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Are you what you consume?

Impact of food, soft drinks, and coffee on cognitive and non-cognitive test scores

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Abstract: Cognitive and non-cognitive tests are key factors in many aspects of economics, especially within labour market analysis. Non-cognitive tests and personality traits are increasingly used, as these are found to be as critical as cognitive abilities for labour market outcomes, while they might be more malleable through life. Intake of caffeine and sugar immediately prior testing is also known to impact cognitive test scores, while almost nothing is known about any similar impact on personality test scores. This work shows, as a first, a significant impact from coffee on the personality trait locus of control. The impact from coffee on locus of control is so large that it significantly alters the results of an analysis of locus of control's importance for labour market behaviour. Consumption of food, soft drinks, or coffee is found to have no impact on verbal, numerical, and Raven's Progressive Matrices tests. The study is based on a large sample of university students in Mozambique.

Key words: cognitive test, non-cognitive test, measurement error, caffeine, glucose, labour market

JEL classification: J24, I2

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1 Introduction

The economics literature is continually expanding the use of both cognitive and non-cognitive skills in a range of settings and find that for many outcomes, non-cognitive personality measures are just as predictive as cognitive measures, even after controlling for a range of other factors (Almlund et al. 2011). Of special interest is the degree to which such skills are consistent over time and to which degree they can be changed via schooling, training, or nudging. In a review of personality traits and their use in economics, Almlund et al. (2011) argue that personality traits, though originally believed to be very time consistent, are malleable to the external environment, and some personality traits might not be stable until the age of 50. Genetics, environmental influences, education, parental investments, and policy interventions are all argued to influence personality traits over time. In comparison, this indicates that personality traits are more malleable than cognitive ability over the life cycle as these are believed to be fixed as early as age 10 (Almlund et al. 2011).

There is also evidence showing that consumption, especially of food and caffeine, have a significant short-term impact on both physical and cognitive performance. Moderate amounts of caffeine increase mood, alertness, vigilance, attention, and reaction time. Evidence for memory and higher order executive function, such as judgement and decision making, is rather less consistent (Smith 2002; Klaassen et al. 2013; McLellan et al. 2016). Similarly, glucose has been found to improve short-term cognitive ability, resulting in enhanced scores on psychological tests, on verbal intelligence, on spatial abilities, and on response time (Benton and Parker 1998). Glucose deprivation has been shown to inhibit performance in several complex tasks such as mental calculations and the Stroop task (McElroy et al. 2014). A recent review of the importance of breakfast for adults finds a small but robust impact on memory, attention, and motor skills, while none on language. The review further concludes that results on glucose regulation vary too much in research designs to make general conclusions (Galioto and Spitznagel 2016).

Surprisingly, the author has found no studies on the direct impact of immediate caffeine or sugar consumption prior to the measurement of personality traits. The results therefore contribute to the existing literature by being the first assessment of personality traits' robustness to caffeine and sugar consumption, prior testing. A large impact is found from caffeine on a verbal test and on locus of control. The latter impact is shown to be from caffeine to testing and not the reverse causality with caffeine consumers being more likely to have a certain personality as assumed in some literature (Lara 2015). Further, the bias from caffeine is so large that it would bias an analysis of locus of control on labour market search strategies. In addition, this is also a contribution to the scant literature on non-cognitive abilities in developing countries.

2 Data

Data is from the baseline of an ongoing study undertaken by University of Copenhagen, Denmark, and Eduardo Mondlane University, Mozambique, tracking university students in Mozambique as they finish their bachelor studies and enter the labour market (Jones et al. 2018). To assess determinants of labour market outcomes, students in their final year of studies took three cognitive tests: numerical, verbal, and Raven's Progressive Matrices (RPM). They also took one non-cognitive personality test: locus of control (LOC). A total of 2,175 students were interviewed. Based on logistic considerations, students are from six universities providing higher education to three-quarters of the total university population in Mozambique. Secondly, the sample was selected

to produce representative statistics of the population by gender and eight major study areas. The sample size was determined following Cochran (Cochran 1977). Based on budget the sample was designed to produce representative estimates at the level of the study area/gender segments, with a 7.5 per cent margin of error and a 90 per cent confidence interval, resulting in a minimum sample 1,477 students. The survey was implemented at the university during what would normally have been a class. Since many more students were present than the minimum sample, all of them were allowed to participate. In cases with more students than available tablets, students were randomly selected. For a p of 50 per cent and a 95 per cent confidence interval the full sample has an error of 1.7 per cent and 2.2 and 2.4 per cent for men and women, respectively. Further documentation on survey and data is found in the survey report (Jones et al. 2018).

LOC was measured with Rotter's external-internal scale (Rotter 1966), which expresses the degree to which people believe that they have control over the outcome of events in their lives, as opposed to external forces beyond their control. LOC is based on 12 questions¹. Rotter's original article (Rotter 1966) has more than 26,000 citations on Google Scholar, and LOC has been significantly related to a long range of outcomes, including obesity (Gale et al. 2008), high school graduation (Almlund et al. 2011), entrepreneurship (Hansemark 2003; Wijbenga and van Witteloostuijn 2007), labour market behaviour and earnings (Caliendo et al. 2015; Heckman et al. 2006; McGee and McGee 2016; Schnitzlein and Stephani 2016), savings behaviour (Cobb-Clark et al. 2016), and technology adaptation (Abay et al. 2017). The degree to which personality traits, including LOC, are stable constructs is still debated. Early literature, including Rotter himself, speculated that LOC would change over the life span as individuals age. Empirical studies could not consistently confirm such regularity over the life span, while some literature supported changes due to critical life events, more than age itself (Kormanik and Rocco 2009). This could be relevant for policy as nudging to non-cognitive traits could influence outcomes later in life while cognitive might not (Almlund et al. 2011). Focusing on a very short time span, and based on a sample of pregnant couples, Ryon and Gleason (2014) find that LOC measured daily does fluctuate with previous day anxiety and hassles.

Cognitive ability was measured by a verbal, a numerical, and a Raven's tests. The verbal test consisted of a text of 91 words and three questions, each with three potential answers. The numerical test consisted of a total of four questions, with a mix of multiple choice and specific answers based on a five by four statistical table and a graph. The Raven's test was an abbreviated version with ten questions of progressive matrices. All four test outcomes (three cognitive and one non-cognitive) have been standardized to a mean of zero and a standard deviation of one.

Towards the end of the interview, students were also asked about their recent consumption of food and drinks in the two hours prior to the interview. The options were food and drinks, and for drinks the type of drink, with the options being water, soda, or coffee or tea. The questionnaire did not specify if students had tea or coffee, or if the drink was caffeinated, but being caffeinated is the norm in Mozambique. Though the intake could be both tea and coffee, the text will refer to coffee or caffeine only from this point onwards. Students were also offered a sugary soft drink at the beginning of the interview, which they could choose to drink or not. Hence, food and drinks were not randomized and are based on self-reported recall questions.

Table 1 shows that there are no or limited systematic differences between consumers of soft drinks, food, or coffee, in terms of age, living situation (living with nuclear family, with a spouse, or alone), having children, marital status, language abilities, or if they relocated to attend the university. There

¹ The scale normally has 13 questions, but the very last question was inadvertently dropped from the questionnaire.

is, however, a significant and systematic difference in the time of the day the interview took place. The later in the day the interview took place, the more likely it is that a student consumed a soft drink and food, while coffee is mostly consumed in the morning (Table 1). Soft drink consumption is linearly increasing over the day, while coffee and food consumption have nonlinear bumps around lunch time (Figure 1). The analysis below controls for undue influence on results due to these sample variations.

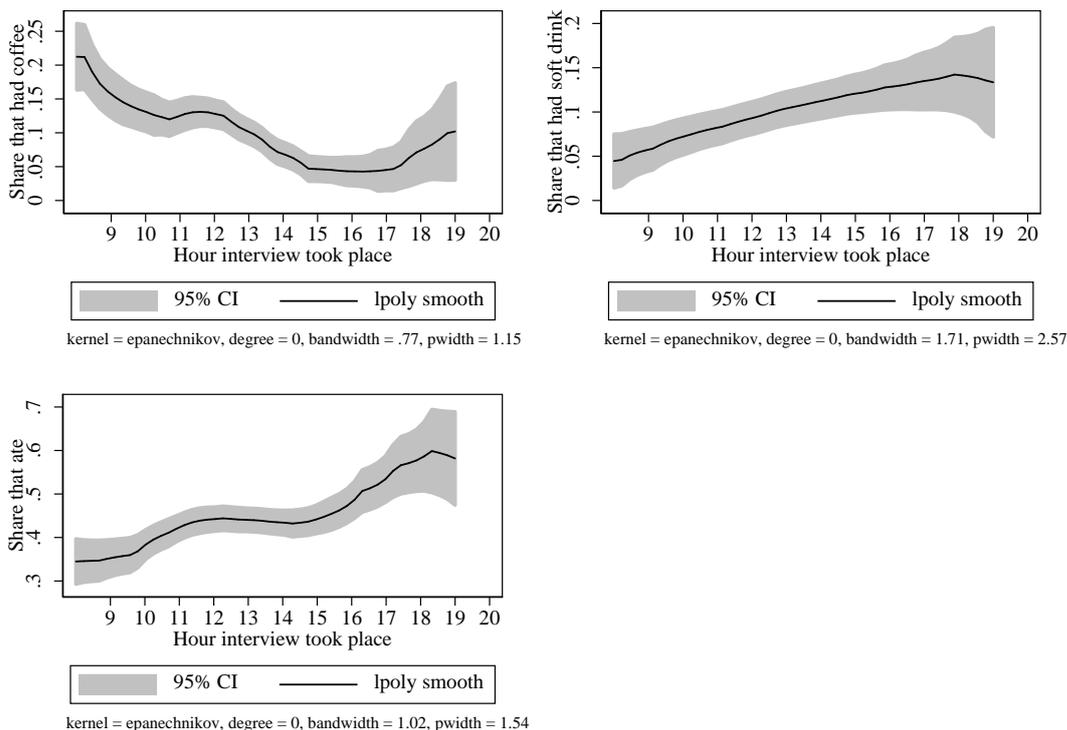
Table 1 Mean differences for those that consume soft drinks, food, and coffee

Sample Characteristics	Mean for full sample	Difference in means between those that did/did not have:		
		Coffee	Soft drink	Food
Age	25.52	-0.60	-0.06	-0.13
Female	0.47	0.08*	-0.09	0.08**
Living with nuclear family	0.54	0.06	-0.04	-0.04
Living with spouse	0.16	0.01	0.04	0.02
Living alone	0.10	-0.04	0.07*	0.01
Has children	0.28	-0.01	0.09*	0.01
Married	0.13	-0.02	0.03	0.01
Relocated to attend	0.32	-0.08*	0.03	0.01
Start hour interview	12.71	-0.94**	0.96**	0.46**
Knows only Portuguese	0.12	0.05*	0.00	0.02
Knows English	0.65	0.03	0.05	0.03
Tests				
Verbal	0.00	0.16*	-0.09	-0.07
Numerical	-0.00	0.02	-0.05	-0.04
Raven's	0.00	0.07	0.02	-0.08
Locus of Control	0.00	0.24**	-0.06	-0.10
Obs. consumed		224	119	942
Obs. did not consume		1,951	2056	1,233
Total obs.	2,175	2,175	2,175	2,175

Notes: The second column shows the mean for the full sample. Columns three to five show the difference in mean between those that did and did not consume soft drinks, food, and coffee. *, ** indicate significance of difference in means at 0.05 and 0.01 level, respectively.

Source: author's own elaboration.

Figure 1 Non-linear relationship between the hour in the day the interview started and the propensity to consume soft drink, food, and coffee



Note: figure is based on a polynomial smooth. Grey shade shows 95 percent confidence interval.

Source: author's own elaboration.

3 Results

3.1 Consumption's impact on cognitive and non-cognitive scores

Simple mean comparisons reveal that there is no difference in any of the cognitive or non-cognitive tests scores among those that consumed food or soft drinks. For coffee consumption, students score significantly higher on the verbal test and are significantly more external (Table 1). To assess the robustness of the mean comparisons, the cognitive and non-cognitive scores are evaluated via OLS regressions and matching. The impact of coffee, soft drinks and food is assessed via: a) a simple OLS regression including only the consumption variables (soft drink, food and coffee) and the outcome of interest (verbal, numerical, and Raven's tests, as well as LOC), and b) same regression as (a) with the additional control variables and fixed effects. The control variables are age of student, gender, family status, marital status, children, language spoken, and if student relocated to study (see mean of variables in Table 1). In addition to control variables, the regressions have fixed effects for the students' university, field of study, and hour of day the interview took place. As a further check on robustness, the impact is also assessed via matching, using the same control variables.

Impact from consumption is found for coffee only, and a significant impact is restricted to LOC. Coffee's impact on LOC is large. Those consuming coffee before the interview have a full quarter of standard deviation higher LOC score –i.e. those that consumed coffee have a more external

personality. The results are robust to fixed effect for the hour of the day the interview took place, as well as other control variables (Table 2), which indicates that the sample variation observed in Table and Figure 1 does not influence the result. Further, testing with different control variables and matching shows that the results are very robust to different specifications and estimation methods (Appendix Tables A1 and A2). The lack of impact from soft drinks and food on LOC is consistent with a recent meta study on the relationship between glucose and self-control. It demonstrated that the evidence on such a relationship is weak (Vadillo et al. 2016).

The significant difference in means for the verbal test between those that had coffee and those that did not (Table 1), is not robust to control variables (Table 2 and Appendix Table A2). The addition of control variables does not lead to a large change in coefficient nor standard errors, but the change is large enough to render the result insignificant. Based on students' cognitive test scores, the three tests (verbal, numerical, and Raven's) can be argued to not be equally difficult. On average, students correctly answered 42, 47 and 62 per cent of questions on the Raven's, numerical, and verbal tests, respectively. The means are all significantly different from each other based on two-sided t-tests. Hence, one can argue that the verbal test was the easiest and Raven's the hardest test. As such, the result could line up with the literature that finds a positive impact of coffee on performance of less demanding tasks, but more limited impact, if any, on more difficult and complex functions (Klaassen et al. 2013; McLellan et al. 2016; Smith 2002).

Table 2 Impact of consumption (soft drink, food, and coffee) on test scores (locus of control, numerical, verbal, and Raven's)

Dependent variable	Verbal		Numerical		Raven's		Locus of control	
Estimation method	OLS	Fixed effect	OLS	Fixed effect	OLS	Fixed effect	OLS	Fixed effect
Consumed:								
Food	-0.05 (0.05)	-0.04 (0.05)	-0.02 (0.05)	0.00 (0.04)	-0.06 (0.05)	-0.03 (0.05)	-0.01 (0.05)	-0.02 (0.05)
Soft drink	-0.05 (0.10)	-0.05 (0.09)	0.03 (0.10)	0.04 (0.09)	-0.02 (0.10)	-0.06 (0.09)	-0.05 (0.09)	-0.04 (0.10)
Coffee	0.18* (0.07)	0.14 (0.07)	0.08 (0.07)	0.00 (0.07)	0.05 (0.07)	-0.01 (0.07)	0.24** (0.07)	0.25** (0.08)
Control variables	No	Yes	No	Yes	No	Yes	No	Yes
N	2175	2175	2175	2175	2175	2175	2175	2175

Notes: standard errors in parentheses. * p<0.05, ** p<0.01. Fixed effects are for university, field of study, and hour of interview. Control variables include a constant, age, gender, if student lives with nuclear family, own family, or on their own, if they are married, if they have child/children, languages spoken, and if they relocated to attend university.

Source: author's own elaboration.

Coffee's impact on LOC and causality

There is literature linking certain personality traits with the likelihood of being a caffeine consumer in general (Lara 2015). If people consuming coffee in general are more likely to be external, then the observed results in Table 2 could be driven by such a correlation and not be an impact of coffee consumption itself. Similarly, the observed correlation between personality traits and being a coffee drinker in general could be driven by coffee consumption prior testing as this is unobserved in most work.

Unfortunately, the baseline did not have information on students being coffee drinkers in general or not. To test if coffee consumption indeed has a causal effect on LOC, students were asked if they are coffee consumers in general during a follow up interview, six months after the baseline (Jones et al. 2018). While 224 had coffee immediately before the test, 1,666 reported to be coffee drinkers in general. The inclusion of a control variable for being a coffee consumer in general does not change results, hence showing that coffee does have a causal impact on LOC. Column two (Table 3) replicates results from Table 2, while column three replicates same regression but with a reduced sample, due to attrition in the second interview. Column four shows that the impact from coffee consumption prior LOC testing is robust to controls for students being coffee consumers in general. Hence, the observed impact is indeed a result of drinking coffee immediately before the tests, and not a result of coffee drinkers in general being more likely to have a certain personality.

Table 3 Impact of coffee on locus of control

Estimation method	Fixed effect	Fixed effect	Fixed effect
Sample	Full sample	Reduced sample	Reduced sample
Dependent variable	Locus of control	Locus of control	Locus of control
Drank coffee before test	0.25** (0.07)	0.31** (0.08)	0.31** (0.08)
Drinks coffee in general			-0.08 (0.06)
Control variables	Yes	Yes	Yes
N	2175	2004	2004

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$. Fixed effects are for university, field of study, and hour of interview. Control variables include a constant, age, gender, if student lives with nuclear family, own family, or on their own, if they are married, if they have child/children, languages spoken, if they consumed food or soft drinks, and if they relocated to attend university.

Source: author's own elaboration.

3.2 Implications for labour market analysis

Many types of analysis rely on LOC, but the impact from coffee consumption is usually unobserved and omitted. Is the observed impact from coffee large enough to be a relevant parameter to consider? This section answers this question in the context of labour market analysis, relating LOC to students' plans after graduation, wage expectations, and labour search strategies.

To assess coffee impact, consider the linear model in (1), where x^* is LOC, y is the outcome of interest (for instance reservation wage), and ∂ LOC's impact on the outcome of interest. θz capture the impact of other relevant variables, and u is the error term. When some people have consumed coffee but others not, and this influences LOC, one can see this as a form of measurement error due to coffee. This can be presented in a model as in (2). Those that did not drink coffee immediately prior the interview are observed as x_i , while those that had coffee immediately prior the interview are observed $x_i + e_i$, with e_i being the influence of coffee.

If the influence of coffee, e , is assumed uncorrelated with the true value of x and y , ∂ will always be biased downwards. However, if the assumption on e does not hold, ∂ can be larger or smaller, due to the impact of e . Further, if LOC is measured with a 'coffee-error', not only ∂ would be biased, but any other dependent variable included in θz could also be biased (Bound et al. 2001).

$$y_i = \partial x_i^* + \theta z_i + u_i \quad (1)$$

$$x_i^* = \begin{cases} x_i + e_i & \text{if coffee} = 1 \\ x_i & \text{if coffee} = 0 \end{cases} \quad (2)$$

To test the empirical relevance of an impact from coffee, students' labour market expectations are used as outcomes in two sets of regressions. Following (1) and (2), one unbiased regression for non-coffee drinkers and one biased regression for coffee drinkers. If the impact from coffee is unimportant for the analysis, the two coefficients should be similar. To test for different coefficients in the two regressions, it's checked whether the coefficient influenced by coffee is equal to the coefficient not influenced by coffee, using a Wald test in the regression for those not influenced by coffee. This test is preferred, as other standard tests for equal coefficients across different regressions (as for instance seemingly unrelated regressions) rely on the covariance matrix between the two regressions, which is also influenced by the coffee impact e .

It has been shown that LOC impacts reservation wages, employment search, and a range of other labour market outcomes (Caliendo et al. 2015; McGee and McGee, 2016; Wang et al. 2010). In this study's data, students are also asked a few questions on their expected entry into the labour market. In a multiple choice question, students are asked about their plans after graduation, with the following options (multiple answers are allowed): 1) continue formal education, 2) continue technical training or TVET education, 3) self-employment, 4) work as employee, 5) work in family business, 6) work on family farm, 7) look for employment, 8) stay home and attend personal or family responsibilities. Furthermore, for those expected to enter the labour market after graduation (excluding students that do not expect to enter the labour market), students are asked in yes/no questions if they expect to use any of the following eight different search strategies for finding employment: 1) family/friends, 2) newspaper adds, 3) job centres, 4) contact employers who do not advertise, 5) student internships, 6) recruitment and temp agencies, 7) internships after graduating, or 8) internet and social networks. In addition, students report their expected wages in their first job. Some options are reported by very few students (for instance expected to work in family farm) and have therefore been excluded from the analysis. Following regressions (1) and (2) above, appendices A3 and A4 show the regression results for each of these 14 outcome variables (y in (1)) for both the sample of those that had coffee and those that did not. All regressions include the same control variables and fixed effects as in Table 2.

Comparing coefficients from those influenced by coffee and those that are not, there are significant difference between the coefficients in eight out of fourteen outcomes for LOC (Table 4). Hence, the influence from coffee is powerful enough to swing results on LOC's relationship to different aspects of the labour market. For six out of the eight outcomes with significant different coefficients on LOC, the coffee drinking sample has smaller coefficients than the non-coffee drinking sample (Appendix Table A3). In four out of eight cases, a significant impact from LOC on the labour market outcome is found for the sample that did not have coffee, while no significance is found on same labour market outcomes for the sample that had consumed coffee. Finally, in five out of eight cases, the coefficient for consuming coffee changes sign. Hence, the influence of coffee on LOC is substantial enough to also drive results found for LOC's impact on labour markets.

Table 4 Number of variables with significant different coefficient

Labor section	LOC
Plans after graduation	2(5)
Expected wage in first job	1(1)
Job search strategy	5(8)
Total	8(14)

Notes: table shows the number of variables with significant different coefficient between coffee and non-coffee drinkers, tested in regression (1) and (2). Appendix Table A3 shows detailed results. Number in parenthesis is total number of variables tested.

Source: auhor's own elaboration.

4 Discussion

The results show a surprisingly large impact of coffee on LOC. An impact so large that it questions LOC's reliability as personality trait that can be used for analytical purposes, when coffee consumption immediately prior LOC testing is not considered. On the positive side, there seem to be no impact on LOC from consumption of food and other drinks, including sugary drinks. Further, no significant impact on cognitive tests (verbal, numerical, and Raven's Progressive Matrices) are found for neither food nor soft drinks nor coffee.

Though results here are very strong and robust to control variables, there are also shortcomings in the study's treatment variable: coffee or tea consumption. The casual effect is believed to be the effect of caffeine, but the exact exposure to caffeine is unknown (generally speaking, coffee has a higher content of caffeine, but there are variations even within tea and coffee). A better research design would be caffeine administered directly to participants in a known dose, with randomization of students. A great advantage, however, is the relatively large sample of more than 2,000 observations and the novel contribution to the literature on impact from coffee on cognitive and non-cognitive scores. In addition, the study is also one of the few studies to assess personality traits in a developing country.

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Appendix

Table A1 Impact of coffee on locus of control

Regression type	OLS	Fixed Effect	Fixed Effect	Propensity Score Matching	Logit Fixed Effect
Column	(1)	(2)	(3)	(4)	(5)
Dependent variable	LOC	LOC	LOC	LOC	Dummy external
Had coffee	0.24** (0.07)	0.24** (0.07)	0.25** (0.08)	0.23** (0.09)	0.34* (0.16)
Control variables	No	No	Yes	No	Yes
N	2175	2175	2175	2175	2175

Notes: standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$. Fixed effects are for university, field of study, and hour of interview. Control variables include a constant, age, gender, if student lives with nuclear family, own family, or on their own, if they are married, if they have child/children, languages spoken, if they consumed food or soft drinks, and if they relocated to attend university. Propensity score matching is based on the list of control variables.

Source: author's own elaboration.

Table A2 Impact of coffee on verbal test scores

Regression type	OLS	Fixed Effect	Fixed Effect	Propensity Score Matching
Column	(1)	(2)	(3)	(4)
Dependent variable	Verbal	Verbal	Verbal	Verbal
Had coffee	0.16* (0.07)	0.13 (0.07)	0.14 (0.07)	0.13 (0.14)
Control variables	No	No	Yes	No
N	2175	2175	2175	2175

Notes: standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$. Fixed effects are for university, field of study, and hour of interview. Control variables include a constant, age, gender, if student lives with nuclear family, own family, or on their own, if they are married, if they have child/children, languages spoken, if they consumed food or soft drinks, and if they relocated to attend university. Propensity score matching is based on the list of control variables.

Source: author's own elaboration.

Table A3 LOC's influence on labour analysis, with and without coffee

		LOC Coef	SE	Control variables	Sig diff. in coef	Obs
<i>Plans after graduation</i>						
Become an employee	Coffee	0.01	-0.03	Yes		224
	No coffee	0.01	-0.01	Yes		1951
Become self-employed	Coffee	0.00	-0.03	Yes	**	224
	No coffee	0.02*	-0.01	Yes		1951
Look for a job	Coffee	0.01	(0.04)	Yes		224
	No coffee	0.01	(0.01)	Yes		1951
Continue academic studies	Coffee	0.07	(0.04)	Yes	**	224
	No coffee	0.00	(0.01)	Yes		1951
Continue practical/TVET studies	Coffee	-0.01	(0.03)	Yes		224
	No coffee	0.00	(0.01)	Yes		1951
<i>Expected wage in first job</i>						
	Coffee	0.02	(0.04)	Yes	*	204
	No coffee	0.00	(0.01)	Yes		1785
<i>Job search strategy</i>						
Through family and friends	Coffee	-0.01	(0.05)	Yes		118
	No coffee	0.01	(0.01)	Yes		1010
Through newspaper adds	Coffee	-0.03	(0.05)	Yes	**	118
	No coffee	0.04**	(0.02)	Yes		1010
Through job center	Coffee	-0.01	(0.05)	Yes		118
	No coffee	0.00	(0.01)	Yes		1010
Through unsolicited approach of employers	Coffee	-0.05	(0.04)	Yes	**	118
	No coffee	0.02	(0.01)	Yes		224
Through student internships	Coffee	-0.04	(0.06)	Yes	**	1951
	No coffee	0.02	(0.02)	Yes		224
Through recruitment and temporary work firms	Coffee	0.01	(0.05)	Yes		1951
	No coffee	0.03**	(0.01)	Yes		224
Through internships after graduating	Coffee	-0.01	(0.06)	Yes	**	1951
	No coffee	0.20**	(0.07)	Yes		224
Through internet and social networks	Coffee	-0.07	(0.05)	Yes	**	1951
	No coffee	0.03	(0.01)	Yes		224

Notes: each row shows a regression of the dependent variable in column 1 in a logit fixed effect regression on LOC plus control variables. First row, each dependent variable is for the sample consuming coffee, second row for sample not consuming coffee. Standard errors in parentheses. * p<0.05, ** p<0.01. Fixed effects are for university, field of study, and hour of interview. Control variables include a constant, age, gender, if student lives with nuclear family, own family, or on their own, if they are married, if they have child/children, languages spoken, if they consumed food or soft drinks, and if they relocated to attend university.

Source: author's own elaboration.