**Impacts of Rural Migration on Agricultural Productivity: Evidence from Brazil**

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**Abstract:** There is intense debate regarding the direction of the impacts exerted by rural-to-urban migration on agricultural productivity. Some studies suggest that migration drains productive workers from rural economies (reducing productivity), while others contend that migrants’ remittances relieve household credit constraints and enable productive investment (increasing productivity). This study is the first to analyze this relationship in Brazil. The analysis draws on data from the Brazilian Demographic Censuses and Municipal Agricultural and Livestock Surveys (PAM, PPM) in order to measure the impacts of rural migration on agricultural land productivity in 4,069 rural municipalities for the years 2000 and 2010. First, migration impacts on the value of agricultural production are estimated for temporary crops, permanent crops, and livestock using a range of panel data model specifications. Results are robust to different empirical strategies, and indicate that immigration exerts positive impacts on agricultural productivity, while emigration exerts generally negative impacts. Next, migration impacts on quantity of production are estimated separately for each of Brazil’s fifteen most widely-produced crops using Heckman Two-Stage Selection models. Results again indicate that immigration exerts positive impacts on agricultural productivity, while emigration exerts mostly negative impacts. Furthermore, the positive impacts associated with immigration exceed the negative impacts of emigration, despite generating distortions in production between net migrant-importing and migrant-exporting regions

**Keywords:** agricultural productivity, rural migration, New Economics of Labor Migration, rural labor market, panel data models

**Resumo:** Há ainda um intenso debate sobre a direção dos impactos da migração rural-urbana sobre a produtividade agrícola. Alguns estudos sugerem que a migração drena os trabalhadores produtivos das economias rurais (reduzindo a produtividade). Outros afirmam que as remessas dos migrantes aliviam as restrições do crédito doméstico e permitem o investimento produtivo (aumento da produtividade). Este estudo é o primeiro a analisar esta relação no Brasil. As análises baseiam-se em dados dos Censos Demográficos Brasileiros e das Pesquisas Municipais Agrícolas e Pecuárias (PAM, PPM) para medir os impactos da migração rural sobre a produtividade agrícola em 4.069 municípios nos anos de 2000 e 2010. Primeiro, os impactos migratórios sobre o valor da produção agrícola são estimados para culturas temporárias, permanentes e pecuária usando diferentes especificações de modelos de dados em painel. Os resultados são robustos às diferentes estratégias empíricas e indicam que a imigração tem impactos positivos na produtividade agrícola, enquanto a emigração geralmente tem impactos negativos. Em seguida, os impactos da migração na quantidade de produção são estimados separadamente para cada uma das quinze culturas mais produzidas do Brasil usando os modelos de Seleção de Duas Etapas de Heckman. Os resultados indicam novamente que a imigração tem um impacto principalmente positivo sobre a produtividade agrícola, enquanto a emigração tem um impacto principalmente negativo. Os resultados também destacam que os impactos positivos da imigração tendem a superar os impactos negativos da emigração rural, apesar de aumentar as distorções produtivas entre regiões importadoras e exportadoras líquidas de migrantes.

**Palavras-chave:** produtividade agrícola, migração rural, New Economics of Labor Migration, mercado de trabalho rural, modelos de dados em painel

**Área ANPEC:** 11 – Economia Agrícola e do Meio Ambiente

**JEL Classifications:** J61; Q19; C23

1. **Introduction**

Brazil has experienced significant rural out-migration flows since the onset of intensive urban industrialization in the 1960s. This industrialization process acted as a significant draw for rural workers in search of better wages and employment (Baeninger, 2012; Golgher, 2012). In parallel, poverty and unequal distribution of land in the countryside constituted substantial push factors for migrants (IPEA, 2011). Collectively, these push and pull factors provoked a veritable rural exodus from the 1960s onwards. The share of rural residents in Brazil’s population declined from 55% in 1960 to just 15% in 2010 (IBGE, 2016). Nevertheless, Brazil still retains 30 million rural residents, the majority of whom are engaged in agricultural production either as family farmers, landless workers, or commercial producers (IBGE, 2016; Vieira Filho, 2014). Many of these actors see their economic activity affected by rural out-migration, either through family ties to migrants, or through the demographic impacts of migration on rural labor markets.

The analysis of the impacts of rural migration on agricultural productivity can be divided into two theoretical currents. The first supposes that migration exerts a generally negative impact on agricultural development, since migrants tend to be younger, better educated, and more enterprising than their non-migrant peers (resulting in productivity losses or “brain drain” from rural regions), and because households receiving remittances from migrants are more likely to direct this income toward consumption or education, rather than productive agricultural investment (Lipton, 1980; Rempel, 1978). Numerous empirical case studies of developing countries have confirmed this hypothesis (Quisumbing & McNiven, 2010; Miluka et al., 2010; Damon 2010).

The second theoretical current, known as the New Economics of Labor Migration (NELM), takes the migrant-sending household, rather than the individual, as the appropriate unit of economic analysis, and interprets migration as a household insurance strategy by which families finance migration under the expectation of remittance income (Stark & Lucas, 1988; Stark & Bloom, 1985). Migrant-sending families may use this income to overcome credit constraints and undertake risky technology adoption or investment, potentially improving agricultural productivity. Empirical analyses of the NELM hypothesis have found that remittances may have a larger impact in the context of international migration (Taylor & Lopez-Feldman, 2010) than in cases of predominantly internal migration (Adams, 1998). Studies that have attempted to disentangle the individual effects of remittances and migration have found that, while remittance receipts have a generally positive impact on agricultural productivity, migration alone has a negative impact, especially when rural labor markets are inelastic (Duc Loc & Grote, 2015; Gonzalez-Velosa, 2011)

Brazil’s sizeable internal migration flows over recent decades, coupled with its diversified agricultural base, provide an important case study of the impacts of rural out-migration on agricultural productivity. Nevertheless, there are few mentions of Brazil to be found in the empirical migration literature (Davis et al., 2010; Rempel, 1978). Motivated to fill this gap, this study analyzes the impacts of rural migration on agricultural land-productivity at the finest available level of geographical disaggregation–Brazil’s 4,069 rural municipalities. A principle contribution of the present study relative to the existing literature is its focus on nationally-representative, aggregate impacts, rather than micro-level (household) effects. Given that migration tends to affect large and small producers in different ways, the central focus of the study is to assess the impacts of migration on the agricultural economy as a whole and the implications for rural development.

The study draws upon data from Brazilian Demographic Censuses (2000 and 2010), Agricultural Censuses (1995 and 2006), and Municipal Agricultural Surveys (*Produção Agrícola Municipal, Pesquisa Pecuária Municipal*). We analyze the impacts of immigration and emigration on (i) the total value of production (temporary crops, permanent crops and livestock), and (ii) physical production of the 15 most widely produced crops in Brazil. Since production values are zero for a significant portion of municipalities, sample selection-bias models are employed to control for possible endogeneity (Angrist & Pischke, 2009) The study is organized as follows. The following section (**Part 2**) explores the theoretical debate over the relationship between migration and agricultural production in developing countries. **Part 3** traces a brief history of the links between agriculture and migration in Brazil, and weighs the potentially divergent impacts of migration on family versus commercial farming. **Part 4** describes data employed in the study and develops panel regression models to estimate migration impacts on agricultural production. **Part 5** presents and interprets regression results. **Part 6** offers concluding remarks.

**2. Theoretical background**

Labor migration in developing countries gained the attention of economists and planners during the second half of the 20th Century, as decolonization and national development programs led to rapid and chaotic urbanization and rural-urban migration *en masse* throughout Africa, Asia, and Latin America (Lucas, 1997; Gilbert, 1996). Many analysts viewed this trend through the lens of failed or overwhelmed urban planning policies, leading them to adopt a pessimistic view of any potential contributions of migration to development.

Lipton (1980), considering the potential impacts of migration on rural productivity, hypothesizes that urban-bound migrants tend to be younger, more enterprising, and more disposed to value labor over leisure, thus leaving behind concentrations of older, less productive, and more leisure-disposed populations in rural areas. As a result, remittances resulting from rural-urban migration are more likely be spent on consumption goods such as housing and education (understood as an investment enabling future migration), rather than on productive agricultural investment. Lipton concludes that migration in most cases offers few prospects of improving rural productivity, and thus argues for a halt to urban-biased development programs that, at the time of writing, continued to generate rural-urban imbalances. Similarly, Rempel & Lobdell (1978), reviewing the existing data and literature, conclude that remittance-receiving households are more likely to spend additional income on increased consumption, disincentivizing productive agricultural investment and potentially delaying rural development.

Lipton and Rempel’s prediction of negative impacts of migration on agricultural development is supported empirically by a range of country-specific case-studies. Quisumbing & Mcniven (2010), drawing on 20-year panel data from the Philippines, find that remittances have no measurable impact on investment in land or agricultural assets for receiving households, though they do have a positive impact on educational expenditure. Similarly, Miluka et al. (2010) find that migration boosts consumption but reduces agricultural labor inputs among Albanian farm households. Both cases suggest that families use remittances as a means of transitioning away from agriculture, rather than as financing for agricultural investment. Damon's (2010) study of small farmers in El Salvador finds that remittances have no impact on agricultural input accumulation, and in fact reduce returns to land and family labor. Finally, Taylor et al. (2003) analyze rural-urban migration in China and conclude that migrant-sending households enjoy income gains from migration but exhibit no measurable changes in agricultural production variables.

Pushing back against Lipton and Rempel’s analysis, Stark (1985) proposes a New Economics of Labor Migration that adopts the farm household, rather than individual migrants, as the appropriate unit of economic analysis. Stark interprets rural out-migration as a household insurance strategy by which families finance migration under the expectation of remittance income, which they can leverage to overcome credit constraints and undertake risky technology adoption or investment. In turn, migrants do not deviate from continued remittance payments because these allow repayment of social debts (incurred through family-financed education) and maintenance of ties and land claims with a household they may have to return to in the event of job-loss or old age (Stark & Lucas, 1988). Thus understood, migration is a multi-period strategic arrangement that facilitates productive investment in agriculture.

The NELM hypothesis is theoretically compelling, but lacks extensive empirical confirmation. Adams, (1998) draws on panel data from Pakistan to explicitly test the NELM hypothesis, and finds that remittance income has a positive impact on agricultural asset accumulation and increases farm households’ propensity to invest. However, he notes that this increase is significantly greater for international remittances than internal remittances. Likewise, Taylor & Lopez-Feldman (2017) find that Mexican households with migrant members in the United States exhibit gains in income and land productivity relative to households without migrants. Furthermore, they find that these gains grow over time, highlighting the importance of adopting longer frames of analysis when considering migration impacts.

More recent empirical studies have engaged with the NELM at a more nuanced level, attempting to disentangle the naturally correlated effects of migration and remittance receipts, or parsing the impacts of migration on agricultural practice rather than raw levels of investment. Duc Loc & Grote (2015), employing panel data from Vietnam, are able to distinguish which migrant-sending households receive or do not receive remittances, and thus identify the unique impacts of migration and transfers. They find that remittance-receiving households see gains in land productivity and losses in labor productivity, while non-remittance receiving, migrant-sending households suffer labor-productivity losses with no compensating gains in land productivity. Similarly, Gonzalez-Velosa (2011) finds that, for a sample of farmers in the Philippines, remittances improve agricultural productivity across a broad range of measures, but migration alone has little effect, given high labor market elasticity. In both cases, the authors conclude that migration alone has little impact where rural labor markets remain elastic, but may manifest negative impacts when families struggle to contract substitute labor for migrants. Finally, Imran et al. (2016) find that Pakistani farmers transition progressively from labor-intensive to land-intensive crops as migration increases, while Li et al. (2013) finds that migration leads farmers to shift from grain production to more capital-intensive and profitable production of cash crops.

Considering the literature as a whole, empirical evidence appears to favor Lipton’s prediction of negligible or negative impacts of migration on agricultural investment, except in cases where migration corresponds to significant remittance receipts (Taylor & Lopez-Feldman, 2010) or where labor markets are especially elastic (Gonzalez-Velosa, 2011). As discussed in the following section, Brazil is not characterized by especially intense international or internal remittance flows, and may be experiencing labor shortages in many rural areas, suggesting that rural out-migration in Brazil may have a negative impact on agricultural productivity at the community level (Maia & Sakamoto, 2014). Furthermore, it appears that migration flows may drive sending communities toward more land-intensive agricultural practices (Imran et al., 2016), or toward more capital-intensive practices (Li et al., 2013). We turn to the evaluation of these alternative scenarios in **Part 4**.

**3. Agriculture and Migration in Brazil**

1. *Historical context*

Since the 1950s, Brazil has undergone a rapid transition from rural to urban society. Early industrial growth, concentrated in the urban centers of the country’s Southeast (primarily the metropolitan areas of São Paulo and Rio de Janeiro), drew migrants from the overwhelmingly rural Northeast with the promise of employment and higher wages (Giambiagi, 2011; IPEA, 2011). Further structural factors stimulated rural out-migration from the Northeast in this period, notably rural poverty and unequal land distributions (the Gini coefficient of land distribution in this region was 0.836 in 1970) (Nascimento de Medeiros, 2010). Consequently, the share of rural residents in Brazil’s population declined from 55% in 1960 to 32% in 1980 (IBGE, 2016).

During the 1980s, rural migration was marked by demographic expansion into the Brazilian interior, particularly the Northern and Center-Western regions. This migratory flow was characterized by a mixture of rural-urban and rural-rural migration as workers sought employment and land along the expanding “agricultural frontier (Baeninger, 2012).” Martine et al. (1988) estimate that approximately 1.56 million people migrated from rural to urban areas annually during the 1970s, while Perz (2000) calculates that 1.6 million migrated annually during the 1980s.

The flow of rural migrants to the new frontier of agricultural development was sharply curtailed by the introduction of modern technologies, equipment, and practices into Brazilian agriculture. (Redin, 2010). This “conservative modernization” of Brazilian agriculture increased agricultural labor productivity and raised barriers to entry for low-skilled migrant laborers on the agricultural frontier (IPEA, 2011). Simultaneously, competition from agribusiness largely marginalized poorer family farmers and put enormous pressure on traditional farming methods.

During the 1990s, the dispersion of industrial activity and urban development outside the Southeastern core, coupled with the exhaustion of the traditional agricultural frontier, resulted in increasing proportions of return migration and in-state migration (Baeninger, 2012). Furthermore, rural push factors began to ease during the latter half of the decade with the introduction of the Family Agriculture Support Program (PRONAF) in 1996, Moderfrota (a subsidized farm-equipment program) in 2000, and a rural extension program (PNATER) in 2003, among other policies (Redin, 2010). These production-side reforms were balanced, after 2003, by labor market reforms and social transfer programs, which introduced significant valorization of the minimum wage, formalization of rural workers, and extensive disbursement of cash transfers (*Bolsa Família*) and rural pensions (Barros, Foguel & Ulyssea, 2007; Beltrão, Camarano & Mello, 2005). Nevertheless, Maia & Buainain (2015) find that Brazil’s rural population declined by a further 6 million between 1991 and 2010.

1. *Family and agriculture*

It is important to differentiate between family and commercial agriculture in the analysis of rural migration impacts.[[1]](#footnote-1) Family farmers are classified as those with a total farming area lower than a regional threshold, with a farm labor force comprised predominantly of family labor, and with income derived primarily from their own farm (Guanziroli, Buainain & Sabbato, 2012). Considering this definition, family farming is most prevalent in Brazil’s North, Northeast, and Southern, while non-family farming dominates the Southeast and Center West (**Table 1**). Family farming is in turn characterized by concentration of the most vulnerable farmers in the North and Northeast regions, and the concentration of profitable, highly-modernized farmers in the South.

**Table 1. Family and non-family farming in Brazil, 2006**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Family Farming** | | **Non-family Farming** | |
| **Region:** | **No. Employed** | **% of Total** | **No. Employed** | **% of Total** |
| **North** | 1,383,640 | 83.57 | 272,009 | 16.43 |
| **Northeast** | 6,365,251 | 82.67 | 1,333,887 | 17.33 |
| **Southeast** | 1,798,935 | 54.79 | 1,484,114 | 45.21 |
| **South** | 2,244,347 | 76.85 | 676,098 | 23.15 |
| **Central West** | 530,937 | 52.57 | 478,987 | 47.43 |
| **Brazil** | 12,323,110 | 74.38 | 4,245,095 | 25.62 |

Source: Agricultural Census, 2006

Nonetheless, both regions with the highest shares of family farming are also those with the highest positive rates of net emigration (see **Table 2**). The Northeast region, Brazil’s poorest, is a net exporter of migrants and presents the second highest proportion of family farmers among total farm establishments (83% in 2006). The Southern region, which is characterized by the highest positive rate of net emigration in the country, also exhibits a high rate of family farming (77% in 2006). In contrast, in the Central West and Southeastern regions, which have absorbed the largest proportion of rural out-migrants, agriculture is predominantly non-family. In other words, rural populations are migrating, for the most part, from regions characterized by family agriculture to regions characterized by modern, non-family agriculture, which may put the sustainability of family agriculture at risk in the medium to long term (Maia & Buainain, 2015).

**Table 2. Net Migration Ratios (rural municipalities)**

|  |  |  |
| --- | --- | --- |
|  | **Net Migration Ratio** | |
| **Region** | **2000** | **2010** |
| **North** | -2.659 | -0.218 |
| **Northeast** | 1.723 | 2.387 |
| **Southeast** | -0.467 | -0.549 |
| **South** | 3.332 | 1.665 |
| **Central West** | -0.915 | -1.024 |
| **Brazil** | 0.203 | 0.452 |

Source: Demographic Census, 2000 and 2010

Net Migration Ratio = (emigrant-immigrant)/population

In line with the NELM hypothesis (Stark & Lucas, 1988), migration out of family agriculture may ease credit constraints and reduce risk associated with technology adoption, encouraging on-farm investment and improving agricultural productivity. However, in the case of low remittance-sending and rural labor market inelasticity, impacts of migration on family agriculture may be negative (Gonzalez-Velosa, 2011). Migration may also have divergent effects on non-family and family agriculture in Brazil. The former is likely to experience labor market shortages and disproportionate loss of productive workers, while the latter may experience both the positive impact of remittances and the negative impact of losing younger, productive family members. The manner in which these potentially opposing factors interact could generate divergent rural development outcomes.

Households engaged in family farming in less-developed regions exhibit high levels of poverty, generally employ few technological inputs, and face punishing competition from non-family producers. Non-family farming is characterized by specialized monoculture production, wage labor, intensive use of technological inputs, and insertion into national or international value chains (Buainain et al., 2014). Furthermore, family and non-family farmers specialize in different crops (**Figure 1**). Family farmers represent 87% of manioc producers, 70% of bean producers, 59% of swine producers, 58% of dairy producers, and 50% of poultry producers, while non-family farmers represent 84% of soybean producers, 79% of wheat producers, 70% of cattle producers, 66% of rice producers, and 62% of coffee producers. Manioc and beans may therefore safely be considered “family farming crops,” while soybeans, wheat, cattle, rice, and coffee may be considered non-family crops (Embrapa, 2014). Family production is generally oriented toward low value-added products that ensure a base of food security in Brazil. Non-family agriculture is largely specialized in the production of high value-added grains, oriented toward export.

**Figure 1. Participation of Family and Commercial Farming for Representative Activities**

Source: Embrapa, 2014

In sum, Brazil’s significant rural migration flows make it an important case-study of the impacts of migration on agriculture. Furthermore, the country’s diversified agricultural base allows a verification of the NELM hypothesis, which supposes that it is precisely the “family” element of agriculture that allows beneficial migration arrangements. The following section (**Part 4**) develops a range of panel regression models to estimate the impacts of immigration and emigration on agricultural productivity (family and non-family) at the municipal level.

**4. Materials and Methods**

*i. Data*

Primary demographic information, including data on migration, are drawn from the Brazilian Demographic Censuses of 2000 and 2010, provided by the *Instituto Brasileiro de Geografia e Estatística* (IBGE). The censuses provide detailed, quality data on individuals and households across a large sample, allowing for robust, nationally-representative analysis of rural migration (IBGE, 2002, 2010). Immigration and Emigration variables were generated from the census question that asks in which municipality all household members were resident five years ago, given that they had resided in their current municipality for less than six years. This question format excludes long-term migration, which is less likely to have a persisting effect on the household’s current economic situation. Where individuals reported their previous municipality of residence, they were tabulated as an immigrant in their current municipality, and as an emigrant in their former municipality.

The Demographic Census provides rich social and economic information at the individual and household level, but does not include information on agricultural production. Therefore, household data from the Demographic Census are aggregated to the municipal level and merged with agricultural data from years 2000 and 2010 of the Municipal Agricultural Survey (*Produção Agrícola Municipal*) and Municipal Livestock Survey (*Pesquisa Pecuária Municipal*), provided by IBGE (IBGE, 2016). Data on land use (temporary crops, permanent crops, and pasture) are drawn from the Agricultural Censuses of 1995 and 2006, also from IBGE. Land use values from 1995 are used as a proxy for the year 2000 cross-section, while 2006 values proxy the 2010 cross-section. Monetary values from 2000 are adjusted to constant 2010 reals according to the implicit deflator of Agricultural GDP provided by IBGE[[2]](#footnote-2).

*ii. Geographical consistency and rural delimitation*

Between 2000 and 2010, new municipalities were either emancipated from larger municipalities, or emerged as the result of municipal division (Bremaeker, 2009). Consequently, IBGE registered 5,507 municipalities in 2000 and 5,565 in 2010. Changes in the number, area and borders of geographical units over the period of analysis would make historical comparisons inconsistent at the municipal level. Therefore, municipalities are aggregated into 5,507 groups which present common borders over the 2000 to 2010 period, in order to obtain a balanced and consistent panel.

The official classification of rural in Brazil encapsulates all areas located outside the borders of municipal centers or districts (IBGE, 2010). The main limitation of these classifications is that they are determined autonomously, and potentially inconsistently, by each municipality. This study adopts an alternative definition of rural, based on Veiga (2007), which defines as rural those municipalities that: i) are not located in any of the 35 metropolitan areas defined by IBGE (2010), ii) have fewer than 50,000 inhabitants, and iii) have population density lower than 80 inhabitants per km2. According to this classification, there were 1,438 urban municipalities and 4,069 rural municipalities in Brazil over the sample period.

*iii. Empirical framework*

Our empirical framework is based on traditional agricultural production functions (Battese, 1992), with the inclusion of independent variables to account for migratory flows. Estimates are obtained for panel data models with 4,069 cross-section units (rural municipalities) and 2 periods (2000 and 2010). The general model may preliminarily be represented by:

 (1)

Where the subscript *i* refers to the *i*-th municipality and *t* to year 2000 or 2010. The dependent variable (ln *Y*) is the log of total production. We estimate value-of-production models (in constant Brazilian Reals) for permanent crops, temporary crops, and livestock, and physical-production models for the fifteen crops with the highest production values in 2010 (by ton: banana, cacao, coffee, cashew, oranges, cotton, rice, sugarcane, beans, tobacco, manioc, maize, soy, sorghum, and wheat). The independent variables ln *I* and ln *E* represent the log of total number of immigrants and emigrants, respectively. The vector **x** contains a set of control variables including: land area, agricultural labor force, and human capital (education and age of labor force). Descriptive statistics of explanatory variables for the two-period panel are presented in **Table 3**.

**Table 3. Descriptive Statistics (Municipal Averages)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **2000** | **2010** |  |
| **Variable** | **Description** | **Mean** | **Mean** | **Source** |
| *Age* | Years | 29.5 | 33.6 | Demographic Census |
| *Education* | =0 if no secondary ed. complete =1 if secondary ed. complete | 0.03 | 0.11 | Demographic Census |
| *Agricultural Labor* | No. agricultural laborers | 2,123 | 2,226 | Demographic Census |
| *Immigration* | No. immigrants | 2,772 | 3,162 | Demographic Census |
| *Emigration* | No. emigrants | 2,648 | 3,140 | Demographic Census |
| *Immigration Proportion* | Immigrants as % of pop. | 0.1 | 0.1 | Demographic Census |
| *Emigration Proportion* | Emigrants as % of pop. | 0.1 | 0.1 | Demographic Census |
| *Temporary Crop Area* | Area in hectares | 8,373 | 10,647 | Agricultural Census |
| *Permanent Crop Area* | Area in hectares | 1,196 | 1,224 | Agricultural Census |
| *Pasture Area* | Area in hectares | 35,747 | 28,807 | Agricultural Census |
| *Temporary Crop Value* | Production value, in Reals | 12,881 | 22,011 | PAM |
| *Permanent Crop Value* | Production value, in Reals | 4,104 | 6,344 | PAM |
| *Livestock Value* | Production value, in Reals | 2,904 | 4,994 | PPM |
|  |  |  |  |  |

Source: Elaborated by the authors using data from IBGE

Our focus are the elasticity coefficients  and , which measure percentage variation in municipal production given a percentage variation in immigration and emigration, respectively. Since we control for area, agricultural labor, and human capital, we can also interpret these coefficients as the net impact of migratory flows on municipal agricultural productivity.

The composite error term  may be represented by (Wooldridge, 2002):

 (2)

Where factor *ci*, or *regional heterogeneity*, refers to unobserved factors that vary across municipalities and are considered constant in time (for instance, soil quality). In turn, factor *dt*, or *time heterogeneity*, refers to unobserved factors that vary in time and are considered constant in space (for instance, technological advances and public incentives). Variable *ε* is the idiosyncratic error, capturing uncontrolled factors not associated with space and/or time. Factors *dt* are controlled using the fixed effect approach (dummy variable). In turn, we test three approaches to control for factor *ci*: i) pooled ordinary least square (POLS), ii) random effects for the 4,069 rural municipalities (RE), and iii) fixed effects for Brazil’s 131 mesoregions (FE). The POLS and RE estimates are only consistent under orthogonality assumptions, where errors  are independent of the independent variables (immigration and emigration). In this case, RE generate the most efficient estimates. However, the orthogonality assumption does not necessarily hold in our case, since regional heterogeneity *ci* is likely to be correlated with migration and other control factors. In this case, FE is the only method that generates consistent, albeit inefficient, estimates(Wooldridge, 2002).

The FE estimator would ideally account for the regional heterogeneity across the 4,069 rural municipalities. This could be done using dummy variables or the within transformation (Wooldridge, 2002, p. 267). Nonetheless, a main problem with fixed effects is the incidental parameters problem, that renders the maximum likelihood estimator (MLE) inconsistent in most nonlinear models (Greene, 2003, p. 715). This is because the within transformation is only valid for linear models and an excess of dummy variables can make the MLE biased and inconsistent. In this sense, a limited number of dummy variables for the FE approach (131 mesoregions, which are administrative groups of municipalities, rather than 4,069 municipalities) aims to attenuate the inconsistency with the MLE. The problem with the linearity of Equation 1 is that the production relation *Yi* is only observed for a subset of municipalities with positive values of production (*Yi*>0). In other words, the sample is characterized by nonrandom selection of municipalities, since the decision to produce (probability of *Y*>0) itself depends on several variables, including municipal characteristics, agricultural histories, and unobserved factors such as entrepreneurship and socioeconomic capital. Ordinary Least Squares estimators will be inconsistent if these unobserved factors are also related to production *Y* (Wooldridge, 2003, p. 506).

The usual approach to represent this type of sample selection is to add a new selection model to Equation 1:

,  (3)

, if *Wi*=1 (4)

Where  and  are jointly normal with zero mean, standard deviations of 1 and *σ*, and correlation of *ρ*. Vector **z** contains the determinants of the production choices. In addition to the exogenous variables presented in equation (4), we require instrumental variables to consistently estimate the coefficients in vector **φ**. In other words, we need variables that are properly related in the selected part of equation (3) and not related in the production function (4). We believe that these instrumental variables may be adequately represented by the municipal-level experience with other types of agricultural crops (see Table 3).

**5. Results**

**Table 4** presents estimates for the total value of production of temporary crops, permanent crops, and livestock. Most estimates are significant at the 1% level, and the models show reasonable goodness of fit measures. The POLS models present R-Squared values ranging from 35.4% (livestock) to 79.8% (permanent crops). Random Effects (RE) and Fixed Effects (FE) models are estimated by MLE and present significant log-likelihood ratio estimates. Estimates differ reasonably between empirical strategies (POLS, RE and FE), and the FE estimates tend to be more consistent, although inefficient.

Coefficients related to the control variables present the expected results. The agricultural land elasticities are positive and significant in all models, with estimates ranging from 0.2% (livestock) to 0.9% (permanent crops). Livestock production is more elastic to labor supply (with estimates ranging from 0.4% to 0.6%) than are temporary or permanent crops. Education exhibits a significant positive association with agricultural production, especially the production of permanent crops. In turn, age, a proxy for working experience, plays a more important role in livestock production, most likely due to the long-term accumulation of financial capital that is needed to increase cattle herds.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 4. Determinants of *ln(value\_of\_production*), Comparative Models** | | | | | | | | | | | | | | | |  |  | | |
|  |  | |  | | | |  |  | |  | |  |  | | |  |  | | |
|  | **\_\_\_\_Temporary Crops\_\_\_** | | | | **\_\_\_\_\_Permanent Crops\_\_\_\_\_** | | | | | | | | | **\_\_\_\_\_\_Livestock\_\_\_\_\_\_\_** | | | | |
|  | Pooled OLS | REs (*munic*) | | FEs (*meso)* | Pooled OLS | | | | REs (*munic)* | | FEs (*meso)* | | | Pooled OLS | REs (*munic)* | | | FEs (*meso)* |
|  | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | | | | | | | | | | | | | |
| **Variable** |  |  | |  | |  | | |  | |  | | |  | |  | |  |
| *ln(immig)* | 0.198\*\*\* | 0.183\*\*\* | | 0.107\*\*\* | | 0.142\*\*\* | | | 0.165\*\*\* | | 0.102\*\*\* | | | 0.085\*\*\* | | 0.125\*\*\* | | 0.099\*\*\* |
|  | (0.018) | (0.016) | | (0.014) | | (0.022) | | | (0.020) | | (0.018) | | | (0.024) | | (0.022) | | (0.020) |
| *ln(emig)* | -0.131\*\*\* | -0.04\*\*\* | | -0.042\*\*\* | | -0.078\*\*\* | | | -0.063\*\*\* | | -0.041\*\*\* | | | -0.129\*\*\* | | 0.015 | | 0.047\*\* |
|  | (0.019) | (0.015) | | (0.012) | | (0.023) | | | (0.018) | | (0.016) | | | (0.026) | | (0.021) | | (0.020) |
| *ln(area)* | 0.905\*\*\* | 0.932\*\*\* | | 0.927\*\*\* | | 0.888\*\*\* | | | 0.883\*\*\* | | 0.87\*\*\* | | | 0.297\*\*\* | | 0.195\*\*\* | | 0.304\*\*\* |
|  | (0.007) | (0.007) | | (0.007) | | (0.006) | | | (0.007) | | (0.006) | | | (0.010) | | (0.010) | | (0.010) |
| *ln(aglaborsupply)* | 0.127\*\*\* | 0.027\*\*\* | | 0.077\*\*\* | | 0.168\*\*\* | | | 0.123\*\*\* | | 0.137\*\*\* | | | 0.571\*\*\* | | 0.333\*\*\* | | 0.414\*\*\* |
|  | (0.019) | (0.018) | | (0.016) | | (0.023) | | | (0.023) | | (0.021) | | | (0.025) | | (0.024) | | (0.022) |
| *Secondary Educ. Dummy* | 5.437\*\*\* | 3.558\*\*\* | | 1.633\*\*\* | | 6.651\*\*\* | | | 5.072\*\*\* | | 2.647\*\*\* | | | 5.87\*\*\* | | 1.646\*\*\* | | 1.225\*\*\* |
|  | (0.248) | (0.193) | | (0.195) | | (0.278) | | | (0.235) | | (0.252) | | | (0.312) | | (0.217) | | (0.271) |
| *Age* |  |  | |  | |  | | |  | |  | | |  | |  | |  |
| *(relative <19 yrs.)* |  |  | |  | |  | | |  | |  | | |  | |  | |  |
| *(20-29)* | 2.529\*\*\* | 0.853\*\*\* | | 0.497\*\* | | 1.867\*\*\* | | | 1.388\*\*\* | | 0.497\* | | | -1.492\*\*\* | | 0.195 | | -0.284 |
|  | (0.317) | (0.250) | | (0.229) | | (0.379) | | | (0.319) | | (0.300) | | | (0.422) | | (0.301) | | (0.331) |
| *(30-39)* | 4.022\*\*\* | 1.947\*\*\* | | 0.311 | | 3.508\*\*\* | | | 2.235\*\*\* | | -0.255 | | | 5.02\*\*\* | | 2.39\*\*\* | | 0.976\*\*\* |
|  | (0.305) | (0.238) | | (0.221) | | (0.362) | | | (0.301) | | (0.288) | | | (0.406) | | (0.287) | | (0.318) |
| *(40-49)* | 4.681\*\*\* | 2.263\*\*\* | | 0.23 | | 4.92\*\*\* | | | 2.966\*\*\* | | 0.336 | | | 7.887\*\*\* | | 3.875\*\*\* | | 2.294\*\*\* |
|  | (0.324) | (0.253) | | (0.235) | | (0.385) | | | (0.320) | | (0.308) | | | (0.428) | | (0.306) | | (0.340) |
| *(50-59)* | 1.59\*\*\* | 0.727\*\*\* | | -0.357\* | | 2.295\*\*\* | | | 1.707\*\*\* | | 0.1 | | | 5.259\*\*\* | | 3.564\*\*\* | | 2.642\*\*\* |
|  | (0.256) | (0.216) | | (0.191) | | (0.304) | | | (0.271) | | (0.250) | | | (0.340) | | (0.266) | | (0.277) |
| *Year Dummy* | -0.336\*\*\* | -0.134\*\*\* | | 0.113\*\*\* | | -0.519\*\*\* | | | -0.324\*\*\* | | -0.021 | | | -0.45\*\*\* | | 0.079\*\*\* | | 0.222\*\*\* |
|  | (0.028) | (0.021) | | (0.022) | | (0.032) | | | (0.026) | | (0.028) | | | (0.035) | | (0.025) | | (0.031) |
| *Município Dummy* |  | FE | |  | |  | | | FE | |  | | |  | | FE | |  |
| *Meso-Region Dummy* |  |  | | FE | |  | | |  | | FE | | |  | |  | | FE |
| *Constant* | -3.057\*\*\* | 1.621\*\*\* | | -0.056 | | 2.565\*\*\* | | | -1.600\*\*\* | | 0.463\* | | | 3.009\*\*\* | | -0.159 | | 0.025 |
|  | (0.228) | (0.205) | | (0.178) | | (0.274) | | | (0.257) | | (0.240) | | | (0.303) | | (0.269) | | (0.261) |
| ***Measures of Fit*** |  |  | |  | |  | | |  | |  | | |  | |  | |  |
| *n=* | 7,218 | 8,117 | | 8,117 | | 7,218 | | | 7,667 | | 7,667 | | | 7,218 | | 7,665 | | 7,665 |
| *Adjusted R2* | 0.795 |  | |  | | 0.798 | | |  | |  | | | 0.354 | |  | |  |
| *Log Likelihood Ratio* |  | 17691.0 | | 14296.50 | |  | | | 19521.9 | | 17005.50 | | |  | | 20136.8 | | 18352.30 |
| *AIC* |  | 17695.0 | | 14298.50 | |  | | | 19525.90 | | 17007.50 | | |  | | 20140.80 | | 18354.30 |

Standard Errors Presented in Parentheses

\*=Significant at 10% Level; \*\*=Significant at 5% Level; \*\*\*=Significant at 1% Level

FE Indicates Control of Fixed Effects of Year, Municipality, and Meso-Region Dummies

Nonetheless, the most relevant results are those related to the variables immigration and emigration. All estimates indicate that immigration tends to increase the value of agricultural production, with the largest impacts in the production of temporary crops. Production of temporary and permanent crops present greater value-added per hectare when practiced with higher levels of technological inputs. Since the models control for labor supply in rural areas, these results may be attributed primarily to the accumulation of capital and knowledge provided by the arrival of rural immigrants. Furthermore, since models control for land area, coefficients of migration variables may be interpreted as impacts on agricultural land productivity.

In turn, rural emigration tends to negatively affect agriculture yield, with elasticities ranging from -0.04% to -0.13%. The impacts on livestock production are not conclusive among the three empirical strategies (POLS, RE and FE). Firstly, these results suggest that rural emigration can in fact compromise agricultural production at the migrants’ municipality of origin. Secondly, the positive impacts of immigration at the migrants’ destination are larger than the negative impacts of emigration in origin: elasticities are higher for immigration than for emigration. In other words, although some regions net migrant-exporting regions are negatively affected by migration, other net importing regions are more than compensated by improved agricultural land productivity resulting from rural migration.

**Figure 2** analyzes the net impact of immigration and emigration on physical production of fifteen different crops. Insignificant estimates are represented by shadowed bars. The complete set of estimates is presented in **Appendix A**. In this stage, we estimated only FE models, which showed the most consistent results. Results strongly reinforce previous analyses, and highlight that immigration tends to increase agricultural production while emigration tends to reduce it. More importantly, we find no clear distinction between the migration-impacts on products more associated with large-scale commercial production, like wheat and sugarcane, and products mainly associated with small-scale and self-subsistence production, like manioc and beans.

**Figure 2. Maximum Likelihood Estimates of Migration Impacts on *ln(quantity\_produced)*, by Crop**

Note: Statistically significant values displayed in solid black and gray; statistically insignificant values displayed in shaded hatching

The only exception to this trend is the negative impact of immigration on the production of banana, which may be associated with the shift toward different crops elicited by migrant arrivals and departures in these destination areas. In turn, the impacts of immigration are higher in the production of rice, beans and maize, which can be related to the experience that arriving immigrants bring with such crops.

The impact of emigration is negative in most crops and only insignificant in the case of coffee, cashew, and orange. Emigration-impacts are higher in the production of maize, cacao and banana, which may indicate the abandonment of some areas of production of these crops in net migrant-exporting regions.

Finally, results also indicate that the positive impacts of immigration tend to compensate for or surpass the negative impacts of emigration in most crop categories, with the exception of banana, cacao and tobacco. These crops are concentrated in areas with very specific socioeconomic contexts, where economic, environmental, and institutional forces have stimulated new types of economic activities.

**6. Conclusions**

A robust and active theoretical debate exists regarding the impacts of rural migration on agricultural productivity. Many empirical case studies (Quisumbing & McNiven, 2010; Miluka et al., 2010; Damon 2010) have measured a negative relationship between migration and productivity across a variety of developing country contexts, supporting early theorizations by Lipton (1980) and Rempel (1978) that migration drains productive workers from rural economies and finances consumption rather than agricultural investment. Further studies have measured positive migration impacts in contexts of substantial international migration (Taylor & Lopez-Feldman, 2010; Adams, 1998), or positive impacts from remittance receipts (though not migration itself) in cases of rural labor market elasticity (Duc Loc & Grote, 2015; Gonzalez-Velosa, 2011), supporting the theoretical predictions of the New Economics of Labor Migration hypothesis (Stark & Lucas, 1988; Stark & Bloom, 1985).

This study is the first to test this theoretical debate using data from Brazil. The inclusion of Brazil, given its diversified agricultural base and significant rural migration flows, provides an important case study of the impacts of migration on agricultural productivity. Furthermore, the study’s use of Census and agricultural survey data allows estimation of nationally-representative, aggregate migration impacts, rather than micro-level (household) effects. Since rural migration parallels labor transitions between agricultural activities and regions, a national perspective allows for analysis and comparison of migration impacts on the agricultural economy as a whole, offering broader insights regarding rural development.

Drawing upon data from the Brazilian Demographic Censuses and Municipal Agricultural and Livestock Surveys (PAM, PPM), we first estimate a range of panel regression models of the impacts of rural migration on agricultural land productivity in 4,069 rural municipalities over a two-period panel of years 2000 and 2010. Results are robust to alternative specifications, and indicate that immigration has a significantly positive impact on agricultural productivity for temporary crops, permanent crops, and livestock, while emigration has significantly negative effects on temporary and permanent crops, and positive effects on livestock. These directional trends are confirmed by estimation of migration impacts on quantity of production for fifteen Brazilian crops using Heckman Two-Stage Selection models to control for sample selection endogeneity. Results from the Two-Stage models again indicate that immigration has a significant positive impact on agricultural productivity, while emigration has a significantly negative impact. Notably, there does not appear to be any clear relationship between migration impacts and the weight of family versus non-family farming for each crop category. If the NELM hypothesis were to hold in Brazil, one would expect that crops dominated by family-farming would exhibit greater migration impacts than would crops dominated by non-family farming. That this is not the case in our estimates suggests that the NELM hypothesis fails in Brazil due to low levels of international migration and remittance flows, and inelastic rural labor markets (Maia, 2014).

A further important finding regards the relative scale of impacts between immigration and emigration. For all crops besides banana, cacao, and tobacco, the positive impacts of immigration are larger than the negative impacts of emigration, suggesting that the aggregate agricultural production effect of rural migration in Brazil is positive. Nonetheless, migration flows may generate production distortions between migrant-exporting regions (more strongly associated with family agriculture and poverty) and migrant-importing regions (more strongly associated with modern, higher-income non-family agriculture) which represent labor force reallocation toward more productive regions and employment. This finding suggests that rural migration has net positive production impacts, but may pose risks to the sustainability of family farming.

**Appendix A.**

**Maximum Likelihood Estimates of Sample Selection Models for ln(*quantity\_produced*), from Panel Data (2000 & 2010) (Part 1 of 3)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Crop Type** | | | | | | | | | | | | | |
|  | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | | | | | | | | | | |
|  | **Banana** | | **Cacau** | | | **Coffee** | | | **Cashew** | | | **Oranges** | | |
|  | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | | | | | | | | |  |
| **Variable** |  |  | |  |  | |  |  | |  |  | |  |  |
| *ln(immig)* | -0.071 | \*\*\* | | -0.056 |  | | 0.069 | \*\*\* | | 0.068 | \* | | 0.055 | \*\*\* |
|  | (0.024) |  | | (0.046) |  | | (0.019) |  | | (0.036) |  | | (0.021) |  |
| *ln(emig)* | -0.071 | \*\*\* | | -0.064 | \* | | -0.015 |  | | -0.014 |  | | 0.024 |  |
|  | (0.021) |  | | (0.039) |  | | (0.018) |  | | (0.028) |  | | (0.019) |  |
| *ln(area)* | 0.975 | \*\*\* | | 0.980 | \*\*\* | | 1.037 | \*\*\* | | 0.974 | \*\*\* | | 1.055 | \*\*\* |
|  | (0.011) |  | | (0.013) |  | | (0.008) |  | | (0.012) |  | | (0.010) |  |
| *ln(aglaborsupply)* | 0.384 | \*\*\* | | 0.143 | \*\*\* | | -0.058 | \*\*\* | | -0.046 |  | | -0.253 | \*\*\* |
|  | (0.027) |  | | (0.056) |  | | (0.022) |  | | (0.040) |  | | (0.023) |  |
| *Secondary Education Dummy* | 15.116 | \*\*\* | | 2.315 | \*\* | | -1.367 | \*\*\* | | -2.619 | \*\*\* | | -10.431 | \*\*\* |
|  | (0.288) |  | | (0.753) |  | | (0.177) |  | | (0.634) |  | | (0.231) |  |
| *Age Dummies* |  |  | |  |  | |  |  | |  |  | |  |  |
| *(relative to <19 yrs.)* |  |  | |  |  | |  |  | |  |  | |  |  |
| *(20-29)* | 4.089 | \*\*\* | | 0.185 |  | | 0.394 |  | | -1.143 | \*\* | | -2.973 | \*\*\* |
|  | (0.395) |  | | (0.898) |  | | (0.310) |  | | (0.578) |  | | (0.355) |  |
| *(30-39)* | 5.695 | \*\*\* | | -0.761 |  | | -0.021 |  | | -2.008 | \*\*\* | | -3.571 | \*\*\* |
|  | (0.382) |  | | (0.805) |  | | (0.299) |  | | (0.551) |  | | (0.344) |  |
| *(40-49)* | 9.573 | \*\*\* | | -0.058 |  | | -0.641 | \*\* | | -4.607 | \*\*\* | | -5.759 | \*\*\* |
|  | (0.392) |  | | (0.910) |  | | (0.303) |  | | (0.579) |  | | (0.350) |  |
| *(50-59)* | 8.432 | \*\*\* | | 0.527 |  | | -0.533 | \*\* | | -2.588 | \*\*\* | | -5.387 | \*\*\* |
|  | (0.311) |  | | (0.755) |  | | (0.249) |  | | (0.436) |  | | (0.271) |  |
| *Meso-Region Dummy* | FE |  | | FE |  | | FE |  | | FE |  | | FE |  |
| *Constant* | -8.132 | \*\*\* | | -1.495 | \*\* | | 0.444 | \* | | 0.160 |  | | 9.455 | \*\*\* |
|  | (0.301) |  | | (0.639) |  | | (0.241) |  | | (0.377) |  | | (0.268) |  |
|  |  |  | |  |  | |  |  | |  |  | |  |  |
| ***Measures of Fit*** |  |  | |  |  | |  |  | |  |  | |  |  |
| *n=* | 5,191 |  | | 391 |  | | 2,956 |  | | 1,181 |  | | 4,682 |  |
| *Sigma* | 0.781 | \*\*\* | | 0.395 | \*\*\* | | 0.443 | \*\*\* | | 0.551 | \*\*\* | | 0.656 | \*\*\* |
|  | (0.008) |  | | (0.015) |  | | (0.006) |  | | (0.012) |  | | (0.007) |  |
| *Rho* | 0.074 |  | | 1.000 |  | | -0.017 |  | | 0.544 | \*\*\* | | 0.087 | \* |
|  | (0.053) |  | | (0.000) |  | | (0.062) |  | | (0.064) |  | | (0.049) |  |
| *Log Likelihood Ratio* | -7,851 |  | | -205 |  | | -3,503 |  | | -1,798 |  | | -7,030 |  |
| *AIC* | 16,028 |  | | 522 |  | | 7,236 |  | | 3,749 |  | | 14,388 |  |

Standard Errors Presented in Parentheses

\*=Significant at 10% Level; \*\*=Significant at 5% Level; \*\*\*=Significant at 1% Level

FE Indicates Control of Fixed Effects of Meso-Region Dummies

**Maximum Likelihood Estimates of Sample Selection Models for ln(*quantity\_produced*), from Panel Data (2000 & 2010) Cont’d. (Part 2 of 3)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Crop Type** | | | | | | | | | | | |
|  | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | | | | | | | |
|  | **Cotton** | | | **Rice** | **Sugarcane** | | | **Beans** | | | **Tobacco** | |
|  | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | | | | | | | |
| **Variable** |  |  |  | |  |  |  | |  |  |  |  |
| *ln(immig)* | 0.027 |  | 0.085 | | \*\*\* | 0.023 | \*\*\* | | 0.095 | \*\*\* | 0.008 |  |
|  | (0.032) |  | (0.013) | |  | (0.010) |  | | (0.015) |  | (0.013) |  |
| *ln(emig)* | -0.023 |  | -0.055 | | \*\*\* | -0.025 | \*\*\* | | -0.057 | \*\*\* | -0.021 | \* |
|  | (0.027) |  | (0.012) | |  | (0.009) |  | | (0.014) |  | (0.013) |  |
| *ln(area)* | 1.065 | \*\*\* | 1.087 | | \*\*\* | 1.064 | \*\*\* | | 0.965 | \*\*\* | 0.999 | \*\*\* |
|  | (0.013) |  | (0.006) | |  | (0.003) |  | | (0.006) |  | (0.004) |  |
| *ln(aglaborsupply)* | -0.006 |  | -0.047 | | \*\*\* | -0.011 |  | | -0.021 |  | 0.024 |  |
|  | (0.038) |  | (0.015) | |  | (0.011) |  | | (0.017) |  | (0.016) |  |
| *Secondary Education Dummy* | 0.971 | \*\*\* | 1.897 | | \*\*\* | 0.822 | \*\*\* | | 2.767 | \*\*\* | 0.165 |  |
|  | (0.382) |  | (0.161) | |  | (0.104) |  | | (0.182) |  | (0.155) |  |
| *Age Dummies* |  |  |  | |  |  |  | |  |  |  |  |
| *(relative to <19 yrs.)* |  |  |  | |  |  |  | |  |  |  |  |
| *(20-29)* | 0.793 |  | -0.872 | | \*\*\* | 0.164 |  | | -0.504 | \* | 0.536 | \*\* |
|  | (0.497) |  | (0.228) | |  | (0.166) |  | | (0.265) |  | (0.255) |  |
| *(30-39)* | 0.645 |  | -0.591 | | \*\*\* | 0.179 |  | | -0.392 |  | 0.486 | \*\* |
|  | (0.495) |  | (0.215) | |  | (0.163) |  | | (0.251) |  | (0.231) |  |
| *(40-49)* | 0.210 |  | -0.877 | | \*\*\* | 0.839 | \*\*\* | | -1.280 | \*\*\* | 0.155 |  |
|  | (0.553) |  | (0.224) | |  | (0.162) |  | | (0.258) |  | (0.228) |  |
| *(50-59)* | 0.428 |  | -0.844 | | \*\*\* | 0.689 | \*\*\* | | -0.679 | \*\*\* | 0.192 |  |
|  | (0.412) |  | (0.179) | |  | (0.130) |  | | (0.205) |  | (0.172) |  |
| *Meso-Region Dummy* | FE |  | FE | |  | FE |  | | FE |  | FE |  |
| *Constant* | 0.093 |  | 0.821 | | \*\*\* | 3.228 | \*\*\* | | 1.225 | \*\*\* | -0.598 | \*\* |
|  | (0.396) |  | (0.164) | |  | (0.124) |  | | (0.201) |  | (0.283) |  |
|  |  |  |  | |  |  |  | |  |  |  |  |
| ***Measures of Fit*** |  |  |  | |  |  |  | |  |  |  |  |
| *n=* | 1,321 |  | 5,565 | |  | 5,314 |  | | 7,094 |  | 1,279 |  |
| *Sigma* | 0.512 | \*\*\* | 0.478 | | \*\*\* | 0.333 | \*\*\* | | 0.637 | \*\*\* | 0.214 | \*\*\* |
|  | (0.010) |  | (0.005) | |  | (0.003) |  | | (0.006) |  | (0.004) |  |
| *Rho* | 0.329 | \*\*\* | 0.102 | | \*\* | 0.228 | \*\*\* | | -0.847 | \*\*\* | 0.382 | \*\*\* |
|  | (0.064) |  | (0.050) | |  | (0.055) |  | | (0.018) |  | (0.083) |  |
| *Log Likelihood Ratio* | -1,834 |  | -6,247 | |  | -2,225 |  | | -8,287 |  | -53 |  |
| *AIC* | 3,878 |  | 12,801 | |  | 4,776 |  | | 16,906 |  | 297 |  |

Standard Errors Presented in Parentheses

\*=Significant at 10% Level; \*\*=Significant at 5% Level; \*\*\*=Significant at 1% Level

FE Indicates Control of Fixed Effects of Meso-Region Dummies

**Maximum Likelihood Estimates of Sample Selection Models for ln(*quantity\_produced*), from Panel Data (2000 & 2010) Cont’d. (Part 3 of 3)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Crop Type** | | | | | | | | | | | |
|  | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | | | | | | | |
|  | **Manioc** | | **Maize** | | **Soy** | | **Sorgum** | | | **Wheat** | | |
|  | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | | | | | | | | | |
| **Variable** |  |  |  |  |  |  | |  |  | |  |  |
| *ln(immig)* | 0.018 | \*\*\* | 0.083 | \*\*\* | 0.002 |  | | 0.013 |  | | 0.051 | \* |
|  | (0.007) |  | (0.015) |  | (0.010) |  | | (0.041) |  | | (0.031) |  |
| *ln(emig)* | -0.016 | \*\*\* | -0.078 | \*\*\* | -0.010 |  | | -0.002 |  | | -0.057 | \* |
|  | (0.006) |  | (0.013) |  | (0.009) |  | | (0.037) |  | | (0.029) |  |
| *ln(areainuse)* | 1.020 | \*\*\* | 1.015 | \*\*\* | 1.025 | \*\*\* | | 0.955 | \*\*\* | | 0.975 | \*\*\* |
|  | (0.003) |  | (0.007) |  | (0.003) |  | | (0.021) |  | | (0.012) |  |
| *ln(aglaborsupply)* | 0.005 |  | 0.010 |  | -0.008 |  | | -0.010 |  | | 0.011 |  |
|  | (0.008) |  | (0.017) |  | (0.011) |  | | (0.046) |  | | (0.035) |  |
| *Secondary Education Dummy* | 0.286 | \*\*\* | 2.372 | \*\*\* | 1.281 | \*\*\* | | 2.407 | \*\*\* | | 4.526 | \*\*\* |
|  | (0.084) |  | (0.160) |  | (0.085) |  | | (0.375) |  | | (0.288) |  |
| *Age Dummies* |  |  |  |  |  |  | |  |  | |  |  |
| *(relative to <19 yrs.)* |  |  |  |  |  |  | |  |  | |  |  |
| *(20-29)* | -0.028 |  | -1.447 | \*\*\* | 0.258 |  | | -0.808 |  | | -0.202 |  |
|  | (0.123) |  | (0.245) |  | (0.174) |  | | (0.702) |  | | (0.587) |  |
| *(30-39)* | -0.072 |  | -1.520 | \*\*\* | -0.494 | \*\*\* | | 0.444 |  | | 0.032 |  |
|  | (0.117) |  | (0.235) |  | (0.161) |  | | (0.672) |  | | (0.529) |  |
| *(40-49)* | 0.143 |  | -1.520 | \*\*\* | 0.311 | \* | | -0.138 |  | | 2.519 | \*\*\* |
|  | (0.121) |  | (0.241) |  | (0.170) |  | | (0.704) |  | | (0.539) |  |
| *(50-59)* | 0.087 |  | -1.012 | \*\*\* | 0.633 | \*\*\* | | -0.853 |  | | 1.521 | \*\*\* |
|  | (0.096) |  | (0.193) |  | (0.135) |  | | (0.575) |  | | (0.419) |  |
| *Meso-Region Dummy* | FE |  | FE |  | FE |  | | FE |  | | FE |  |
| *Constant* | 2.517 | \*\*\* | 2.414 | \*\*\* | 0.611 | \*\*\* | | 0.997 | \* | | -0.041 |  |
|  | (0.091) |  | (0.181) |  | (0.128) |  | | (0.535) |  | | (0.478) |  |
|  |  |  |  |  |  |  | |  |  | |  |  |
| ***Measures of Fit*** |  |  |  |  |  |  | |  |  | |  |  |
| *n=* | 7,033 |  | 7,900 |  | 2,574 |  | | 878 |  | | 1,332 |  |
| *Sigma* | 0.286 | \*\*\* | 0.616 | \*\*\* | 0.222 | \*\*\* | | 0.506 | \*\*\* | | 0.496 | \*\*\* |
|  | (0.002) |  | (0.005) |  | (0.003) |  | | (0.012) |  | | (0.010) |  |
| *Rho* | -0.033 |  | -0.698 | \*\*\* | -0.141 | \*\* | | -0.141 |  | | -0.147 |  |
|  | (0.067) |  | (0.075) |  | (0.070) |  | | (0.112) |  | | (0.164) |  |
| *Log Likelihood Ratio* | -1,601 |  | -7,763 |  | -33 |  | | -1,578 |  | | -1,138 |  |
| *AIC* | 3,534 |  | 15,857 |  | 281 |  | | 3,351 |  | | 2,423 |  |

Standard Errors Presented in Parentheses

\*=Significant at 10% Level; \*\*=Significant at 5% Level; \*\*\*=Significant at 1% Level

FE Indicates Control of Fixed Effects of Meso-Region Dummies

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1. Many authors argue that the term “commercial farming” should be avoided in favor of “non-family farming.” This is because family agriculture may also be commercial in nature, especially in Brazil’s Southern region, where small producers are highly mechanized and integrated into export markets (Buainain, Romeiro & Guanziroli, 2003). “Non-family agriculture” is used throughout the remainder of the text. [↑](#footnote-ref-1)
2. Between 2000 and 2010, the cumulative agricultural GDP deflator for Brazil was 2.0247. [↑](#footnote-ref-2)