce grupos y dos regiones divergentes. Finalmente, para probar si alguno de los subgrupos originales puede fusionarse para formar clubes de convergencia más grandes, aplicamos el procedimiento de prueba de fusión descrito en la sección de metodología. Después de una nueva revisión de los datos, se identifican seis clubes de convergencia y dos economías divergentes. En el Apéndice A se proporciona una lista de los miembros de cada club. Los resultados de la prueba *log t* se presentan en el Cuadro 1, donde informamos los parámetros estimados y los errores estándar correspondientes junto con el PIB per cápita promedio para el año 2018 de las economías pertenecientes a cada club.

Algunas regularidades son visibles en los clubes de convergencia obtenidos. Primero, hay un aparente efecto geográfico, es decir, las economías que se encuentran en el mismo espacio geográfico tienden a agruparse (Quah, 1996). En segundo lugar, los países miembros de cada club se encuentran estrechamente relacionados con la clasificación que realiza el Banco Mundial en los cuatro grupos de ingreso. En este sentido, es necesario destacar que, según la nueva clasificación del Banco Mundial (2019), algunos países subieron de clasificación: Georgia, Sri Lanka y Argentina forman parte del grupo de países de ingreso mediano alto; mientras que, Senegal y Zimbabwe pasan a formar parte del grupo de ingreso mediano bajo. La prueba de

CUADRO 1

CLASIFICACION DE LOS CLUBES DE CONVERGENCIA

Clubes	Coeff	T–stat	PIB pc 2018	N
Conjunto total	-0,594	-30,894	19199,41	176
Club1	-0,026	-0,678	32207,61	87
Club2	0,008	0,163	10817,38	38
Club3	0,086	1,591	4879,13	18
Club4	-0,034	-0,831	2433,44	26
Club5	0,044	0,615	1367,23	3
Club6	-1,441	-1,155	853,32	2
Grupo divergente	-0,802	-39,141	4535,59	2

Fuente: Elaboración propia a partir de datos del Banco Mundial, 2020.

convergencia entre los clubes evidencia la coherencia con la nueva clasificación que hace el Banco Mundial. Los resultados de dicho procedimiento de fusión descrito en la sección metodología podrían indicar que las regiones que ahora pertenecen a diferentes clubes están convergiendo lentamente entre sí. Por otra parte, podría simplemente señalar fronteras bastante borrosas entre los clubes, ya que algunas regiones podrían estar en transición hacia un club más alto o más bajo. Phillips y Sul (2009) encuentran resultados similares en un análisis del comportamiento de transición en los ingresos per cápita en 152 países desde 1970 hasta 2003.

4.2. Factores que condicionan la membresía del club

Con el objetivo de explorar el efecto de una sola variable en la probabilidad de pertenencia a un club específico, mostramos los efectos marginales promedios sobre las probabilidades de cada variable evaluada en su media. Como resultado, podemos observar las probabilidades de pertenecer a un determinado club dependiendo del nivel de la variable correspondiente. En el Cuadro 2 presentamos los efectos marginales para cada resultado de la variable del club (1 al 6). Es posible notar que excluimos de esta parte del análisis a los dos países que no forman parte de ningún club de convergencia. En la parte inferior de la tabla, mostramos el número de países que pertenecen a un club en particular.

CUADRO 2

EFECTOS MARGINALES SOBRE LAS PROBABILIDADES

Variable	Club1	Club2	Club3	Club4	Club5	Club6
Control de la corrupción	-0,17211* (-1,76)	0,00866 (0,77)	0,03824 (1,62)	0,09812* (1,75)	0,01361 (1,29)	0,01348 (1,26)
Efectividad del gobierno	0,60784*** (5,91)	-0,03059 (-0,86)	-0,13505*** (-3,36)	-0,34652*** (-5,07)	-0,04807* (-1,8)	-0,04761* (-1,73)
Estabilidad política y ausencia de violencia	0,05511 (1,29)	-0,00277 (-0,68)	-0,01224 (-1,23)	-0,03142 (-1,31)	-0,00436 (-1,03)	-0,00432 (-1,04)
Imperio de la ley	-0,02311 (-0,21)	0,00116 (0,19)	0,00513 (0,21)	0,01317 (0,21)	0,00183 (0,21)	0,00181 (0,21)
Calidad regulatoria	-0,00676 (-0,08)	0,00034 (0,08)	0,00150 (0,08)	0,00385 (0,08)	0,00054 (0,08)	0,00053 (0,08)
Voz y rendición de cuentas	-0,18269*** (-3,85)	0,00920 (0,89)	0,04059*** (2,84)	0,10415*** (3,32)	0,01445* (1,68)	0,01431 (1,64)
N	87	38	18	26	3	2
Valores Umbral	0,05066	1,68588	2,68056	5,56535	6,56807	–

Nota: * p<0.1; ** p<0.05; *** p<0.01 y Estadístico z ente paréntesis.
Fuente: Elaboración propia a partir de datos del Banco Mundial, 2020.

Las derivadas parciales individuales muestran el cambio en la probabilidad de pertenecer a un club específico a causa de un pequeño cambio en las variables explicativas. De esta manera, la probabilidad asociada a las variables Efectividad del gobierno y Voz y rendición de cuentas muestra tener gran importancia por medio de los clubes de convergencia. Pese a que la probabilidad de pertenencia al club 2 no es explicada adecuadamente por medio de las variables seleccionadas, todas las variables incluidas juegan un papel importante en su conjunto para explicar la membresía de una economía en un club específico, debido a que la razón de probabilidad chi-cuadrado fue 79,15 con un valor-p de 0, lo que indica que el modelo en su conjunto es estadísticamente significativo, en comparación con el modelo nulo sin predictores. Al aplicar el test de Hausman (1978) a los resultados de las dos estimaciones se observó que no es posible rechazar la hipótesis nula de exogeneidad, pues el valor-p asociado a chi-cuadrado es 0,001. Por tanto, los coeficientes presentados en el Cuadro 2 son consistentes.

Los resultados obtenidos muestran que un pequeño cambio positivo en el nivel de control de corrupción disminuye la probabilidad de pertenecer a un club de altos ingresos (club 1), mientras que incrementa la probabilidad de pertenecer al resto de clubes. Debido a que los índices poseen la misma escala (-2,5 a 2,5) es posible expresar que un cambio positivo de esta variable llevará una probabilidad asociada de pertenecer al club 4 mayor que el resto de clubes. Asimismo, un incremento en el índice de Efectividad del gobierno, al igual que en Estabilidad política, aumenta la probabilidad de pertenecer al primer club. Finalmente, un cambio positivo en los índices de Imperio de la ley, Calidad regulatoria y Voz y rendición de cuentas conlleva una disminución en la probabilidad de pertenecer al club de altos ingresos. Adicionalmente, al igual que ocurre con la variable Control de la corrupción, dicho cambio incrementa, en mayor medida, la probabilidad de pertenecer al club 4. Al observar la dirección de los efectos marginales, estos resultados muestran un comportamiento claramente definido respecto del efecto que posee la calidad institucional para determinar la pertenencia a cada club de convergencia, pues no existe duplicidad en la direccionalidad de los efectos entre clubes. Si bien esta conducta no es muy usual, esta se debe a que las sumas de las derivadas parciales estimadas son iguales a cero para una misma variable entre los seis clubes y las sumas de las probabilidades siempre deben ser iguales a uno para cada club. Es posible señalar que la significancia estadística que posee las variables descritas es muy baja, por lo que no es posible aseverar con total certeza que el comportamiento descrito se cumpla. No obstante, la direccionalidad del efecto y la magnitud del coeficiente obtenido pueden brindar evidencia que permita intuir cómo afecta la calidad institucional sobre el nivel de convergencia a nivel global como se ha expuesto en esta investigación.

El hecho que una mejora en la calidad de instituciones conduzca, primordialmente, a niveles de convergencia de grupos medio bajos (club 4) muestra que las democracias más débiles parecen estar asociadas con trampas de baja calidad de burocracia, ley y orden y viabilidad de los contratos. Por tanto, es posible señalar que la calidad de las instituciones suelen ser el resultado de políticas de *statu quo* de la élite empresarial

y política, que encuentran que los desarrollos institucionales están en contra de sus intereses creados. En la mayoría de los casos, estos intereses creados pueden impulsar su agenda en democracias más débiles, a pesar de las demandas populares de cambio institucional. Un marco democrático más fuerte puede ayudar a los países a salir de este tipo de situaciones. Este hallazgo da continuidad a los resultados obtenidos por Kar *et al.* (2019). Por tanto, un punto clave de acción para los gobiernos es reforzar las percepciones de la calidad de los servicios públicos, la calidad del servicio civil, el grado de independencia de las presiones políticas, la calidad de la formulación e implementación de políticas, y la credibilidad del compromiso del gobierno con dichas políticas, así como también las percepciones de la probabilidad de inestabilidad política o violencia por motivos políticos, con el fin de crecer económicamente.

5. CONCLUSIONES

En este artículo hemos sugerido un procedimiento de dos pasos para probar empíricamente la hipótesis de convergencia condicional para 176 economías durante el período 1996-2018. Primero, aplicamos la prueba *log-t* para identificar de manera endógena los clubes potenciales de convergencia y, en un segundo paso, analizamos qué factores tienen un impacto en la probabilidad de pertenecer a un club determinado. En particular, probamos si la membresía de un club depende de la calidad de las instituciones de un país. Esta contribución nos permitió separar de manera más concisa la convergencia en club de la convergencia condicional empleada en otros estudios.

Nuestros principales hallazgos se pueden resumir de la siguiente manera: Primero, los resultados de la prueba *log t* apuntan a la existencia de seis clubes de convergencia en términos de PIB per cápita. Los países ricos, especialmente los ubicados en América del Norte, Europa occidental, Australia y Nueva Zelanda, forman parte del primer club de convergencia. El resultado final de la conformación de clubes guarda similitud con la clasificación que hace el Banco Mundial por grupos de ingreso. Los países en los primeros clubes generalmente poseen instituciones de mejor calidad que los países en vías de desarrollo, por ello resulta coherente observar que la clasificación obtenida también mantiene concordancia con los postulados teóricos expuestos.

Segundo, las estimaciones de un modelo logístico ordenado revelan que la calidad de las instituciones, de manera especial lo referente a Efectividad del gobierno y Estabilidad política, pueden explicar la probabilidad de una economía de pertenecer a un club de ingresos altos. El primero de estos indicadores resulta estadísticamente significativo. De esta forma la investigación permitió establecer la jerarquía de los indicadores por medio de la importancia al momento de determinar la pertenencia a determinado club. Por tanto, podemos concluir que dichas variables pueden constituir puntos clave de análisis para los formuladores de política económica y los diferentes actores involucrados en el proceso de toma de decisiones a nivel tanto micro como macroeconómico.

Finalmente, nos gustaría señalar algunas posibles vías para futuras investigaciones acerca de la convergencia de clubes. El tema probablemente más desafiante está relacionado con la pregunta respecto de qué variables debería elegir idealmente el investigador al analizar la relevancia de los factores condicionantes para el proceso de convergencia de una economía. Una necesidad relacionada con este desafío es la extensión de los conjuntos de datos existentes a períodos de tiempo más largos, especialmente a nivel subregional.

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ANEXOS

ANEXO A

CLASIFICACION DE LOS PAISES

Clubes	Países
Club1	(87) Albania, Argentina, Armenia, Australia, Austria, Azerbaiyán, Bahréin, Bielorrusia, Bélgica, Bután, Bosnia y Herzegovina, Botsuana, Brunei Darussalam, Bulgaria, Canadá, Chile, China, Colombia, Costa Rica, Croacia, Chipre, República Checa, Dinamarca , República Dominicana, Guinea Ecuatorial, Estonia, Finlandia, Francia, Georgia, Alemania, RAE de Hong Kong, Hungría, Islandia, India, Indonesia, Irán, Irak, Irlanda, Israel, Italia, Japón, Kazajstán, Corea, Kuwait, República Democrática Popular Lao, Letonia, Lituania, Luxemburgo, RAE de Macao, Malasia, Malta, Mauricio, Mongolia, Myanmar, Países Bajos, Nueva Zelanda, Macedonia del Norte, Noruega, Omán, Panamá, Perú, Polonia, Portugal, Puerto Rico, Rumania, Federación de Rusia, Arabia Saudita, Serbia, Seychelles, Singapur, República Eslovaca, Eslovenia, España, Sri Lanka, San Cristóbal y Nieves, Suecia, Suiza, Tailandia, Trinidad y Tobago, Turquía, Turkmenistán, Emiratos Árabes Unidos, Reino Unido, Estados Unidos, Uruguay, Uzbekistán, Vietnam.
Club2	(38) Argelia, Angola, Antigua y Barbuda, Bahamas, Bangladesh, Barbados, Bolivia, Brasil, Cabo Verde, Camboya, Dominica, Ecuador, Egipto, Eswatini, Etiopía, Fiji, Gabón, Ghana, Grecia, Granada, Guyana, Líbano, Maldivas, México , Moldavia, Marruecos, Namibia, Nigeria, Paraguay, Filipinas, Sudáfrica, Santa Lucía, San Vicente y las Granadinas, Sudán, Surinam, Tayikistán, Túnez, Ucrania.
Club3	(18) Belice, República del Congo, El Salvador, Guatemala, Honduras, Jamaica, República Kirguisa, Lesoto, Nepal, Nicaragua, Pakistán, Papua Nueva Guinea, Ruanda, Samoa, Tanzania, Tonga, Cisjordania y Gaza, Zambia.
Club4	(26) Benín, Burkina Faso, Camerún, Chad, Comoras, Costa de Marfil, Gambia, Guinea, Haití, Kenia, Kiribati, Malawi, Malí, Islas Marshall, Mauritania, Micronesia, Mozambique, Senegal, Sierra Leona, Islas Salomón, Togo, Tuvalu , Uganda, Vanuatu, Yemen, Zimbabue.
Club5	(3) República Democrática del Congo, Guinea-Bissau, Madagascar
Club6	(2) República Centroafricana, Níger
Grupo divergente	(2) Burundi, Jordán

Fuente: Elaboración propia.

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BRECHA DE INGRESOS LABORALES POR GENERO EN BOLIVIA. UN ANALISIS DE SU EVOLUCION EN EL PERIODO 1993 A 2018*

THE GENDER LABOR INCOME GAP IN BOLIVIA. AN ANALYSIS OF ITS EVOLUTION BETWEEN 1993 AND 2018

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Resumen

En Bolivia las mujeres reciben menores remuneraciones que los hombres en trabajos similares, además de estar concentradas en trabajos de baja remuneración. El presente documento analiza la evolución de la brecha de ingresos por género en el periodo entre 1993 a 2018 en Bolivia. Utilizando encuestas de hogares y dos modelos de medición de las diferencias en el ingreso laboral, la descomposición Blinder-Oaxaca y la descomposición Ñopo, se encuentra evidencia de una importante reducción en la brecha de ingreso por género en el periodo observado. Esta reducción se explica tanto por la reducción de diferencias en las características observables que afectan el mercado laboral, principalmente educación y el impacto de las características familiares respecto del acceso al empleo. El segundo componente que explica la reducción de la brecha se debe a la reducción

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del componente no explicado de la brecha, que se asume generalmente como discriminación.

Palabras clave: *Economía de género, diferencias salariales, discriminación.*

Clasificación JEL: *J16, J31, J71.*

Abstract

In Bolivia, women working in similar positions as men face lower remunerations, besides being concentrated in low-paid jobs. This paper sheds lights over the gender labor income gap evolution in Bolivia over a 25-year period (1993 to 2018). Using household surveys and applying two different methods, the Blinder-Oaxaca decomposition and the Ñopo decomposition, we find sound evidence of an important reduction in the gender labor income gap during the analyzed period. This reduction is due to, firstly, the reduction of the number of observable characteristics affecting the labor market such as education and the impact of family characteristics on access to employment. Secondly, it shows the reduction in the unexplained component, which is usually assumed to be discrimination.

Keywords: *Gender economics, wage differentials, discrimination.*

JEL Classification: *J16, J31, J71.*

1. INTRODUCCION

América Latina y el Caribe (ALC) han mostrado grandes avances hacia la igualdad de género (Chioda, 2011). La visibilidad de las mujeres en el hogar, en la escuela, en el mercado laboral y en el ámbito político ha evolucionado significativamente en estos últimos años (Ñopo, 2012). Sin embargo, y a pesar de todos estos avances, en la mayoría de los países de ALC los hombres ganan más que las mujeres por un mismo trabajo y las diferencias en el ingreso laboral en favor de los hombres persisten. Constituyéndose todavía como una de las formas más injustificables de desigualdad (OIT, 2019).

En Bolivia, a pesar de los avances normativos en temas relacionados a la equidad de género, las mujeres aún sufren de discriminación en diferentes ámbitos. Además del alto nivel de violencia doméstica y machismo, las mujeres presentan menores oportunidades de estudio, asistencia médica, oportunidades laborales, perciben menores ingresos laborales y presentan una mayor probabilidad de ser pobres.

En lo que se refiere al ámbito económico, Bolivia se encuentra en el puesto 105 (de 153) en el ámbito de participación y oportunidades económicas dentro del Índice Global de Brechas de Género del Foro Económico Mundial (WEF, 2020), donde destaca particularmente la inequidad en los ingresos entre hombres y mujeres ante trabajos similares, ocupando el puesto 134 de 153. Asimismo, datos del Sistema de Información de Mercados Laborales y Seguridad Social del Banco Interamericano de Desarrollo (BID) confirman este hecho y muestran que en 2018 las mujeres ganaban en promedio 82% de lo que gana su contraparte masculina por hora trabajada, siendo que el promedio de la región era de 93[1]. Adicionalmente, alrededor de 50% de las mujeres presenta ingresos laborales mensuales menores al salario mínimo nacional y tienen una mayor probabilidad a tener peores condiciones laborales, a desempeñarse en trabajos informales o estar desempleadas.

A pesar de la situación, la disponibilidad de información acerca del tema es todavía limitada y existen solo algunos estudios que analizan la diferencia de ingresos laborales entre mujeres y hombres en Bolivia. Siendo que, además, estos estudios utilizan métodos empíricos diferentes, lo que dificultan la comparabilidad entre los mismos y, por esta razón, el seguimiento de la evolución de la problemática.

El presente documento busca reducir la brecha de conocimiento de la temática al proponer un análisis riguroso de la evolución de la brecha de ingresos entre hombres y mujeres en Bolivia en el periodo 1993 a 2018. Para esto, el documento analiza la evolución de la brecha de ingresos laborales utilizando dos metodologías: primero usa la descomposición de Blinder-Oaxaca y posteriormente la descomposición Ñopo, posibilitando además la comparación de evidencia obtenida mediante un modelo paramétrico con un modelo no paramétrico para un periodo amplio de tiempo. La posibilidad de utilizar ambas metodologías nos permite contar con un amplio espectro de análisis y tratar de identificar las variables que estarían determinando su evolución.

Los resultados muestran una importante reducción en la brecha de ingresos laborales por género en los 25 años analizados. Esta reducción puede ser explicada por dos hechos. Primero, por una reducción en las diferencias observables de las mujeres con relación a los hombres, principalmente gracias a la reducción de la brecha educacional de las mujeres en el mercado de trabajo y a cambios en el entorno social y familiar que permitió el ingreso de mujeres al mercado laboral. La segunda parte de la reducción de la brecha de ingresos puede ser entendida por la reducción del componente asociado a la discriminación por género. Adicionalmente, el presente documento encuentra evidencia de que la brecha de ingresos laborales por género es menor a mayores niveles de educación y en el sector formal.

Lo que resta del documento se divide de la siguiente manera: la sección 2 presenta una revisión de la literatura relevante; la sección 3 realiza una descripción de los datos

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[1] Con información circa a 2018, incluye Argentina, Bolivia, Brasil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, México, Panamá, Paraguay, Perú, República Dominicana y Uruguay. [Acceso, marzo - 2020].

utilizados y presenta datos descriptivos de la evolución de la brecha de ingresos a lo largo de los 25 años analizados. La sección 4 describe las metodologías utilizadas para el cálculo de la brecha de ingresos laborales de género. La sección 5 presenta los resultados del estudio. La sección 6 presenta pruebas de consistencia. Finalmente, la sección 7 presenta las principales conclusiones del documento.

2. REVISION DE LA LITERATURA

Los avances de la región hacia la igualdad de género en los últimos años han sido propiciados por la mayor visibilidad de las mujeres en distintos ámbitos. Un punto de particular relevancia tienen que ver con la mayor participación de las mujeres en el mercado laboral a partir de 1980[2] (Chioda, 2011). Sin embargo, esta participación no se da en igualdad de condiciones, las mujeres todavía tienen una mayor representación en puestos de trabajo mal remunerados, en trabajos informales y la brecha de ingresos laborales continúa siendo un tema relevante (Ñopo, 2012).

En lo que se refiere a la brecha de ingresos, la literatura ha tratado de distinguir la brecha de ingresos referente a las diferencias en características individuales y dotación de capital humano, de aquella no explicada y mayormente relacionada a prejuicios de género o discriminación (Atal *et al.*, 2009).

Psacharopoulos y Tzannatos (1992) estudian la diferencia de ingresos laborales en 15 países de ALC a finales de los 80. Los autores encuentran evidencia de que las mujeres obtenían ingresos laborales por tan solo el 65% de lo que obtiene un hombre. Siendo que el porcentaje de la brecha de ingresos explicada por las diferencias en el nivel de educación y capital humano representaban solamente un tercio de la diferencia total, dejando una gran porción (alrededor del 43%) de la diferencia sin explicación y posiblemente asociada a discriminación. Evidencia algo más reciente muestra que la brecha de ingresos se redujo desde 16% hasta 9% (Ñopo y Hoyos, 2010) entre 1992 y 2007. Sin embargo, la brecha no explicada representaba el 34% en 1992 y el 30%, en 2007. Es importante destacar que una parte significativa de la reducción de la brecha de ingresos en los últimos años se explica por el incremento de nivel educativo obtenido por las mujeres que ingresaron al mercado laboral (Chioda, 2011; Gasparini y Marchionni, 2015). Finalmente, la OIT (2019) en un análisis de 17 países y mediante la descomposición no paramétrica de Ñopo encuentran que la brecha no explicada de ingresos se redujo en el quinquenio 2012 y 2017 entre 2 y 3 puntos porcentuales (pp)

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[2] La evidencia sugiere que la inserción de la mujer al mercado laboral ha sido facilitada por el crecimiento económico de la región, el comercio, liberalización, urbanización, el incremento de nivel educacional obtenido y la reducción de la tasa de fertilidad. Gasparini y Marchionni (2015) indican que el incremento en la participación femenina en el mercado laboral de los países ALC también se puede explicar por el crecimiento económico de los 2000 y las políticas implementadas para incentivar y proteger el trabajo de las mujeres.

y donde la brecha es más pronunciada entre los trabajadores de más bajos ingresos y donde las brechas son mayores para aquellos trabajadores autoempleados.

En el caso de Bolivia, existe alguna evidencia respecto de la evolución de la brecha de ingresos por género. Psacharopoulos y Tzannatos (1992), con datos de 1989, encontraron que las mujeres percibían el 62% del ingreso que percibe un hombre, donde solo el 15% de la brecha observada podía ser explicada por diferencias en la dotación en capital humano[3]. Rivero y Jiménez (1999) analizan las diferencias de ingreso en áreas urbanas de Bolivia entre 1981 y 1997, encuentran que la brecha de ingresos por género se redujo de 32% en 1981 a 11% en 1997. Asimismo, Contreras y Galván (2003) revisan la evolución de la discriminación contra mujeres e indígenas de Bolivia entre 1994 y 1999[4]. En este estudio se confirma la existencia de discriminación de ingresos por género y etnicidad, siendo que el hecho de ser mujer e indígena incrementaba la brecha de ingresos entre 3,2 pp y 4 pp.[5] Ñopo (2010), con datos de 2005 a nivel nacional, encuentra evidencia de que la brecha de ingresos no explicada podría llegar a ser tan alta como 17%. Finalmente, OIT (2019) encuentra que la brecha no explicada de ingresos, siguiendo la descomposición de Ñopo, es de 30 pp para los trabajadores autoempleados y 8 pp para los trabajadores asalariados.

Sin embargo y a pesar de la evidencia recién expuesta, los estudios analizados utilizan modelos empíricos y grupos poblaciones de estudio diferentes, lo que imposibilita su comparación y por tanto el seguimiento de la evolución de la brecha de género. Siendo este hecho particularmente relevante para el diseño e implementación de políticas públicas que permitan acotar la brecha y permitir un acceso acorde a las necesidades de las mujeres al mercado laboral. El presente documento pretende contribuir a la literatura al proponer un análisis de la evolución de la brecha de género en Bolivia desde 1993 hasta 2018.

3. DATOS Y ESTADISTICA DESCRIPTIVA

Datos

Los datos utilizados en este documento provienen de las Encuestas de Hogares armonizadas por el Banco Interamericano de Desarrollo (BID)[6]. El presente documento utiliza 5 encuestas en el periodo de los 25 años analizados, según la disponibilidad de las mismas. Para esto, se utilizan datos de la Encuesta Integrada de Hogares 1993,

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[3] Información presentada en la tabla A-1 en el estudio de Psacharopoulos y Tzannatos (1992).

[4] El estudio utiliza ecuaciones de Mincer corregidas para sesgo de selección y subsecuentemente una Descomposición de Fields.

[5] Mediante su Descomposición de Fields.

[6] Banco de datos de Encuestas de Hogares Armonizadas.

posteriormente para 1999, 2006, 2013 y 2018 se utilizan las Encuestas de Hogares. Todas recolectadas por el Instituto Nacional de Estadística (INE).

Una característica importante para señalar tiene que ver con el hecho que las encuestas utilizadas en este documento presentan un diseño similar y el mismo nivel de representatividad. La única diferencia existente se da en la encuesta de 1993, que tiene representatividad solo a nivel de ciudades capitales. Para superar esta diferencia, el documento limita su ámbito de estudio al área urbana[7], aunque se presentan resultados a nivel general en la sección 5. Un punto a destacar es el proceso de armonización de las encuestas de hogares que asegura la comparabilidad de las mismas en el transcurso de los años estudiados.

El presente análisis se restringe para personas entre 15 a 65 años y toma en cuenta únicamente información relacionada a la actividad económica primaria.

Como primer punto, se analiza la muestra de las cinco encuestas definidas para el presente estudio (Tabla 1), donde se observa que la encuesta de 1993 presenta 10.723 observaciones en el rango de edad a ser analizado. En 1999, la muestra se reduce

TABLA 1

NUMERO DE OBSERVACIONES POR ENCUESTA

	1993		1999		2006		2013		2018	
	N	%	N	%	N	%	N	%	N	%
Género										
Hombres	5.487	46	2.038	47	3.197	47	8.309	47	8.908	47
Mujeres	6.402	54	2.294	53	3.630	53	9.269	53	9.853	53
Edad										
15-25	4.476	38	1.668	39	2.601	38	5.880	33	6096	32
26-35	2.855	24	996	23	1.586	23	4.224	24	4458	24
36-45	2.235	19	827	19	1.266	19	3.264	19	3721	20
46-55	1.425	12	543	13	872	13	2.496	14	2552	14
56-65	898	8	298	7	502	7	1.714	10	1934	10
Total	11.889	100	4.332	100	6.827	100	17.578	100	18.761	100

Fuente: Elaboración propia a base de encuestas de hogares 1993, 1999, 2006, 2013 y 2018.

[7] La Encuesta Integrada de Hogares 1993 únicamente consideraba ciudades capitales excluyendo a Cobija e incluyendo a la ciudad de El Alto, mientras que en 1999, 2006, 2013 y 2018 las encuestas tienen representación nacional. Considerando que para el presente documento restringimos el análisis a áreas urbanas, se sugiere precaución al comparar los resultados de 1993.

a 4.444 observaciones, para 2006 se tienen 7.017 observaciones, en 2013 la cantidad de observaciones incrementó hasta 16.341 y finalmente en 2018 la encuesta recoge 19.210 observaciones en el rango etario definido. La reducción en el tamaño de muestra evidenciado entre 1993 y 1999 se explica por la decisión del INE de incluir al área rural e incluir secciones a la encuesta[8]. Desde 1999 hasta el 2018 el tamaño de muestra ha ido incrementándose gradualmente.

En promedio el 53% de la muestra está conformado por mujeres y esta tendencia se mantiene para las cinco encuestas consideradas. La composición de edades es similar en todas las encuestas, aunque se observa un crecimiento en la participación de personas mayores de 55 años, coherente con el desarrollo demográfico del país.

Estadística descriptiva

A continuación se presenta información referente a la diferencia de ingresos por género en Bolivia. La Tabla 2 presenta la diferencia de ingresos entre hombres y mujeres a base del ingreso real por hora, diferenciando por algunas características demográficas. Para facilitar la comparación, los datos corresponden al ingreso por hora de las mujeres relativo al ingreso masculino (100%) para cada categoría.

Se puede observar que, en relación con el ingreso de los hombres, en 1993, las mujeres ganaban 39% menos. Esta diferencia se redujo hasta 10% en 2018, lo que nos presenta una primera evidencia de la reducción de la brecha de ingresos laborales en Bolivia.

Con relación a los rangos de edad, la menor diferencia entre hombres y mujeres se da en el rango de edad entre 26 y 35 años. Siendo esto cierto para todos los años analizados, aunque se puede evidenciar que la magnitud de la diferencia también se redujo sustancialmente. En 1993, una mujer entre 26 y 35 años obtenía solamente el 74% de lo que un hombre en ese rango etario, mientras que, en 2018, obtienen el 94% que el ingreso por hora de un hombre. Un hecho particularmente relevante a destacar es la reducción de las brechas de ingresos para todos los rangos etarios, incluso para aquellos entre 56 y 65 años, que es el rango de edad donde mayores diferencias de ingreso se observan.

Respecto del nivel educativo, se observa que las mujeres con educación terciaria pasaron de obtener el 60% del ingreso por hora de un hombre en 1993 a recibir un ingreso similar (89%) al de los hombres en 2018. Se evidencia también una reducción de la brecha para todos los niveles educativos, aunque aquellas mujeres que no tienen educación formal obtienen 17% menos que un hombre con la misma característica educativa.

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[8] La encuesta de 1999 fue ejecutada como parte del programa para el Mejoramiento de las Encuestas y la Medición de Condiciones de vida en América Latina y el Caribe (MECOVI). A partir de 1999 las encuestas de hogares en Bolivia tienen representación nacional.

TABLA 2

INGRESO POR HORA DE LAS MUJERES RELATIVO AL INGRESO POR HORA DE LOS HOMBRES

	1993 (%)	1999 (%)	2006 (%)	2013 (%)	2018 (%)
General	61,4	82,8	63,0	81,8	89,6
Edad					
15-25	60,0	69,6	48,6	81,9	84,3
26-35	74,4	84,2	73,2	79,9	94,1
36-45	61,3	90,7	64,0	82,1	87,8
46-55	57,6	75,7	62,2	85,6	95,5
56-65	39,5	87,5	69,8	75,2	78,9
Nivel de Educación					
Ninguna	62,7	78,2	70,0	67,2	82,7
Primaria	54,8	67,1	76,0	76,7	86,5
Secundaria	74,7	105,6	61,0	79,3	85,9
Terciaria	60,4	79,7	63,5	90,2	88,9
Sector Económico					
Minería e hidrocarburos	n,d,	27,6	n,d,	82,6	77,6
Manufactura	61,2	65,0	76,0	71,3	60,9
Construcción	n,d,	47,4	37,7	85,0	83,5
Comercio	57,1	83,4	61,7	74,8	78,2
Transporte y Almacenamiento	n,d,	n,d,	n,d,	60,8	69,5
Servicios Financieros	61,9	71,5	31,6	86,1	129,3
Servicios Sociales	51,9	75,3	64,3	82,7	92,2
Ocupación					
Profesionales, Técnicos y Directivos	74,2	94,1	57,5	94,5	92,7
Administrativos	88,5	88,7	87,1	95,6	110,0
Comerciantes y Vendedores	48,0	86,5	61,6	59,4	77,0
Servicios	52,8	103,4	90,6	101,0	99,8
Trabajadores No Agropecuarios	59,2	49,9	72,5	60,6	68,7
Fuerzas Armadas y Policía	n.d.	n.d.	54,9	n,d,	69,3
Formalidad					
Informal	n.d.	75,4	60,0	74,4	84,1
Formal	n.d.	112,4	83,4	98,9	103,6

Fuente: Elaboración propia a base de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018.
Nota: Servicios Sociales incluye las actividades de electricidad, agua y gas.
n.d. No Disponible. Cuando los datos disponibles no son suficientes para calcular el porcentaje.

Por sector económico, en 2018, los sectores de servicios financieros, construcción y servicios son los sectores donde los ingresos entre hombres y mujeres son iguales, mientras que, en el sector de comercio y manufactura, todavía persisten diferencias de más de 20 pp. Nuevamente, es importante destacar la evolución en la brecha de ingresos, particularmente en los sectores de servicios financieros y sociales a lo largo de los 25 años analizados. Por ocupación, los directivos, profesionales, técnicos y

servicios administrativos son las ocupaciones que presentan mayores niveles de equidad de ingresos. En 1993 una mujer directiva, profesional o técnico ganaba el 74% de lo que ganaba un hombre, mientras que en 2018 obtenía un ingreso similar por hora trabajada (93%).

Finalmente, y con relación a la formalidad[9] de los empleos a los que acceden los trabajadores en Bolivia, las mujeres que se desempeñan en trabajos formales obtienen un ingreso igual o superior al de los hombres. La penalidad de ingresos para las mujeres en el sector informal pasó de aproximadamente el 25% en 1999 hasta 16% en 2018.

4. ESTRATEGIA EMPIRICA

Descomposición Blinder y Oaxaca

A continuación se cuantificará y analizará la evolución de la brecha de género en Bolivia en los últimos 25 años. Para hacer esto, se analizará la porción de la brecha de ingresos laborales que puede explicarse por diferencias en el capital humano (llámese educación, experiencia laboral, etc.) y aquella parte que no puede ser explicada y estaría asociada a discriminación de género[10].

La literatura usualmente ha afrontado esta pregunta utilizando la descomposición de Blinder-Oaxaca. El método Blinder-Oaxaca utiliza ecuaciones de salario del tipo Mincer para dividir la diferencia de ingresos laborales en dos grupos, uno que se puede "explicar" por diferencias grupales y características productivas como la educación o la experiencia laboral y un segundo componente residual, no explicado, generalmente asociado a discriminación (Jann, 2008).

La racionalidad formal de la metodología es la que sigue: dados dos grupos, hombres (H) y mujeres (M); un resultado de interés que es nuestra variable Y (en este caso el logaritmo del ingreso por hora); y un grupo de variables explicativas X (educación, experiencia, etc.). La pregunta de interés a responder es ¿Cuánto de la diferencia media del ingreso laboral se debe a diferencias grupales en los predictores X?:

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9 En el presente documento se considera formal aquel trabajador que tiene acceso a los beneficios de seguridad de largo plazo (pensiones).

10 Varios modelos económicos han tratado formalmente la oferta y demanda de los factores que pueden explicar la brecha de ingresos en las minorías. Becker (1957) por ejemplo propone una teoría conocida como *Taste for Discrimination* donde la discriminación se debe a un prejuicio personal o un "gusto" personal en contra de asociarse con un grupo en particular. Consecuentemente, los empleadores actúan como si hubiera un costo no económico por emplear a un grupo en particular. Otra explicación común es la *discriminación estadística* que describe a la discriminación como el acto de agentes racionales de utilizar características grupales agregadas para evaluar características individuales, esto implica que agentes de distintos grupos pueden ser tratados de forma diferenciada. Por ejemplo, si las empresas creen que las mujeres en edad fértil tienen una probabilidad mayor de pausar sus carreras por tener hijos, pagarían menores sueldos a las mujeres en este rango de edad para mitigar la probabilidad de perder a una trabajadora (Hoyos *et al.*, 2010).

$$EGap = E(Y_H) - E(Y_M) \quad (1)$$

Donde $E(Y_g)$ denota la esperanza de la variable de interés. Utilizando una ecuación tipo Mincer para explicar el ingreso, podemos desagregar el mismo tal que $Y_g = \alpha_g + \sum_{i=1}^{k} X_{ik}\beta_{gik} + \epsilon_{gi}$, donde g describe si la ecuación se realiza a hombres (H) o mujeres (M). La expresión puede ser reemplazada en la ecuación [1], tal que:

$$EGap = E\left(\alpha_H + \sum_{i=1}^{k} X_{ik}\beta_{Hik} + \epsilon_{Hi}\right) - E\left(\alpha_M + \sum_{i=1}^{k} X_{ik}\beta_{Mik} + \epsilon_{Mi}\right) \quad (2)$$

$$EGap = \hat{\alpha}_H + \sum_{i=1}^{k} \overline{X_{ik}}\hat{\beta}_{Hik} - \hat{\alpha}_M - \sum_{i=1}^{k} \overline{X_{ik}}\hat{\beta}_{Mik} \quad (3)$$

Reordenando algunas variables podemos identificar la contribución de las diferencias grupales en los predictores al resultado final.

$$EGap = \left(\hat{\alpha}_H - \hat{\alpha}_M\right) + \sum_{i=1}^{k} \overline{X}_{ik}(\hat{\beta}_{Hik} - \hat{\beta}_{Mik}) + \sum_{i=1}^{k} (\overline{X}_{Hik} - \overline{X}_{Mik})\ \hat{\beta}_{Hik} \quad (4)$$

Donde el último componente de la ecuación [4] corresponde a la brecha de ingresos explicada por las diferencias observables, mientras que los dos primeros componentes corresponden a las diferencias no observables.

La descomposición de Blinder-Oaxaca es el método mayormente utilizado para el cálculo de brechas de ingreso, sin embargo, presenta algunas limitaciones que son relevantes de mencionar. Primero, la relación entre características e ingresos no necesariamente podría ser lineal como asume el modelo Blinder-Oaxaca. Segundo, el modelo es únicamente informativo acerca de la descomposición de la brecha de ingresos. Tercero, el método no logra restringir su comparación a individuos comparables, debido a las diferencias en el soporte de la distribución empírica de las características de los individuos (Ñopo, 2012).

Descomposición de Ñopo

Como respuesta a las limitaciones, Ñopo (2008) desarrolló un método de descomposición no paramétrico. El método responde a la misma pregunta contrafactual, considerando las diferencias a lo largo de la distribución de ingresos y no solo en el promedio, como lo hace Blinder-Oaxaca.

En este sentido, la metodología de Ñopo restringe la comparación de diferencias únicamente entre hombres y mujeres con características comparables. Por lo que crea una muestra sintética de individuos al emparejar hombres y mujeres con características observables idénticas y así no necesita asumir ninguna forma funcional entre la

relación entre características e ingresos. El emparejamiento se realiza por medio de características discretas, de este modo, el emparejamiento no necesita el uso de *Propensity Score* u otra noción de distancia entre las características de hombres y mujeres (Ñopo 2008).

Este procedimiento crea tres juegos de individuos: i) aquellas mujeres y hombres que están emparejados (soporte común); ii) aquellas mujeres con características observables para las que no existen hombres comparables (conocido según la metodología como *Maid Effect*) y, iii) aquellos hombres para los que no existen mujeres comparables (conocido como *CEO Effect*). Por construcción, aquellos hombres y mujeres en el soporte común no presentan características observables diferentes y en consecuencia las diferencias en ingresos, si es que existieran, no se podrían explicar por estas características.

En este sentido, el procedimiento descompone la brecha de ingreso en cuatro elementos:

$$\delta = \delta_X + \delta_H + \delta_M + \delta_0 \tag{5}$$

El primero explica la diferencia de ingreso en relación con las características observables (δ_X), el segundo y tercer elementos explican la diferencia de aquellos individuos fuera del soporte común $(\delta_H$ y $\delta_M)$ y el último elemento que puede ser interpretado como discriminación (δ_0). Un punto importante a notar es el hecho de que el componente no explicado de Ñopo es comparable al componente no explicado en el modelo Blinder-Oaxaca, solo que restringido al soporte común dentro de la distribución.

A pesar de que la metodología de descomposición de Ñopo tiene atributos importantes que corrigen limitaciones específicas del modelo Blinder-Oaxaca, también presentan sus propias limitaciones que se deben mencionar. Primero, debido a que el emparejamiento se construye con variables discretas, la probabilidad de encontrar una persona con las mismas características y dotaciones para cada hombre o mujer disminuye a medida que se incrementa el número de variables incluidas (Enamorado *et al.*, 2009), lo que reduce el soporte común si el análisis se realiza con una cantidad importante de características observables. Este fenómeno se conoce en la literatura como la *Maldición de Dimensión*. En general, el tamaño del soporte común estará restringido en función al número de variables a incluirse en el análisis.

Un punto que atañe a ambas metodologías, es el hecho que tanto la descomposición de Ñopo como la de Blinder-Oaxaca solamente consideran características observables, omitiendo aquellas características no observables como son el esfuerzo, interés por participar en el mercado laboral o responsabilidades del hogar, lo que posiblemente genere estimaciones sesgadas por omisión de variables. El resultado de nuevas investigaciones referentes a la participación de las mujeres en el mercado laboral encuentran evidencia de que las preferencias y actitudes entre hombres y mujeres hacia el trabajo no son necesariamente idénticas (Chioda, 2011).

El presente documento empleará ambas metodologías en el análisis de la evolución de la brecha de ingresos entre hombres y mujeres en Bolivia. Utilizar ambas metodologías permite aprovechar las ventajas metodológicas de cada una para tratar de entender la evolución y sus posibles explicaciones. Asimismo, utilizar ambas metodologías permite crear un marco metodológico comparable con los estudios existentes y con futuras actualizaciones, independientemente de la metodología que se utilice.

5. RESULTADOS

Considerando que el presente documento utiliza ambos métodos de evaluación, se utilizarán las mismas variables explicativas tanto para para la descomposición Blinder-Oaxaca como para la descomposición de Ñopo. Se consideran las siguientes variables: años de educación, experiencia laboral estimada[11]; experiencia laboral al cuadrado; una variable *dummy* para cada grupo educacional (existen cuatro grupos: sin educación o inferior a primaria, primaria completa, secundaria completa y terciaria, el grupo sin educación es el grupo base); una variable *dummy* para cada grupo de edad (15-25, 26-35, 36-45 y de 56-65, el grupo entre 45 y 56 es el grupo base); una variable *dummy* que toma el valor de 1 si la persona está casada; una variable *dummy* por cada sector económico; una *dummy* que toma el valor de 1 si trabaja formalmente; y una *dummy* que toma el valor de 1 ante la presencia de menores a 6 años en el hogar. Por comparabilidad con la descomposición de Ñopo, no se incluye el grupo ocupacional en este primer análisis, aunque sí más adelante.

La Tabla 3 presenta los resultados del cálculo de la brecha de ingreso por hora utilizando el modelo Blinder-Oaxaca. Los resultados muestran que la diferencia en el ingreso por hora por género en 1993 era 32% del ingreso laboral promedio de los hombres, de esta diferencia, la parte explicada representa tan solo el 11% mientras que la parte sin explicación representa el 20%[12]. Donde la porción de la brecha explicada corresponde al mayor nivel educativo y de experiencia laboral de los hombres. En 1999, la diferencia de ingresos fue de aproximadamente 21%, donde la parte no explicada de la brecha era de 15%. En 2006, la brecha de ingresos reduce hasta 17%, del que 12% no era explicada por características observables. En 2013, la diferencia continuó su tendencia decreciente hasta 11%, siendo 8% que corresponde al componente no explicado. Finalmente, para el 2018, la brecha representaba solamente el 7% de los ingresos, de estos, 6% corresponde al componente no explicado.

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[11] Calculado como Experiencia=edad-años de educación-6.

[12] La brecha de género está calculada como Diferencia/Estimación Hombre. La brecha con explicación se calcula como "Explicada"/Estimación Hombre. La brecha no explicada se calcula como "No Explicada"/ Estimación Hombre.

TABLA 3

DESCOMPOSICION BLINDER-OAXACA

	Logaritmo del ingreso por hora				
	1993	1999	2006	2013	2018
Diferencial					
Estimación Hombre	1,696***	1,973***	1,921***	2,200***	2,258***
	(116,29)	(76,61)	(98,33)	(214,02)	(268,25)
Estimación Mujer	1,158***	1,560***	1,594***	1,964***	2,095***
	(59,30)	(42,10)	(60,87)	(140,61)	(166,14)
Diferencia	0,538***	0,413***	0,327***	0,235***	0,163***
	(22,08)	(9,15)	(10,02)	(13,58)	(10,72)
Descomposición					
Explicada	0,191***	0,120***	0,0903***	0,0662***	0,0291**
	(10,04)	(3,69)	(4,05)	(5,91)	(2,83)
No Explicada	0,347***	0,293***	0,237***	0,169***	0,133***
	(14,63)	(6,57)	(7,43)	(9,83)	(8,51)
Descomposición (como porcentaje del ingreso laboral por hora para los hombres)					
Total	32%	21%	17%	11%	7%
Explicada	11%	6%	5%	3%	1%
No Explicada	20%	15%	12%	8%	6%
Observaciones	6.313	2.330	3.807	10.418	10.603

Estadístico t en paréntesis
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Fuente: Elaboración propia a base de los datos de las encuestas de hogares 1993, 1999, 2006, 2013 y 2018.

Es interesante destacar la disminución de la brecha de ingresos por género en los últimos 25 años, pasando de 32% en 1993 a 7% en el 2018. Destaca la reducción del porcentaje explicado de la brecha que pasó de 11% a 1%, aunque también la reducción del componente no explicado, que se redujo de 20% a 6%.

Para analizar las causas de la reducción de la brecha explicada, la Tabla 4 presenta una desagregación de los principales componentes que explican las diferencias entre hombres y mujeres. Para esto se agregan las variables relacionadas a características educativas, aquellas relacionadas a la experiencia, aquellas relacionadas a características personales y familiares, el sector de actividad, la región y la formalidad. Destaca la reducción de la porción explicada de la brecha asociada a diferencias educacionales, las que pasaron de ser las más relevantes a no ser significativas. Este se debe a un mayor acceso de mujeres con mayores niveles de educación al mercado laboral, como se puede evidenciar en la Tabla A1. Asimismo, se observa que las características familiares dejan de ser relevantes para explicar la diferencia de ingresos, lo que hace referencia al impacto de los cambios culturales y de roles en el país, ser una mujer

TABLA 4

COMPONENTES DE LA DIFERENCIA EXPLICADA – BLINDER-OAXACA

	Logaritmo del ingreso por hora				
	1993	1999	2006	2013	2018
Diferencia Explicada	0,191***	0,120***	0,090***	0,066***	0,029**
Educación	0,113***	0,091***	0,041**	0,016**	-0,005
Experiencia	-0,007	-0,020	-0,013	-0,004	0,001
Características personales y familiares	0,021***	0,009	0,017**	0,013***	0,002
Sector de Actividad	0,055***	0,034	0,028*	0,036***	0,026***
Región	0,009	0,000	0,002	-0,002	0,000
Sector Formal	n.d.	0,007	0,015**	0,007**	0,004

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fuente: Elaboración propia a base de los datos de las encuestas de hogares 1993, 1999, 2006, 2013 y 2018.

casada deja de ser relevante para explicar las diferencias de ingreso. De la misma forma, es importante destacar que el sector de actividad donde se desempeñan las mujeres sigue siendo relevante para explicar la diferencia de ingresos y que nos da luces acerca de segregación sectorial. En Anexos se presenta el mismo análisis incluyendo la variable de ocupación (Tabla A2.), donde también se evidencia un menor acceso de mujeres a las ocupaciones con mayores ingresos. Estas afirmaciones se pueden contrastar en la sección en el Anexo 2, que presenta una metodología para la descomposición de ingresos a base de las variables explicativas utilizadas conocida como *Descomposición de Fields*.

La Tabla 5 presenta los resultados de la descomposición Ñopo. Si bien se utiliza el mismo set de variables explicativas, aunque considerando que la metodología de Ñopo emplea datos discretos para el emparejamiento, se incluyen variables de grupo de niveles de educación en lugar de la variable años de educación. Considerando la *Maldición de Dimensión,* porque la inclusión de variables explicativas tiene un impacto negativo en el soporte común, el resultado no incluye la variable de ocupación laboral, como en el caso de la Descomposición de Blinder-Oaxaca recién reportado. En la sección 5 se presentará los resultados incluyendo esta variable.

La primera columna de la Tabla 5 muestra que la brecha de ingreso por género en 1993 era de 43% del ingreso promedio de los hombres, siendo la parte no explicada de 31%. El componente explicado es 8%. El *CEO Effect* (hombres para los cuales el procedimiento no halló mujeres con las mismas características) es positivo en la brecha de género y es igual a 5%. Asimismo, el *Maid Effect* (mujeres para las que no hay hombres con las mismas características) es negativo (-0,4%). Es interesante notar que el porcentaje de hombres y mujeres en el soporte común es de 55% y 72%, respectivamente, de acuerdo con lo que se esperaba debido a la metodología de emparejamiento.

TABLA 5

DESCOMPOSICION ÑOPO

	1993 (%)	1999 (%)	2006 (%)	2013 (%)	2018 (%)
δ (Total)	43	28	23	13	7
$\delta_0\delta_0$ (No explicada)	31	21	16	11	5
$\delta_M\delta_M$ (Maid Effect)	-0	-4	-1	-2	-2
$\delta_F\delta_F$ (CEO Effect)	5	4	2	2	1
$\delta_X\delta_X$ (Explicado)	8	8	6	2	2
% Hombres	55	36	41	57	53
% Mujeres	72	53	58	76	78
Error Estándar					
Error Estándar δ_0	2	4	3	1	1

Fuente: Elaboración propia a base de los datos de las encuestas de hogares 1993, 1999, 2006, 2013 y 2018.

Siguiendo el análisis, en 1999 la brecha se redujo a 28% con un componente no explicado de 21% y un componente explicado igual a 8%. El *CEO Effect* fue de 4% y el *Maid Effect* negativo e igual a -4%. El 36% de los hombres y 53% de las mujeres se encontraban en el soporte común.

Para el 2006 la brecha tuvo una nueva reducción a 23% con un componente no explicado de 16%[13], un *CEO Effect* de 2% y un *Maid Effect* igual a -1% En 2013, la brecha de ingresos llegó a ser 13% del ingreso promedio, compuesto básicamente por el componente no explicado o de discriminación 11%.

Finalmente, para el 2018, la brecha de ingresos se redujo a la mitad y llego a 7% del ingreso promedio. La parte no explicada de la brecha es de 5%. En este caso, el 53% de los hombres así como 78% de las mujeres se encontraban en el soporte común.

Dos resultados destacan en particular del presente análisis. Primero, la descomposición Ñopo muestra un proceso de cierre de brecha en el periodo de 43% a 7%. Segundo, la reducción en la brecha explicada por diferencias observables es consistente con los datos del análisis de Blinder-Oaxaca (BO), reduciéndose de 8% a 2%. También es importante destacar la reducción del *CEO Effect*, la parte de la diferencia explicada por hombres con características no replicables para las mujeres, componente que tradicionalmente se asocia a la presencia de hombres en altos cargos jerárquicos, se redujo, lo que podría interpretarse como una señal de un mejor acceso de mujeres a puestos gerenciales. Sin embargo, datos del Instituto Nacional de Estadística, en su reporte de remuneraciones del sector privado, muestran una menor participación de mujeres en puestos gerenciales, lo que coincide con datos provenientes de la Encuesta

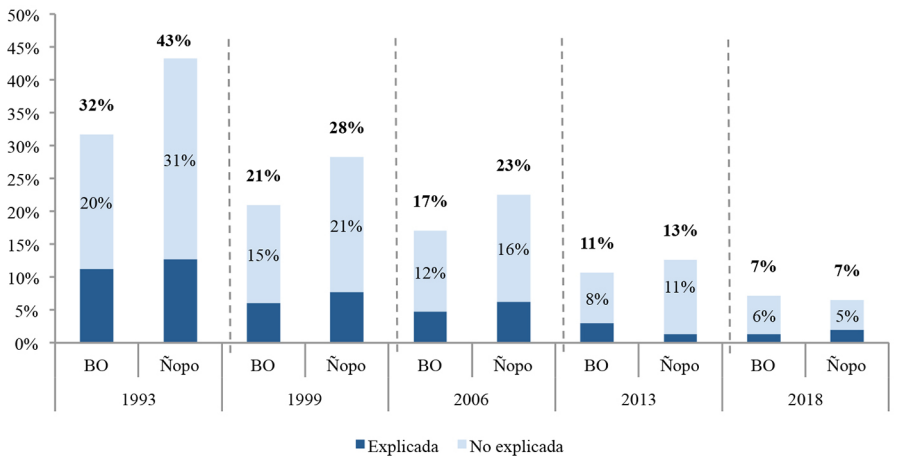
[13] Este porcentaje es similar al 17% que encuentra Ñopo (2010) para el año 2005.

de Demanda Laboral en Bolivia[14], donde también se evidencia que las empresas siguen prefiriendo mayoritariamente a hombres para puestos gerenciales.

El Gráfico 1 presenta el resumen del total de la brecha por género encontrada bajo el cálculo de ambas metodologías para los 25 años analizados, el resumen incluye tanto el componente explicado y el componente no explicado. Destaca la convergencia de la brecha con ambas metodologías.

GRAFICO 1

BRECHA DE INGRESO TOTAL ESTIMADA MEDIANTE LA METODOLOGIA DE BLINDER-OAXACA Y ÑOPO



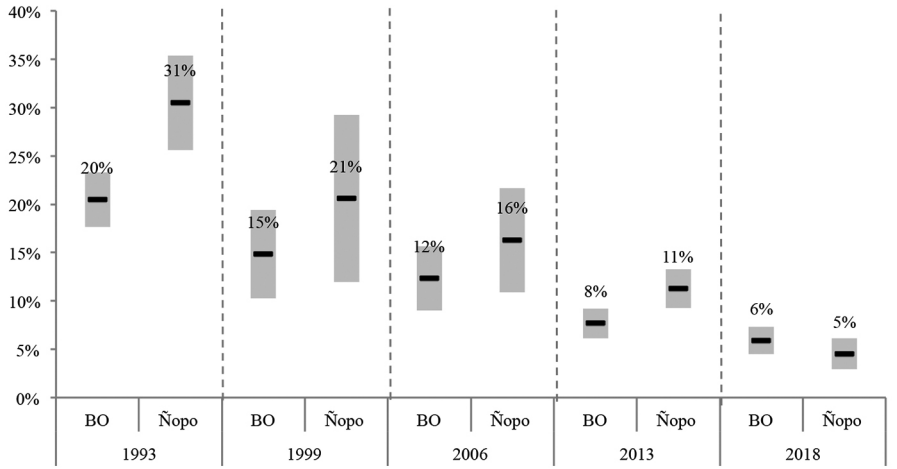
Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente explicado y no explicado de la brecha de ingresos por género. Para la metodología de Ñopo, el dato del componente explicado se calcula como la sumatoria del componente explicado, el *CEO Effect* y el *Maid Effect*.

A continuación se presenta la evolución de la brecha de ingresos no explicada en el periodo analizado empleando ambos procedimientos. El Gráfico 2 presenta la brecha no explicada incluyendo variaciones 2 desviaciones estándar arriba y abajo del estimador. Los resultados nos muestran una evolución robusta de la brecha no explicada con ambas metodologías, donde destaca que las diferencias entre ambos estimadores no son estadísticamente diferentes, con excepción del año 1993.

[14] Encuesta recolectada por el BID en Bolivia entre 2015 y 2016. Urquidi *et al.* (2018) "Encuesta Mercado Laboral: Oferta 2016, Demanda 2015-2016".

GRAFICO 2

BRECHA DE INGRESO NO EXPLICADA COMPARATIVA



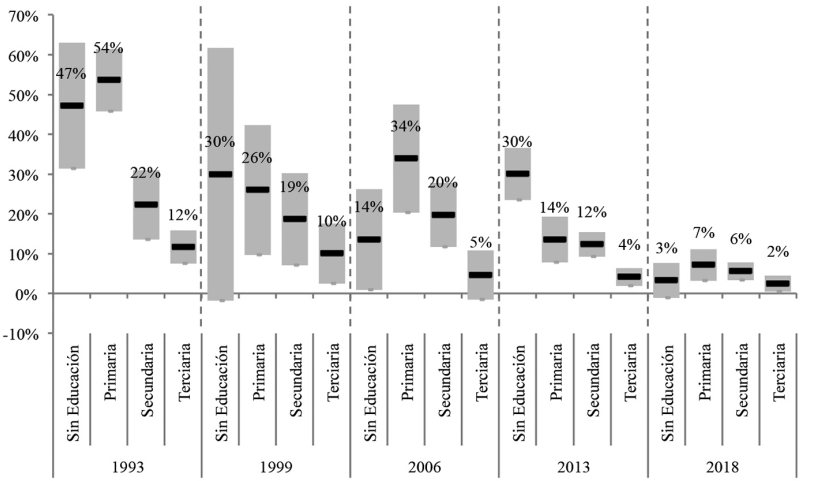
Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente no explicado al 95% de nivel de confianza.

La descomposición de Ñopo permite explorar de forma desagregada la brecha de ingresos. El Gráfico 3 presenta la diferencia en la brecha de género por nivel de educación. Se observa que la brecha no explicada de ingresos se reduce a mayor nivel de educación: mientras que la brecha de ingresos era de 47% y 54% para aquellas mujeres sin educación y con educación primaria en 1993, la brecha alcanzaba a 23% y 12% si se compara aquellas mujeres con estudios secundarios y terciarios, respectivamente. En 2018, la brecha no explicada para las mujeres sin educación era de 5%, para las mujeres con educación primaria y secundaria 7% y 6%, respectivamente, y para aquellas mujeres con educación terciaria, la brecha de ingresos era de apenas 2%. Vale la pena destacar que en 1993 la brecha no explicada se reducía drásticamente al nivel de educación secundaria, mientras que en 2018, la brecha cae para aquellas mujeres con estudios terciarios. Este fenómeno se puede explicar por el incremento del nivel educativo de la fuerza laboral.

Respecto de la evolución del componente no explicado de la brecha de ingresos laborales por grupo etario, se puede evidenciar una mayor discriminación para aquellas trabajadoras en las colas de la distribución de edad, los jóvenes entre 15 y 25 años y las personas más cercanas a la edad de jubilación (56 a 65 años) presentan mayores diferencias no explicadas en los ingresos (Gráfico 4).

GRAFICO 3

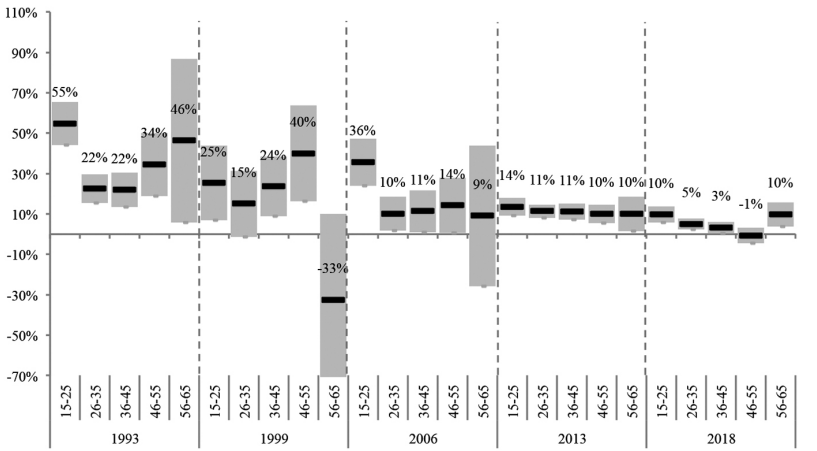
BRECHA DE INGRESOS NO EXPLICADA POR NIVEL DE EDUCACION
MEDIANTE LA DESCOMPOSICION DE ÑOPO



Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente no explicado al 95% de nivel de confianza.

GRAFICO 4

BRECHA DE INGRESOS NO EXPLICADA POR EDAD
MEDIANTE LA DESCOMPOSICION DE ÑOPO

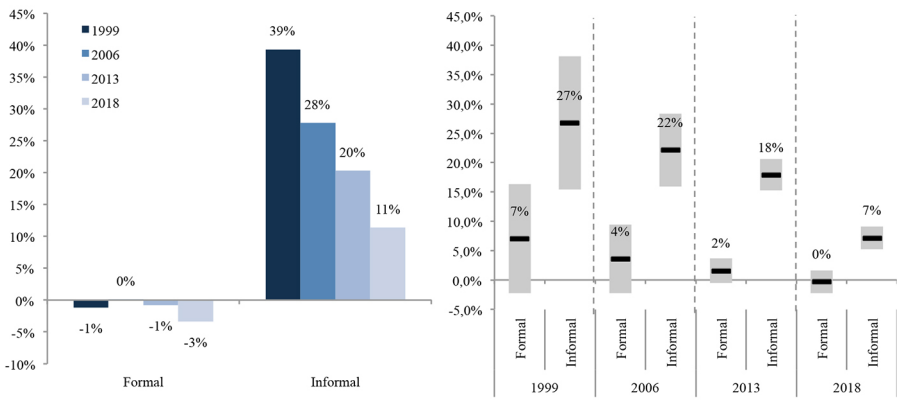


Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente no explicado al 95% de nivel de confianza.

Desagregando el impacto de la brecha no explicada por formalidad, se observa que la brecha no explicada es mucho mayor en el sector informal. El análisis al respecto no incluye información para 1993, debido a que la encuesta no disponía información que permita calcular de forma homogénea la definición de informalidad (acceso a seguridad social de largo plazo) como en las otras encuestas. La brecha no explicada se redujo desde 7% en el sector formal en 1999 hasta 0% en 2018. Para el sector informal la brecha no explicada era tan alta como 27% en 1999, se redujo hasta 22% en 2006, pasando a 18% en 2013 y finalmente a 7% en 2018 (Gráfico 6, panel derecho). Es importante destacar que la brecha total de ingresos es negativa en el sector formal (Gráfico 5, panel izquierdo), debido a la presencia de mujeres con mayor nivel educacional en el sector formal y consecuentemente con mejores trabajos.

GRAFICO 5

BRECHA DE INGRESOS POR FORMALIDAD MEDIANTE LA DESCOMPOSICION ÑOPO
BRECHA TOTAL (IZQ.), BRECHA NO EXPLICADA (DER.)



Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente no explicado al 95% de nivel de confianza.

Respecto de la brecha de ingresos en el sector informal, es importante recordar el alto nivel de informalidad en Bolivia que alcanza a 80% de la población ocupada, siendo 73% en el área urbana. Considerando esto, se puede desagregar el análisis de informalidad en dos grupos. El primero corresponde a los asalariados informales, donde la brecha de ingresos no explicada se redujo desde 23% en 1999 hasta 4% en 2018, la brecha podría estar explicada por un menor control gubernamental por las características de este tipo de trabajo, que ya de por sí no tiene acceso a seguridad social (Gráfico A1). El segundo grupo corresponde a los informales por cuenta propia, que son el grupo (de estos analizados) con mayores niveles de brecha no explicada,

el que pasó de 29% en 1999 a 9% en 2018, las explicaciones de estas diferencias se pueden entender por una sobrerrepresentación de las mujeres en las ocupaciones que generan menores ingresos (Tabla A3).

6. PRUEBA DE ROBUSTEZ

Para evaluar la validez de los resultados se analiza el efecto respecto de las estimaciones incluyendo al área rural y la variable omitida de ocupación, en el caso de la Descomposición Ñopo.

El Gráfico 6 presenta los resultados de la descomposición de ingresos no explicada mediante la metodología de Blinder-Oaxaca después de incluir el área rural. Se puede observar que la inclusión del área rural tiene un impacto significativo en la brecha estimada. Como se esperaba, la inclusión del área rural incrementa la brecha no explicada en 1999 de 15% a 24%, de 12% a 16% en el 2006, de 8% a 10% el 2013 y de 6% a 8% en 2018[15]. La brecha de ingresos es mayor en las áreas rurales debido a que el empleo agropecuario se caracteriza por ser independiente o familiar, por este motivo el jefe de hogar (generalmente hombre) es la persona que comúnmente declara ingresos laborales, los que pueden incluir el trabajo de otros miembros del hogar o familia, especialmente de las mujeres.

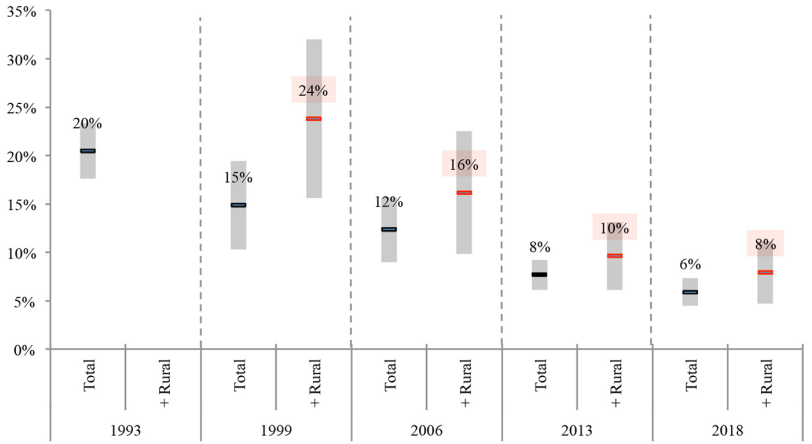
El Gráfico 7 presenta el cálculo de la brecha mediante la Descomposición de Ñopo incluyendo el área rural. La inclusión del área rural tiene un impacto significativo en el incremento de la brecha de ingresos no explicada, aunque en una menor proporción que en el método Blinder-Oaxaca, el indicador pasa de 21% a 26% en 1999; de 16% a 17% el 2006, de 11% a 13% en el 2013 y en 2018, la brecha de ingreso presenta un ligero incremento desde 5% hasta 6%.

El Gráfico 8 presenta el impacto en el cálculo de la brecha de ingresos laborales incluyendo la variable ocupación en la Descomposición de Ñopo. La variable fue omitida por su impacto en el porcentaje de hombres y mujeres en el soporte común. Los resultados nos muestran que a pesar de un incremento importante (13pp) en la brecha no explicada para 1999, la brecha no explicada no es estadísticamente diferente del cálculo cuando se omite la variable. El problema central de incluir la variable es la pérdida de validez externa, ya que el soporte común se reduce en 20 pp para las mujeres y 15 pp para los hombres.

[15] La encuesta de hogares de 1993 contiene únicamente datos urbanos.

GRAFICO 6

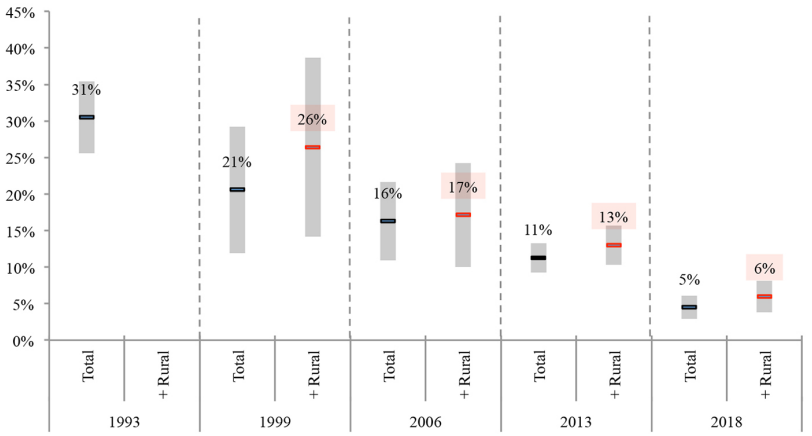
BRECHA DE INGRESOS LABORALES NO EXPLICADA UTILIZANDO DESCOMPOSICION BLINDER-OAXACA INCLUYENDO EL AREA RURAL



Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente no explicado al 95% de nivel de confianza. La encuesta de 1993 no contiene información del área rural.

GRAFICO 7

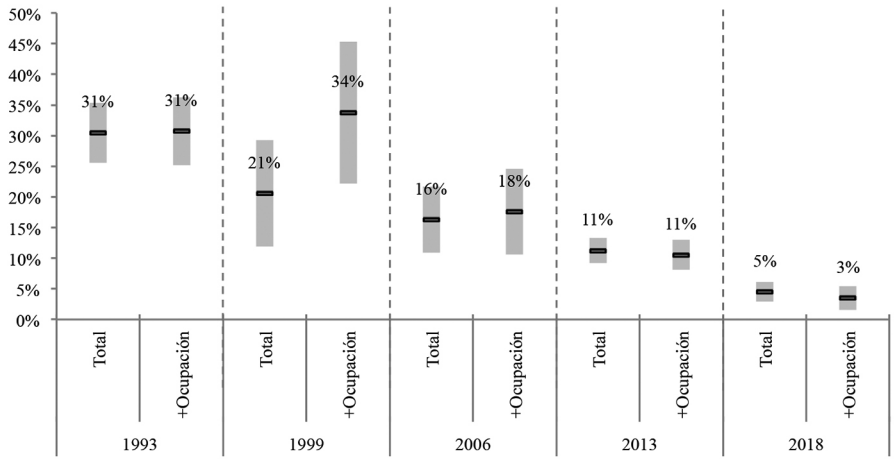
BRECHA DE INGRESOS NO EXPLICADA UTILIZANDO LA DESCOMPOSICION DE ÑOPO INCLUYENDO EL AREA RURAL



Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente no explicado al 95% de nivel de confianza. La encuesta de 1993 no contiene información del área rural.

GRAFICO 8

BRECHA DE INGRESO NO EXPLICADA INCLUYENDO LA VARIABLE OCUPACION
UTILIZANDO LA DESCOMPOSICION ÑOPO



Fuente: Elaboración propia utilizando datos de encuestas de hogares de 1993, 1999, 2006, 2013 y 2018. Las barras presentan el componente no explicado al 95% de nivel de confianza.

CONCLUSIONES

En Bolivia las mujeres no solo tienen menores oportunidades en algunos sectores y ocupaciones, sino que reciben menores ingresos que los hombres y se concentran en trabajos con menores salarios. El presente documento tiene como objetivo principal cuantificar y analizar la evolución de la brecha de ingreso por género y proponer explicaciones racionales al comportamiento de la brecha en Bolivia en los últimos 25 años.

Utilizando cinco encuestas de hogares y dos métodos de descomposición del ingreso diferentes: uno paramétrico, la Descomposición Blinder-Oaxaca y otro no paramétrico, la Descomposición Ñopo, encontramos evidencia robusta de una importante reducción en la brecha de ingresos por género utilizando ambos procedimientos, donde destaca que ambos procedimientos muestran una evolución y estimaciones similares. La Descomposición Blinder-Oaxaca nos muestra una reducción de 32% de la brecha de ingresos en 1993 a 7% el 2018 y la Descomposición Ñopo nos muestra una reducción en la brecha de 43% a 7% en el mismo período.

Esta reducción se explica por la disminución de ambos componentes, el primero explicable por la baja en las diferencias en las características observables, especialmente el relacionada a mejoras en la educación de las mujeres y en el impacto de características

familiares. El segundo componente que explica la reducción de la brecha se debe a la reducción del componente no explicado, asumido como discriminación. El componente explicado muestra una reducción de 11% a 1% mediante la metodología Blinder-Oaxaca y de 8% a 2% utilizando el método de Ñopo. El componente no explicado muestra también una reducción de 14 pp o 26 pp, utilizando procedimientos paramétricos y no paramétricos, respectivamente.

Aprovechando la descomposición de Ñopo, se puede explorar las diferenciales de ingreso a base de las características observables, encontramos que la brecha no explicada de ingresos por género se reduce drásticamente para aquellas mujeres con educación terciaria, siendo tan solo 2% del ingreso promedio de hombres en 2018.

Asimismo, considerando la formalidad, encontramos una ausencia de brecha no explicada por género en el sector formal, mientras que en el sector informal es de casi 7% del ingreso promedio. Más aún, la brecha total de ingresos por género es negativa para el sector formal y esto se puede atribuir a que las mujeres necesitan una mayor cantidad de credenciales educativas para acceder a mejores trabajos y consecuentemente a mejores ingresos.

Los resultados son robustos luego de la inclusión del área rural. Lo que refuerza los hallazgos e hipótesis acerca de la reducción de la brecha explicada y no explicada (discriminación) en los últimos 25 años.

Estos resultados tienen implicaciones importantes en cuanto a la posibilidad de implementar políticas públicas. Es necesario continuar con la reducción de la brecha de ingresos, para eso es necesario impulsar un acceso igualitario de las mujeres a sectores y ocupaciones que generan mayores retribuciones. Esto se puede alcanzar mediante la capacitación y la inserción laboral de mujeres en ocupaciones y sectores no tradicionales, que les permita mejorar su productividad laboral y consecuentemente sus ingresos laborales. Esto es especialmente relevante para aquellas mujeres con menores niveles de educación y que trabajan en el sector informal. Sin embargo, este tipo de políticas deben estar diseñadas para ser amigables con el rol que ejerce la mujer dentro del hogar y en la sociedad. De esta forma se puede asegurar no solo mejoras en la empleabilidad y en la remuneración, sino también en el bienestar familiar.

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ANEXOS

TABLA A1

DATOS PROMEDIO POR AÑO Y GÉNERO – DESCOMPOSICION BLINDER-OAXACA

	1993 (%)		1999 (%)		2006 (%)		2013 (%)		2018 (%)	
	Hombres	Mujeres	Hombres	Mujeres	Hombres	Mujeres	Hombres	Mujeres	Hombres	Mujeres
Años de Educación	9,9	8,3	10,6	9,3	10,9	10,0	12,2	11,5	11,7	11,2
Ninguno	12	28	16	29	17	27	10	18	12	21
Primaria	44	34	33	26	29	23	20	18	23	18
Secundaria	26	16	33	28	33	29	42	34	45	37
Terciaria	18	22	17	17	21	21	28	30	19[16]	25
Años de Experiencia	19,9	20,7	19,6	20,9	19,2	20,4	19,5	20,5	20,5	21,9
15-25	22	26	22	21	22	21	18	18	16	14
26-35	31	28	29	29	29	28	30	28	29	28
36-45	26	26	26	28	24	27	25	24	27	28
46-55	15	14	17	15	17	17	18	19	17	19
56-65	6	6	6	7	7	7	10	10	11	11
Casados	73	53	75	59	72	59	67	54	71	54
Niños menores de 6 años en el hogar	53	46	46	42	45	41	37	34	35	30
Minería e Hidrocarburos	3	0	2	0	3	0	3	0	2	0
Manufactura	20	13	18	14	18	14	17	10	16	11
Construcción	16	0	16	0	17	0	16	1	21	1
Comercio	20	41	20	46	18	39	18	42	18	47
Transporte y Almacenamiento	15	1	17	1	16	4	15	1	17	1
Servicios Financieros	5	3	1	1	8	5	2	3	2	2
Servicios Sociales	21	41	26	38	20	38	30	43	24	38
Formal	nd,	nd,	26	22	25	21	33	31	28	27

Fuente: Elaboración propia a base de los datos de las encuestas de hogares 1993, 1999, 2006, 2013 y 2018.
nd. No disponible.

[16] Esta reducción del porcentaje de hombres con educación terciaria en 2018 respecto de 2013 amerita un análisis en la siguiente encuesta de hogares con el fin de confirmar sus causas.

TABLA A2

COMPONENTES DE LA DIFERENCIA EXPLICADA INCLUYENDO OCUPACION BLINDER-OAXACA

	1993	1999	2006	2013	2018
Diferencia Explicada	0,231***	0,144***	0,117***	0,101***	0,048***
Educación	0,092***	0,079***	0,033**	0,015**	0,001
Experiencia	-0,004	-0,020	-0,011	-0,004	0,000
Características personales y familiares	0,016**	0,010	0,017***	0,014***	0,004
Sector de Actividad	0,048***	0,031	0,008	0,017*	0,027**
Ocupación	0,070***	0,040	0,056**	0,055***	0,012
Región	0,009*	-0,001	0,002	-0,001	0,000
Sector Formal	n.d.	0,004	0,012**	0,005**	0,004

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Fuente: Elaboración propia a base de los datos de las encuestas de hogares 1993, 1999, 2006, 2013 y 2018.

GRAFICO A1

BRECHA DE INGRESOS NO EXPLICADA POR FORMALIDAD UTILIZANDO LA DESCOMPOSICION ÑOPO

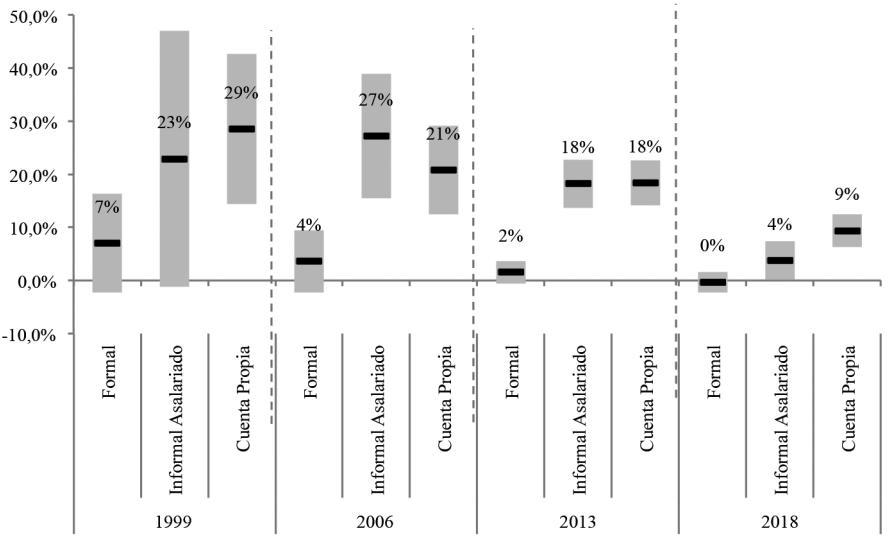

TABLA A3

PARTICIPACION POR OCUPACION E INGRESO PROMEDIO POR HORA PARA FORMALES POR CUENTA PROPIA

	1993		1999		2006		2013		2018	
	Participación Mujeres	Ingreso por hora (Bs)	Participación Mujeres	Ingreso por hora (Bs)	Participación Mujeres	Ingreso por hora (Bs)	Participación Mujeres	Ingreso por hora (Bs)	Participación Mujeres	Ingreso por hora (Bs)
Directivos, profesionales y técnicos	26%	24,8	25%	21,8	33%	31,3	29%	17,3	29%	16,4
Administrativos	70%	7,0	24%	7,1	51%	5,5	42%	8,9	50%	9,8
Comerciantes y vendedores	79%	5,2	82%	8,7	76%	7,2	76%	11,1	76%	9,5
Servicios	77%	5,3	86%	10,5	89%	10,1	89%	13,9	88%	12,9
Obreros	22%	6,6	20%	8,4	24%	8,0	18%	10,3	16%	9,6
Total	50%	8,0	52%	9,7	51%	10,9	46%	11,9	43%	10,6

Fuente: Elaboración propia a base de los datos de las encuestas de hogares 1993, 1999, 2006, 2013 y 2018.

ANEXO 2

DESCOMPOSICION DE FIELDS[17]

Una forma conveniente y consistente de descomponer la inequidad de ingresos ha sido la desarrollada por Gary S. Fields (Andersen, 1999). Este método se aplica a ecuaciones de ingreso Mincer estándar y requiere multiplicar cada coeficiente de la estimación por la desviación estándar de la variable explicativa y la correlación entre la variable y la variable dependiente, como resultado se obtiene el Ponderador Relativo de Inequidad (F.I.W. por sus siglas en inglés) que se encuentra en una escala que suma 1 (Andersen, 1999).

Formalmente el F.I.W. se calcula de la siguiente manera:

Sea una ecuación Mincer estándar:

$$Y = \sum_j a_j * X_j \qquad \text{[A1]}$$

Donde Y es un vector que contiene el logartimo del ingreso por hora de todos los individuos y X es la matriz con j variables explicativas.

Considerando que una medida simple de inequidad es la varianza del logaritmo del ingreso laboral por hora. En este sentido se puede aplicar varianza a ambos lados de la ecuación siguiendo el teorema de Mood, Graybill y Boes que señala que:

Teorema de Mood, Graybill & Boes: Sea $X_1,\ldots, X_j$ y $Y_1,\ldots,Y_M$ dos sets de variables aleatoria y $a_1,\ldots, a_j$ y $b_1,\ldots b_M$ dos sets de contantes. Entonces

$$cov\left[\sum_{j=1}^{J} a_j X_j ; \sum_{m=1}^{M} b_m Y_m\right] = \sum_{j=1}^{J}\sum_{m=1}^{M} a_j b_m cov\left[X_j ; Y_m\right] \qquad \textit{[MG\&B]}$$

Entonces aplicando el teorema a la ecuación A1 obtenemos:

$$cov\left[\sum_{j=1}^{J} a_j X_j ; Y\right] = \sum_{j=1}^{J} cov\left[a_j X ; Y\right] \qquad \text{[A2]}$$

Donde el coeficiente de la izquierda es el valor de la covarianza entre Y y ella misma, que es la varianza de Y. Entonces dividiendo ambos lados por la varianza de Y, tenemos

---

[17] Texto adaptado de Andersen (1999) "Wage Differentials Between Bolivian Cities".

$$1 = \frac{\sum_{j=1}^{J} cov\left[a_j X; Y\right]}{\sigma^2(Y)} \equiv \sum_{j=1}^{J} s_j \qquad [A3]$$

Donde cada ponderador s_j está definido como

$$s_j = \frac{cov\left[a_j X_j; Y\right]}{\sigma^2(Y)} = \frac{a_j \sigma\left(X_j\right) * corr\left[X_j; Y\right]}{\sigma(Y)} \qquad [A4]$$

Donde sj son los ponderadores de inequidad que suman a 1 sobre todas las variables explicativas. Cada sj es afectado de forma positiva ante incrementos en el coeficiente (a_j), por la desviación estándar $\left(\sigma\left(X_j\right)\right)$ y por la correlación entre la variable explicativa y la variable dependiente $corr[X_j;Y]$.

Este método ha sido aplicado en Bolivia por Fields *et al.* (1998), Andersen (1999) y Andersen (2001) y concluyen que aproximadamente la mitad de la inequidad en el ingreso explicada se debe a la variable educación y las otras variables independientes solo pueden explicar una porción menor de la diferencia en ingresos. Sin embargo, el poder explicativo de las ecuaciones de ingreso es generalmente bajo.

Siguiendo la metodología arriba descrita, nuestras estimaciones para los años estudiados nos demuestran también que entre 1993 y 2018 la educación (tanto en años como en variables *dummy* de nivel) explicaba aproximadamente la mitad de las diferencias "explicadas" en el ingreso y las otras variables afectan de manera menor la diferencia explicada.

Es interesante notar la disminución en la importancia de la educación como factor de inequidad en el ingreso, posiblemente causado por el incremento del nivel de educación de la población boliviana y el cierre de la brecha de educación.

TABLA A3

DESCOMPOSICION DE FIELDS

	Logaritmo del ingreso por hora									
	1993		1999		2006		2013		2018	
	Coeficiente	F.I.W.	Coeficiente	F.I.W.	Coeficiente	F.I.W.	Coeficiente	F.I.W.	Coeficiente	F.I.W.
Diferencial Explicado	38%		31%		31%		22%		22%	
Años de Educación	0,077	19,2%	0,080	14,8%	0,078	14,8%	0,053	8,6%	0,024	5,0%
Dummy (mujer==1)	-0,357	5,0%	-0,290	2,6%	-0,237	1,9%	-0,166	1,2%	-0,131	0,9%
Experiencia	0,033	-1,3%	0,012	-0,6%	0,023	-0,7%	0,025	0,6%	0,014	-1,2%
Experiencia al cuadrado	0,000	1,8%	0,000	-0,3%	0,000	0,8%	0,000	0,7%	0,000	1,7%
Primaria (=1)	0,013	-0,1%	-0,140	1,0%	-0,312	2,5%	-0,203	1,3%	-0,003	0,0%
Secundaria (=1)	0,149	0,7%	-0,054	-0,2%	-0,311	0,4%	-0,219	1,2%	-0,007	0,0%
Terciaria (=1)	0,541	9,5%	0,185	2,3%	0,037	0,6%	-0,014	-0,3%	0,279	5,5%
26 a 35 años	0,052	0,2%	0,107	0,2%	-0,066	-0,1%	-0,070	0,0%	-0,018	0,0%
36 a 45 años	0,001	0,0%	0,111	0,3%	-0,089	-0,2%	-0,124	-0,4%	-0,004	0,0%
46 a 55 años	-0,102	-0,2%	-0,038	-0,1%	-0,099	-0,3%	-0,159	-0,5%	0,022	0,0%
56 a 65 años	-0,208	0,1%	-0,253	0,2%	-0,273	0,1%	-0,199	-0,2%	0,150	0,2%
Casado (=1)	0,103	1,0%	0,095	0,5%	0,126	0,7%	0,090	0,5%	0,020	0,0%
Construcción	0,144	0,1%	0,416	0,6%	0,094	0,0%	0,270	0,3%	0,169	0,0%
Comercio	-0,052	0,5%	0,162	-1,1%	-0,025	0,2%	0,021	-0,2%	0,006	-0,1%
Transporte y Almacenamiento	0,185	0,5%	0,195	0,2%	0,069	0,0%	0,099	-0,1%	0,072	-0,1%
Servicios Financieros	0,236	0,7%	0,634	0,6%	0,138	0,4%	0,164	0,2%	0,172	0,2%
Servicios Sociales	0,058	0,2%	0,257	2,1%	0,111	1,0%	0,193	2,5%	0,175	2,7%
Presencia de niños en el hogar (< a 6 años)	-0,031	0,1%	-0,118	0,6%	0,001	0,0%	0,013	0,0%	-0,019	0,1%
La Paz			0,116	-0,6%	-0,040	0,1%	-0,028	0,2%	-0,003	0,0%
Cochabamba			0,462	1,1%	0,223	0,4%	0,063	0,0%	0,068	0,1%
Oruro			-0,062	0,1%	-0,234	0,3%	-0,019	0,0%	-0,005	0,0%
Potosí			0,083	-0,1%	0,000	0,0%	0,105	0,0%	-0,011	0,0%
Tarija			0,337	0,0%	0,211	0,2%	0,270	0,6%	0,026	0,0%
Santa Cruz			0,558	2,3%	0,256	0,4%	0,228	0,7%	0,076	0,1%
Beni			0,446	0,5%	0,177	-0,1%	0,157	0,0%	-0,009	0,0%
Pando			0,687	1,4%	0,601	0,7%	0,206	0,1%	0,076	0,1%
Formal (=1)			0,178	2,1%	0,368	5,8%	0,266	4,6%	0,285	6,0%

Fuente: Elaboración propia a base de los datos de las encuestas de hogares 1993, 1999, 2006, 2013 y 2018.

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