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División de Economía
Universidad Carlos III de Madrid
Calle Madrid, 126
28903 Getafe (Spain)
Fax (341) 624-9875

MIGRATION AND RISK: AN EMPIRICAL APPLICATION TO THE COCA ECONOMY IN PERU

Julio E. Revilla*

Abstract

This paper studies the growth of the Peruvian illegal coca economy as a result of the migratory process. The paper describes peasant attitudes towards migration as a portfolio decision making process, where peasants allocate labor to the coca fields or the urban sector according to relative earnings and risk structure. The empirical estimation, using data on wages and risk factors (i.e. political violence) for the coca region and Lima, shows that migration to the coca sector is an economically rational decision. Using log-linear and non-linear specifications, it is shown that wage differentials and political violence in the coca region and the urban sector are significant in affecting migration to the coca sector. Unemployment in the urban sector shows an inconclusive effect. The variables used, although they seem to have non-stationary properties, are cointegrated and therefore validate standard inference procedures. A simple test of stability of the parameters shows that they do not change significantly through time.

Key words: Coca Economy, Internal Migration, Migration and Risk, Migration in LDCs.

*Departamento de Economía, Universidad Carlos III de Madrid.
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1. Introduction

Anti-drug policy of the U.S. government has placed great emphasis on attacking production sources. The aim has been to reduce production directly by eradication and indirectly by denying inputs to coca production. These policies are not without controversy. In the emotion-laden debate it is difficult to consider alternatives analytically. This paper attempts to analyze empirically the factors determining labor migration to the coca region. It studies the factors determining migration patterns of the peasantry from the Andean region to the coca fields in the jungle areas of Peru, especially to the Upper Huallaga Valley.

The paper will use the limited data on labor supply in the coca region, wage differentials between the coca sector and the urban sector, and proxies for risk, and it tests the implications of a portfolio decision model with the aim of explaining the determinants of migration to the coca fields from the 1970s on.

Labor migration in less developed countries have been an important topic for both theoretical and empirical analysis in economic development. The traditional approach to explain migration has been the expected income hypothesis, which analyzes migration as a consequence of the expected income of the alternative destinations compared to the original location, considering the probability of not getting a job. Risk as an important element in the decision to migrate has been a recent addition to the migration literature in economics. In anthropological studies, nevertheless, the concept of risk has been used fairly extensively since the 1970s to explain peasant choice of alternative crops and behavior toward other opportunities of economic diversification.

It would be easy to predict that, given the condition of the Peruvian economy, migration to the coca fields should be immediate and massive, causing unlimited availability of labor. Yet this has not happened. This apparent paradox may be explained by the high risk in the area, not only because coca is an illegal economic activity but also because of political violence. Labor is thus inhibited from migrating. One of the main ideas of this paper is that migration is not only a function of expected income differentials, or of the perception of income variability in one region, but also of the income variability in all sectors of the economy. Just as investors diversify their assets to minimize risk, so do peasants and migrants in general. They diversify their different economic activities so as to manage the inherent risk to their livelihoods.

The peasantry finds an optimal allocation of labor, and therefore of migration, based not only on income differentials but also on the variability of income. This empirical exercise looks at variables of income differentials and perceptions of risk through indicators of political violence. The results show that both income differentials and risk factors such as violence are important in determining the supply of labor to the coca region.

The description of the economics of coca production and trade are well beyond the scope of this paper. We should know, however, that the production and trade of coca, coca paste, and cocaine, as a result of growing world demand, has had a significant impact in the Peruvian economy as a whole. Coca paste and cocaine base are not only the main Peruvian export, but also the most important agricultural commodity in terms of employment generation.[1]

2. Migration and Risk Aversion in the Andes

Income derived from off-farm activities is significant for almost every peasant group in Latin America. According to Collins (1987), an examination of empirical studies on labor scarcity and income obtained from off-farm work for the peasant population of Latin America shows that on average, more than 50 percent of income generated by peasants came from off-farm

[1] For a detailed account of the coca economy, see Morales (1989), Alvarez (1991), Briceño and Martínez (1989), and Revilla (1992).

employment; income from wages was 30 percent or more. These percentages were usually higher for families with smaller plots of land.

Ability to earn wages from off-farm work are not the only reason why peasants leave the land. Peasants take part in many other economic activities such as commerce, artisanry, and remittances, which provide alternative incomes for subsistance. Deere and de Janvry (1979) found that northern Peruvian peasants obtained almost half of their total income from wages while only a quarter of it was provided by agriculture and animal husbandry.[2] According to Collins:

> "This diversification of activities represents an attempt on the part of rural families to increase levels of income absolutely, as well as to accommodate the risk inherent in individual activities." [3]

From the empirical estimates available in relation to income diversification for small farm households in Latin America, we can establish that of all the alternative incomes migration for wages (in manufacturing or even in other agricultural activities) is the most important way of off farm income for the rural family, sometimes, as in the southern Andes of Peru, labor income is greater than farm income. Migration is both a seasonal phenomena in response to different labor requirements in agriculture, as well as a permanent decision based on leaving the farm in order to look for a higher expected income and to decrease total risk. Seasonal migration has been usually considered as the only kind of migration that peasants will make in order to decrease uncertainty. However, when the decision making agent is the family, even the permanent migration of a family member is part of the risk aversive strategy, due to the fact that remittances are used.[4]

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[2] Deere and de Janvry (1979), p. 607.

[3] Collins (1987), p. 21.

[4] The issue of remittances has been empirically studied by Lucas (1985) in Botswana.

The decision of the peasant family to diversify income is influenced by many different factors. Land (and paradoxically labor) scarcity is one of the reasons for migration. Although they seem contradictory, they do occur at the same time. One of the consequences of land scarcity is a reduction of household income. This reduction forces some of the productive members of the household into other activities, and sometimes even to leave the rural areas permanently. The decline in the prices of rural goods (or decline in the rural-urban terms of trade) is another reason why diversification occurs via production of other products or migration.[5]

Different diversification strategies are, of course, limited by the availability of resources of the peasant household. The economic activities in which the households would allocate labor require different levels of labor and skills. Children, adults, women or the elderly, would have different abilities and strengths to use in various activities.

Studies on the peasant population of the central and southern highlands of Peru show a good example of seasonal migration. The peasants on the northern shore of Lake Titicaca cultivate high-altitude crops, while at the same time nearly a third of the same population grows coffee on the slopes of the Andes. There is also seasonal migration to the coast for wages as well as migration for commerce and wage labor on the highlands. The peasant population of these highlands (the Aymara indians) represent a very good example of the diversification of economic activities, not only on their own land through crop diversification, but also through seasonal migration, which has utilized the available labor resources to the limit.[6]

By looking at the value of subsistence production, Painter (1986), examines the pattern of migration and other economic activities of a peasant region in Puno. He estimates first the market value of an hour of labor in subsistence agriculture, and then those of the other income generating activities. With the

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[5] Collins (1987), p. 22.

[6] Collins (1987), p. 27.

empirical data available it is feasible to test a hypothesis of risk aversion and utility maximization.[7]

3. Risk and Uncertainty in Peruvian Agriculture

The concepts of risk and uncertainty applied to the Peruvian Andes are explained by Guillet (1981). He argues that the maximization of output is constrained not only by the inputs and prices but also by the level of information pertaining to possible outcomes. He uses the concept of risk management to explain how the peasantry use different production strategies to minimize risk and uncertainty. The same way that investors diversify their assets to minimize risk, peasants diversify their different economic activities to manage the inherent risk to their livelihoods. The most common method of diversifying risk in the highlands is through the use of mixed subsistence strategies, consisting in the use of a mixed agro-pastoral production. In the high altitude regions in the Andes, for instance, agricultural production of potatoes and other tubers is combined with keeping small animals, such as guinea pigs. Another strategy of spreading risk is diversification of staples, which can be done horizontally or vertically. The first strategy, is called horizontal because it is done at the same altitude, through the production of mixed staples (i.e. potatotoes and maize) and the latter is called vertical because it is done by planting crops of different varieties of crops, at different altitudes.[8] The combination of these two products with other products such as protein rich quinhoa, tarwi and cañihua is also used as a way of diversifying risk to obtain a minimum

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[7] See Painter (1986).

[8] The use of hundreds of different varieties of potatoes as a way of responding to the changing weather is a clear example of diversifying risk in a horizontal space diversification.

of production for subsistence.[9] A third way in which the peasantry diversifies to minimize risk is through their interaction with different sectors of the economy. The most common among these alternatives is the use of labor migration for wages in the coastal cities, in the highlands, and colonization or migration for wages in the jungle. Migration, nevertheless, is not the only way to diversify through the different economic sectors; there are other ways that include commerce, artisanry, sale of dairy products and many other small activities.

In the southern Peruvian Andes, the case of one peasant community and its attitudes regarding risk management is presented by Guillet (1981). He shows that not only are peasants risk averse, but that there is also a large tradition of risk avoidance, and that the peasant family will evaluate any possible alternative so as to get the maximum amount of information available upon which to base a decision. This applies not only to innovative risks (such as the introduction of a new cash crop) but also to situations of uncertainty such as market prices and costs of inputs.

4. Some Theoretical Perspectives on Migration

Migration as a result of a rational decision by poor peasants in less developed countries has been an important topic for both theoretical and empirical analysis in development economics. Most of the literature is concentrated around the topic of rural-urban migration and the implications of that process for rural development, as well as the impact on the urban areas and the economic development of the country. Inter-regional migration for less developed countries has been less studied than the case for developed countries, but it has usually been linked to the rural-urban dilemma.

[9] It is precisely this complexity of production strategies in order to diversify risk that gives rise to the extreme parcelling of peasant lands found in the Andes.

One way of including the effects of risk on migration is suggested by the Expected Income Hypothesis (EIH) of Todaro (1969) and Harris and Todaro (1970), which considers that if we utilize an intertemporal utility function, we can incorporate not only income but risk (or income variability). It seems fair to assume that risk in the urban sector will decrease with time, when opportunities of work would be easy to find as a network of contacts is developed, to a point of being lower than the risk faced in the rural sector. Rural to urban migration will occur if a person is willing to exchange lower risk for higher risk now, but lower risk later. Katz and Stark (1986) dismiss this explanation because it imposes narrow bounds on the time discount factor.

In Stark and Lehvari (1982), it is presented that the EIH does not include risk or risk aversion in its modelling. When faced with the fact that some migration could occur with lower expected income in the urban areas, the EIH answers with an intertemporal utility function such that future urban expected income is going to be high so as to compensate for initial lower expected income. All of this does not include risk or variability. They sustain that expected income is a positive factor for migration, while risk is negative (i.e. migrants derive utility from income, and disutility from risk). If expected incomes are equal in the rural and the urban sector, and even with high risk in the urban sector, migration can occur so as to minimize risk. It is no longer a process of expected income maximization but one of risk aversion.

Stark and Lehvari (1982) therefore suggest that by perfecting or creating a rural insurance market, migration from the rural to the urban sector could decrease. This is the case in the production of coca, which, as an illegal activity presents a high risk, but is ironically less risky than the production of other crops, as credit is more readily available to the farmer, because the drug traffickers make credit readily available to the coca growers, and reducing the uncertainty of the final crop. It can be seen, then, how the process of migration of peasants to the urban sector and the coca region is more a result of risk aversion than of risk loving.

There is a growing tendency in the economic literature to shift the focus of attention from the individual to the family as the most relevant economic agent. References to this can be found at the theoretical level in Kotlikoff and Spivak (1981), and empirically in migration and remittance issues by Lucas and Stark (1985). According to this approach then, migration by the individual will then diversify the income of the family and will, by that reason, diminish the overall risk.

Katz and Stark (1986) offer the following alternative for a model that includes the family as the unit of analysis: 1) The head of the family is the only authority. And, 2) a cooperative arrangement between the family and the migrant is established for a number of purposes: Tipically these are to trade in risks and establish coinsurance arrangements. Devices must also be set to handle principal agent and moral hazard problems. For example, the migrant sometimes may understate his success in the urban areas, or increase his standard of living in order to increase his surplus. If there is migration by 2 or more family members, problems of coalition formation may arise.

Models of migration using the portfolio analysis have been suggested by Stark and Bloom (1985) and Stark (1991). A simple model developed in order to explain the process of labor supply allocation, from the perspective of a utility maximizing and risk averse peasant family, is presented in Revilla (1992). The migration process takes place from the rural (agricultural) sector to the urban (industrial) sector and to the coca sector. The decision making unit is the family and not the individual because the peasant family is the unit of production in agriculture. It is also the family that makes the decisions as to what to produce or where individual members must go. These decisions are made in the interest of increasing the earnings of the whole family or diminishing the risk associated with only one economic activity such as agriculture. In this model, it is explained how a utility maximizing family with a risk averse utility function will decide on migration patterns, by allocating family members to different sectors. Considered here will be expected earning differentials, as well as the risk structure of each particular sector.

5. Empirical Testing of Labor Migration to the Coca Region

According to a very general portfolio specification, migration to the coca region will be analyzed not only as a function of income differentials, but also as a function of the general perception of risk attached to the alternative regions targeted for migration.[10]

A portfolio approach suggest that there are two sets of variables: expected earnings (Z_i), and variances of the earnings (σ_i^2) in the two sectors of the economy. In general we can define the allocation of labor destined to the coca sector, with the following non-functional form:

$$L = f\ [\ (Z_1 - Z_2)\ ,\ \sigma_i\ ] \qquad (1)$$

for $i = 1,2$

From this reduced form equation, it should be expected that the effect of the changes on incomes and risks on labor allocated to the coca region (the signs of the partial derivatives) will be as follows: $\partial L/\partial Z_1 > 0$, $\partial L/\partial Z_2 < 0$, (and $\partial L/\partial (Z_1 - Z_2) > 0$) on the expected income side, and $\partial L/\partial \sigma_1 < 0$, and $\partial L/\partial \sigma_2 > 0$, on the risk side.

We will use an aggregate measure: the total labor allocated to the coca sector in the Upper Huallaga Valley (where most of the Peruvian coca is grown and most of the coca paste is manufactured). This variable is derived from estimates of the amount of land assigned to coca cultivation in the Upper Huallaga

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[10] For a more detailed presentation of a simple portfolio model of migration, see Revilla (1992). Portfolio models were originally developed by Tobin (1958), Sharpe (1964), and Merton (1973). An empirical test is suggested by Fama and MacBeth (1973).

Valley. A quarterly time series from 1980 to 1990 is then generated. For an explanation of the assumptions used, the sources, and the series, see Appendices 1 and 2. Figure 1 shows the evolution of labor supply in the coca fields.

FIGURE 1

On the right hand side of the equation to be estimated, the first variable to be considered is expected labor earnings differentials. The variable to be used is the difference between the average wage income in the Upper Huallaga Valley and the minimum wage in Lima.[11] These wages are measured at constant prices of 1979 in thousands of Intis. For a more detailed description of these two series, see Appendices 1 and 2. Figure 2 shows the difference between the daily wage in the coca region and the minimum wage in Lima.

FIGURE 2

The second set of variables on the right hand side of the equation to be estimated is related to risk measurement. Given that we do not have measures for the distribution of earnings on a quarterly basis, we must rely on alternative or proxy measures of risk to observe the variances of expected income.[12] To obtain

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[11] In the calculation of wages for the Upper Huallaga valley, when meals has been used as partial payment, its approximate value has been included.

[12] It should be noted that the variance is not always the best measurement of risk. This can be shown for many utility functions in which a reduction in variance, keeping the expected income constant, does not necessarily correspond to an increase in expected utility, therefore, making the variance not a good indicator for risk. However, if the utility function is quadratic, or the distribution function of income is fully described by its mean and variance, the variance is still

proxies for the true measure of risk, probably the most difficult variable to observe, we consider two different variables. The first is unemployment in the urban sector. This variable has been traditionally used as a risk variable in migration models. The variable used is the inverse of the one represented in Figure 3 as the index of employment in Lima's petty trader sector.

FIGURE 3

The second variable is an index of violent acts (mostly political) in the different regions. We believe that violence, given the current political situation in Peru, is a good proxy for risk and uncertainty in the economy as a whole, as well as in the two specific sectors: Lima and the coca sector in the Upper Huallaga Valley.[13]

Figures 4 and 5 show the number of violent acts in the coca region and in the province of Lima for each quarter since 1980.

FIGURES 4 AND 5

5.1. Estimation with Risk in the Urban Sector

Our objective in this section is to look at the effect of income differentials, violence in the urban sector, and unemployment in the urban sector with respect to labor allocated to the coca sector. Given the previous data, the equation that we will test is the following:

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monotonically decreasing in utility. See Newbery and Stiglitz (1981), pp. 76-77.

[13] The numbers used for both variables and how were they obtained is discussed in the Appendices 3 and 4.

$$LCO_t = C + \beta_1 \, LWD_t + \beta_2 \, LVL_t + \beta_3 \, LUN_t + \mu_t \qquad (2)$$

Where:

LCO_t is the dependent variable and is equal to the natural logarithm of the total labor supply allocated to the coca sector in the period t.

C is the intercept.

LWD_t is the natural logarithm of the differential of wages paid to coca peasants in the Upper Huallaga Valley and the minimum wage paid to unskilled workers in the urban sector.

LVL_t is a proxy for risk in the urban sector, and the level of political violence is equal to the natural logarithm of the number of violent acts in the Province of Lima.

LUN_t is the natural logarithm of the inverse of the employment index for the petty trader sector in Lima.

μ_t is a randomly distributed random error.

When we run the regressions under OLS, we assume two patterns of behavior. The first regression takes the data "as is", that is, as the original data with no correction for seasonality. The second regression includes dummy variables to control for seasonality of the series. The results are shown in the first two columns of table 1.

We found no significant differences between the estimates of the two specifications of the model (with and without dummies for seasonality), although the presence of seasonality seems significant and produces a slightly better fit. In both cases, with almost the same estimates, wage differentials and risk factors such as violence and unemployment prove to be statistically significantly different from 0. The signs are positive as expected, with a greater elasticity of 3.1 for unemployment in the urban sector, 0.65 for the wage differential, and 0.25 for violence in the urban sector.

Due to the low Durbin-Watson statistics, we can see a problem of positive first order serial correlation of the residuals. This is further pointed out by the Box-Pierce Q-

Statistic.[14] The high values of the Box-Pierce Q-Statistic for the specifications in the first two columns of the table 1 make us reject the null hypothesis of no serial correlation of the residuals.

There are several reasons why the error terms are autocorrelated. The first is that the model is not completely specified, that is, some explanatory variables are not included. This can be especially true given the general difficulty of measuring risk as an economic variable, particularly in the case of the coca economy. The second reason can be a misspecification of the equation to be tested. This is relevant to our case because our reduced equation model is very general. Even if we were testing the original formulation of the portfolio relationship, assuming an explicit risk averse utility function, we should test the validity of such a function. The third source for serial correlation of the errors is the possibility of a measurement error in the dependent variable. This can also be relevant to our case. In fact, our model may suffer from each of these problems.

There are different techniques to correct for serial correlation of residuals. By looking at the autocorrelation and partial autocorrelation tables of the Box-Jenkins identification procedure, we find that a Moving Average (MA) process can best explain the serial correlation of the residuals. This procedure shows the values of total and partial autocorrelation of the residual, and allows us to see the specific autoregressive or moving average specification to be tested for the residuals.

In order to correct the problems of serial correlation of residuals, we use a generalized least squares estimation procedure, including the moving averages of the residuals. This

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[14] The Box-Pierce Q statistic is a test for the different autocorrelations of the residuals, for a number of lags (M). If all the autocorrelations are zero, then the error term of the model is called "white noise". This statistic is distributed as a chi-square with degrees of freedom equal to M minus the number of parameters of the model. In all the tables presented in this paper, the Box-Pierce Q statistic uses 20 as the number of lags to measure (i.e. M = 20).

procedure is asymptotically equivalent to a maximum likelihood estimation.

In this case, we will again include one estimation with the dummies for seasonality and one without. The results of both estimations are shown in the third and fourth columns of table 1.

The results are not significantly different from those of the OLS estimation, all coefficients are significantly different from zero, and they do not show a problem of serial correlation in the residuals. This is shown both in the Durbin Watson close to 2 and a Box-Pierce Q-Statistic of 9.47 and 8.76, for the non-seasonal and for seasonally adjusted data, respectively. This means we should not reject the null-hypothesis of non serial correlation of the residuals with a probability of 0.98 and 0.99, respectively.

The use of MA(1), MA(2), MA(3) and MA(4) is consistent with the fact that the dependent variable is explained by a fourth order moving average process. This in turn can be explained by the seasonality of the series.[15] The results of this estimation for most of the variables are very similar with those in which we do not include dummies for seasonality.

TABLE 1

All of these results seem to be consistent with the assumptions of a positive relationship between labor supply allocation on the one hand, and both wage differentials between the coca and the urban sector, and risk variables in the urban sector, on the other. No significant difference comes from the

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[15] This is equivalent to a moving average process of 4th order. A moving average process of nth order, includes the (n-1)th previous moving averages. But in the estimation process used, an nth moving average (MA(n)) only includes the nth moving average. This allows more flexibility in order to choose a more precise specification in case an intermediate moving average is not relevant.

use of dummies for the seasonal components in terms of the estimators or their significance.

It may seem that these estimates are robust, but the fact that in the urban sector unemployment and violence have been growing, while real wages have been falling can also be a explained by a major change in the Peruvian economy. In order to control for these effects, a time trend is used as a proxy for other factors that can influence the growth of the coca sector. For most of the 1980s, the Peruvian economy was stagnant. This stagnation can help explain the growth of the coca economy. By using a time trend, we are not only trying to understand how much of the dependent variable is explained by the trend, but also how much is explained by variables that are independent of the trend. Thus in table 2, we test the same specifications as before, but add a time trend as an explanatory variable.

TABLE 2

When we include the time trend in this specification of the regression, the variables behave similarly, with the exception of unemployment. This loses statistical significance, or even becomes negative, suggesting that the estimate for unemployment is not a robust estimator. The values of the elasticities estimated for wage differential and violence in the urban sector remain with a positive sign (although the parameters are smaller by one half as compared to those of table 1), and are still statistically significant. The time trend seems to be statistically significant, but a parameter of 0.05 implies that a change in the time trend only affects the labor supply to the coca sector with a 5 percent change.

One of the measurements of risk in the urban sector, the variable of unemployment, can also be an endogenous variable, even though it has been included as exogenous. This is because we specify that unemployment in the urban sector affects the labor supply to the coca sector, but it is also likely that labor supply to the coca sector affects unemployment in the urban sector. In order to solve for this simultaneous equation problem, we use a 2SLS procedure, in which we use the index of industrial production in Lima as an instrument for unemployment in the urban petty trader sector in Lima. This is done because industrial production in Lima is correlated with employment in Lima, but not with employment in the coca sector. Figure 6 shows the evolution of the Peruvian industrial output from 1980 to 1990.

FIGURE 6

The results of the different 2SLS estimations are presented in table 3. The first column is a 2SLS estimation where no seasonality correction is used. The second column includes seasonal dummies for the same estimation. The third column has no seasonality correction but corrects for serial correlation of the residuals with a fourth order moving average process. Finally, the fourth column includes the moving average representation of a fourth order, as well as the dummies for seasonality. Table 4 presents a similar estimation, but it includes a time trend.

TABLES 3 AND 4

The results of the two 2SLS estimations are similar to those of the previous estimations. Again, the generalized least squares estimation considering the moving average process solves for serial correlation of the residuals. In table 3, the Box-Pierce Q-Statistic for the third and fourth columns (without and with seasonal dummies) supports the null hypothesis of non-serial correlation of the errors with probability of 0.99 in both cases. Including the trend, in table 4, a first and fourth order moving average process for the non-seasonally adjusted regression do not reject the null hypothesis of no serial correlation of the errors. The inclusion of the seasonal dummies and a complete fourth order moving average process changes the probability of no serial correlation of the errors to 0.99.

In both cases (with and without a time trend) the estimates of the parameters for wage differentials and violence in the urban sector are positive and statistically significant. The estimates for the parameter on urban unemployment is not statistically significant.

The different estimations of this model of labor supply allocation to the coca sector tend to show that income differentials are important in affecting the size of labor supply to the coca sector, with an elasticity of approximately 0.6, or 0.3 if we include a time trend. The level of political violence in the urban sector (represented by the province of Lima) is also significant, with elasticities of approximately 0.2 and 0.1 respectively. Finally, the risk of being unemployed in the urban sector seems to play an inconclusive role, given that the high elasticity (greater than 3) shown in the first estimations loses statistical significance if we introduce a time trend. The 2SLS estimation (even with no time trend) shows a relatively low statistical power for urban unemployment.

In order to look at a more complete specification of the risk variables for both urban and coca sectors, we next use indicators of political violence simultaneously for both sectors.

5.2. Estimation of a Log-Linear Model with Income and Risk in Both Sectors

Here we present see a different specification of the model, where instead of concentrating on the urban sector as the only source of risk, we will test a more complete model where both sectors have an expected income and a variable that indicates risk. The risk variables will be represented by political violence in Lima and in the Upper Huallaga Valley.

In this estimation, we test the model as presented in equation (1), assuming as in the previous sub-section a log-linear specification of the variables.

$$LCO_t = C + \beta_1 LWD_t + \beta_2 LVL_t + \beta_3 LVC_t + \mu_t \quad (3)$$

Where LCO, LWD and LVL are defined as before, and

LVC is the proxy for risk in the coca sector (represented by the level of political violence in the coca region, the Upper Huallaga Valley), and is equal to the natural logarithm of the number of violent acts in the Departments of Huánuco and San Martín.

The results of the estimation, using OLS and the correction for serial correlation of the errors by a moving average specification, is presented in table 5. As in the first model estimated, we present the estimations with and without the inclusion of dummies for seasonality, in the first and second columns. The third and fourth columns use a fourth order moving average of the residuals to estimate the parameters, in order to solve for serial correlation of the residuals.

TABLE 5

Looking at these estimates, we see that the estimate of the elasticity for wage differential is close to 0.5 and is statistically significant. That is, an increase of 10 percent in wage differentials increases the labor allocated to the coca sector by 5 percent. The estimates for the elasticities of risk (i.e. political violence) are 0.16 and 0.21 for the coca region and the urban sector respectively. The value for the urban sector is positive as predicted by the model, but the elasticity of violence in the coca region should have had the opposite sign.

In order to see how much of this effect can be attributed to a general trend in the Peruvian economy, we examine the effect of introducing a trend factor on labor allocation to the coca region. A trend variable is useful because most of the changes in the Peruvian economy are related to the general stagnation of the 1980s. At the same time that migration to the coca economy was constantly growing during the 1980s, political violence was growing in the urban sector as well as in the coca region (and the rural sector in general). Labor allocation to the coca region can be explained by this general trend because, among other reasons, wages in the urban sector eroded as unemployment grew. Political violence can be interpreted as one more sign of the general stagnation of the economy.

In table 6, we run regressions with the same specifications as those of table 5, but now using a time trend variable.

TABLE 6

Table 6 shows that the time trend is statistically significant.[16] As before, the estimate of the elasticity parameter for the wage differential is statistically significant and positive. Regarding the risk variables, violence in the coca region now shows a negative value of -0.06 and is also significant. This is because the trend is no longer an element in the formation of this and other right hand side variables but is considered by itself. The parameter for violence in the urban sector is still significant, but now is equal to 0.10.

One of the main assumptions used to justify the use of a time trend is that the Peruvian economy was either stagnant or contracting during most of the 1980s. As we can see from table 7, there are at least two years in which this was not true, in 1986 and 1987. This was mostly due to the heterodox economic policy of the Alan García administration, during which aggregate

[16] A null coefficient test on the third and fourth regressions of table 6 in comparison to those of table 5, gives very high values of a Chi square, with the probability of that estimate being null extremely close to 0. We can then say that the time trend seems to be a significant variable in this estimation.

demand increased significantly. In order to allow for this we will include a dummy for these two years of high growth. The results are shown in table 8.

TABLES 7 AND 8

With the inclusion of the dummy variable for the two years of the heterodox experience, the results are consistent with those found in the previous estimations, and even more significant. Not only is this dummy variable statistically significant, but the inclusion of this dummy generates a "better fit" estimation. This is shown by the higher t statistics for most of the variables.

In general, this log linear specification is a more complete specification of the model than the previous one, and seems to be more adequate to explain the allocation of labor to the coca sector as a function of income differentials and specific risks. It has, however, the problem of being restrictive in the parameters. By assuming a log linear specification, we are imposing a set of restrictions that our original model, developed in Section Five, did not have. In order to see if this model can be improved by looking at the interaction between the different variables, we will allow for a different specification.

5.3. Estimation of a Translog Specification

A more general specification for the model is given by a translog function of the natural logarithm of the labor supply allocated to the coca sector (LCO). The translog function imposes the least amount of restrictions on the relations between the variables, and is considered to be the a good approximation of an arbitrary function.[17]

In the case of labor allocated to the coca sector as a function of income differentials and risk variables in both sectors, the translog function is given by:

$$LCO = \beta_0 + \sum_{i=1}^{3} \beta_i \ln x_i + 1/2 \sum_{i=1}^{3} \sum_{j=1}^{3} \beta_{ij} \ln x_i \ln x_j \qquad (4)$$

Where ln x_1 is the natural logarithm of the wage differential (LWD), x_2 is the natural logarithm of risk in the coca sector, or the number of violent acts (LVC), and x_3 is the natural logarithm of the equivalent variable for the urban sector (LVL).

When i=j, we get the squares of the logarithms of the original functions. The equation to be estimated is the following:

$$\begin{aligned} LCO_t = {} & C + \beta_1 LWD_t + \beta_2 LVL_t + \beta_3 LVC_t + \beta_{1,1} (LWD)^2_t \\ & + \beta_{2,2} (LVL)^2_t + \beta_{3,3} (LVC)^2_t + \beta_{1,2} (LWD)(LVL)_t \\ & + \beta_{1,3} (LWD)(LVC)_t + \beta_{2,3} (LVL)(LVC)_t + \mu_t \qquad (5) \end{aligned}$$

By using a translog specification, we are not only allowing for a more unrestricted version of the model, but we can also see the different relationships between the variables included in the model. The results of different estimations of equation (5) are shown in table 9.

TABLE 9

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[17] The translog function (defined usually for a cost function), is a good second order Taylor approximation of an arbitrary cost function.

As in the other specifications of the model, the OLS estimations seem to have serial correlation of the errors, and we use the Box-Jenkins identification procedure to find the best specification to correct for autocorrelation. In this case, a second order moving average process seems to be the best procedure, as seen by the low values of the Box-Pierce statistic.

The estimates of the coefficients for the translog specification, when corrected for autocorrelation of the errors and with no seasonal adjustment, are similar to those with dummies for seasonality, but also show higher statistical significance. Furthermore, seasonality does not seem significant according to the values for the t statistics. Our comments will therefore be based on the GLS estimates presented in the third column of table 9. The estimated coefficients found in the following equation:

$$LCO_t = 10.75 + 2.00\ LWD_t + 0.68\ LVL_t - 1.02\ LVC_t + 0.43\ (LWD)^2_t - 0.08\ (LVL)^2_t + 0.17\ (LVC)^2_t - 0.77\ (LWD)(LVC)_t \qquad (6)$$

Now the elasticities are not constant, as in the log linear case, but are functions that can change when other variables change. Each elasticity represented below measures the relative change in labor allocated to the coca sector (LCO), when there is a relative change in any three of the variables (LWD, LVC, LVL).

The elasticities shown in the functions below (using the partial derivatives of the dependent variable LCO with respect to the independent variables LWD, LVC, and LVL)[18] will take into consideration only the estimates of the coefficients that are statistically significant. Beginning with the wage differential,

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[18] By using the partial derivatives and not the total derivatives as the definition of elasticity implies, we are assuming that LWD, LVC and LVL independent variables or exogenous to each other.

elasticity of labor supply to the coca sector is represented by equation (7):

$$\epsilon_{wd} = 2.00 + 0.43\ (LWD) - 0.77\ (LVC) \quad (7)$$

The translog specification shows that the constant term of the elasticity of labor supply with respect to the wage differential is 2.00, and the value for the coefficient of $(LWD)^2$ is 0.43. This means that the function that relates LWD to LCO is not only increasing but also convex, such that the higher the level of the wage differential, the higher the increase in labor supply. In other words, the elasticity of LCO with respect to LWD will be higher at higher levels of LWD. This means that labor migration to the coca region will not only increase, but increase at higher rates the higher the wage differential, or that an increase in wage differentials will increase the value of the elasticity of labor supply with respect to wage differentials.

The coefficient of LVC in equation (7) shows that an increase in violence in the coca sector will diminish the value of the total elasticity. That is, the response of labor supply to a change in wage differential will be less by a constant value determined by the coefficient of (LWD)(LVC) in equation (6). It should be noted that the greater effect at higher levels of the wage differential means that the intercept (in an LCO LWD space) has not changed, but that the rate at which labor supply grows due to the wage differential has been reduced as violence increases.

The value for the elasticity of labor supply allocation to the coca sector with respect to the risk variable LVC (political violence) in the coca region is given by (8):

$$\epsilon_{vc} = -1.02 + 0.17\ (LVC) - 0.77\ (LWD) \quad (8)$$

The estimate for the coefficient of the logarithm of violence in the coca being equal to one, implies a negative unit elastic term of the elasticity of labor supply with respect to violence in the coca region. This means that as violence in the coca region increases, labor supply will decrease at the same rate. Also, the value for the coefficient of $(LVC)^2$ of 0.17, shows that as the level of violence increases, the absolute value of this elasticity decreases. In other words, the effect of additional violence as a deterrent to additional migration becomes less and less important as the level of absolute violence increases. The negative value of the elasticity of labor supply to the coca region with respect to violence in the coca region becomes smaller, in absolute terms. This result could be explained in psychological terms by the idea that some reported violence is frightening, but more reports of violence are merely numbing.

The negative coefficient of -0.77 for the LWD variable in equation (8) shows that an increase in the wage differential decreases the absolute value of the effect of coca sector violence on labor migration to that sector. For a given level of violence in the coca region, greater wage differentials decrease the elasticity of labor migration. Although this result seems counter-intuitive, a possible explanation is that at increasing levels of wage differentials (when workers become richer) the perception of risk attached to violence in the coca region is more significant, and that the negative response to violence in the coca sector becomes larger.

Finally, the elasticity measure of the effect of the level of violence in the urban region on the allocation of labor to the coca sector is given by (9):

$$\epsilon_{vl} = 0.68 - 0.08\ (LVL) \qquad (9)$$

As expected, the effect of violence in the urban sector (Lima) on the migration of labor to the coca region is positive. The value of the constant term of the elasticity estimated is 0.68, and the coefficient for $(LVL)^2$ is -0.08. This means that the effect of Lima political violence on the labor migration to the coca fields decreases at higher levels of violence.

The translog specification gives us more information in terms of the reduced form of the original model. The log linear specification was too restrictive by not considering change in the estimates as the variables of the model changed. In fact, a test of null coefficients seems to support the translog model as compared to the log linear model.[19]

5.4. Stationarity of the series

In order to determine if it is better to use a time trend or take the nth differences of the variables in the regression, we must look at the stationarity of these series. If the series are shown to be stationary, and if we run a regression in levels (that is the variables taken as they are) the estimators will still be valid from the point of view of the inference procedures used in regression. If the series are non stationary, the variables must be differenced to obtain unbiased estimators.

A variable in a time series is defined as weakly stationary if it has finite mean, variance and covariances, and all of them are independent of time. More rigorously, a disturbance term ϵ_t in a regression is said to be a stationary stochastic process if, for any value of t, ϵ_t has a zero mean, a constant variance, and is uncorrelated with any other variable in the sequence.[20]

Stationarity is important because it is the basic assumption for the standard inference procedures of regression models. If a series is non-stationary it invalidates many standard results of the regression. A non-stationary series is reflected in the presence of a unit root, and if a series must be differenced d

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[19] The Chi square value, testing the null hypothesis of significance the added variables on the translog specification of the second column of table 9 as compared to the log linear model of the second column of table 6, is 25.58. Thus the probability of not rejecting the null hypothesis of the added coefficients being equal to zero, is almost equal to zero. That is, the new translog specification seems to be an improvement over the log linear one.

[20] See Harvey (1991), pp. 23-30.

times to make it stationary, it is called integrated of order d. The test for stationarity of a series is the unit root test.

In this analysis, we use the simple model of equation (3) to test for stationarity. In table 10 the variables of the equation (3) are tested for unit roots.

TABLE 10

From the results obtained in table 10 we can establish that most series fail to reject the hypothesis of presence of unit roots.[21] According to this test, if the regression uses levels and not first differences, the estimators will still be valid according to the statistical procedures used in the regression. But in order to see if it is still possible to use the variables at their levels as opposed to using their first differences we must test to see if these variables are cointegrated.

If series are non-stationary and integrated of order one, their linear combination will also be integrated of order one. Therefore, if the variable represented by the residuals (a linear combination of the series that are regressed) of the regression of these variables has a unit root its variance will explode. But if the regression between any variables is to make any sense, the residuals of the regression cannot be a linear combination of the series regressed, that is, they must reject the presence of unit roots (and be stationary). If the residuals are stationary, the variables are said to be cointegrated. In general, the variables are cointegrated if each one individually is non stationary (has unit roots) but a linear combination of the variables (that is the residual of the regression among the variables) is stationary.

[21] We have also tested for unit roots of the first differences of the levels of the variables, we rejected the presence of unit roots, therefore establishing that the original series were integrated of order one.

In table 11 we test for cointegration of the variables of equation (3). The left hand side series (LCO) is regressed on the remaining series (LWD, LVC, LVL, ALAN), a constant, and a trend variable.

TABLE 11

The results of the cointegration tests show that the series are cointegrated. The regression analysis done in levels is therefore validated, and the properties of the estimators found are valid.

5.5. <u>Stability of the Results</u>

Another problem found in time series is the sensitivity of the parameters to changes in the time structure of the series. That is, we want to know if the parameters are constant through time. Again, by using the regression based on equation (3), we will test for the stability of the results by dropping the last four, eight and twelve quarters.

The results of this exercise are presented in tables 12 and 13. Table 12 includes the dummy variable for the two years of the heterodox experience, and table 13 does not. The year listed at the top of each column (i.e. 1988) is the last year included in the regression.

TABLES 12 AND 13

The results of these stability tests are in favor of the regression postulated. Looking at table 12 in which a more complete specification is presented, the three variables LWD, LVC and LVL not only maintain the same sign and are statistically significant in the four cases tested, but have relatively stable parameters. The only exception to this case is the regression ending in 1988, in which LWD and LVC lose significance and all the parameters are smaller. It is interesting to note that the results (both in the size of the parameters and the statistical significance) of the "complete" regression ending in 1990 are very similar to those of the regression ending in 1987.

The results presented in table 13 show that the main conclusions are still valid. The value of the parameters does not change significantly with the length of the time period chosen, although the problem of the regression ending with 1988 persists, and the size and statistical significance of LVC seems to decrease as the length of the time period decreases.

Given the problem of low degrees of freedom as the time period decreases, we can say that the results are relatively stable through time.

6. Conclusions

The growth of the coca economy, as seen by the increase in illegal coca exports, the number of migrants to the Upper Huallaga Valley, and the persistence of relatively high wages in the midst of an stagnant economy, has been one of the most significant economic phenomena of the Peruvian economy during the last decade.

A portfolio model applied to the migration decision process of a peasant family suggests that not only the expected utility maximizing individuals of a family unit would migrate according to expected earnings considerations, but also that as instability in the urban sector increases, an increase in the migration flow to the coca sector would result. At the same time, an increase in the risk attached to the coca sector would negatively affect migration to that sector.

Using different variables and specifications, in order to see their relative explanatory power, the empirical testing of migration to the coca sector produced suggestive results.

The empirical estimation of a log-linear specification shows that earning differentials are important in affecting the amount of labor allocated to the coca sector. Political violence in the urban sector also has a positive effect in the growth of labor on the coca fields, while violence in the coca region has a negative effect. Unemployment in the urban sector shows an inconclusive effect on migration to the coca sector. The variables used, although they seem to have non-stationary properties, are cointegrated and therefore validate standard inference procedures. A simple test of stability of the parameters shows that they do not change significantly through time.

With a more general (translog) specification, it is not only shown that the wage differentials between the coca and urban sectors have a positive effect on labor migration to the coca sector, but it is also shown that the higher the level of wage differential, the higher the response of migration to changes in wage differentials. In relation to the risk variables, it is shown that: on the one hand, the effect of violence in the coca sector as a deterrent to migration is negative, but becomes less important as the level of violence increases; on the other hand, the level of violence in the urban sector has a positive effect on migration to the coca sector, but this effect decreases when the level of violence in the urban sector increases.

TABLE 1

FIRST ESTIMATION OF EQUATION (2)

	OLS	OLS (S. Adj.)	GLS	GLS (S. Adj.)
Constant	10.22 (67.81)	10.07 (63.84)	10.38 (78.08)	10.24 (85.52)
LWD	0.66 (8.03)	0.64 (8.03)	0.58 (8.92)	0.57 (9.75)
LVL	0.24 (6.19)	0.26 (6.74)	0.19 (5.30)	0.20 (6.56)
LUN	3.07 (7.16)	3.09 (7.47)	3.56 (9.63)	3.87 (11.85)
D1		0.17 (2.07)		0.17 (2.81)
D2		0.12 (1.51)		0.13 (2.23)
D3		0.01 (0.06)		0.03 (0.43)
MA(1)			0.45 (2.66)	0.68 (3.93)
MA(2)			0.28 (1.76)	0.73 (3.73)
MA(3)			0.44 (2.73)	0.47 (2.32)
MA(4)			0.44 (2.96)	0.11 (0.62)
Adj. R2	0.94	0.95	0.96	0.97
D. W. Stat.	1.02	0.86	1.75	1.89
B-P Q Stat.	47.73	66.29	9.47	8.76

N = 44

t values are in parenthesis

TABLE 2

SECOND ESTIMATION OF EQUATION (2)

	OLS	OLS (S. Adj.)	GLS	GLS (S. Adj.)
Constant	9.98 (97.80)	9.89 (94.92)	10.08 (138.79)	9.93 (135.05)
LWD	0.31 (4.46)	0.31 (4.67)	0.27 (5.84)	0.25 (5.28)
LVL	0.10 (3.03)	0.11 (3.43)	0.05 (2.34)	0.09 (3.75)
LUN	-0.97 (-1.62)	-0.76 (-1.29)	-0.84 (-2.13)	0.003 (0.006)
TREND	0.05 (7.59)	0.05 (7.33)	0.05 (11.88)	0.05 (10.13)
D1		0.10 (1.89)		0.11 (2.98)
D2		0.11 (2.23)		0.13 (3.74)
D3		0.03 (0.64)		0.05 (1.49)
MA(1)			0.98 (12.42)	0.96 (5.33)
MA(2)			0.13 (1.14)	0.82 (3.53)
MA(3)				0.38 (1.73)
MA(4)			0.45 (6.29)	0.10 (0.59)
Adj. R2	0.97	0.98	0.99	0.99
D. W. Stat	0.88	0.71	1.84	1.97
B-P Q Stat	62.96	76.07	22.46	9.69

N = 44

t values are in parenthesis

TABLE 3

THIRD ESTIMATION OF EQUATION (2)

	2SLS	2SLS (S. Adj.)	2SLS (GLS)	2SLS (S. Adj.) (GLS)
Constant	9.93 (26.81)	9.79 (24.18)	10.41 (47.40)	10.23 (60.32)
LWD	0.88 (3.68)	0.88 (3.46)	0.65 (5.54)	0.61 (5.78)
LVL	0.43 (2.54)	0.47 (2.62)	0.22 (2.22)	0.23 (2.91)
LUN	-1.24 (-0.34)	-1.79 (-0.47)	2.36 (1.19)	2.80 (1.69)
D1		0.12 (0.65)		0.15 (2.27)
D2		0.05 (0.25)		(0.12) (1.65)
D3		-0.09 (-0.47)		0.02 (0.21)
MA(1)			0.40 (2.17)	0.58 (2.81)
MA(2)			0.16 (0.87)	0.60 (2.50)
MA(3)			0.36 (2.04)	0.37 (1.53)
MA(4)			0.44 (2.80)	0.10 (0.48)
Adj. R2	0.78	0.72	0.96	0.96
D. W. Stat	0.76	0.67	1.73	1.87
B-P Q Stat	31.15	36.11	5.08	4.78

N = 44

t values are in parenthesis

TABLE 4

FOURTH ESTIMATION OF EQUATION (2)

	2SLS	2SLS (S. Adj.)	2SLS (GLS)	2SLS (S. Adj.) (GLS)
Constant	9.45 (17.42)	9.47 (22.04)	10.03 (70.37)	10.11 (71.32)
LWD	-0.18 (-0.38)	-0.18 (-0.43)	0.25 (2.00)	0.38 (2.82)
LVL	-0.08 (-0.43)	-0.09 (-0.49)	0.06 (1.27)	0.12 (2.20)
LUN	-9.61 (-1.21)	-9.49 (-1.38)	-1.28 (-0.61)	2.38 (1.06)
TREND	0.13 (1.72)	0.13 (1.96)	0.05 (2.71)	0.02 (1.05)
D1		-0.48 (0.23)		0.14 (2.45)
D2		0.08 (0.54)		0.13 (2.92)
D3		0.05 (0.36)		0.04 (0.97)
MA(1)			0.86 (54.03)	0.83 (5.42)
MA(2)				0.80 (5.00)
MA(3)				0.49 (2.96)
MA(4)			0.52 (36.19)	0.14 (1.05)
Adj. R2	0.83	0.83	0.99	0.98
D. W. Stat	0.41	0.37	1.63	1.77
B-P Q Stat	104.72	110.54	24.75	8.73

N = 44
t values are in parenthesis

TABLE 5

FIRST ESTIMATION OF EQUATION (3)

	OLS	OLS (S. Adj.)	GLS	GLS (S. Adj.)
Constant	10.01	9.92	10.29	10.18
	(54.12)	(48.17)	(57.09)	(51.44)
LWD	0.45	0.45	0.46	0.50
	(3.50)	(3.41)	(3.76)	(3.96)
LVC	0.26	0.25	0.16	0.16
	(4.29)	(4.04)	(2.75)	(2.72)
LVL	0.23	0.25	0.21	0.23
	(4.16)	(4.28)	(4.04)	(4.27)
D1		0.09		0.09
		(0.86)		(0.87)
D2		0.08		0.09
		(0.76)		(0.93)
D3		-0.03		-0.02
		(-0.33)		(-0.22)
MA(1)			0.50	0.50
			(2.61)	(2.46)
MA(2)			0.46	0.62
			(2.47)	(3.13)
MA(3)			0.43	0.47
			(2.32)	(2.37)
MA(4)			0.22	0.13
			(1.13)	(0.64)
Adj. R2	0.90	0.90	0.91	0.91
D. W. Stat	1.41	1.38	1.91	1.91
B-P Q Stat	24.29	25.19	11.65	9.31

N = 44

t values are in parenthesis

TABLE 6

SECOND ESTIMATION OF EQUATION (3)

	OLS	OLS (S. Adj.)	GLS	GLS (S. Adj.)
Constant	10.04 (104.03)	9.93 (100.00)	10.14 (139.57)	10.02 (128.62)
LWD	0.40 (5.92)	0.40 (6.24)	0.36 (7.40)	0.31 (6.65)
LVC	-0.05 (-1.24)	-0.06 (-1.54)	-0.05 (-1.73)	-0.06 (-1.92)
LVL	0.12 (4.02)	0.14 (4.59)	0.08 (3.42)	0.10 (4.34)
TREND	0.04 (10.40)	0.04 (11.10)	0.05 (14.44)	0.05 (15.33)
D1		0.12 (2.33)		0.10 (2.65)
D2		0.12 (2.38)		0.09 (2.14)
D3		0.04 (0.69)		0.01 (0.31)
MA(1)			0.85 (5.11)	0.96 (4.81)
MA(2)			-0.01 (-0.04)	0.68 (2.70)
MA(3)			0.09 (0.70)	0.31 (1.61)
MA(4)			0.53 (3.51)	0.09 (0.65)
Adj. R2	0.98	0.98	0.99	0.99
D. W. Stat	0.93	0.71	1.80	1.99
B-P Q Stat	51.99	66.12	18.13	13.53

N = 44

t values are in parenthesis

TABLE 7

RATES OF GROWTH OF THE PERUVIAN

GROSS DOMESTIC PRODUCT (1980 - 1990)

1980	5.40
1981	5.31
1982	0.08
1983	-13.22
1984	4.59
1985	1.69
1986	10.83
1987	9.72
1988	-7.36
1989	-12.35
1990	-2.35

SOURCE: Webb and Fernández Baca (1991), p. 362

TABLE 8

THIRD ESTIMATION OF EQUATION (3)

	OLS	OLS (S. Adj.)	GLS	GLS (S. Adj.)
Constant	10.06 (141.68)	9.96 (147.66)	10.08 (154.12)	10.01 (141.66)
LWD	0.35 (6.92)	0.35 (7.92)	0.35 (7.74)	0.36 (7.26)
LVC	-0.05 (-1.53)	-0.06 (-2.05)	-0.05 (-1.59)	-0.06 (-2.33)
LVL	0.09 (4.03)	0.10 (5.03)	0.10 (4.72)	0.08 (3.93)
TIME	0.05 (14.58)	0.05 (16.89)	0.04 (15.22)	0.05 (18.22)
ALAN	0.23 (5.85)	0.22 (6.59)	0.20 (6.02)	0.24 (6.02)
D1		0.11 (3.10)		0.12 (3.76)
D2		0.12 (3.49)		0.14 (4.31)
D3		0.04 (1.23)		0.05 (1.62)
MA(1)			0.03 (0.22)	0.38 (1.99)
MA(2)			-0.32 (-3.08)	0.27 (1.39)
MA(3)			0.35 (3.43)	-0.25 (-1.49)
MA(4)			0.73 (6.75)	-0.56 (-3.46)
Adj. R2	0.99	0.99	0.99	0.99
D. W. Stat	1.65	1.45	1.84	1.86
B-P Q Stat	26.75	13.19	9.90	7.15

N = 44
t values are in parenthesis

TABLE 9

ESTIMATION OF EQUATION (5)

	OLS	OLS (S. Adj.)	GLS	GLS (S. Adj.)
Constant	10.89	10.96	10.75	10.53
	(14.06)	(13.69)	(17.01)	(15.55)
LWD	1.99	2.38	2.00	1.76
	(1.51)	(1.72)	(1.83)	(1.49)
LVC	-0.99	-1.12	-1.02	-1.00
	(-1.79)	(-1.99)	(-2.18)	(-2.08)
LVL	0.36	0.37	0.68	0.61
	(1.32)	(1.30)	(2.86)	(2.46)
$(LWD)^2$	0.32	0.42	0.43	0.41
	(0.94)	(1.20)	(1.53)	(1.36)
$(LVC)^2$	0.09	0.08	0.17	0.14
	(0.85)	(0.74)	(1.90)	(1.48)
$(LVL)^2$	-0.04	-0.05	-0.08	-0.07
	(-0.70)	(-0.83)	(-1.51)	(-1.22)
(LWD)(LVC)	-0.42	-0.43	-0.77	-0.65
	(-1.76)	(-1.78)	(-3.74)	(-3.07)
(LWD)(LVL)	-0.08	-0.16	0.13	0.12
	(-0.23)	(-0.45)	(0.47)	(0.39)
(LVL)(LVC)	0.17	0.21	0.08	0.12
	(0.82)	(1.00)	(0.50)	(0.66)
D1		0.13		0.13
		(1.28)		(1.55)
D2		0.09		0.09
		(0.83)		(1.03)
D3		-0.01		-0.002
		(-0.18)		(-0.03)
MA(1)			0.76	0.47
			(4.55)	(2.66)
MA(2)			0.47	0.47
			(2.89)	(2.77)
Adj. R2	0.92	0.92	0.95	0.94
D. W. Stat	1.25	1.22	2.00	1.87
B-P Q Stat	29.57	32.51	7.49	6.97

N = 44

t values are in parenthesis

TABLE 10

TESTING FOR UNIT ROOTS

X	ADF(0)	ADF(1)	ADF(2)	ADF(3)	ADF(4)
LCO	-0.42	-0.56	2.27	1.11	-0.63
LWD	-0.30	-0.19	-0.37	-0.78	-0.29
LVC	-5.03	-3.14	-3.09	-2.81	-2.65
LVL	-5.12	-4.49	-2.85	-2.14	-1.81
R(LCO-A)	-2.49	-2.60	-2.37	-2.61	-2.91

Note: ADF(q), the augmented Dickey-Fuller test, is the t-statistic of the estimated value of ρ in the regression:

$$\Delta X_t = \text{CONSTANT} + \text{TREND} + \rho X_{t-1} + \sum_{i=1}^{q} X_{t-i}$$

R(LCO-A) are the residuals of the regression of LCO in the variable ALAN.

$$\Delta X_t = X_t - X_{t-1}$$

The critical values by MacKinnon are -3.52 for the 5% level and -3.19 for the 10% level.

TABLE 11

ENGLE-GRANGER TEST FOR COINTEGRATION

	ADF(0)	ADF(1)	ADF(2)	ADF(3)	ADF(4)
LCO-Xs	-5.38	-5.84	-4.03	-3.11	-2.72

Note: LCO-Xs is the regression in which the test for cointegration has been applied. The variables tested for cointegration are LCO, LWD, LVC, LVL and ALAN.

The critical values by MacKinnon are -5.14 for the 5% level and -4.76 for the 10% level.

TABLE 12

FIRST STABILITY TEST OF THE REGRESSION OF EQUATION (3)

	1987	1988	1989	1990
Constant	10.16	9.75	9.88	10.01
	(57.00)	(171.54)	(159.17)	(141.66)
LWD	0.50	0.05	0.22	0.36
	(4.43)	(0.82)	(3.99)	(7.26)
LVC	-0.06	-0.02	-0.05	-0.06
	(-2.08)	(-1.28)	(-1.93)	(-2.33)
LVL	0.08	0.04	0.08	0.08
	(2.72)	(2.85)	(3.97)	(3.93)
TIME	0.04	0.06	0.05	0.05
	(5.69)	(18.66)	(17.49)	(18.22)
ALAN	0.22	0.11	0.18	0.24
	(4.10)	(4.54)	(6.42)	(6.02)
D1	0.11	0.11	0.11	0.12
	(2.00)	(5.27)	(3.77)	(3.76)
D2	0.16	0.16	0.15	0.14
	(4.69)	(8.14)	(5.12)	(4.31)
D3	0.05	0.07	0.07	0.05
	(0.90)	(3.58)	(2.26)	(1.62)
MA(1)	0.46	0.85	0.52	0.38
	(2.44)	(3.80)	(2.40)	(1.99)
MA(2)	-0.22	0.65	0.34	0.27
	(-0.87)	(2.23)	(1.44)	(1.39)
MA(3)	-0.50	0.26	0.24	-0.25
	(-1.84)	(0.92)	(0.99)	(-1.49)
MA(4)	-0.62	-0.03	0.04	-0.56
	(-2.84)	(-0.11)	(0.20)	(-3.46)
Adj. R2	0.99	0.99	0.99	0.99
D. W. Stat	1.91	1.97	1.97	1.86
B-P Q Stat	7.84	6.26	6.64	7.15
	N=32	N=36	N=40	N=44

t values are in parenthesis

TABLE 13

SECOND STABILITY TEST OF THE REGRESSION OF EQUATION (3)

	1987	1988	1989	1990
Constant	9.93	9.79	9.86	10.02
	(164.23)	(138.77)	(173.50)	(128.62)
LWD	0.30	0.08	0.19	0.31
	(4.45)	(1.00)	(3.88)	(6.65)
LVC	-0.02	-0.02	-0.05	-0.06
	(-1.28)	(-0.91)	(-2.22)	(-1.92)
LVL	0.06	0.06	0.08	0.10
	(3.12)	(3.06)	(4.83)	(4.34)
TIME	0.06	0.06	0.06	0.05
	(16.74)	(15.13)	(21.31)	(15.33)
D1	0.12	0.10	0.11	0.10
	(5.02)	(3.02)	(3.89)	(2.65)
D2	0.17	0.11	0.15	0.09
	(6.74)	(3.42)	(5.61)	(2.14)
D3	0.06	0.03	0.07	0.01
	(2.66)	(1.08)	(2.66)	(0.31)
MA(1)	0.91	0.91	0.86	0.96
	(4.21)	(3.78)	(7.47)	(4.81)
MA(2)	0.85	0.80	0.77	0.68
	(4.09)	(2.57)	(10.75)	(2.70)
MA(3)	0.48	0.19	0.97	0.31
	(2.54)	(0.62)	(14.94)	(1.61)
MA(4)	0.13	0.06	0.77	0.08
	(0.88)	(0.31)	(6.74)	(0.65)
Adj. R2	0.99	0.99	0.99	0.99
D. W. Stat	1.79	1.78	1.83	1.99
B-P Q Stat	6.12	18.22	17.09	13.53
	N=32	N=36	N=40	N=44

t values are in parenthesis

FIGURE 1

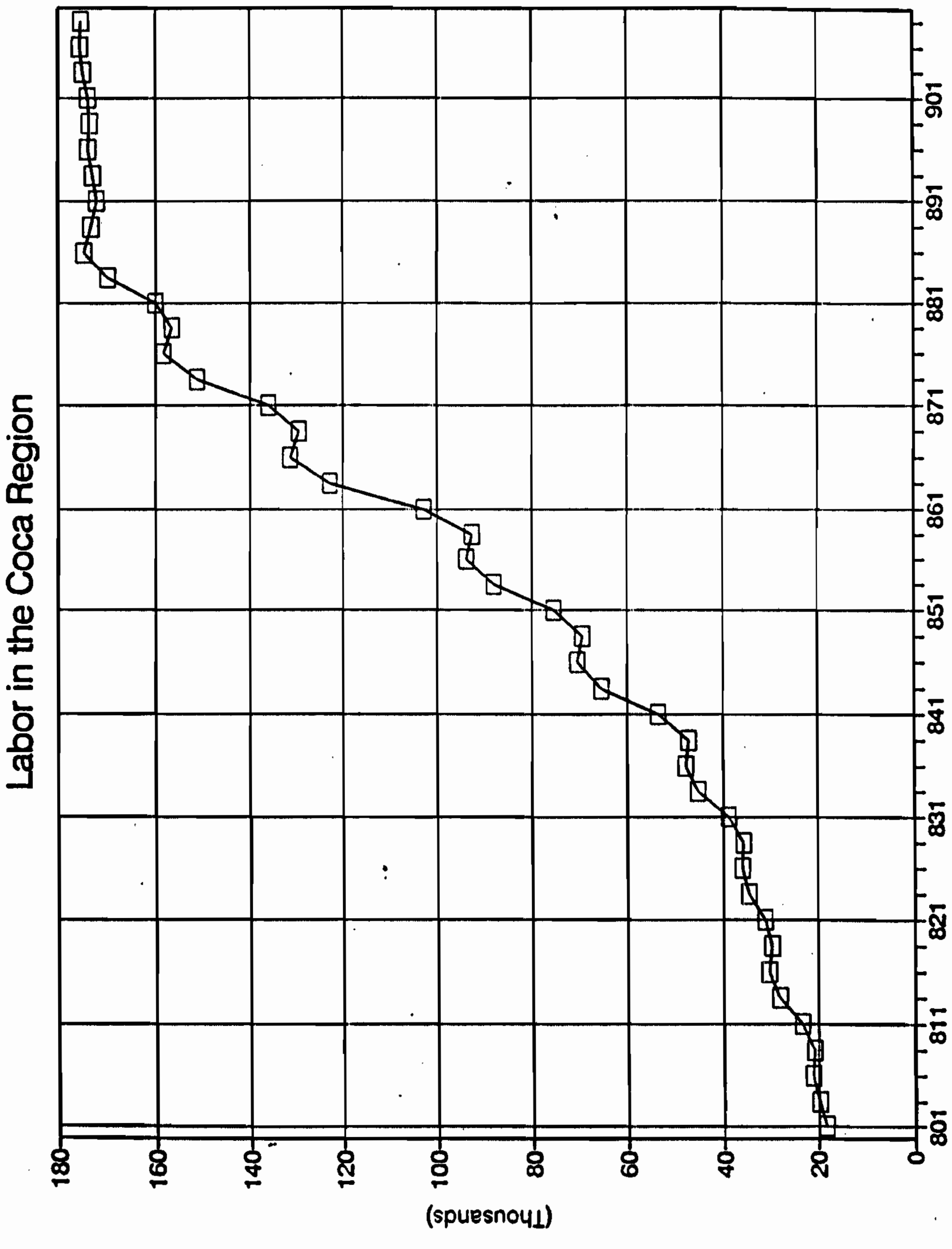
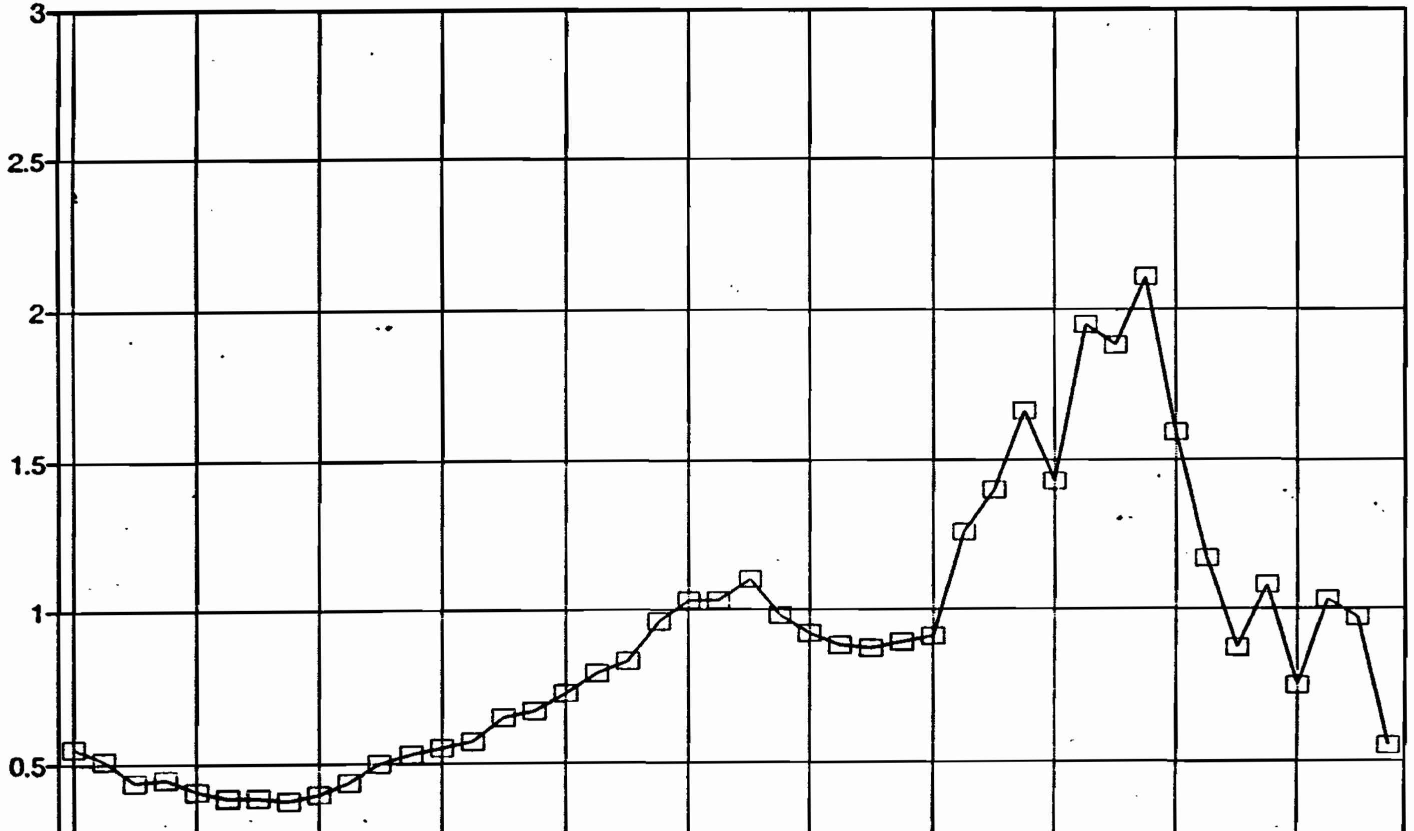

Labor in the Coca Region
(Thousands)
180
160
140
120
100
80
60
40
20
0
801
811
821
831
841
851
861
871
881
891
901

FIGURE 2

COCA WAGE AND MINIMUM WAGE
DIFFERENTIAL (Constant 1979 Intis)



INDEX OF EMPLOYMENT IN LIMA IN THE PETTY TRADER SECTOR

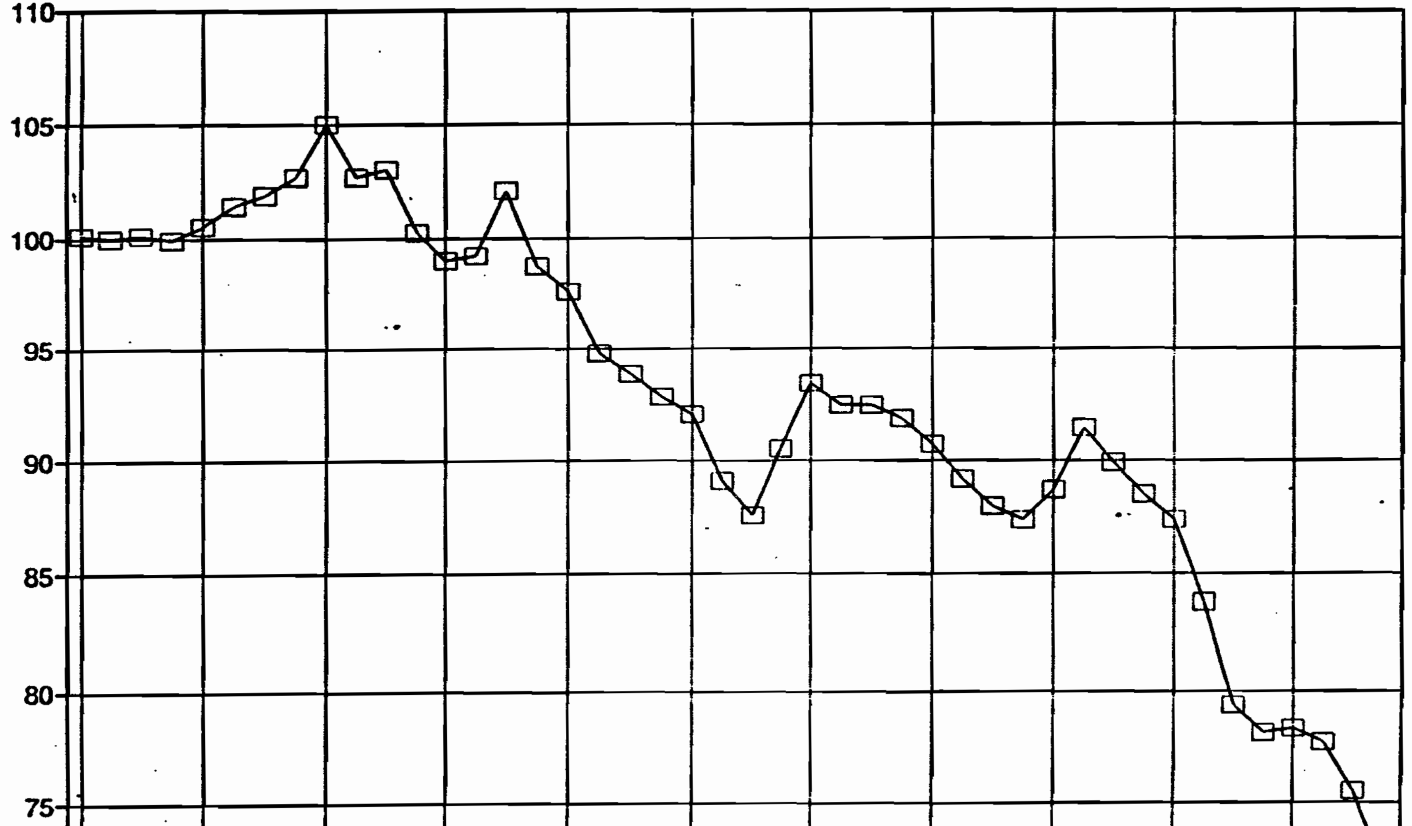


FIGURE 3

NUMBER OF VIOLENT ACTS
IN THE COCA REGION

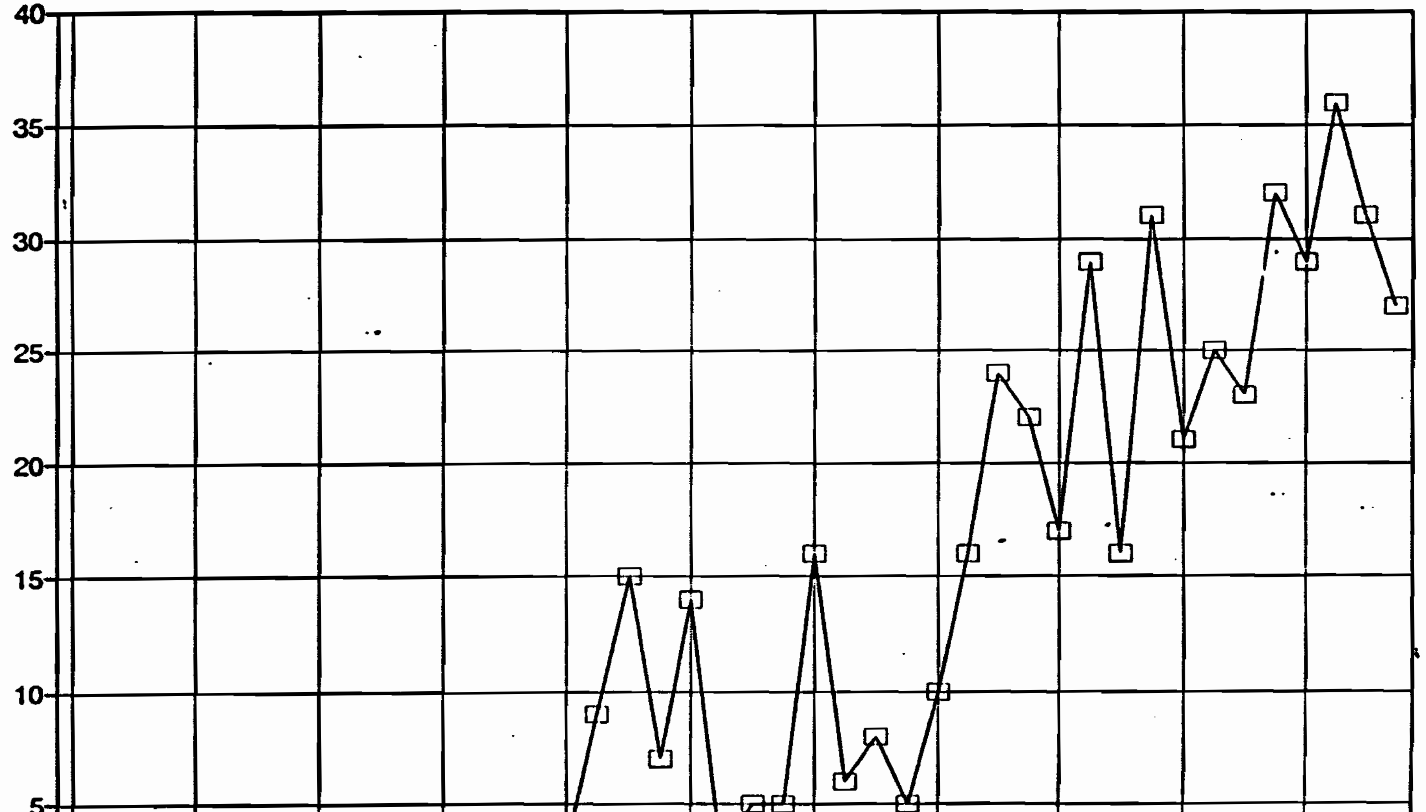
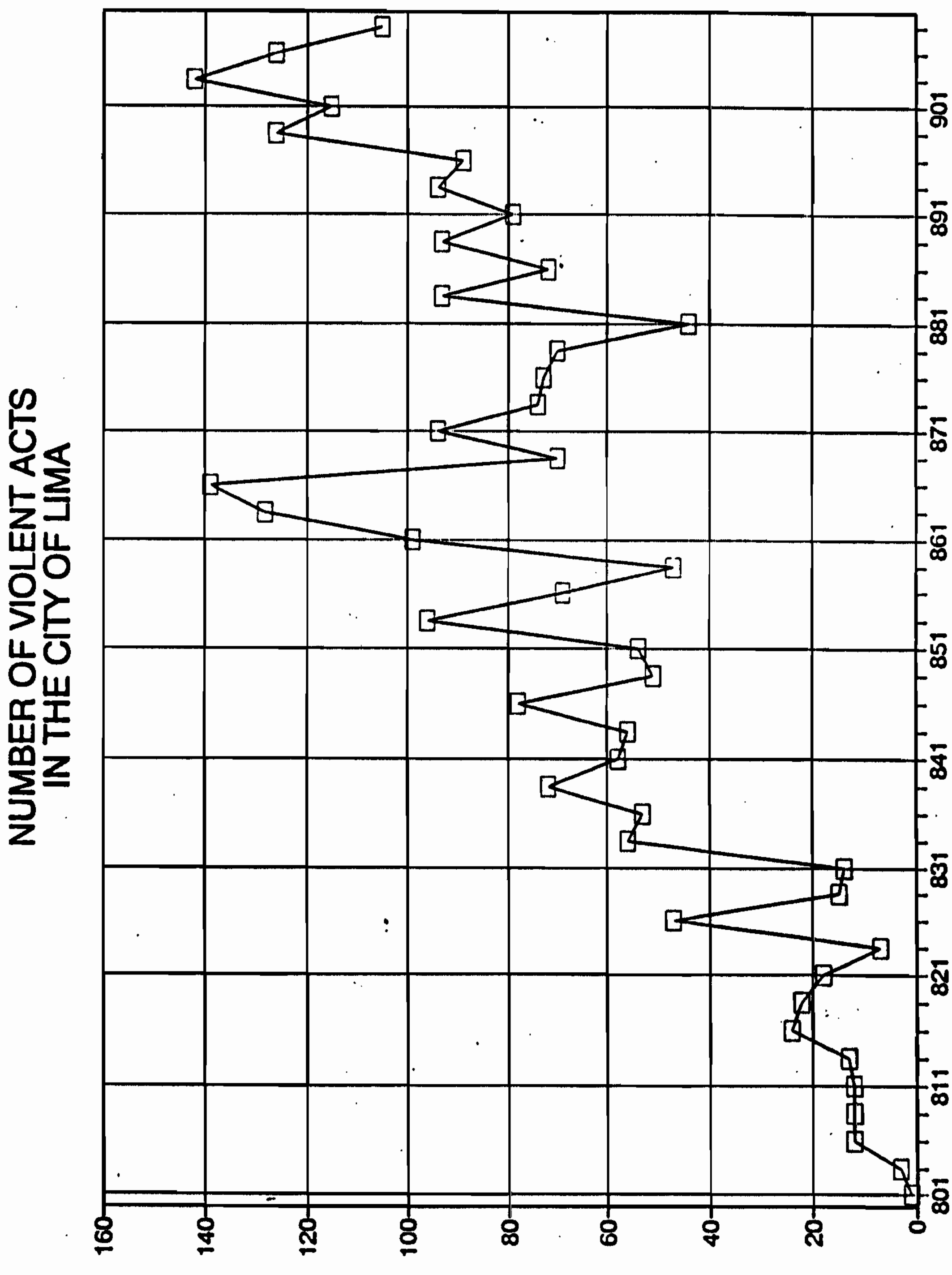


FIGURE 4

FIGURE 5



NUMBER OF VIOLENT ACTS
IN THE CITY OF LIMA
160
140
120
100
80
60
40
20
0
801
811
821
831
841
851
861
871
881
891
901

INDEX OF PERUVIAN INDUSTRIAL OUTPUT
(1979 = 100.0)

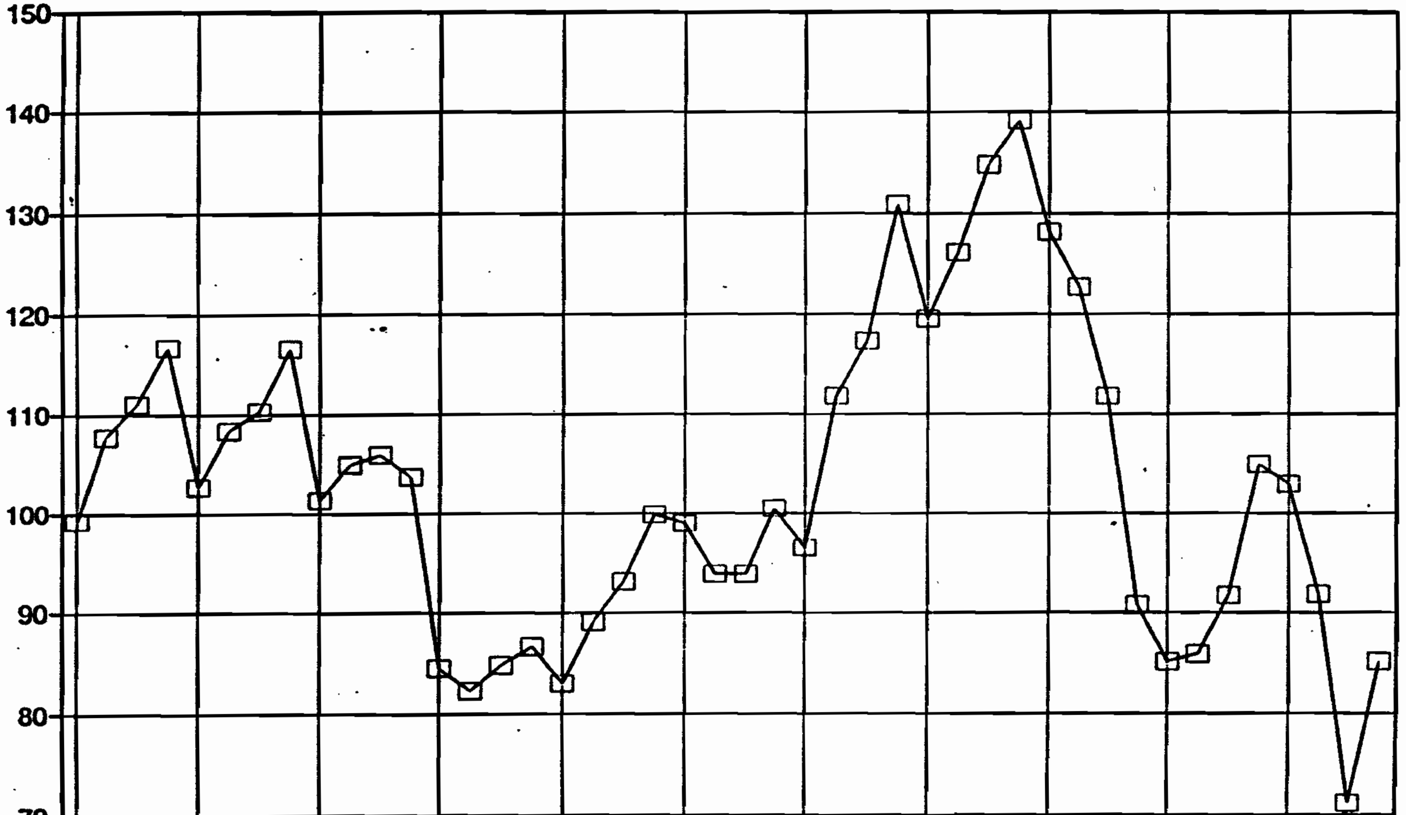


FIGURE 6

APPENDIX 1

SOURCES AND METHODOLOGY OF THE DATA USED

The data used in the estimation of the models reported in Section 6 of this paper is presented in Appendix 2. What follows is a description of the sources and of how the data was obtained:

1) Labor in the coca sector.

The total labor used in coca and coca paste production for the Upper Huallaga Valley has been calculated by using the estimates of total land utilized for the production of coca in the valley. This annual data has been taken from Briceño and Martínez (1989) for the years 1980 to 1987. For these years we use the numbers reported by the authors, and originally from the Ministry of Agriculture and other official agencies, as estimates of the total size of the land where coca is cultivated in the Upper Huallaga Valley. To calculate the rate of growth in the year 1980, we have used the estimate of coca production for 1979 as reported by Maletta (1985) for the Department of Huánuco, who also uses official sources as estimates. To estimate the land of coca cultivated for 1988 to 1990 we have used the rate of growth of the agricultural coca value added as presented by Webb and Fernández-Baca (1991).

After obtaining an annual series for land cultivated with coca in the Upper Huallaga Valley, the numbers obtained are the total land cultivated at the end of the year. We obtain estimates of quarterly labor use with the following assumptions: The agricultural labor will have both a seasonal and a non-seasonal component. The non-seasonal component is identified as the harvest, given that it is done an average of four to six times a year, while the non-seasonal component is the seeding and cultivation of the land. The industrial labor has only a non seasonal component. According to Tantahuilca (1989), the non-seasonal coefficient of labor use for the agricultural sector is equivalent to 0.833 laborers per year per hectare, or 250 required work days out of 300. The industrial labor coefficient has been taken from Alvarez (1991) who estimates an average of 0.5 units of industrial (i.e. coca paste) labor for every unit of agricultural labor in the coca fields. Furthermore, we assume that both the industrial and the non-seasonal agricultural labor use grows at a constant rate during the year. The seasonal aspect of the agricultural labor use, on the other hand, follows a seasonal pattern, where we have taken the quarterly estimates of labor use for coca reported by Maletta (1985). The seasonal component is obtained by multiplying the number of hectares added in a particular year times the seasonality index for the quarter times 0.66 (or 198 labor days out of 300 working days). Taking the sum of these three components we obtain a rough estimate of the labor used in coca production for each quarter from 1980 until 1990.

2) Wages in the coca sector.

The wage figure for the coca sector is the one reported for agricultural work in the coca fields of the Upper Huallaga Valley in different studies and reports. We have used an estimate of the wages in the coca region by taking different measures for peasant wages in different sources, such as Andean Report (1985-1990), Bedoya and Verdera (1987), Peru-CORAH (1991), Instituto Libertad y Democracia (1991), Laity (1989), Morales (1986) and (1989), Perú Económico (1989), Peru Report (1989), and Tantahuilca (1989). We have taken the wage reported (most times in current U.S. dollars) and converted them into thousands of soles at 1979 prices, at the black market exchange rate. For the quarters in which there is no information available, we have assumed a constant rate of growth in dollar wages.

3) Wages in the urban sector.

The variable that measures the earnings in an alternative (urban) sector will be the minimum wage, which, given the existence of unemployment is binding for any worker that can find a job; it is also a good measure of the wage for unskilled labor in Peru. The source is the monthly data published in Peru (1991), as the "Compendio Estadístico 1990-91", Vol. 1, p. 460, and the series is in constant prices of 1979, adjusted by the Lima consumer price index obtained from the same source, Vol. 2, p. 351, 355. To obtain quarterly data, we have averaged the monthly data over three months.

4) Unemployment.

The first variable to be used as a measure of risk in the urban sector is unemployment. There are no monthly or quarterly statistics on unemployment for Peru or Lima, but there are monthly indexes of total employment in some sectors. The employment index that we use is the one for permanent employment in the Lima petty trade sector. This is consistently reported by the National Institute of Statistics from a survey of small firms, but since this is an index of employment, we have used the inverse of the index of employment for the "petty traders" in Lima as a proxy for unemployment in that sector. The source is the "Compendio Estadístico 1990-91" in Peru (1991), Vol 1, p. 423.

5) Political Violence.

We have taken the number of violent acts as reported by Desco (1990) for the Province of Lima, and for the Provinces of the Departments of San Martín and Huánuco, for the years 1980 to 1988. These include mostly politically motivated violent acts, but in the Departments of San Martín and Huánuco. The distinction between political and organized crime violence is not always clear, and we assume that they are equivalent. For the years 1989 and 1990 we have used the <u>Resumen Semanal</u>, (several issues).

6) Industrial Output.

The index of industrial production used as an instrumental variable for unemployment in the urban sector is the three month average of the monthly the index of physical volume of output taken from "Compendio Estadístico 1990-91" in Peru (1991), Vol. 2, p. 141.

APPENDIX 2

DATA USED IN THE ESTIMATION OF THE MODELS

DATE	LABOR	WgCo	WgLi	ViC	VLi	EMPLO	INDUS
801	18324	1.00	0.45	1	1	100.1	99.2
802	21373	0.98	0.47	1	3	100.0	107.7
803	21145	0.91	0.47	1	12	100.1	111.1
804	20775	0.89	0.44	2	12	99.9	116.7
811	26080	0.81	0.40	2	12	100.5	102.7
812	30618	0.78	0.39	1	13	101.4	108.3
813	30282	0.77	0.38	1	24	101.9	110.3
814	29745	0.76	0.38	1	22	102.7	116.6
821	32947	0.77	0.37	1	18	105.0	101.4
822	36343	0.80	0.36	1	7	102.7	105.0
823	36068	0.85	0.35	3	47	103.0	106.0
824	35575	0.89	0.36	1	15	100.2	103.8
831	42507	0.92	0.37	1	14	99.0	84.7
832	48255	0.97	0.40	4	56	99.2	82.5
833	47808	1.02	0.37	2	53	102.1	84.9
834	47040	1.02	0.35	4	72	98.7	86.7
841	60134	1.03	0.30	3	58	97.6	83.1
842	70882	1.06	0.27	9	56	94.8	89.2
843	70092	1.12	0.29	15	78	93.9	93.0
844	68840	1.25	0.29	7	51	92.8	99.8
851	82165	1.29	0.26	14	54	92.0	98.9
852	94314	1.26	0.23	3	96	89.1	93.7
853	93384	1.35	0.25	5	69	87.6	93.8
854	91820	1.24	0.26	5	47	90.5	100.5

DATE	LABOR	WgCo	WgLi	ViC	VLi	EMPLO	INDUS
861	113621	1.19	0.27	16	99	93.4	96.5
862	132140	1.14	0.26	6	128	92.4	111.8
863	130750	1.10	0.23	8	139	92.4	117.3
864	128474	1.16	0.27	5	70	91.8	130.9
871	143557	1.14	0.23	10	94	90.7	119.5
872	158832	1.56	0.30	16	74	89.2	126.1
873	157601	1.70	0.30	24	73	88.0	134.8
874	155399	1.95	0.29	22	70	87.4	139.1
881	164608	1.69	0.26	17	44	88.7	128.1
882	174848	2.19	0.24	29	93	91.4	122.7
883	173979	2.14	0.26	16	72	89.9	111.8
884	172350	2.30	0.19	31	93	88.5	90.7
891	171675	1.72	0.13	21	79	87.4	85.3
892	173714	1.28	0.11	25	94	83.8	86.0
893	173532	0.99	0.12	23	89	79.4	91.6
894	173175	1.19	0.11	32	126	78.1	105.0
901	174122	0.86	0.11	29	115	78.3	103.0
902	175278	1.14	0.11	36	142	77.7	91.8
903	175174	1.07	0.10	31	126	75.5	71.3
904	174970	0.65	0.10	27	105	72.0	85.2

Sources: See Appendix 1.

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