Modelling rural labor: an application to Sao Paulo, Brazil*

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RESUMO

A questão de modelar o trabalho rural é discutida, sugerindo-se um modelo de regressões aparentemente não relacionadas (SUR). Apresenta-se uma aplicação analisando três categorias de trabalho no Estado de São Paulo: trabalhadores familiares do proprietário, trabalhadores permanentes e trabalhadores temporários. O teste de Breusch-Pagan resultou significativo, indicando a necessidade de uso do SUR.

Palavras-chave: trabalho rural; tecnologia; regressões aparentemente não relacionadas (SUR).

ABSTRACT

The question of modelling rural labor is discussed and a seemingly unrelated regressions (SUR) model is suggested. An application is presented analyzing three labor categories in the State of Sao Paulo, Brazil: farmer's family workers, permanent workers and temporary workers. A significant Breusch-Pagan test indicates the need of SUR.

Key words: rural labor; technology; seemingly unrelated regressions (SUR).

JEL classification: C00, C31, J00, J43.

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1 Introduction

Several assumptions are usual when dealing with labor in agriculture: traditionally workmanship is transferred from agriculture to other economy sectors; agriculture uses less skilled workers; cattle-breeding uses less workers than plant-cultivation; technology innovations have a tendency to decrease labor demand. But these assumptions are seldom tested on field conditions. So, the general aim of this paper is to establish an econometric model for rural labor based on farm features, with an application to Sao Paulo State, Brazil.

The number of workers in rural activities in this state has changed along time, from 1,583 thousand people (in 1970), to 1,467 (1979), 1,625 (1988), 1,497 (1990), 1,185 (1997) and 1,273 (1999), due to structural changes but also to conjuncture oscillations. (Vicente and Baptistella, 1986; Baptistella *et al.*, 2000) The modernization process of agriculture has partially transformed home farming to business farming - mainly for sugar cane and citrus crops -, modifying labor relationships. In the last three decades of 20th century, farmers absenteeism, hired labor and temporary labor have increased, as long as traditional labor relationship such as tenant farmers tended to decrease. (Garcia, 1986; Baptistella *et al.*, 2000) The use of modern agricultural machinery and inputs increased land and labor productivity. (Gonçalves, 1997) However, the slower modernization of harvesting augmented labor seasonality and the need for temporary workers. (Graziano da Silva, 1980) The mechanization of the last production step - the harvesting - in soybean, corn, wheat and others is now substituting temporary labor for skilled permanent labor. (Borba, 1994; Ricci, 1994)

This paper does not deal with labor demand and supply, but with the effects of agronomy variables over rural workers occupation. Other kinds of analysis are met in the literature, such as relating agricultural production and labor demand (Astroga Lira and Commander, 1989), or modelling rural employment changes (Schmitt, 2000), or studying labor in the context of stochastic processes (Amano and Wirjanto, 1997). See also Hamermesh (1999) for a discussion on modelling labor.

2 Theoretical model and hypotheses

The model for rural labor is expected to give the average use of different kinds of human labor in a specified rural area as a set of technical coefficients. Hence, large and small farmers should be included, economically efficient or not, typical or not, at several soils and climates, producing any kind of rural commodities. Moreover, if the data arise from a census, it is also expected the model to reflect reality, instead of an ideal situation, as in a model based on data

from an expert choice or any other purposive sample. Four main hypotheses are considered.

The **first hypothesis** is related to the labor categories. We assume that along time Brazilian agricultural production started with the labor of the farmer family, changed to family enterprises and then to enterprises. So, the first kind of labor to appear was the **farmer's family labor**, i.e., the farmer and his relatives labor. Mathematically the number of family members working at the farm (F) should be written as a function of a variables set U:

$$F = f_1(U)$$

When this category of labor is not enough the farmer looks rather for permanent workers, i.e., the number of **permanent workers** (P) in the farm should be written as a function of the same variables set U and also the number of family members already working at the farm:

$$P = f_2(U,F)$$

At last, when farmer's family labor plus permanent workers labor is not enough (mainly due to production seasonality, but also to other fast variations on the labor demand) the farmer looks for temporary workers, so the number of **temporary workers** (T) in the farm should be written as a function of the same variables set U, the number of family members and the number of permanent workers already working at the farm:

$$T = f_3(U,F,P)$$

The **second hypothesis** is related to the rural business size. Labor in a farm is obviously a function of the rural business size, measured by the cultivated area or the number of animals. Therefore, the variables set U has to include the cultivated area of the main crops and the number of animals of cattle and poultry. The level of each individual rural activity should be positively (as usually) or negatively related to each kind of labor. E.g., if a rural business is typical of home farms, it should be positively related to the number of farmer's family members working at the farm, but negatively related to number of temporary workers. The opposite should happen if the rural business is typical of business farms.

The **third hypothesis** is related to the interactions between rural activities. The **interaction**[1] between two rural activities may change the number of workers in each kind of labor,

1 The word interaction is used here in a statistical sense, as in experimental analysis.

negatively (as usual) or positively. Given two rural activities, two situations may occur: a) both activities influence the number of workers in the same way, i.e., both negatively or both positively. In this case, the interaction will have the opposite sign; b) the activities influence the number of workers with opposite signs. In this case, the interaction will have an intermediate effect, and may be negative, null or positive.

Note that, in the context of this paper, if two rural activities never occur in the same farm during the same year, then the interaction will be null. On the other hand, if they always occur together in the same farm during the same year, then the individual effects over rural labor may not be shared, so they have to be jointly estimated. Therefore, the interaction may be estimated in the intermediate situations, i.e., if the activities may occur both together or not in the same farm. However, even if the interaction is significant this does not imply synergy between the two activities, although the opposite is usually true.

Finally, the interaction may be additive or multiplicative. In the former case, both activities are developed in the same area, e.g., corn may be planted between two rows of coffee trees. In the latter case, the activities are developed in the same farm but not necessarily in the same area.

The **fourth hypothesis** is related to other factors. Other variables besides the rural activity level or size seems to influence the amount of labor in a farm, as the farmer profile, the production technology and the administration technology. Characteristics as a home farm or a business farm,[2] a resident or an absentee farmer, the farmer educational level, and the degree of organization of the farmers (in producers co-operatives, associations or syndicates) should influence each labor category. In fact, it is expected business farms to employ more temporary workers and less farmer's family members, as well as absentee farmers to employ more permanent workers and less members from his own family. Some technologies or production techniques may increase labor productivity, diminishing the number of workers. Nevertheless, there are two cases to consider: a) In a home farm, some technologies allow the farmer's family members themselves to be more productive, avoiding other labor categories, so these technologies will be positively related to the number of farmer's family workers and negatively related to the number of workers, both permanent and temporary; b) In a business farm, some technologies increase permanent workers productivity, diminishing the demand for temporary labor, so these technologies will be negatively related to the number of temporary workers.

2 In this paper the expressions "home farm" and "business farm" will not be rigorously defined. In a broad sense, a home farm will be seen as a small business managed by the owner, in opposition to the business farm, seen as an enterprise managed by the owner himself or by professionals.

Some technologies also substitute non-qualified workers by a less amount of qualified workers, earning higher salaries, discharging human being from excessively hard tasks, as well, e.g., in the sugar-cane harvest. Other technologies increase the land (or the animals) productivity, so demanding more permanent and temporary workers. Technological adoption may also depend on the geographical region (topography, soil and climate), farm size, crops, etc.

3 Model estimation

The proposed theoretical model points out to a model with several related equations. In fact, a shock affecting the demand for one of the labor categories may affect the demand for another category in a substitution effect, i.e., the effect over one equation may be transferred to the other equations via the disturbance terms. (Kennedy, 1998) If so, the errors will be contemporaneously correlated, violating one of the hypotheses of the ordinary least squares method. Hence, jointly estimating the equations will give more efficient estimates comparatively to a single equation. Equations with contemporaneous correlation were called seemingly unrelated by Zellner (1962).[3] The correlation between the disturbance terms do not occur inside each equation, but among the equations of the system. (Pindick and Rubinfeld, 1998)

The Statistical Analysis Software (SAS®) has been used for estimation (see for detail SAS, 2002; Zellner, 1962; Greene, 2000; Griffiths *et al.*, 1993; Judge *et al.*, 1988, Johnston and DiNardo, 1997; Pindyck and Rubinfeld, 1998).

Breusch and Pagan (1980) developed the following statistical test to detect the existence of contemporaneous correlation, in order to decide for using SUR:

$$\lambda = n \sum_{i=2}^{m} \sum_{j=1}^{i-1} r_{ij}^{\,2}$$

where n is the number of observations and $r_{ij}^{\,2}$ is the squared correlation, defined by

$$r_{ij}^{\,2} = \frac{\hat{\sigma}_{ij}^{\,2}}{\hat{\sigma}_{ii}\,\hat{\sigma}_{jj}}$$

3 See Hill *et al.* (1997).

This is used to test the following hypotheses:

H_0 $\sigma_{ij} = 0$, the contemporaneous covariance equals zero for all i e j, $i \neq j$;

H_A. at least one covariance does not equal zero.

Under the hypothesis H_0, λ is asymptotically distributed as χ^2 with $m(m-1)/2$ degrees of freedom, and the null hypothesis is rejected for high values of λ.

4 Application

The model has been applied to rural labor in the State of Sao Paulo, Brazil, using data from an agricultural census known as LUPA Project, surveyed in 1995-96, with 277.149 observations,[4] each corresponding to a farm. Some crops were grouped into classes such horticulture because they were mainly explored in a combined way and their effects could not be shared. (Pino *et al.*, 2000a; Pino and Francisco, 1999)

There are three equations in the system: the first for the number of farmer's family members working at the farm (simplified to familiar model), the second for the number of permanent workers at the farm (simplified to permanent workers model) and the third for the maximum number of temporary workers[5] at the farm (simplified to temporary workers model). The units of the estimated coefficients are the following: number of people per hectare (when the independent variable is a cultivated area), number of people per animal (for cattle and poultry), number of people per unit (for machines and others) and number of people per farm (for the intercept, other crops, other animals, and dummy variables). The complete estimation results of almost 400 variables (including almost 300 interactions) will not be presented here, and only few estimates will be analyzed, concerning to the main variables.

The Breusch-Pagan test is highly significant ($\lambda = 2{,}598.552$), so the hypothesis that contemporaneous covariances equal zero is rejected. Therefore, the seemingly unrelated regressions approach must be used.

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4 A few observations were disregarded due to errors.

5 Note that the temporary labor is represented by the maximum number of workers contracted during one year, because this variable is strongly seasonal and the maximum was the only proxy available in that survey.

4.1 Human variables

The intercept in each model means the average initial level of labor, from which the number of people is added or subtracted depending on the value of each variable. It showed to be significant in the first and the third models, so we start with the average of almost one (0.8) farmer's family members in each farm, almost zero permanent workers and almost 3 temporary workers.

The maximum number of temporary workers is negatively related to the number of farmer's family workers and positively related to the number of permanent workers, which is consistent since farmer's family workers are related to home farms, but the others are related to business farms. Non-absentee farmers add one family worker but subtracts one permanent worker. The existence of settled landless laborers is positively related to familiar and permanent labor but negatively to temporary workers, as should be expected, since they like small farmers. The opposite occurs with tenant farmers, which are negatively related to familiar labor and negatively to temporary labor.

4.2 Agriculture and livestock

From the labor point of view the sugar cane (industry and fodder) showed to be the most important crop variable, using almost 2 permanent workers and the maximum of 29 temporary workers per 100 ha (farmer's family workers are negligible). It has the major planted area in the state of Sao Paulo, with 2.9 million ha and 97% of single cultivation. (Pino and Francisco, 1999) The interaction sugar cane x citrus is consistent and probably occurs in the frontier between the producing regions. It adds farmer's family workers and subtracts temporary workers (probably transformed into permanent workers). The interactions with eucalyptus and pine tree occur also regionally. Some interactions with *Leguminosae* plants (peanut, bean, soybean) occur while reforming sugar cane plantations (in the state, most peanut is intertilled with sugar cane, according to Pino and Francisco, 1999). In most cases, sugar cane cultivation is associated to business farming. However, the interactions with cotton, rice, poultry, cattle and coffee may be associated to home farming. At last, note that sugar cane farmers (and sugar factories owners) are usually absentee.

The citrus[6] crops used 3 permanent workers and the maximum of more than 7 temporary workers per 100 ha. These results are consistent with the 8.1 workers per 100 ha occupied in

6 Includes oranges, tangerines, mandarins, lemons, citron, sour orange, sweet lime, grapefruit, and others.

citrus cultivation, in 1996, according to SEADE (2001). Orange has the third planted area in the state, with 98% of single cultivation and Sao Paulo is the main world producer. It is cultivated on medium and large farms, widely using modern inputs, such as fertilizers, pesticides and agricultural machinery, and requiring hired workers, both permanent and temporary. (Martinelli Jr., 1987) Orange combined with corn is positively related to farmer's family workers.

Coffee crops used almost 5 permanent workers and the maximum of 28 temporary workers per 100 ha. These results are consistent with the 35.5 workers per 100 ha occupied in this crop, in 1996, according to SEADE (2001). Since the number of trees per hectare has increased in the last decade - and is still increasing - the number of trees and the number of trees per hectare were also considered in the models. The former showed to be positively correlated to the number of permanent workers and the latter to the number of farmer's family workers, although with negligible values. At that, one concludes that thicker coffee cultivation demand more labor. An important interaction is coffee x cattle (dairy), negatively correlated with permanent workers. Some others are feasible, such as with corn, peanut (green manure), citrus, sugarcane, poultry, hog.

The second crop in terms of planted area is the corn, with only 63% in single crops, and adding one permanent worker and decreasing 5 temporary workers per 100 ha (according to SEADE, 2001, only 1.5 worker per 100 ha was occupied in corn cultivation, in 1996). These results indicate a strongly technical cultivation in all production steps, demanding skilled workers. Corn is used in the state to feed hog and poultry, but less for cattle, thence the corresponding interactions.

Soybean adds 5 temporary workers per 100ha (according to SEADE, 2001, 1.7 worker per 100 ha was occupied, in 1996). Since it is mechanically harvested, temporary workers are probably used in other tasks. Soybean is often cultivated in rotation with corn and sorghum. Soybean plus sorghum is positively related to farmer's family workers, but the interaction soybean x sorghum subtracts 2 temporary workers at each 100 x 100 ha. The interaction soybean x corn is negatively related to permanent workers. Almost all sorghum (and a part of corn) is planted in rotation with soybean in the state of Sao Paulo. Only industrialized soybean bran is used to feed cattle, hog and poultry. These results are consistent with the fact that soybean is cultivated in medium and large farms, with intensive use of technology (inputs and machinery), thus saving labor.

Cotton adds 18 temporary workers per 100 ha, because it has to be harvested in a short time and it is only partially mechanized (in the larger farms with good topographical conditions),

although there are strong regional differences of technological levels. According to SEADE (2001) 16.7 workers per 100 ha were occupied, in 1996.

Horticulture,[7] a typical home farming, cultivated in small areas, adds few farmer's family workers, 4 permanent workers and subtracts 7 temporary workers per 100 ha. These crops require intensive labor and care, thence the positive relationship to farmer's family and permanent workers. The general behavior of horticulture is similar for corn, grape and guava. Grape adds 29 skilled permanent workers per 100 ha, including share-croppers.

Sao Paulo is the main Brazilian producer of rubber tree, most planted by tenant farmers, thereupon adding 4 permanent workers and subtracting 1 farmer's family worker and 19 temporary workers per 100 ha. Labor is less necessary to form the rubber plantation, but important to keep the production from the 10th to the 30th year. (Toledo and Ghilardi, 2000) The interactions with several annual crops are relevant to maintain the tenant farmers during the first years, such as corn, peanut and bean. As a matter of fact, corn occurs in 35% of the farms with rubber tree (Pino *et al.*, 2000b) and the cultivation of corn between lines of rubber tree is the main tillage combination of the latter crop. (Pino and Francisco, 1999)

Bean adds farmer's family and temporary workers; it is accomplished in three harvests per year, only 44% in single cultivation, with irrigation in the winter, most with mechanized planting and manuring, and chemical weeding. (Mello, 2000) Cassava, onion, passion fruit and sweet potato add only farmer's family members. Cassava is largely cultivated in small business farms, with handy harvesting (mechanization is not economically feasible yet). Flowers[8] and peach add only (skilled in the former crop) permanent workers. Like soybean and cotton, macadamia nut and peanut add only temporary workers. Mango adds farmer's family and subtracts temporary workers, banana adds permanent and subtracts temporary workers, eucalyptus subtracts farmer's family and adds permanent workers, potato subtracts permanent workers, coconut, paraná pine and triticale subtracts farmer's family workers. Some crops appear in the models only as part of interactions: avocado, black-eyed bean, custard-apple, heart of palm, Italian millet, oats, papaya, persimmon, pineapple, rice, strawberry, tomato, watermelon, wheat,

7 Includes vegetables such as artichoke, asparagus, beet, broccoli, Brussels sprouts, burdock, cabbages, carrot, cauliflower, celery, chayote, coriander, cucumber, egg-plant, endive, fennel, garden parley, garlic, leek, lettuce, marjoram, okra, oregano, pea, radish, scallion, spinach, Swedish turnip, sweet pepper, Swiss chard, turnip, water-cress, wild chicory, and others.

8 Includes carnation, chrysanthemum, daisy, gladiolus, lily, rose and others.

other tropical fruits (including Barbados cherry, cashew, litchi, melon, pecan tree, pomegranate, prickly pear and others), other non-tropical fruits (including apple, fig, kiwi, nectarine, pear, plum, raspberry and others).

Inverting the coefficient of these variables one obtain the area per worker (*coeteris paribus*, i.e., not considering technology and regional differences), e.g., 57 ha/permanent and 3.5 ha/temporary worker in sugar cane, 29 ha/permanent and 13 ha/temporary worker in citrus, 22 ha/permanent and 4 ha/temporary worker for coffee, 96 ha/permanent worker for corn, 5.5 ha/temporary worker for cotton, 1.5 ha/permanent worker for flowers, 3.5 ha/permanent worker for grape, 23 ha/permanent worker for rubber tree, 4.717 chickens/permanent worker for poultry (egg) or 114.679 chicken/permanent worker for poultry (slaughter). In 1996, these were the values of ha/EHA[9] in the state of Sao Paulo: 7.6 for sugar cane, 12.3 for orange, 2.8 for coffee, 6.0 for cotton, 0.6 for grape, and 4.4 for rubber tree. These data are not directly comparable, since the definitions and methodologies are different, but they support each other in some sense. Fruit crops are more labor intensive than grain, cotton and sugar cane crops, requiring less seasonal skilled labor. The grape cultivation requires more labor than the others (0.6 ha/EHA); the next group is formed by fig, peach and guava (1.1 to 1.3 ha/EHA), followed by passion fruit, banana and watermelon (2.1 to 2.8 ha/EHA); pineapple requires less labor (4.8 ha/EHA).

The results from the models allow us to assert that increasing sugar cane, citrus, coffee, cotton, soybean and bean areas would increase temporary labor. Labor contracts are formal in sugar cane, but only in the largest farms of citrus, coffee and cotton; infant labor is decreasing and has been eliminated in some crops, such as sugar cane and citrus. On the other hand, increasing citrus, coffee, horticulture, rubber tree, flowers and fruits will increase permanent labor. (Amaro *et al.*, 2001)

In the main, extensive cattle-raising does not employ many workers. Asses and mules are positively related to farmer's family workers, mainly in small farms, but has no relationship with the other categories of labor. Cattle for slaughter is negatively related to farmer's family workers and to temporary workers (minus 3 and 37 workers for each 10,000 animals). Dairy cattle diminishes 3 permanent and 12 temporary workers for each 1,000 animals). Those farmers with high productivity dairy cattle have rather use corn (and corn silage) than sugar cane to

9 EHA means the labor of an adult man working 8 hours per day during 200 days/year and does not correspond to the number of people working in a given crop. (SEADE, 2001)

feed the animals, except those with intensive grazing. However, sugar cane may be used to feed cattle for slaughter and dual purpose cattle during the winter.

Poultry for eggs adds 21 permanent and subtracts 17 temporary workers for each 100,000 animals. Poultry for slaughter adds 9 permanent and subtracts 20 temporary workers for each 100,000 chickens. The low seasonality of poultry production support permanent rather than temporary labor. Hogs breeding adds almost 2 permanent workers per 1,000 animals. Horses are negatively related to farmer's family workers and adds 2 permanent workers per 100 animals.

4.3 Technology, administration and improvements

As known, agricultural machinery modifies the labor demand in a farm. So, farm tractors adds permanent skilled workers, subtracting the other labor categories. Hitched harvesters are associated to home farming, but each self-propelling directly substitute 11 temporary workers, mainly in sugar cane and grain harvesting (according to FIM, 1996, each sugar cane harvester should substitute up to 120 harvesters). Sugar cane is important for non-skilled migrant workers survival, i.e., native from other Brazilian states looking for temporary jobs. (FIM, 1996) As seen here, these will be the most affected people in the mechanization process of sugar cane harvesting.

The sugar cane loader (usually not self-propelled) is associated to handy harvest, each one adding 7 permanent and 7 temporary workers. This kind of machine needs a skilled worker, usually permanent, not temporary, and it is also related to business farms, probably belonging to or in association with a sugar factory, in which several different farms are harvested together. This facts explain the increasing number of permanent workers. On the other hand, a faster loading operation needs more temporary workers cutting sugar cane. Therefore, it is probable that the existence of sugar cane loader increases the maximum number of temporary workers, but decreasing the period of harvesting. This conjecture may not be proved from this analysis, but it is plausible.

Electricity used in rural activities saves labor, decreasing both farmer's family and temporary workers. As a matter of fact, electricity allows the use of technologies affecting labor. Nevertheless, some technologies improving agricultural production may increase labor demand, such as chisel plow, irrigation, subsoiling and even soil conservationist practices (including soil conservation, soil analysis and liming).

Some technologies save labor but adding skilled permanent labor,[10] such as tractors and hitched harvesters, others, such as self-propelled harvesters, only save labor. Some technologies increase land productivity, such as chisel plow (characteristic of home farming), subsoiling (usually in large farms with sugar cane), green manure and small tractors (usually in small farms with horticulture), bred or selected seeds (usually in soybean, corn and bean), and soil conservation practices, add some kind of labor.

Some crops are technologically homogeneous, i.e., small and large producers use almost the same technology, e.g., soybean; others are heterogeneous, e.g., corn, bean, cotton, peanut and rice.

Cattle-breeding technology such as artificial insemination, cattle confinement, intensive grazing, and milk cooler are negatively associated to some labor categories. On the other hand, cool chamber and milking machine demand skilled permanent workers but not temporary workers.

The way a farm is managed also affects labor demand. Book-keeping and the use of computers are indicators of business farming - less than 1% of the farms up to 1 ha used computers, compared to 65% of those from 5,000 to 10,000 ha (Francisco and Martin, 1999); moreover, book-keeping and computers are useful in controlling and paying a lot of workers, specially the temporary ones. Larger farms with sugar cane and citrus use computers to control all the tasks, registering absences, striking and performance of each worker. (Ricci *et al.*, 1994) Hence, they are negatively related to the number of farmer's family workers and positively related to the maximum number of temporary workers and to the number of permanent workers. Using credit increases all the categories of labor, probably because it allows a higher production level; using private and/or governmental technical assistance also increases farmer's family and temporary labor, due to the same reason and also because it allows the farmer to avoid some kinds of skilled workers.

Some improvements also affect the labor demand. Small industries, such as brick factories, sugar mills and flour mills are related to home farming. Also does the existence of greenhouse, usual in horticulture, flowers cultivation and nursery-garden, as well as the existence of ration mills. Packing houses are positively related to farmer's family and permanent workers, since they need skilled and well trained workers. The existence of houses and churches are positively related to all the labor categories. Houses, laboratories and the large sugar factories are strongly related to permanent workers, as should be expected. Dams, processing machines and

10 Recently contracted through a special enterprise, not directly by the farmer.

grain elevator decrease permanent workers. Warehouses and grain dryers are positively related to temporary labor.

Finally, it is remarkable that in recent years some skilled permanent workers have been not directly contracted by the farmer, but through a specialized enterprise.

4.4 Geographical variables

The variables related to the geographical space probably reflect different soil and climate conditions, but in a larger area should also reflect different human cultures and different rural activities combinations. In the state of Sao Paulo, permanent workers are positively related to the southern regions (Itapeva, Presidente Venceslau and Assis) and negatively to the northern ones (Orlândia, Jaboticabal and Barretos). Temporary workers are concentrated in the important agribusiness centers of Ribeirão Preto, Jaú, Barretos and Jaboticabal, but negatively related to the neighbor region of Araraquara. Farmer's family workers are positively related to a less developed region (Itapeva) and to a region with many settled landless laborers (Presidente Venceslau, also known as Pontal do Paranapanema).

4.5 Prediction

The estimated models should be used to make some predictions[11] about rural labor in micro or macroeconomic levels. For example, multiplying the planted area with sugar cane in 1995-96 (2.9 million ha) by the corresponding parameter (and disregarding the iterations) we obtain that sugar cane might have employed 50,799 permanent workers during that years. The same calculations result in 30,216 permanent workers for orange (0.9 million ha), 12,977 for corn (1.2 million ha), 10,584 for coffee (0.2 million ha) and 3,580 for poultry (411 million chickens for slaughter). Some comparable values from independent surveys are the following: 70,323 permanent workers in coffee cultivation (November 2000, unpublished data surveyed as described in Pino *et al.*, 2001), 52,289 (in 1997), 43,548 (in 1998) and 36,246 (in 1999) permanent workers in orange cultivation (Amaro *et al.*, 2001), 70,721 (June 1998) and 54,414 (November 1998) permanent workers (including tenant farmers and others) in sugar cane (unpublished data from a sample survey by the Institute of Agricultural Economics. Although not directly comparable, it is interesting to note the values of 368.961 EHA for sugar cane (includ-

11 Sometimes meaning "estimating" an unknown value, others in the sense of "forecasting" a future value.

ing both permanent and temporary labor), 72.735 for orange, 16.115 for corn, and 94.909 for coffee. (SEADE, 2001)

Using the models to predict values at microeconomic level, i.e., at farm level is possible, although less precise. Consider, e.g., the data of three farms from an independent sample survey, taken in November 2000, and compare the observed values and the values predicted by the models.[12] The first farm, coded 003-2124, with 318 ha of sugar cane, 232 ha of orange, 90 ha of corn, 4.84 ha of bean, 2 ha of peanut, and 1.96 ha of eucalyptus, informed no farmer's family workers against zero predicted by the model, 17 permanent workers against 20 predicted, and no temporary workers at the last week, against the maximum number of 105 temporary workers predicted by the model. Obviously, orange and sugar cane crops were already harvested at the time of the sample survey. For the second farm, coded 550-35, with 125.84 ha of orange and 87 animals of dual purpose cattle, we have no observed nor predicted farmer's family workers, 11 observed against 6 predicted permanent workers, and 25 observed in the last week against 34 predicted maximum number of temporary workers. The third farm, coded 032-537, with 503.2 ha of sugar cane and 194 ha of rubber tree, informed 2 non-resident farmer's family workers against 13 predicted by the model, 14 observed against zero predicted permanent workers, and no temporary workers at the last week against 125 of predicted maximum. The reason for the difference in temporary labor is the same as for first farm. The very large number of predicted familiar labor is due to the interaction sugar cane x rubber tree, but in fact, the farm was managed into partnership with a sugar factory, which supplied the permanent labor in substitution to the familiar labor.

The effect of substituting a rural activity by another should also be studied from these models, subtracting the respective parameters (under *coeteris paribus* conditions). Then, substituting 100 ha: a) of citrus by sugar cane subtracts 2 permanent workers, but adds 21 temporary workers to the maximum; b) of citrus by coffee adds one permanent and 20 temporary workers; c) of sugar cane by coffee adds 3 permanent and subtracts one temporary workers; d) of soybean by citrus adds 4 permanent and 3 temporary workers; e) of soybean by coffee adds 5 farmer's family and 23 temporary workers; f) soybean by sugar cane adds 2 permanent and 24 temporary workers.

12 These are just examples, since the sample survey did not informed about technological variables. Therefore, the predictions will be somewhat poor.

4 Concluding remarks

It is worth while to emphasize that the models presented in this paper reflects an average situation in a large area, such as an state. They include farming, cattle-breeding and forestry at many different technological levels. Although it is not directly applicable to specific situations or to other states, they allow some interesting predictions, such as the effect of substituting a rural activity by another, and the characterization of how several variables influence the use of labor.

Many of the results in this paper support the idea that, contrariwise to what happened during the two foregoing decades, in the nineties the proportion of permanent workers increased while that of temporary workers decreased, but requiring skilled workers able to work in different tasks along the year.

In summa, in the context of this paper, technological adoption may have strong impact over agricultural labor, so it has to be considered in the models. However, it is not treated as essentially bad to create employees, since at long run some functions may be substituted by other better ones. As for the discharging of non-qualified workers, there is no other option as education to transform the no more demanded workers into others more adequate to the needs of modern society.

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