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Trust and Perceptions of Autonomous Vehicles in Latin America

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Abstract

Beliefs or perceptions about new technologies can affect their adoption and impact on economic progress. In this research note, we examine if trust in others is associated with positive perceptions of autonomous vehicles (AVs). Using a representative survey from Latin America, we find that that is, indeed, the case for that region. We also find that individuals who are male, favor globalization, support foreign investment, and approve of democracy are more likely to perceive AVs positively. Our results are consistent with the literature on the ethics of artificial intelligence claiming that the factors that determine trust in others can be mapped into factors that determine trust in automation and AVs.

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1. Motivation

A self-driving car or autonomous vehicle (AV) is a particular application of artificial intelligence (AI) that uses different technologies, such as radar, lidar, and GPS, to operate on its own without the need of human intervention (Narla 2013). The AI software installed in AVs utilizes large amounts of data collected by these technologies to sense the surrounding environment and make real-time decisions (Ma *et al.* 2020). This process also allows AVs to learn and adapt their behavior over time (Adnan *et al.* 2018).

AVs come with key benefits vis-à-vis traditional cars. Of the 1.35 million road deaths and 50 million injuries that occur globally each year, it is estimated that human error is responsible for up to 95% of all incidents (Threlfall 2020). AVs could drastically reduce these numbers as well as produce more efficient traffic flow, reduce energy consumption and pollution, and increase driver productivity (Litman 2020). AVs have been estimated to save between $2,000 and $4,750 per vehicle per year in terms of accident costs, travel time reduction, fuel efficiency and parking (Fagnant and Kockelman 2015).

AVs could be commercially available by 2030 (Litman 2020). According to the 2020 KPMG's Autonomous Vehicles Readiness Index, Singapore, the Netherlands, Norway, the United States and Finland are the countries most prepared for their implementation. In Latin America, Chile, Mexico and Brazil lead the way but lag far behind the world leaders. Several factors such as GDP, infrastructure, public policies, car production, technology level and/or public perception of AVs, play a role in determining whether a country is prepared or not for the introduction of AVs.

While all of the aforementioned factors are important, public perception of AVs have been highlighted by industry and academic literature and received considerable attention in recent years.[1] Public perceptions reflect belief systems, which, following the literature on institutional economics, are an important determinant of the adoption of efficient institutions and technologies (North, 1999). The next question is, of course, what determines those belief systems. We are interested in exploring this question for the case of AVs.

We pose that social trust or generalized trust in others (Papagapitos and Riley 2009) is an important building block for the positive perception or beliefs about AVs.[2] We contribute, in this regard, to the larger literature on the relationship between trust and AI. Bartneck, Lütge, Wagner, and Welsh (2021), argue, for example, that users will accept AI systems if they perceive them as trustworthy, find them useful and can afford them.

[1] The literature on perceptions about AVs is sizable. For instance, Hulse *et al.* (2018) found that people perceived AVs as riskier than human-operated vehicles when they saw themselves as passengers but perceived them as less risky when they saw themselves as pedestrians. Additionally, Waytz *et al.* (2014) found that the higher the level of anthropomorphism (attribution of human characteristics to a non-human agent) the AVs had, the more likely it was that an individual would trust the vehicle. The extent to which AVs can enhance an individual's lifestyle is also an important factor in determining attitudes towards these vehicles. Bennett *et al.* (2019) found that individuals with physical disabilities were more likely to view AVs positively when compared to people without disabilities. Finally, both Haboucha *et al.* (2017) and Wang *et al.* (2020) evaluated and compared attitudes towards AVs in both privately owned and shared settings (AVs use in taxi/ride-sharing services). Haboucha *et al.* (2017) found that "Pro-AV sentiments" was the strongest of the latent variables in predicting AV use in both privately owned and shared settings. Individuals that held "Pro-AV sentiments" viewed the vehicles as an opportunity with various benefits. Additionally, Wang *et al.* (2020) found that people who were adopters of new technology and supporters of rigid traffic regulations held more positive views of AVs. In both of these studies, individuals who favored AVs tended to be younger and male.

[2] Social trust has been long identified as a key element for positive economic outcomes (see, for example Banfield 1958; Greif 1993; Coleman 1988; Putnam 2000; Putnam, Leonardi, and Nanetti 1993; Fukuyama 1995; Zak and Knack 2001; Algan and Cahuc 2010 and Arrow 1972).

These authors argue that, to be perceived as trustworthy, AI systems should display beneficence, be explicable and not compromise their autonomy. We suggest that the perception of AI systems, like AVs, is partially derived from social trust: trusting humans can lead us to trust AI systems.

Our hypothesis on the link between social trust and the perception of AVs is inspired by ideas developed in the literature on the ethics of AI. In particular, Coeckelbergh (2012) claims that trusting robots can be an indirect result of trusting humans in fields related to technology. Additionally, Choi and Ji (2015) show that factors associated with social trust are also significant factors associated with trusting AVs. Their argument is based on the suggestion that social trust depends on ability, benevolence, and integrity (Mayer *et al.* 1995), and that each of these three factors can be mapped into trust in automation and AVs.[3] Our work builds on this literature by assessing the specific link between social trust and the perception of AVs in Latin America.

Our results suggest that social trust is, indeed, significantly associated with positive perceptions of AVs. We address selection bias using different matching algorithms and also assess the sensitivity of our results to potential hidden bias.

2. Data, methods, and results

We use data from the 2017 Latinobarometro survey (Latinobarometro, 2017), which includes approximately 20,000 interviews in 18 Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela). The survey represents a population of 600 million in the region.[4]

Two questions in the survey allow us to test our hypothesis regarding the effect of social trust on the perception of AVs:

(1) Thinking about the future, would you ride in a robot-driven car? The possible answers are “yes” = 1, and “no” = 0 (yes = 0.23, sd = 0.42). We named the associated categorical variable *Robot.driver*.

(2) In general, would you say one can trust most people or one cannot be too careful when dealing with others? This question has two possible answers: “one can trust most people” = 1 , and “one cannot be too careful” = 0 (one can trust most people = 0.14, sd = 0.35). We named the associated categorical variable *Trust.others*.

Figure 1 presents the correlation between these two variables. Most individuals in the survey would not ride in AVs and also voice low trust in others. High-trust individuals, however, are more likely to be willing to ride in AVs by almost 8 percentage points. The Pearson residuals show that more individuals than expected answered yes to both questions.

[3] Moreover, Lütge *et al.* (2021) suggest that the automotive industry can play an important role in fostering trust in AVs by increasing transparency dealing with technical issues regarding human agency and oversight, privacy and data governance, accountability, etc. Given that these elements first foster trust in humans, their argument is similar to that of Coeckelbergh (2012).

[4] See https://www.latinobarometro.org/lat.jsp

Figure 1: Will to ride in an AV and social trust.

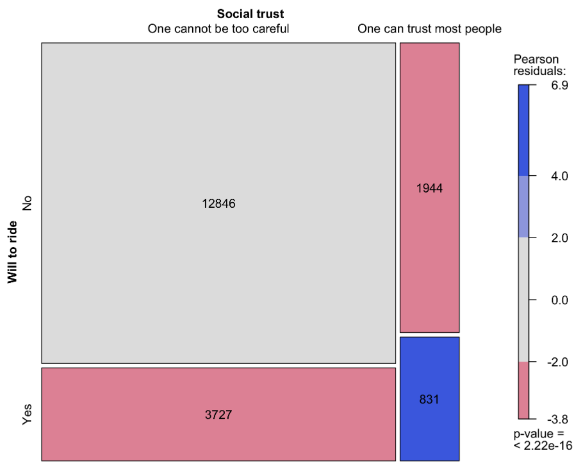
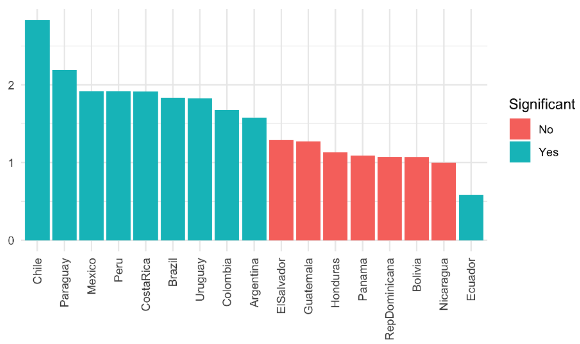


Table I shows our main results. Our dependent variable is *Robot.driver* and our independent variable is *Trust.others*. Model 1 is a simple logit regression between these two variables. Model 2 adds demographic variables, Model 3 adds economic variables, Model 4 adds individual-level variables, and Model 5 adds political variables. We see Model 5 as our most complete specification. This model shows that, keeping other variables at mean values, a high-trust individual (versus a low-trust one) is 6.1% more likely of being willing to ride in an autonomous vehicle. Other significant variables are *Male* (0.068), *Globalization* (0.039), *Foreign.investment* (0.034), *Education* (0.013), *Life.satisfaction* (-0.013), *Salary* (0.016), and *Democracy* (0.031).[5]

Figure 2 shows the odd ratios of country variables corresponding to Model 5. Notice that the odds of being willing to ride in AVs in Chile is almost three times larger than the same odds in Venezuela (the reference country). In fact, Venezuela is one of the countries with the lowest odd ratios in the region. Only Ecuador presents a lower odd ratio than Venezuela.

Figure 2: Odds ratios of *Robot.driver*



Note: Significant at 1%

Our logit estimates could be, of course, biased because social trust is not randomly

[5] Appendix 1 presents a table with descriptive statistics for all of the variables considered in our study. Appendix 3 reproduces the questions from the 2017 Latinobarometro from which the variables are derived.

Table I: Predicting Probability of Being Willing to Ride an AV

	Dependent variable: *Robot.driver* Numbers reported are marginal effects				
	(1)	(2)	(3)	(4)	(5)
Trust.others	0.070***	0.073***	0.060***	0.064***	0.061***
	(0.009)	(0.010)	(0.012)	(0.012)	(0.013)
Male		0.080***	0.068***	0.070***	0.068***
		(0.007)	(0.008)	(0.008)	(0.009)
Age		−0.004***	−0.005***	−0.005***	−0.006***
		(0.001)	(0.001)	(0.001)	(0.002)
Agesq		0.00002	0.00004**	0.00004**	0.00004**
		(0.00001)	(0.00002)	(0.00002)	(0.00002)
Married.cohabitant		−0.016**	−0.008	−0.006	−0.003
		(0.007)	(0.008)	(0.009)	(0.009)
Indigenous		−0.020*	−0.013	−0.014	−0.009
		(0.011)	(0.014)	(0.015)	(0.016)
Life.satisfaction		−0.004	−0.012**	−0.015***	−0.013**
		(0.004)	(0.005)	(0.005)	(0.006)
Salary			0.013***	0.014***	0.016***
			(0.005)	(0.005)	(0.006)
Education			0.012***	0.013***	0.013***
			(0.001)	(0.001)	(0.001)
Unemployed			−0.020**	−0.020**	−0.018*
			(0.009)	(0.010)	(0.011)
Globalization			0.043***	0.042***	0.039***
			(0.007)	(0.007)	(0.007)
Foreign.investment			0.034***	0.032***	0.034***
			(0.011)	(0.012)	(0.013)
Optimism				0.005	0.003
				(0.004)	(0.005)
Catholic				−0.001	−0.007
				(0.009)	(0.010)
Democracy					0.031***
					(0.009)
Left.right					0.001
					(0.002)
Country controls	*yes*	*yes*	*yes*	*yes*	*yes*
Observations	19,348	16,729	11,822	11,308	9,614
Log Likelihood	-10,239.080	-8,813.993	-6,233.370	-5,984.390	-5,131.049
Akaike Inf. Crit.	20,516.150	17,677.990	12,526.740	12,032.780	10,330.100
Adjusted R^2	0.031	0.051	0.065	0.067	0.062

Note: *p<0.1; **p<0.05; ***p<0.01

assigned among individuals in the survey. Social trust might be correlated with other observed covariates, which also affect the outcome variable. This can make our logit results unreliable. In order to address selection bias, we conduct Propensity Score Matching (PSM) and match high social trust observations with low social trust observations according to the covariates used in Table I. Observations that do not find a match are dropped. This approximates creating a counterfactual where social trust is a randomly assigned treatment. We use five different matching algorithms (Table II). For all of them, the average treatment effect on the treated (ATT) is positive and significant. Averaging the ATTs we find that high-trust individuals are 6% more likely to ride in AVs than low-trust individuals.

Table II: Propensity Score Matching

	Trust.others		Sample sizes	
Matching algorithm	ATT	s. e.	Control	Treated
Nearest without replacement	0.059**	0.100	1076	1076
Nearest with replacement	0.050**	0.105	897	1076
Nearest without replacement, ratio 2	0.069***	0.086	2152	1076
Nearest with replacement, ratio 2	0.057***	0.091	1606	1076
Nearest with replacement, caliper 0.25	0.072***	0.103	947	1076

Note: Outcome variable is *Robot.driver* *p<0.1; **p<0.05; ***p<0.01

We further examine the link between *Trust.others* and *Robot.driver* using genetic matching (Table III). Genetic matching does not match on the propensity-score (one vector) but uses all covariates (several vectors). It uses an algorithm (Diamond and Sekhon 2013), which reaches optimal balance after matching. In Sekhon (2011, 1) words: "Genetic Matching, is a method which automatically finds the set of matches which minimize the discrepancy between the distribution of potential confounders in the treated and control groups—i.e., covariate balance is maximized."

The results of genetic matching in Table III are consistent with our previous results: high-trust individuals are 7.7% more likely to be willing to ride in AVs than low-trust individuals.

Table III: Genetic Matching

Variable	Model 6
Trust.others (ATT)	0.077***
Standard error	0.105
Additional controls	yes
Country controls	yes
Adjusted R^2	0.071

Note: Genetic algorithm with replacement.
*p<0.1; **p<0.05; ***p<0.01
Observations: control = 912, treated = 1076.
Controls are the same as in Model 5 in Table I.

Sensitivity analysis

One of the weakness of PSM and genetic matching is that they only let us address endogenous bias, which are due to observables confounders. It is possible, however, that there are variables that we do not observe, which affect social trust and willingness to ride in AVs simultaneously, i.e. hidden bias. Unfortunately, our data does not allow us to employ variables as instruments to address this issue. We can, however, follow Rosenbaum (2002) to estimate how big a potential hidden bias would need to be to question our results. Appendix 2 shows the results of this analysis. The upper bound p-value crossed the critical threshold of 10% at $\Gamma = 1.2$ for *Trust.others*. This indicates that if we do not control for confounders linked to 20% of the variation of *Trust.others*, and these confounders are statistically associated with *Robot.drivers*, then *Trust.others* could potentially be no longer be significant at the 10% level of confidence.

3. Conclusion

We show that social trust is significantly linked to favorable perceptions of AVs in Latin America. This result confirms those of the literature on the ethics of AI, which show that trusting robots can be an indirect result of trusting humans in fields related to technology and/or that factors associated with social trust are also significant factors associated with trusting AVs. We address selection bias using PSM and genetic matching. Our sensitivity analysis shows that our results are robust to moderate levels of hidden bias.

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Appendix 1

Table IV: Descriptive statistics

Statistic	N	Mean	St. Dev.	Min	Max
Robot.driver	19,759	0.234	0.423	0	1
Trust.others	19,748	0.143	0.351	0	1
Male	20,200	0.478	0.500	0	1
Age	20,200	40.348	16.388	16	95
Agesq	20,200	1,896.5	1,497.7	256	9,025
Married.cohabitant	20,155	0.529	0.499	0	1
Indigenous	17,481	0.102	0.303	0	1
Life.satisfaction	20,053	3.040	0.850	1	4
Salary	19,817	2.537	0.868	1	4
Education	19,037	8.680	4.162	0	14
Worried.unemployment	13,380	2.738	1.103	1	4
Unemployed	20,065	0.333	0.471	0	1
Globalization	18,303	3.024	0.620	1	4
Foreign.investment	15,780	0.852	0.355	0	1
Optimism	19,263	3.395	1.026	1	5
Catholic	20,007	0.601	0.490	0	1
Democracy	18,386	0.587	0.492	0	1
Left.right	17,117	5.256	2.953	0	10

Appendix 2

Table V: Sensitivity analysis

Γ	Lower bound	Upper bound
1	0.00168	0.00168
1.1	5.00E-05	0.02417
1.2	0	0.13539
1.3	0	0.38191
1.4	0	0.66946
1.5	0	0.86943
1.6	0	0.96097
1.7	0	0.99084
1.8	0	0.99825
1.9	0	0.99972
2	0	0.99996

Note: Rosenbaum bounds.

Appendix 3

Question codes, questions and possible, recorded, answers – translation from Spanish. Latinobarometro, 2017:

S6 "What is your marital status? Married/cohabitant = 1, other = 0 [*Married.cohabitant*].

S10 "To what race do you think you belong? Indigenous = 1, other = 0 [*Indigenous*].

P1ST "In general terms, do you think you are satisfied with your life? Would you say you are? Not satisfied at all = 1, not very satisfied = 2, satisfied = 3, very satisfied = 4 [*Life.satisfaction*].

S5 "The salary or wage that you earn and total family income, allows you to cover your needs sufficiently? In what situation do you find yourself in? It is not enough, she has great difficulties = 1; not enough, she has difficulties = 2; just enough, without great difficulties = 3; enough, she can save = 4 [*Salary*].

S14 "What level of education do you have? What is the last year completed? None = 0, 1 = 1, 2 = 2, ... 12 = 12, incomplete college = 13, complete college = 14 [*Education*].

S4 "How worried would you say you are to be without a job or to be unemployed during the next twelve months, or you do not have a job?" Do not have a job = 1, has a job = 0 [*Unemployed*].

P56N.F "Globalization is an opportunity for economic growth." Very much disagree = 1, disagree = 2, agree = 3, verry much disagree = 4 [*Globalization*].

P48STM "Do you think that foreign investment is beneficial or harmful for the economic development of the country, or you do not enough to tell? Beneficial = 1, harmful = 2 [*Foreign.investment*].

P7STGBS "And in the next twelve months, do you think your economic situation, and that of your family will be much better, a little better, the same, a little worse, or much worse than it is today? Much worse = 1, worse = 2, the same = 3, a little better = 4, much better = 5 [*Optimism*].

S9 "What is your religion? Catholic = 1, other = 0 [*Catholic*].

P8STGBS "Do you agree: Democracy is preferable to any other form of government? Yes = 1, no = 0 [*Democracy*].

P19STC "In politics people normally talk about "left" and "right." In a scale where "0" is "left" and "10" is "right", where are you located? Left = 0, ... right = 10 [*Left.right*].