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The elasticity of substitution and labor-saving innovations in the Spanish regions*

La elasticidad de sustitución y las innovaciones ahorradoras de trabajo en las regiones españolas

Antonio Cutanda**

Abstract

This paper performs a nonlinear estimation of a normalized CES production function within a system of equations with a panel of Spanish regions for the period 1964-2013. It obtains an elasticity of substitution below one and identifies different rates of factor-augmenting technical progress. The results support for labor-saving innovations hypothesis for the Spanish case. Nevertheless, they do not support a relationship between the elasticity of substitution and the initial regional capital per worker. The results do not change if labor is adjusted by human capital.

Key words: *Production function, CES, normalization, regional data.*

JEL Codes: *C33, E23, O47.*

Resumen

En este trabajo se estima no linealmente una función de producción CES normalizada en el seno de un sistema de ecuaciones con datos de panel de las regiones españolas, para el período 1964-2013. Se obtiene una elasticidad de sustitución menor que uno y se identifican diferentes tasas de progreso técnico aumentativo de la eficiencia de los factores productivos. Los resultados obtenidos sustentan la hipótesis de innovaciones ahorradoras de trabajo para el caso español. Sin

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embargo, no dan apoyo a la existencia de una relación entre la elasticidad de sustitución y el capital regional inicial por trabajador. Los resultados no cambian cuando se ajustan los datos del trabajo por capital humano.

Palabras clave: *Función de producción, CES, normalización, datos regionales.*

Códigos JEL: *C33, E23, O47.*

1. Introduction

For much of the 20th century, the stability of factor income shares has been considered a stylized fact of macroeconomic empirical analysis. Nevertheless, despite important measurement problems, there is now robust evidence of a decline in the labor income share.[1] Karabarbounis and Neiman (2014) explain the decline in the US by the fall in the relative price of investment goods, although Lawrence (2015) criticizes this explanation for assuming an elasticity of substitution greater than one along with Hicks-neutral technical progress. He argues that the decline can be better explained by an elasticity lower than one, a claim that is supported by US empirical evidence.[2]

The estimation of the Constant Elasticity of Substitution (CES) production function has traditionally been a very complex task, not least due to the *identification issue*. On the one hand, the *impossibility theorem* proposed by Diamond *et al*. (1978) states that it is not feasible to simultaneously identify the elasticity of substitution and biased technical change with a CES production function. On the other, the empirical research has not reached a clear consensus on the value of the elasticity, although it seems to agree that it is below one for the US economy (Chirinko, 2008; Young, 2013; Chirinko and Mallick, 2020; Gechert *et al*., 2021; Knoblach, Rößler and Zwerschke, 2020; Knoblach and Stöckl, 2020).

However, the normalization procedure, developed by De La Grandville (1989) and Klump and De La Grandville (2000), has further raised the interest in the estimation of the CES production function. According to Klump *et al*. (2007), it resolves the identification problem, especially when the CES function is estimated within a system of equations that includes the first-order conditions of profit maximization. In this study, it is applied this procedure to run a nonlinear estimation of a CES production function with Spanish regional data, although unlike Klump *et al*. (2007) I do not first log linearize it, to avoid the approximation bias. I check for the effect of human capital and heterogeneity, as well as biased technical change, as this approach allows to simultaneously

[1] See, for example, Rodriguez and Jayadev (2010).

[2] Recently, Glover and Short (2020) criticize Karabarbounis and Neiman (2014) for not having considered the effect of consumption in their analysis.

identify the elasticity of substitution and the rates of factor-augmenting technical progress. Finally, I apply a fixed-effects approach to our panel of regional data. In this sense, the application of panel data techniques to the estimation of the production function enjoys more degrees of freedom and can yield more efficient estimates. To my knowledge, this is the first estimation of a CES production function within a system of equations with Spanish regional data.

In contrast to previous studies, the results allow to conclude that the Spanish elasticity of substitution is below one, as in the US and other developed countries. I find that the *impossibility theorem* holds when the CES function is estimated as a single equation, the most used estimation method in previous empirical analysis for the Spanish economy, but not when it is estimated within a system of equations. Similar to Villacorta (2017), but unlike Dorazelski and Jaumandreu (2016), I obtain a negative estimate of the growth rate of labor-augmenting technical progress for the Spanish economy. In fact, the results can be taken as evidence of labor-saving (Boldrin and Levine 2002; Zuleta 2008) or labor-eliminating technical progress (Seater, 2005; Peretto and Seater, 2013). Finally, they also reject the existence of a relationship between the elasticity of substitution and the initial capital per worker.

The study is organized as follows: section 2 presents the theoretical model while section 3 describes the data; in section 4 the results are presented and commented, and section 5 concludes.

2. A CES Production Function for the Spanish Regions

Following Klump *et al*. (2007), we consider a linear homogeneous CES regional production function with technical change augmenting the efficiency of both inputs, capital and labor. For region *i*:

$$Y_{it} = C\left[\pi_i \left(E_{it}^K K_{it}\right)^{-\rho} + \left(1-\pi_i\right)\left(E_{it}^L L_{it}\right)^{-\rho}\right]^{-\frac{v}{\rho}} \tag{1}$$

where Y_{it} is the aggregate output, K_{it} and L_{it} are, respectively, the aggregate capital stock and labor, all in real terms and for region *i*, and E_{it}^j represents the level of efficiency of each input *j=K,L*. Following Arrow *et al*. (1961), $\pi_i \in (0,1)$ is the *distribution* parameter, reflecting capital intensity in production. Additionally, *C* is an efficiency parameter and ρ is the substitution parameter, with $\sigma = \frac{1}{1+\rho}$ being the elasticity of substitution between capital and labor whose value is very important for growth.[3] Note that, unlike Villacorta (2017) but the same as Kilponen and Viren (2010), who focused on a multi-country setting, we

[3] See Azariadis (1993) and Barro and Sala-i-Martin (1993).

are assuming the same elasticity for all regions. Moreover, unlike Klump *et al*. (2000), I do not impose constant returns to scale in production, with $\nu > 0$.

Although expression (1) can be estimated directly using nonlinear methods, it has been standard practice to estimate the log-linearized version (Kmenta 1967). This procedure consists of taking logs of expression (1) and applying a second order Taylor expansion around $\rho = 0$, so that a simple least squares estimation can be performed[4]:

$$\begin{aligned} log\left(Y_{it}\right) = logC - \frac{\nu}{\rho} log\left(\pi_i \left(E_{it}^K K_{it}\right)^{-\rho} + \left(1-\pi_i\right)\left(E_{it}^L L_{it}\right)^{-\rho}\right) = logC + \nu\pi_i log\left(E_{it}^K K_{it}\right) + \\ \nu\left(1-\pi_i\right) log\left(E_{it}^L L_{it}\right) - \frac{1}{2}\rho\nu\pi_i\left(1-\pi_i\right)\left[log\left(E_{it}^K K_{it}\right) - log\left(E_{it}^L L_{it}\right)\right]^2 \end{aligned} \tag{2}$$

This approach has been widely applied, though it suffers from an approximation bias that Thursby and Lovell (1978) showed was relevant for small samples, especially in estimating the elasticity of substitution and the more different it is from one.[5] Additionally, Diamond *et al*. (1978) proved that it is not feasible to jointly identify the technical progress parameters and the elasticity of substitution regardless of whether the function is log-linearized. In order to prevent this problem, standard practice since then has been to assume Hicks-neutrality, even after Antràs (2004) found that it could bias the results in favor of the Cobb-Douglas function.

As Klump *et al*. (2007) pointed out, the elasticity of substitution is always defined as a point elasticity, which means that it is related to one specific baseline point on one particular isoquant. Thus, the estimated parameters for the CES function lack theoretical or empirical meaning, given that they are dependent on the values of this point and the elasticity of substitution. Specifically, if we denote them by subscript 0:

$$\pi_{i0} = \frac{r_{i0} K_{i0}^{1/\sigma}}{r_{i0} K_{i0}^{1/\sigma} + w_{i0} L_{i0}^{1/\sigma}}$$

Klump *et al*. (2007) propose normalizing the CES function and representing it in consistent indexed numbers, since, in this case, the parameters have a clear empirical meaning.[6] Given that the baseline point holds at a particular moment in time $t = t_0$, following Klump *et al*. (2012), we assume the following functional form for the growth rates of efficiency of both inputs:

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4 Note that the last term in expression (2) disappears when $\rho = 0$.

5 This debate has a lot in common with the recent debate around the estimation of log-linearized consumption Euler equations (see Carroll, 2001).

6 Note that expression (1) is implicitly normalized at the point where inputs are equal to one.

$$E_{it}^{j} = E_{i0}^{j} e^{\gamma_j (t-t_0)} \tag{3}$$

where γ_j, $j = K, L$, are the growth rates of capital and labor-augmenting technical progress and E_{i0}^{j} are the efficiency levels of each region at the baseline time t_0.

After normalizing, all members of the same family of production functions should share the same fixed point, but with different σ. To ensure this, we consider the following normalized values:

$$E_{i0}^{L} = \frac{Y_{i0}}{L_{i0}} \left(\frac{1}{1-\pi_{i0}} \right)^{\frac{v}{\rho}}; \; E_{i0}^{K} = \frac{Y_{i0}}{K_{i0}} \left(\frac{1}{\pi_{i0}} \right)^{\frac{v}{\rho}}; \; e^{\gamma_K (t_0 - t_0)} = e^{\gamma_L (t_0 - t_0)} = 1 \tag{4}$$

Only at the baseline point, the distribution parameters π_{i0} and $1-\pi_{i0}$ are equal to the factor shares of income. Thus, the normalized CES production function will be:

$$Y_{it} = Y_{i0}^{v} \left[\pi_{i0} \left(e^{\gamma_K (t-t_0)} \frac{K_{it}}{K_{i0}} \right)^{-\rho} + \left(1-\pi_{i0}\right) \left(e^{\gamma_L (t-t_0)} \frac{L_{it}}{L_{i0}} \right)^{-\rho} \right]^{-\frac{v}{\rho}} \tag{5}$$

Special cases, with Hicks-neutral technical progress, are Bentolila and Saint Paul (2003), where $N_0 = K_0 = Y_0 = 1$, or Antràs (2004), where $N_0 = K_0 = 1$.[7]

Assuming competitive markets and profit maximization, León-Ledesma *et al*. (2010) and Klump *et al*. (2012) show the effect of technical bias and capital deepening on factor income shares, what depends on the value of the elasticity of substitution.

The proposal by Klump *et al*. (2007) consists of estimating the normalized CES production function within a supply-side system of equations including the first-order conditions of profit maximization (FOC). So, this system comprises equation (5) and the two FOC[8]:

$$Y_{it} = Y_{i0}^{v} \left[\pi_{i0} \left(e^{\gamma_K (t-t_0)} \frac{K_{it}}{K_{i0}} \right)^{-\rho} + \left(1-\pi_{i0}\right) \left(e^{\gamma_L (t-t_0)} \frac{L_{it}}{L_{i0}} \right)^{-\rho} \right]^{-\frac{v}{\rho}} \tag{5}$$

7 As is well-known, Hicks neutrality requires $\gamma = \gamma_K = \gamma_L > 0$, while Solow neutrality requires $\gamma_K > 0$, $\gamma_L = 0$, and Harrod neutrality $\gamma_K = 0$, $\gamma_L > 0$, while $\gamma = > 0 \neq \gamma_L > 0$ indicates general factor-augmenting technical progress.

8 The analysis by Klump *et al.* (2007) differs from ours in that they log-linearize the function and consider a mark-up.

$$\pi_{it} = \pi_{i0}\left(\frac{Y_{it}/Y_{i0}}{K_{it}/K_{i0}}\ \frac{1}{e^{\gamma_K(t-t_0)}}\right)^{\frac{\rho}{\nu}} \tag{6}$$

$$1-\pi_{it} = \left(1-\pi_{i0}\right)\left(\frac{Y_{it}/Y_{i0}}{L_{it}/L_{i0}}\ \frac{1}{e^{\gamma_L(t-t_0)}}\right)^{\frac{\rho}{\nu}} \tag{7}$$

León-Ledesma *et al*. (2010) review the available methods to estimate the CES function through Monte-Carlo analysis, concluding in favor of the system of equations. However, Luoma and Luoto (2011) have criticized the use of Feasible Generalized Nonlinear Least Squares (FGNLS) to estimate the system of equations, given that it is not consistent when the errors of the equations are correlated; they instead propose a Bayesian full information method.

Although Sturgill (2012) shows that the estimation of production functions with only capital and labor can be problematic,[9] difficulties with Spanish regional data prevent us from using more than two factors of production in our empirical work. In any case, we follow Duffy and Papageorgiou (2000) in considering labor data, both raw and adjusted for human capital, given their relevance for economic growth (Romer 1986). Like Tallman and Wang (1994), we define the human capital stock as follows:

$$H_{it} = E_{it}^{\varnothing}$$

where E_t is the average years of schooling of the labor force, and $\varnothing > 0$ a parameter capturing the returns to education. So, we define labor adjusted by human capital (HL_{it}) as

$$HL_{it} = H_{it}xL_{it} = E_{it}^{\varnothing}L_{it} \tag{8}$$

Given that the estimation of $\varnothing$ has proven to be very problematic, especially with nonlinear regression, we follow Lucas (1988), Rebelo (1991) and Duffy and Papageorgiou (2000) in setting $\varnothing$ equal to one. We will use both L_{it} and HL_{it} in estimating the CES production function[10].

Evidently, normalization requires the researcher to choose the *appropriate* values for the baseline point. Klump *et al*. (2007) suggest using available data and calculating them through sample averages. However, except with the log

9 In this respect, Sturgill (2012) found that non-reproducible factors of production shares decrease with the stage of economic development in contrast to those of reproducible factors.

10 We consider that raw labor data and labor data adjusted by human capital enter the CES function in the same way. Also Gumbau and Maudos (2006) consider the effect of human capital on the production function.

linear CES function, there is no reason why the sample should exactly coincide with the implicit fixed point of the empirical function. Therefore, following these authors, we introduce an additional parameter ζ, so that $Y_{i0} = \zeta \overline{Y}_i$, $K_{i0} = \overline{K}_i$, $L_{i0} = \overline{L}_i$, $\pi_{i0} = \overline{\pi}_i$, $t_0 = \overline{t}$, where the bar refers to sample averages.[11] Klump *et al*. (2007) use geometric averages to determine the baseline point values for the output and inputs, and arithmetic averages for those of capital income share and time.

The literature on normalized CES functions has paid special attention to the distribution parameter, π_{it}, although unlike with the Cobb-Douglas function, it does not have to be equal to the capital income share; in fact, it is only required that $\pi_{it} \in [0,1]$. As Klump *et al*. (2007) point out, it can be directly calculated from data when fixing the baseline point values, or, alternatively, it can be estimated jointly with other parameters. They suggest using their estimate as a criterion for judging how reasonable the results are. At any rate, there is no universally agreed approach: while Klump *et al*. (2007) estimate it, León-Ledesma *et al*. (2010 and 2015) do not.[12]

3. The Data and the Point of Normalization

In this paper, I perform a nonlinear estimation of the CES production function using different methods. First, it is estimated the non-normalized CES function, in levels and in logs, following the Kmenta approach. Next, it is estimated their normalized version, comparing their results with those previously obtained for the non-normalized one. Finally, I compare all these results with those obtained by estimating the system of equations (5) to (7) using both nonlinear feasible least squares (FGNLS or NLSUR) and the nonlinear generalized method of moments (NLGMM), robust to correlated errors.

Our regional data merge two Spanish statistical sources. I have taken the GDP in constant 2010 euros, the employment and workforce data from RegData, the Fundación de Estudios de Economía Aplicada (FEDEA) database, and the productive capital stock in constant 2010 euros from the Instituto Valenciano de Investigaciones Económicas (IVIE) database.[13] Although RegData covers the period from 1955 to 2016, IVIE's capital series are only available from 1964 to 2013. All other variables used, such as labor income share, have been taken from the RegData database.[14]

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[11] ζ deviates from one when sample averages are different from the respective baseline point values.

[12] Klump *et al.* (2007) obtained an estimate for the US economy slightly above 0.2, while León-Ledesma *et al.* (2010) fixed it at 0.4. León-Ledesma *et al.* (2015) point out that setting a different value does not affect the results.

[13] The RegData database can be downloaded from http://encifras.fedea.net/, and the capital data from https://www.ivie.es/es_ES/bases-de-datos/capitalizacion-y-crecimiento/el-stock-y-los-servicios-de-capital/.

[14] I have excluded from the analysis the autonomous cities of Ceuta and Melilla.

There is no consensus in the literature on the most suitable measure of labor for estimating production functions: both the workforce and the aggregated worked hours are used. In line with Duffy and Papageorgiou (2000), and as Gumbau and Maudos (2006), I use the workforce. I have also used the value added of production to measure output, though we have confirmed that using GDP does not change the results.

As Krueger (1999) and Gollin (2002) point out, it is difficult to disentangle labor income from capital income in available self-employed income data. Nevertheless, the RegData database provides an estimate of aggregate labor income including labor income of self-employed workers. I note that it provides a very reasonable average total labor income share of 0.66 (0.59 in 2015) for the period 1955-2015.

In this paper, I follow Klump *et al*. (2007) in normalizing the CES production function, taking both the arithmetic and geometric averages of variables as baseline point values. Basically, these values could be determined by any reasonable criterion. In fact, Mallick (2012) and Villacorta (2017) use the initial values of the sample, and Kilponen and Viren (2010) use both, sample country averages and panel averages as baseline values. Nevertheless, given that some variables increase substantially over our long sample period, I have taken 1974 onwards as the reference period to calculate the averages.[15] Although the data has a panel structure, the normalization circumvents the need to demean or difference the series to eliminate regional fixed effects, a very complex task with the nonlinear CES function.[16]

The available empirical evidence for Spain has not produced a consensus on the value of the elasticity of substitution. Many of the first attempts at estimation have been within multi-country studies: the estimates obtained by Duffy and Papageorgiou (2000) and by Villacorta (2017) were above one, whereas Mallick (2012) estimated a value below one. Raurich *et al*. (2012), following Antràs (2004), obtained an estimate above one with time series data, while Doraszelski and Jaumandreu (2018) reported estimates of around 0.5 using industrial data.

4. Empirical Results

In Table 1 are presented the results of the nonlinear estimation of the CES production function, in levels and in logs, assuming Hicks-neutral technical progress. Cols. (1) to (4) present the results of estimating the non-normalized function, while cols. (5) to (10) present those of estimating the normalized one. At the bottom of every Table the results of the ADF test of the residuals are shown. I also estimate the model both with and without constant returns to scale, i.e., imposing $\nu = 1$ or estimating it. As can be seen, the results show a very good econometric fit, measured by the $\overline{R}^2$, while the estimated elasticity

[15] I have checked that the results are robust to this decision.

[16] To the best of my knowledge, only Duffy and Papageorgiou (2000) have attempted this task, with mixed results.

of substitution is always well below one. This result does not change with the returns to scale assumption, given that ν is estimated very close to one. For the non-normalized function (cols. (1) to (4)), the estimate for π is very low, 0.2 at most. The estimated rate of technical progress, λ, is extremely low, especially for the model in levels, for which it is not statistically significant.[17] Given that this model provides a similar estimate for the elasticity of substitution and a more reliable one for the distribution parameter, while at the same time avoiding the approximation bias, I use it to estimate the CES function for the rest of the paper.

TABLE 1
NONLINEAR SINGLE EQUATION ESTIMATES

					Normalized					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	($\nu = 1$)		($\nu = 1$)		($\nu = 1$)		($\nu = 1$)		($\nu = 1$)	
	Lev.	Lev.	Log.	Log.	Lev.	Lev.	Lev.	Lev.	Lev.	Lev.
C	0.451	0.370	0.293	0.279						
	0.131	0.098	0.063	0.065						
ζ					1.024	1.156	1.024	1.155	1.011	1.127
					0.018	0.057	0.019	0.056	0.005	0.055
π	0.101	0.204	0.032	0.045	0.428	0.432	0.424	0.427		
	0.148	0.147	0.069	0.084	0.143	0.126	0.157	0.139		
ρ	2.895	2.092	3.408	3.135	2.814	2.911	3.168	3.273	3.083	3.198
	0.946	0.291	1.686	1.472	0.447	0.376	0.465	0.416	0.246	0.269
λ	0.002	–0.001	0.009	0.008	–0.001	0.001			0.001	0.001
	0.005	0.003	0.003	0.004	0.002	0.002			0.001	0.001
$\lambda_{64\text{-}73}$							–0.002	–0.001		
							0.003	0.003		
$\lambda_{74\text{-}13}$							–0.001	0.001		
							0.002	0.002		
ν		1.085		1.025		0.972		0.972		0.975
		0.023		0.034		0.011		0.011		0.010
σ	0.257	0.323	0.227	0.242	0.262	0.256	0.240	0.234	0.245	0.238
N obs.	850	850	850	850	850	850	850	850	850	850
$\overline{R}^2$	0.980	0.982	0.972	0.973	0.997	0.997	0.997	0.997	0.997	0.997
ADF	0.001	0.000	0.000	0.000	0.008	0.004	0.001	0.001	0.009	0.006

Note: The Tables report the estimated parameters and, below, the standard errors. We also report the p-value of the ADF test for the residuals.

[17] The estimate obtained by Duffy and Papageorgiou (2000) for the log-linearized no normalized CES was always negative and statistically significant, what they attributed to the 70s' productivity slowdown.

In Table 1 I also compare the results of the estimation of the normalized CES function in levels when π is left free (cols. (5) to (8)) or is taken from the data (cols. (9) and (10)). As can be seen, the results are very similar in both cases. On the one hand, the parameter ζ, measuring the adjustment of normalization, is close to one, but worsens when ν is left free; on the other, the results improve when π is taken directly from the data.[18] The elasticity of substitution is now estimated at slightly above 0.2, very near to the estimate with the non-normalized equation. I note that these values are very close to the estimate of 0.127 reported by Mallick (2012) using Spanish time series. Given that the estimate for λ is not statistically significant, I follow Duffy and Papageorgiou (2000) in estimating the model with two different rates of technical progress, before and after 1973 (cols. (7) and (8)), in an attempt to identify a hypothetical structural change. As can be seen, the estimates are similar both in value and in statistical significance, and also similar to the estimate for the entire period. The only noteworthy difference is a very small reduction in the estimated elasticity of substitution. Additionally, the estimate of π is very reasonable, around 0.4, and the results do not change when I set it at their sample value (cols. (5) and (6) vs. cols. (9) and (10)), except for a slight improvement in the adjustment parameter. I thus substitute it for their sample average from here on.

Table 2 presents the results of estimating the system of equations (5) to (7), both by FGNLS or NLSUR (cols. (1), (2), (5) and (6)) and by NLGMM (cols. (3), (4), (7) and (8)). In Cols. (5) to (8) labor is adjusted by human capital.[19] As in Table 1, I compare the results when I impose ν=1 or I leave it free. They show a very reasonable goodness of fit, measured by the $\overline{R}^2$ for the FGNLS and by the Hansen test for the NLGMM, and the estimate for the elasticity of substitution remains below one. Interestingly, the FGNLS estimates obtained with raw labor data are bigger than the NLGMM ones, but the opposite is true for those obtained with labor adjusted by human capital. Considered as a whole, the results in Tables 1 and 2 support the constant returns to scale hypothesis: when it is estimated, ν is very close to one, and when imposed, the results do not change significantly. The estimates for the adjustment parameter ζ indicate a worst fit with labor adjusted by human capital. Finally, the estimate for the rate of Hicks-neutral technical change increases with the normalized CES function with the system of equations, especially within the NLGMM estimates, although, similarly to Duffy and Papageorgiou (2000), it is negative.[20]

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[18] Our estimates for ζ are bigger than those obtained by Klump *et al.* (2007), ranging from 1.00 to 1.04. However, it should be borne in mind that we estimate the model in levels, while they do it in logs.

[19] On the effect of human capital in Spanish productivity, see Serrano (1997) and Carrion-i-Silvestre and Surdeanu (2016).

[20] As I have already mentioned, changing the period for the baseline values in normalization does not affect the results. In this respect, I have check it with different periods used for computing the baseline values; additionally, I have verified that changing $\emptyset$ or considering, as Bils and Klenow (2000), $HL_{it} = e^{\emptyset(E_{it})} L_{it}$, where $\emptyset(E_{it})$ is the return to education and E_{it} are the years of schooling, does not affect the results either. In this case, following

TABLE 2
NORMALIZED NONLINEAR SYSTEM ESTIMATES

	L_{it}				HL_{it}			
	FGNLS	FGNLS	NLGMM	NLGMM	FGNLS	FGNLS	NLGMM	NLGMM
	($\nu = 1$)		($\nu = 1$)		($\nu = 1$)		($\nu = 1$)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ζ	0.995	1.033	1.095	1.100	1.081	1.173	1.146	1.138
	0.008	0.015	0.008	0.010	0.007	0.018	0.016	0.013
ρ	1.872	1.674	3.802	2.553	4.507	3.924	2.656	2.781
	0.227	0.248	0.582	0.225	0.629	0.745	0.210	0.218
λ	0.001	0.001	–0.006	–0.010	–0.009	–0.008	–0.018	–0.017
	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
ν		0.990		1.001		0.980		1.001
		0.002		0.001		0.003		0.001
σ	0.348	0.374	0.208	0.281	0.182	0.203	0.274	0.264
N obs.	850	850	850	850	850	850	850	850
$\overline{R}^2$	0.997	0.997			0.996	0.996		
Hansen			4.944	5.810			8.959	7.266
			0.976	0.971			0.941	0.967
ADF_Y	0.000	0.040	0.012	0.019	0.000	0.000	0.000	0.000
$ADF_{\pi K}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$ADF_{\pi L}$	0.000	0.000	0.043	0.000	0.000	0.001	0.000	0.004

Note: The instruments in col. (3) are:
- eq. 1: the 2nd and 3rd differences of the log of GDP and a constant.
- eq. 2: the 2nd and 3rd differences of occupied (O), real added value of output (VA), labor force (LF) and a constant.
- eq. 3: the 2nd and 4th differences of VA, the 3rd and 4th differences of LF and the 4th difference of O and a constant.

The instruments in col. (4) are the same as in col. (3), adding for eq. 1 the 2nd and 3rd differences of O.

The instruments in cols. (7) and (8) are:
- eq. 1: the 2nd to 4th differences of the log of GDP, the 2nd and 4th differences of O, the 2nd difference of the capital income share (KS) and a constant.
- eq. 2: the 2nd and 3rd differences of O, VA, LF and a constant.
- eq. 3: the 2nd and 4th differences of VA, the 3rd and 4th differences of LF, the 2nd difference of O and a constant.

In Table 3 I abandon the Hicks-neutrality assumption, allowing for different rates of factor-augmenting technical progress. It is noteworthy that the estimate of the elasticity of substitution more than doubles with respect to Table 2. In addition, the estimates for both λ are now meaningful, compared to previous results. Notably, I obtain a positive growth rate of capital-augmenting technical progress, averaging above 2% and reaching more than 6% in one case. At the

Requena (2015), I have tried values of the rate of return to education ranging from 8% to 10%. All these results are available upon request.

TABLE 3
NORMALIZED NONLINEAR SYSTEM ESTIMATES

	L_{it}				HL_{it}			
	FGNLS	FGNLS	NLGMM	NLGMM	FGNLS	FGNLS	NLGMM	NLGMM
	($\nu = 1$)		($\nu = 1$)		($\nu = 1$)		($\nu = 1$)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ζ	0.990	1.030	0.957	0.969	1.079	1.111	1.071	1.105
	0.006	0.032	0.010	0.009	0.006	0.025	0.009	0.028
ρ	0.612	0.544	0.223	0.173	1.027	0.818	0.432	0.402
	0.137	0.233	0.107	0.070	0.200	0.272	0.240	0.253
λ_K	0.027	0.031	0.048	0.056	0.016	0.020	0.052	0.061
	0.005	0.011	0.019	0.019	0.003	0.007	0.021	0.026
$\lambda_{L/HL}$	–0.008	–0.009	–0.016	–0.019	–0.017	–0.019	–0.029	–0.033
	0.002	0.005	0.008	0.008	0.001	0.003	0.008	0.011
ν		0.990		0.995		0.992		0.996
		0.006		0.004		0.004		0.006
σ	0.620	0.648	0.818	0.853	0.493	0.550	0.698	0.713
N obs.	850	850	850	850	850	850	850	850
$\overline{R}^2$	0.997	0.997			0.997	0.997		
Hansen			15.389	15.350			9.868	17.654
			0.880	0.846			0.873	0.610
ADF_Y	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000
$ADF_{\pi K}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$ADF_{\pi L}$	0.000	0.000	0.040	0.016	0.000	0.000	0.006	0.001

Note: The instruments in cols. (3) and (4) are:
- eq. 1: the 2nd to 4th lag of the log of O, the 2nd lag of VA and a constant.
- eq. 2: the 2nd to 4th differences of VA, O and KS, the 3rd and 4th differences of LF and a constant.
- eq. 3: the 2nd to 4th differences of VA, LF, KS and a constant.

The instruments in col. (7) are:
- eq. 1: 2nd to 4th lags of the log of VA, the 2nd to 5th differences of the GDP divided by LF, and the 2nd, 3rd and 5th differences of labor force adjusted by human capital (LFH).
- eq. 2: the 2nd to 4th differences of the labor income share (LS) and the 2nd lag of occupied adjusted by human capital (OH).
- eq. 3: the 2nd to 4th differences of KS, and the 2nd, 4th and 5th differences of the log of OH.

The instruments in col. (8) are:
- eq. 1: the 2nd to 4th lags of the log of VA, the 2nd to 5th differences of the GDP divided by LF, and the 2nd to 4th differences of the log of O and a constant.
- eq. 2: the 2nd to 4th differences of LS, the 2nd to 4th lags of the log of O, the 2nd to 4th differences of the KS and a constant.
- eq. 3: the 2nd to 4th differences of the KS, and the 3rd and 4th differences of the GDP divided by O.

same time, I obtain a negative growth rate of labor-augmenting technical progress, averaging below –2%, with very similar results with raw labor data and adjusted by human capital. Finally, the adjustment parameter ζ shows similar

behavior to previous Tables, increasing with labor adjusted by human capital data, and the estimate for ν is again very close to one.

For the US economy, Klump *et al*. (2007) obtained factor-augmenting technical progress rates of 0.004 and 0.015 for capital and labor, respectively, with an elasticity of substitution between 0.5 and 1. This evidence has raised some controversy. Assuming an elasticity below one, Lawrence (2015) combines labor-augmenting technical progress with the fall in the relative price of capital to explain the decline in the US labor income share, although he argues that there is a discrepancy between the increase observed in the *measured* capital-labor ratio and the fall observed in the *effective* ratio. Alternatively, Karabarbounis and Neiman (2014) consider an elasticity above one, explaining the decline in the US labor income share by the fall in the price of investment, although they assume that the rate of capital-augmenting technical progress is orthogonal to shocks.

Thus, the results indicate that the behavior of technical progress in the US differs from that in Spain. They are in line with those obtained in the multi-country panel study by Villacorta (2017), although they contradict those obtained by Doraszelski and Jaumandreu (2018) with industrial data.[21] Complicating matters, while the former study obtained an elasticity of substitution above one, the second reported a value below one. In any case, it seems very unlikely that the same reasons could explain the recent decline in the labor income share in both Spain and in the US, given the extremely different behavior of their respective labor markets. In this respect, the fall in the Spanish labor share has been more pronounced since 1975, being smaller today, as the Spanish capital-labor ratio has experienced a catch-up process with the US ratio.[22] Given the high degree of hysteresis of the Spanish unemployment rate, reaching values above 25% twice in the last 30 years,[23] Spanish labor productivity should be very high in relative terms, whereas we observe exactly the opposite, along with a relatively low total factor productivity.[24] Thus, our results can be taken as evidence supporting labor-saving innovations (Boldrin and Levine 2002; Zuleta 2008) or labor-eliminating

21 Villacorta (2017) obtains –1.1% and 1.7%, respectively, for the Spanish rates of labor- and capital-augmenting technical progress.

22 The correlation coefficient between the national aggregates of both variables with my data amounts to –0.8091, with a *p-value* of 0.0000. After detrending a linear trend, the coefficient falls to –0.0753, with a *p-value* of 0.6034, rejecting the existence of a statistically significant relationship between them. So, imposing Hicks' neutrality provides the same result as estimating the model without a trend, what explains the highest estimated elasticity when it is not imposed. I am grateful to an anonymous referee for suggesting both the calculation of these correlations and its connection to the results.

23 In fact, from 1975 to 2019, the Spanish unemployment rate shows a growing linear trend, in contrast to US unemployment rate.

24 On labor productivity in Spain and the Spanish labor market, see Hospido and Moreno-Galbis (2015) and Bande *et al.* (2019). Spain not only presents a low labor productivity in relative terms; it is also the only economy in the EMU that exhibits a counter-cyclical pattern of this variable. Jalón *et al.* (2017) shows that Spanish labor productivity shifted from a strongly procyclicality to a countercyclical pattern since 1984, coinciding with the legislative reform that introduced the temporary contracts.

technical progress (Seater, 2005; Peretto and Seater, 2013), simultaneously leading to capital deepening and the fall in the labor income share.[25, 26]

Tables 1, 2, and 3 confirm the conclusion drawn by León-Ledesma *et al*. (2010) regarding the clear advantages of normalization for estimating the CES function, especially to jointly identify the elasticity of substitution and the parameters of technical progress. They do not support labor-augmenting technical progress for Spain and, at the same time, place the Spanish elasticity of substitution clearly below one. The discrepancies with the results reported by Doraszelski and Jaumandreu (2018) could be due to the fact that those authors used data from the industrial sector only rather than the overall economy, and because they use a different measure for labor.[27]

There has been growing interest recently in the relationship between the elasticity of substitution, the efficiency of the capital accumulation process and economic growth.[28] In this regard, Duffy and Papageorgiou (2000) extract different subsamples of countries depending on the initial value of capital per worker, attempting to identify differences in the elasticity depending on the level of economic development. In addition, Mallick (2012) regresses the rate of economic growth on elasticities previously estimated, finding a strong and robust relationship.[29] In this context, I have extracted two subsamples depending on whether, in the first year of the sample, the regions are above or below the average for real capital per worker; I then use these subsamples

25 Acemoglu (2007) shows how an equilibrium technology can exist that be relatively biased toward the more abundant productive factor, in the sense that a change in technology, induced by small changes in factor supplies, increases their demand or their marginal product. Additionally, Acemoglu and Restrepo (2018, 2019) and Ray and Mookherjee (2020) analyze technologies rendering labor redundant.

26 Recently, Seater and Yenokyan (2019) develop a model with, simultaneously, factor-augmentation and factor-elimination, and they prove that factor-augmenting technical change is a misspecification when the second is present. This could explain the obtaining of a negative estimate of the rate of labor-augmenting technical change in the Spanish economy.

27 Young (2013) estimated a normalized CES production function within a system of equations for 35 US industries, finding an aggregate elasticity of substitution less than unity and also finding that technical change "appears to be net labor-augmenting" (p. 861); specifically, he obtained net labor-augmentation for a different number of industries depending on the estimation method used, 12, 18 or 29 out of 35.

28 The relationship between the elasticity of substitution and economic growth has always featured in normalization analysis; see, for example, De La Grandville (1989) and Klump and De la Grandville (2000).

29 Nevertheless, Kilponen and Viren (2010) find that the correlation between the elasticity of substitution and growth rates is virtually zero; additionally, the conclude that the "evidence on a varying elasticity of substitution is rather weak" (page 313).

to estimate the elasticity of substitution.[30, 31] In this exercise, we assume constant returns to scale. In Table 4 we present the results obtained by estimating the normalized system and using raw labor data. As can be seen, the Hicks-neutral technical change assumption provides very similar results for the two subsamples and the entire sample. The estimated elasticities of substitution for both are similar, around 0.2/0.3, and the adjustment parameter ζ is also similar. Finally, as in Tables 2 and 3, the estimated elasticity of substitution increases significantly when I allow for different rates of technical progress, especially for the high capital per worker sample. In any case, the estimated elasticities are still significantly different from one. These results seem to indicate that the model's technological assumptions condition the estimation of the elasticity of substitution. Additionally, this relationship also seems to be affected by the specific value of the capital-labor ratio, although deeper research would be needed. In this respect, Young (2013) found that the estimated elasticity varies between industrial sectors which differ in their technological and productive characteristics.

When the Hicks-neutrality assumption is abandoned, the adjustment parameter ζ decreases slightly for both subsamples. Notably, the markedly different estimated rates of technical progress for the two factors in both samples also indicates very different regional technical progress processes. The high capital per worker sample provides an estimate for the rate of capital-augmenting technical progress of around 10%, while the estimated rates for labor-augmenting technical progress are negative, at around –4/4.5%. The results for the other sample are not conclusive, given that both estimators provide different results. This could well be explained by the smaller sample size. In any case, they constitute evidence of an important degree of regional heterogeneity in Spain, both within and between the samples.[32]

In Table 5 I replicate this exercise using labor adjusted by human capital. As with the total sample, the estimated ζ increases slightly, although, not surprisingly, the estimates are less precise. The estimated elasticities are lower than those obtained using raw labor data, but the rest of the results are very similar. Again, we cannot conclusively identify a clear pattern for both samples, and the Hicks-neutrality assumption is a key determinant of the estimated value for

[30] I choose not to use initial income per worker as benchmark in order to avoid selection bias. Moreover, rather than using the average, Duffy and Papageorgiou (2000) divide their sample into four groups of equal size. Our smaller sample has prevented from extracting more than two groups.

[31] The regions below the average in 1965 were Andalusia, the Balearic Islands, Castilla-La Mancha, the Valencian Community, Extremadura, Galicia, Murcia, La Rioja and the Canary Islands. Above-average regions were Aragón, Asturias, Cantabria, Castilla-León, Catalonia, Madrid, Navarre and the Basque Country.

[32] Bande *et al*. (2019) find that labor productivity has followed a similar path in low- and high-income Spanish regions, although with a very different pattern of employment behavior in both.

TABLE 4
NORMALIZED NONLINEAR SYSTEM ESTIMATES

	L_{it}							
	High Capital per Worker Sample				Low Capital per Worker Sample			
	FGNLS	FGNLS	NLGMM	NLGMM	FGNLS	FGNLS	NLGMM	NLGMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ζ	0.993	0.983	1.091	0.955	0.991	0.959	1.112	0.984
	0.010	0.006	0.015	0.010	0.008	0.011	0.009	0.003
ρ	1.767	0.055	5.789	0.069	2.134	0.473	2.815	0.100
	0.258	0.009	0.660	0.026	0.290	0.095	0.751	0.030
λ	0.001		–0.004		0.002		–0.009	
	0.001		0.001		0.001		0.002	
λ_K		0.122		0.087		–0.052		0.075
		0.008		0.032		0.006		0.019
$\lambda_{L/HL}$		–0.054		–0.035		0.051		–0.036
		0.004		0.014		0.005		0.010
σ	0.361	0.948	0.147	0.935	0.319	0.679	0.262	0.909
N obs.	400	400	400	400	450	450	450	450
$\overline{R}^2$	0.998	0.998			0.996	0.997		
Hansen			2.393	4.626			2.258	3.917
			0.999	0.913			0.999	0.998
ADF_Y	0.032	0.000	0.023	0.000	0.002	0.000	0.001	0.001
$ADF_{\pi K}$	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.008
$ADF_{\pi L}$	0.000	0.000	0.020	0.000	0.000	0.008	0.001	0.000

Note: The instruments in cols. (3) and (7) are:
- eq. 1: the 2nd and 3rd differences of the log of real GDP and a constant.
- eq. 2: the 2nd and 3rd differences of the VA, O, LF and a constant.
- eq. 3: the 2nd and 4th differences of the VA, the 4th difference of O, the 3rd and 4th differences of LF and a constant.

The instruments in col. (4) are:
- eq. 1: the 2nd and 4th lags of the log of O, the 2nd difference of the log of VA and a constant.
- eq. 2: the 2nd difference of O, VA, the 3rd difference of LF and the 3rd and 4th differences of the log of VA.
- eq. 3: the 2nd and 4th differences of VA, the 3rd difference of LF and a constant.

The instruments in col. (8) are:
- eq. 1: the 2nd and 4th lags of VA, the 2nd and 3rd differences of K and a constant.
- eq. 2: the 2nd and 4th differences of the VA, the 3rd and 4th differences of LF, of LFH and of KS.
- eq. 3: the 2nd and 4th differences of VA, the 3rd difference of LF, K and a constant.

the elasticity. Both samples yield a similar FGNLS estimate for it, of around 0.2, and a negative and statistically significant rate of Hicks-neutral technical progress, of around –0.01. However, unlike in Table 4, the two estimates for both rates of technical progress with the low capital per worker sample are very similar, while the opposite is true for the complementary sample. In my opinion, this confirms a high degree of regional heterogeneity in the sample.

TABLE 5
NORMALIZED NONLINEAR SYSTEM ESTIMATES

	HL_{it}							
	High Capital per Worker Sample				Low Capital per Worker Sample			
	FGNLS	FGNLS	NLGMM	NLGMM	FGNLS	FGNLS	NLGMM	NLGMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ζ	1.086 0.008	1.070 0.007	1.146 0.029	1.083 0.007	1.072 0.008	1.050 0.013	1.133 0.014	1.018 0.027
ρ	5.287 0.657	0.062 0.011	2.626 0.283	0.735 0.310	4.101 0.799	0.410 0.096	3.185 0.762	0.895 0.110
λ	–0.009 0.001		–0.019 0.003		–0.008 0.001		–0.015 0.002	
λ_K		0.111 0.008		0.038 0.014		–0.058 0.007		–0.052 0.003
$\lambda_{L/HL}$		–0.063 0.004		–0.022 0.004		0.035 0.004		0.092 0.008
σ	0.159	0.942	0.276	0.576	0.196	0.709	0.239	0.528
N obs.	400	400	400	400	450	400	450	450
$\overline{R}^2$	0.997	0.998			0.995	0.997		
Hansen			7.122 0.981	9.119 0.908			4.316 0.987	4.843 0.993
ADF_Y	0.001	0.000	0.008	0.014	0.005	0.000	0.003	0.004
$ADF_{\pi K}$	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.031
$ADF_{\pi L}$	0.000	0.000	0.002	0.008	0.000	0.011	0.008	0.000

Note: The instruments in col. (3) are:
- eq. 1: the 2nd to 4th differences of the log of real GDP, the 2nd and 4th differences of O, the 2nd and 4th difference of KS and a constant.
- eq. 2: the 2nd and 3rd differences of O, of the VA, LF and a constant.
- eq. 3: the 2nd and 4th differences of VA, the 3rd and 4th differences of LF and the 4th difference of O and a constant.

The instruments in col. (4) are the same as in col. (7) of Table 3.
The instruments in col. (7) are the same as in cols. (3) and (7) of Table 4.
The instruments in col. (8) are the same as in col. (8) of Table 4.

In any case, taken together, the results of Tables 4 and 5 do not support the hypothesis of a different elasticity of substitution at the regional level depending on the initial capital per worker.[33]

[33] Duffy and Papageorgiou (2000) are not conclusive about this hypothesis. Additionally, although Mallick (2012) finds a robust relationship between the growth rate and the

5. Conclusion

The decline in the labor income share in developed countries has called into question the use of the Cobb-Douglas production function in macroeconomic analysis. In parallel, the normalization technique and the improvement in nonlinear estimation procedures have encouraged the estimation of the CES function. In this context, we have combined information from the regional database RegDat with capital data from the IVIE database to estimate a CES production function for Spain. My main aim has been to estimate the elasticity of factor substitution, which I have done through different empirical strategies (levels vs. logs; normalized vs. non-normalized; single equation vs. system of equations), and then compared the results.

According to the results, the CES function shows a good econometric fit to the regional Spanish data. We have obtained an estimate below one for the Spanish elasticity of substitution. This can be considered a relevant finding, given the current controversy on its value and the evolution of the labor income share. In addition, the results support the hypothesis of constant returns to scale for the Spanish economy.

I have also verified that the Hicks-neutrality assumption generates a downward biased estimate of the elasticity of substitution and masks the true characteristics of Spanish technical progress. Thus, by allowing for different rates of factor-augmenting technical progress, we have obtained more reasonable results and an estimate for the elasticity doubled in value, albeit remaining below one. Nevertheless, I have also obtained a negative growth rate of labor-augmenting technical progress. Additionally, the results confirm the conclusion of León-Ledesma *et al*. (2010) on the superiority of the system of equations approach to estimate the CES function, with the added advantage that it circumvents the identification problem. The results also support the hypothesis on labor-saving technical progress for the Spanish case.

Finally, following Duffy and Papageorgiou (2000), I have decomposed our regional sample into smaller subsamples depending on the value of initial capital per worker. Using these subsamples, I have been able to detect differences in the econometric fit of the CES function and in the characteristics of technical progress at the regional level, but not in the elasticity of substitution, or at least not clear differences. As such, the results do not allow to conclude in favor of a clear relationship between the level of economic development and the elasticity of substitution.

Further research should seek to verify whether the use of a different measure for labor, such as total hours worked, could affect the results. This could be relevant for the Spanish case, given the behavior of unemployment in Spain.

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elasticity of substitution, he also finds evidence indicating that it is, at the very least, highly complex: a positive elasticity is estimated for the US, above that of most of the European countries, but below that of many less developed countries, such as Chad, Lesotho, Mauritius or Paraguay, among others.

At the same time, the unusual characteristics of the Spanish labor market make it especially interesting to check if a modified CES function incorporating a mark-up would provide different results. Finally, it could be relevant also to check if spillover effects between regions are important.

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Intellectual property rights and North-South trade: Exports vs. foreign direct investment*

Derechos de propiedad intelectual y comercio Norte-Sur: exportaciones frente a inversión extranjera directa

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Abstract

This paper examines whether a Northern firm prefers to export or to engage in FDI to serve the South. If the firm engages in FDI, its technology is imitated, and a Southern firm enters the market that may sell in both markets. The Northern firm may invest to prevent product piracy in the North. The two markets may have different sizes. We find that when the cost of preventing product piracy in the North is great enough: (i) If the Southern market is large enough the Northern firm engages in FDI, allowing piracy in its home market, and the South obtains the greater welfare; (ii) If the Southern market is small enough the Northern firm exports and the government of the South imposes a strong Intellectual Property Rights protection, attracting the Northern firm and improving the welfare of both countries.

Key words: *Foreign direct investment, intellectual property rights (IPR), North-South trade, imperfect competition.*

JEL Classification: *L13, F13, O34*.

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Resumen

Este trabajo examina si una empresa del Norte prefiere exportar o realizar inversión extranjera directa (IED) para servir al Sur. Si la empresa realiza IED, su tecnología es imitada y entra en el mercado una empresa del Sur que puede vender en ambos mercados. La empresa del Norte puede invertir para evitar la piratería del producto en el Norte. Los dos mercados pueden tener tamaños diferentes. Se observa que cuando el coste de impedir la piratería del producto en el Norte es lo suficientemente grande: (i) Si el mercado del Sur es lo suficientemente grande, la empresa del Norte realiza IED, permitiendo la piratería en su mercado nacional, y el Sur obtiene el mayor bienestar; (ii) Si el mercado del Sur es lo suficientemente pequeño, la empresa del Norte exporta y el gobierno del Sur impone una fuerte protección de los derechos de propiedad intelectual, atrayendo a la empresa del Norte y mejorando el bienestar de ambos países.

Palabras clave: *Inversión extranjera directa, derechos de propiedad intelectual, comercio Norte-Sur, competencia imperfecta.*

Clasificación JEL: *L13, F13, O34*.

1. Introduction

When a firm in the North serves the market of a Southern country with a less developed Intellectual Property Rights (IPR) regime, one of the main concerns is that its products may be pirated in the South.[1] Due to local knowledge spillovers, Southern firms can more easily imitate products produced by multinationals in the South than those produced in the North (see Glass and Saggi, 2002). In consequence, multinationals might choose a safer alternative to serve the South: investing to prevent product piracy at least in their home market. Moreover, in recent years the sources of pirated products are mainly labor intensive and are highly concentrated in those major producers.[2] Countries with lax labor regulations and high local demand levels such as China and India are among the

[1] An example is provided by the case of Weining AG, a German firm that has been manufacturing machine tools for the Chinese market in its plant located in China since 1997, which claims that Chinese manufacturers are copying its machines. Similarly, Airbus has announced that it plans to build plants in China, which has set off a debate over the need to protect European aircraft construction secrets (Spiegel Online International, February 22, 2006).

[2] Data from customs seizures in OECD countries reveals that 58% of pirated and counterfeit products come from the five main sources, which are all located in Asia (OECD, 2008, pp. 101).

world's largest recipients of Foreign Direct Investment (FDI) and are also the key sources of pirated products.[3]

This paper examines the decision by a Northern firm on how to serve a market located in the South: by setting up a plant in the South (FDI) or by exporting. This market is characterized by potential piracy and little government motivation to strengthen local IPR protection.[4] To carry out this study we focus on several factors: the size of the Southern market compared to the Northern one, the difference in labor costs between the two countries, the IPR policy in the South, trade costs and the investment made by Northern firms to prevent product piracy in their domestic market.

The literature that analyzes North-South trade has considered how this trade is affected by IPR regimes assuming a strategic approach.[5] It is usually assumed that a Southern firm competes with a Northern firm in the South, which permits the Southern firm to imitate Northern technology. In this regard, Leahy and Naghavi (2010) analyze whether a Northern firm enters the Southern market by engaging in FDI or by setting up a joint venture with a local partner.[6] They assume that joint ventures permit local firms to imitate the Northern technology. They show that the joint venture is the equilibrium market structure when IPR is strong and R&D intensity is moderate. The South can gain from increased IPR protection because it encourages joint ventures. Naghavi (2007) analyzes

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3 See the 2022 Kearney Foreign Direct Investment Confidence Index, Global Business Policy Council (https://www.kearney.com/foreign-direct-investment-confidence-index).

4 There may be a big difference between approving IPR legislation and enforcing it in the South. An example is provided by the case of China: although it has implemented strong laws to protect IPR the country faces severe problems with enforcement which make it difficult for a foreign firm to protect its IPR in China (Keupp *et al*., 2010; Fink and Maskus, 2005, Chap. 12). In this regard, Grossman and Lai (2004) find that the South provides weaker patent protection than the North by assuming that both market size and innovation capacity in the North are greater than in the South. Moreover, using confidential microdata from the U.S. Census, Lin and Lincoln (2017) find that firms that hold patents are more likely to export to countries with strong IPR protection.

5 This literature has also analyzed this issue considering product cycle models. See, for example, Glass and Saggi (2002) and Yang and Maskus (2001). Markusen (2001) analyzes a related issue, focusing the analysis on moral hazard problems, assuming a multinational firm that hires a local agent in the host country who learn the technology in the first period and can start a rival firm in the second period.

6 Mattoo *et al*. (2004) also analyze this issue, but they do not consider technology spillovers. They differentiate between FDI and acquisition of existing domestic firms. Campi *et al*. (2019) find that the increase in mergers and acquisitions derived from a strengthening of IPR protection is greater in developing countries than in developed ones. Liao and Wong (2009) analyze how competition between a firm in the North and a firm in the South is affected by the North's subsidy on technology improvements and the South's IPR policy. Ghosh *et al*. (2018) show that when there is a tariff reduction between countries, the strength of IPR protection is affected by the possibility that the South may serve as an export platform to other markets for the Northern firm. Ghosh and Ishikawa (2018) analyze the case in which absorption capacity in the South affects the extent of imitation. Dong and Bárcena-Ruiz (2014) study a related issue assuming a mixed duopoly.

whether the Northern firm serves the Southern market through exports to prevent its technology from being exposed or by engaging in FDI to avoid trade costs. FDI causes a spillover of its technology to the Southern firm. The IPR regime determines the level of the spillover and thus the knowledge of technology than can be absorbed by the Southern firm. It is shown that a stringent IPR regime is always optimal for the South. Yang and Maskus (2009) consider a similar analysis assuming that a Northern firm competes with a Southern firm in both markets. The Northern firm invests in R&D and the Southern firm may imitate its technology. The Northern firm can prevent imitation by licensing its technology to the rival firm. They show that stronger IPR enhances technology transfer through licensing and reduces the Southern firm's marginal cost production, increasing its exports to the North. They show a strong IPR regime reduces welfare in the South.

In this paper we examine the factors that influence the decision of a Northern firm on whether to export or to engage in FDI to serve the South. Production costs are higher in the North since labor is only unionized there. We consider a quantity-setting duopoly in which a firm in the North competes with a potential pirate firm in the South.[7] Local investors may imitate the technology of this firm, setting up a new firm that enters the market. In the case of exporting it is not possible to imitate the Northern firm. We consider three cases: In the first case, the firm in the North exports to the South, thus preventing product piracy. In the second case the firm in the North engages in FDI but does not invest to prevent piracy. In this case the pirate firm enters the market and competes with the Northern firm in both countries. Note that both firms have to pay a trade cost when exporting products. In the third case the firm in the North engages in FDI and invests to prevent piracy in the domestic market. In this case the pirate firm can only sell its products in the South.[8] We assume initially that the Northern firm cannot prevent product piracy in the South if it engages in FDI. Later, we analyze whether the government of the South imposes a strong IPR protection.

Our study differs from the papers cited above in several important points. First, they assume that when the Northern firm produces in the South it can prevent imitation by licensing its technology, by choosing the R&D level or by refusing to enter into a joint venture with local partners. However, we assume that when the Northern firm produces in the South it cannot prevent imitation in

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7 It is well established in the literature on FDI that labor market characteristics and institutions in the host country are major determinants for multinationals' choice of location when product piracy in the host country is not considered (Mucchielli and Saucier, 1997; Leahy and Montagna, 2000; Lommerud *et al*., 2003; Dong and Bárcena-Ruiz, 2021). This also applies to the decision of a Northern firm on whether or not to engage in FDI when there is a threat of product piracy in the South.

8 We assume away the possibility of the Southern firm investing to produce in the North. Given that the Southern firm copies the products of the Northern firm the effort of this firm means that IPR policies in the North exclude this case. For example, the Northern firm may require its government to prohibit the importing or consuming of pirated products, or to enforce copyright legislation in the Northern country (Banerjee, 2006).

that market. Only if the government of the South imposes a strong IPR protection can imitation be prevented. Second, Leahy and Naghavi (2010) and Naghavi (2007) do not consider that the Southern firm may sell in the Northern market. Third, although Yang and Maskus (2009) assume that the Southern firm can sell in the Northern market, the Northern firm can prevent imitations without incurring any cost. However, to prevent the Southern firm from selling its pirated products in the North, the Northern firm usually needs to make an effort, which implies investing a certain amount of money.[9] The fact that the firm in the North often invests to protect its domestic market has been ignored. Finally, the relative size of the Southern market may be an important factor in this analysis, but it is not considered in the papers cited above.[10] This means that those papers fail to capture important aspects concerning FDI decisions with potential piracy in the South and cannot fully explain the coexistence of inward FDI and product piracy in big markets such as China and India.

We find that all three cases are possible in equilibrium. When the cost of preventing product piracy in the Northern market is low enough the Northern firm engages in FDI and invests to prevent piracy in its home market. This result does not depend on the relative sizes of the markets. In this case, the welfare of the North is never the highest. When both the cost of avoiding product piracy in the Northern market and the relative size of the Southern market are great enough, the Northern firm engages in FDI, allowing piracy in its home market. Thus, we obtain that Northern firms may allow product piracy in their domestic markets in order to gain access to large markets in the South. In this case the South obtains the greatest welfare. Finally, when the relative size of the Southern market is small enough and the cost of preventing product piracy in the Northern market is high enough, the Northern firm exports. In this case, as the foreign market is small, the Northern firm prefers to prevent product piracy in its domestic market by exporting rather than by engaging in FDI and investing to protect the domestic market. In this case, the South obtains the lowest welfare.

Next we analyze whether the government of the South prefers to strengthen the local IPR protection. To that end, we consider an alternative case in which the government of the South prohibits product piracy. We show that only when the Northern firm chooses to export does the government of the South impose a strong IPR protection, thus preventing product piracy. This policy permits the

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9 The investment includes the measures usually employed by firms to prevent piracy, such as costly holograms and packaging, watermarks and color change inks. It also includes enforcement efforts such as hiring full-time employees to work in anti-counterfeiting, efforts to identify and sue pirates, and investments in vertical integration of downstream retail stores (see, Qian, 2014; Zhang *et al*., 2012). In this regard, Klein (2020) highlights the complementary relationship between the enforcement of IPR protection by the government and the enforcement investment by the intellectual property holder by considering that a firm that holds a patent bears the cost of identifying the source of piracy.

10 It should be noted that the size of the host country's market is important for a firm's decision to establish foreign production when it does not compete with a local pirate firm (Norbäck, 2001; Belderbos *et al*. 2008).

Southern country to attract FDI while avoiding exports from the North. When the Northern firm engages in FDI (with or without piracy), the government of the South does not strengthen IPR protection. This is because the Northern firm locates a plant in the South regardless of what IPR policy is implemented in the South. This result helps to explain why some countries in the South are sometimes reluctant to strengthen their IPR protection enforcement even though an IPR regime could be used as a way of attracting inward FDI.

The rest of the paper is organized as follows: Section 2 presents the model. Section 3 compares results under the three IPR regimes to examine how the firm in the North decides to serve the South and the resulting welfare consequences. Section 4 examines the incentives of the government of the South to strengthen local IPR protection. Section 5 considers several extensions of the basic model and Section 6 concludes.

2. Model

We consider a world market that comprises two countries: the North (*N*) and the South (*S*). Firm 1, owned by investors from the North, produces in the North to serve domestic consumers. This firm wants to expand its market by selling products in a foreign market *S*. To serve the South, firm 1 has two options: to set up a plant to produce in the South (i.e. to engage in FDI) or to export products from the North. If firm 1 chooses to serve the South by engaging in FDI a pirate firm, firm 2, enters the market of country *S*; this firm is owned by investors from the South. This second firm unlawfully uses the technological know-how of firm 1 to produce the same product. In this case firm 2 may compete with firm 1 not only in the South but also in the North by exporting to the Northern country. Anticipating the entry of the pirate firm in the host country, firm 1 considers investing a fixed amount f to prevent firm 2 from selling pirated products in the North. However, if firm 1 exports products to the South it is assumed that firm 2 cannot copy its technology and thus cannot pirate the products of firm 1, which means that firm 2 does not enter the market. To simplify the analysis, we assume that products are homogenous, and that firm 2 cannot engage in FDI in the North.

Firms must incur a trade cost to export the product: the cost of delivering one unit of output from one country to the other is denoted by t, $t<1/3$.[11] Moreover, to simplify the model we assume that the cost of setting up a production facility in the South is zero when firm 1 engages in FDI, and that firm 2 incurs no cost in its illegal copying or counterfeiting.

[11] We assume that $t<1/3$ (which means that the transport cost is not high enough) to reduce the number of cases that arise in the model, thus simplifying the presentation of results. This assumption does not affect the main results of the model. Moreover, Geng and Saggi (2022) find that constraining tariffs between countries helps to facilitate the coordination of international IPR protection.

The markets are segmented and the inverse demand functions in the North and the South, respectively, are:

$$p_N = 1 - q_{N1} - q_{N2}, p_S = k - q_{S1} - q_{S2}, \tag{1}$$

where *pj* is the price of the product in country *j* and q_{ji} is the output sold by firm *i* in country *j*, *i*=1, 2; *j*=*N, S*. Parameter *k* measures the market size of the South, which may be different from that of the North. Thus *k*=1 means that the two countries have markets of the same size, while *k* >1 (*k* <1) means that the market is larger (smaller) in the South. We assume that $k > \max\{\underline{k}, t\}$, $\underline{k} = 3\sqrt{f}$, ,[12] to ensure that firm 1 produces a positive output and obtains no losses in any cases.

In both countries, labor is the only factor used in the production process, and each unit of output requires one unit of labor. Both firms have the same technology and exhibit constant returns to scale such that $q_{ji} = L_{ji}$, where L_{ji} denotes the workers hired by the plant *ji*, *j*=*N, S; i*=1, 2. We assume that only the workers in the North are unionized. Because workers are not unionized in the South, wage costs there are lower than in the North. To simplify the analysis, and with no loss of generality, we assume that the wage paid in the South is normalized to zero. In the North, unionized workers set up independent unions at plant level. We consider that firm 1 builds a new plant whether it decides to serve market *S* through exports or FDI. If firm 1 decides to exports the new plant is located in country *N*, where workers are unionized, while if it decides to engage in FDI the new plant is located in country *S*, where the wage is zero. To determine the wage set in the North we consider the monopoly-union model, which assumes that the unions set the wage while the firm chooses the employment level once the wage has been set by unions (see Booth, 1995). The utility function of the union at plant *j* in firm 1 is its wage bill:[13]

$$U_{j1}(w_j, L_{j1}) = w_j L_{j1}, j=N, S, \tag{2}$$

where w_j denotes the wage paid to the workers in the plant of firm 1 that produces the goods sold in country *j*.[14]

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[12] Specifically, we assume that $k>\underline{k}$ to assure that firm 1 obtains profits when it engages in FDI and invests to prevent piracy.

[13] The main results of the paper hold if it is consider that workers are organized in a firm union, whose objective function is $U_N = U_{N1} + U_{S1} = w_N L_{N1} + w_S L_{S1}$. This is because when firm 1 exports it is a monopolist in both markets. As there is no competition and markets are segmented, the wage paid to workers at plant *N*1 does not depend on that paid at plant *S*1 and vice versa. As a result, when firm 1 exports, the wage paid at each plant is the same regardless of whether workers are organized in plant unions or in a firm union. When firm 1 engages in FDI it has one plant located in each market so the result does not change if a firm union is considered.

[14] The main results hold if wages are decided by Nash bargaining between unions and firm 1 in the North.

Firm 1 may serve market *S* by exporting or engaging in FDI. Firm 1 builds a new plant in both cases.[15] If firm 1 exports to country *S*, firm 2's profit is zero since it cannot pirate the products of firm 1. This means that firm 1's profit is the sum of the monopoly profits in both markets:

$$\pi_1 = (1 - q_{N1} - w_N)\, q_{N1} + (k - q_{S1} - w_S - t)\, q_{S1}. \tag{3}$$

If firm 1 engages in FDI in the South it saves the wage costs of serving the Southern country but it competes with firm 2 at least in one market (depending on whether or not it invests to prevent piracy). Thus its total profit is given by:

$$\pi_1 = (1 - q_{N1} - q_{N2} - w_N)\, q_{N1} + (k - q_{S1} - q_{S2})\, q_{S1} - f. \tag{4}$$

Given that firm 2 has zero costs in regard to both production and illegal copying, when firm 1 engages in FDI firm 2's total profit if it serves the two markets is given by:

$$\pi_2 = (1 - q_{N1} - q_{N2} - t)\, q_{N2} + (k - q_{S1} - q_{S2})\, q_{S2}, \tag{5}$$

where, in expressions (4) and (5), q_{N2} and q_{S2} are positive if firm 1 does not invest to prevent product imitation (i.e. if $f = 0$). Besides, $q_{S2} > 0$ and $q_{N2} = 0$ if firm 1 invests to prevent piracy (i.e. if $f > 0$).

As usual, social welfare comprises the consumer surplus, *CS*, the producer surplus, *PS*, and the rents obtained by the workers, *U*. Specifically we assume that the welfare of country *j* is given by:

$$W_j = CS_j + PS_j + U_j, \tag{6}$$

where $CSj = (q_{j1} + q_{j2})^2/2$, $PS_j = \pi_j$ and U_j is the wage bill of the workers in country *j*; *j=N, S*. $U_S = 0$ since the wage in the South is normalized to zero and U_N is the wage bill of the workers of firm 1 who produce in country *N*, where $U_N = U_{N1} + U_{S1} = w_N L_{N1} + w_S L_{S1}$ if firm 1 exports and $U_N = U_{N1} = w_N L_{N1}$ if firm 1 engages in FDI.

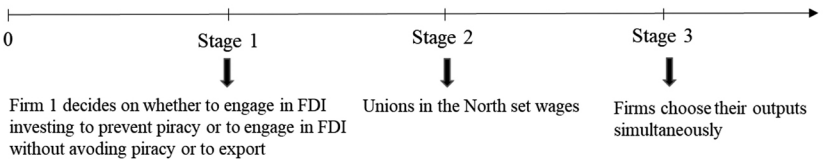
The objective of this paper is to study the factors that influence firm 1's decision on whether to engage in FDI in the South when there is a potential pirate firm located there. To that end we compare three cases: First we assume that firm 1 chooses to serve the South by exporting and thus firm 2 cannot produce (we denote this case by *E*). In the second case, firm 1 engages in FDI to serve country *S*, but does not invest to prevent piracy. Thus piracy is accommodated in

[15] As the markets are segmented we consider that products are not homogeneous and that they differ in some characteristic that adapts them to the local market. Thus, firm 1 sets up a new plant to produce the goods to export. It can be shown that the main results of the paper hold if we consider that firm 1 produces goods (which are homogeneous) for both markets in a single plant.

both countries (we denote this case by *FP*). In this case firm 2 can freely pirate the original products and the two firms compete in both countries. Finally, in the third case, firm 1 engages in FDI in the South and invests a fixed amount *f* to prevent piracy in the North (we denote this case by *F*). This investment enables firm 1 to successfully prevent firm 2 from exporting pirated products to country *N*, thereby forcing it to sell only in country *S*.

We propose a three stage game with the following timing. In the first stage, firm 1 chooses whether to engage in FDI in the South or to export there. If it decides to engage in FDI, firm 1 then decides whether or not to invest to prevent product piracy in its home market. In the second stage, unions in the North set wages. Finally, in the third stage firms simultaneously choose their outputs. The timing of the game is summarized in Table 1. We solve the game by backward induction to obtain a subgame perfect Nash Equilibrium.

TABLE 1
TIMING OF THE GAME



3. Results

Next we solve the third and second stages in the three cases considered in the model.

3.1. Firm 1 Exports (E)

When firm 1 exports products to the South, the technology or know-how is protected from exposure to firm 2 and, thus, product piracy is prevented in both markets. In the third stage firm 1 chooses quantities q_{N1} and q_{S1} to maximize its profit given by (3). Solving this stage the following is obtained:

$$q_{N1}(w_N) = \frac{1 - w_N}{2},\ q_{S1}(w_S) = \frac{k - t - w_S}{2}. \tag{7}$$

In the second stage, plant unions set wages that maximize wage bills, U_{N1}, U_{S1}, given by (2). By solving this stage we obtain the following.

Lemma 1. *When firm 1 exports to country S, in equilibrium:*

$$w_N^E = \frac{1}{2},\ w_S^E = \frac{k-t}{2},\ q_N^E = \frac{1}{4},\ q_S^E = \frac{k-t}{4},\ \pi_1^E = \pi_{N1}^E + \pi_{S1}^E = \frac{1}{16} + \frac{(k-t)^2}{16},$$

$$U_N^E = \frac{1}{8} + \frac{(k-t)^2}{8},\ CS_N^E = \frac{1}{32},\ CS_S^E = \frac{(k-t)^2}{32}, W_N^E = \frac{7+6(k-t)^2}{32}, W_S^E = \frac{(k-t)^2}{32}.$$

This Lemma shows that firm 1 sells more abroad than at home if the foreign market is large enough (i.e. if $k > 1 + t$). In that case, the plant that sells abroad pays higher wages. Country *S* obtains a greater consumer surplus if firm 1 sells more abroad than at home. Moreover, country *N* obtains greater welfare since firm 1 is owned by investors from country *N*, and the workers of this country get higher incomes.

3.2. Firm 1 Engages in FDI and does not Invest to Prevent Piracy (FP)

In this case the two firms compete in both countries since firm 2 can export the pirated products to country *N*. In the third stage firm 1 chooses q_{N1} and q_{S1} that maximize its profit given by (4) with $f = 0$, and firm 2 chooses q_{N2} and q_{S2} that maximize its profit given by (5). By solving this stage we obtain the following:

$$(8) \qquad q_{N1}(w_N) = \frac{1+t-2w_N}{3},\ q_{S1} = q_{S2} = \frac{k}{3},\ q_{N2}(w_N) = \frac{1-2t+w_N}{3}.$$

In the second stage, the union in country *N* chooses the wage that maximizes *UN*1 given by (2). By solving this stage we obtain the following.

Lemma 2. *When firm 1 engages in FDI but does not invest to prevent piracy, in equilibrium:*

$$w_N^{FP} = \frac{1+t}{4},\ q_{N1}^{FP} = \frac{1+t}{6},\ q_{S1}^{FP} = q_{S2}^{FP} = \frac{k}{3},\ q_{N2}^{FP} = \frac{5-7t}{12},$$

$$\pi_1^{FP} = \pi_{N1}^{FP} + \pi_{S1}^{FP} = \frac{(1+t)^2}{36} + \frac{k^2}{9}, \pi_2^{FP} = \pi_{N2}^{FP} + \pi_{S2}^{FP} = \frac{(5-7t)^2}{144} + \frac{k^2}{9}, U_N^{FP} = \frac{(1+t)^2}{24},$$

$$CS_N^{FP} = \frac{(7-5t)^2}{288}, CS_S^{FP} = \frac{2k^2}{9}, W_N^{FP} = \frac{69+32k^2-30t+45t^2}{288}, W_S^{FP} = \frac{48k^2+(5-7t)^2}{144}.$$

Lemma 2 shows that the two firms sell the same quantity of output in country *S* since both firms produce there with the same technology and labor costs. However, firm 2 sells more in country *N* than firm 1 since the transport cost is lower than the wage paid by firm 1 $\left(w_N^{FP} > t\right)$.

Both firms obtain the same profit in country *S*, but firm 2 makes more than firm 1 in country *N* since the advantage of lower labor costs has a greater effect

than paying a transport cost. Thus, the pirate firm obtains a greater total profit. Moreover, country *S* obtains a greater consumer surplus if $k > (7\text{-}5t)/8$ since in that case the output sold in country *S* is greater than that sold in country *N*. Finally, country *S* obtains greater welfare than country *N* if the market of country *S* is great enough (i.e. if $k > (19+110t-53t2)1/2/8$).

3.3. Firm 1 Engages in FDI and Invests to Prevent Piracy in Country N (F)

In this case firm 1 engages in FDI and invests a fixed amount *f* to prevent firm 2 from selling pirated products in country *N*, so firm 2 can only compete with firm 1 in country *S*. If firm 1 chooses to engage in FDI it makes a positive profit in country *S* since $k > 3\sqrt{f} = \underline{k}$.

In the third stage firm 1 chooses the output of the two plants, q_{N1} and q_{S1}, that maximizes its profit given by (4) and firm 2 chooses the output sold in country *S*, q_{S2}, that maximizes (5), with $f > 0$ and $q_{N2} = 0$. By solving this stage we obtain the following:

$$q_{N1}(w_N) = \frac{1 - w_N}{2},\ q_{S1} = q_{S2} = \frac{k}{3},\ q_{N2} = 0. \tag{9}$$

In the second stage, the union in the plant serving country *N* sets the wage that maximizes its wage bill *UN*1 given by (2). Solving this stage the following result is obtained.

Lemma 3. *When firm 1 engages in FDI and invests to prevent firm 2 from exporting pirated products to country N, in equilibrium:*

$$w_N^F = \frac{1}{2},\ q_{N1}^F = \frac{1}{4},\ q_{S1}^F = q_{S2}^F = \frac{k}{3},\ q_{N2}^F = 0,\ \pi_1^F = \pi_{N1}^F + \pi_{S1}^F - f = \frac{1}{16} + \frac{k^2}{9} - f,$$

$$\pi_2^F = \pi_{S2}^F = \frac{k^2}{9}, U_N^F = \frac{1}{8},\ CS_N^F = \frac{1}{32}, CS_S^F = \frac{2k^2}{9},\ W_N^F = \frac{63 + 32k^2}{288} - f, W_S^F = \frac{k^2}{3}.$$

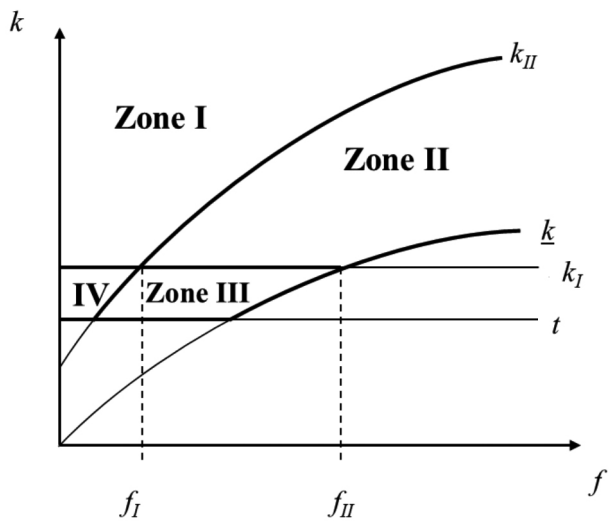
As both firms obtain the same profit in country *S*, it is obtained that $\pi_1^F > \pi_2^F$ if $f < 1/16$; i.e. if the amount invested to prevent piracy is lower than the profit obtained in country *N*. The consumer surplus is greater in country *S* than in country *N* if its market is big enough (i.e. if $k > 3/8$). Welfare is greater in country *N* if *f* is low enough and the market in *S* is small enough ($W_N^F > W_S^F$ if $288f + 64k^2 < 63$); otherwise welfare is greater in country *S*.

Once the third and the second stages of the game are solved, it remains to analyze the first stage of the game.

3.4. FDI vs. Exports

Before solving the first stage of the game we analyze whether firm 1 prefers to export or to engage in FDI (with or without piracy). To that end we use the results obtained in Lemmas 1 to 3. Let k_I denote the value of parameter k such that $\pi_1^{FP} = \pi_1^E$, where $\pi_1^{FP} > \pi_1^E$ if $k > k_I$. Therefore, if $k > k_I$ firm 1 prefers to engage in FDI and allow piracy, while if $k < k_I$ it prefers to export. Let k_{II} denote the value of parameter k such that $\pi_1^F = \pi_1^E$, , where $\pi_1^F > \pi_1^E$ if $k > k_{II}$. Therefore, if $k > k_{II}$ firm 1 prefers to engage in FDI and prevent piracy, while if $k < k_{II}$ it prefers to export. Comparing k_{II} with k_I we obtain that $k_{II} = k_I$ if $f = f_I$. Moreover, $k_{II} > k$ and $k_I = k$ if $f = f_{II}$, where $f_I < f_{II}$. The values of k_I, k_{II}, f_I and f_{II} are relegated to the Appendix and are shown in Figure 1.

FIGURE 1
ILLUSTRATION OF PROPOSITION 1 FOR A GIVEN VALUE OF T



Next we define the following zones: Zone I comprises the value of the parameters such that $k \geq \max\{k_I, k_{II}\}$; Zone II comprises the value of the parameters such that $k_{II} > k \geq \max\{k_I, \underline{k}\}$; Zone III comprises the value of the parameters such that $\min\{k_I, k_{II}\} > k \geq \max\{t, \underline{k}\}$; finally, Zone IV comprises the value of the parameters such that $k_I > k \geq \max\{t, k_{II}\}$.

We consider a given value of t to represent Figure 1. As t varies k_I and k_{II} vary, so the sizes of the zones change. If t increases k_I decreases, so the zone in which firm 1 prefers to export rather than to engage in FDI and allow piracy becomes smaller. Moreover, k_{II} decreases (grows) with t if $f > t^2/9$ ($f < t^2/9$).

Thus, if $f > t^2/9$ the area in which firm 1 prefers to exports rather than to engage in FDI and forbid piracy decreases as t increases; if $f < t^2/9$ the opposite is true as t increases.

Proposition 1. *In equilibrium*:

(i) *in Zone I firm* 1 *engages in FDI under both piracy and non piracy;*
(ii) *in Zone II firm* 1 *engages in FDI under piracy and exports under non piracy*;
(iii) *in Zone III firm* 1 e*xports under both piracy and non piracy*;
(iv) *in Zone IV firm* 1 *exports under piracy and engages in FDI under non piracy*.

Proposition 1 is illustrated in Figure 1. The proof is in the Appendix. Compared with the export case, engaging in FDI means that firm 1 has lower labor costs and saves the costs of delivering the goods to country *S*. However, under FDI if firm 1 wants to prevent piracy in the domestic market it has to invest the amount *f*. Moreover, if firm 1 engages in FDI it confronts firm 2 in at least one market: the firms compete in the two markets if no investment to prevent piracy is made, while firm 1 competes with firm 2 only in market *S* if it invests to prevent piracy. Finally, if firm 1 exports it is a monopolist in the two markets.

When firm 1 engages in FDI under piracy, the two firms compete in both markets. In this case firm 1 gains more in the domestic market when it exports $\left(\pi_{N1}^{E} > \pi_{N1}^{FP}\right)$ since it is better to be a monopolist in the domestic market than to compete with firm 2 there with its higher production cost.[16] Moreover, firm 1 gains less in the foreign market in the export case $\left(\pi_{S1}^{E} < \pi_{S1}^{FP}\right)$ because even though duopoly competition is entailed in the foreign market under FDI, the costs saved (and thus the increase in profit) outweigh the loss in the monopolistic profit in the export case. Thus, when firm 1 engages in FDI rather than exporting, it loses (gains) profits in the domestic market (foreign market). Given that the profit obtained in the foreign market depends on the size of that market, when the market in country *S* is large enough ($k > k_I$) the increase in profit in that country outweighs the decrease in profit in country *N* and firm 1 prefers to engage in FDI. When the market in country *S* is small enough ($k < k_I$) the opposite result holds and firm 1 prefers to export.

When firm 1 engages in FDI and invests to prevent piracy, the two firms compete only in market *S*. In that case, in plant *N*1 firm 1 obtains the same profit as in the export case since piracy is prevented there $\left(\pi_{N1}^{E} = \pi_{N1}^{F}\right)$. In plant *S*1, firm 1 makes more profit (net of *f*) in the FDI case $\left(\pi_{S1}^{E} < \pi_{S1}^{F}\right)$ for the same reason as in the case of FDI without piracy. However, to prevent piracy firm 1 has to pay a fixed amount *f*. Moreover, the profit obtained in the foreign market increases with the size of that market. Therefore, when the market in country *S* is large enough ($k > k_{II}$) the increase in the profit in that country outweighs

[16] Note that when competing with firm 2 under FDI the wage paid by firm 1 is lower than in the export case, but it is greater than the transport cost of its rival ($w^E > w^{FP} > t$).

the investment to prevent piracy and firm 1 prefers to engage in FDI. When the market in country *S* is small enough ($k < k_{II}$) the opposite result holds and firm 1 prefers to export.[17]

Parameter k_{II} is lower than k_I unless the fixed cost *f* is high enough ($f > f_I$) since k_I does not depend on *f* whereas k_{II} increases with *f*. As a result, $k_{II} > k_I$ for a high enough parameter *f*.

Therefore, in Zone I firm 1 engages in FDI in both FDI cases (i.e. under piracy and non piracy) because the size of the foreign market, *k*, is large enough ($k \geq \max\{k_I, k_{II}\}$). In Zone III firm 1 exports since *k* is small enough in both FDI cases ($k < \min\{k_I, k_{II}\}$). In Zone II, the market in country *S* is only large enough under piracy (since *k* is larger than k_I but smaller than k_{II}). Therefore, firm 1 exports under non piracy and engages in FDI under piracy. That is, in this zone FDI appears only when firm 1 does not fight piracy. Finally, in Zone IV, the market in country *S* is only large enough under non piracy (since *k* is larger than k_{II} but smaller than k_I). Therefore, firm 1 exports under piracy and engages in FDI under non piracy. Thus, FDI appears when piracy is prevented in the domestic market.

3.5. Firm 1's Decision on Whether to Engage in FDI or to Export

In the first stage, firm 1 decides whether or not to engage in FDI and whether or not to invest to prevent piracy if it engages in FDI. From Lemmas 1 to 3 and Proposition 1 the following result is obtained.

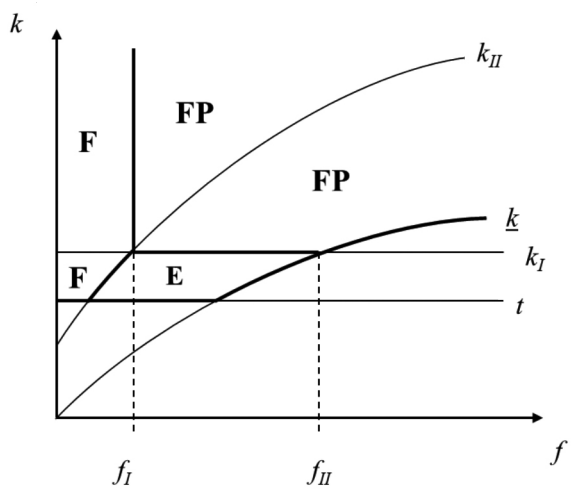
Proposition 2. *In equilibrium:*

i) If $f \leq f_I$ *and* $k \geq \max\{t, k_{II}\}$*, firm 1 engages in FDI and invests to prevent piracy;*
ii) If $f > f_I$ *and* $k \geq \max\{k_I, k\}$*, firm 1 engages in FDI and allows piracy;*
iii) For the remaining values of the parameters firm 1 exports.

Proposition 2 is illustrated in Figure 2. The proof is in the Appendix. The results are obtained by comparing the profit obtained by firm 1, in the different cases, within each zone. In Figure 2, *F* denotes the area in which, in equilibrium, firm 1 engages in FDI and allows piracy; *FP* denotes the area in which, in equilibrium, firm 1 engages in FDI and invests to avoid piracy; and, finally, *E* denotes the area in which, in equilibrium, firm 1 exports.

[17] Note that as the cost of the investment to prevent piracy increases, firm 1 needs to serve a larger market to obtain more profits that can offset that investment. This implies that k_{II} increases with *f*.

FIGURE 2
ILLUSTRATION OF PROPOSITION 2 FOR A GIVEN VALUE OF *T*



As in Figure 1, k_I and k_{II} vary with t. The variations of k_I and k_{II} with t are the same as in Figure 1, which affects the size of the different areas. If t increases f_I decreases, so the area in which firm 1 chooses to engage in FDI forbidding (allowing) piracy becomes smaller (greater).

As in Proposition 1, in Zone III firm 1 prefers to export rather than to engage in FDI. In Zone I firm 1 engages in FDI rather than exporting. In this case, if firm 1 chooses to engage in FDI with piracy (without piracy) it competes with firm 2 in both markets (only in market *S*). By comparing the profit obtained by firm 1 in the two FDI cases, we obtain that firm 1 obtains the same profit in market S $\left(\pi_{S1}^{FP} = \pi_{S1}^{F}\right)$ and a higher profit in market N by investing to prevent piracy $\left(\pi_{N1}^{F} > \pi_{N1}^{FP}\right)$.. Considering the amount f spent to prevent piracy, we obtain that when the fixed cost f is low enough ($f < f_I$) firm 1 invests to prevent piracy, otherwise ($f > f_I$) it does not do so.

In Zone IV, firm 1 exports under piracy and engages in FDI under no piracy. By comparing the profits obtained by firm 1 in these two cases, we obtain that it makes the same profit in market N $\left(\pi_{N1}^{F} = \pi_{N1}^{E}\right)$ and a higher profit (net of f) when engaging in FDI in market S $\left(\pi_{S1}^{F} > \pi_{S1}^{E}\right)$. But to prevent piracy under FDI firm 1 has to spend the amount f. Given that in Zone IV market S is large enough ($k > k_{II}$) and the cost of the investment to prevent piracy is low enough ($f < f_I$), firm 1 obtains more profit by engaging in FDI and investing to prevent piracy.

Finally, in Zone II firm 1 engages in FDI under piracy and exports under non piracy. By comparing the profit obtained by firm 1 in these two cases, we obtain that in the export case the profit in market N is greater $\left(\pi_{N1}^{E} > \pi_{N1}^{FP}\right)$ and

the profit in market *S* is lower $\left(\pi_{S1}^{E} < \pi_{S1}^{FP}\right)$. In Zone II market *S* is large enough ($k > k_I$), so firm 1 obtains more profit by engaging in FDI and allowing piracy.

Next we compare the equilibrium welfares obtained by the two countries in the three cases discussed so far (*E*, *FP* and *F*). To that end we first compare the consumer surplus and the utility of workers obtained in the three cases.

Lemma 4. *In equilibrium:*

i) $CS_S^{FP} = CS_S^F > CS_S^E$ *and* $\pi_2^{FP} > \pi_2^F > \pi_2^E = 0$;

ii) $CS_N^{FP} > CS_N^F = CS_N^E$ *and* $U_N^E > U_N^F > U_N^{FP}$.

Proof: See the Appendix.

The consumer and producer surpluses in country *S* can be compared straightforwardly. Under FDI with and without piracy, the consumer surplus is the same $\left(CS_S^F = CS_S^{FP}\right)$ since the two firms sell in market *S* in both cases. However, the producer surplus is greater under piracy $\left(\pi_2^{FP} > \pi_2^F\right)$ since firm 2 can export to country *N* and it thus obtains more profit. Moreover, under FDI without piracy the two firms compete in market *S* with zero costs while in the case of exports firm 1 monopolizes with positive costs. Thus, both the producer surplus and the consumer surplus are higher in the first case $\left(CS_S^F > CS_S^E,\ \pi_2^F > \pi_2^E\right)$.

Next we compare consumer surpluses in country *N*. When firm 1 engages in FDI and prevents piracy the same consumer surplus is obtained as when it exports $\left(CS_N^F = CS_N^E\right)$ since only firm 1 sells in country *N* in both cases. However, when firm 1 engages in FDI and allows piracy the consumer surplus is greater than in the other two cases since firm 2 has access to market *N* and, thus, competition in this market is stronger.

In country *N* the utility of domestic workers is the higher (lower) when firm 1 exports (engages in FDI allowing piracy): $U_N^E > U_N^F > U_N^{FP}$.. When firm 1 exports the utility of domestic workers is greater than if firm 1 engages in FDI since in the first case the firm has two plants producing in country *N* and is a monopolist in both markets. Moreover, when firm 1 engages in FDI and prevents piracy the workers obtain the same utility (zero) in the foreign market and more utility in the domestic market than when firm 1 engages in FDI and allows piracy. The reason is that competition in market *N* is weaker by avoiding product piracy and firm 1 obtains greater profit in market *N* which allows workers to get greater wages.

Let $k_{III} = \left(54t + \sqrt{6(22 - 110t - 453t^2}\right) / 22$. From Lemma 4 and Proposition 1 the following result is obtained.

Proposition 3. *In equilibrium:*

i) S*ocial welfare in the South is the greatest when firm 1 engages in FDI and allows piracy, and the lowest when firm 1 exports* $\left(W_S^{FP} > W_S^F > W_S^E\right)$.

ii) When $k < k_{III}$ *social welfare in the North is highest if firm 1 engages in FDI and allows piracy; when* $k > k_{III}$ *social welfare in the North is highest if firm 1 exports. Social welfare in the North is never the greatest if firm 1 engages in FDI and invests to prevent piracy.*

Proof: See the Appendix.

Lemma 4 shows that $CS_S^{FP} = CS_S^F > CS_S^E$ and $\pi_2^{FP} > \pi_2^F > \pi_2^E = 0$. Thus, it is easily obtained that $W_S^{FP} > W_S^F > W_S^E$ since when firm 1 engages in FDI and allows piracy country *S* obtains the greater consumer and producer surpluses while when firm 1 exports country *S* obtains the lower consumer and producer surpluses. As a result, government *S* prefers FDI to exports. In the FDI case, this government prefers firm 1 not to invest to prevent piracy in the North.

The comparisons of welfare in country *N* are more complex. They depend on the size of the foreign market, *k*, and the transport cost, *t*. Note first that compared to the case of FDI under piracy, the case of FDI under non piracy gives the lower consumer surplus, the higher income of unions (by Lemma 4), and the higher or lower producer surplus depending on the value of *f* (by Proposition 2). In this case the effect of a lower consumer surplus on social welfare outweighs the net effect of the producer surplus and utility of workers. Social welfare in the case of FDI under non piracy is therefore lower than that in FDI under piracy. Therefore, welfare in country *N* is never at its highest if firm 1 engages in FDI and invests to prevent piracy. Next we compare the social welfare levels obtained in the other two cases.

Proposition 1 shows that π_1^{FP} is greater than π_1^E if $k > k_I$. Moreover, Lemma 4 shows that $CS_N^{FP} > CS_N^E$ and $U_N^E > U_N^{FP}$. Note that $CS_N^{FP} - CS_N^E$ does not vary with *k* since it depends only on the size of market *N*. Moreover, π_1^{FP} increases more with *k* than π_1^E. Finally, U_N^E increases with *k* while U_N^{FP} does not vary with *k* and thus $U_N^E - U_N^{FP}$ increases with *k*.

It is obtained that when $k < k_{III}$ ($k > k_{III}$) social welfare in the North is greatest if firm 1 engages in FDI and allows piracy (exports). Comparing k_{III} with k_I (see the Appendix) we obtain that $k_{III} > k_I$ if $t > 0.0940$.

We consider first that the transport cost is great enough ($t > 0.0940$). If $k < k_I$, given that parameter *k* is low enough, greater welfare is obtained under FDI with piracy allowed since the greater consumer surplus outweighs the lower utility of workers and producer surplus. If $k_I < k < k_{III}$, greater welfare is obtained under FDI allowing piracy. In this case, when firm 1 engages in FDI and allows piracy, although the consumer surplus does not vary with *k*, the greater consumer and producer surpluses outweigh the lower utility of workers. If $k > k_{III}$, since *k* is now great enough, when firm 1 exports the greater utility of workers outweighs

the lower consumer and producer surpluses and, as a result, social welfare in the North is greatest if firm 1 exports.[18]

If the transport cost is low enough ($t < 0.0940$), we obtain that if $k < k_{III}$ social welfare in the North is greatest if firm 1 engages in FDI allowing piracy; given that k is low enough, when firm 1 engages in FDI allowing piracy the greater consumer surplus outweighs the lower utility of workers and producer surplus. If $k_{III} < k < k_I$ when firm 1 exports the greater producer surplus and utility of workers outweighs the lower consumer surplus. Finally, if $k > k_I$ the greater utility of workers when firm 1 exports outweighs the lower producer and consumer surpluses.

4. Does government S want to impose strong IPR protection?

Next we analyze whether government *S* decides to prohibit piracy by legislation (or by enforcing the copyright legislation), thus preventing the pirate firm from appearing in its country, and whether this decision is in the interest of country *N*. We denote this case by superscript *P*. For this purpose we compare the welfare of the two countries in each Zone. Note that in this case if government *S* acts to prevent piracy, firm 1 does not need to invest the fixed amount *f* to prevent piracy in its domestic market when it engages in FDI.

Proposition 4. *In equilibrium, in Zone III government S prohibits piracy and firm 1 engages in FDI. Both countries obtain greater welfare in that case.*[19]

The proof is in the Appendix. When government *S* prohibits piracy, firm 1 has two options: export or engage in FDI without investing to prevent piracy. It is easy to show that firm 1 makes more profit (and thus the producer surplus is higher) than in the other three cases discussed so far. This is because in this case when serving country *S* firm 1 can save both transport cost and labor costs without confronting the pirate firm in both markets. Therefore when government

[18] Note that the difference in the union incomes plays an important role in this comparison. Under FDI the plant that remains in country *N* does not export and so U_N^{FP} does not vary with k; however, the exports and thus U_N^E increases with k. Therefore, the difference between union incomes in the two cases $\left(U_N^E - U_N^{FP}\right)$ increases with k and this effect dominates when k is great enough. This might help to explain why some firms have been encouraged to switch to exporting or back off from investing in countries with piracy problems, such as China, in past financial crises.

[19] When prohibiting piracy in the South is costless, we find that $W_S^{FP} > W_S^F > W_S^P > W_S^E$, , so the Southern government is interested in attempting to prevent piracy when firm 1 chooses to export. If preventing piracy has a fixed cost f_S we find that it is better to prevent piracy than to export if $W_S^{FP} - f_s > W_S^E$, , i.e. if $f_s < W_S^{FP} - W_S^E$ (if the cost of avoiding piracy is sufficiently small). In that case firm 1 does not export and prefers to engage in FDI. However, if f_S is sufficiently large, it does not pay to make the effort to prevent piracy.

S prohibits piracy it is a dominant strategy for firm 1 to engage in FDI without investing the amount *f*, thereby monopolizing both markets.

To compare the welfare of country *S* when its government prohibits piracy with that obtained in the other cases, first note that the producer surplus of country *S* is the same as in the export case, zero, since firm 1 is a monopoly $\left(PS_S^P = PS_S^E = 0\right)$. On the other hand the consumer surplus is higher than in the export case $\left(CS_S^P > CS_S^E\right)$ since engaging in FDI means a greater output in market *S*. It follows that welfare is higher than in the export case $\left(W_S^P > W_S^E\right)$. Moreover, the producer and consumer surpluses when government *S* prohibits piracy are smaller than under FDI without piracy $\left(PS_S^P < PS_S^F,\, CS_S^P < CS_S^F\right)$ in which firm 2 enters and the two firms compete in country *S*. Therefore, when government *S* prohibits piracy the welfare of country *S* is lower than when firm 1 engages in FDI and invests to prevent piracy in the domestic market $\left(W_S^P < W_S^F\right)$. Finally, according to Proposition 3, as $W_S^{FP} > W_S^F$ it is obtained that when government *S* prohibits piracy the welfare of country *S* is lower than when firm 1 engages in FDI and allows piracy; thus: $W_S^{FP} > W_S^F > W_S^P > W_S^E$. This implies that government *S* prohibits piracy only in Zone III, since it is only in this zone that firm 1 decides to export.

To show that the decision taken by government *S* increases welfare in country *N*, we have to compare W_N^P with W_N^E. Compared with the export case, it can be shown that in country *N* the decrease in union income $\left(U_N^P < U_N^E\right)$ is outweighed by the increase in the producer surplus $\left(PS_N^P > PS_N^E\right)$ when the South prohibits piracy. Note that the consumer surplus is the same in both cases $\left(CS_N^P = CS_N^E\right)$. Thus, welfare in country *N* is higher than in the export case $\left(W_N^P > W_N^E\right)$.

5. Extensions

In order to analyze the robustness of the results obtained in the above Sections, we now consider some extensions of the basic model. A scheme of the proof of the results shown in this section is given in the Appendix.

5.1. The cost of preventing piracy depends on the market size

The cost of preventing piracy from the potential Southern rival could depend on the size of the market to be protected. This is because the larger the market, the greater the investment needed to prevent piracy. In order to analyze this case we extend the model by considering that $p_N = a - q_{N1} - q_{N2}$ and $p_S = a\,k - q_{S1} - q_{S2}$. The cost of preventing piracy is now af, so it increases with the size of the Northern market. In Section 2 we analyze the case in which $a = 1$.We find that the results of the paper hold for values of a other than from 1. As it is now less attractive to engage in FDI and prevent piracy, the range of values of parameters such that firm 1 prefers this option to the other two becomes smaller.

5.2. Positive fixed costs of setting up a new production plant

Next we extend the model to consider that the Northern firm has a fixed cost of setting up a new production plant in the South. This cost is equal to that of market entry for the Southern firm, and is denoted as C. As this cost is fixed, the total profits of both firms in cases F and FP, shown in Lemmas 2 and 3 respectively, are reduced by C. The profit of firm 1 if it exports does not change. Thus, as C increases k_I and k_{II} are shifted upwards as the market size of the South has to be larger to offset the decrease in firm 1's profits when it engages in FDI. As a result, if C is zero there are parameter values such that firm 1 chooses to engage in FDI, both under piracy and non piracy, while if C is positive firm 1 exports for those parameter values. Therefore, the existence of a positive fixed cost for setting up a production plant which is equal for both firms encourages exporting.

5.3. FDI subsidies

In order to carry out the analysis and focus on the decision as to whether to export or to engage in FDI, some alternative policies such as FDI subsidies are left behind. If we consider that either the government of the North or the government of the South grants a fixed subsidy to firm 1 in case of FDI, the main result of the paper holds. As shown in the above section, if there is a positive fixed cost of setting up a new production plant which is equal for both firms the main result of the paper holds and a fixed subsidy only reduces that fixed cost. The existence of a fixed subsidy is an incentive for firms to engage in FDI since it is now more attractive than exporting.

Tanaka and Iwaisako (2014) analyze how IPR protection affects innovation and FDI using a North-South quality-ladder model incorporating the exogenous and costless imitation of technology and subsidy policies for both R&D and FDI. They assume that the Southern government pays each multinational firm a percentage of its profits as FDI subsidies. Considering FDI subsidies as a percentage of the multinational's profit is beyond the scope of this article and is left for future research.

5.4. Governments set an import tax

The cost of delivering one unit of output from one country to the other, t, can also be interpreted as an import tax per unit of output that firms have to pay when exporting. We extend the model to consider that governments optimally choose t (intended as an import tax) to extract part of the rents of the firms.

The decision by firms to engage in FDI is a long-term decision since it may extend over time and affect how they act in the future. In addition, the decision by governments on optimal import taxes is a short-term decision since it may change from one period to another. Therefore, in our model, firm 1 decides whether to engage in FDI or export before the optimal import tax is chosen by

governments. Solving the game taking this into account we find that the main results of the paper hold since when t is exogenous the results of the model are satisfied for all t.

5.5. The wage paid in the South is positive

We finally analyze how the results of the paper change if the wage in the South (denoted now by w) is positive rather than zero. The main results obtained in the paper hold except when w and t are sufficiently high. In the extreme case where w and t are sufficiently high (e.g., for $t = 0.2$ and $w = 0.35$) it is obtained that firm 1 always prefers to engage in FDI and allow piracy. This is because firm 2 is at a strong disadvantage when competing in the Northern market, given that w and t are sufficiently high. In addition, half of the sales in the South are accounted for by each firm since both firms face the same costs. Therefore, it is not worth paying the cost of preventing piracy in the case of FDI as firm 2 gets a small share of the Northern market. Nor does it pay to export, since what is gained in the South by engaging in FDI and allowing piracy more than offsets what is lost by competition in the North.

6. Conclusion

Recently the sources of product piracy in the world have been highly concentrated in large Southern countries that are recipients of inward FDI from the North. This phenomenon cannot be fully explained by the relevant studies. Seeking to fill this gap, in this paper we examine a Northern firm's decision, with export and FDI as options, on how to serve a Southern country with potential piracy and lax local IPR protection. We also examine the Southern government's motivation to strengthen its local IPR protection.

To study whether a Northern firm prefers to export or to engage in FDI to serve the South where there is piracy, we consider a quantity-setting duopoly in which a Northern firm competes with a potential pirate firm in the South where the market size may differ from the North. We assume that production costs are lower in the South and compare the Northern firm's profits in equilibrium outcomes under its different decisions on how to serve the South.

Compared to the case where the Northern firm exports, if it engages in FDI its technology may be imitated by a Southern firm, which may compete with it in both countries. In this case the Northern firm may invest to prevent piracy in its domestic market. We find that the Northern firm engages in FDI and invests to prevent piracy in the North when the cost of that investment is low enough. When that cost is high enough, the Northern firm engages in FDI and allows piracy in its home market, provided that the Southern market is relatively large enough. Thus Northern firms may allow product piracy in their domestic markets in order to enter a large Southern market. We also show that when the cost of preventing product piracy is great enough, the Northern firm exports

to avoid potential piracy in both markets, provided that the Southern market is relatively small enough.

To analyze the Southern government's motivation to strengthen local IPR protection, we compare welfare in the Southern country when its government prohibits and allows product piracy. We show that only when the Northern firm prefers to export does the Southern government prohibit product piracy, thereby attracting inward FDI and improving welfare in both countries in comparison to the export case. The Southern government does not prohibit piracy when the Northern firm engages in FDI, because when the Northern firm chooses FDI its decision is not affected by the IPR regime in the host country. This result helps to explain why some Southern governments may be reluctant to strengthen local IPR protection enforcement even though their IPR regime could be used as a means of attracting inward FDI.

In order to analyze the robustness of the results obtained in the paper we consider some extensions of the basic model. We consider that the Northern firm has a fixed cost of setting up a new production plant in the South that is equal to that of market entry for the Southern firm, and we find that this encourages exporting. We also analyze how the results of the paper change if the wage in the South is positive. We find that the main results obtained in the paper hold except when the wage in the South and the transport cost are sufficiently high. In that case the Northern firm always prefers to engage in FDI and allow piracy. Finally, we have checked that the results of the paper hold in several cases: If the cost of preventing piracy depends on the market size, on whether the Northern firm can obtain a fixed subsidy in case of FDI, and on whether governments set an import tax.

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APPENDIX

Proof of Proposition 1

$\pi_1^{FP} - \pi_1^E = \left(7k^2 - 5 + 8t + 18kt - 5t^2\right)/144 > 0$ if $k > k_I$, and $\pi_1^F - \pi_1^E = \left(7k^2 - 144f + 18kt - 9t^2\right)/144 > 0$ if $k > k_{II}$, where $k_I = \left(\sqrt{35 - 56t + 116t^2} - 9t\right)/7$ and $k_{II} = 3\left(4\sqrt{7f + t^2} - 3t\right)/7$.

Comparing k_{II} with k_I we obtain: $k_{II} - k_I = \left(12\sqrt{7f + t^2} - \sqrt{35 - 56t + 116t^2}\right)/7 > 0$ if $f > f_I$. Besides, $k_{II} > \underline{k}$ and $k_I > \underline{k}$ if $f < f_{II}$, where $f_I = \left(5 - 8t - 4t^2\right)/144$, $f_{II} = \left(35 - 56t + 197t^2 - 18t\sqrt{35 - 56t + 116t^2}\right)/441$. Finally, $f_I - f_{II} = \left(-35 - 372t^2 + 8t\left(7 + 4\sqrt{35 - 56t + 116t^2}\right)\right)/784 < 0$ since $t < 1/3$.

Proof of Proposition 2

By comparing the results obtained within each zone in Proposition 1, we obtain the following. In Zone I, $\pi_1^{FP} - \pi_1^F = \frac{1}{144}\left(144f - 5 + 8t + 4t^2\right) < 0$ if $f < f_I$. In Zone II $\pi_1^{FP} > \pi_1^E$ since $k > k_I$. In Zone III, as shown in Proposition 1, when firm 1 exports the profit is higher than in FDI in both cases. Finally, in Zone IV, $\pi_1^F > \pi_1^E$ since $k > k_{II}$.

Proof of Lemma 4

$$CS_S^{FP} = CS_S^F = \frac{2k^2}{9} > CS_S^E = \frac{(k-t)^2}{32};\ CS_N^{FP} = \frac{(7-5t)^2}{288} > CS_N^F = CS_N^E = \frac{1}{32}.$$

Proof of Proposition 3

In country *S* we obtain: $W_S^{FP} - W_S^F = (5 - 7t)^2/144 > 0$; $W_S^F - W_S^E = \left(29k^2 + 6kt - 3t^2\right)/96 > 0$ since $k > t$. Then: $W_S^{FP} > W_S^F > W_S^E$. In country *N* we obtain: $W_N^{FP} - W_N^F = f + \left(2 - 10t + 15t^2\right)/96 > 0$ since $t < 1/3$; $W_N^{FP} - W_N^E = \left(6 - 22k^2 - 30t + 108kt - 9t^2\right)/288 > 0$ if $k < k_{III}$, where $k_{III} = \left(54t + \sqrt{6\left(22 - 110t + 453t^2\right)}\right)/22$; $W_N^E - W_N^F = f + \frac{1}{144}\left(11k^2 - 54kt + 27t^2\right)$, this expression is positive if $k > k_{III}$. It can easily be shown that $k_{III} > k_I$ if $t > 0.0940$.

Proof of Proposition 4

When firm 1 engages in FDI and there is no piracy in either markets, in the third stage firm 1 chooses q_{N1} and q_{S1} to maximize its profit given by $\pi_1 = (1-q_{N1}-w_N)q_{N1} + (k-q_{S1})q_{S1}$. Solving this we obtain: $q_{N1}(w_N) = L_N(w_N) = \frac{1-w_N}{2}$, $q_{S1} = L_S = \frac{k}{2}$. In the second stage, the union sets the wage that maximizes the wage bill. By solving this stage we obtain the equilibrium wage. The following result is thus obtained: $w_N^P = \frac{1}{2},\ q_N^P = \frac{1}{4},\ q_S^P = \frac{k}{2},\ \pi_1^P = \pi_{N1}^P + \pi_{S1}^P = \frac{1}{16} + \frac{k^2}{4},$ $U_N^P = \frac{1}{8},\ CS_N^P = \frac{1}{32},\ \ CS_S^P = \frac{k^2}{8},\ W_N^P = \frac{7+8k^2}{32},\ W_S^P = \frac{k^2}{8}.$

It is easy to verify that $\pi_1^P > \pi_1^E$. By comparing the equilibrium welfare in the different cases, we obtain for country *S* that: $W_S^F - W_S^P = 5k^2/24 > 0;$ $W_S^P - W_S^E = (3k-t)(k+t)/32 > 0;$ so: $W_S^{FP} > W_S^F > W_S^P > W_S^E$. This means that welfare in country *S* is greater if government *S* prohibits piracy (and firm 1 engages in FDI) than if firm 1 exports. As a result, government *S* prohibits piracy in Zone III. In country *N* we obtain $W_N^P - W_N^E = \left(k^2 + 6kt - 3t^2\right)/16 = \left(k^2 + 3t(2k-t)\right)/16 > 0.$ Therefore, country *N* obtains greater welfare in Zone III if government *S* prohibits piracy.

Extensions of the basic model

The cost of preventing piracy depends on the market size

If the cost of preventing piracy increases with market size, k_{II} turns upward since it is now less attractive to engage in FDI avoiding piracy. However, k_I does not change since when exporting and engaging in FDI without preventing piracy firm 1 does not make the expense *af*. Figure A1 shows how the zones of Proposition 2 change when the cost of preventing piracy is *af* (in red) rather than *f* (in black). If the cost of preventing piracy increases with market size, for $k > k_I$ the zone in which firm 1 engages in FDI and invest to prevent piracy (F) becomes smaller, and the zone in which firm 1 engages in FDI and allows piracy (FP) becomes larger. This is due to the higher cost of preventing piracy. Similarly, when $k < k_I$, the zone in which firm 1 exports (E) increases, and the zone in which it engages in FDI and invests to prevent piracy becomes smaller.

Positive fixed costs of setting up a new production plant

Figure A2 shows how the zones shown in Proposition 2 change when we consider a positive fixed cost of setting up a production plant for both firms (in red). We denote this case by the subscript C. We assume that $k > \max\{\underline{k}_C, t\}$, $k_C = 3\sqrt{f+C}$, to ensure that neither firm obtains any losses in any case.

FIGURE A1

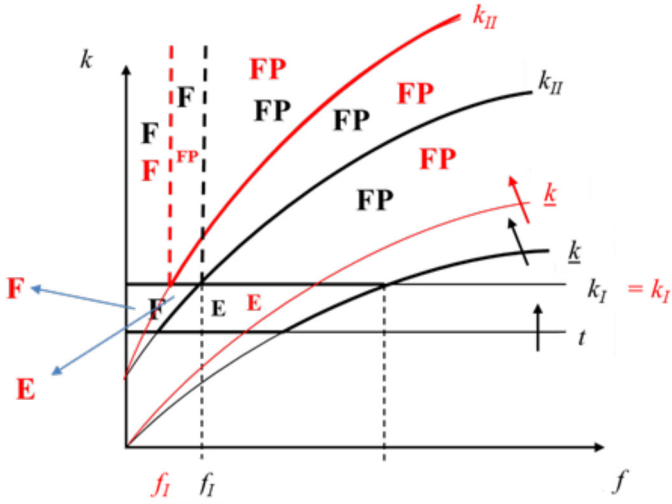
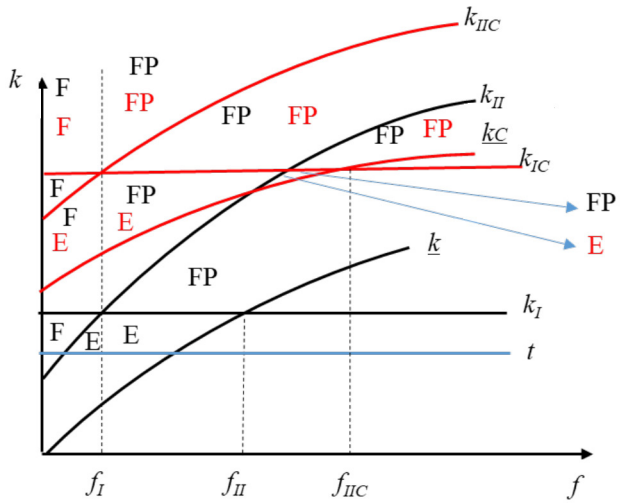


FIGURE A2

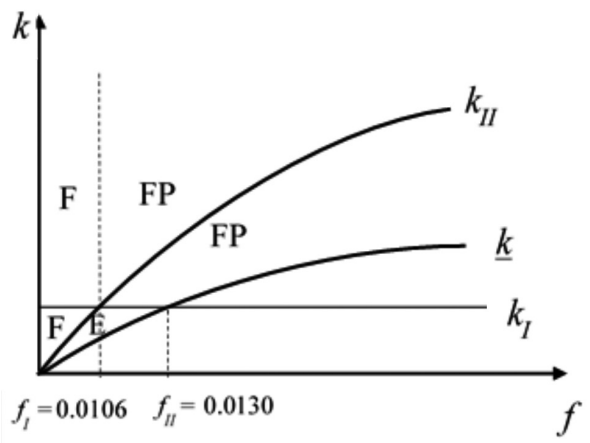


As Figure A2 shows, if *C* is zero (in black) there are parameter values such that firm 1 chooses to engage in FDI both under piracy and non piracy while if C is positive (in red) firm 1 exports for those parameter values.

Governments set an import tax

We consider a four-stage game with the following timing: In the first stage, firm 1 chooses whether to engage in FDI in the South or to export there. If firm 1 decides to engage in FDI, it then decides whether or not to prevent product piracy in its home market. In the second stage, both governments choose the import tax in case of exports. The government of country *N* chooses the import tax t_N when firm 1 engages in FDI and does not prevent product piracy since in that case firm 2 can export pirated products to country *N*. The government of country *S* chooses the import ta t_S when firm 1 exports to country *S*. In the third stage, unions in the North set wages and, finally, in the fourth stage firms simultaneously choose their outputs. On solving this four-stage game we find that the main results of the paper hold, because when *t* is exogenous the results of the model are satisfied for all *t*. The results of this four-stage game are shown in Figure A3.

FIGURE A3



The wage paid in the South is positive

When the wage in the South (denoted by *w*) is positive rather than zero the results hold, except when *w* and *t* are sufficiently high. For a sufficiently high given *t*, increasing *w* reduces the area in which firm 1 chooses to engage in FDI and invest to prevent piracy. For example, for $t = 0.2$ and $w = 0.3$ (case in red in Figure A4) the area in which firm 1 engages in FDI and invests to prevent piracy disappears. The situation when $t = 0.2$ and $w = 0$ is shown in black.

FIGURE A4

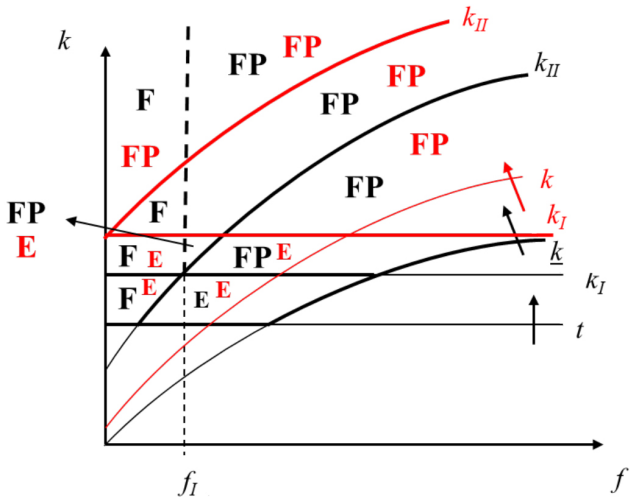


Figure A4 shows (in red) that for high k, firm 1 prefers to engage in FDI and allow piracy. For low k, exporting is preferred. The area in which firm 1 engages in FDI and invests to prevent piracy disappears. The explanation is the following: The transportation cost t only affects the firm selling in the other market. Thus, when t is low firm 1 can choose any of the three options, which is the case analyzed in the paper. When t is high and w is not high enough (e.g., for $t = 0.2$ and $w = 0.3$) firm 1 does not engage in FDI and prevent piracy. If it allows piracy it pays the cost f, but firm 2 is at a strong disadvantage in the North since w and t are high. Firm 1 continues to prefer to export for low k. It is better to be a monopolist in the North than to share a small market in the South, where costs are high.

In the extreme case where w and t are sufficiently high (e.g., for $t = 0.2$ and $w = 0.35$) it is obtained that firm 1 always prefers to engage in FDI and allow piracy. Therefore, the area in which firm 1 exports disappears.

Does college make you *progre*? Evidence from Bolivia*

¿Te hace progre *la universidad? La evidencia en Bolivia*

Antonio Saravia**

Abstract

I examine the association between college education and left-leaning views in Bolivia using novel survey data. My findings suggest that college education is associated with left-leaning social preferences (college-educated individuals favor social equality and a tax system in which not everybody must pay taxes) but right-leaning individual preferences (they favor individual liberty and respect for private property). My results fit the connotation given to terms like progre or socialista caviar commonly used in Latin America to refer to educated individuals who consider themselves progressive, or even socialist, but admit and enjoy the benefits of individual liberty and markets.

Key words: *Bolivia, education, college, public opinion, ideology.*

JEL Classification: *I23, A13, P16.*

Resumen

En este artículo examino la asociación entre educación universitaria y pensamiento de izquierda en Bolivia usando datos nuevos de una reciente encuesta. Mis resultados sugieren que la educación universitaria está asociada a preferencias de izquierda en términos sociales (los individuos con experiencia universitaria favorecen la igualdad social y un sistema impositivo en el que no todos paguen impuestos), pero está asociada a preferencias de derecha en términos individuales (los individuos con experiencia universitaria favorecen la libertad individual y el respeto por la propiedad privada). Estos resultados son consistentes con la connotación que se le da a términos como progre o

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socialista caviar comúnmente usados en América Latina para referirse a individuos educados que se consideran progresistas, o incluso socialistas, pero admiten y disfrutan de los beneficios de la libertad individual y los mercados.

Palabras clave: *Bolivia, educación, universidad, opinión pública, ideología.*

Clasificación JEL: *I23, A13, P16.*

1. Introduction

There is ample evidence suggesting that college students and graduates in the U.S. tend to be more liberal (left leaning in the ideological spectrum) than the general population. The 2019 College Pulse survey, for example, finds that almost 40% of college students have a favorable opinion of socialism while, according to the 2020 NPR/PBS News Hour/Marist survey, only 28% of the U.S. population do. Similarly, the 2018 General Social Survey reports that 50% of college students identify themselves as liberal, while only 28% of the U.S. population do.[1]

The association of college education and left-leaning views seems to have strengthen over time. According to a 2016 Pew Research Center report, the percentage of those with a college degree that were considered "consistently liberal" (based on their answers to a set of policy questions) grew from 5% in 1994 to 24% in 2015. For those with only some college experience, these numbers were 4 and 12%, respectively.[2] The number of socialist or liberal organizations spurring across campuses in the U.S. provides another metric for this trend. The organization Young Democratic Socialists of America, for example, grew from 12 chapters in 2016 to 150 in 2021 (Young Democratic Socialists of America, 2021).

Is the same true in other parts of the world? Using novel survey data, I assess whether a similar phenomenon is present in Bolivia.

The importance of assessing the effect of college on ideological leanings in developing countries reside on the strong relative importance of college graduates on public opinion. It has been largely documented that college education is strongly associated with "successful citizenship" (see, for example, Astin, 1997) and various forms of political engagement (see Nie, *et al.*, 1996, Burns, *et al*., 2001 and Hillygus, 2005). College educated individuals have an important influence, therefore, on politics and policy making decisions. Moreover, their

[1] See College Pulse (2019), NPR/PBS News Hour/Marist (2020) and Smith, *et al*. (2018).
[2] See Pew Research Center (2016).

relative influence on these arenas is likely to be higher in countries with lower rates of literacy and college attendance ratios like Bolivia.[3]

While the mechanisms behind the association of college education and left-leaning views in the U.S. may also be at work in Bolivia, there are important idiosyncratic factors that could make a difference.

First, from 2006 to 2019, Bolivia was governed by a political party (the Movement Towards Socialism or MAS) aligned with the 21st Century Socialism paradigm. Although the government did not directly suppress the functioning of the market economy, it did nationalize "strategic" companies, embraced aggressive income redistribution policies, exercised political influence over the judicial system and established public schools and universities with strong indoctrinating components. Thus, the social, economic and political environments in which students attended college in Bolivia during those years, were very different from the ones American students faced. This could have had an important effect on ideological leanings, particularly for students that attended public universities.

Second, Latin America in general, and Bolivia in particular, have a rich history of left-leaning student movements developed within public universities. Arocena and Sutz (2005) report that during the 1970s and 1980s, the student movement in Latin America "favored, on the one hand, special relations of public universities with some collective actors –trade unions and left-wing parties among others– and, on the other hand, lasting enmities with right wing political powers, as well as very weak relations with entrepreneurs". In Bolivia, the Bolivian University Federation (the main national organization of college students) was established in 1928 with a strong socialist orientation. In its 1949 Declaration of Principles, the Bolivian University Federation determined that the "social character and aspirations of the current university generations cannot be other than a socialist education in a socialist state" (see Federación Universitaria Boliviana, 1949). The 1970 University Revolution inspired by the guerrilla movements of that decade, intensified this ideological inclination.

Third, Bolivia and the U.S. are clearly different in terms of economic conditions and development levels. These differences have an impact on the quality of instruction that students receive and on the choice of social, economic and political paradigms emphasized in classrooms. Thus, universities in Bolivia may be inclined to put a stronger emphasis on issues of poverty and income inequality than their U.S. counterparts.

I assess the association of college education and left-leaning views in Bolivia using data from the 2020 CERES survey, which covered all nine Bolivian regions or departments (Laserna, 2020). The survey included 73 questions designed to elicit opinions on different social, economic and political topics, as well as demographic characteristics including years of education.

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[3] College educated individuals have been historically very important and highly visible in Latin American politics. Petersen (1970) mentions the cases of the overthrow of the regimes in Cuba (1933 and 1959), Guatemala (1944), Venezuela (1958) and Bolivia (1964).

To capture ideological views, I use four questions addressing fundamental economic, social and political paradigms. The first question asks if the respondent believes that private property must be respected, the second question asks if individual liberty is important, the third question asks if social equality is important, and the fourth question asks if everybody must pay taxes.

I use these questions as dependent variables and run ordered logit regressions where the explanatory variable is a dummy that takes the value of 1 if the respondent attended at least one year of college. I address potential endogeneity concerns using Propensity Score Marching (PSM) and the Rosenbaum's bounding approach (Rosenbaum, 2002).

My findings are mixed. On one hand, I find that attending college is robustly associated with believing that individual liberty is important. As I argue below, this result would suggest that attending college is associated with right-leaning rather than left-leaning views. On the other hand, however, I find that attending college is robustly associated with believing that social equality is important and not associated with thinking that everybody must pay taxes. As I also argue below, these last results suggest that attending college is associated with left-leaning views.

The relationship between college education and believing that private property must be respected is less robust. While the ordered logit regressions show a positive and significant relationship between these two variables (which would suggest that college education is associated with right-leaning views), the PSM results cast some doubts on this finding.

The overall pattern that emerges is one in which college-educated individuals display left-leaning social preferences (they favor social equality and a tax system in which not everybody must pay taxes), but right-leaning individual preferences (they favor individual liberty and, to some extent, respect for private property, which are variables that are likely to affect them more directly).

This interpretation of the results fits the connotation given to terms like *progre* or *socialista caviar*, commonly used in Latin America to refer to educated individuals who consider themselves progressive, or even socialist, but admit and enjoy the benefits of individual liberty and markets (see Álvarez, 2017). These terms remind us of the expression *radical chic* coined by journalist Tom Wolfe in his famous essay *Radical Chic: That Party at Lenny's*, where he described the adoption of radical political views by celebrities, socialites and affluent individuals (see Wolfe, 1970).[4]

[4] Ideological categories are certainly difficult to define. "Left" and "right" can be characterized in multiple dimensions and do respond to historical and social context. The Pew Research Center (2021), for example, uses nine different classifications in its 2021 survey of US adults that range from "Progressive Left" to "Faith and Flag Conservatives". Another common classification is that of Nolan (1971), which uses a chart with four quadrants to define liberal, libertarian, conservative and authoritarian individuals along personal and economic dimensions. According to the chart, liberals (left-wing) can be defined as those supporting low economic freedom and high personal freedom. Libertarians support high

The next section presents a brief review of the literature on the effect of college on ideological attitudes. Section 3 presents an overview of recent trends in college education in Bolivia. Section 4 presents the data. Section 5 discusses the methodology. Section 6 presents the results, and section 7 concludes.

2. Related Literature

Different mechanisms explaining the effect of college education on ideological leanings have been advanced in the literature. Bowman (2013), Strother, *et al*. (2020), and Dey (1997), for example, argue that attending college allows students to interact and socialize with individuals from diverse social and economic backgrounds, which produces peer-effects and a natural interest to further understand political and social dynamics. Campbell and Horowitz (2016) argue that colleges provide a "free space" that permits and encourages the development of political ideologies. Klatch (1999) and Polleta (2004) argue that this feature of college education has been instrumental in moving political views to the left. For their part, Astin (1997), Hanson, *et al*. (2012), and Horowitz (2007) argue that college provides an environment in which professors are very influential and can easily transmit their own ideological leanings to their students.

Not much is known about the effect of college on ideological views in Latin America. An important exception is that of Saravia and Marroquín (2021) who use the 2017 wave of the Latinobarómetro and find that attending college in Latin America is positive and significantly associated with left-leaning economic views "in general/abstract terms and as they pertain to domestic economic issues," but not when it comes to international trade issues.

Graham and Sukhtankar (2004) and Wiesehomeier and Doyle (2012) assess the effect of the number of years of education on ideological views in Latin America. Using the 2000-2002 waves of the Latinobarómetro, Graham and Sukhtankar (2004) find that the number of years of education is negatively associated with satisfaction with the market economy and support for market policies in the region, but positively associated with support for regional economic integration,

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economic and personal freedom. Conservatives support high economic freedom and low personal freedom, and authoritarians (supporters of statism) support low economic and personal freedom. In the Nolan chart, the Latin American *progre* or *socialista caviar* would be probably classified in the liberal quadrant. Notice, however, that the chart assumes that personal and economic freedom can be independent of one another. That is how liberals can be defined as supporting the former but not the latter. In reality, however, the two freedoms are intimately related. Low economic freedom, for example, imposes restrictions on individuals (e.g. attacks to private property rights), which would inevitably result in low personal freedom. This is where the interpretation of the Latin American *progre* or *socialista caviar* proposed above deviates from the chart's classification. In this paper, these terms refer to somebody that favors and enjoys the control of his property rights and individual liberty (personal freedom that includes personal economic freedom), but also voices support for low economic freedom for the rest of society.

a proxy for free international trade. Using the 2006 wave of the Latinobarómetro, Wiesehomeier and Doyle (2012) find that "education has a weak negative, but highly significant effect on left-right placement, indicating that individuals with higher education tend to identify with the left".

I contribute to this literature by assessing the effect of college education on ideological views in Bolivia using data not previously exploited.

3. Recent Trends in College Education in Bolivia

Gross enrollment in Bolivian colleges increased from 655,000 students in 2012 to 700,000 in 2016, and 771,000 in 2019. In relative terms, these numbers represented enrollment ratios of 48%, 48% and 51%, respectively (Instituto Nacional de Estadística, 2021). For comparison, the enrollment ratios for Latin America were 45%, 51% and 53%, respectively (World Bank, 2021).[5]

Importantly, the modest increase in enrollment numbers seems to have concentrated in public institutions. Indeed, the share of students enrolled in private colleges in Bolivia decreased from 34% in 2012 to 31% in 2016, and 25% in 2019 (see Instituto Nacional de Estadística, 2021). This is important because, as mentioned in the introduction, public universities in Bolivia are likely to be more influenced by the politics of the government party than private universities, and because they have a strong tradition of left-leaning student movements.[6]

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[5] The enrollment ratio in colleges is defined as gross enrollment as a percentage of the total population of the five-year age group following on secondary school leaving (World Bank, 2021).

[6] The institutional arrangement that governs public universities in Bolivia is highly conducive to political influence. First, university presidents and other executive positions are not selected through competitive recruitment processes but through elections in which professors and students have the right to vote. Thus, if a professor wants to become president, he or she needs to build a political organization and form coalitions that can guarantee him or her more votes. This is often done promising higher salaries and less rigorous evaluations to professors, and less rigorous grading criteria to students. It is also important, of course, to receive support from national political parties especially if they are in power. Political ideology and campaign promises become, therefore, more important than results-oriented programs. Second, students share the university governance with the president and professors' committees. This is the result of co-governance or *co-gobierno*, which, to my knowledge, is a feature present only in Bolivian public universities. *Co-gobierno* gives students strong political power and becoming a representative of the student body is a highly sought-after position. Episodes of corruption and unethical political maneuvers have been common since the establishment of *co-gobierno* in 1930. Students engage in political rivalry, which often leads to chaos and violence. In March of 2021, for example, at least five students died during a protest leading to a student congress in the public university of El Alto. More recently, in May of 2022, four students died in a stampede provoked by tear gas released during a student assembly in Potosí. This episode led to the discovery of corrupt organizations led by student representatives who had been playing that role for over 30 years receiving salaries and using administrative loopholes (and protection from

Moreover, contrary to the tendency in the region, there was an overall decrease in the number of colleges operating in the country. This number went from 62 in 2016 to 56 in 2019. The number of public colleges went down from 14 to 12 (a 14% decrease) and the number of private colleges went down from 48 to 44 (an 8% decrease) (Ministerio de Educación, 2016; and Webometrics, 2021).[7]

The slow increase in enrollment ratios has an effect on the demographics observed in our data. The average age of those with college experience is 36.38, whereas the average age of those without college experience is not too far ahead at 38.79. Note that that age difference is much larger for the region. Using the 2017 Latinobarómetro, Saravia and Marroquín (2021) find that the average age of those with college experience was 36.81 whereas the average age of those without college experience was 42.28.

In terms of access to higher education, despite starting at a higher level than the region, the participation of the poorest 50% of the population in Bolivia seems to have stagnated. According to Ferreyra, *et al*. (2017), approximately 28% of the students enrolled in colleges in 2000 came from the bottom half of the income distribution. This number increased to 30% by 2012 (representing only a 7% increase). For comparison, these numbers were 16% and 24% for the entire region (a 50% increase).

Unfortunately, the 2020 CERES survey does not allow us to identify whether somebody with college experience attended a public or private college, nor what major or field of study they pursued. This is certainly a limitation of the study as these factors could make a difference. Data for the U.S. suggests, for example, that fields in the humanities tend to have a stronger effect moving ideological views to the left than fields in the sciences.[8]

Finally, there may be regional effects as colleges not established in the capital or the most populated cities, where the political debate is more intense, may give less importance to the study and discussion of ideological issues. I use department dummies to capture any idiosyncratic regional effects.

executives and administrators who benefited from the alliances) to update their student registrations year after year.

7 This trend reversed a rapid increase in private colleges observed from 1995 to 2005. During this period the number of private colleges grew approximately by 53%. This positive development came to a halt after 2005, however, and the number of private colleges has remained more or less constant ever since (see Autoridad de Fiscalización y Control Social de Empresas, 2014).

8 According to the 2019 College Pulse survey, students majoring in the humanities were favorable to socialism 51% of the time. Students majoring in the sciences, on the other hand, were favorable to socialism only 38% of the time (College Pulse, 2019).

4. Data

The data is derived from the 2020 CERES survey (Laserna, 2020), which includes 2,213 interviews with individuals 18 years of age or older conducted in all nine Bolivian departments (Chuquisaca, La Paz, Cochabamba, Oruro, Potosí, Tarija, Santa Cruz, Beni and Pando).[9] The survey took place between November 27 and December 7, 2020. Approximately half of the respondents were met in person while the other half were contacted by phone. The sample represents approximately 90% of the country's population with a 3% sample error.[10]

Table 1 lists the variables considered in the study and compares means and standard deviations for those with at least one year of college experience (whether they graduated or not) and those without any college experience.

In terms of dependent variables, disagreeing with the statement "private property must be respected" or thinking that individual liberty is not important, can be considered left leaning. These opinions would suggest a preference for a collective approach to the distribution of resources rather than a laissez-faire approach in which such distribution is determined by individual and voluntary actions in the marketplace.

Thinking that social equality is important can also be considered left leaning. The most common interpretation of the term social equality in Latin America (*igualdad social*) is that of economic equality, which requires the state sponsored provision of certain "social rights" such as health services, education, housing, etc. The term suggests the need for an "equitable" distribution of income, a concept closely associated with that of "social justice" (see CEPAL, 2016 and 2018). Clearly, the term social equality goes beyond the mere idea of equality before the law.

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9 CERES is a non-profit research institute domiciled in Cochabamba, Bolivia (https://ceresbolivia.org).

10 Notice that the survey was conducted in the midst of the ongoing Covid-19 pandemic. While the specific weeks in which the survey was conducted were not characterized by a strong wave of contagion in Bolivia, the social circumstances determined by the disease and the public policies designed to combat it, may have had an influence on the responses. Some respondents may have felt more inclined to emphasize the importance of individual liberty, for example, if they were growing tired of lock-downs or mask mandates. Some others may have felt more inclined to consider social equality as important if they resented the differences in the quality of health services in public hospitals vis-à-vis private hospitals. Indeed, survey responses are always influenced by context and circumstances. Given, however, that the survey sampling followed standard protocols to make sure that the respondents were randomly chosen, there are no reasons to believe that the pandemic produced systematic individual bias. Unfortunately, the questionnaire did not include questions that could allow us to identify respondents highly affected by the pandemic (those who were sick or had close relatives that were sick or died).

TABLE 1
VARIABLES

Variable	Value	College		No College		Mean diff.
		Mean	SD	Mean	SD	
Dependent Variables						
Do you agree with the statement "private property must be respected"?						
PrivProp	1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree	3.38	0.61	3.19	0.59	***
How important is individual liberty for you?						
IndLib	1=not important at all, 2=a little bit important, 3=somewhat important, 4=very important	3.76	0.58	3.44	0.84	***
How important is social equality for you?						
SocEqual	1=not important at all, 2=a little bit important, 3=somewhat important, 4=very important	3.74	0.65	3.47	0.85	***
Do you agree with the statement "everybody must pay taxes"?						
Taxes	1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree	2.91	0.76	2.71	0.73	***
Control Variables: Demographics						
Age	18 through 75	36.38	12.48	38.79	15.33	***
Indigenous	2=indigenous, 1=any other race or ethnicity	1.57	0.49	1.67	0.46	***
Female	1=male, 2=female	1.48	0.5	1.49	0.5	
Catholic	1=Catholic, 0=any other religion or no religion	0.68	0.46	0.68	0.46	
MarStat	1=married, 0=not married	0.32	0.46	0.31	0.46	
Control Variables: Income						
In which income bracket would you place the total monthly income of your household including remittances?						
Income	0 or 16 possible income brackets ranging from greater than 0 to greater than Bs. 7,500 ($1,071)	9.11	4.66	5.37	4.17	***
Are you currently employed?						
Employed	0=not employed, 1=employed	0.59	0.49	0.54	0.49	**
Control Variables: Satisfaction, Trust and Technology						
Do you think that the economic situation in the country is better, worse or equal to the economic situation twelve months ago?						
EconPerc	1=worse, 2=equal, 3=better	1.61	0.71	1.81	0.81	***
Would you say that the people in your neighborhood or community is:						
Trust	1=not trustworthy at all, 2=a little bit trustworthy, 3=somewhat trustworthy, 4=very trustworthy	2.73	0.85	2.54	0.92	***
Do you have a WhatsApp account?						
WA	0=no, 1=yes	0.92	0.27	0.66	0.47	***
Independent Variable						
College	1=complete or incomplete college (at least 13 years of education), 0=no college experience (less than 13 years of education)	Mean	0.41↑	SD	0.49↑	

Two-tails t-test statistical significance: *<0.1, **<0.05, ***<0.01.
↑ Values for the entire sample.
N between 1,099 and 2,205.

The fourth dependent variable asks for the respondent's opinion on the statement "everybody must pay taxes". The interpretation of this question depends on what we think the respondent had in mind as the plausible alternative. If the respondent thought that the alternative was "nobody must pay taxes," then disagreeing with the proposed statement can be considered right leaning (i.e. disagreement with a collective administration of resources). If, however, the respondent thought that the alternative was "not everybody, but some, must pay taxes," then disagreeing with the original statement can be considered left leaning. This alternative would be most likely associated with thinking that only those capable of paying taxes (those earning a higher income) must do. This is consistent with a progressive tax system designed to redistribute wealth.

The last interpretation seems the most appropriate. Government, and government provided public goods, have played a primary role in Bolivia since at least the 1952 National Revolution. A paradigm with no taxes (and, therefore, no actionable government) is not something that Bolivians are likely to consider as a realistic alternative.[11]

In average, college-educated individuals are significantly more likely to think that private property must be respected and that individual liberty is important. For these two variables, therefore, in average, attending college seems to be associated with right-leaning views. When it comes to social equality and taxes, however, I get the opposite result. College-educated individuals are significantly more likely to think that social equality is important and that not everybody must pay taxes.

I use a rich set of demographic, income, satisfaction and technology control variables. The difference in means, between those that are college educated and those that are not, is statistically significant for most of them. In terms of demographics, college-educated individuals are younger and less indigenous than their non-college educated counterparts. Both groups are, however, indistinguishable when it comes to the proportion of males vs. females, Catholics vs. non-Catholics, and married vs. non-married.

In terms of income, as expected, college-educated individuals are significantly more likely to place in higher income brackets and be employed. Also,

[11] As pointed out by an anonymous referee, the opinion on the statement "everybody must pay taxes" could have also depended on the type of taxes that the respondent had in mind when answering the question, which is something that the survey did not specify. The type of tax considered could have determined whether the statement "everybody must pay taxes" implied that everybody must pay the same amount or rate, or not. For example, a low-income person may have agreed with the statement if he thought that the question referred to a progressive income tax. Of course, a high-income person may have disagreed with the statement for the same reason. The responses could flip, however, if the tax considered was a tax on sales. While this is a valid concern at the margin, it is more likely that the respondents thought of the statement as referring to the general idea of taxes, rather than to a specific type. Most people understand taxes as a general concept but only a small number of respondents would have been able to consider specific types and effects when considering the question.

college-educated individuals are significantly more pessimistic about the economic situation in the country, significantly more likely to think that people in their neighborhood or community are trustworthy, and significantly more likely to have a WhatsApp account (a proxy for access to the internet and technology).

Finally, notice that, according to the survey, 41% of the respondents had at least one year of college education. This ratio is twice the corresponding value in 2010. According to the Barro-Lee database, the percentage of the population 15 years old or older with tertiary education in Bolivia in 2010 (whether they completed it or not) was 21%. That was the second highest percentage among Latin American countries (Panama was first with 22%). That year, the average for Latin America was 11% and the percentage for the U.S. was 54% (see Barro and Lee, 2013).

5. Methodology

I first run ordered logit regressions and assess the association of college education with each of the four dependent variables using odds-ratios.

The obvious empirical challenge is endogeneity. Underlying factors could prompt a person to attend college and also develop certain attitudes toward private property, individual liberty, social equality and taxes. Given that the data don't provide a natural experiment that can be used to address the identification problem, I partially address this challenge using PSM. This procedure allows us to compare responses to the four dependent variables by respondents who are similar across observable characteristics except for whether they attended college or not. Essentially, therefore, the treatment *attending college* becomes equivalent to a random event at the individual level considering observable characteristics.[12]

PSM controls for potential endogenous effects produced by observable characteristics but not for those of unobservable ones. Thus, the results could still be affected by hidden bias. I use a sensitivity analysis known as Rosenbaum's bounding approach (Rosenbaum, 2002) to estimate how big a potential hidden bias should be in order to cast doubts on the robustness of the PSM results.

The data derived from the survey provides only one observation point per respondent. Unfortunately, therefore, I am not able to follow respondents over time and observe their ideological inclinations (as well as other personal characteristics) before and after attending college. It would be useful, for example, to compare what a respondent thought right before entering college and then immediately after their college experience. An imperfect substitute to that analysis consists on limiting the aforementioned regressions to include only respondents between the ages of 18 (the youngest in the survey) and 25. While the bias produced

[12] For more details on PSM see, for example, Caliendo and Kopeining (2005), and Heinrich *et al*. (2010).

by unobservable factors would not disappear, such bias is likely to be smaller. First, the effect of college education on ideological inclinations is likely to be stronger on young respondents given how recent the college experience was. Second, young respondents are less likely to have been exposed to other life cycle factors that may confound the effect of college experience. For example, they would have little work experience and most of them would still be single (in fact, only 9 respondents below the age of 25 indicated that they were married). I present the results of this analysis in the Appendix.

Another common method to deal with endogenous effects is the use of instrumental variables. In this case, the goal would be to find a variable (the instrument) highly correlated with attending college, but not correlated with ideological views as captured by the dependent variables. This method is meant to remove endogenous effects as whatever determines the instrumental variable does not simultaneously determine ideological views.

The most common instrumental variable used in studies that try to assess the effect of college on behavioral variables is college proximity (see, for example, Card, 1995). The idea is that college proximity reduces the cost of attending college and, therefore, induces attendance, independently of personal inclinations to attend college, which could be determined by the same factors that determine the dependent variable.[13]

The survey has data on the geographic coordinates of the location where the interview took place, but only for 48% of the respondents. Even if I was willing to limit the analysis to a much smaller sample, however, I could still not use this information to build a reliable instrument. First, as mentioned before, I only know if the respondent attended college, but not what college or university they attended. Thus, I cannot know whether their college was proximate for them or not. Second, many of those who responded that they attended college, may have moved to a different location after graduation. Thus, current location is not a reliable measure of where they were living when deciding whether to attend college or not. A potential way around this problem is to consider only those respondents under the age of 26, who are more likely to be currently attending college and for whom college proximity may be relevant. Considering only those in this group age, however, reduces the sample to only 180 respondents and, of course, does not solve the problem of not knowing what college they attended. Other instruments used in the literature include randomly assigned scholarships and mandatory enrollments. This information could potentially allow us to build a natural experiment but is not something provided by the survey.

[13] The implicit assumption is, of course, that individuals do not choose their location in relation to their college in response to personal inclinations associated with attending college.

6. Results

6.1. Ordered Logit Regressions

Table 2 presents the results of ordered logit regressions for each dependent variable. While eight department dummies are included in the regressions as control variables (Pando is excluded as the reference category), I do not report the coefficients as that would produce an excessively long table. I also control for Age^2 to capture a potential non-linear effect of the age of the respondents.

TABLE 2
ODDS-RATIOS FOR ORDERED LOGIT MODELS

	PrivProp	IndLib	SocEqual	Taxes
College	1.432**	2.519***	1.809***	1.223
Demographics				
Age	1.009	0.998	1.014	0.997
Age^2	1.000	1.000	0.999	1.000
Indigenous	0.733**	0.841	1.452**	0.709**
Female	0.928	1.239	1.261	0.697***
Catholic	0.973	0.979	0.869	1.114
MarStat	1.218	1.001	0.959	0.985
Income				
Income	1.048***	1.067***	1.047**	1.069***
Employed	0.940	0.809	0.899	0.809
Satisfaction, Trust and Technology				
EconPerc	0.968	1.138	1.194*	1.088
Trust	1.117	1.331***	1.214**	1.141*
WA	2.134***	2.467***	2.551***	1.684***
Department dummies	yes	yes	yes	yes
N	968	965	963	961
Pseudo R^2	0.047	0.081	0.073	0.054
Lipsitz p-value	0.51	0.95	0.66	0.92

Calculated using robust standard errors.
Statistical significance: *<0.1, **<0.05, ***<0.01
If the Lipsitz p-value is above 0.1, the model satisfies the proportional odds assumption (see Lipsitz, *et al*., 1996).

Notice that the odds-ratio for the independent variable, College, is greater than one and statistically significant for the PrivProp, IndLib and SocEqual regressions. These results suggest that attending college is associated with support for private property and individual liberty but also with support for social equality. As College takes the value of 1, the odds of observing PrivProp, IndLib and SocEqual take the maximum value of 4 (strongly agree or very important) is 1.432, 2.519 and 1.809 times higher than the odds of observing any of the other three, less favorable, categories, respectively. The coefficients are not only significant but also sizable. On the contrary, the coefficient of College is not statistically significant when the dependent variable is Taxes. This last result suggests that attending college is not significantly associated with thinking that everybody must pay taxes.

The aforementioned results can be interpreted as suggesting that college-educated individuals have a preference for left-leaning social features (they favor social equality and a tax system in which not everybody must pay taxes), but that that preference reverses when it comes to private property and individual liberty. In other words, college-educated individuals seem to display left-leaning social preferences but right-leaning individual preferences (preferences over variables that affect them more personally). This interpretation of the results fits the definition of *progre* or *socialista caviar* that I provided in the introduction.

In terms of control variables, the only consistent effects are those of Income, WA and Trust. As expected, higher income levels are associated with support for private property and individual liberty, but, perhaps surprisingly, they are also associated with a preference for social equality and a tax system in which not everybody must pay taxes. The same is true for those who have a WhatsApp account and trust their neighbors.

The Appendix presents the results when limiting the sample to individuals between the ages of 18 and 25. As mentioned in the previous section, this exercise is likely to reduce hidden bias as the effect of college education is more proximate and respondents are less likely to have been exposed to other life cycle factors. I find similar results. The only difference is that the coefficient of College is not significant when the dependent variable is PrivProp. Thus, if anything, the effect of college education on younger people is slightly stronger moving respondents to the left.

6.2. Propensity Score Matching

The first step is to estimate propensity scores of observing the treatment (College = 1). To do this I use a logit model with College as the dependent variable. Table 3 shows the results in terms of odds-ratios. Older people (at a decreasing rate), non-indigenous, those earning a higher income, those less optimistic about the economy and those having a WhatsApp account, are more likely to have college experience. The propensity score mean is 0.378.

TABLE 3
ODDS-RATIOS FOR LOGIT MODEL OF THE PROPENSITY TO HAVE COLLEGE EDUCATION

Dependent variable: College	Coefficient
Age	1.088**
Age^2	0.999**
Indigenous	0.576***
Female	1.067
Catholic	1.036
MarStat	0.876
Income	1.185***
Employed	0.791
EconPerc	0.825*
Trust	0.912
WA	3.493***
Constant	0.081***
Common support	[0.013, 0.926]
Propensity score mean	0.378
Propensity score st. dev.	0.249
N	970
Pseudo R^2	0.217

Calculated using robust standard errors.

The next step is to compute the average treatment effects on the treated (ATT). To compute ATT I use the following common matching algorithms: nearest neighbor, no replacement, 50 nearest neighbors and kernel. Table 4 shows the results.[14]

[14] Different matching techniques have been developed for the purpose of constructing pair-matched samples. They all have advantages and disadvantages depending on the nature and extension of the dataset (see Greifer, 2022, for a list of matching methods supported by the R programming language). Following Rosenbaum and Rubin (1983), PSM has become the standard technique in the literature. I have additionally tried genetic and cardinality matching. The results, available upon request, are qualitatively similar. Indeed, after comparing large-scale applications of cardinality matching and PSM, Fortin *et al*. (2021) conclude that "both matching techniques achieved comparable candidate covariate balance and expected systematic error". Similarly, in a simulation exercise, Donzé and Lai (2011) compare genetic matching and PSM and find that their "results are very contrasted and don't show the superiority of genetic matching, particularly without propensity scores".

TABLE 4
AVERAGE TREATMENT EFFECT ON THE TREATED

Outcome variable	Matching algorithm	ATT	Rubin's B	Rubin's R	Bias before matching	Bias after matching
PrivProp	Nearest neighbor	0.048	31.4	1.09	20.5	5.3
	No replacement	0.137***	58.7	1.52	20.5	9
	50 nearest neighbors	0.087**	22.2	1.41	20.5	4.2
	Kernel	0.061	15.4	1	20.5	3
IndLib	Nearest neighbor	0.192**	30.7	1.03	20.4	5.9
	No replacement	0.330***	58.8	1.5	20.4	8.7
	50 nearest neighbors	0.258***	21.7	1.39	20.4	4
	Kernel	0.226***	16.5	0.99	20.4	3.4
SocEqual	Nearest neighbor	0.209**	43.9	0.81	20.5	6.8
	No replacement	0.180***	59.9	1.58	20.5	8.4
	50 nearest neighbors	0.161***	22	1.42	20.5	3.8
	Kernel	0.221***	15.6	1	20.5	3
Taxes	Nearest neighbor	0.037	35.8	0.77	20.5	6.6
	No replacement	0.121**	58	1.56	20.5	8.4
	50 nearest neighbors	0.057	21.5	1.4	20.5	3.9
	Kernel	0.027	16.5	1.04	20.5	3.4

Statistical significance: *<0.1, **<0.05, ***<0.01.

Notice that the matching algorithms 'nearest neighbor' and 'no replacement', do not satisfy the balancing property recommended by Rubin (2001) for any of the outcome variables. Rubin (2001) recommends B to be less than 25 and R to be between 0.5 and 2. In the case of these two matching algorithms, B is always greater than 25. This means that treated and untreated respondents with the same propensity scores do not have similar distributions for all baseline variables, i.e. we do not have a balanced control group. This shortcoming is also reflected in the bias after matching, which is always much higher when using these two algorithms than when using '50 nearest neighbors' and 'kernel'. These last algorithms, on the other hand, perform well in terms of the Rubin's (2001) balancing property.[15]

Considering only the '50 nearest neighbors' and 'kernel' algorithms, the results are as follows:

- For PrivProp, the ATT is only significant when using the '50 nearest neighbors' algorithm. In that case, the average value of PrivProp is 8.7% higher among those who are college educated than among those who are not (remember

[15] Table A.2 in the Appendix shows the number of observations under common support.

that higher values of PrivPro indicate agreement with the statement "private property must be respected").

- For IndLib, the ATT is significant when using both algorithms. The effect is sizable. The average value of IndLib is 22.6 to 25.8% higher among those who are college educated than among those who are not (remember that higher values of IndLib indicate that the respondent considers that individual liberty is important).
- For SocEqual, the ATT is significant when using both algorithms and the effect is sizable. The average value of SocEqual is 16.1 to 22.1% higher among those who are college educated than among those who are not (remember that higher values of SoqEqual indicate that the respondent considers social equality important).
- In the case of Taxes, the ATT is not significant for any of the two algorithms. This means that there is no distinction among college educated individuals and non-college educated individuals when it comes to agreeing with the statement "everybody must pay taxes".

In summary, although college-educated individuals continue to be strongly in favor of individual liberty, they do not seem as inclined to support private property as the ordered logit regressions had first suggested (the ATT is significant for only one of the algorithms and it is not sizable). On the other hand, college-educated individuals continue to be strongly in favor of social equality and not significantly different from those who are not college educated when it comes to agreeing with the statement "everybody must pay taxes".

As mentioned before, PSM allows us to control for potential endogenous effects produced by observable characteristics, but cannot rule out hidden bias. I perform a sensitivity analysis that suggests how big a potential hidden bias should be in order to cast doubts on the robustness of the results. Table 5 presents this analysis (Rosenbaum, 2002).[16]

In Table 5, Γ (gamma) represents the odds of receiving treatment (attending college) and is standardized to one for randomized experiments. In observational studies, Γ may be larger than one indicating that the odds of receiving treatment are not the same as the odds of not receiving it. The larger the value of Γ, the more the study departs from the experimental design benchmark. Thus, as Γ increases, so does the range of possible p-values because of the uncertainty generated by the potential hidden bias.

[16] The application of the Rosenbaum's bounding approach in Table 5 is based on the kernel matching algorithm.

TABLE 5
SENSITIVITY TO HIDDEN BIAS: ROSENBAUM BOUNDS

Γ (gamma)	PrivProp		IndLib		SocEqual		Taxes	
	sig+	sig–	sig+	sig-	sig+	sig–	sig+	sig–
1	<0.001	<0.001	0	0	<0.001	<0.001	0.049	0.049
1.05	<0.001	<0.001	0	0	<0.001	0	**0.104**	**0.02**
1.1	<0.001	<0.001	0	0	<0.001	0	0.188	0.007
1.15	0.002	<0.001	<0.001	0	<0.001	0	0.299	0.002
1.2	0.007	<0.001	<0.001	0	<0.001	0	0.427	<0.001
1.25	0.018	<0.001	<0.001	0	<0.001	0	0.557	<0.001
1.3	0.037	<0.001	<0.001	0	<0.001	0	0.676	<0.001
1.35	0.069	<0.001	<0.001	0	<0.001	0	0.777	<0.001
1.4	**0.116**	**<0.001**	<0.001	0	<0.001	0	0.854	<0.001
1.45	0.18	<0.001	<0.001	0	<0.001	0	0.909	<0.001
1.5	0.258	<0.001	<0.001	0	<0.001	0	0.946	<0.001
1.55	0.348	<0.001	<0.001	0	<0.001	0	0.969	<0.001
1.6	0.444	<0.001	<0.001	0	<0.001	0	0.983	<0.001
1.65	0.54	<0.001	<0.001	0	<0.001	0	0.991	<0.001
1.7	0.631	0	<0.001	0	<0.001	0	0.995	<0.001
1.75	0.713	0	<0.001	0	<0.001	0	0.997	<0.001
1.8	0.784	0	<0.001	0	<0.001	0	0.999	<0.001
1.85	0.841	0	<0.001	0	<0.001	0	0.999	<0.001
1.9	0.887	0	<0.001	0	<0.001	0	0.999	<0.001
1.95	0.921	0	<0.001	0	<0.001	0	0.999	<0.001
2	0.947	0	<0.001	0	0.001	0	0.999	<0.001

Γ: Log odds of differential assignment due to hidden factors.
sig+: upper bound significance level.
sig–: lower bound significance level.

Take the first model (PrivProp) as an illustration. In this case, the upper bound p-value crosses the critical threshold of 10% at Γ = 1.4. This means that if 1) we fail to account for an unobservable characteristic associated with at least a 40% increase in the odds of being treated and, 2) that characteristic has a strong relationship with the dependent variable; then the significance level of the College coefficient may go above 10%. Thus, the PSM result for this model is moderately sensitive to hidden bias.

Similarly, the PSM result for the Taxes model is highly sensitive to hidden bias as the upper bound p-value crosses the critical threshold of 10% at Γ = 1.05.

On the other hand, the PSM results for the IndLib and SocEqual models are very robust to hidden biases. The upper bound p-value doesn't cross the critical threshold of 10% at any of the Γ values in any of the two models.

In general, the PSM results confirm those of the ordered logit regressions but cast some doubts on the positive relationship between college education

and believing that property rights must be respected. The positive effect verifies with the application of only one of the four matching algorithms, the ATT is not sizable and the result is somewhat sensitive to hidden bias.

7. Conclusion

I have examined the association between college education and left-leaning views in Bolivia using the 2020 CERES survey.

My ordered logit regression results suggest that attending college is significantly associated with agreeing that private property must be respected and that individual liberty is important. These results alone would suggest that attending college is associated with right-leaning views. I also find, however, that attending college is significantly associated with believing that social equality is important and is not significantly associated with thinking that everybody must pay taxes. These results alone would suggest that attending college is associated with left-leaning views.

The obvious empirical challenge is endogeneity as underlying factors could prompt a person to attend college and also determine his ideological leanings. I partially address this challenge using PSM, which builds a counterfactual to treatment (attending college) to control for potential endogenous effects produced by observable characteristics. While PSM and ordered logit regressions are different methodologies, the results are consistent in terms of individual liberty, social equality and taxes. The PSM results suggest that those with college experience are 22.6 to 25.8% more likely to consider that individual liberty is important, and 16.1 to 22.1% more likely to consider that social equality is important. These results are very robust to hidden bias. Moreover, the ATT is not significant when the dependent variable is Taxes.

Contrary to the ordered logit results, however, the PSM results suggest that attending college is not robustly associated with believing that private property must be respected. The ATT is significant when applying only one of the two valid algorithms and is not sizable at only 8.7%. Moreover, this result is somewhat sensitive to hidden bias.

The overall pattern that emerges out of this exercise is one in which college-educated individuals display left-leaning social preferences (they favor social equality and a tax system in which not everybody must pay taxes), but right-leaning individual preferences (they favor individual liberty and, to a lesser extent, private property, which are variables that affect them more directly). This interpretation of the results fits the connotation given to terms like *progre* or *socialista caviar* commonly used in Latin America to refer to educated individuals who consider themselves progressive, or even socialist, despite admitting and enjoying the benefits of individual economic freedom.

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Appendix

TABLE A.1
ODDS-RATIOS FOR ORDERED LOGIT MODELS
RESPONDENTS AGES 18 TO 25

	PrivProp	IndLib	SocEqual	Taxes
College	1.544	2.762**	2.511*	1.022
Demographics				
Age	1.568	28.126**	0.126	3.125
Age^2	0.987	0.925**	1.045	0.972
Indigenous	1.232	1.145	2.773**	0.843
Female	0.511**	1.295	1.352	0.709
Catholic	0.753	0.926	0.665	0.955
MarStat	1.265	0.6	0.753	11.132**
Income				
Income	1.077**	1.111**	1.057	1.081**
Employed	0.754	1.033	1.039	0.584*
Satisfaction, Trust and Technology				
EconPerc	0.913	0.916	0.739	1.116
Trust	0.786	0.971	0.848	1.29
WA	2.426*	1.535	2.569*	2.352*
Department dummies	yes	yes	yes	yes
N	212	211	211	209
Pseudo R^2	0.068	0.101	0.08	0.08

Calculated using robust standard errors.
Statistical significance: *<0.1, **<0.05, ***<0.01.

TABLE A.2
COMMON SUPPORT REGIONS

	Untreated Off	Untreated On	Treated Off	Treated On	Total
PrivProp	0	602	17	349	968
IndLib	0	598	19	348	965
SocEqual	0	598	16	349	963
Taxes	0	594	20	347	961

Herding behavior in the Chinese stock market and the impact of COVID-19*

Conducta manada en el mercado bursátil de China y el impacto del COVID-19

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Abstract

We analyze herding behavior in the Chinese stock markets in the context of the COVID-19 pandemic using the cross-sectional absolute deviation (CSAD) model proposed by Chang et al. (2000) to detect herding behavior in the time period between January 30, 2001, and June 12, 2020. We consider stock prices for all firms listed (A-shares) on the Shanghai Stock Exchange (SHSE) and Shenzhen Stock Exchange (SZSE) in China. We report the presence of herding behavior during the period under study and that herding behavior becomes stronger after December 31, 2019 (the COVID-19 event date). We also study herding activity in the context of potential asymmetries in market return and volatility states. The results show that when the market return is high and the volatility is low, there is a more predominant herding behavior trend. Our results do not depend on using different time windows. Results do not change when time-varying coefficients are considered using rolling regressions. Other control variables which may be relevant in explaining CSAD do not change the results when included in the estimations.

Key words: *Herding behavior, investor behavior, COVID-19, chinese stock market and cross-sectional absolute deviation (CSAD) model.*

JEL Classification: *G12, G14, G40.*

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Resumen

En este estudio analizamos la conducta manada en los mercados accionarios de China en el contexto de la pandemia COVID-19, usando el modelo de desviación absoluta de corte transversal (CSAD) propuesto por Chang et al. (2000) para detectar conducta manada entre el 30 de enero de 2001 y 12 de junio de 2020. Consideramos los precios accionarios de todas las firmas listadas (acciones clase A) en el mercado bursátil de Shanghai (SHSE) y el mercado accionario de Shenzhem (SZSE) en China. Reportamos la presencia de conducta manada durante el período bajo estudio y esta conducta se hace más fuerte después del 31 de diciembre de 2019 (la fecha del evento COVID-19). Adicionalmente estudiamos la actividad de manada en el contexto de potenciales asimetrías en estados asociados al retorno de mercado y la volatilidad. Los resultados muestran que cuando el retorno del mercado es alto y la volatilidad es baja es más predominante la tendencia hacia conducta manada. Nuestros resultados no dependen de usar ventanas de tiempo diferentes. Los resultados tampoco cambian cuando se incorporan coeficientes que varían en el tiempo por medio de regresiones con ventanas móviles. Al incorporar otras variables de control que pudieran ser relevantes al momento de explicar CSAD, los resultados no se alteran.

Palabras clave: *Conducta manada, conducta del inversionista, COVID-19, mercado accionario chino y modelo de desviación absoluta de corte transversal (CSAD).*

Clasificación JEL: *G12, G14, G40.*

1. Introduction

The COVID-19 virus was first identified in the city of Wuhan in the Hubei region of China and led to a global sanitary crisis. On March 11, 2020, with more than 100,000 people infected with COVID-19 and thousands dead, the World Health Organization (WHO) declared a global pandemic. Two months later, the number of infections exceeded five million and hundreds of thousands of deaths had been reported worldwide. From February 2020 onwards, in light of information regarding COVID-19 and its progression, global stock markets experienced several shock waves.

The first global alert from the WHO regarding COVID-19 was announced on January 30, 2020, and the initial reaction on the Chinese stock market, as shown on the Shanghai Composite Index (SSEC), was a negative return of 2.75%. When China's A-share market reopened on February 3, 2020, the SSEC fell by 7.72%. Accumulating the market return since February 3, 2020, we can see the return to positive terrain took approximately five months, coming on July 2, 2020. Indeed, Liu *et al.* (2020) report a negative and significant cumulative average abnormal return (CAAR) in the Chinese stock market between January 20 and

February 6, 2020. The CAAR was –6.39% for the Shanghai Stock Exchange (SHSE) and –3.78% for the Shenzhen Stock Exchange (SZSE).

The COVID-19 pandemic has generated major interest from scholars that study stock market behavior. A paper from Baig *et al.* (2020), for example, that studies both liquidity and volatility in US stock markets, shows that the increase in confirmed COVID-19 cases and deaths due to COVID-19 is linked to a significant increase in stock market illiquidity and volatility. Similarly, Albulescu (2020) finds a significant increase in the S&P 500 realized volatility. Testing the impact of the pandemic in 75 countries, Erdem (2020) reports a significant negative impact on stock markets expressed in decreasing returns and increasing volatility. Furthermore, because how COVID-19 data is processed by investors depends on the level of market freedom in the jurisdiction in which they operate, the results suggest that more market freedom is associated with lower negative returns and volatility.

Mazur *et al.* (2020) study US stock market performance at the industry level. They find that stocks representing certain economic sectors (e.g., natural gas, food, healthcare, and software) experience high positive returns, whereas equity values in petrol, real estate, entertainment, and hospitality sectors fall dramatically. Moreover, losing stocks show extreme asymmetric volatility that correlates negatively with stock returns.

In terms of the Chinese stock market, few articles have analyzed COVID-19 and its impact. The studies that have done so generally focus on stock market return behavior and the contagion effect associated with COVID-19. Al-Awadhi *et al.* (2020), for example, report that the daily growth in confirmed COVID-19 cases and number of deaths have a significant and negative impact on stock market returns in China across all companies. Topcu and Gulal (2020) document that the negative impact of the COVID-19 pandemic on emerging stock markets has gradually fallen and began to taper off in mid-April 2020. Akhtaruzzman *et al.* (2020) report that companies in China and G7 countries have shown significant increases in the conditional correlations between their stock returns, implying clear financial contagion transmission across firms and borders, with higher magnitudes of increase for financial firms. This finding is supported by Okorie and Lin (2020) who report considerable fractal contagion for market return and market volatility. Notably, they employ detrended moving cross-correlation analysis (DMCA) and detrended cross-correlation analysis (DCCA), which are less restrictive methodologies because they do not require time series processes to be stationary and directly use the moment properties of the series to establish the cross-correlation (contagion effects) in both regimes.

This study contributes to the existing literature in a number of ways. Although Wu *et al.* (2020) study the impact of COVID-19 on daily Chinese stock market returns between June 3, 2019, and October 12, 2020, they use an older methodology and conclude that herding behavior is significantly lower during the period of the COVID-19 pandemic under study. We provide new evidence regarding the impact of COVID-19 on herding behavior in the Chinese stock market. Wu *et al.* (2020) also do not implement any additional

robustness checks, which are relevant when studying a longer time period. Because the existing empirical evidence is not conclusive on the presence of herding behavior in the Chinese stock market, as can be observed in Table 1, our study considers a longer time period and compares different time periods. In addition, there is no agreement in the literature on whether there is more or less pronounced herding behavior in bull markets compared to bear markets. And more research is required on herding behavior in different stock market volatility regimes (high and low). Both of these issues are investigated, and the results are presented in this study.

Both China's stock markets, the SHSE in Shanghai and the SZSE in Shenzhen, trade two types of shares: A-shares and B-shares. A-shares are very common, they are traded on both stock markets and are denominated in Chinese Renminbi (RMB). Only Chinese nationals from mainland China and Qualified Foreign Institutional Investors (QFIIs) are permitted to trade A-shares. B-shares are Chinese stocks denominated in foreign currencies. On the SHSE, B-shares are denominated in US dollars (USD); B-shares that trade on the SZSE are denominated in Hong Kong dollars (HKD). The A-share market is larger than the B-share market, measured by number of shares, market capitalization, and trade volume (Ng and Wu, 2006). Because of the size of the A-share market and the volume traded, it is more attractive for investors to exclusively trade A-shares.

We collected data on stock prices for all firms listed on the SHSE and SZSE in the period between January 30, 2001, and June 12, 2020, and employ the cross-sectional absolute deviation (CSAD) model proposed by Chang *et al.* (2000) to test for herding behavior in the Chinese stock market, with particular focus on the impact of COVID-19 on herding. To check the robustness of our results, we verify herding behavior in several different time windows, and our investigation covers periods when the stock market is trending downward and upward, as well as during periods of high and low volatility. In the context of systemic or global adverse events, such as a pandemic, stock markets become stressed and show a high degree of instability, experiencing high volatility and significant uncertainty. We therefore use rolling window regression methodology as a further robustness check for the presence of herding behavior.

We find that herding behavior becomes stronger after the COVID-19 event date (December 31, 2019 and this result holds when using different time windows. When we study potential asymmetries in returns and volatility, results show that when market returns are high, and volatility is low there is a more predominant herding behavior trend. Our results do not depend on using different time windows, and they do not change when time-varying coefficients are taken into account using rolling regressions. We include a number of variables to control for other common market shocks that might explain CSAD behavior. None of the initial results change with control variables included, and a stronger tendency towards herding behavior during the period of the COVID-19 pandemic under study and similar results for rising and falling stock markets and for high and low volatility regimes can still be observed.

This study is organized in five sections. Section 2 presents a theoretical background with empirical evidence regarding herding behavior and introduces the hypotheses. Section 3 describes the data and the methodology used to test for herding behavior. Section 4 reports the main results and provides a discussion. Section 5 presents a series of robustness checks. And Section 6 concludes and proposes future avenues of research.

2. Theoretical Background and Hypotheses

In this section we provide a brief explanation of herding behavior and summarize the empirical evidence on herding behavior from several global stock markets. We then review empirical studies on herding behavior in Chinese stock markets.

2.1. Herding behavior

Herding behavior is a social behavior that occurs when individuals subordinate their individual will, thoughts, and behaviors and imitate those of the herd-that is, the majority or group of which they form part. Herding behavior does not require a leader, just individuals coming together at the same time to act, and it can be influenced by social and economic factors. In finance, herding is the inclination of investors (or organizations) to mimic the actions of other investors following the interactive observation of each other's actions (Hirshleifer and Hong, 2003). According to Erdenetsogt and Kallinterakis (2016), herding assumes that individuals follow the behavior of others without taking their own private information or prevailing market fundamentals into account.

One group of scholars argues that herding arises from the psychological biases of investors. Devenow and Welch (1996) and Lux (1995), for example, claim that herding occurs whenever investors do not consider their prior beliefs and blindly follow the trading strategies of other investors. Another group of researchers claim that herding can also take place among rational market participants. In this view, the knowledge that the actions of informed traders may reveal inside information induces outsiders to follow the investment strategies of these informed traders (Shleifer and Summers, 1990; Chari and Kehoe, 2004; Calvo and Mendoza, 2000).

A recent bibliometric study by Choijil *et al.* (2022) that examines the literature on herding behavior in financial markets over the last 30 years reveals significant research growth in this area but does not find consensus regarding the causes of the phenomenon. When the stock market is stressed by major events such as a financial crisis due to a pandemic, the study of herding behavior is particularly fruitful (see Chiang and Zheng, 2010; Chen *et al.*, 2012; Teng and Liu 2014; Sharma *et al.*, 2015) because of the high level of uncertainty and significant market fluctuations. The studies that have focused on the presence

of herding behavior during the COVID-19 pandemic differ mainly in terms of the region or countries under study: Bouri *et al.* (2021) study 49 global markets; Kizys *et al.* (2021) consider 72 countries from both developed and emerging economies; Wu *et al.* (2020) focus on China; Luu and Luong (2020) analyze Taiwan and Vietnam; Espinosa and Arias (2021a, 2021b) look at Europe and Australia; Fang *et al.* (2021) study Eastern Europe; Wen *et al.* (2021) analyze Hong Kong; and Jabeen *et al.* (2021) evaluate markets in Pakistan. Most of these studies report the presence of herding behavior in the period they study during the COVID-19 pandemic.

2.2. Herding behavior in Chinese stock markets: empirical evidence

The results of the various studies on herding behavior in the Chinese stock markets undertaken before the COVID-19 pandemic are summarized in Table 1, and it is clear that they are not conclusive. Only one study, however, reports the absence of herding behavior in this market (Demirer and Kutan, 2006). The results obtained by Fu and Lin (2010) depend on the methodology used to test for herding behavior.

Zheng, Li, and Xiaowei (2015) suggest that herding activity is more pronounced for actively traded stocks. Investors with less experience and less information show stronger herding behavior, imitate the behavior of more sophisticated peers, and make decisions based on trends. Local Chinese investors, who can only invest in A-shares, often lack both knowledge and experience in investing in stock markets compared to foreign institutional investors and these characteristics may manifest in herd behavior. Nonparametric results have suggested strong presence of herd behavior in A-share stock trading (Mahmud and Tinic, 2017).

The most common methodology used to test for herding behavior was developed by Chang *et al.* (2000). This methodology has the advantage of detecting the nonlinear behavior of returns. Wu *et al.* (2020) do not employ this methodology to test herding behavior and report a lower level of herding activity during the COVID-19 pandemic in the Chinese stock market, when compared to other time periods. Jabeen *et al.* (2021), who do not detect herding behavior during the COVID-19 pandemic, look at the stock market as a whole, but when the data is split by economic sector herding behavior is detected in some sectors.

Most of the empirical studies from around the world report herding behavior in the period they study during the COVID-19 pandemic. We therefore expect to find herding behavior in the Chinese stock markets. We also expect herding activity to be more pronounced for A-type shares because they can only be traded by local, less experienced, and less knowledgeable investors, as opposed to foreign institutional investors, which may result in a proclivity for herd behavior.

TABLE I
PREVIOUS EMPIRICAL STUDIES ON HERDING BEHAVIOR IN THE CHINESE STOCK MARKETS

Author(s)	Method	Sample	Main Result (s)
Demirer and Kutan (2006)	CH	1999-2002	Herding does not exist
Tan *et al.* (2008)	CCK	1994-2003	Herding in dual listing market shares (A and B). Herding presence in both upper and lower extremes of Rmt
Fu and Lin (2010)	CH and CCK , state space model	2004-2009	Herding does not exist. However, the tendency for herding is more dominant in market downstream.
Chiang and Zheng (2010)	CCK	1988-2009	Herding exists in both in up and down markets. It is more profound in rising markets.
Chiang *et al.* (2010)	CCK and quantile regression	1996-2007	Herding only found in A-shares but not in B-shares using CCK method. When using quantile regression herding is found for both classes of shares
Lao and Singh (2011)	CCK	1999-2009	Herding in A-Shares and stronger when market falling and volume is high.
Chiang *et al.* (2012)	CCK, using rolling regressions	1996-2007	Herding in both A-Shares and B-Shares at firm and industry level.
Chiang *et al.* (2013)	CCK, using time varying coefficients	1997-2009	Time varying coefficients lead to stronger evidence of herding behavior.
Lee *et al.* (2013)	CCK	2011-2010	Industry herding in A-shares. Herding in bull and bear markets. High Tech sector is relevant.
Yao *et al.* (2014)	CH	1999-2008	Herding is stronger in B-shares, more prevalent at industry-level, greater for largest stocks, stronger for growth stocks. Stronger under declining markets
Chen *et al.* (2015)	CCK	1994-2013	Herding exists in Chinese stock market. It is stronger during The 2008 Global Financial Crisis period.
Xie *et al.* (2015)	WCSV (Weighted Cross-Sectional Variance)	2007-2008	Herding in Chinese A-shares long lasting with a decaying trend.
Sharma *et al.* (2015)	CCK	2007-2010	Herding in up and down markets. Herding is sector-specific and time-varying.
Hou *et al.* (2017)	CCK	2007-2010	Herding depending on high frequency data.
Chong *et al.* (2017)	CCK	2000-2011	Herding in up and down markets.
Li *et al.* (2017)	CCK, using time-varying coefficients	2006-2015	Herding in turbulent periods and not in others.
Mahmud and Tinic (2017)	Non-parametric kernel regressions	2003-2014	Herding is strong in A-shares and weak in B-shares.
Kabir and Shakur (2018)	Smooth transition regression	1995-2014	Herding is present in high volatility regimes as opposed to low return scenarios.
Chen and Ru (2019)	Simulated method of moments	2010-2018	Herding behavior in both large and small capitalization stocks.
Chen (2020)	CCK	2016-2019	Herding is present and it shows an increasing tendency.
Wu *et al.* (2020)	CH	June 3 2019 Oct. 12 2020	Herding behavior is lower during the COVID-19 period. Herding is more pronounced when markets return are high and volatility is low.

Note: CH = Christie and Huang (1995); CCK = Chang, Cheng and Khorona (Chang *et al.,* 2000).

Hypothesis 1. *Herding behavior occurs in Chinese stock markets.*

The COVID-19 virus produced a scenario unprecedented in the last 100 years and caused a different type of financial crisis, characterized by stock market falls and high volatility. This leads to the following hypothesis:

Hypothesis 2. *In the period after the COVID-19 event date, we expect stronger herding behavior in Chinese stock markets.*

Another interesting phenomenon to study is herding behavior asymmetry between bear and bull markets. Investors fear potential losses (loss aversion) when a market crashes more than they delight in the potential gains when the market is booming. McQueen *et al.* (1996) suggest that this can be explained by the fact that all stocks tend to respond quickly to negative macroeconomic news. Small stocks, however, tend to have a delayed reaction to positive macroeconomic news. It could also be argued that as markets suffer losses investors may be less likely to behave in a coordinated fashion because they are reluctant to realize immediate losses and, therefore, hesitate to sell their shares as stock prices drop (Statman *et al.*, 2006).

In the case of the Chinese stock market, some authors show that there is herding when the market is down (Fu and Lin, 2010; Lao and Singh, 2011; Yao *et al.*, 2014; Chen *et al.*, 2015) and others show that herding not only occurs in bull markets but also in bear markets (Tan *et al.*, 2008; Chiang and Zheng, 2010; Lee *et al.*, 2013; Sharma *et al.*, 2015; Chong *et al.* 2017; Chen, 2020). Wu *et al.* (2020) find more pronounced herding behavior in reaction to upside market movement during the COVID-19 period they study.

Hypothesis 3. *Asymmetric herding behavior exists in the Chinese stock market during both bull and bear markets*.

A group of studies, most of which do not include Chinese stock market data in their sample, analyze herding behavior in low and high volatility market regimes. Kabir and Shakur (2018), for example, study herding behavior in Asian and Latin American markets. They find no evidence of nonlinearity across market regimes in six countries (China, India, Malaysia, Singapore, Argentina, and Brazil). They also report that investors in most of the markets, except Argentina and Brazil, display herding behavior during high volatility regimes. Lam and Qiao (2015) test herding behavior at the market and industrial level in the Hong Kong stock market and find evidence for herding activity during a bull market, when the trading volume is high, as well as in both high and low volatility regimes. Vo and Phan (2019) analyze the effect of idiosyncratic volatility on the herding behavior of investors in the Vietnamese stock market. Using established models, proposed by Christie and Huang (1995) and Chang *et al.* (2000), and index return data for the period between 2005 and 2016, they report herding behavior and find distinct herding patterns under different stock

portfolios depending on the levels of market volatility. Their results are robust throughout the whole sample period. Finally, Wu *et al.*(2020), in a paper that does include Chinese stock market data, report that herding behavior is more pronounced in lower market volatility regimes caused by COVID-19.

Based on these findings, we examine potential asymmetric effects of herding behavior with respect to volatility in market return and posit the following hypothesis:

Hypothesis 4. *Asymmetric herding behavior occurs in the Chinese stock market during high and low volatility regimes.*

3. Data and Methodology

The SHSE in Shanghai and the SZSE in Shenzhen, trade two types of shares: A-shares and B-shares. A-shares are very common, they are traded on both stock markets, and are denominated in Chinese Renminbi (RMB). Only Chinese nationals from mainland China and Qualified Foreign Institutional Investors (QFIIs) are permitted to trade A-shares. B-shares are Chinese stocks denominated in foreign currencies. On the SHSE, B-shares are denominated in US dollars (USD); B-shares that trade on the SZSE are denominated in Hong Kong dollars (HKD). The A-share market is larger than the B-share market, measured by number of shares, market capitalization, and trading volumes (Ng and Wu, 2006).

The majority of herding behavior studies have focused on the A-share markets in the SHSE and SZSE, and we also focus exclusively on A-shares, which means that our results are more comparable with the existing body of work on this subject. Furthermore, A-shares have a higher market capitalization, which means that they are more representative of the market, and they also have a larger trading volume, which means we are working with liquid stocks and that helps us to test CSAD without having a bias generated by illiquid stocks.

We collected data on stock prices (A-shares) for all firms listed on the SHSE and SZSE in the period between January 30, 2001, and June 12, 2020. Tan *et al.* (2008) report that frequency of the data used to study herding behavior matters and that herding activity is more evident when using daily data than weekly or monthly data. Accordingly, we use daily stock returns data calculated as $R_{it} = 100 \times (log(P_{it}) - log(P_{it-1}))$.

The computation of the return dispersion measure in Equation (1) requires the calculation of an average market portfolio return, $R_{m,t}$. Following the literature, we use the equally-weighted average of stock returns as a proxy for $R_{m,t}$. There are 426 firms in the SHSE and 199 firms in the SZSE giving a total 5,054 observations in the selected time window.

In terms of detecting herding behavior, the return dispersion method is an approach that is frequently used (Demirer and Kutam, 2006; Tan *et al.*, 2008; Lao and Singh, 2011; Mobarek *et al.*, 2014; Yao *et al.*, 2014). Chang *et al.*

(2000) use individual stock returns and market returns, as does Christie and Huang (1995), who also propose a cross-sectional standard deviation of returns (CSSD) model to detect herding activity in the market.

Christie and Huang (1995) and Chang *et al.* (2000) claim that during normal periods rational asset pricing models predict that the dispersion in returns will increase with the absolute value of the market return because investors are trading with their own private information, which is diverse. In periods when the market exhibits extreme movements, investors tend to subdue their own beliefs and are more likely to follow the market consensus, consistent with herding behavior. During these periods, increases in dispersion in returns can be observed but at a decreasing rate, showing a nonlinear behavior in the proxy for return dispersion. Although the cross-sectional standard deviation of returns (CSSD) model proposed by Christie and Huang is an intuitive measure to capture herd behavior, the authors recognize that the measure can be considerably affected by the existence of outliers. For this reason, Christie and Huang (1995) and Chang *et al.* (2000) both propose an alternative: the cross-sectional absolute deviation (CSAD) model. They differ, however, in the way they test for herding behavior: Christie and Huang analyze extreme returns, whereas Chang *et al.* (2000) introduce a methodology that includes the entire distribution of stock market returns. Several papers suggest that the Christie and Huang (1995) testing methodology is too strict and requires a far greater magnitude of nonlinearity to find evidence of herding (Gleason, *et al.*, 2004 and Tan *et al.*, 2008).

We adopt the CSAD methodology proposed by Chang *et al.* (2000) for two main reasons. First, the COVID-19 period under study in this paper can be characterized by a major stock market turbulence and the presence of outliers. The methodology used by Christie and Huang is less appropriate, therefore, because it is less able to capture the magnitude of nonlinearity. Chang *et al.* (2000), however, observe that herding is more likely to be present during periods of relatively large price shifts and suggest that fluctuations in investor sentiment related to investment activity may be reflected in the dispersions of cross-sectional stock returns. Second, most studies of herding behavior in the Chinese stock market employ CSAD methodology and, therefore, our results can be more easily compared with existing studies.

Chang, *et al.* (2000), Gleason *et al.* (2004), and Tan *et al.* (2008) suggest using the following CSAD model to facilitate the recognition of herding behavior over the entire distribution of market return (baseline model):

$$CSAD_t = \beta_0 + \beta_1 \left| R_{m,t} \right| + \beta_2 \, (R_{m,t})^2 + \varepsilon_t, \tag{1}$$

where $CSAD_t$ is a measure of return dispersion and $R_{m,t}$ is the equally-weighted average stock return in the portfolio (market return). We compute CSAD at time t as follows:

$$CSAD_t = \frac{1}{N} \sum_{i=1}^{N} \left| R_{i,t} - R_{m,t} \right|,$$

where $CSAD_t$ is a measure of average absolute return dispersion from $R_{m,t}$ to measure return dispersion. $|R_{m,t}|$ is the absolute value of market return and $R_{i,t}$ is the individual stock return of stock i. β_0 is the intercept and ε_t is an error term.

Because our study is based on the CSAD model, a statistically significant and negative coefficient β_2 would indicate the presence of herding behavior in the Chinese stock market. As β_1 out to be positive, it would indicate that a nonlinear model explains CSAD. Herding behavior is present as far as CSAD increases at a decreasing rate (β_2 has to be negative), which implies a lower dispersion and indicates that investors are mimicking the investment decisions of their peers.

We extend the baseline model to assess the effect of COVID-19 on herding behavior using the following specification of Equation (1):

$$CSDA_t = \gamma_0 + \gamma_1 D^{covid} \left|R_{m,t}\right| + \gamma_2 \left(1 - D^{covid}\right)\left|R_{m,t}\right| + \gamma_3 D^{covid} (R_{m,t})^2 + \gamma_4 \left(1 - D^{covid}\right)(R_{m,t})^2 + \varepsilon_t. \tag{2}$$

Equation (2) is a modified version of Equation (1) and is used to assess the presence of herding behavior in the Chinese stock market before and after the COVID-19 event date (December 31, 2019). Significantly negative values for γ_3 and γ_4 would indicate the presence of herding behavior before and after the COVID-19 event date. The COVID-dummy (D^{covid}) equals 1 after December 31, 2019, and 0 before that date.

Equation (1) and Equation (2) enable the evaluation of Hypothesis 1 and Hypothesis 2, respectively. We then introduce three control variables that might affect CSAD. The first control variable is the stock return from a regional stock market index, the MSCI Asia Pacific, to account for the market integration among countries in the region. The second control variable considers the integration of the Chinese stock market with the rest of the world. We proxy this potential effect by including the stock returns from a global stock market index, the MSCI all country world index. The third control variable is the return on the exchange rate, which is included because of changes to the renminbi's exchange rate regime in 2015. Thus, we extend Equation (1) and run the following model:

$$CSAD_t = \beta_0 + \beta_1 \left|R_{m,t}\right| + \beta_2 (R_{m,t})^2 + \beta_3 R_{mregion,t} + \beta_4 R_{mworld,t} + \beta_5 R_{rexchrate,t} + \varepsilon_t. \tag{3}$$

By including the control variables, Equation (2) becomes Equation (4), which is expressed as follows:

$$CSDA_t = \gamma_0 + \gamma_1 D^{covid} \left|R_{m,t}\right| + \gamma_2 \left(1 - D^{covid}\right)\left|R_{m,t}\right| + \gamma_3 D^{covid} (R_{m,t})^2 + \gamma_4 \left(1 - D^{covid}\right)(R_{m,t})^2 + \gamma_5 R_{mregion,t} + \gamma_6 R_{mworld,t} + \gamma_7 R_{rexchrate,t} + \varepsilon_t. \tag{4}$$

Equation (3) and Equation (4) also enable the evaluation of Hypothesis 1 and Hypothesis 2, respectively, including the control variables.

To check the robustness of the results we use four different time windows (2005.07.21-2020.06.12; 2010.01.04-2020.06.12; 2015.01.05-2020.06.12; and 2018.01.05-2020.06.12). These subsamples let us isolate important events such as the subprime mortgage crisis in 2008-09 and the major Chinese market turbulence in 2015-16. In the first month of the 2015-16 Chinese market turbulence, A-shares on the SHSE lost more than 30% of their market value and more than half of the listed companies (more than 1,400) stopped trading their stocks to prevent higher losses. Beginning on June 12, 2015, the turbulence ended in early February, 2016 and is therefore included in the 2015.01.05-2020.06.12 window. The time window subsamples allow us to compare the results that included the Chinese market turbulence with those obtained for the 2018.01.05-2020.06.12 time window, where the crisis is excluded.

In addition, we consider two effects from the literature (Tan *et al.*, 2008; Mobarek *et al.*, 2014; Batmunkh *et al.*, 2020) that can affect herding behavior: asymmetric effects of market return, and high and low volatility regimes. Because the direction of the market return may affect investor behavior (Tan *et al.*, 2008; Mobarek *et al.*, 2014), we are interested in detecting any asymmetry in herd behavior conditional on whether the market is upstreaming or downstreaming before and after the COVID-19 event date. And we also examine the asymmetric effects of herding behavior relating to the volatility of stock markets during the same time periods. We characterize market volatility as high when the observed volatility is higher than the moving average of volatility from the previous 30 days and as low when it is below the moving average of volatility from the previous 30 days. According to previous studies, a 30-day period is the most suitable to reveal volatility effects (Chang *et al.* 2000; Tan *et al.* 2008). The volatility in market return is calculated as the standard deviation of market daily return multiplied by the square root of the 252 trading days. Finally, we analyze if the increase in herding behavior is maintained after the COVID-19 event date using rolling window regression methodology. We build windows of 100, 200, 400, and 600 days to generate series of the estimated coefficients and especially analyze β_2 in Equation (1). For robustness we reestimate the models recursively.

4. Results and Discussion

Table 2 presents the descriptive statistics for the CSAD measure and the average market return, calculated using both equal weights for each stock market. The results show that mean values (1,433 and 1.440) and standard deviations (0.677 and 0.696) of CSAD are high in both the SHSE and the SZSE. A higher mean value suggests significantly higher market variations across stock returns. A higher standard deviation may indicate that markets have unusual cross-sectional variations due to unexpected events (Chiang and

Zheng, 2010). Similar to the results in Chang *et al.* (2000), we find first order autocorrelation of CSAD in both stock markets: 0.776 for the SHSE, and 0.732 for SZSE. In order to account for this, all standard errors of the estimated regression coefficients in subsequent tests are adjusted for heteroscedasticity and autocorrelation, based on the approach suggested by Newey and West (1987). Furthermore, the unit root (Dickey-Fuller) tests indicate that the CSAD series exhibits stationarity.

TABLE 2
DESCRIPTIVE STATISTICS AND UNIVARIATE TEST OF CSAD AND MARKET RETURN OF THE SHSE AND THE SZSE

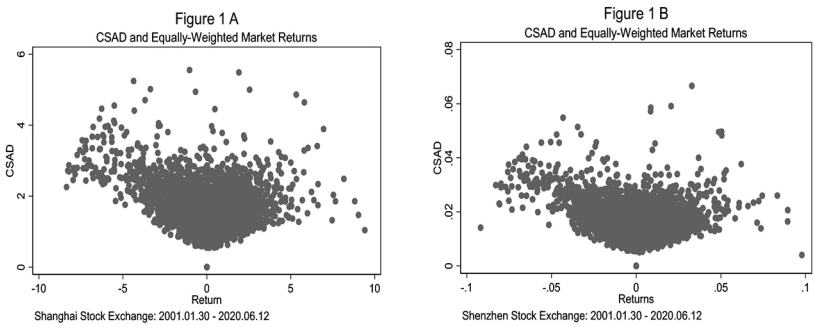
	SHSE		SZSE	
	CSAD	$R_{m,t}$	CSAD	$R_{m,t}$
N° Obs.	5054		5054	
Mean	1.433	0.201	1.440	0.028
Std. Dev.	0.677	1.72	0.696	1.677
Min	0	–8.35	0	–9.19
Max	5.553	9.41	6.661	9.78
Serial Correlation at Lag				
1	0.776	0.112	0.732	0.111
2	0.672	–0.005	0.638	–0.000
3	0.565	0.002	0.540	–0.000
4	0.510	0.042	0.463	0.028
5	0.497	0.060	0.482	0.052
20	0.362	0.013	0.350	0.020
DF-test	–16.547***	-40.954***	–16.687***	–41.3***

Table 3 reports the results of estimating the Equation (1) and Equation (2) for the SHSE and the SZSE. In Equation (1), $CSAD_t$ reaches its maximum value when $|R_{m,t}|^* = -\beta_1/(2\beta_2)$. That is, $|R_{m,t}|^* = 7.76\%$ for the SHSE and 7.33% for the SZSE. These outcomes suggest that, during large price movements in market returns that exceed the threshold level $|R_{m,t}|^*$, the $CSAD_t$ increases at a decreasing rate, as shown in Figure 1.

When $|R_{m,t}|$ increases over the range where realized average daily returns in absolute terms are less than $|R_{m,t}|^*$, the $CSAD_t$ exhibits an increasing trend. Conversely, when $|R_{m,t}|^*$ is greater than $|R_{m,t}|^*$, the return dispersion measure $CSAD_t$ starts to increase at a decreasing rate, which is captured by a significantly negative coefficient β_2. Thus, the nonlinear relationship between the market return and the return dispersion would indicate the occurrence of herding behavior. And a statistically significant and negative coefficient β_2 would indicate the presence of herding behavior. We detect herding behavior in both markets (the SHSE and

SZSE) because β_2 is significantly negative at the 1% level (–0.029 and –0.0332, respectively). This is consistent with previous empirical results from Tan *et al*. (2008), Lao and Sinh (2011), Chiang and Nelling (2013), and Yao *et al.* (2014), among others. The combined herding effect and linear relationship between $CSAD_t$ and $|Rm,|$ explain 33% on average of the total variation in $CSAD_t$. With these results, Hypothesis 1 is not rejected.

FIGURE 1
RELATIONSHIP BETWEEN THE DAILY CROSS-SECTIONAL ABSOLUTE DEVIATION $CSAD_{i,t}$ AND THE CORRESPONDING EQUALLY-WEIGHTED MARKET RETURN $R_{m,t}$



Equation (2) shows the effect of COVID-19 on herding behavior. We report a negative and statistically significant estimated coefficient (γ_3). The sizes of the coefficient capture the magnitudes of the herding behavior (Lao and Singh, 2011). Both γ_3 and γ_4 are statistically significant, but for different sizes. For the SHSE, γ_3 = –0.047 and γ_4 = –0.029, and for the SZSE, γ_3 = –0.0605 and γ_4 = –0.0315. In summary, we find herding behavior before and after the COVID-19 event date, and the results show an asymmetric herding behavior that is more pronounced in the period between December 31, 2019, and June 12, 2020, the period of the COVID-19 pandemic considered in this study. With these results, we do not reject Hypothesis 2.

Table 4 reports the results of estimating Equation (3) and Equation (4) for the SHZE and the SZSE. We find results consistent with herding behavior: β_2 is –0.027 for the SHSE and –0.031 the SZSE in Equation (3); and γ_3 is –0.054 for the SHSE and -0.039 for the SZSE in Equation (4). We also observe that regional stock return has a significant a negative impact on CSAD. When the control variables are included, the results do not change, which do not reject Hypothesis 1 and Hypothesis 2.

TABLE 3
ESTIMATES OF HERDING BEHAVIOR IN THE FULL SAMPLE PERIOD

Equation 1	β_0	β_1	β_2			R-squared		
SHSE	1.000*** (0.0129)	0.449*** (0.0142)	–0.029*** (0.00253)			0.33		
SZSE	0.975*** (0.0133)	0.487*** (0.0147)	-0.0332*** (0.00265)			0.341		
Equation 2	γ_0	γ_2	γ_2	γ_3	γ_4	R-squared	t-stat (H0:	t-stat (H0:)
SHSE	1.000*** (0.0129)	0.528*** (0.0604)	0.447*** (0.0143)	–0.047*** (0.0127)	–0.029*** (0.00256)	0.33	–60,375***	–27,983***
SZSE	0.977*** (0.0133)	0.550*** (0.0570)	0.481*** (0.0149)	–0.061*** (0.0105)	–0.032*** (0.00270)	0.343	–61,333***	–27,859***

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

TABLE 4
ESTIMATES OF HERDING BEHAVIOR IN THE FULL SAMPLE PERIOD
WITH CONTROL VARIABLES

Equation 3	$\beta 0$	$\beta 1$	$\beta 2$	$\beta 3$	$\beta 4$	$\beta 5$	R-squared
SHSE	1.085***	0.438***	–0.027***	–0.121***	0.003	–0.036	0.343
	(0.018)	(0.018)	(0.003)	(0.023)	(0.023)	(0.139)	
SZSE	1.057***	0.482***	–0.031***	–0.114***	0.003	–0.157	0.362
	(0.018)	(0.019)	(0.003)	(0.023)	(0.024)	(0.130)	

Equation 4	$\Upsilon 0$	$\Upsilon 1$	$\Upsilon 2$	$\Upsilon 3$	$\Upsilon 4$	$\Upsilon 5$	$\Upsilon 6$	$\Upsilon 7$	R-squared	t–stat1 (H0: $\Upsilon 1 = \Upsilon 2$)	t–stat1 (H0: $\Upsilon 3 = \Upsilon 4$)
SHSE	1.085***	0.455***	0.437***	–0.039***	–0.027***	–0.121***	0.003	–0.030	0.343	299.5***	42.55***
	(0.018)	(0.045)	(0.018)	(0.011)	(0.003)	(0.023)	(0.023)	(0.139)			
SZSE	1.060***	0.484***	0.475***	–0.054***	–0.029***	–0.113***	0.001	–0.136	0.365	330.2***	53.11***
	(0.018)	(0.042)	(0.019)	(0.009)	(0.003)	(0.023)	(0.023)	(0.128)			

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5. Robustness

In this section, we explore whether the results presented in Section 4 change when the sample is split into several different time windows, analyze whether any change is produced by high and low market regimes, and use rolling window methodology to observe changes in herding behavior after the COVID-19 event.

5.1. Time Windows

We split the sample into four different time windows to evaluate whether or not herding activity depends on the particular time window chosen. Thus, we estimate Equation (2) for the period 2005.07.21-2020.06.12 (column 1), 2010.01.04-2020.06.12 (column 2), 2015.01.05-2020.06.12 (column 3), and 2018.01.05-2020.06.12 (column 4). Table 5.1 reports the results. Panel A shows the results for the SHSE and Panel B for the SZSE. In all cases, the results show a negative and significant γ_3, confirming herding behavior during the period of COVID-19 under study. On the other hand, because γ_3 is greater than γ_4, we can conclude that herding behavior is stronger during COVID-19. Furthermore, when we include the control variables (Equation 4) results do not change, as shown in Table 5.2.

5.2. Market Regimes

We now consider two effects from the literature that may impact herding behavior: asymmetric effects of market return and high and low volatility regimes. Accordingly, we concentrate on the results from Equation (2) and Equation (4).

Table 6.1 shows the results regarding Equation (2) for SHSE, and Table 6.2 shows the results for SZSE. In both tables, Panel A corresponds to the period 2001.01.30-2020.06.12, Panel B to the period 2010.01.04-2020.06.12, Panel C to the period 2015.01.05-2020.06.12; and Panel D to the period 2018.01.05-2020.06.12. In each panel, Columns (1) and (2) show the results for $R_{m,t} > 0$ (bull market) and $R_{m,t} < 0$ (bear market), respectively; and Columns (3) and (4) show the results for $\sigma^{\text{HIGH}} > \sigma^{\text{MA}}{}_{\text{t–30}}$ (high volatility) and $\sigma^{\text{LOW}} < \sigma^{\text{MA}}{}_{\text{t–30}}$ (low volatility), respectively.

With respect to the results showing the asymmetric effects of market return, we observe herding behavior in both bull and bear markets ($R_{m,t} > 0$ and $R_{m,t} < 0$). In a bull market, the impact is higher on the CSAD compared to a bear market across all time windows. The absolute magnitude of γ_3 for the SHSE (Table 6.1, Panel A) is 0.112 (in a bull market) and 0.078 (in a bear market), and for the SZSE (Table 6.2, Panel A) the absolute magnitude of γ_3 is 0.150 (bull market) and 0.07 (bear market). These results are consistent with Yao, Ma, and He (2014) who report that return dispersions are often lower during extreme negative market movements. In addition, $\gamma_3 > \gamma_4$ (absolute value) in the SHSE and the SZSE, which implies that herding behavior is stronger after December 31, 2019 (the COVID-19 event date). Different time windows show similar results

TABLE 5.1
TIME WINDOW ESTIMATIONS
(EQUATION 2 FOR BOTH STOCK MARKETS)

	Panel A					Panel B			
SHSE	2005-2020	2010-2020	2015-2020	2018-2020	SZSE	2005-2020	2010-2020	2015-2020	2018-2020
	1	2	3	4		1	2	3	4
$\Upsilon 0$	1.082***	1.019***	0.978***	1.056***	$\Upsilon 0$	1.057***	1.003***	1.000***	1.047***
	(0.018)	(0.019)	(0.026)	(0.037)		(0.018)	(0.020)	(0.027)	(0.039)
$\Upsilon 1$	0.459***	0.513***	0.548***	0.481***	$\Upsilon 1$	0.489***	0.530***	0.533***	0.497***
	(0.045)	(0.047)	(0.051)	(0.052)		(0.039)	(0.042)	(0.044)	(0.046)
$\Upsilon 2$	0.435***	0.369***	0.482***	0.315***	$\Upsilon 2$	0.474***	0.400***	0.468***	0.319***
	(0.019)	(0.023)	(0.033)	(0.044)		(0.019)	(0.026)	(0.037)	(0.044)
$\Upsilon 3$	–0.038***	–0.045***	–0.049***	–0.041***	$\Upsilon 3$	–0.054***	–0.058***	–0.059***	–0.055***
	(0.009)	(0.011)	(0.011)	(0.010)		(0.008)	(0.008)	(0.009)	(0.008)
$\Upsilon 4$	–0.026***	–0.009**	–0.022***	–0.017*	$\Upsilon 4$	–0.028***	–0.012**	–0.019***	–0.024**
	(0.003)	(0.005)	(0.006)	(0.009)		(0.003)	(0.006)	(0.007)	(0.010)
Obs.	3,887	2,725	1,420	636	Obs.	3,887	2,725	1,420	636
R-squared	0.336	0.365	0.450	0.256	R-squared	0.359	0.351	0.403	0.237
t-stat1 (H0: $\Upsilon 1 = \Upsilon 2$)	284.6***	155.5***	127.3***	47.39***	t-stat1 (H0: $\Upsilon 1 = \Upsilon 2$)	316.2***	159.4***	115.3***	59.37***
t-stat1 (H0: $\Upsilon 3 = \Upsilon 4$)	37.7***	10.22***	14.81***	8.143***	t-stat1 (H0: $\Upsilon 3 = \Upsilon 4$)	51.79***	24.88***	24.74***	22.53***

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

TABLE 5.2
TIME WINDOW ESTIMATIONS
(EQUATION 4 FOR BOTH STOCK MARKETS)

SHSE	2005-2020	2010-2020	2015-2020	2018-2020	SZSE	2005-2020	2010-2020	2015-2020	2018-2020
	1	2	3	4		1	2	3	4
$\gamma 0$	1.085***	1.020***	0.978***	1.054***	$\gamma 0$	1.059***	1.003***	0.999***	1.045***
	(0.018)	(0.019)	(0.026)	(0.038)		(0.018)	(0.020)	(0.027)	(0.040)
$\gamma 1$	0.456***	0.515***	0.550***	0.487***	$\gamma 1$	0.485***	0.533***	0.535***	0.502***
	(0.045)	(0.047)	(0.051)	(0.052)		(0.042)	(0.043)	(0.046)	(0.047)
$\gamma 2$	0.437***	0.373***	0.487***	0.320***	$\gamma 2$	0.476***	0.404***	0.475***	0.321***
	(0.018)	(0.023)	(0.033)	(0.044)		(0.019)	(0.026)	(0.037)	(0.045)
$\gamma 3$	–0.039***	–0.047***	–0.051***	–0.043***	$\gamma 3$	–0.054***	–0.060***	–0.060***	–0.056***
	(0.011)	(0.011)	(0.012)	(0.011)		(0.009)	(0.009)	(0.009)	(0.008)
$\gamma 4$	–0.027***	–0.011**	–0.024***	–0.019**	$\gamma 4$	–0.029***	–0.013**	–0.021***	–0.025**
	(0.003)	(0.005)	(0.006)	(0.009)		(0.003)	(0.006)	(0.007)	(0.010)
$\gamma 5$	–0.122***	–0.134***	–0.143***	–0.098*	$\gamma 5$	–0.114***	–0.134***	–0.140**	–0.053
	(0.023)	(0.032)	(0.053)	(0.059)		(0.023)	(0.033)	(0.056)	(0.056)
$\gamma 6$	0.003	0.033	0.029	0.023	$\gamma 6$	0.001	0.041	0.040	0.033
	(0.023)	(0.026)	(0.040)	(0.042)		(0.023)	(0.028)	(0.042)	(0.041)
$\gamma 7$	–0.030	0.138	0.106	0.224	$\gamma 7$	–0.136	–0.010	–0.056	0.113
	(0.139)	(0.142)	(0.158)	(0.217)		(0.128)	(0.127)	(0.139)	(0.200)
Obs.	3.887	2.724	1.420	636	Obs.	3.887	2.724	1.420	636
R-squared	0.343	0.372	0.455	0.262	R-squared	0.365	0.356	0.407	0.239
t-stat1 (H0: $\gamma 1=\gamma 2$)	297.8***	155.6***	127.7***	48.78***	t-stat1 (H0: $\gamma 1=\gamma 2$)	330***	157.2***	112.3***	58.94***
t-stat1 (H0: $\gamma 3=\gamma 4$)	42.50***	10.29***	14.95***	8.594***	t-stat1 (H0: $\gamma 3=\gamma 4$)	53.42***	22.52***	22.10***	22.89***

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

TABLE 6.1
MARKET REGIMES (EQUATION 2 FOR THE SHANGHAI STOCK EXCHANGE, SHSE)

	Panel A: Period 2001.01.30-2020.06.12				Panel B: Period 2005.07.21-2020.06.12				Panel C: Period 2010.01.04-2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$
$\Upsilon 0$	1.239***	0.813***	1.054***	0.963***	1.340***	0.881***	1.171***	1.037***	1.296***	0.832***	1.052***	0.977***
	(0.017)	(0.020)	(0.025)	(0.019)	(0.020)	(0.025)	(0.033)	(0.022)	(0.019)	(0.026)	(0.035)	(0.025)
$\Upsilon 1$	0.433***	0.803***	0.423***	0.764***	0.290***	0.747***	0.341***	0.670***	0.351***	0.788***	0.424***	0.747***
	(0.104)	(0.080)	(0.053)	(0.091)	(0.100)	(0.077)	(0.052)	(0.088)	(0.100)	(0.080)	(0.055)	(0.092)
$\Upsilon 2$	0.204***	0.669***	0.455***	0.442***	0.151***	0.705***	0.447***	0.410***	–0.016	0.644***	0.409***	0.432***
	(0.024)	(0.021)	(0.025)	(0.029)	(0.029)	(0.024)	(0.028)	(0.030)	(0.032)	(0.028)	(0.035)	(0.043)
$\Upsilon 3$	–0.112**	–0.078***	–0.030***	–0.123***	–0.073*	–0.071***	–0.021***	–0.104***	–0.090**	–0.076***	–0.031***	–0.120***
	(0.044)	(0.014)	(0.008)	(0.033)	(0.041)	(0.013)	(0.007)	(0.031)	(0.042)	(0.014)	(0.008)	(0.033)
$\Upsilon 4$	–0.009	–0.053***	–0.030***	–0.040***	0.004	–0.059***	–0.029***	–0.034***	0.053***	–0.047***	–0.015***	–0.058***
	(0.006)	(0.003)	(0.004)	(0.008)	(0.007)	(0.004)	(0.004)	(0.008)	(0.009)	(0.005)	(0.006)	(0.014)
Obs .	2,570	2,484	2,487	2,567	2,065	1,822	1,795	2,092	1,409	1,316	1,189	1,536
R-squared	0.131	0.489	0.331	0.259	0.133	0.504	0.330	0.250	0.212	0.519	0.397	0.230
t-stat1 (H0: $\Upsilon 1 = \Upsilon 2$)	40.62***	530.6***	177.8***	129.4	15.77***	426.4***	123.9***	102.4***	6.696***	267.2***	77.55***	64.49***
t-stat1 (H0: $\Upsilon 3 = \Upsilon 4$)	4.100**	145.4***	31.38***	16.84***	1.863	144.2***	24.45***	13.71***	18.85***	60.91***	8.984***	13.01***

	Panel D: Period 2015.01.05-2020.06.12				Panel E: Period 2018.01.05-2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$
$\Upsilon 0$	1.211***	0.802***	1.102***	0.915***	1.296***	0.867***	1.089***	0.988***
	(0.028)	(0.036)	(0.048)	(0.033)	(0.036)	(0.052)	(0.055)	(0.061)
$\Upsilon 1$	0.474***	0.812***	0.389***	0.826***	0.353***	0.759***	0.398***	0.733***
	(0.107)	(0.085)	(0.057)	(0.099)	(0.099)	(0.087)	(0.059)	(0.115)
$\Upsilon 2$	0.144***	0.760***	0.482***	0.441***	0.021	0.587***	0.337***	0.368***
	(0.044)	(0.044)	(0.047)	(0.059)	(0.054)	(0.055)	(0.056)	(0.111)
$\Upsilon 3$	–0.124***	–0.079***	–0.027***	–0.136***	–0.090**	–0.072**	–0.028***	–0.117***
	(0.045)	(0.014)	(0.008)	(0.036)	(0.041)	(0.014)	(0.008)	(0.036)
$\Upsilon 4$	0.031***	–0.059***	–0.025***	–0.050**	0.010	–0.050***	–0.020*	–0.076**
	(0.011)	(0.006)	(0.007)	(0.020)	(0.014)	(0.009)	(0.011)	(0.035)
Obs .	734	686	694	726	307	329	371	265
R-squared	0.305	0.588	0.436	0.271	0.070	0.443	0.265	0.233
t-stat1 (H0: $\Upsilon 1 = \Upsilon 2$)	12.55***	161***	55.38***	46.24***	6.326***	67.48***	27.42***	20.59***
t-stat1 (H0: $\Upsilon 3 = \Upsilon 4$)	8.539***	51.95***	9.123***	9.138***	2.713*	22.73***	6.125***	5.960***

TABLE 6.2
MARKET REGIMES (EQUATION 2 FOR THE SHENZHEN STOCK EXCHANGE, SZSE)

	Panel A: Period 2001.01.30-2020.06.12				Panel B: Period 2005.07.21-2020.06.12				Panel C: Period 2010.01.04-2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$
$\gamma 0$	1.191***	0.809***	1.018***	0.951***	1.297***	0.871***	1.122***	1.022***	1.281***	0.832***	1.031***	0.960***
	(0.018)	(0.021)	(0.026)	(0.020)	(0.020)	(0.025)	(0.031)	(0.023)	(0.022)	(0.027)	(0.036)	(0.027)
$\gamma 1$	0.609***	0.673***	0.479***	1.132***	0.462***	0.629***	0.412***	1.008***	0.483***	0.657***	0.471***	1.117***
	(0.113)	(0.066)	(0.043)	(0.131)	(0.108)	(0.064)	(0.042)	(0.127)	(0.109)	(0.066)	(0.045)	(0.133)
$\gamma 2$	0.275***	0.672***	0.497***	0.465***	0.218***	0.718***	0.494***	0.446***	0.006	0.653***	0.446***	0.468***
	(0.027)	(0.023)	(0.027)	(0.032)	(0.027)	(0.027)	(0.029)	(0.033)	(0.042)	(0.033)	(0.038)	(0.047)
$\gamma 3$	–0.150***	–0.070***	–0.051***	–0.380***	–0.112***	–0.066***	–0.044***	–0.337***	–0.117***	–0.069***	–0.050***	–0.374***
	(0.043)	(0.009)	(0.007)	(0.070)	(0.039)	(0.009)	(0.006)	(0.066)	(0.040)	(0.009)	(0.007)	(0.071)
$\gamma 4$	–0.017***	–0.051***	–0.034***	–0.041***	–0.002	–0.057***	–0.031***	–0.037***	0.059***	–0.046***	–0.018***	–0.068***
	(0.007)	(0.004)	(0.005)	(0.009)	(0.007)	(0.004)	(0.004)	(0.009)	(0.014)	(0.006)	(0.007)	(0.017)
Obs.	2,556	2,498	2,503	2,551	2,041	1,846	1,862	2,025	1,381	1,344	1,225	1,500
R-squared	0.165	0.481	0.342	0.269	0.171	0.510	0.357	0.269	0.216	0.484	0.366	0.237
t-stat1 (H0: $\gamma 1=\gamma 2$)	57.85***	440.5***	182.9***	122.4***	37.24***	374.6***	154.5	102.9***	10.08***	214.7***	89.02***	64.48***
t-stat1 (H0: $\gamma 3=\gamma 4$)	8.767***	109.5***	44.29***	21.97***	4.050***	114.2***	42.32***	19.73***	14.57***	52.67***	26.76***	19.43***

	Panel D: Period 2015.01.05-2020.06.12				Panel E: Period 2018.01.05-2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$
$\gamma 0$	1.259***	0.830***	1.118***	0.920***	1.289***	0.879***	1.081***	0.937***
	(0.030)	(0.038)	(0.050)	(0.036)	(0.035)	(0.054)	(0.057)	(0.066)
$\gamma 1$	0.514***	0.658***	0.415***	1.189***	0.472***	0.624***	0.439***	1.158***
	(0.114)	(0.069)	(0.047)	(0.143)	(0.114)	(0.071)	(0.050)	(0.172)
$\gamma 2$	0.093*	0.739***	0.469***	0.482***	0.023	0.551***	0.320***	0.491***
	(0.053)	(0.052)	(0.051)	(0.064)	(0.049)	(0.059)	(0.057)	(0.118)
$\gamma 3$	–0.125***	–0.069***	–0.044***	–0.399***	–0.115***	–0.065***	–0.047***	–0.389***
	(0.041)	(0.009)	(0.007)	(0.075)	(0.041)	(0.009)	(0.007)	(0.081)
$\gamma 4$	0.046***	–0.055***	–0.022**	–0.070***	0.015	–0.050***	–0.024**	–0.111***
	(0.017)	(0.008)	(0.008)	(0.022)	(0.013)	(0.010)	(0.011)	(0.040)
Obs.	722	698	717	703	299	337	380	256
R-squared	0.279	0.524	0.377	0.261	0.157	0.357	0.233	0.252
t-stat1 (H0: $\gamma 1=\gamma 2$)	10.37***	116.8***	53.38***	45***	8.844***	57.08***	39.17***	22.72***
t-stat1 (H0: $\gamma 3=\gamma 4$)	9.938***	42.81***	23.10***	16.46***	5.211***	30.57***	22.86***	11.99***

(Panel, B, C, D and E) in Tables 6.1 and 6.2. We cannot reject Hypothesis 3. And we can say, therefore, that we find that herding behavior before and after the COVID-19 event date and that herding behavior is stronger during down market regimes than up market scenarios.

One potential explanation for an asymmetry in herding activity between bull and bear markets might be the flow of positive and negative information. If the market is booming, it is possible to find more buy than sell recommendations. If investors make decisions based on these recommendations, then we should observe stronger herding behavior in bull markets than in bear markets. Another possibility is the common belief in the market that the government will intervene when markets decline significantly, which makes herding behavior less likely when markets fall. It may also be the case that investors are more focused on big companies in bull markets when they engage in herding activity. Due to loss aversion, investors may be less likely to act in a coordinated manner in a downward trending market because they are unwilling to assume immediate losses, and they therefore avoid selling their shares as market prices fall (Statman, Thorley, and Vorkink, 2006). Empirical results are consistent with more pronounced herding behavior in rising markets as opposed to falling markets. Moreover, Duffee (2001) finds that aggregate trading volume tends to be higher on days when the stock market rises than on days when it falls. Finally, Seetharam and Britten (2013) argue that this type of investor behavior may be due to quicker responses to any type of news in a down market, and because low-market investors become under confident and try to follow market fundamentals instead of trends.

The results for herding behavior under high and low volatility states are conclusive. In Table 6.1 and Table 6.2 (Panel A) the estimates for γ_3 are greater during low volatility states (in absolute terms). And these results hold across the other time windows. In addition, $\gamma_3 > \gamma_4$ (in absolute value) in both the SHSE and the SZSE. This shows that herding behavior increases after the COVID-19 event date. The difference between the γ_3 and γ_4 estimates is statistically significant in all cases. When comparing high volatility and low volatility states, it becomes clear that herding behavior is stronger in a low volatility state, regardless of the time window. We can say, therefore, that herding behavior is more pronounced in lower levels of volatility and after the COVID-19 event date, and Hypothesis 4 cannot be rejected.

Chiang *et al.* (2013) report similar results using a time-varying coefficients model. Herding is positively related to state of market return but negatively related to market volatility. Our results are consistent with more pronounced herding behavior in bull markets and in low volatility regimes before and after the COVID-19 event date. Low volatility might be associated with a higher level of agreement in the market regarding the quality of stocks; therefore, it is more likely that investors will coincide in their appraisals of investment decisions. Something similar happens with analysts. In low volatility regimes, analysts give more similar advice on which investors tend to rely, which makes herding behavior more likely.

To check the robustness of our results, we estimate Equation (4) including the control variables. The results for the SHSE are reported in the Table 7.1, and

TABLE 7.1
MARKET REGIMES (EQUATION 4 FOR THE SHANGHAI STOCK EXCHANGE, SHSE)

	Panel A: Period 2001.01.30-2020.06.12				Panel B: Period 2005.07.21-2020.06.12				Panel C: Period 2010.01.04-2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$
$\gamma 0$	1.344***	0.879***	1.173***	1.038***	1.343***	0.878***	1.172***	1.038***	1.298***	0.828***	1.050***	0.977***
	(0.020)	(0.025)	(0.033)	(0.022)	(0.020)	(0.025)	(0.033)	(0.022)	(0.019)	(0.027)	(0.035)	(0.026)
$\gamma 1$	0.336***	0.794***	0.341***	0.687***	0.336***	0.795***	0.341***	0.687***	0.395***	0.862***	0.431***	0.765***
	(0.095)	(0.080)	(0.049)	(0.087)	(0.095)	(0.081)	(0.050)	(0.087)	(0.093)	(0.085)	(0.053)	(0.090)
$\gamma 2$	0.160***	0.714***	0.449***	0.417***	0.161***	0.716***	0.450***	0.417***	0.001	0.657***	0.416***	0.438***
	(0.027)	(0.025)	(0.028)	(0.030)	(0.027)	(0.025)	(0.028)	(0.030)	(0.033)	(0.029)	(0.035)	(0.043)
$\gamma 3$	–0.072*	–0.076***	–0.023***	–0.114***	–0.073*	–0.076***	–0.023***	–0.114***	–0.088**	–0.084***	–0.034***	–0.128***
	(0.039)	(0.013)	(0.008)	(0.030)	(0.039)	(0.013)	(0.008)	(0.030)	(0.039)	(0.014)	(0.009)	(0.032)
$\gamma 4$	0.006	–0.059***	–0.030***	–0.037***	0.005	–0.059***	–0.030***	–0.037***	0.052***	–0.047***	–0.018***	–0.062***
	(0.007)	(0.003)	(0.004)	(0.008)	(0.007)	(0.004)	(0.004)	(0.008)	(0.010)	(0.005)	(0.006)	(0.015)
$\gamma 5$	–0.158***	0.094***	–0.112***	–0.148***	–0.160***	0.094***	–0.113***	–0.148***	–0.166***	0.087*	–0.153***	–0.135***
	(0.030)	(0.036)	(0.031)	(0.031)	(0.030)	(0.037)	(0.031)	(0.031)	(0.040)	(0.050)	(0.051)	(0.035)
$\gamma 6$	–0.014	–0.015	–0.005	0.022	–0.014	–0.015	–0.005	0.022	0.002	0.033	0.031	0.045
	(0.028)	(0.034)	(0.032)	(0.031)	(0.028)	(0.034)	(0.032)	(0.031)	(0.031)	(0.039)	(0.041)	(0.033)
$\gamma 7$	0.034	–0.117	0.128	–0.229**	0.035	–0.117	0.128	–0.229**	0.323*	0.041	0.356	–0.093
	(0.174)	(0.235)	(0.215)	(0.116)	(0.174)	(0.235)	(0.215)	(0.116)	(0.176)	(0.239)	(0.238)	(0.104)
Obs .	2,070	1,835	1,813	2,092	2,065	1,822	1,795	2,092	1,408	1,316	1,189	1,535
R-squared	0.153	0.507	0.337	0.260	0.153	0.507	0.337	0.260	0.231	0.522	0.405	0.239
t-stat1 (H0: $\gamma 1=\gamma 2$)	20.95***	427.5***	131.3***	108.3***	21.17***	422.6***	130.2***	108.3***	9.302***	267.9***	80.25***	67.02***
t-stat1 (H0: $\gamma 3=\gamma 4$)	2.274	147.8***	27.95***	16.99***	2.262	147***	28.03***	16.99***	18.78***	65.51***	10.43***	14.95***

	PanelD:Period2015.01.05–2020.06.12				PanelE:Period2018.01.05–2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$
$\gamma 0$	1.215***	0.799***	1.095***	0.914***	1.295***	0.865***	1.083***	0.982***
	(0.028)	(0.036)	(0.048)	(0.033)	(0.037)	(0.051)	(0.055)	(0.062)
$\gamma 1$	0.537***	0.898***	0.398***	0.849***	0.375***	0.891***	0.407***	0.753***
	(0.099)	(0.097)	(0.056)	(0.096)	(0.098)	(0.106)	(0.058)	(0.117)
$\gamma 2$	0.161***	0.778***	0.494***	0.448***	0.035	0.622***	0.347***	0.373***
	(0.047)	(0.044)	(0.048)	(0.059)	(0.064)	(0.056)	(0.058)	(0.111)
$\gamma 3$	–0.125***	–0.088***	–0.030***	–0.142***	–0.085**	–0.087***	–0.031***	–0.117***
	(0.041)	(0.015)	(0.009)	(0.034)	(0.039)	(0.015)	(0.009)	(0.034)
$\gamma 4$	0.031***	–0.059***	–0.028***	–0.053***	0.009	–0.049***	–0.025**	–0.079**
	(0.011)	(0.006)	(0.007)	(0.020)	(0.014)	(0.009)	(0.011)	(0.035)
$\gamma 5$	–0.234***	0.164**	–0.159*	–0.115**	–0.108	0.250**	–0.130	–0.032
	(0.073)	(0.078)	(0.083)	(0.053)	(0.081)	(0.098)	(0.086)	(0.078)
$\gamma 6$	0.026	–0.026	–0.003	0.095*	0.002	–0.029	–0.016	0.101
	(0.056)	(0.053)	(0.060)	(0.048)	(0.053)	(0.059)	(0.056)	(0.062)
$\gamma 7$	0.316	0.059	0.269	–0.081	0.521*	–0.080	0.295	0.027
	(0.194)	(0.271)	(0.258)	(0.110)	(0.305)	(0.228)	(0.300)	(0.248)
Obs .	734	686	694	726	307	329	371	265
R-squared	0.325	0.592	0.444	0.279	0.100	0.460	0.281	0.244
t-stat1 (H0: $\gamma 1=\gamma 2$)	16.80***	163.8***	57.91***	49.53***	7.728***	68***	29.83***	21.09***
t-stat1 (H0: $\gamma 3=\gamma 4$)	19.549***	55.67***	10.44***	10.89***	2.688*	24.91***	7.136***	6.525***

TABLE 7.2
MARKET REGIMES (EQUATION 4 FOR THE SHENZHEN STOCK EXCHANGE, SZSE)

	Panel A: Period 2001.01.30-2020.06.12				Panel B: Period 2005.07.21-2020.06.12				Panel C: Period 2010.01.04-2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH} > \sigma^{MA}_{t-30}$	$\sigma^{HIGH} < \sigma^{MA}_{t-30}$
γ_0	1.301***	0.872***	1.125***	1.023***	1.301***	0.869***	1.122***	1.023***	1.284***	0.827***	1.024***	0.961***
	(0.019)	(0.025)	(0.031)	(0.023)	(0.019)	(0.025)	(0.031)	(0.023)	(0.022)	(0.027)	(0.036)	(0.027)
γ_1	0.496***	0.651***	0.404***	1.006***	0.498***	0.653***	0.406***	1.006***	0.529***	0.720***	0.475***	1.122***
	(0.106)	(0.069)	(0.044)	(0.132)	(0.106)	(0.069)	(0.044)	(0.132)	(0.104)	(0.077)	(0.048)	(0.137)
γ_2	0.224***	0.719***	0.494***	0.454***	0.226***	0.721***	0.497***	0.454***	0.022	0.661***	0.455***	0.472***
	(0.025)	(0.027)	(0.028)	(0.032)	(0.025)	(0.027)	(0.028)	(0.032)	(0.042)	(0.033)	(0.039)	(0.047)
γ_3	–0.110***	–0.067***	–0.044***	–0.331***	–0.110***	–0.067***	–0.044***	–0.331***	–0.116***	–0.075***	–0.052***	–0.374***
	(0.038)	(0.009)	(0.007)	(0.073)	(0.038)	(0.009)	(0.007)	(0.073)	(0.037)	(0.010)	(0.008)	(0.078)
γ_4	–0.000	–0.057***	–0.032***	–0.040***	–0.000	–0.057***	–0.033***	–0.040***	0.059***	–0.047***	–0.021***	–0.071***
	(0.006)	(0.004)	(0.004)	(0.008)	(0.006)	(0.004)	(0.004)	(0.008)	(0.014)	(0.006)	(0.007)	(0.016)
γ_5	–0.117***	0.021	–0.111***	–0.124***	–0.119***	0.020	–0.113***	–0.124***	–0.160***	0.023	–0.162***	–0.112***
	(0.032)	(0.038)	(0.031)	(0.032)	(0.032)	(0.038)	(0.031)	(0.032)	(0.041)	(0.055)	(0.050)	(0.037)
γ_6	–0.032	0.022	0.007	–0.004	–0.032	0.023	0.008	–0.004	–0.009	0.075*	0.057	0.034
	(0.030)	(0.034)	(0.030)	(0.034)	(0.030)	(0.034)	(0.030)	(0.034)	(0.033)	(0.042)	(0.039)	(0.036)
γ_7	–0.025	–0.312*	–0.007	–0.278**	–0.025	–0.312*	–0.007	–0.278**	0.187	–0.165	0.164	–0.169
	(0.162)	(0.185)	(0.190)	(0.126)	(0.162)	(0.185)	(0.191)	(0.126)	(0.160)	(0.183)	(0.201)	(0.116)
Obs .	2,046	1,859	1,880	2,025	2,041	1,846	1,862	2,025	1,381	1,344	1,225	1,500
R-squared	0.182	0.511	0.362	0.277	0.183	0.511	0.363	0.277	0.228	0.487	0.373	0.243
t-stat1 (H0: $\gamma_1=\gamma_2$)	45.50***	364.6***	159.8***	107.4***	46.16***	362.3***	160***	107.4***	13.20***	205.2***	88.17***	65.28***
t-stat1 (H0: $\gamma_3=\gamma_4$)	4.214**	113***	41.42***	19.30***	4.231***	113.1***	41.91***	19.30***	14.93***	53.71***	24.99***	18.17***

	PanelD:Period2015.01.05–2020.06.12				PanelE:Period2018.01.05–2020.06.12			
	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH}>\sigma^{MA}_{t-30}$	$\sigma^{HIGH}<\sigma^{MA}_{t-30}$	$R_{m,t}>0$	$R_{m,t}<0$	$\sigma^{HIGH}>\sigma^{MA}_{t-30}$	$\sigma^{HIGH}<\sigma^{MA}_{t-30}$
γ_0	1.263***	0.827***	1.110***	0.917***	1.292***	0.872***	1.074***	0.924***
	(0.030)	(0.038)	(0.049)	(0.036)	(0.036)	(0.054)	(0.057)	(0.066)
γ_1	0.574***	0.729***	0.414***	1.201***	0.448***	0.746***	0.441***	1.171***
	(0.107)	(0.091)	(0.051)	(0.146)	(0.102)	(0.105)	(0.051)	(0.174)
γ_2	0.110**	0.750***	0.482***	0.486***	0.016	0.580***	0.327***	0.499***
	(0.055)	(0.052)	(0.052)	(0.064)	(0.053)	(0.061)	(0.057)	(0.116)
γ_3	–0.125***	–0.076***	–0.046***	–0.407***	–0.104***	–0.078***	–0.048***	–0.402***
	(0.039)	(0.011)	(0.008)	(0.081)	(0.039)	(0.012)	(0.007)	(0.080)
γ_4	0.046***	–0.055***	–0.025***	–0.071***	0.016	–0.050***	–0.027**	–0.114***
	(0.017)	(0.008)	(0.009)	(0.022)	(0.014)	(0.010)	(0.011)	(0.039)
γ_5	–0.202***	0.060	–0.170**	–0.076	0.009	0.126	–0.107*	0.093
	(0.075)	(0.088)	(0.075)	(0.059)	(0.072)	(0.111)	(0.065)	(0.090)
γ_6	–0.008	0.051	0.032	0.119**	–0.017	0.056	0.028	0.143
	(0.057)	(0.057)	(0.052)	(0.060)	(0.041)	(0.061)	(0.045)	(0.089)
γ_7	0.187	–0.217	0.060	–0.146	0.326	–0.149	0.263	–0.077
	(0.169)	(0.204)	(0.216)	(0.120)	(0.273)	(0.234)	(0.245)	(0.319)
Obs .	722	698	717	703	299	337	380	256
R-squared	0.292	0.527	0.384	0.267	0.166	0.369	0.242	0.276
t-stat1 (H0: $\gamma_1=\gamma_2$)	14.42***	111.7***	52.25***	44.56***	10.06***	48.70***	38.27***	22.71***
t-stat1 (H0: $\gamma_3=\gamma_4$)	10.38***	40.97***	19***	15.28***	4.834***	27.59***	21.91***	12.90***

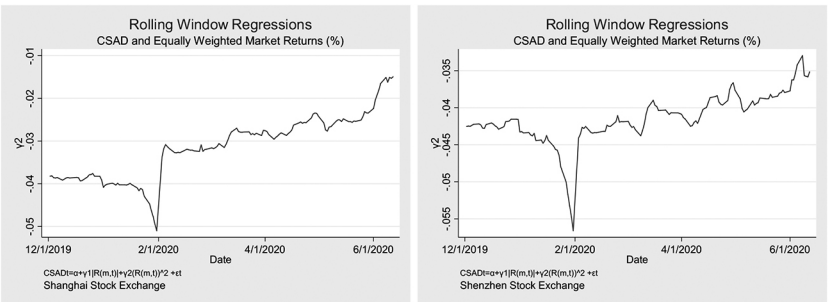
Table 7.2 shows the results for the SZSE. In most of the time windows, herding behavior is stronger in down markets compared to up markets. In terms of volatility states, however, herding is stronger in all time windows when the market exhibits low volatility.

5.3. Rolling Window Analysis

Now we analyze if the increase in herding behavior holds after the COVID-19 event date, using rolling window regression methodology. We build windows of 100, 200, 400, and 600 days to generate series of the estimated coefficients, particularly looking to analyze β_1 and β_2 from Equation (1). For robustness we re-estimate the models recursively. The results turned out to be similar.

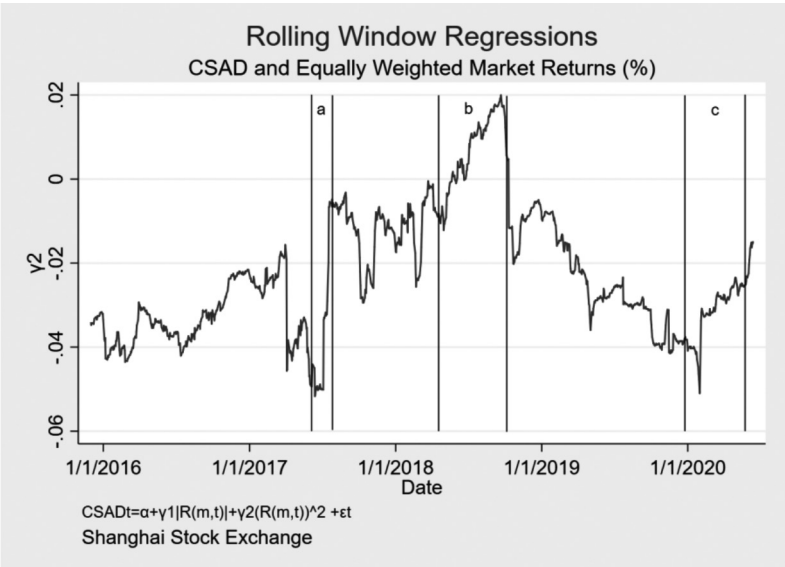
Figure 2 shows the evolution of β_2 from Equation (1) for the SHSE and SZSE during the period between December 01, 2019, and June 12, 2020. Every coefficient is statistically significant at 5% and even at lower levels of statistical significance. The average R^2 is 0.25 (min 0.21, max 0.30) for the SHSE and 0.19 (min 0.17, max 0.23) for the SZSE. We find that herding behavior increases after December 31, 2019 (the COVID-19 event date). As bad news about the pandemic continued to be announced (COVID-19 cases and deaths), herding activity decreased with the same intensity as it increased. This could indicate that in the face of events that create an extreme perception of systemic gravity, investors participating in a market rely on their own decisions to a greater extent. Finally, we explore the behavior of β_2 in Equation (1) over a five-year period. We find that herding behavior during this period shows similar patterns in terms of a decrease in magnitude in different previous periods. As shown in Figure 3, (a) identifies the period in which diplomatic relations between China and Panama began (immediately after the breakdown of diplomatic relations between Panama and Taiwan); (b) is the period that encompasses the high-point for China-US relations, inferring that the COVID-19

FIGURE 2
ROLLING WINDOW REGRESSION (RWR) FOR SHSE AND SZSE.
RWR to $CSAD_t = \alpha + \beta_1 |R_{m,t}| + \beta_2 (R_{m,t})^2 + \varepsilon_t$



pandemic is a new factor that influences the behavior of stock markets; and (c) is the period after the COVID-19 announcement. WHO's declaration that COVID-19 was a pandemic.

FIGURE 3
ROLLING WINDOW REGRESSION OVER SHSE



6. Conclusions

The results reported in this study confirm the existence of herding behavior in the Chinese stock market by using the cross-sectional absolute deviation (CSAD) model on stock return data in the period between January 30, 2001, and June 12, 2020. We consider A-share stock prices for all firms traded on the SHSE and SZSE. We show that herding behavior occurred during the entire period.

We include three control variables (regional stock return, world stock return, and exchange rate) to see if herding behavior is still observable in both stock markets. The results clearly show that herding activity is observable even when the controls are included and that the size of the coefficient estimates do not change significantly.

We split the sample according to the market return level (to identify bull and bear markets) and we show that there is asymmetric behavior, revealing stronger herding behavior in an up market. Moreover, we show that herding behavior is more pronounced during the period of COVID-19 under study. In terms of market volatility, we find that lower levels of volatility are associated with more pronounced herding behavior.

Our results show more pronounced herding behavior occurs in bull markets and in low volatility regimes (before and after the COVID-19 event date). More pronounced herding activity in a low volatility market might be associated with a higher level of agreement in the market regarding the quality of stocks; in this scenario, it is more likely that investors will coincide in their appraisals of investment decisions. Something similar happens with analysts, who give more similar advice in low volatility markets on which investors tend to rely, which makes herding behavior more likely. On the other hand, in stock markets with high volatility and negative returns, investors will gather more information to make decisions and try to avoid losses. Moreover, analysts in the market will not agree on investment decisions because there is a high uncertainty regarding the future of the economy and, therefore, the future of the stock market.. Finally, we cannot affirm that herding behavior is good or bad for market, as the reasons for the behavior might be rational or irrational.

To check the robustness of our results, we split the sample into a series of different time windows. The results show stronger herding behavior in the stock market after December 31, 2019 (the COVID-19 event date). However, as further bad news about the COVID-19 pandemic continued to be announced (COVID-19 cases and deaths), herding behavior decreases with the same intensity as it increased. It is clear that herding activity is weaker when the market is low (bear market) and in a high volatility state. It is likely that in situations with extreme perception of systemic gravity, investors may have a greater degree of trust in their own decisions, as opposed to the collective beliefs of market participants. As a robustness check, we use time-varying coefficients using rolling regressions.

This paper contributes to the literature on herding behavior in stock markets by examining four hypotheses related to Chinese stock markets and how herding behavior changes after the COVID-19 event date. We controlled for other variables to confirm the presence of herding behavior in our results and they did not change: herding behavior is still present during the period of COVID-19 under study. Indeed, our results are distinct and opposite to those obtained by Wu *et al.* (2020).

This article is not absent of limitations. First, similar to other studies on herding behavior, we are able to identify herding but not able to associate it with one or more alternative explanations for the behavior. Second, Equation (2) is regularly used in the literature to isolate potential herding behavior during COVID-19; however, it is impossible to discern if herding increases during the time period under study or if the movement comes from a common shock. This is a common limitation in all studies that employ CSAD methodology. We control by three relevant variables (regional market return, world market return, and exchange rate return) to mitigate this limitation as far as possible.

In terms of avenues of future research, as previous studies in herding behavior have come to different conclusions, it might be useful to explore other methodologies, such as nonparametric kernel regressions and smooth transition regressions, to test for herding behavior. Furthermore, the date of the COVID-19 event could be identified endogenously, which would be particularly interesting

if used in conjunction with a cross-country study. Finally, once there is universal agreement regarding the end of the COVID-19 pandemic, it will be necessary to repeat these studies on the presence of herding behavior in stock markets using data from a time period that covers the pandemic as a whole.

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Credenciales universitarias y diferenciales salariales en la estructura productiva argentina*

University credentials and wage differentials in the Argentine productive structure

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Resumen

Este trabajo estima el retorno salarial de las distintas credenciales educativas de nivel universitario en Argentina, a partir de datos administrativos para 2019. Los resultados indican considerable variabilidad según jerarquía del título y área del conocimiento. Las Ciencias Aplicadas obtienen los mejores resultados, mientras que lo contrario ocurre para las Humanidades. Estos efectos son mayores para individuos situados en la cola derecha de la distribución condicional de salarios.

Palabras clave: *Retornos a la educación, credenciales, regresiones cuantílicas.*

Clasificación JEL: *I26, J31.*

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Abstract

We estimate the wage return of the different university-level educational credentials in Argentina using administrative data for 2019. The results indicate sizeable variability according to the hierarchy of the degree and area of knowledge. Applied Sciences obtain the best results, while the opposite is true for the Humanities. These effects are higher for individuals located in the right tail of the conditional wage distribution.

Key words: *Returns to education, credentials, quantile regressions.*

Clasificación JEL: *I26, J31.*

1. Introducción

La literatura laboral incluye una importante tradición de medición de los retornos salariales al capital humano adquirido en la educación formal. Desde los primeros estudios acerca de capital humano (Schultz, 1961), existe amplio consenso en que las credenciales educativas tienen un impacto considerable en los salarios a lo largo de la vida de los individuos, aunque no siempre existe acuerdo respecto de los mecanismos que explican esta asociación (Spence, 1973). Si bien la magnitud de estos retornos ha sido extensamente estudiada, la evidencia pertinente a variabilidad entre credenciales provenientes de distintas áreas del conocimiento es mucho más limitada.

La desigual retribución de los distintos tipos de títulos universitarios en el mercado de trabajo puede responder a una variedad de razones. Si estos rendimientos reflejan la escasez relativa de cada perfil profesional, esto puede considerarse una consecuencia natural de la dificultad en la obtención de cada tipo de credencial, o bien de las preferencias reveladas de los agentes que en muchos casos optan por estudiar carreras en las que el componente salarial no es el único determinante de la elección. Sin embargo, no es posible descartar que existan asimetrías informativas u otras fallas de mercado que expliquen este fenómeno, lo que constituiría una oportunidad para el diseño de políticas públicas capaces de mejorar los resultados observados.

Este trabajo hace uso de una nueva base de datos de graduados universitarios para aportar evidencia empírica de los diferenciales salariales asociados a distintos tipos de credenciales universitarias en Argentina. Hasta el momento, la literatura laboral empírica ha trabajado con variables educativas expresadas en años de escolaridad o bien en forma dicotómica (como la presencia o ausencia de una credencial determinada); la contribución de este trabajo consiste en incorporar una dimensión de calidad en la medición del retorno salarial a los títulos universitarios. En particular, se muestra que los resultados salariales varían considerablemente entre títulos de distintas jerarquías y áreas del conocimiento.

Se trata del primer estudio de este tipo para América Latina; las encuestas de hogares disponibles en la región generalmente no permiten una caracterización tan detallada de los perfiles profesionales observados en el mercado de trabajo, de modo que el trabajo con una base que surge de combinar dos fuentes de datos administrativas para Argentina representa la principal innovación de este trabajo. Los resultados obtenidos indican que la variabilidad entre primas (o penalidades) salariales asociadas a distintos títulos universitarios no solo es considerable, sino que además ofrece distintos patrones sectoriales.

El trabajo está estructurado de la siguiente manera. La sección 2 repasa la literatura existente. La sección 3 describe las fuentes de datos utilizadas en los ejercicios empíricos realizados. La sección 4 detalla la metodología implementada. La sección 5 presenta los resultados más relevantes. Finalmente, la sección 6 ofrece algunas conclusiones.

2. Revisión de la literatura

La relación entre el salario y el nivel educativo ha sido estudiada tradicionalmente en el marco de la teoría del capital humano[1]. Bajo este enfoque de corte neoclásico, los individuos deciden invertir en determinadas actividades, entre ellas la educación[2], que les permiten elevar sus ingresos futuros al aumentar sus productividades individuales, es decir, que dicha inversión les rendirá un retorno.

Una conceptualización alternativa de la relación entre educación y salarios viene dada por los llamados modelos de señalización (*signalling*). En este marco, la información asimétrica en el mercado de trabajo, es decir, el hecho de que las empresas no pueden observar *ex ante* la productividad idiosincrática de los trabajadores evita que los salarios reflejen diferenciales de productividad en ausencia de señales informativas que subsanen esa falla de mercado. Una señal informativa podría ser, por ejemplo, una credencial educativa que, en este contexto, no tendría un efecto causal en la productividad, aunque sí en el salario. Por supuesto, este enfoque y el de capital humano no son mutuamente excluyentes, de modo que es plausible asumir que ambos fenómenos operan en alguna magnitud en la práctica.

Estas tradiciones teóricas dieron origen a un importante caudal de investigaciones empíricas orientadas a medir el impacto de la educación en los salarios, con o sin estrategias de identificación causal. El ejercicio empírico arquetípico es la estimación de alguna variante de la llamada ecuación de Mincer (1974), cuya variable dependiente es (generalmente, el logaritmo de) alguna medida salarial y sus variables independientes incluyen una o varias medidas de nivel educativo. Corresponde notar que mientras que la teoría del capital humano

1 Becker (1964) es habitualmente considerada la referencia seminal de esta literatura.

2 Entrenamiento laboral, atención médica, migración y búsqueda de información de precios y de ingresos son otras formas de inversión en capital humano. Todas ellas incrementan habilidades, conocimientos y salud y, por esta razón, ingresos futuros.

predice incrementos continuos en el salario ante cada aumento en la cantidad de años de educación, los modelos de señalización predicen discontinuidades, ya que sería la completitud de ciertos "bloques educativos" (verificables a nivel de credenciales) la que determina el salario obtenido (Hungerford y Solon, 1987; Belman y Heywood, 1991; Arkes, 1999).

Psacharopoulos y Patrinos (2004) y Peracchi (2006) proveen extensas revisiones de la literatura empírica de retornos a la educación en todo el mundo, incluyendo resultados tanto para la educación en general como para las credenciales universitarias en particular. En cambio, la evidencia en los diferenciales salariales asociados a distintos campos de estudio es más acotada. En general, estos trabajos encuentran que los graduados universitarios de las ramas de humanidades y ciencias sociales tienen, *ceteris paribus*, menores salarios que aquellos con títulos de disciplinas más "cuantitativas", como negocios[3], ingenierías o ciencias básicas (Arcidiacono, 2004; Buonanno y Pozzoli, 2009). Asimismo, la probabilidad de encontrar un empleo y la velocidad de hacerlo también son mayores en esas disciplinas.

Grave y Goerlitz (2012) realizan un ejercicio de descomposición para el caso de Alemania y encuentran que las brechas entre disciplinas se deben principalmente a diferencias en atributos observables mayormente asociados a características del puesto, de la firma o del mercado laboral, más que a atributos personales o al área de estudio elegida. En otras palabras, los graduados de artes y humanidades se insertan relativamente más en firmas, puestos, sectores o modalidades de trabajo que correlacionan con menores salarios. También muestran que las brechas decrecen a medida que se gana experiencia laboral.

Asimismo, Eide *et al.* (2016) se enfocan en las interacciones entre las disciplinas y el prestigio de las universidades en Estados Unidos y encuentran que el área de negocios presenta una prima salarial muy alta independientemente de la posición de la universidad. En cambio, las disciplinas llamadas STEM (ingenierías y ciencias básicas) no tienen diferencias significativas entre universidades. Finalmente, las ciencias sociales presentan una prima solo en universidades rankeadas en nivel alto.

En la misma línea, Britton *et al.* (2021) utilizan registros administrativos de Gran Bretaña y hallan una importante variabilidad de los retornos a la educación entre universidades y carreras. En particular, encuentran que las carreras LEM (derecho, economía y gestión) se asocian a primas salariales altas; Otras Carreras (artes, humanidades e idiomas), a penalidades y las carreras STEM (ciencia, tecnología, ingeniería y matemática), a resultados variados: medicina, informática, ingeniería y matemática obtienen buenos resultados, mientras que ciencias veterinarias, agricultura, psicología y ciencias biológicas, no[4]. Belfield

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[3] Entre graduados de posgrado en el área de negocios, las mayores primas salariales aparecen en finanzas y en tecnologías de la información (Grove y Hussey, 2011). La categoría también incluye áreas del conocimiento tales como administración y *marketing*.

[4] STEM y LEM por sus siglas en inglés: Science, Technology, Engineering and Mathematics (STEM) y Law, Economics and Management (LEM)

et al. (2018) arriban a similares resultados para ese territorio, aunque lo diferencian por género: varones que estudian artes creativas, idioma o filosofía tienen penalidades salariales, mientras que en medicina y economía reportan primas de alrededor de 20%; las mujeres no reportan penalidades en ninguna carrera, y al estudiar medicina o economía, las primas ascienden a 60%.

Para Argentina, la evolución de los retornos a la educación para los distintos niveles educativos (incluyendo el ámbito universitario) en las últimas décadas ha sido extensamente documentada (Groisman y Marshall, 2015; Ciaschi, 2017; Fiszbein *et al*., 2007; Paz, 2009), incluyendo una considerable discusión acerca de sus posibles determinantes. Sin embargo, no se han hallado estudios enfocados puntualmente en la variación de remuneraciones según disciplinas para graduados universitarios en general. Groisman y García de Fanelli (2009) proveen un punto de partida interesante al analizar los salarios de los docentes universitarios. Los autores encuentran una penalidad respecto de graduados universitarios no docentes, que además es heterogénea según profesión: la brecha es mayor entre contadores, abogados e ingenieros.

3. Datos

Este trabajo combina dos fuentes de información. La primera es la base de datos del sistema Araucano, utilizado por la Secretaría de Políticas Universitarias del Ministerio de Educación (SPU), donde se registran los estudiantes y graduados universitarios de todas las universidades públicas de Argentina, así como de la mayoría de las universidades privadas. La segunda es la base de datos del Sistema Integrado Previsional Argentino (SIPA) de noviembre de 2019, que contiene información de todos los puestos de trabajo asalariados registrados en ese mes.

La base Araucano indica, para cada estudiante, la institución y carrera correspondientes, además de la fecha de graduación, cuando corresponde. De esta base, se obtiene una muestra de 276 131 graduados entre 2016 y 2018. Esta información se cruza con los datos del SIPA para caracterizar la situación laboral de cada graduado en noviembre de 2019. Naturalmente, esto implica que no hay información acerca de aquellos graduados que no estén en un puesto laboral asalariado formal, sea porque se encuentran inactivos, desocupados o bien porque están trabajando en puestos informales o por cuenta propia. De este modo, las primas reportadas en este trabajo deben ser interpretadas como primas formales, ya que las informales son imposibles de estimar con datos administrativos. Además, debido a que se trabaja con un corte transversal, no es necesario transformar los valores monetarios, que están expresados en pesos corrientes del período de análisis. Por último, no se cuenta con información de horas trabajadas, de manera que no es posible computar salarios horarios.

La SPU clasifica carreras universitarias en cinco ramas que a su vez se dividen en 37 disciplinas y estas, a continuación, en 146 áreas. Sin embargo,

15 áreas[5] registran una cantidad muy pequeña de observaciones (inferior a 30) como para ser útiles en términos estadísticos, de modo que la base de trabajo final contiene solo 131 áreas. En las estimaciones se utilizan los tres niveles de agrupamiento como efectos fijos. Todos estos títulos universitarios pueden clasificarse por jerarquía de acuerdo con la siguiente estructura: pregrado y títulos intermedios, tecnicaturas, grado y profesorado, posgrado. En general, se usará el término "carreras" para referirse, genéricamente, a ramas, disciplinas o áreas, según corresponda.

La base final incluye algunas simplificaciones metodológicas. En primer lugar, algunos individuos obtuvieron más de un título universitario. En estos casos, se elige, para cada uno, el de mayor jerarquía; si dos o más tienen la misma jerarquía, se elige el más antiguo. Finalmente, si dos o más coinciden en jerarquía y en antigüedad (algo que ocurre en menos del 2% de los casos), se elige uno al azar. Análogamente, un mismo individuo puede ocupar más de un puesto de trabajo. En esos casos, se opta por computar el salario total de todas sus ocupaciones y asignarle el sector productivo de la actividad principal, es decir, la que genera mayor ingreso[6].

De este modo, la base de trabajo solo incluye un título para cada graduado que se encuentra en el mercado de trabajo formal. El objetivo de estas simplificaciones es evitar el trabajo con una base excesivamente complicada, en un contexto en que tanto el pluriempleo como la posesión de credenciales educativas provenientes de áreas distintas del conocimiento son inusuales y por tanto poco relevantes para nuestro análisis. Por otra parte, la elección del mes de noviembre de 2019 responde a distintas consideraciones, particularmente al interés por permitir cierto paso del tiempo entre la graduación y la inserción profesional y, al mismo tiempo, evitar el trabajo con meses típicamente afectados fuertemente por factores estacionales.

4. Metodología

Para estimar las primas salariales asociadas a distintos tipos de credenciales universitarias, se estiman distintas versiones de la siguiente ecuación:

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5 Se trata de áreas formadas por carreras que incluyen relativamente pocos estudiantes en Argentina. La mayoría pertenecen a la rama de ciencias aplicadas: sistemas aéreos y navales, geoquímica, oceanografía, ingeniería azucarera, ingeniería en vías de comunicación, demografía y balística, entre otras.

6 De este modo, se intenta captar, por un lado, el ingreso laboral total del individuo, y por otro, su inserción sectorial principal. En algunos sectores (como enseñanza, salud y comercio) el pluriempleo tiene cierta importancia y coexiste con jornadas laborales algo más reducidas (como se desprende de las encuestas de hogares tradicionales de Argentina), de modo que el cómputo adecuado de la prima salarial de interés requiere contemplar la posibilidad de que el individuo se desempeñe en varios puestos de trabajo.

$$\ln w_{ipcuj} = x_{1i}\beta + x_{2p}\pi + \gamma_c + \delta_u + \eta_j + \mu_{ipcuj} \quad (1)$$

Donde ln w_{ipcuj} es el logaritmo natural del salario del individuo *i*, que trabaja en la empresa u organización *p* y se graduó de la carrera de tipo *c* y jerarquía *j* en la universidad *u*. El tipo de carrera puede corresponder a la rama, disciplina o área de la carrera en cuestión y cada caso será mencionado como modelo 1, 2 y 3 respectivamente. El vector χ_{1i} está formado por atributos observables del individuo (género, edad, experiencia laboral formal[7] y provincia de residencia) y el vector χ_{2p} contiene características de la empresa en que el individuo *i* trabaja (tamaño y sector productivo al que pertenece)[8]. μ es un término de error con propiedades habituales que naturalmente incluye cualquier heterogeneidad inobservable entre individuos, particularmente todo lo relacionado a talento y preferencias.

Debido a que esta heterogeneidad inobservable factiblemente está correlacionada con la elección de carrera universitaria, no es posible dar interpretación causal a la estimación de estos modelos por mínimos cuadrados ordinarios (MCO). Sin embargo, los valores obtenidos a partir de esta estimación sí permiten describir los resultados alcanzados en el mercado laboral formal por los graduados de cada carrera universitaria, *ceteris paribus* otros atributos individuales observables. De este modo, se centrará el análisis en los valores obtenidos para los efectos fijos por carrera y jerarquía (γ y η) en cada modelo, además de los coeficientes asociados a algunos regresores de interés contenidos en χ_{1i} y χ_{2p}. En las variables categóricas, la categoría base siempre es elegida de modo tal que su valor observado para la variable dependiente sea el más cercano a la media general, con el fin de facilitar la interpretación de los coeficientes estimados.

Es posible que la endogeneidad no provenga solo de la existencia de heterogeneidades inobservables sino también del hecho de que algunas variables de control (en particular, las que caracterizan el puesto de trabajo) sean en sí mismas funciones de las variables de interés, lo que originaría un problema de *malos controles* (Angrist y Pischke, 2009). Efectivamente, la hipótesis de que la remuneración se determina en conjunto con (por ejemplo) el sector productivo de inserción merece atención en la investigación futura. La base de datos utilizada en este estudio no ofrece una estrategia de identificación que permita aislar los efectos de la credencial educativa sobre el salario y la elección de la ocupación.

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7 Calculada a partir de rastrear retrospectivamente a cada individuo en las bases de datos del SIPA.

8 La clasificación en tamaños incluye microempresas (menos de 10 empleados), empresas pequeñas (10 a 49), medianas (50 a 200) y grandes (más de 200). La clasificación por sector productivo se realiza a nivel de letra y con base en el Clasificador de Actividad Económica (CLAE) utilizado por la Administración Federal de Ingresos Públicos (AFIP).

También es importante señalar que, por tratarse de una base de datos de origen administrativo, solo se cuenta con información correspondiente al mercado de trabajo formal. Naturalmente, la probabilidad de inserción en el segmento formal del mercado de trabajo factiblemente no es igual para todos los individuos, lo que sugiere que las estimaciones realizadas pueden estar afectadas por sesgo de selección. Lamentablemente, no se cuenta con información que permita realizar algún tipo de corrección (en particular, la base no contiene variables que permitan caracterizar el origen socioeconómico de los graduados), por tanto, esta posibilidad no será explorada en el trabajo.

Finalmente, es interesante contemplar la posibilidad de que el parámetro asociado a las variables de interés varíe a lo largo de la distribución condicional del salario. En particular, considerando que el término de error puede interpretarse en términos de atributos individuales inobservables que afectan el salario, es posible que una determinada credencial universitaria tenga un retorno salarial distinto para individuos con distintas dotaciones de esos atributos. Para evaluar esta posibilidad, se estiman regresiones cuantílicas condicionales:

$$Q_\tau(\ln w_{ipcuj} \mid z_{ipcuj}) = x_{1i}\beta^\tau + x_{2p}\pi^\tau + \gamma_c^\tau + \delta_u^\tau + \eta_j^\tau \quad (2)$$

Donde z_{ipcuj} es el vector que incluye todas las variables independientes (tanto las que forman parte de χ_{1i} y χ_{2p}, como las *dummies* de tipo de carrera, universidad y jerarquía) y Q_τ es el cuantil τ de una distribución.

5. Resultados

5.1. Descriptivos

La Tabla 1 presenta información descriptiva para el año 2018. Con el fin de indagar en la cuestión de la representatividad de la base de datos utilizada, se compara lo observado con la información publicada por la SPU en sus Anuarios Estadísticos[9]. Como se observa, la única diferencia relevante entre las dos fuentes de información es cierta sobrerrepresentación del sistema público en Araucano, que a su vez va de la mano con una subrepresentación de las universidades más pequeñas. Esto es algo esperable, ya que el uso del sistema Araucano solo es obligatorio para el sistema de universidades públicas, de modo que las universidades privadas pueden optar por no cargar sus datos en él. Además, es posible que las universidades públicas más pequeñas tengan mayores dificultades para cumplir con esta obligación.

[9] Registros que contienen a la totalidad de la población de estudiantes universitarios en Argentina.

TABLA 1
ESTADÍSTICA DESCRIPTIVA, ARAUCANO Y DATOS ADMINISTRATIVOS SPU, 2018

Variable	Araucano		SPU	
	Grado y pregrado (%)	Grado, pregrado y posgrado (%)	Grado y pregrado (%)	Grado, pregrado y posgrado (%)
Graduados totales	100,0	100,0	100,0	100,0
% varones totales	39,7	40,0	38,9	
Régimen público	73,9	73,9	65,5	65,4
% varones en régimen público	39,9	40,1	39,5	
Rama: Ciencias Aplicadas	24,2	23,5	22,0	21,1
Rama: Ciencias Básicas	2,2	2,4	1,9	2,4
Rama: Ciencias de la Salud	17,1	18,7	17,3	19,0
Rama: Ciencias Humanas	14,2	13,8	14,4	13,9
Rama: Ciencias Sociales	42,2	41,5	44,4	43,6
Rama: Sin rama	0,1	0,1	0,0	0,0
Universidad Buenos Aires (UBA)	13,1	14,9	12,4	14,1
Universidad Rosario (UNR)	8,5	8,1	10,1	9,3
Universidad Córdoba (UNC)	5,6	5,9	5,1	5,3
Universidad La Plata (UNLP)	5,4	4,9	4,9	4,8
Univ. Tecnológica Nacional (UTN)	4,8	4,7	3,8	3,6
Resto universidades	62,6	61,5	63,7	63,0
Región: AMBA	43,0	43,9	43,0	45,5
Región: Cuyo	5,9	5,7	5,8	5,7
Región: Noreste	6,9	6,7	5,0	4,8
Región: Noroeste	8,2	8,0	5,5	5,2
Región: Pampeana	31,6	31,3	38,6	36,8
Región: Patagonia	4,4	4,4	2,1	2,1

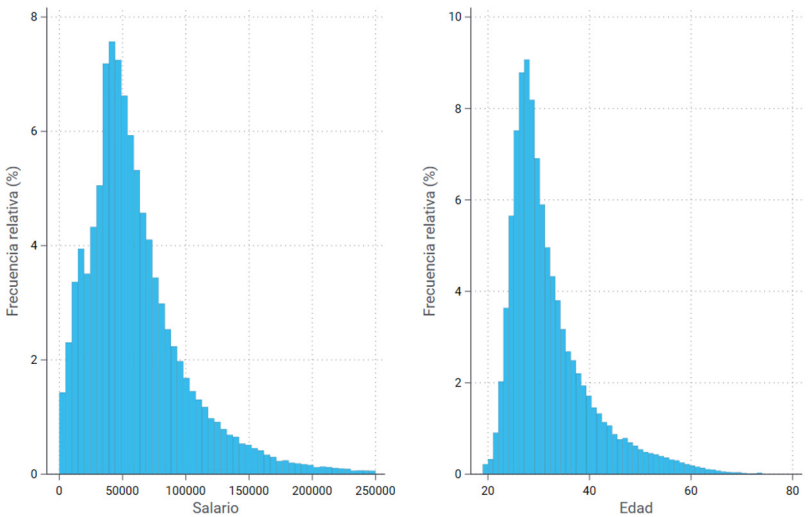
Fuente: Elaboración propia en base a datos de la SPU.

La base de datos utilizada registra 60% de mujeres, un dato en línea con la evidencia internacional acerca de la reversión de la brecha de género en acceso a la educación (Goldin, 2014). El 74% de los graduados cursaron sus estudios en el sistema público; a su vez, aproximadamente el 40% egresó de alguna de las cinco universidades públicas más grandes del país (UBA, UNR, UNC, UNLP y UTN). La UBA y la UNLP concentran el 20% de los graduados totales, en línea con el hecho de que el 44% de los individuos se insertan laboralmente en el Área Metropolitana de Buenos Aires (AMBA), según indican los datos del SIPA.

En cuanto a la distribución de los graduados por rama, se observa que Ciencias Sociales es la más grande, con 41,5% del total de la base. Este resultado responde principalmente al hecho de que esta rama incluye la mayoría de las carreras de derecho y ciencias económicas, que gozan de gran tradición en el país. Otras áreas incluidas en esta rama (aunque con un peso menor) son sociología, servicio social, ciencia política, comunicación social y turismo.

La segunda rama en importancia es Ciencias Aplicadas (23,5%), que incluye todas las ingenierías, además de arquitectura y diversas carreras vinculadas al ámbito industrial (en particular, las áreas de seguridad industrial y tecnología de alimentos). Ciencias de la Salud, formada principalmente por carreras de medicina, paramedicina, odontología y veterinaria, acumula el 19% de las personas graduadas; mientras que el 14% se agrupa en carreras de Ciencias Humanas, una categoría relativamente amplia en la que se destacan educación, psicología, letras y artes como disciplinas principales. Finalmente, la rama de Ciencias Básicas solo incluye al 2% de los graduados totales, distribuidos en solo cuatro disciplinas: matemática, física, biología y química.

GRÁFICO 1
SALARIO Y EDAD, DISTRIBUCIONES EMPÍRICAS



Fuente: Elaboración propia sobre la base de SIPA y Araucano.

La distribución de salarios tiene la forma asimétrica habitual. El salario medio es de 63.455 pesos (17% mayor que la media general del empleo formal observado en SIPA para ese mes), mientras que el mediano es de 52.163 pesos (26% mayor que la mediana general). En cuanto a la edad, se observa una distribución consistente con una franja joven del mercado de trabajo: la edad media es 32,4 años mientras que la edad mediana es 30 años. Sin embargo, vale la pena mencionar que solo el 10% de los individuos en la muestra tiene 25 años o menos, mientras que el 25% tiene más de 35 años.

La Tabla 2 presenta la distribución de puestos por sector productivo. Casi el 31% de la muestra son trabajadores de la administración pública, 20% trabajadores de la educación, mientras que tanto salud como industria manufacturera se ubican ligeramente por debajo del 8%.

TABLA 2
COMPOSICIÓN SECTORIAL DE LOS PUESTOS OBSERVADOS

Sector productivo	Proporción de puestos (%)
A. Agro	0,8
B. Minas y canteras	1,2
C. Industria manufacturera	7,7
D. Electricidad y gas	0,9
E. Agua y saneamiento	0,4
F. Construcción	1,9
G. Comercio	5,6
H. Transporte y almacenamiento	1,5
I. Hotelería y restaurantes	0,8
J. Información y comunicaciones	4,6
K. Intermediación financiera	4,5
L. Servicios inmobiliarios	0,4
M. Servicios profesionales	5,2
N. Actividades administrativas	2,8
O. Administración pública	30,9
P. Enseñanza	20,1
Q. Salud y servicios sociales	8
R. Servicios culturales	0,4
S. Servicios de asociaciones	2,2
U. Servicios de organizaciones extraterritoriales	0,1

Fuente: Elaboración propia sobre la base de SIPA.

5.2. Salarios

A continuación se presentan los principales resultados obtenidos en las regresiones para salarios. La Tabla 3 muestra las estimaciones para la ecuación (1).

TABLA 3
REGRESIONES LINEALES PARA EL LOGARITMO DEL SALARIO

Variables explicativas	Modelo 1	Modelo 2	Modelo 3
Edad	0,0111***	0,0113***	0,0106***
Mujer	–0,0996***	–0,0848***	–0,0846***
Título: Pregrado	–0,1219***	–0,1397***	–0,1709***
Título: Tecnicatura	–0,1147***	–0,1132***	–0,1005***
Título: Posgrado	0,2180***	0,2200***	0,2396***
Experiencia: menos de 1 año	–0,8025***	–0,7837***	–0,7708***
Experiencia: 1 a 2 años	–0,2841***	–0,2773***	–0,2702***
Experiencia: 5 a 10 años	0,1989***	0,1919***	0,1873***
Experiencia: más de 10 años	0,3962***	0,3869***	0,3826***
Tamaño: micro	–0,2928***	–0,2900***	–0,2858***
Tamaño: mediana	0,1541***	0,1482***	0,1472***
Tamaño: grande	0,2834***	0,756***	0,2672***
Efectos fijos	Rama	Disciplina	Área
Observaciones	156741	156741	156529
R2	0,3617	0,3743	0,3822

Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: *** significativo al 99%, ** al 95%, * al 90%. Las categorías base son grado o profesorado (título), 2 a 5 años (experiencia) y empresa pequeña (tamaño).

Las tres especificaciones ofrecen resultados similares. Los valores obtenidos para los coeficientes asociados a la edad indican que el salario crece a lo largo de la vida del trabajador a razón de 1% por año. La brecha de género, por su parte, se ubica entre 8 y 10% aproximadamente.

La prima por experiencia exhibe tamaños particularmente grandes: los puestos con más de 10 años de experiencia registran un diferencial salarial del orden del 40%, mientras que los trabajadores recientemente contratados sufren una penalidad de alrededor de 80%, comparado con trabajadores cuya antigüedad en el mercado de trabajo formal se ubica entre los dos y los cinco años. Estos resultados son previsibles por tratarse de una franja joven del mercado de trabajo en la que la adquisición de capital humano específico constituye una ventaja fundamental.

Respecto de los diferenciales salariales por tamaño de empresa, se encuentra que, tomando como categoría base las empresas u organizaciones pequeñas, las medianas registran salarios 15% mayores, mientras que esta prima asciende a 27% o 28% en firmas grandes. Los trabajadores de microempresas, en cambio, sufren penalidades salariales del orden del 29%.

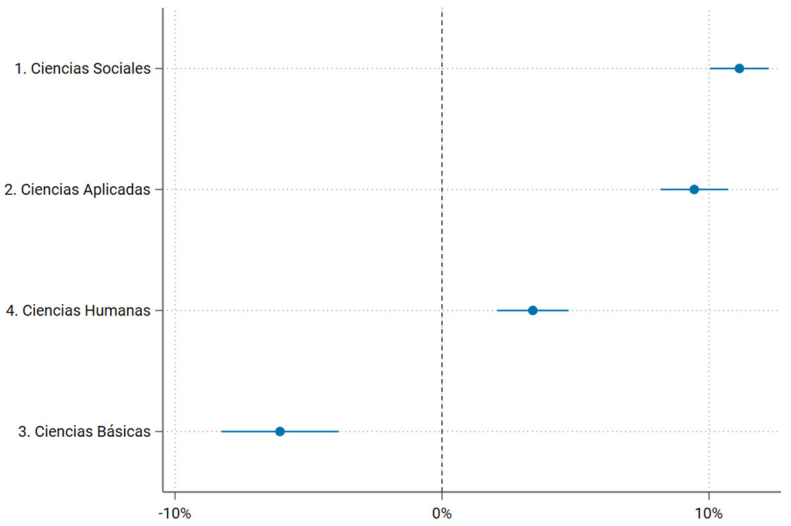
El control por provincia arroja resultados esperados en los tres modelos: los salarios más altos *ceteris paribus* son los observados en las provincias patagónicas (con excepción de Río Negro), mientras que los más bajos corresponden a las provincias del noroeste y noreste. También las *dummies* de sector productivo ofrecen valores en línea con lo previsto y con la evidencia reportada para Argentina (Schteingart *et al.*, 2022, forthcoming): las mayores primas salariales

se hallan en los sectores hidrocarburífero, energético, financiero y en los servicios de organizaciones extraterritoriales. En cambio, las mayores penalidades corresponden a enseñanza, servicios culturales, y hotelería y restaurantes (ver el Gráfico A.3 en el anexo para mayores detalles). La bondad de ajuste de los modelos se ubica entre 36% y 38%.

En cuanto a las variables de interés de este estudio, si se toman como referencia los títulos de grado, se observa lo siguiente: quienes poseen un título de posgrado obtienen una prima de entre 22% y 24%, en tanto que las tecnicaturas sufren una penalización salarial de entre 10% y 11,5%, mientras que para los títulos de pregrado esta oscila entre 12% y 17%. Los efectos fijos por universidad exhiben considerable variabilidad: la mayor prima salarial para una universidad es de 40%, mientras que la mayor penalidad es de 53% (utilizando la Universidad de Buenos Aires como categoría base por ser la universidad con mayor cantidad de graduados). Es interesante señalar que, cuando solo se incluye una *dummy* de universidad privada, la estimación del coeficiente asociado es de 2% (estadísticamente distinto de cero con 99% de confianza).

El Gráfico 2 presenta los resultados para los coeficientes asociados a las ramas en el modelo 1. Si se toma como categoría base Ciencias de la Salud, se observa una penalidad solo para las Ciencias Básicas (6%), primas relativamente moderadas para Ciencias Sociales y aplicadas (11% y 9%, respectivamente) y una prima pequeña para ciencias humanas (3%).

GRÁFICO 2
PRIMAS SALARIALES POR RAMA



Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: Las líneas celestes indican intervalos de confianza de 95%.

El Gráfico A.1 en el anexo muestra los resultados a nivel de disciplina usando como categoría base medicina. Allí se observa que las primas de mayor tamaño corresponden a otras ciencias sociales (28%), informática (23%), derecho (19%), matemática (18%), otras ciencias aplicadas (17%) y bioquímica y farmacia (17%). Corresponde aclarar que la primera categoría está formada principalmente por graduados de criminología, mientras que la anteúltima contiene mayormente carreras del área de transporte. Otras disciplinas con primas estadísticamente significativas son ingeniería (15%), educación (12%), economía y administración (11%) e industrias (8%). En cambio, numerosas disciplinas exhiben penalidades salariales considerables, particularmente arqueología (57%), astronomía (45%), física (24%), veterinaria (17%), artes (17%), odontología (16%) y psicología (14%).

Cuando se desagrega a nivel de área, con ingeniería en sistemas como categoría base, se encuentran las mayores primas salariales en procuración (35%), pedagogía (32%), farmacia (29%), ingeniería naval (28%), ingeniería petrolera (27%), ingeniería eléctrica (25%) y criminología (24%). El rol protagónico de las ingenierías es visible: ocupan diez puestos entre los primeros veinte. Las mayores penalidades observadas a este nivel de desagregación corresponden a dermatología (63%)[10], arqueología (62%), astronomía (48%), teatro y danza (41%), ciencias naturales (41%) y agrotecnia (36%).

Como fue discutido en la sección metodológica, estos resultados pueden estar afectados por sesgo de selección, ya que la probabilidad de un individuo de acceder al mercado de trabajo formal plausiblemente esté correlacionada con su probabilidad de obtener un título universitario. Debido a que esta correlación es factiblemente positiva (en la medida en que individuos que provienen de hogares con mayores recursos económicos probablemente gocen de mayor acceso tanto al empleo formal como a la educación universitaria), el retorno salarial de las credenciales universitarias sería incluso mayor para los individuos no observados en la muestra, es decir, para aquellos que trabajan en la parte informal de la economía.

Las primas salariales pueden variar considerablemente entre puestos pertenecientes a distintos sectores productivos. Para investigar esta posibilidad, se estiman versiones de la ecuación (1) que incluyen interacciones entre *dummies* de carreras y de sectores. Los resultados se encuentran resumidos en la Tabla 4.

[10] Esta área no es una especialización médica, sino que está formada por graduados en tecnicaturas en cosmetología o dermatocosmiatría.

TABLA 4
PRIMAS SALARIALES POR RAMA, POR SECTOR PRODUCTIVO

Sector	Ciencias Sociales	Ciencias Aplicadas	Ciencias Básicas	Ciencias Humanas
A. Agro	0,0528	0,1732***	0,0305	–0,0429
B. Minas y canteras	–0,0839	0,2334	–0,0629	–0,0723
C. Industria manufacturera	0,0282	0,1233***	0,0577	–0,0724
D. Electricidad y gas	–0,1030	–0,0030	–0,2926	–0,2815*
E. Agua y saneamiento	0,0444	0,1277	0,1113	0,0144
F. Construcción	–0,1385	0,0430	0,1262	–0,3233**
G. Comercio	0,0181	0,1768***	0,0330	–0,1718***
H. Transporte y almacenamiento	0,0232	0,2090***	0,0018	–0,0007
I. Hotelería y restaurantes	0,0735	0,0545	0,0155	–0,2250***
J. Información y comunicaciones	0,4241***	0,6436***	0,7108***	0,3424***
K. Intermediación financiera	0,3910***	0,3443***	0,2111	0,1691***
L. Servicios inmobiliarios	0,1793	0,3488	–0,0411	–0,2978
M. Servicios profesionales	0,3524***	0,4658***	0,2653***	0,3278***
N. Actividades administrativas	0,2652***	0,3277***	0,3266***	0,0275
O. Administración pública	0,1405***	–0,0743***	–0,1806***	–0,1771***
P. Enseñanza	0,2012***	–0,0080	0,0052	0,2717***
Q. Salud y servicios sociales	–0,0225	0,0661***	0,0257	–0,1899***
R. Servicios culturales	0,3746***	0,2180*	0,3305	0,2386**
S. Servicios de asociaciones	0,1800***	0,2031*	–0,1641*	–0,1147***
U. Servicios de organizaciones extraterritoriales	0,0151	0,4921	0,7709	0,2216

Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: *** significativo al 99%, ** al 95%, * al 90%.

Los sectores de servicios profesionales e información y comunicaciones destacan como los que ofrecen mayores retornos salariales a los cuatro grupos de carreras analizados (respecto de Ciencias de la Salud, la categoría base elegida), con primas de entre 27% y 47% en el primer caso y de entre 34% y 71% en el segundo. Algo similar ocurre en el sector financiero, donde las primas oscilan entre 17% y 39% (aunque no para los egresados de Ciencias Básicas), y en el de actividades administrativas, con primas de hasta 32% (aunque no para los egresados de Ciencias Humanas).

La industria manufacturera ofrece primas salariales bien diferenciadas a los egresados de Ciencias Aplicadas (del 12%), al igual que el sector agropecuario (en 17%). Previsiblemente, el sector de salud remunera de manera preferencial a los graduados de ciencias de la salud, aunque las Ciencias Aplicadas también obtienen aquí un plus salarial del orden del 6%.

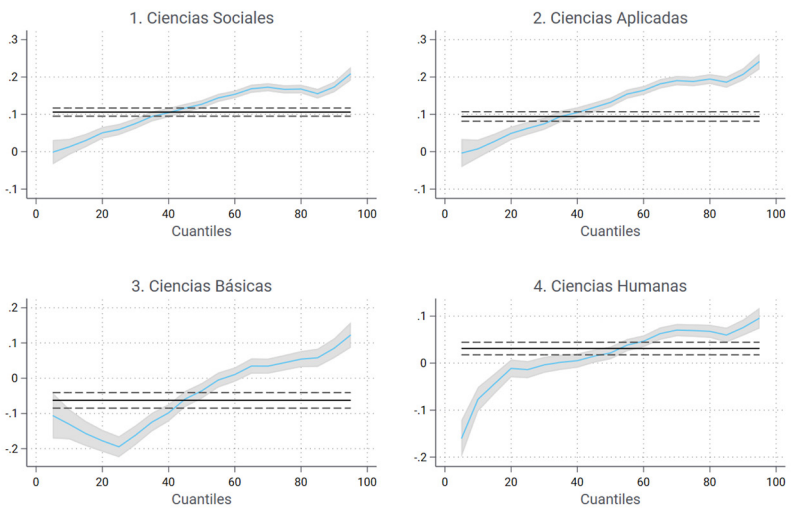
La administración pública ofrece un patrón particular. Ciencias Sociales es la única rama beneficiada con una prima salarial respecto de Ciencias de la Salud (14%), mientras que las demás ramas sufren penalidades considerables de hasta 18%. Algo similar ocurre en enseñanza (sector con una importante proporción de establecimientos públicos), en el que las Ciencias Sociales exhiben una prima

del 20%, la mayor prima se da en las Ciencias Humanas (27%), y las Ciencias Básicas y las Aplicadas no son estadísticamente diferentes de las Ciencias de la Salud en términos salariales. Estos rasgos particulares de la estructura de remuneraciones de la administración pública podrían deberse a las características propias de los bienes públicos que el Estado provee o bien a decisiones de política, ya que es posible que las agencias estatales elijan remunerar a los trabajadores de manera diferente a como lo hace el sector privado, debido a sus propias preferencias o bien a consideraciones distributivas.

Finalmente, en algunos sectores no se halla evidencia de primas salariales estadísticamente significativas por rama. Es el caso de minería, agua y saneamiento, servicios inmobiliarios y servicios extraterritoriales.

Por último, se explora la posibilidad de que las primas salariales por distintos tipos de carreras difieran entre individuos que se ubican en distintos tramos de la distribución condicional de salarios, a partir de la metodología tradicional de regresiones cuantílicas. Al igual que en el ejercicio anterior, la categoría base empleada es Ciencias de la Salud por ser aquella cuya media no condicional está más cerca de la media general de la muestra total.

GRÁFICO 3
REGRESIONES CUANTÍLICAS PARA EL LOGARITMO DEL SALARIO, POR RAMA



Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: Las líneas sólidas en negro indican la estimación por MCO, las líneas punteadas en negro corresponden al intervalo de confianza al 95% para esa estimación. Las líneas celestes representan los resultados de las regresiones cuantílicas, las franjas grises corresponden al intervalo de confianza al 95% para esa estimación.

Las cuatro curvas cuantílicas obtenidas exhiben una pendiente positiva, lo que indica que la prima salarial es creciente a lo largo de la distribución condicional del salario. Debido a que esta distribución está controlada por los atributos observables incluidos en el modelo, se la puede interpretar como la distribución de los atributos inobservables que caracterizan a cada individuo.

En particular, si se interpretan estos atributos inobservables como una medida sintética de talento o productividad, los resultados indican que la correlación parcial entre la obtención de una credencial universitaria y el salario de un individuo es creciente en esta medida. La educación universitaria genera mejores resultados laborales en aquellos individuos que son idiosincráticamente más talentosos. De hecho, la pendiente de las curvas aumenta en el quinto quintil, lo que sugiere que el beneficio asociado a un título universitario es particularmente alto en individuos que tienen una dotación inusualmente alta de talento.

A modo de ejemplo, la prima salarial asociada a una carrera de Ciencias Sociales, que es de 11% para un "individuo promedio", asciende a alrededor de 20% para aquellos situados en la cola derecha de la distribución condicional de salarios. Por su parte, la penalidad salarial de 6% asociada a las carreras de Ciencias Básicas se transforma en una prima en torno al 10% para los individuos ubicados en los percentiles más altos de la distribución condicional. También es interesante notar que, en todos los casos, la prima para la mediana condicional es mayor a la obtenida para la media, lo que sugiere que esta última probablemente esté muy influida por las observadas en la cola izquierda de cada distribución.

El Gráfico A.4 en el anexo muestra resultados análogos a nivel de disciplina. No hay un patrón general y en muchos casos la curva cuantílica y la estimación por MCO tienen intervalos de confianza que se solapan en la mayoría de los percentiles. Sí corresponde destacar que solo dos carreras muestran curvas con pendiente negativa: paramedicina y otras ciencias sociales. Si bien no se puede descartar que la prima salarial en algunas carreras sea efectivamente mayor en individuos con menor dotación de talento, corresponde aclarar que, al menos en el caso de medicina, la medición del ingreso laboral puede introducir un sesgo relevante, ya que se trata de una profesión donde el trabajo por cuenta propia es muy habitual y se encuentra generalmente asociado a ingresos elevados (se retoma esta discusión en la sección siguiente).

6. Conclusión

Este trabajo provee evidencia novedosa respecto de los retornos salariales a distintos tipos de credenciales educativas de nivel universitario en el mercado de trabajo formal argentino. Los resultados presentados aportan evidencia empírica acerca de temas de interés tradicionales de la literatura laboral, como las brechas de género, los retornos a la experiencia, las primas salariales sectoriales y otros. Sin embargo, el principal hallazgo de esta investigación es la importante variabilidad asociada al área del conocimiento de la que provenga la credencial.

Las personas graduadas obtienen distintos resultados en el mercado de trabajo dependiendo de la rama, disciplina y área de estudio que eligen al momento de inscribirse en una universidad. Más interesante aún es que esa variabilidad es todavía mayor cuando se separan los resultados entre puestos de trabajo pertenecientes a distintos sectores productivos.

Una interpretación posible para estos hallazgos es aquella que identifica los valores relativos de las distintas credenciales universitarias como precios que reflejan la escasez relativa de cada perfil profesional en la estructura productiva argentina tomada en su conjunto, o bien en la de cada sector en particular. De este modo, las importantes primas asociadas, por ejemplo, a las carreras de ingeniería, reflejarían la escasez de graduados en esas áreas, lo que a su vez puede atribuirse a la dificultad intrínseca en obtener esas credenciales, o bien a preferencias heterogéneas entre los agentes.

Esta interpretación también es consistente con un modelo en que las credenciales universitarias son entendidas por los demandantes de trabajo como productos diferenciados ya sea verticalmente (porque algunas son consideradas unívocamente mejores que otras) u horizontalmente (porque distintas estructuras productivas implican preferencia por ciertas credenciales por sobre otras en la demanda). Nuevamente, un modelo de ese tipo predeciría que aquellas carreras que son relativamente más demandadas son aquellas que registran primas salariales mayores.

Es oportuno destacar que una credencial educativa puede ser adquirida por razones que van más allá de su retorno laboral, ya que no parece extraño suponer que los individuos obtienen satisfacción de sus estudios universitarios. Por tanto, no se puede descartar que las carreras peor remuneradas en términos salariales provean, en cambio, diferenciales de satisfacción que compensen sus menores rendimientos monetarios. Desde esta perspectiva, las carreras mejor remuneradas podrían ser, simplemente, las menos preferidas o las que sufren ciertas desventajas estructurales que deben ser compensadas en términos económicos.

Si los diferenciales salariales encontrados fueran producto exclusivamente de escasez relativa fundada en preferencias, sería difícil encontrar políticas públicas capaces de ofrecer resultados superadores. Sin embargo, diversas consideraciones sugieren que este bien puede no ser el caso, tanto problemas de información asimétrica como de inconsistencia temporal en las decisiones podrían hacer que la asignación observada sea subóptima. La heterogeneidad en el retorno según la posición relativa en la distribución condicional del salario también parece relevante aquí: es posible que la elección óptima de carrera dependa de factores inobservables, parcialmente desconocidos incluso para los propios estudiantes.

La mayoría de quienes estudian en la universidad ingresan al sistema en la franja de edad esperada, es decir, luego de terminar los estudios secundarios: el 20% ingresa a los 18 años, mientras que el 50% tiene 20 años o menos al momento de comenzar. Los jóvenes son una porción de la sociedad que probablemente sufre importantes barreras en el acceso a información confiable, ya

sea por menor experiencia general o por mayor sensibilidad a la influencia de diversos factores propios del entorno. De este modo, políticas públicas orientadas a difundir información pertinente a los resultados laborales de las distintas opciones de estudios disponibles podrían inducir resultados socialmente preferibles, a un costo muy bajo.

También se debe considerar la cuestión de la distribución geográfica del acceso a las distintas carreras. Si bien una proporción elevada de los graduados universitarios argentinos estudian en el Área Metropolitana de Buenos Aires, donde la oferta de carreras disponibles es muy amplia (incluso si solo se toma en cuenta el sistema público), una franja no despreciable egresa de universidades situadas en provincias menos pobladas, donde no todas las áreas del conocimiento se encuentran representadas en la oferta universitaria local. La investigación futura deberá echar luz respecto de hasta qué punto esta desigualdad territorial en el acceso a la educación superior puede ser considerada un determinante de los resultados presentados aquí.

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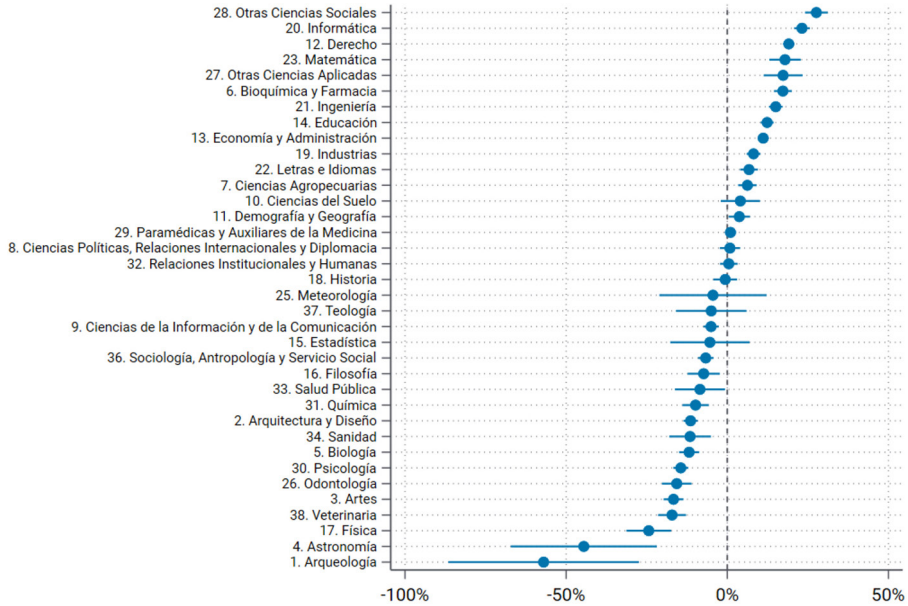
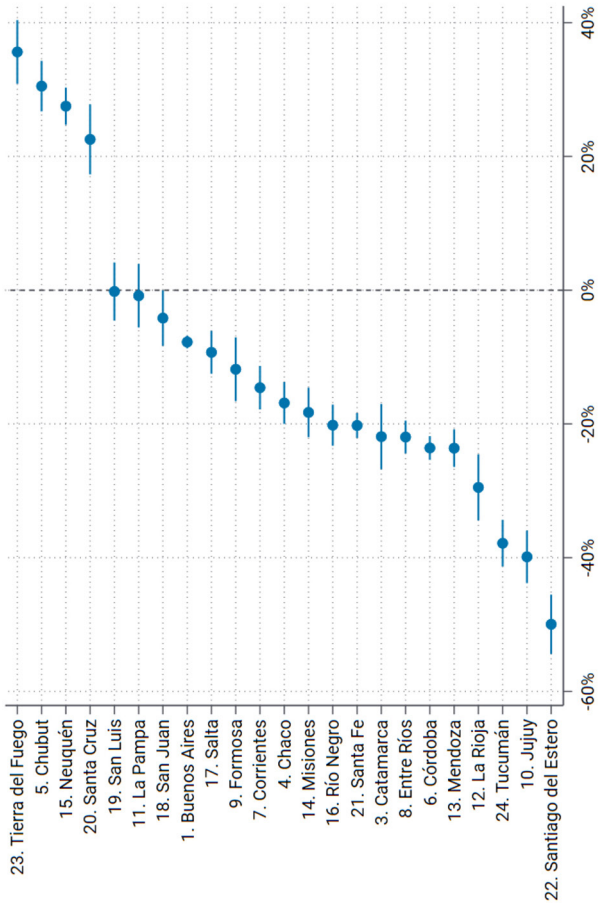
Anexo

GRÁFICO A.1
PRIMAS SALARIALES POR DISCIPLINA



Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: Las líneas celestes indican intervalos de confianza de 95%.

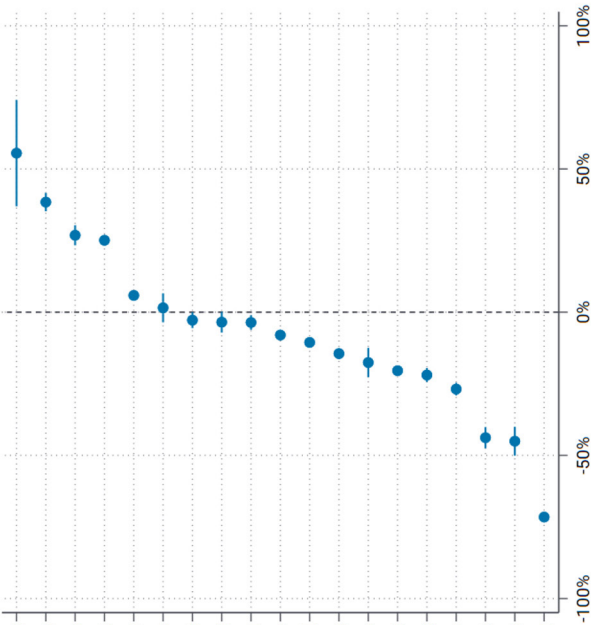
GRÁFICO A.2
RESULTADOS PARA *DUMMIES* PROVINCIALES EN LA ECUACIÓN (1), MODELO 1



Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: Las líneas celestes indican intervalos de confianza de 95%.

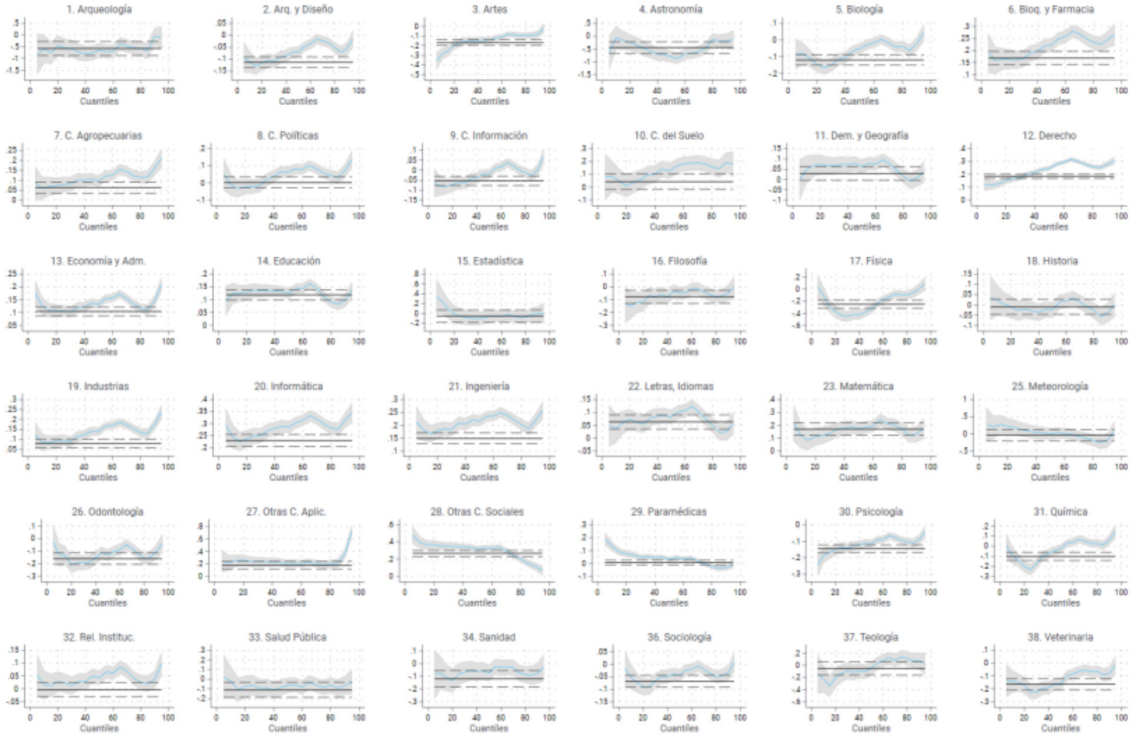
GRÁFICO A.3

RESULTADOS PARA *DUMMIES* SECTORIALES EN LA ECUACIÓN (1), MODELO 1



Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: Las líneas celestes indican intervalos de confianza de 95%.

GRÁFICO A.4
REGRESIONES CUANTÍLICAS PARA EL LOGARITMO DEL SALARIO, POR DISCIPLINA



Fuente: Elaboración propia sobre la base de SIPA y Araucano.
Nota: La categoría base utilizada es medicina. Las líneas sólidas en negro indican la estimación por MCO, las líneas punteadas en negro corresponden al intervalo de confianza al 95% para esa estimación. Las líneas celestes representan los resultados de las regresiones cuantílicas, las franjas grises corresponden al intervalo de confianza al 95% para esa estimación.

TABLA A.1
CLASIFICACIÓN DE DISCIPLINAS SEGÚN RAMA

Rama	Disciplina
Ciencias Aplicadas	Arquitectura y Diseño Ciencias del Suelo Ciencias Agropecuarias Ingeniería Industrias Informática Estadística Meteorología Astronomía Bioquímica y Farmacia Otras Ciencias Aplicadas
Ciencias Básicas	Matemática Física Química Biología
Ciencias de la Salud	Paramédicas y Auxiliares de la Medicina Medicina Odontología Veterinaria Sanidad Salud Pública
Ciencias Humanas	Filosofía Letras e Idiomas Educación Historia Psicología Teología Artes Arqueología
Ciencias Sociales	Derecho Economía y Administración Ciencias Políticas, Relaciones Internacionales y Diplomacia Sociología, Antropología y Servicio Social Ciencias de la Información y de la Comunicación Relaciones Institucionales y Humanas Demografía y Geografía Otras Ciencias Sociales

Fuente: Elaboración propia en base a SPU.

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