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The unemployment invariance hypothesis and the implications of added and discouraged worker effects in Latin America

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Abstract

This research explores the long-term equilibrium relationship between unemployment and labour force participation rates for six selected countries in Latin America at both aggregate and gender-disaggregated levels. Cointegration analysis focused on the study of time series is used to validate the unemployment invariance hypothesis and explore added and discouraged worker effects in depth. The results suggest mixed dynamics for the aggregate model; however, a clear gender bias is revealed towards the added worker effect for women, while the discouraged worker effect is confirmed for men. The validity of the unemployment invariance hypothesis in several countries appears to reflect some rigidities that prevent the improvement of nations' labour markets, exposing issues that economic policies must strategically address.

Keywords: cointegration; added worker effect; discouraged worker effect; unemployment invariance; unemployment rate; labour force participation rate.

JEL codes: E24, C10, J21, J64, J68.

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1. Introduction

This study explores the long-run equilibrium relationship between the unemployment rate and the labour force participation rate at aggregate and gender-disaggregated levels for six selected countries in Latin America. The nature of this relationship has broad implications for understanding the dynamics of Latin American and related economies' labour markets. At present, the informative value of the unemployment rate as an exclusive indicator to delve into labour market conditions may not be reliable if changes occur in the participation rate during a given period.

Ramos-Veloza et al. (2021) suggest that although the unemployment rate is traditionally used to diagnose the current state of the labour market, it does not reflect the potential rigidities that prevent labour from flowing freely over the business cycle. If no long-run equilibrium relationship is found between labour force participation and unemployment rates (i.e. validating the unemployment invariance hypothesis), this indicates that economic policies adopted to influence the size of the labour supply will not be congruent with changes in the unemployment rate. Therefore, attention should focus on other potential factors that promote higher labour demand to balance the labour market. In contrast, if a long-run relationship between unemployment and labour force participation rates is corroborated (i.e. invalidating the unemployment invariance hypothesis), this will allow us to investigate whether changes in unemployment rates trigger an added or discouraged worker effect in Latin American economies.

Humphrey (1940) and Woytinsky (1940) suggest that the added worker hypothesis assumes the addition of extra individuals into the labour force during recessions, given certain family circumstances. In particular, when the head of household loses a job, forcing other members of the household to look for work. In contrast, the discouraged worker effect involves the abandonment of work activity during economic downturns, primarily by an individual who is already out of work. Specifically, this refers to unsuccessful job seekers who, for various reasons, including high unemployment rates, cease participating in the labour market because they are tired of looking for a job or consider it almost impossible to secure one.

According to Martín-Román (2022) the added worker hypothesis is validated when the relationship between the active and unemployment rates is positive, while the discouraged worker hypothesis is validated when it is negative.

However, as added and discouraged worker effects tend to have a greater incidence when disaggregated by gender, the analysis is extended to include variables for both men and women.

In this research, we apply the cointegration analysis methodological strategy proposed by Johansen (1988) to time series with a quarterly frequency covering 2005 to 2019 for six Latin American countries. This methodology aligns with that used by Österholm (2010) and replicated by Emerson (2011), Kakinaka and Miyamoto (2012), Tansel et al. (2016) and Nguyen Van (2016). In this regard, the literature analysing the above hypotheses is strong for countries such as Sweden, the United States (US), Japan, Türkiye and Australia, among others. However, no general consensus has been reached regarding the dynamics between labour force participation and unemployment rates.

As a complement to the scientific contribution on the subject, this study is not only novel because of the quantitative technique that is used to delve into these relationships, but also because it offers results that have not been produced regarding the Latin American region. Thus, the findings of this work could serve as a basis for determining possible economic policy strategies to improve nations' labour markets.

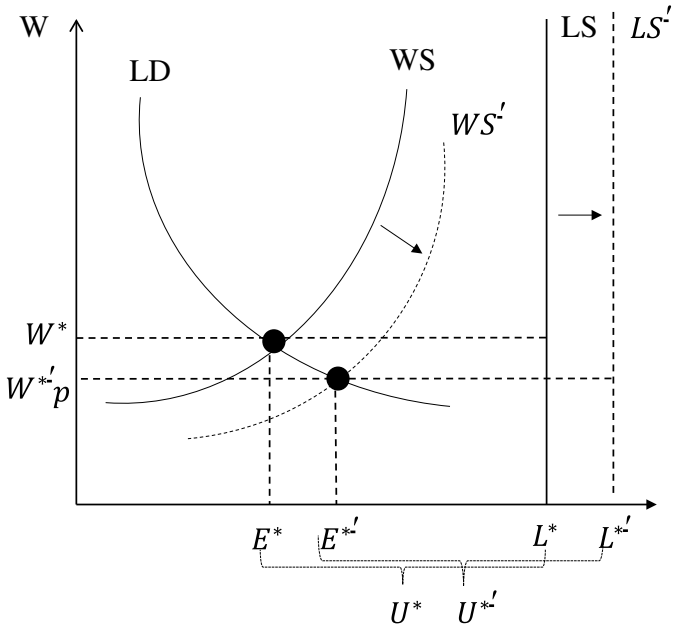
This research is structured into five sections. This introduction is followed by section 2, presenting the literature review related to the approach implemented in this study. In section 3, the selected countries in Latin America are detailed, along with the period of analysis and the methodology used to validate the unemployment invariance hypothesis and added and discouraged worker effects. In section 4, the treatment of the series and the econometric results are discussed. Finally, section 5 presents the conclusions and policy recommendations associated with the findings.

2. Background

To understand the unemployment invariance hypothesis more comprehensively, it will be explained on the basis of some assumptions. Its validation implies that the overall unemployment rate does not change in response to changes in the labour force participation rate. Given labour market conditions, a movement in the latter variable will be counteracted by wage-setting and the interaction between labour supply and demand. Subsequently, policymakers should be

cautious when applying labour market stimuli to reduce the long-term unemployment rate.

Figure 1: The effect of an increase in the labour force



The unemployment invariance hypothesis is visually illustrated in Figure 1, where LD denotes the labour demand curve, while WS represents the wage-setting curve. The latter variable presents the equilibrium real wage (W*) for an aggregate employment level (E*). Labour supply (LS) simulates the labour supply curve, while U* denotes the unemployment standard.

Referencing Nguyen Van (2016), an increase in the size of the LS shifts this curve to the right from LS to LS'. Because there is a larger LS, the labour market will adjust via price to maintain equilibrium, as set by classical supply and demand conditions. This would shift the WS curve to the right, from WS to WS', reducing wages proportionally to the increase in LS. Therefore, there would be no change in the long-term unemployment rate and U* would be equal to U*'.

The validation of the unemployment invariance hypothesis not only has important implications for theory but also for the overall empirical framework in which macroeconomic policies and labour economics unfold. Its development will uncover recommendations for the adoption of policy strategies to improve labour markets according to changes in labour force composition. It will also contribute to future research on added and discouraged worker effects on economies.

Beyond this dynamic, controversy remains regarding consensus on the validity of the unemployment invariance hypothesis, with several notable studies

in the economic literature investigating these relationships using a time series approach, applying the cointegration methodology with autoregressive models.

For example, in favour of this hypothesis, Oţoiu and Ţiţan (2016) and Nguyen Van (2016) examine Romania and Australia, respectively. Similarly, using a cointegration analysis, Altuzarra et al. (2019) validate the unemployment invariance hypothesis for the Spanish economy with a model examining unemployment and labour force participation rates in aggregate and disaggregated male groupings. The results are not applicable to the model in its female adaptation, as the unemployment invariance hypothesis is rejected, revealing discouraged worker effects in this stratum, which is congruent with the findings of Tansel et al. (2016) for the Canadian economy. For the US, Emerson (2011) also analyses the long-run equilibrium relationship between these specific rates, determining that the unemployment invariance hypothesis is not satisfied for the aggregate model in addition to when disaggregated by gender. The presence of discouraged workers is found in the male version of the model, congruent with the findings of Österholm (2010) for Sweden. Kakinaka and Miyamoto (2012) examine the Japanese economy, revealing a long-run relationship between labour force participation and unemployment rates in male disaggregation, but not in the female version. Therefore, for the first stratum, the unemployment invariance hypothesis was not valid for that country, but the results of this research provide strong evidence of the presence of the added worker effect for middle-aged men.

As previously noted, time series analysis focusing on cointegration with autoregressive models are commonly used to investigate the unemployment invariance hypotheses and examine added and discouraged worker effects primarily for countries that are considered advanced or developed. However, additional studies delve deeper into these dynamics, applying various time series econometric techniques to aggregate data. For example, Benati (2001) applies a band-spectrum regression model, revealing the presence of discouraged workers for the aggregate series in the US economy, which contrasts with Emerson (2011), who demonstrates an added worker effect in the US. Alternatively, applying a structural time series methodology for the US, France, Japan and Sweden, Darby et al. (2001) find evidence in favour of the discouraged worker effect in these economies that is particularly stronger for women in business cycle downturns. For the Spanish economy, Congregado et al. (2011) use a threshold cointegration modelling methodology to confirm the predominance of the added worker effect over the discouraged worker effect at the aggregate level only when

unemployment is below 11.7%. Another study regarding the Spanish economy is Martín-Román et al. (2020), which complements Congregado et al. (2011) by providing evidence in favour of the discouraged worker in Spain when the unemployment rate is above 13%. However, in a follow-up effort on gender disaggregation, Congregado et al. (2014) confirms a discouraged worker effect for men and an added worker effect for women, which is consistent with the findings of Prieto-Rodríguez and Rodríguez-Gutiérrez (2000) for the latter stratum. Gong (2011) also finds an added worker effect for Australian women. In the case of Germany, Fuchs and Weber (2013) orient towards the application of unobserved component models, finding a mixed effect for the aggregate model in which both added worker and discouraged worker effects are validated. In a follow-up study that is stratified by gender, Fuchs and Weber (2017) uncover a discouraged worker effect for women, young workers and older adults when unemployment is of short duration. For middle-aged men and women, the authors found a contradictory added worker effect.

While the methodological approach of the current research is very similar to that proposed by the various studies noted in this literature review, it is essential to note that there is minimal research investigating added and discouraged worker effects in the Latin American region. Lee and Parasnis (2014) provide an overview of the framework. Based on the generalised method of moments, the authors observe that the discouraged worker effect is evident in developed economies, while the added worker effect is validated for developing economies. Notably, Colombia and Peru are included among the developing economies among the 13 countries selected. For Mexico, similar to that established by Serrano et al. (2019), Hernández and Romano (2011) analyse the cyclical variations of female participation in the labour market, finding that it is countercyclical in the low-skilled segment during severe recessions, as predicted by the added worker effect. For low-skilled men, labour force participation is procyclical, suggesting a discouraged worker effect. Lee and Cho (2005) examine the issue for Argentina and the Republic of Korea. Based on household surveys in these countries, the authors reveal an added worker effect in the latter and a discouraged worker effect in the former. The different degrees of risk aversion/discrimination against women's participation and remuneration in labour markets are explained as the rationale for these dynamics during periods of economic recession and structural adjustment considered. Although the authors suggest that significant progress has been made in encouraging Argentine female workers to enter the labour market, Groisman (2011) points out that factors that

limit or hinder the female population's access to better quality jobs still seem to persist. Finally, in Brazil, Fernandes and De Felício (2005) analyse the entry of married women into the Brazilian labour market as a result of their spouses' unemployment. The results reveal the presence of an added worker effect in the female population, suggesting that Brazilian families have serious difficulties adopting alternative strategies to smooth income and consumption during periods when the head of household is unemployed.

In summary, the research addressing the relationships between labour force participation and unemployment rates primarily examines developed countries. In this sense, this study offers unprecedented results to advance the construction of macroeconomic policies to improve the condition of Latin American labour markets. A quantitative approach is implemented to deepen the investigation of added and discouraged worker effects for six Latin American economies using a cointegration approach. The approach references Johansen's (1988) cointegration test to determine how the results change in relation to previous findings for different countries.

3. Data and methodology

3.1. Data

Time series with quarterly frequency covering the period between 2006 and 2019 are used, which are obtained from the Center for Distributive, Labor and Social Studies (CEDLAS) (2022) database of the National University of La Plata in Argentina. The specific[1] rates used are as follows:

$$Labour\ force\ participation\ rate\ (LFP) = \frac{Labour\ force}{Working\ age\ population}$$

$$Unemployment\ rate\ (UR) = \frac{Unemployed\ population}{Labour\ force}$$

The selected countries and the periods of analysis are detailed in Table 1, according to the availability of the information provided by CEDLAS (2022).

[1] At both the aggregate level and separately for men and women. For the grouping by gender, given the limited data availability, the study focuses on adults between 25 and 64 years of age. The time series used are seasonally adjusted using the Eviews 10, Census X-12 seasonal component adjustment method.

Table 1: Selected countries and periods of analysis

Country	Period	Observations
Brazil	2012:Q1–2019:Q4	32
Chile	2012:Q2–2019:Q4	31
Ecuador	2010:Q4–2019Q:Q4	37
Mexico	2011:Q4–2019:Q4	33
Peru	2006:Q3–2019:Q1	51
Uruguay	2008:Q1–2019:Q4	48

Source: Center for Distributive, Labor and Social Studies, University of La Plata, Argentina.

The sample of six countries out of 13 are chosen from the Latin American labour market data published by CEDLAS (2022), as the periodic data series were obtained for these countries without methodological changes to household surveys during the period of analysis. In the other cases, the data series are extremely short-term and there are gaps in the data composition.

To provide an overview of the evolution of the variables under study, Figure 2 reveals a certain congruence between upward trends in the labour force participation rate of each country and acceleration of economic growth in the region as a result of the favourable dynamics of commodities prices until mid-2015. This allowed an increase in production and encouraged greater labour participation. For example, Ecuador, Uruguay and Peru achieved labour participation rates between 65% and 70%. Notwithstanding, along with the slowdown in the rate of economic growth for most of the countries in the region, after 2015 labour force participation rates showed a downward trend.

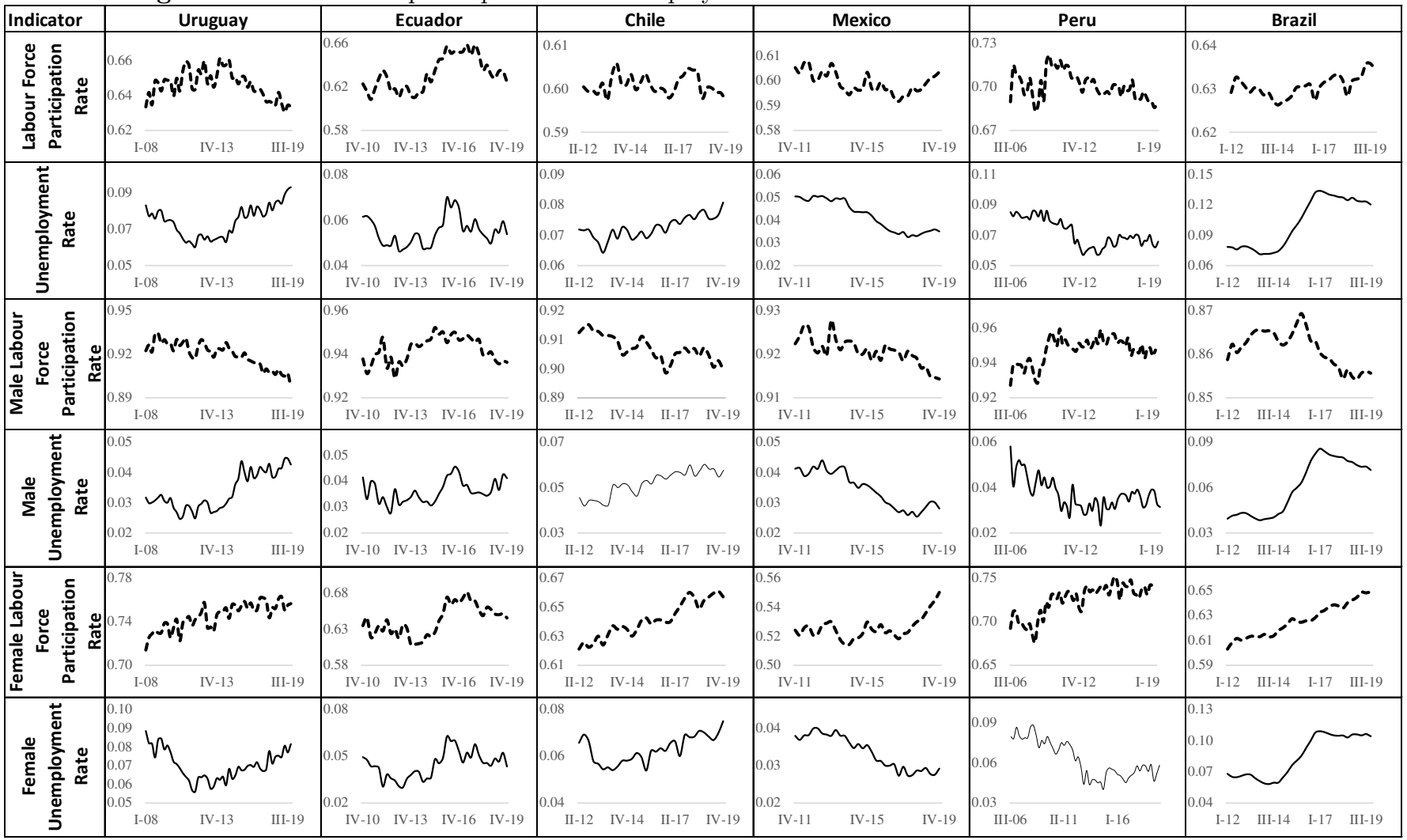
With a certain degree of volatility, the disaggregation of the labour force participation rate by gender indicates a possible added worker effect for women and a discouraged worker effect for men. A downward trend in male labour participation is evident for most of the selected countries during the period of analysis. In contrast, female labour force participation rate had an upward trend in all six economies under study. Notably, men are the primary participants in the labour markets of these countries. The participation differential between men and women ranges from 14% for Uruguay to 36% for Mexico.

Regarding the unemployment rate, at both the aggregate level and between men and women, very low levels are observed for most economies until mid-2015. From that year onwards, according to CEPAL (2019), the region experienced a generalised and synchronous economic slowdown, which led to a sustained deterioration in employment.

Consequently, Figure 2 indicates that countries such as Brazil had an unemployment rate of around 12% in 2019, which was twice the amount reflected in 2012. Similar performance is observed for Chile and Uruguay, which went from unemployment rates close to 6% in 2014 to around 8% in 2019.

While the trend dynamics are replicated with a certain degree of dispersion for the variables disaggregated by gender, despite a notable increase in female labour participation during the period under analysis, there are more unemployed women than unemployed men, with an average unemployment rate differential of 3% for countries like Brazil, Peru and Uruguay.

Figure 2: Labour force participation and unemployment rates for selected Latin American economies



Source: Socio-Economic Database for Latin America and the Caribbean (Center for Distributive, Labor and Social Studies, University of La Plata, Argentina and the World Bank).

3.2. Methodology

The approach proposed by Nguyen Van (2016) is referenced to examine the long-run equilibrium relationship between labour force participation and unemployment rates at aggregate and gender-disaggregated levels. Thus, a vector error correction model (VECM) may be applied as part of the multivariate time series approach when some considerations are met.

The VECM is a restricted vector autoregressive model (VARM), which identifies the possible cointegrating relationships of the variables under study. In this model, the variables that conform are restricted to converge to the long-term equilibrium, while also exposing the short-term adjustment dynamics. Referencing the methodology of Johansen (1988) which is replicated in the research approaches of Österholm (2010) and Altuzarra et al. (2019), the unrestricted VARM is represented as follows:

$$y_t = \alpha + \sum_{i=1}^{k} \mathrm{A}_j \mathrm{y}_{t=i} + \varepsilon_t \qquad \mathbf{(1)}$$

Here, y_t is the data vector containing n variables at time t (labour force participation and unemployment rates), and ε_t is a vector of innovations that is independent and identically distributed.

According to Nguyen Van (2016) the VARM of equation 1 can be rewritten as follows:

$$\Delta y_t = \alpha + \pi y_{t-1} + \textstyle\sum_{t=1}^{k-1} \mathrm{r}_i \, \Delta y_{t-1} + \varepsilon_t \qquad \mathbf{(2)}$$

Here, $\pi = \sum_{i=1}^{k} \mathrm{A}_i - \mathrm{I}$ and $\mathrm{r}_i = -\sum_{j=i+1}^{k} \mathrm{A}_j$

If the variables in vector y_t are integrated time series of order 1 (I(1)), the matrix π in equation 2 will have a rank of r ($0 \leq r < n$), where r is the number of cointegrated equations. If there are r cointegrating equations, the VARM in the very first differences in equation 2 will have misspecification since it omits the lagged level component πy_{t-1}.

If so, since π has a reduced rank ($0 \leq r < n$), π may be calculated as $\alpha\beta'$, with $\beta' y_t$ being stationary, with α *y* β, both *rxn* rank *r* matrixes. α is a vector with *nxr* adjustment coefficients in the VECM, setting β as the cointegrating vector to measure the long-term equilibrium relationships between the variables.

The results are presented in section 4, simultaneously examining the unemployment invariance hypothesis and whether the added or discouraged worker effect prevails for each of the six economies under study, in both aggregated and gender-disaggregated forms.

4. Results

Given the nature of the time series variables, the coefficients obtained by estimating the VARM could be subject to spurious regression. Consequently, it is essential to verify the degree of stationarity of the stochastic processes through unit root tests. This study applies 1) augmented Dickey–Fuller (ADF), 2) Phillips–Perron (PP) and 3) Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests.

In the first two cases, the null hypothesis of the presence of a unit root in the series is applied. If it is rejected, this indicates that the series are stationary and integrated at an order of zero I(0). If it is not rejected, the series requires differentiation to make it stationary, indicating an integrated order of one I(1), in which the differentiation is sufficient to achieve stationarity. With respect to the KPSS test, the stationarity hypothesis is raised if it is rejected, it is necessary to proceed with the differentiation of the series to make it stationary.

Prior to the execution of the aforementioned tests, the model to be used must be determined; thus, a regression is run to determine the variable levels using a linear trend and a constant. Different unit root tests were conducted depending on the significance level of each explanatory variable for the regression specification. For some cases, the model is run without a deterministic component, including a constant term or in addition to a constant, to elicit linear trends. The following results obtained are presented in Table 2.

Table 2: Unit root tests

Country	Level	Variables	Test Equation Specification	ADF (H0 = unit root)	PP (H0 = unit root)	KPSS (H0 = stationarity)
Brazil	Aggregated	LFP	C-T	-4.12	-2.47	0.16**
		ΔLFP	Sin C-T / For KPSS with C	-6.38**	-6.38**	0.09
		UR	C-T	-1.93	-1.50	0.10
		ΔUR	Sin C-T / For KPSS with C	-1.74*	-1.67*	0.15
	Men	LFP	C-T	-2.39	-2.41	0.17**
		ΔLFP	Sin C-T / For KPSS with C	-5.13**	-5.13**	0.28
		UR	C-T	-2.02	-1.2	0.10
		ΔUR	Sin C-T / For KPSS with C	-1.73*	-1.83*	0.17

Country	Level	Variables	Test Equation Specification	ADF (H0 = unit root)	PP (H0 = unit root)	KPSS (H0 = stationarity)
	Women	LFP	C-T	-1.86	-2.81	0.12*
		ΔLFP	Sin C-T / For KPSS with C	-0.74	-4.07**	0.04
		UR	C-T	-1.89	-1.82	0.1
		ΔUR	Sin C-T / For KPSS with C	-2.02**	-2.10**	0.14
Chile	Aggregated	LFP	C	-3.35	-3.32	0.09
		ΔLFP	Sin C-T / For KPSS with C	-7.00**	-7.00**	0.07
		UR	C-T	-3.48	-3.22	0.15*
		ΔUR	Sin C-T / For KPSS with C	-5.55**	-5.89**	0.12
	Men	LFP	C-T	-2.71	-2.76	0.1
		ΔLFP	Sin C-T / For KPSS with C	-5.91**	-5.91**	0.06
		UR	C-T	-3.84	3.84	0.14*
		ΔUR	Sin C-T / For KPSS with C	-1.23	-7.59**	0.13
	Women	LFP	C-T	-3.93	-3.03	0.06
		ΔLFP	Sin C-T / For KPSS with C	-5.20**	-5.20**	0.15
		UR	C-T	-2.72	-2.42	0.16**
		ΔUR	Sin C-T / For KPSS with C	-6.40**	-6.43**	0.23
Ecuador	Aggregated	LFP	C-T	-1.47	-1.55	0.12
		ΔLFP	Sin C-T / For KPSS with C	-6.53**	-6.53**	0.16
		UR	C	-2.35	-2.33	0.16
		ΔUR	Sin C-T / For KPSS with C	-6.67**	-6.66**	0.08
	Men	LFP	C	-2.35	-2.35	0.26
		ΔLFP	Sin C-T / For KPSS with C	-9.64**	-9.31**	0.22
		UR	C-T	-3.63	-3.7	0.08
		ΔUR	Sin C-T / For KPSS with C	-9.06**	-8.90**	0.16
	Women	LFP	C-T	-2.07	-2.08	0.1
		ΔLFP	Sin C-T / For KPSS with C	-7.80**	-7.73**	0.08
		UR	C-T	-2.62	-2.54	0.1
		ΔUR	Sin C-T / For KPSS with C	-7.20**	-7.22**	0.12
Mexico	Aggregated	LFP	C-T	-2.14	-2.03	0.16*
		ΔLFP	Sin C-T / For KPSS with C	-6.68**	-6.82**	0.17
		UR	C-T	-1.14	-1.30	0.11
		ΔUR	Sin C-T / For KPSS with C	-4.22**	-4.19**	0.2
	Men	LFP	C-T	-4.35**	-4.36**	0.1
		ΔLFP	Sin C-T / For KPSS with C	-7.87**	-9.25**	0.50
		UR	C-T	-1.97	-2.08	0.10
		ΔUR	Sin C-T / For KPSS with C	-5.53**	-5.53**	0.12
	Women	LFP	C-T	-0.51	-0.63	0.15**
		ΔLFP	Sin C-T / For KPSS with C	-4.48**	-4.54**	0.31
		UR	C-T	-2.23	-2.36	0.11
		ΔUR	Sin C-T / For KPSS with C	-7.35**	-7.17**	0.09
Peru	Aggregated	LFP	C-T	-4.06	-4.29**	0.12*
		ΔLFP	Sin C-T / For KPSS with C	-10.18**	-10.36**	0.13
		UR	C-T	-1.93	-1.67	0.17**
		ΔUR	Sin C-T / For KPSS with C	-9.35**	-9.44**	0.21
	Men	LFP	C-T	-2.04	-3.36	0.17**
		ΔLFP	Sin C-T / For KPSS with C	-9.69**	-9.85**	0.18
		UR	C-T	-2.22	-4.38**	0.23**
		ΔUR	Sin C-T / For KPSS with C	-7.60**	-14.94**	0.26
	Women	LFP	C-T	-3.49	-3.52	0.15*

Country	Level	Variables	Test Equation Specification	ADF (H0 = unit root)	PP (H0 = unit root)	KPSS (H0 = stationarity)
		ΔLFP	Sin C-T / For KPSS with C	-9.32**	-10.33**	0.15
		UR	C-T	-2.09	-1.97	0.15**
		ΔUR	Sin C-T / For KPSS with C	-8.64**	-8.66**	0.13
Uruguay	Aggregated	LFP	C-T	-3.56	-3.56	0.23**
		ΔLFP	Sin C-T / For KPSS with C	-10.25**	-12.04**	0.35
		UR	C-T	-1.17	-1.77	0.21**
		ΔUR	Sin C-T / For KPSS with C	-9.06**	-8.81**	0.56
	Men	LFP	C-T	-3.88	-3.78	0.24**
		ΔLFP	Sin C-T / For KPSS with C	-8.41**	-8.85**	0.39
		UR	C-T	-2.55	-2.47	0.17**
		ΔUR	Sin C-T / For KPSS with C	-7.47**	-7.47**	0.13
	Women	LFP	C-T	-6.01**	-6.01**	0.15**
		ΔLFP	Sin C-T / For KPSS with C	-9.59**	-21.13**	0.5
		UR	C	-2.41	-2.33	0.23
		ΔUR	Sin C-T / For KPSS with C	-9.58**	-9.78**	0.51

Notes: ADF and PP tests are based on the critical values of MacKinnon (1996).
The KPSS test is based on the critical values of KPSS.
Ho = null hypothesis, C = constant and T = linear trend. Δ denotes the variable at its first difference.
*, ** and *** indicate that the null hypothesis is rejected at 10%, 5% and 1% levels, respectively. Figures without * indicate that the null hypothesis is accepted, at least at 1%, 5% or 10% levels.

Table 2 demonstrates that most of the variables are non-stationary, indicating that they are integrated variables at an order of 1. When the unit root tests are run again in the differentiated version with the given specifications, they remain stationary. However, some tests indicate that the series under review are integrated at an order of 0. Despite this, the analysis continues to use at least one result in favour of integration at an order of 1 for the time series concerned. Such was the case for the female version of the Uruguayan model in relation to labour force participation rate in levels, as the presence of a unit root is only obtained using the KPSS test.

Although the VARM and VECM models could be run with the variables that are determined to be integrated at an order of 1 and 0 order in their differentiated version, this did not occur in the Mexican economy because the male labour force participation rate was stationary for the three unit root tests above.

Once the order of integration of the series is established, the methodology developed by Johansen (1988) is used to investigate the long-run equilibrium relationships between the model variables. Replicating this methodology, an unrestricted VARM (p) is estimated for the series at the global level and disaggregated by gender in each selected country. In this way, the stability of the

proposed VARM model and the fulfilment of the Gauss-Markov assumptions are corroborated. The results of the Lagrange multiplier test for serial autocorrelation rules out the presence of serial correlation at a 5% level of significance.

White's joint test for heteroscedasticity applied to autoregressive models indicates that the variance of the residuals is homoscedastic at a 95% confidence level. The residuals are normally distributed, per the Jarque–Bera statistic and probability values indicate that they follow a normal multivariate distribution, both individually and jointly.

Subsequently, the VECM is estimated to investigate the conformation of the model with the cointegrated variables (i.e. labour force participation and unemployment rates). After this, the rank of the r matrix is tested using the Johansen (1988) cointegration test to determine the presence of cointegration in the proposed VECM. The results are presented in Table 3 below.

Table 3: Cointegration test results

Country	No. of cointeg. relations	Aggregated		Male		Female	
		Prob. J_{traza}	Prob. J_{max}	Prob. J_{trace}	Prob. J_{max}	Prob. J_{trace}	Prob. J_{max}
Brazil	Any	0.24	0.56	0.00*	0.00*	0.00*	0.00*
	At least 1	0.04*	0.04*	0.04*	0.04*	0.14	0.14
Chile	Any	0.04*	0.03*	0.03*	0.03*	0.04*	0.03*
	At least 1	0.50	0.50	0.33	0.33	0.52	0.52
Ecuador	Any	0.03*	0.03*	0.04*	0.15	0.12	0.20
	At least 1	0.23	0.23	0.03*	0.03*	0.10	0.10
Mexico	Any	0.15	0.17	n/a	n/a	0.51	0.63
	At least 1	0.21	0.21	n/a	n/a	0.20	0.20
Peru	Any	0.00*	0.00*	0.01*	0.13	0.00*	0.00*
	At least 1	0.06	0.06	0.00*	0.00*	0.09	0.09
Uruguay	Any	0.00*	0.00*	0.15	0.11	0.00*	0.00*
	At least 1	0.29	0.29	0.75	0.75	0.13	0.13

Notes: * denotes rejection of the null hypothesis at a 5% level; n/a = not available.

The results of trace and maximum-Eigenvalue tests suggest the presence of a long-run equilibrium relationship between labour force participation and unemployment rates for the aggregate version of the model for Ecuador, Chile, Peru and Uruguay, but not for Brazil and Mexico.

The modelling by gender reveals a long-run equilibrium relationship between labour force participation and male unemployment rates only for Chile. For the remaining countries, the hypothesis is rejected. Finally, a long-run convergence is revealed for the model applied to the female data series for Brazil, Chile, Peru and Uruguay, but not Ecuador and Mexico.

Based on the results previously indicated, Table 4 summarises the validation of the unemployment invariance hypothesis, only accepting it for cases indicating no long-run equilibrium relationship between the model variables. This is applicable to Brazil and Mexico for the aggregate model. In the male version, it is accepted in four of the six countries (Brazil, Ecuador, Peru and Uruguay), while for the female segment it is only accepted in two (Ecuador and Mexico).

Table 4: Results regarding the unemployment invariance hypothesis and added or discouraged worker effects

Time period	Country	Aggregated model	Male model	Female model
2012:Q1–2019:Q4	Brazil	Accepted	Accepted	Rejected
	Effect	-	-	Added worker
2012:Q2–2019:Q4	Chile	Rejected	Rejected	Rejected
	Effect	Discouraged worker	Discouraged worker	Added worker
2010:Q4–2019Q:4	Ecuador	Rejected	Accepted	Accepted
	Effect	Added worker	-	-
2011:Q4–2019:Q4	Mexico	Accepted	n/a	Accepted
	Effect	-	-	-
2006:Q3–2019:Q1	Peru	Rejected	Accepted	Rejected
	Effect	Added worker	-	Discouraged worker
2008:Q1–2019:Q4	Uruguay	Rejected	Accepted	Rejected
	Effect	Discouraged worker	-	Added worker

Notes: n/a = not available.

For the models in which a long-run equilibrium relationship is revealed, the countries for which added or discouraged worker effects predominate are shown below.

Indeed, the estimation of the cointegration vector for the aggregate model indicates that by normalising the coefficients associated with the labour force participation rate to unity (β_{TA}=1), the long-run relationship with respect to the unemployment rate presents a mixed equilibrium, although there are marked differences in the incidence of each effect. The added worker effect prevails for Ecuador and Peru, whereas the discouraged worker hypothesis is validated for Chile and Uruguay.

As shown in Table 5, the added worker effect is stronger in Ecuador, indicating that for each percentage point increase in the unemployment rate, the labour force participation rate increases by an average of 3%. In Peru, the sensitivity was inelastic at around 0.4% in the participation rate for each percentage point increase in the unemployment rate. The dynamics of the discouraged worker effect are more intense in Uruguay than in Chile, as for each

percentage point increase in unemployment rate, labour participation falls by 0.78% and 0.11%, respectively.

Regarding the dynamics classified by gender, a discouraged worker effect is evident in Chile, revealing a 0.7% drop in labour force participation rate for the male population for each percentage point increase in the unemployment rate, which is higher than that recorded at the aggregate level (0.11%). In contrast, the added worker effect predominates in most of the countries for the female model, such as Brazil (0.68%), Uruguay (0.22%) and Chile (1.67%). The incidence was much higher for Chile than in the remaining the countries.

This dynamic aligns with the trends observed in Figure 2, as Latin American women engaged greater participation in the region's labour markets during the 2006–2019 cycle of analysis, to the detriment of the evolution of male labour participation. However, in Peru, a discouraged worker effect of 0.97% is observed women for each increase in its unemployment rate.

Table 5: Cointegration vectors

Country	Variable	Aggregated	Male	Female
Brazil	Labour force participation rate	n/a	n/a	1
	Unemployment rate	n/a	n/a	-0.68
	Standard error	n/a	n/a	(0.04)
Chile	Labour force participation rate	1	1	1
	Unemployment rate	0.11	0.67	-1.67
	Standard error	(0.15)	(0.08)	(0.5)
Ecuador	Labour force participation rate	1	n/a	n/a
	Unemployment rate	-3.02	n/a	n/a
	Standard error	(0.62)	n/a	n/a
Mexico	Labour force participation rate	n/a	n/a	n/a
	Unemployment rate	n/a	n/a	n/a
	Standard error	n/a	n/a	n/a
Peru	Labour force participation rate	1	n/a	1
	Unemployment rate	-0.41	n/a	0.97
	Standard error	(0.22)	n/a	(0.19)
Uruguay	Labour force participation rate	1	n/a	1
	Unemployment rate	0.78	n/a	-0.22
	Standard error	(0.11)	n/a	(0.26)

Note: n/a = not available.

It is essential to acknowledge that it is not possible to make conclusions regarding added or discouraged worker effects for the male population in Mexico

since, as determine previously, it is not possible to apply the VECM methodology because its labour force participation rate is an integrated series at the order of 0. Finally, as no cointegration is found in the aggregate version of some of the models (Brazil and Mexico) and those disaggregated by male (Brazil, Ecuador, Peru and Uruguay) or female (Ecuador and Mexico) populations, it is also not possible to explore these effects in detail.

5. Conclusions and policy recommendations

This study examines the long-term equilibrium relationships between labour force participation and unemployment rates for six countries in Latin America applying a cointegration analysis for aggregate time series that is also classified by male and female populations. The results of the proposed econometric models demonstrate no long-run equilibrium relationship for the aggregate model for Brazil and Mexico, while this is evident for the economies of Ecuador, Chile, Peru and Uruguay, confirming the unemployment invariance hypothesis is for Brazilian and Mexican economies, but not for the remaining countries.

This indicates that labour policies designed to address changes in labour participation in Brazil and Mexico have not had any influence on the nations' long-term unemployment rate. In contrast, in Ecuador, Chile, Peru and Uruguay, when a long-run equilibrium relationship between the variables of the model is verified, there is scope for policy intervention in labour markets to address added and discouraged worker effects.

In fact, for countries where the unemployment invariance hypothesis is not accepted, in which the results in favour of cointegration are consolidated, the predominance of the added worker effect is validated for Ecuador and Peru. This scenario is consistent with Lee and Parasnis (2014). The magnitude of this effect is particularly strong in the case of Ecuador, suggesting that the working age population reacts sensitively to changes in the economic cycle, looking for work in periods of recession when household heads lose a job or when there are greater opportunities for finding work (economic booms).

The discouraged worker effect prevails in Uruguay and Chile, indicating that some who look for work without success due to high unemployment rates stop participating in the labour market because they are tired of looking for work, becoming part of the economically inactive population during downturns. This

effect implies an underestimation of unemployment in these economies when the economies experience difficulties.

The disaggregation by gender demonstrates no long-term equilibrium relationship between labour force participation and unemployment rates for men in Brazil, Ecuador, Peru and Uruguay. Therefore, the unemployment invariance hypothesis is accepted only in these cases. The hypothesis is not fulfilled in the Chilean economy, given that the series did cointegrate, finding evidence in favour of discouraged workers in men, which is in accordance with the findings of Hernández and Romano (2011) for Mexico, Kakinaka and Miyamoto (2012) for Japan, Österholm (2010) for Sweden and Emerson (2011) for the US.

No long-term convergence is evidenced for the female populations in countries such as Ecuador and Mexico. Therefore, the unemployment invariance hypothesis in these economies is accepted. This is consistent with the relative position of Latin American women in professional fields. It is clear from this finding that the margin of labour policy intervention in favour of women in these countries is limited and has not influenced the long-term female unemployment rate as expected. Conventionally, mostly men participate in the labour market and there are more unemployed women than unemployed men.

The traditional added worker effect is corroborated for the female populations of most of the selected countries. This is the case for Brazil, supporting the results found by Fernandes and De Felício (2005). Similarly, this is corroborated for Chile and Uruguay. In contrast, a dynamic in favour of the discouraged worker is observed for Peru.

This research provides formal evidence suggesting that the policies adopted in the past 14 years to increase the size of the LS in several economies of the region are incongruent with the changes exhibited in long-term unemployment rates. The findings raise several challenges for Latin American public policy, particularly policies involving efforts to address added and discouraged worker effects.

Although women's decisions to join the labour force as part of the added worker effect may help mitigate the impact of increased unemployment on household income, if the labour market is unable to absorb this added LS, unemployment rates will rise. The unemployment rate would then be overestimated during recessions. Improved labour legislation based on tax incentives to encourage businesses to hire women who are married or have

children can contribute to the absorption of additional participants in the labour force. In addition, governments can establish opportunities to support women' entry into the labour market by providing free or subsidised childcare services and universal coverage for the nutritional needs of children at an early age.

In turn, the decrease in labour force participation in periods of higher unemployment as a consequence of the discouraged worker effect implies that the measured unemployment rate will underestimate the level of unemployment in an economy. Consequently, the official record may not reflect the severity of the recessionary effect on unemployment. As a result, it is crucial for policymakers to consider the flow of discouraged workers out of the labour force. To mitigate the adverse effects of discouraged workers' migration from labour market activity to inactivity, application of policies that encourage the unemployed to actively pursue job searched is of particular importance. In addition, the implementation of universal and rapid access to unemployment insurance to support the personal finances of the unemployed during the jobless stage is essential.

In summary, this research demonstrated the importance of considering added and discouraged worker effects. Although potential solutions to the problems arising from the validation of both hypotheses are proposed, the traditional scope of Latin American economic policy must be further enhanced with proposals that guarantee efficient and effective labour market interventions. These challenges should be part of both research and public agenda development to maximise populations' well-being.

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