Comunicaciones en Estadística
Julio 2024, Vol. 17, No. 1, pp. 55–67

Multistage Models for Rural-Urban Migration and Agricultural Production in Peru: 2022

Modelos Multietápicos para la Migración Rural-Urbana y la Producción Agrícola en Perú: 2022

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Resumen

Sobre la base de la Nueva Economía de Migración Laboral (NELM), la migración rural-urbana tiene un impacto significativo y adverso en la producción agrícola de los hogares peruanos. La emigración de un miembro del hogar a zonas urbanas está relacionada, de media, con una reducción del valor de la producción agrícola del hogar de hasta el 48%. Es fundamental implementar políticas que aborden los desafíos económicos y sociales derivados de esta migración, así como promover estrategias que garanticen la seguridad alimentaria de las comunidades rurales, reconociendo el papel crucial de los trabajadores agrícolas activos en este proceso. Las remesas también ejercen una influencia negativa sobre el valor productivo agrícola, aunque moderada, con una caída del 12% frente a un aumento del 10%. Este último hallazgo contradice los resultados de Taylor (1999) y Bassie et al. (2022), donde se establece una relación positiva.

***Palabras clave*:** Migración, Producción Agrícola, Remesas.

Abstract

Based on the New Economics of Labor Migration (NELM), rural-urban migration has a significant and adverse impact on the agricultural production of peruvian households. The emigration of a household member to urban areas is related, on average, to a reduction in the value of the household's agricultural production of up to 48%. It is essential to implement policies that address the economic and social challenges derived from this migration, as well as promote strategies that guarantee the food security of rural communities, recognizing the crucial role of active agricultural workers in this process. Remittances also exert a negative influence on agricultural productive value, although moderate, with a drop of 12% compared to an increase of 10%. This last finding contradicts the results of Taylor (1999) and Bassie et al. (2022), where a positive relationship is established.

***Keywords*:** Migration, Agricultural Production, Remittances.

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1 Introduction

Internal migration in Peru has been a phenomenon rooted since colonial times, experiencing a notable intensification since the mid-20th century. According to (INEI, 2022b), 8.9% of the Peruvian population censused in 1940 migrated from one department to another (interdepartmental migration), while in the 1993 and 2017 censuses these figures increased to 22.1% and 20.3%, respectively. Regarding interprovincial migration recorded in the 2007 and 2017 censuses, the figures reached 25.6% and 26.7%, respectively; On the other hand, district migration reached the figure of 34.9% in 2007 and 36.1% in 2017. Despite the dynamics of these migratory flows, the studies focused their attention on rural-urban migration (from the countryside to the city) and between cities (urban-urban), due to their regularity and relevance (Rodríguez, 2017). Here too the analysis focuses on the first case.

Rural-urban migration was an involuntary phenomenon in its beginnings, a result of the marginalization of communities and/or displacement from their lands (Matos, 1991). This fact was brought about by the introduction of the encomiendas and haciendas, which represented the first forms of organization and exploitation of the labor force in the colonial era (Spalding, 1984). Starting in 1940, with the rise of exports, foreign investment, the modernization of the economy, public investment and agrarian reform (Matos, 1991), migration acquired a more voluntary rather than forced character. People began to look for better work, educational and living opportunities in cities or in areas close to them.

According to census information from (INEI, 2021a), in 1940, the urban area represented 35.4% of the total population, while in 1993 and 2017, the figures reached 70.1% and 82.4%, respectively. As a result, significant transitions have occurred in economic activities, including agriculture.

The agricultural sector constitutes around 3.7% of Peru's real GDP (BCRP, 2024). In terms of the employed Economically Active Population (EAP), this is mainly concentrated in rural areas, reaching 69.5% and, in turn, represents approximately 25% of the total EAP (INEI, 2022a). In this way, the importance of the agricultural workforce in the economic structure of the country is highlighted.

The link between rural-urban migration and agriculture has been widely studied. Some of the recent work is listed below. Selod and Shilpi (2021) highlight shifts from agricultural employment to other industries; Ge et al. (2020) emphasize the boost of labor migration in agricultural transformation; Greiner and Sakdapolrak (2013) show relationships between migration, agricultural change and the environment; Hanif et al. (2020) explore the push-pull factors that generate the migration of agricultural workers; Mbah et al. (2016) analyze the factors associated with the migration of young people among agricultural families.

In this context, the objective of the research is to identify the impact of rural-urban migration on agricultural production, validate the New Economics of Labor Migration (NELM) and evaluate its implications on agricultural sustainability and food security in Peru. The latter is aligned with what FAO (2020) points out, where it is warned that the structural transformation of rural migration could be endangering agricultural production and food security.

The methodology used includes the use of multistage regression models to solve dynamic systems, as developed by Bassie et al. (2022), Goldsmith et al. (2004) y Adaku (2013).

2 Related literature

Much of the rural-urban migration literature focuses on the causes/consequences of migration at the destination. However, what happens with agricultural production in the place of origin of the migration is analyzed here.

The NELM considers that migration affects agricultural production through two channels. On the one hand, a change is observed in the agricultural labor supply and on the other, the earnings of migrants in the form of remittances stand out, which can be channeled to their non-migrant relatives (Stark, 1991). While the direction of impacts is ambiguous, NELM argues that a positive effect would suggest that migration contributes to the growth of agricultural production by easing credit or capital constraints through remittances. On the other hand, a negative impact would indicate that increased migration intensifies the supply of agricultural labor (Rozelle et al., 1999).

Li et al. (2013), based on a multistage econometric model, supports the NELM theory and their results are consistent with the findings of (Taylor, 1999), who indicates that migration aggravates labor shortages, but remittances act as a compensatory mechanism to counteract that loss, thus improving agricultural production -fundamentally in the short term-. Zahonogo (2011) offers partial validity of the NELM by concluding that migration weakens the functioning of rural markets, in particular, the rural labor market. Instead, De Brauw (2020) finds evidence that seasonal migration generates a displacement of labor-intensive crops by land-intensive crops, rather than there being changes in productivity or greater use of capital in agricultural production .

Bassie et al. (2022) uses a three-stage linear regression model. He reveals a significant and positive relationship between remittances and agricultural production, but none between rural-urban migration and agricultural production. In line with the NELM, they reaffirm that if rural-urban labor migration generated labor shortages in peak seasons, remittances would help migrant households alleviate credit constraints on agricultural production. Finally, Adaku (2013) finds that temporary migration significantly reduces agricultural production in Ghana, while permanent migration had no significant impact (as did remittances). This result once again validates the NELM hypothesis at least partially.

3 Theory

The theoretical framework is based on the NELM and the model developed by Stark (1991). Let the function $f : A \subset \mathbb{R}^3 \to \mathbb{R}$, $X \in A$. Then, adding subscripts, it can be written:

$$Y_i = f(M_i, R_i; u_i) \tag{1}$$

where Y_i is the agricultural production of the i-th household, M_i is the number of household members who migrated from rural to urban areas, R_i is the remittances sent by migrants to their families, and u_i comprises other factors that affect Y_i.

When implementing a Cobb-Douglas production function, grouping variables by components, we have

$$\ln Y_i = \ln(\alpha_0) + \alpha_1 \ln(M_i) + \ln(\mathbf{n'}_i)\boldsymbol{\alpha_2} + \ln(\mathbf{x'}_i)\boldsymbol{\alpha_3} + \alpha_4 \ln(u_i) \tag{2}$$

where $\mathbf{n}_i$ denotes a vector of production factors associated with agricultural production (including R_i), and $\mathbf{x}_i$ represents a vector of household and/or household head-related controls. To mitigate the potential ambiguity in equation (2)[1], we can apply a monotonic transformation so that the latter equation can be expressed as:

$$\ln Y_i = \alpha_0 + \alpha_1 M_i + \ln(\mathbf{n'}_i)\boldsymbol{\alpha_2} + \ln(\mathbf{x'}_i)\boldsymbol{\alpha_3} + \upsilon_i \tag{3}$$

where $\upsilon_i = ln(u_i)$ is the stochastic perturbation.

Due to the simultaneity between migration and production (Adaku, 2013; Rozelle et al., 1999; Taylor, 1999), a second structural equation is defined:

$$M_i = \beta_0 + \beta_1 ln(Y_i) + \ln(\mathbf{z'}_i)\boldsymbol{\beta_2} + \ln(\mathbf{x'}_i)\boldsymbol{\beta_3} + \omega_i \tag{4}$$

where w_i is the stochastic perturbation. In this way, the theoretical structural system is defined as:

$$\begin{cases} \ln Y_i = \alpha_0 + \alpha_1 M_i + \ln(\mathbf{n'}_i)\boldsymbol{\alpha_2} + \ln(\mathbf{x'}_i)\boldsymbol{\alpha_3} + \upsilon_i \\ M_i = \beta_0 + \beta_1 ln(Y_i) + \ln(\mathbf{z'}_i)\boldsymbol{\beta_2} + \ln(\mathbf{x'}_i)\boldsymbol{\beta_3} + \omega_i \end{cases} \tag{5}$$

It is clear that the endogeneity of M_i requires the use of a set of valid instruments, denoted as $\mathbf{z'}_i$. The instrument vector must satisfy the assumption of relevance, meaning the instruments must be statistically correlated with M_i:

$$cov(\mathbf{z'}_i, M_i) \neq 0 \tag{6}$$

Likewise, the instruments must verify the exogeneity assumption, namely, they must not be correlated with the error term υ_i. Mathematically:

$$cov(\mathbf{z'}_i, \upsilon_i) = 0 \tag{7}$$

[1] M_i may take the value of zero.

If the assumptions are verified, the estimator is known as Two-Stage Least Squares (2SLS) estimator or $\hat{\alpha}_1^{2SLS}$. The first stage involves estimating equation (4) by Ordinary Least Squares (OLS), which comprises two components: the non-problematic component $\beta_0 + \beta_1 ln(Y_i) + \ln(\mathbf{z'}_i)\boldsymbol{\beta_2} + \ln(\mathbf{x'}_i)\boldsymbol{\beta_3}$ and the problematic component ω_i. The prediction of this equation $(\hat{M_i})$, which allows discarding the last component, is used to estimate equation (3) by OLS (the second stage). As established by Stock and Watson (2020), the distribution of the 2SLS estimator is not exact; however, as the sample size is large, the 2SLS estimator is consistent:

$$\hat{\alpha}_1^{2SLS} \overrightarrow{p} \frac{cov(\mathbf{z'}_i, Y_i)}{cov(\mathbf{z'}_i, M_i)} = \alpha_1 \tag{8}$$

By the Central Limit Theorem, the 2SLS estimator is normally distributed[2] with parameters $N(\alpha_1^{2SLS}, \sigma^2_{2SLS})$, where:

$$\sigma^2_{2SLS} = \frac{1}{n} \frac{var(\mathbf{z'}_i - \mu_z)v_i)}{cov(\mathbf{z'}_i, M_i)} \tag{9}$$

A variant of 2SLS estimates is the limited information maximum likelihood (LIML) estimator, which has a more centered distribution around the true parameter. It can be calculated using Maximum Likelihood, so it is invariant to normalization and is also usually more resistant to weak instruments. Finally, the three-stage least squares estimator (3SLS) follows the same procedure as 2SLS, only now there is one more equation, which allows the three stages to be completed. The idea of adding one more equation is because presumably the orthogonality of the instruments with the error is not being verified, that is:

$$E(\mathbf{z'}_i w_i) \neq 0 \tag{10}$$

4 Data and Methodology

The data used corresponds to the 2022 National Household Survey (ENAHO), provided by the National Institute of Statistics and Informatics (INEI). The survey includes 36,848 private homes distributed in all departments of Peruvian territory, of which 12,592 are in rural areas. The survey collects information on the characteristics of household members, housing/household, health, education, employment-income, pensions, financial inclusion, agricultural activity, social programs and citizen participation. In this case, all available information was used, so no particular sample was used.

Modules 300 (education), 400 (health), 500 (employment and income), summary (calculated variables), 2000, 2010 and 2400 (the last three linked to agricultural

[2]For a detailed demonstration, see Stock and Watson (2020).

activity) were used. The filter variable corresponds to all those who are dedicated to agricultural activity (9,279 households).

The number of migrant household members (*migration*) has been calculated using an approximation since there is no information about it in ENAHO; For the same reason, it was not possible to discriminate between temporary and permanent migrations. The districts were classified as urban and rural according to the threshold established by INEI (2021b): rural areas are territories made up of populated centers, settlements and rural localities with less than 2000 inhabitants, while urban urban areas are populated centers with 2000 and more inhabitants. From this, the variables *p401g* and *p401g2* were used to identify how many household members migrated from the rural area (district) to the urban area (district).

The land size (*size*) includes the total number of owned, borrowed, rented or assigned hectares that the household currently uses for agricultural exploitation.

Remittances received from emigrants (*remittances*) include the amount -in soles- that the household received from other households or people domiciled within Peruvian territory during the last 6 months.

Agricultural production (*production*) includes the total value of production -in soles- generated during the last 12 months by the household[3], including the total value of agricultural by-products.

Expenses on productive factors used during the last 12 months were reproduction seeds (*seeds*); fertilizer expenditure (*fertilizer*); spending on pesticides, insecticides and fungicides (*protection*); payment to day laborers (*workers*); technical assistance expenditure (*assistance*); expense such as rental of machinery and/or purchase of agricultural tools (*capital*).

The characteristics of the head of the agricultural household that were considered are marital status (*emarriage*), sex, educational level (*educ*), years of schooling, frequency with which he or she works in agriculture (*frequency*), number of household members of working age[4] (*members*), average household expenditure (*expenditure*), age and area of residence (*area*). Given that more experienced and educated household heads may have more educated members with a greater probability of migrating (Shi, 2018), the experience of the household head (*exper*) is found as established by Mincer (1974).

The quantitative variables were transformed via natural logarithm, while the qualitative variables were converted into dichotomous or polytomous, depending on the number of attributes they admit. Extreme values were smoothed using the *winsor2* command in Stata.

The estimation of the system of equations defined in equation (5) was done in Stata using 2SLS, restricted 2SLS and IV-GMM. The instruments have been defined

[3]Only households that carry out their agricultural activity independently were considered.
[4]In Peru, the minimum age to work is 14 years, in accordance with the provisions of Convention 138 of the International Labor Organization.

according to Rozelle et al. (1999), Adaku (2013) and Shi (2018). Among them, *area*, *expenditure*, delay time -in hours- to reach a health facility (*thealth*), location of the health facility in the district or outside the district were considered him, years of schooling and *frequency*.

5 Results

According to Table 1, the average production value is 13,775 soles. Its high standard deviation value means that it is relatively far from the median. A similar situation occurs with the other variables linked to productive factors. The average expenditure on workers and fertilizer represents 2.8% and 5.8% of the average production value, respectively, while the average expenditure on seeds represents 4.8%. In the case of technical assistance, the large number of missing values makes it lose importance for modeling.

The average remittances received by households is 17.8 soles, which represents a minimum value compared to production costs. The age of the heads of household follows a normal distribution. On average, households have 3.2 members of working age, so the total average expenditure per capita would be close to 5430.1 soles. The average schooling is around 5.9 years. Some authors, such as Yamada (2012), highlight that the average schooling of migrants is higher than that of non-migrants.

Finally, the heterogeneity in the agricultural plots and the delay in reaching a health facility stands out.

Variable	**Obs**	**Mean**	**Std. dev.**	**Min**	**Max**
production	9279	13775.23	16170.59	180.00	52408.00
seeds	9279	655.18	860.77	0.00	2782.00
fertilizers	9279	799.88	1226.08	0.00	3840.00
protection	9279	256.75	438.67	0.00	1400.00
workers	9279	392.03	696.88	0.00	2040.00
capital	9279	261.13	384.58	0.00	1160.00
assistance	9279	3.74	124.64	0.00	21600.00
remittances	9279	17.86	52.12	0.00	200.00
size	9279	8.44	10.67	0.10	35.00
age	9279	48.61	20.40	14.00	98.00
expenditure	9279	17084.93	10689.29	3358.29	43057.34
members	9279	3.15	1.74	1.00	16.00
schooling	9279	5.91	4.29	0.00	18.00
thealth	2993	0.55	0.78	0.03	5.00

Table 1: Summary statistics of quantitative variables.

Figure 1 indicates that in both men and women, average agricultural production increases as the educational level of the head of the household increases; in turn, production in patriarchal households is greater than in matriarchal ones. In the case of matriarchal households, production is lower in cases of widowhood or divorce

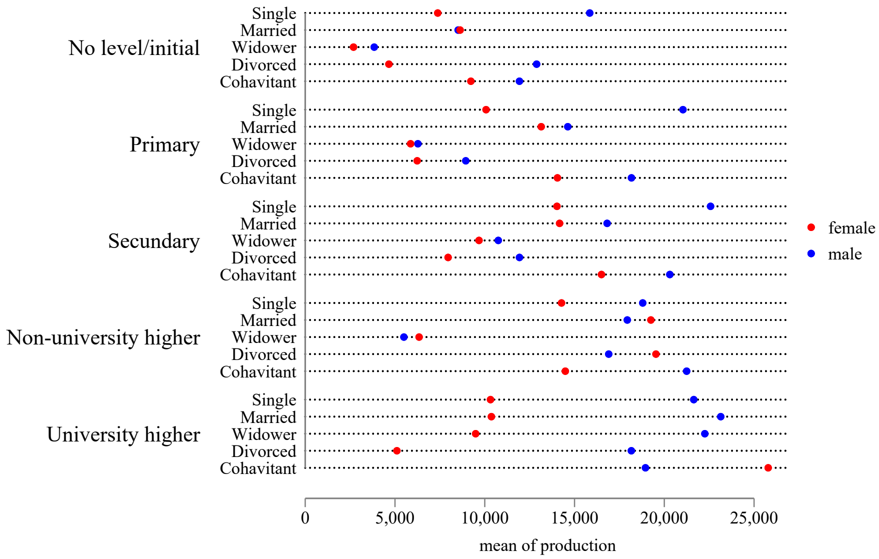

Figure 1: Average agricultural production according to educational level, marital status and sex of the head of household.

at almost all educational levels. In patriarchal homes, this pattern is not clearly distinguished. Furthermore, the gap in agricultural production between single patriarchal households stands out over the other categories - regardless of the educational level achieved -, a trait that is not shared by matriarchal households.

The Table 2 shows the main regressions within each family of estimated models. The coefficients are interpreted as percentages since the independient variables are expressed in logarithms. The first four columns are estimates by instrumental variables, in which the Durbin and Wu-Hausman statistics allowed us to reject the hypothesis that the migration variable is exogenous, as suggested by Baum et al. (2003). The last two columns, for their part, were estimated taking into account the ordinal nature of the endogenous migration variable, which is why Poisson regression is used in the first stage (Taylor et al., 2003). To identify that the instruments used are strongly correlated with the endogenous variable, the goodness-of-fit statistics of the first stage (Bound et al., 1995) were used.

The majority of variables are statistically significant, which is reflected in the goodness-of-fit indicators. Perhaps one of the most important differences between IV and Poisson regressions is the greater impact of migration on production in the former (for obvious reasons). In that case, the emigration of a household member to the urban area generates, on average, a decrease of 48% in the value of the household's agricultural production (in the Poisson regressions this value is close to 3%). An increase in fertilizer spending by 10% generates an increase in productive

	(1) 2SLS	(2) 2SLS	(3) LIML	(4) LIML	(5) 2SLS-P	(6) 3SLS-P
migration	-0.673***	-0.493***	-0.341**	-0.420***	-0.0148***	-0.0452***
	(-16.12)	(-7.12)	(-13.92)	(-6.25)	(-12.52)	(-4.36)
l_seeds	0.0700***	0.0823**	0.330***	0.0720***	0.121***	0.118***
	(22.01)	(14.67)	(54.88)	(23.23)	(24.22)	(49.13)
l_fertilizers	0.181***	0.270***	0.0716***	0.178***	0.212***	0.197***
	(46.23)	(47.30)	(13.05)	(46.45)	(39.41)	(72.97)
l_protection	0.201***	0.246***	0.199***	0.198***	0.181***	0.0570***
	(51.25)	(29.29)	(27.01)	(50.94)	(26.92)	(19.17)
l_workers	0.236**	0.383***	0.332***	0.236***	0.459***	0.252***
	(50.02)	(32.64)	(37.53)	(51.86)	(59.50)	(81.10)
l_capital	0.0936***	0.0981***	0.110***	0.0855***	0.140***	0.0765***
	(25.59)	(17.31)	(20.70)	(21.71)	(25.11)	(28.22)
l_size	0.186**	0.107***	0.0825***	0.185***	0.0784***	0.188**
	(66.85)	(22.13)	(19.05)	(69.04)	(17.16)	(98.91)
l_age	0.0129	0.745***	0.809***	0.0167*	0.237***	-0.0883***
	(1.71)	(13.94)	(21.78)	(2.28)	(23.38)	(-5.81)
l_members	0.353***	0.111***	0.187***	0.363***	0.330***	0.241***
	(40.46)	(6.89)	(13.14)	(41.74)	(21.80)	(36.63)
l_remittances	-0.0155**	-0.139**	-0.320***	-0.0192***	-0.199***	1.210***
	(-2.95)	(-18.35)	(-38.79)	(-3.75)	(-26.33)	(16.47)
exper		-0.0152***	-0.0175***			-0.00324***
		(-10.28)	(-17.96)			(-10.12)
gender					0.143***	
					(9.43)	
_cons	3.793***	0.574***	1.547***	3.852***	1.571***	-1.103**
	(74.72)	(4.54)	(15.38)	(76.17)	(18.21)	(-3.09)
N	43313	12304	12865	43313	13525	88481
F					6078.8	18605.7
r2	0.732	0.781	0.856	0.750	0.832	0.698

Nota: t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Econometric estimates

value between 0.7% and 2.7%. Something analogous occurs with spending on other productive factors, in addition to the fact that they are, as expected, inelastic inputs.

The size of the plots is also a direct function of the productive value. An increase in plots by 10% generates an average agricultural production of 13.8%. The age of the head of the household also affects agricultural activity, as well as the number of employees and sex. Busso et al. (2021), Alarima (2018) and Xiao and Zhao (2018) highlight that youth and young adults are more likely to migrate.

The experience works slightly against the production value. With 10 more years of work experience of the head of the household, the agricultural value can decrease by about 0.1%. A finding contrary to those found by (Shi, 2018) and (Rozelle et al., 1999), for example.

Regarding remittances, an increase in remittances by 10% can generate a decrease in productive value of up to 12%. As indicated, the argument is that rural households, by receiving non-work income, now direct their time towards other economic activities or even leisure (Stark, 1991).

It is essential that decision makers consider economic and/or social policies that integrate the role of working-age workers in agricultural households. Lack of attention to this factor can compromise both the profitability and long-term sustainability of agricultural activity. Furthermore, it could represent a threat to food security, underscoring the need to implement relevant policy strategies. Discussions about this can be found in Duda et al. (2018), Nickanor et al. (2016), Choithani (2017), among others.

It should be noted that factors such as the seasonality of migration, the modernization of agriculture and climatic/political events could alter the results found. However, the paucity of statistical information represented a significant limitation, which poses a future challenge.

6 Conclusions

Based on the NELM, the findings reveal that rural-urban migration exerts a significant and adverse impact on household agricultural production in Peru. The emigration of a household member to urban areas leads, on average, to a decrease of up to 48% in the value of the household's agricultural production. Likewise, it highlights the need to implement policies that not only address the economic and social challenges associated with rural-urban migration, but also promote strategies to safeguard the food security of rural communities, recognizing the fundamental role of active agricultural workers in this process.

Remittances also exert a negative influence on productive value, although their impact is more moderate, with a drop of 12% compared to an increase of 10%. Although this finding seems to contradict the trend observed in most empirical studies, the coherence of the sign of migration in relation to the decrease in productive value allows us to partially validate the postulates of the NELM.

The complexity of migratory dynamics suggests that factors such as the seasonality of migration, the modernization of agriculture, as well as current climatic and political events, can influence the results found.

Recibido: 19 de marzo de 2024
Aceptado: 21 de junio de 2024

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