Technical change and employment in Brazil, Colombia, and Mexico. Who are the most affected workers?

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Motivation

- The advances in computer technologies initially, and then the development and spread of Information and Communication Technologies (ICTs) have been pervasive and strong occurrences for many global economies over the last three decades.

- Autor, Leavy, and Murnane (ALM) in 2003 argues that technological changes have resulted in the replacement of routine tasks with computers and other machines (routinization hypothesis).

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- In Latin America, most of the studies on the topic focus on the basic theoretical framework which considers just two groups of workers (skilled and unskilled) and which predicts that technological advances only affect the most skilled ones (always increasing their wages).

- The net effect of the technological change on employment and wages in a country depends on several factors including its industrial structure, its position in the international division of labor, its demographic developments, and its economic and social policies

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- The main contribution of this paper is to provide empirical evidence concerning the role of the demand for skills using a task-based framework in urban labor markets in Brazil, Colombia, and Mexico.

- Have labor opportunities polarized recently in Latin America? Can employment patterns in routine manual jobs be explained by technological change or by changes among industries? Which socio-demographic groups have been most affected by the routinization process?

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Literature review

- ALM (2003), Acemolgu and Autor (2011).

- Autor et al., (2003, 2006, and 2008), Goos and Manning (2007), Spitz-Oener (2006), Dustin et al. (2009), Anghel, et al. (2014), Michaels et al. (2014), Adermon and Gustavsson (2015).

- Campos-Vasquez (2013), Medina and Posso (2010)

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Metodology

- **Job complexity**

In the seminal paper, ALM (2003) used the Dictionary of Occupational Titles (DOT) to measure the skill content of occupations.

We follow the approach of Goos et al., (2009) and we use median wages by occupation as a proxy for the skill content of a job.

We group occupations into broad categories (26 in this case) in which for example we can identify group of jobs that can be replaced more by technological advances.

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- **Routine and Non-routine jobs**

We group jobs into broad categories according to whether most of the tasks performed in each one are Non-Routine Analytic (NRA), Non-Routine Interactive (NRI), Routine Cognitive (RC), Routine Manual (RM) or Non-Routine Manual (NRM).

This classification combines elements from the ALM (2003) and Acemoglu and Autor (2011) approaches

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Table I. Classification of occupations

Occupations	Classification
Physicist, mathematicians, engineering profess.	
Life science and health professionals	
Economist, accountants	
Lawyers	Non-routine analytic
Writers, artists and sportsmen	NRA
Education workers	
Other professionals	
Executive managers	Non-routine interactive
Other managers	NRI
Secretaries, stenographers, typists	Routine cognitive 1
Cashiers, tellers and the similar	RC1
Telephone switchboard operators	
Other clerks	Routine cognitive 2
Sales	RC2
Street salesperson	
Machinery operators	Routine manual
Precision, handicraft, and related workers	RM
Drivers	
Building workers	
Cookers, bartenders, porters	
Protective services workers	Non-routine manual NRM
Other services	
Other	

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- **Shift-share decomposition**

We perform a standard shift-share decomposition of the change in the overall share of employment in occupation j over time interval as follows

$$\Delta E_{jt} = \sum_k \Delta E_{kt} \lambda_{jk} + \sum_j \Delta \lambda_{jkt} E_k$$

$$\equiv \Delta E^B_t + \Delta E^W_t$$

- **Multinomial Logit Model**

The MLM allows us to estimate the probability of a worker belonging to a specific category (i.e. NRA) rather than a base category (i.e. NRM) given a set of covariates.

We use this model because explanatory variables are observed only for the chosen alternative and not for the other alternatives (Cameron and Trivedi, 2010, p.498).

- The MLM can be expressed as follows:

$$p_{ij} = \frac{\exp(\boldsymbol{x}_i' \beta_j)}{\sum_{l=1}^{m} \exp(\boldsymbol{x}_i' \beta_l)}, j = 1, \ldots, m$$

- To simplify the interpretation of the estimations, we consider the transformation to odds ratios or relative-risk ratios. This transformation is given by:

$$\frac{\Pr(y_i = Non\_routine\ analytic)}{\Pr(y_i = Non\_routine\ manual)} = \exp(\boldsymbol{x}_i' \beta_{NRA})$$

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Data

- The empirical analysis is based on employment and wage data from household surveys conducted by the respective bureau of statistics in each country.

- For Brazil, we use the (*Pesquisa Nacional por Amostra de Domicilos*) PNAD from 2002 to 2014. For Colombia, we use the *Encuesta Continua de Hogares* (ECH) from 2002 to 2006 and the *Gran Encuesta Integrada de Hogares* (GEIH) after that. For Mexico, we use the *Encuesta Nacional de Empleo Urbano* (ENEU) from 2002 to 2005 and the *Encuesta Nacional de Empleo* (ENOE) thereafter

Regarding the classification of occupations, no changes were made from 2002 to 2012. From the third quarter of 2012 Mexico implemented a new classification structure. Thus, in order to compare the old and new classification in this country we harmonized the two classifications according to instructions from the bureau of statistics (INEGI).

The raw classification of occupations in Brazil has 481 jobs; in Colombia it has 82 jobs, while in Mexico it reports 407 jobs. To analyze employment changes, we group all these jobs into 26 broad categories comparable across countries as in Table I.

Table II. Employment statistics

	Brazil		Colombia		Mexico	
	2002 (1)	2002-2014 (2)	2002 (3)	2002-2015 (4)	2002 (5)	2002-2015 (6)
Total employees	79,994	19,453	7,370	3,304	17,326	6,624
Gender						
Male	58.7	-1.8	55.4	-1.6	63.1	-3.8
Female	41.3	1.8	44.6	1.6	36.9	3.8
Age						
<18	7.0	-3.7	3.1	-1.2	3.7	-1.3
18-29	30.6	-4.8	28.7	-0.4	32.0	-6.3
30-44	36.1	0.6	41.6	-5.7	39.3	-1.8
45 or more	26.3	7.9	26.6	7.3	24.9	9.4
Education						
Primary or less	36.9	-15.5	25.86	-7.4	26.5	-7.0
High school dropout	28.6	-3.2	22.46	-5.6	40.7	-6.9
High school	22.2	9.9	26.37	2.3	11.0	4.2
Some college	4.2	3.3	9.78	10.5	4.1	6.2
College or more	8.2	5.5	15.54	0.2	17.8	3.6
Industry						
Manuf. of food, textiles, wood	9.1	-1.9	12.2	-3.4	10.8	-3.6
Manuf. of chemical, machinery	6.7	-0.6	6.2	-0.8	7.9	1.1
Other industries	9.5	1.9	6.1	1.3	7.1	1.7
Trade and repair	22.1	-0.5	27.8	-3.1	22.6	-1.4
Hotels, restaurants, transport	10.8	1.3	14.0	3.6	12.5	1.7
Education and health	11.5	0.7	10.0	0.6	11.1	0.0
Other services	30.3	-0.9	23.8	1.8	28.0	0.4

Empirical results

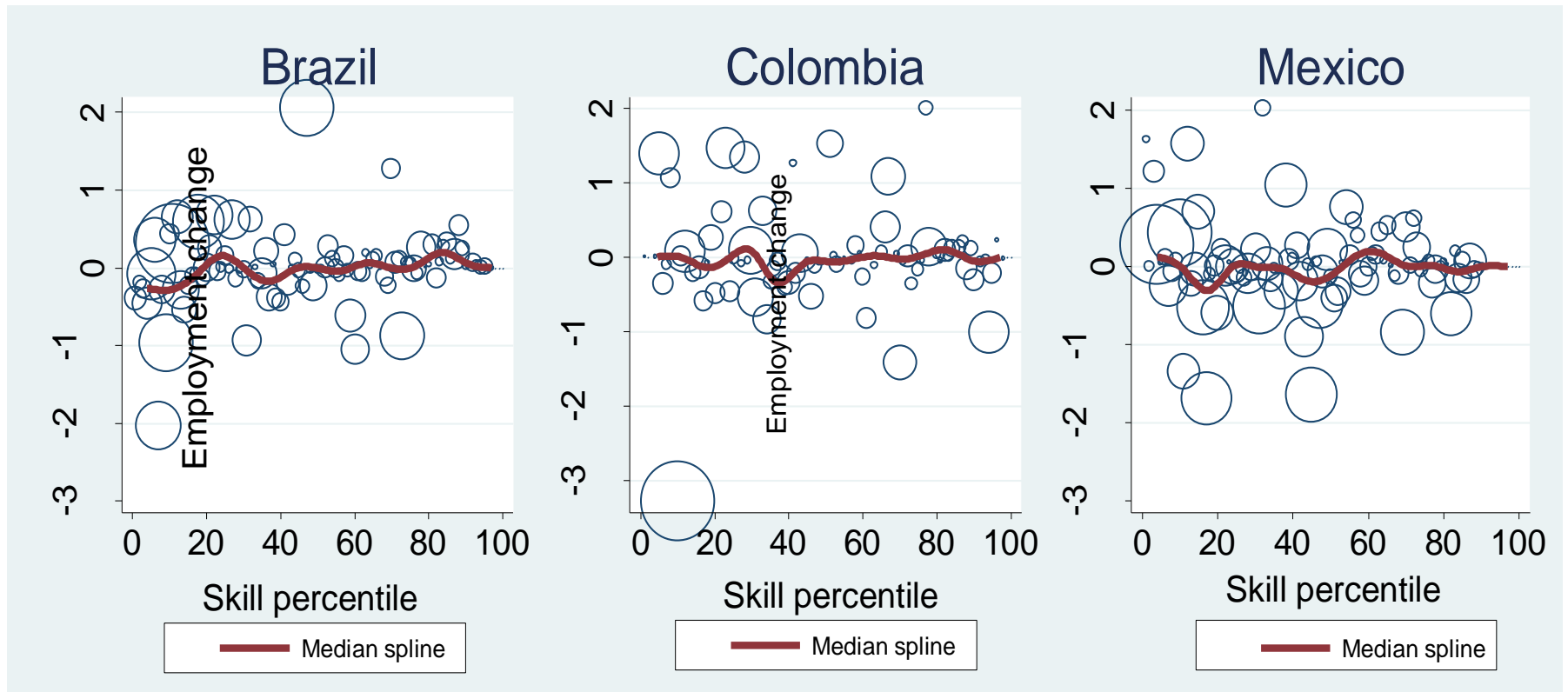**Figure 1. Changes in employment share by skill percentile 2002-2015**

Table III. Employment share by occupations

Brazil	2002 (1)	Change 2002-2014 (2)	Colombia	2002 (3)	Change 2002-2015 (4)	Mexico	2002 (5)	Change 2002-2015 (6)
Life science and health professionals	1.08	0.42	Executive managers	0.03	0.00	Executive managers	3.14	1.54
Physicists, mathematicians, profess.	0.87	0.46	Life science and health professionals	1.38	-0.13	Education workers	4.36	-0.22
Lawyers	0.58	0.36	Physicists, mathematicians, profess.	1.65	0.23	Life science and health professionals	1.37	0.43
Economist, accountants	0.44	0.20	Economist, accountants	1.29	-0.11	Physicists, mathematicians, profess.	1.39	0.53
Executive managers	6.30	-0.36	Lawyers	1.17	-0.25	Other professionals	0.44	0.62
Protective services workers	0.21	0.04	Education workers	3.96	-0.84	Economist, accountants	1.31	-0.11
Education workers	4.76	0.44	Other professionals	0.55	0.12	Lawyers	0.81	0.19
Other associate professionals	2.03	0.05	Life science and health associate	0.22	0.14	Writers, artists and sportsmen	0.92	0.17
Physicists, mathematicians, ass. prof.	1.67	0.08	Writers, artists and sportsmen	1.52	0.35	Other managers	5.99	-3.78
Other professionals	1.39	0.55	Physicists, mathematicians, ass. prof.	0.66	1.90	Other associate professionals	1.67	0.82
Life science and health associate prof	1.07	0.27	Other associate professionals	0.14	0.00	Life science and health assoc.	1.05	0.06
Writers, artists and sportsmen	1.34	0.15	Secretaries, stenographers, typists	2.63	-1.27	Physicists, mathematicians, ass. prof.	1.74	0.39
Other managers	2.71	-1.12	Cashiers, tellers and the similar	2.84	0.23	Secretaries, stenographers, typists	3.71	-1.35
Drivers	4.73	0.26	Other clerks	4.69	0.70	Other clerks	4.32	0.82
Other clerks	5.34	2.31	Machinery operators	2.01	-0.71	Drivers	5.70	0.66
Telephone switchboard operators	0.45	0.19	Other managers	7.49	-1.04	Telephone switchboard operators	0.11	0.00
Secretaries, stenographers, typists	1.85	-0.97	Telephone switchboard operators	0.15	1.21	Building workers	5.59	-0.31
Cashiers, tellers and the similar	1.89	-0.02	Protective services workers	3.42	0.09	Machinery operators	5.69	-1.44
Precision, handicraft, and related	9.44	-1.39	Cookers, bartenders, porters	7.22	0.66	Cashiers, tellers and the similar	1.44	-0.05
Sales	10.14	0.68	Precision, handicraft, and related	13.12	-2.25	Protective services workers	2.47	-2.31
Machinery operators	4.29	-0.76	Drivers	7.52	1.53	Precision, handicraft, and related	12.72	-1.00
Cookers, bartenders, porters	6.48	0.61	Building workers	4.56	1.58	Other	0.97	-0.02
Street salesperson	3.30	-1.86	Other services	4.77	1.84	Other services	3.08	5.51
Other services	9.77	0.38	Other	1.77	-0.48	Cookers, bartenders, porters	5.68	-0.67
Building workers	6.85	2.25	Sales	16.41	-0.76	Sales	15.41	-0.11
Other	2.12	-0.51	Street salesperson	3.25	-0.66	Street salesperson	4.43	0.14

Table IV. Changes in routine and non-routine occupations

Occupation	Brazil			Colombia			Mexico		
	2002 (1)	**2014 (2)**	**Change (3)**	**2002 (4)**	**2015 (5)**	**Change (6)**	**2002 (7)**	**2015 (8)**	**Change (9)**
Non-Routine Analytic	16.9	19.7	2.83	13.5	14.5	0.98	15.8	18.8	3.08
Non-Routine Interactive	10.0	8.2	-1.84	8.1	6.7	-1.35	9.6	7.2	-2.33
Routine Cognitive 1	4.7	3.7	-0.98	6.1	6.0	-0.02	5.5	4.1	-1.45
Routine Cognitive 2	20.8	21.6	0.73	26.2	24.6	-1.62	25.3	26.3	1.03
Routine Manual	15.2	12.6	-2.68	16.3	12.7	-3.63	19.3	16.8	-2.45
Non-Routine Manual	32.4	34.4	1.94	29.9	35.5	5.63	24.6	26.7	2.10

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Figure 2. Changes in employment share of routine and non-routine occupations by industries
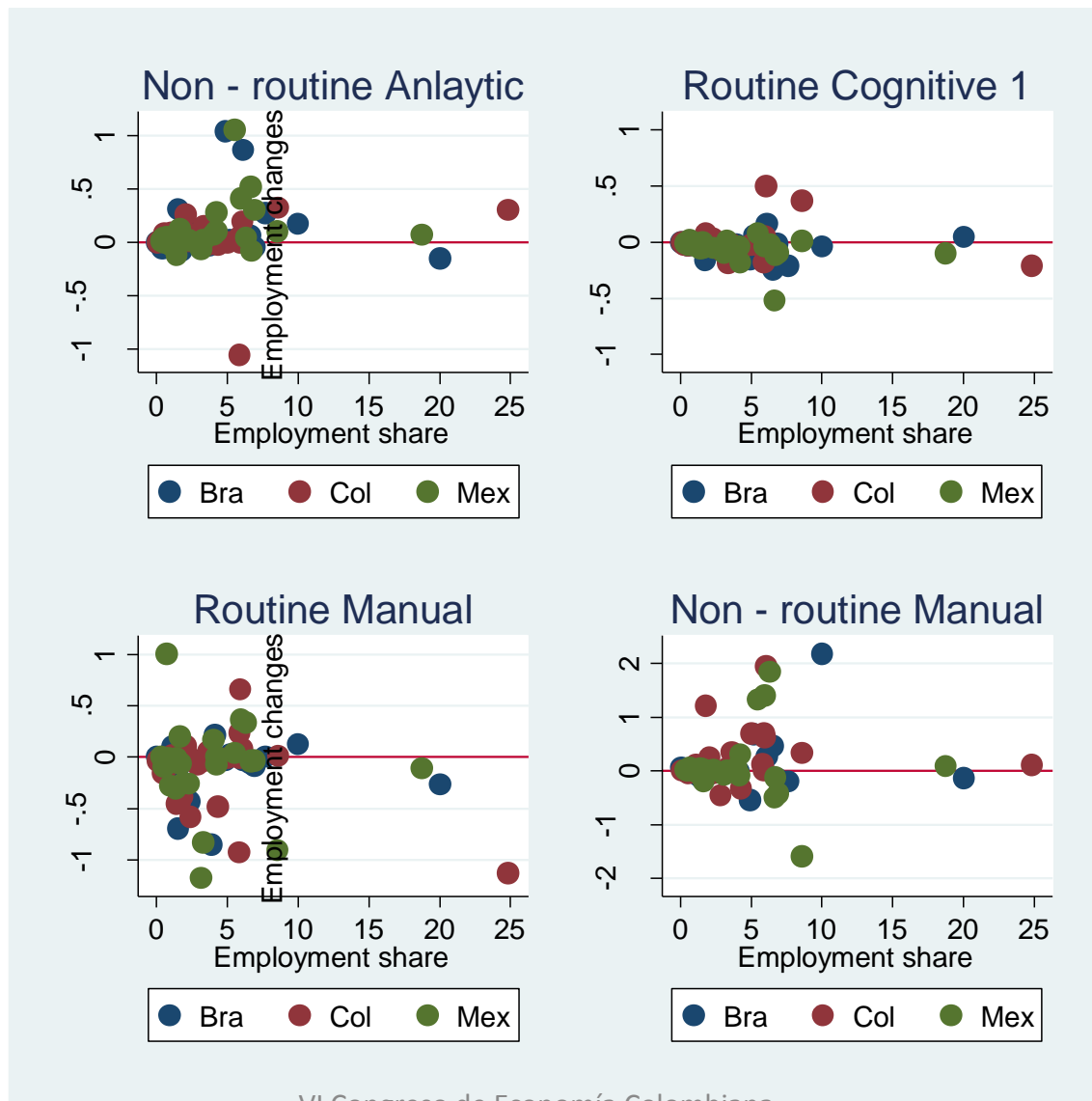
Figure 3. Changes in employment share of routine and non-routine occupations by regions

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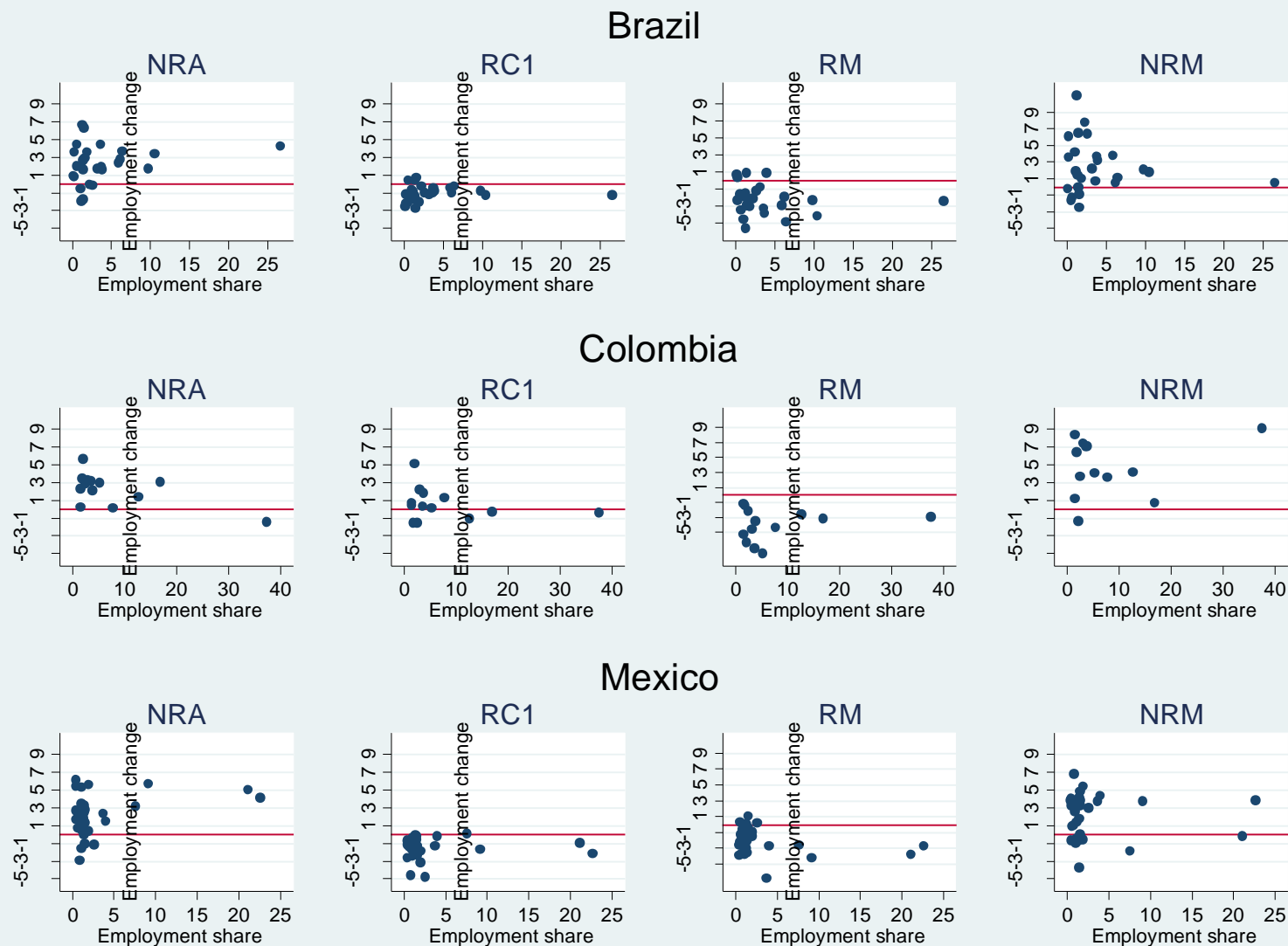
Explaining employment patterns

Table V. Decomposition of employment changes

Occupation	Brazil			Colombia			Mexico		
	B	W	Total	B	W	Total	B	W	Total
Non-Routine Analytic	0.27	2.50	2.77	0.15	0.83	0.98	0.65	2.42	3.08
Non-Routine Interactive	-0.08	-1.77	-1.85	0.21	-1.59	-1.37	-0.14	-2.19	-2.33
Routine Cognitive 1	0.05	-1.05	-1.00	0.35	-0.37	-0.01	0.01	-1.46	-1.45
Routine Cognitive 2	-0.54	1.23	0.69	-2.02	0.39	-1.63	0.41	0.61	1.03
Routine Manual	-1.77	-0.93	-2.70	-2.34	-1.30	-3.65	-2.54	0.09	-2.45
Non-Routine Manual	2.05	0.02	2.07	3.61	2.03	5.65	1.59	0.52	2.11

Note: B is the between change and W is the within change.

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Occupational changes and socio-demographic groups

Table VI. Estimation results of the Multinomial Logit (NRM is base)

	Brazil			Colombia			Mexico		
	Relative-Risk ratios	Std. Err.	P-value	Relative-Risk ratios	Std. Err.	P-value	Relative-Risk ratios	Std. Err.	P-value
Age									
NRA	1.020	0.0000	0.00	1.022	0.0002	0.00	1.029	0.0001	0.00
NRI	1.042	0.0000	0.00	1.040	0.0001	0.00	1.043	0.0001	0.00
RC1	0.961	0.0001	0.00	0.988	0.0002	0.00	0.996	0.0001	0.00
RC2	0.990	0.0000	0.00	1.008	0.0001	0.00	1.015	0.0001	0.00
RM	0.995	0.0000	0.00	1.010	0.0001	0.00	0.993	0.0001	0.00
Age*time									
NRA	0.998	0.0001	0.00	0.982	0.0002	0.00	0.981	0.0001	0.00
NRI	0.996	0.0001	0.00	0.986	0.0002	0.00	0.981	0.0001	0.00
RC1	1.006	0.0001	0.00	0.986	0.0002	0.00	1.000	0.0001	0.94
RC2	1.001	0.0000	0.00	0.998	0.0001	0.00	0.994	0.0001	0.00
RM	1.002	0.0000	0.00	0.999	0.0001	0.00	1.001	0.0001	0.00
Female									
NRA	2.372	0.0023	0.00	1.474	0.0050	0.00	5.073	0.0109	0.00
NRI	0.879	0.0010	0.00	1.237	0.0042	0.00	1.965	0.0048	0.00
RC1	3.445	0.0049	0.00	5.581	0.0232	0.00	19.637	0.0590	0.00
RC2	2.449	0.0020	0.00	1.461	0.0032	0.00	3.575	0.0059	0.00
RM	1.253	0.0011	0.00	0.917	0.0023	0.00	1.619	0.0029	0.00

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Table VI. Estimation results of the Multinomial Logit (NRM is base)

	Brazil			Colombia			Mexico		
	Relative-Risk ratios	Std. Err.	P-value	Relative-Risk ratios	Std. Err.	P-value	Relative-Risk ratios	Std. Err.	P-value
Female*time									
NRA	0.972	0.0012	0.00	0.652	0.0028	0.00	0.483	0.0013	0.00
NRI	1.291	0.0019	0.00	0.957	0.0043	0.00	0.707	0.0023	0.00
RC1	1.723	0.0035	0.00	0.752	0.0040	0.00	0.565	0.0023	0.00
RC2	1.105	0.0012	0.00	1.189	0.0033	0.00	0.816	0.0017	0.00
RM	0.772	0.0010	0.00	1.062	0.0035	0.00	0.781	0.0018	0.00
Education									
NRA	1.584	0.0002	0.00	1.872	0.0010	0.00	1.559	0.0004	0.00
NRI	1.317	0.0002	0.00	1.436	0.0006	0.00	1.457	0.0004	0.00
RC1	1.285	0.0003	0.00	1.378	0.0007	0.00	1.254	0.0004	0.00
RC2	1.149	0.0001	0.00	1.115	0.0003	0.00	1.162	0.0003	0.00
RM	1.034	0.0001	0.00	1.043	0.0003	0.00	1.015	0.0002	0.00
Education*time									
NRA	1.103	0.0002	0.00	0.964	0.0007	0.00	1.146	0.0004	0.00
NRI	1.053	0.0002	0.00	1.057	0.0007	0.00	1.085	0.0004	0.00
RC1	0.961	0.0003	0.00	0.962	0.0007	0.00	1.052	0.0005	0.00
RC2	1.007	0.0001	0.00	0.983	0.0004	0.00	0.989	0.0003	0.00
RM	0.997	0.0002	0.00	0.973	0.0004	0.00	0.985	0.0003	0.00

Table VII. Predicted probabilities

Age=30	Brazil				Colombia				Mexico			
	Male		Female		Male		Female		Male		Female	
Schooling=12	2002	2014	2002	2014	2002	2015	2002	2015	2002	2015	2002	2015
NRA	0.187	0.139	0.261	0.189	0.079	0.089	0.084	0.064	0.123	0.134	0.212	0.165
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
NRI	0.142	0.089	0.073	0.060	0.098	0.058	0.088	0.052	0.116	0.078	0.077	0.054
	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
RC1	0.049	0.026	0.099	0.090	0.042	0.043	0.170	0.135	0.026	0.021	0.174	0.116
	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0001)	(0.0000)	(0.0002)	(0.0001)
RC2	0.214	0.223	0.307	0.356	0.308	0.261	0.326	0.340	0.280	0.264	0.340	0.387
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
RM	0.141	0.153	0.103	0.087	0.182	0.141	0.121	0.103	0.199	0.193	0.110	0.123
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Age=45												
Schooling=12												
NRA	0.225	0.171	0.332	0.244	0.094	0.089	0.103	0.066	0.156	0.145	0.262	0.176
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.0001)	(0.0002)	(0.0001)	(0.0003)	(0.0002)
NRI	0.235	0.146	0.129	0.102	0.151	0.081	0.139	0.074	0.178	0.103	0.116	0.071
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0001)
RC1	0.024	0.015	0.052	0.053	0.030	0.027	0.124	0.088	0.020	0.018	0.131	0.101
	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0001)	(0.0000)	(0.0002)	(0.0001)
RC2	0.165	0.182	0.251	0.304	0.296	0.267	0.323	0.359	0.289	0.282	0.342	0.407
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0004)	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0002)
RM	0.115	0.137	0.090	0.082	0.180	0.152	0.123	0.115	0.147	0.163	0.079	0.102
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)

Note: Standard Errors are below predicted probabilities and they were obtained by the Delta-method

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Conclusions

In this paper, we study the recent employment changes across skill distribution for labor markets in Brazil, Mexico, and Colombia. We use, for the first time, detailed data on occupations to account for the changes in routine and non-routine jobs using a task-based framework.

The results from the shift-share decomposition of the routine and non-routine employment changes suggest that in general, the fall in the share of routine cognitive 1 (secretaries, stenographers, cashiers) is fully explained by the routinization hypothesis. By contrast, the changes in routine manual occupations in the three countries are explained more by changes in economic structure.

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- An econometric estimation of MLM suggests that women were the most affected negatively by changes in RC1. On the contrary, younger and highly educated workers benefited from changes in the NRA occupations.

- The effect of the technical change on job informality in Latin America is one of the most interesting issues for future research.

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