

# Panel Analyses Report

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2021-06-20



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# Chapter 1

## Prerequis

Ceci est *une étude* des données de panel avec **Markdown**.

The **bookdown** package can be installed from CRAN or Github:

La structure de ce rapport est que chaque fichier RMD porte un chapitre et un thème bien spécifique de notre analyse

Nous avons utilisé XeLaTeX pour compiler ce document en PDF.



## Chapter 2

# Introduction

Dans ce document nous cherchons à modéliser les taxes perçues dans différents pays , formant un panel dont la période est 10 ans. Ainsi, nous expliquerons la variable taxe par:

- (1) Le poids des Marchandises
- (2) La qualité des Marchandises

Le but est d'arbitrer entre:

- (1) le modèle *pooling*
- (2) le *modele à effet fixe* et
- (3) le *modèle à effet aléatoire*

et en fin produire un **modèle dynamique** permettant d'expliquer la variation du taxe au cours du temps, avec comme variable dépendante additionnelle le taxe décalé

Nous expliquons Notre méthodologie dans la partie suivante.





## Chapter 3

# Literature



## Chapter 4

# The One-way Error Component Regression Model

### 4.1 INTRODUCTION

A panel data regression differs from a regular time-series or cross-section regression in that it has a double subscript on its variables, i.e.

$$y_{it} = \alpha + X'_{it}\beta + u_{it}$$
$$i = 1, \dots, N; t = 1, \dots, T$$

(2.1)

with  $i$  denoting households, individuals, firms, countries, etc. and  $t$  denoting time. The  $i$  subscript, therefore, denotes the cross-section dimension whereas  $t$  denotes the time-series dimension.

$$\alpha$$

is a scalar,

$$\beta$$

is

$$K \times 1$$

and  $X_{it}$  is the  $i$ th observation on  $K$  explanatory variables. Most of the panel data applications utilize a one-way error component model for the disturbances, with

$$u_{it} = \mu_i + v_{it}$$

(2.2)

where  $\mu_i$  denotes the unobservable individual-specific effect and  $v_{it}$  denotes the remainder disturbance. For example, in an earnings equation in labor economics,  $y_{it}$  will measure earnings of the head of the household, whereas

$$X_{it}$$

may contain a set of variables like experience, education, union membership, sex, race, etc. Note that  $\alpha_i$  is time-invariant and it accounts for any individual-specific effect that is not included in the regression. In this case we could think of it as the individual's unobserved ability. The remainder disturbance

$$v_{it}$$

varies with individuals and time and can be thought of as the usual disturbance in the regression. Alternatively, for a production function utilizing data on firms across time,

$$y_{it}$$

will measure output and

$$X_{it}$$

will measure inputs. The unobservable firm-specific effects will be captured by the

$$\mu_i$$

and we can think of these as the unobservable entrepreneurial or managerial skills of the firm's executives. Early applications of error components in economics include Kuh (1959) on investment, Mundlak (1961) and Hoch (1962) on production functions and Balestra and Nerlove (1966) on demand for natural gas. In vector form (2.1) can be written as

$$y = \alpha i_{NT} + X\beta + u = Z\delta + u \quad (2.3)$$

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where  $y$  is  $NT \times 1$ ,  $X$  is  $NT \times K$ ,  $Z = [i_{NT}, X]$ ,  $\delta' = (\alpha', \beta')$  and  $i_{NT}$  is a vector of ones of dimension  $NT$ . Also, (2.2) can be written as

$$u = Z_\mu \mu + v \quad (2.4)$$

$$y_{it} = \alpha + X'_{it} + U_{it}$$

,  $i=1, \dots, N$ ;  $t=1, \dots, T$  with  $i$  denoting households, individuals, firms, countries, etc. and  $t$  denoting time. The  $i$  subscript, therefore, denotes the cross-section dimension whereas  $t$  denotes the time-series dimension.  $\alpha$  is a scalar,  $\beta$  is  $K \times 1$  and  $X_{it}$  is the  $i$ th observation on  $K$  explanatory variables. disturbances, with it

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where  $y$  is  $NT \times 1$ ,  $X$  is  $NT \times K$ ,  $Z = [i_{NT}, X]$ ,  $\delta = (\alpha', \beta')$  and  $i_{NT}$  is a vector of ones of dimension  $NT$ . Also, (2.2) can be written as

$$u = Z_\mu \mu + v \quad (2.4)$$

where  $u = (u_{11}, \dots, u_{1T}, u_{21}, \dots, u_{2T}, \dots, u_{N1}, \dots, u_{NT})$  with the observations stacked such that the slower index is over individuals and the faster index is over time.  $Z = IN \otimes T$  where  $IN$  is an identity matrix of dimension  $N$ ,  $T$  is a vector of ones of dimension  $T$  and  $\otimes$  denotes Kronecker product.  $Z_\mu$  is a selector matrix of ones and zeros, or simply the matrix of individual dummies that one may include in the regression to estimate the  $\alpha_i$  if they are assumed to be fixed parameters.  $\delta = (\alpha, \beta)$  and  $\nu' = (\nu_{11}, \dots, \nu_{1T}, \dots, \nu_{N1}, \dots, \nu_{NT})$ . Note that  $Z_\mu Z_\mu' = I_N \otimes J_T$  where  $J_T$  is a matrix of ones of dimension  $T$  and  $P = Z(Z'Z)^{-1}Z'$ , the projection matrix on  $Z_\mu$ , reduces to  $IN \otimes J_T$  where  $J_T/T = \bar{J}$ .  $P$  is a matrix which averages the observation across time for each individual, and  $Q = INT - P$  is a matrix which obtains the deviations from individual means. For example, regressing  $y$  on the matrix of dummy variables  $Z_\mu$  gets the predicted values  $P_y$  which has a typical element

$$\bar{y}_i = \sum_{t=1}^T \frac{y_{it}}{T}$$

repeated  $T$  times for each individual. The residuals of this regression are given by  $Qy$  which has a typical element

$$(y_{it} - \bar{y}_i)$$

$P$  and  $Q$  are (i) symmetric idempotent matrices, i.e.

$P' = P$  and  $P^2 = P$ . This means that  $\text{rank}(P) = \text{tr}(P) = N$  and  $\text{rank}(Q) = \text{tr}(Q) = N(T-1)$ . This uses the result that the rank of an idempotent matrix is equal to its trace (see Graybill, 1961, theorem 1.63). Also, (ii)  $P$  and  $Q$  are orthogonal, i.e.  $PQ = 0$  and (iii) they sum to the identity matrix  $P + Q = INT$ . In fact, any two of these properties imply the third (see Graybill, 1961, theorem 1.68).

## 4.2 THE FIXED EFFECTS MODEL

In this case, the  $\alpha_i$  are assumed to be fixed parameters to be estimated and the remainder disturbances stochastic with  $v_{it}$  independent and identically distributed  $IID(0, \sigma_v^2)$ . The  $X_{it}$  are assumed independent of the  $v_{it}$  for all  $i$  and  $t$ . The fixed effects model is an appropriate specification if we are focusing on a specific set of  $N$  firms, say, IBM, GE, Westinghouse, etc. and our inference is restricted to the behavior of these sets of firms. Alternatively, it could be a set of  $N$  OECD countries, or  $N$  American states. Inference in this case is conditional on the particular  $N$  firms, countries or states that are observed. One can substitute the disturbances given by (2.4) into (2.3) to get

$$y = i_{NT} \alpha + X\beta + Z_\mu \mu + v = Z\delta + Z_\mu \mu + v \quad (2.5)$$

and then perform ordinary least squares (OLS) on (2.5) to get estimates of  $\alpha$ ,  $\beta$ , and  $\mu$

Note that  $Z$  is  $NT \times (K+1)$  and  $Z$ , the matrix of individual dummies, is  $NT \times N$ . If  $N$  is large, (2.5) will include too many individual dummies, and the matrix to be inverted by OLS is large and of dimension  $(N + K)$ . In fact, since  $\alpha$  and  $\beta$  are the parameters of interest, one can obtain the LSDV (least squares dummy variables) estimator from (2.5), by premultiplying the model by  $Q$  and performing OLS on the resulting transformed model:

$$QY = QX + Qv \quad (2.6)$$

This uses the fact that  $QZ_\mu = Qi_{NT} = 0$ , since  $PZ_\mu = Z_\mu$  the  $Q$  matrix wipes out the individual effects. This is a regression of  $\tilde{y} = QY$  with element  $(y_{it} - \bar{y}_{i.})$  on  $\tilde{X} = QX$  with typical element

$$\tilde{\beta} = (X'QX)^{-1} X'Qy$$

(2.7) with  $\text{var}(\tilde{\beta}) = \sigma_v^2 (X'QX)^{-1} = \sigma_v^2 (\tilde{X}'\tilde{X})^{-1}$ .  $\tilde{\beta}$  could have been obtained from (2.5) using results on partitioned inverse or the Frisch–Waugh–Lovell theorem discussed in Davidson and MacKinnon (1993, p. 19). This uses the fact that  $P$  is the projection matrix on  $Z_\mu$  and  $Q = I_{NT} - P$  (see problem 2.1). In addition, generalized least squares (GLS) on (2.6), using the generalized inverse, will also yield  $\tilde{\beta}$  (see problem 2.2).

Note that for the simple regression

$$y_{it} = \beta x_{it} + \mu_i + v_i$$

(2.8)

and averaging over time gives

$$\bar{y}_{i.} = \beta \bar{x}_{i.} + \mu_i + \bar{v}_i$$

(2.9)

Therefore, subtracting (2.9) from (2.8) gives

$$y_{it} - \bar{y}_{i.} = \beta(x_{it} - \bar{x}_{i.}) + (v_{it} - \bar{v}_{i.})$$

(2.10)

Also, averaging across all observations in (2.8) gives

$$\bar{y}_{..} = \alpha + \beta \bar{x}_{..} + \bar{v}_{..}$$

(2.11) where we utilized the restriction that  $\sum_{i=1}^n \mu_i = 0$ . This is an arbitrary restriction on the dummy variable coefficients to avoid the dummy variable trap, or perfect multicollinearity; see Suits (1984) for alternative formulations of this restriction. In fact only  $\beta$  and  $(\alpha + \mu_i)$  are estimable from (2.8), and not  $\alpha$  and  $\mu_i$  separately, unless a restriction like

$$\sum_{i=1}^n \mu_i = 0$$

is imposed. In this case,  $\tilde{\beta}$  is obtained from regression (2.10),

$$\tilde{\alpha} = \bar{y}_{..} - \tilde{\beta} \bar{x}_{..}$$

can be recovered from (2.11) and

$$\tilde{\mu}_i = \bar{y}_{i.} - \tilde{\alpha} - \tilde{\beta} \bar{x}_{i.}$$

from (2.9). For large labor or consumer panels, where  $N$  is very large, regressions like (2.5) may not be feasible, since one is including  $(N - 1)$  dummies in the regression. This fixed effects (FE) least squares,

also known as least squares dummy variables (LSDV), suffers from a large loss of degrees of freedom. We are estimating  $(N - 1)$  extra parameters, and too many dummies may aggravate the problem of multicollinearity among the regressors. In addition, this FE estimator cannot estimate the effect of any time-invariant variable like sex, race, religion, schooling or union participation. These time-invariant variables are wiped out by the Q transformation, the deviations from means transformation (see (2.10)). Alternatively, one can see that these time-invariant variables are spanned by the individual dummies in (2.5) and therefore any regression package attempting (2.5) will fail, signaling perfect multicollinearity. If (2.5) is the true model, LSDV is the best linear unbiased estimator (BLUE) as long as  $v_{it}$  is the standard classical disturbance with mean 0 and variance-covariance matrix  $\sigma^2 I_{NT}$ . Note that as  $T \rightarrow \infty$  the FE estimator is consistent. However, if  $T$  is fixed and  $N \rightarrow \infty$  as is typical in short labor panels, then only the FE estimator of  $\alpha$  is consistent; the FE estimators of the individual effects  $\alpha + \mu_i$  are not consistent since the number of these parameters increases as  $N$  increases. This is the incidental parameter problem discussed by Neyman and Scott (1948) and reviewed more recently by Lancaster (2000). Note that when the true model is fixed effects as in (2.5), OLS on (2.1) yields biased and inconsistent estimates of the regression parameters. This is an omission variables bias due to the fact that OLS deletes the individual dummies when in fact they are relevant.

- (1) *Testing for fixed effects.* One could test the joint significance of these dummies, i.e.  $H_0: \mu_1 = \mu_2 = \dots = \mu_{N-1} = 0$ , by performing an F-test. (Testing for individual effects will be treated extensively in Chapter 4.) This is a simple Chow test with the restricted residual sums of squares (RRSS) being that of OLS on the pooled model and the unrestricted residual sums of squares (URSS) being that of the LSDV regression. If  $N$  is large, one can perform the Within transformation and use that residual sum of squares as the URSS. In this case

$$F_0 = \frac{\frac{RRSS - URSS}{N - 1}}{\frac{URSS}{NT - N - K}} \sim F_{N-1, N(T-1)-K} \quad (2.12)$$

- (2) *Computational warning.* One computational caution for those using the Within regression given by (2.10). The  $s^2$  of this regression as obtained from a typical regression package divides the residual sums of squares by  $NT - K$  since the intercept and the dummies are not included. The proper  $s^2$ , say  $s^{*2}$  from the LSDV regression in (2.5), would divide the same residual sums of squares by  $N(T - 1) - K$ . Therefore, one has to adjust the variances obtained from the Within regression (2.10) by multiplying the variance-covariance matrix by

$$\frac{s^2}{s^{*2}}$$

or simply by multiplying by  $[NT - K]/[N(T - 1) - K]$

- (3) *Robust estimates of the standard errors.* For the Within estimator, Arellano (1987) suggests a simple method for obtaining robust estimates of the standard errors that allow for a general variance-covariance matrix on the  $v_{it}$  as in White (1980). One would stack the panel as an equation for each individual:

$$y_i = Z_i \delta + \mu_i i_T + v_i \quad (2.13)$$

where  $y_i$  is  $T \times 1$ ,  $Z_i = [1_T, X_i]$ ,  $X_i$  is  $T \times K$ ,  $\mu_i$  is a scalar,  $\delta' = (\alpha, \beta')$ ,  $i_T$  is a vector of ones of dimension  $T$  and  $v_i$  is  $T \times 1$ . In general,  $E(v_i, v_i') = \Omega_i$  for  $i = 1, 2, \dots, N$ , where  $\Omega_i$  is a positive definite matrix of dimension  $T$ . We still assume  $E(v_i, v_j') = 0$  for  $i \neq j$ .  $T$  is assumed small and  $N$  large as in household or company panels, and the asymptotic results are performed for  $N \rightarrow \infty$  and  $T$  fixed. Performing the Within transformation on this set of equations (2.13) one gets

$$\tilde{y}_i = \tilde{X}_i\beta + \tilde{v}_i \quad (2.14)$$

where

$$\tilde{y} = Qy$$

,

$$\tilde{X} = QX$$

and

$$\tilde{v} = Qv$$

, with

$$\tilde{y} = (\tilde{y}'_1, \dots, \tilde{y}'_N)'$$

and

$$\tilde{g}_i = (I_T - \bar{J}_T)y_i$$

Computing robust least squares on this system, as described by White (1980), under the restriction that each equation has the same  $\beta$  one gets the Within estimator of  $\beta$  which has the following asymptotic distribution:

$$N^{\frac{1}{2}}(\tilde{\beta} - \beta) \sim N(0, M^{-1}VM^{-1}) \quad (2.15)$$

where

$$M = \frac{p \lim(\tilde{X}'\tilde{X})}{N}$$

Note that

$$\tilde{X}_i = (I_T - \bar{J}_T)X_i$$

and

$$\tilde{X}'diag[\Omega_i]Q\tilde{X}$$

(see problem 2.3). In this case,  $V$  is estimated by

$$\tilde{V} = \frac{\sum_{i=1}^N \tilde{X}'_i \tilde{u}_i \tilde{u}'_i \tilde{X}_i}{N}$$

where

$$\tilde{u}_i = \tilde{g}_i - \tilde{X}_i\tilde{\beta}_i$$

. Therefore, the robust asymptotic variance–covariance matrix of  $\beta$  is estimated by

$$\text{var}(\tilde{\beta}) = (\tilde{X}'\tilde{X})^{-1} \left[ \sum_{i=1}^N \tilde{X}'_i \tilde{u}_i \tilde{u}'_i \tilde{X}_i \right] (\tilde{X}'\tilde{X})^{-1}$$



### 4.3 THE RANDOM EFFECTS MODEL

There are too many parameters in the fixed effects model and the loss of degrees of freedom can be avoided if the  $\mu_i$  can be assumed random. In this case  $\mu_i \sim \text{IID}(0, \sigma_\mu^2)$ ,  $v_{it} \sim \text{IID}(0, \sigma_v^2)$  and the  $\mu_i$  are independent of the  $v_{it}$ . In addition, the  $X_{it}$  are independent of the  $\mu_i$  and  $v_{it}$ , for all  $i$  and  $t$ . The random effects model is an appropriate specification if we are drawing  $N$  individuals randomly from a large population. This is usually the case for household panel studies. Care is taken in the design of the panel to make it “representative” of the population we are trying to make inferences about. In this case,  $N$  is usually large and a fixed effects model would lead to an enormous loss of degrees of freedom. The individual effect is characterized as random and inference pertains to the population from which this sample was randomly drawn.

But what is the population in this case? Nerlove and Balestra (1996) emphasize Haavelmo’s (1944) view that the population “consists not of an infinity of individuals, in general, but of an infinity of decisions” that each individual might make. This view is consistent with a random effects specification. From (2.4), one can compute the variance–covariance matrix

$$\begin{aligned}\Omega &= E(uu') = Z_\mu E(\mu\mu') Z_\mu' + E(vv') \\ &= \sigma_\mu^2 (I_N \otimes J_T) + \sigma_v^2 (I_N \otimes I_T)\end{aligned}\tag{4.1}$$

This implies a homoskedastic variance  $\text{var}(u_{it}) = \sigma_\mu^2 + \sigma_v^2$  for all  $i$  and  $t$ , and an equicorrelated block-diagonal covariance matrix which exhibits serial correlation over time only between the disturbances of the same individual. In fact,

$$\begin{aligned}\text{cov}(u_{it}, u_{js}) &= \sigma_\mu^2 + \sigma_v^2 \quad \text{for } i = j, t = s \\ &= \sigma_\mu^2 \quad \text{for } i = j, t \neq s\end{aligned}$$

and zero otherwise. This also means that the correlation coefficient between  $\mu_{it}$  and  $\mu_{js}$  is  $\rho = \text{correl}(u_{it}, u_{js}) = 1$  for  $i = j, t = s$  and  $\sigma_\mu^2 / (\sigma_\mu^2 + \sigma_v^2)$  for  $i = j, t \neq s$  and zero otherwise.

In order to obtain the GLS estimator of the regression coefficients, we need  $\Omega^{-1}$ . This is a huge matrix for typical panels and is of dimension  $NT \times NT$ . No brute force inversion should be attempted even if the researcher’s application has a small  $N$  and  $T$ . We will follow a simple trick devised by Wansbeek and Kapteyn (1982b, 1983) that allows the derivation of  $\Omega^{-1}$ . Essentially, one replaces  $J_T$  by  $T\bar{J}_T$  and  $I_T$  by  $(E_T + \bar{J}_T)$  where  $E_T$  is by definition  $(I_T - \bar{J}_T)$ . In this case

$$\Omega = T\sigma_\mu^2 (I_N \otimes \bar{J}_T) + \sigma_v^2 (I_N \otimes E_T) + \sigma_v^2 (I_N \otimes \bar{J}_T)$$

Collecting terms with the same matrices, we get

$$\Omega = (T\sigma_\mu^2 + \sigma_v^2) (I_N \otimes \bar{J}_T) + \sigma_v^2 (I_N \otimes E_T) = \sigma_1^2 P + \sigma_v^2 Q\tag{4.2}$$

where  $\sigma_1^2 = T\sigma_\mu^2 + \sigma_v^2$ . (2.18) is the spectral decomposition representation of  $\Omega$ , with  $\sigma_1^2$  being the first unique characteristic root of  $\Omega$  of multiplicity  $N(T-1)$ . It is easy to verify, using the properties of  $P$  and  $Q$ , that

$$\Omega^{-1} = \frac{1}{\sigma_1^2} P + \frac{1}{\sigma_v^2} Q\tag{4.3}$$

and

$$\Omega^{-1/2} = \frac{1}{\sigma_1} P + \frac{1}{\sigma_v} Q\tag{4.4}$$

In fact,  $\Omega^r = (\sigma_1^2)^r P + (\sigma_v^2)^r Q$  where  $r$  is an arbitrary scalar. Now we can obtain GLS as a weighted least squares. Fuller and Battese (1973, 1974) suggested premultiplying the regression equation given in (2.3) by  $\sigma_v \Omega^{-1/2} = Q + (\sigma_v/\sigma_1) P$  and performing OLS on the resulting transformed regression. In this case,  $y^* = \sigma_v \Omega^{-1/2} y$  has a typical element  $y_{it} - \theta \bar{y}_i$ , where  $\theta = 1 - (\sigma_v/\sigma_1)$  (see problem 2.4). This transformed regression inverts a matrix of dimension  $(K+1)$  and can easily be implemented using any regression package.

The best quadratic unbiased (BQU) estimators of the variance components arise naturally from the spectral decomposition of  $\Omega$ . In fact,  $Pu \sim (0, \sigma_1^2 P)$  and  $Qu \sim (0, \sigma_v^2 Q)$  and

$$\hat{\sigma}_1^2 = \frac{u'Pu}{\text{tr}(P)} = T \sum_{i=1}^N \bar{u}_i^2 / N \quad (4.5)$$

and

$$\hat{\sigma}_v^2 = \frac{u'Qu}{\text{tr}(Q)} = \frac{\sum_{i=1}^N \sum_{t=1}^T (u_{it} - \bar{u}_i)^2}{N(T-1)} \quad (4.6)$$

provide the BQU estimators of  $\sigma_1^2$  and  $\sigma_v^2$ , respectively (see problem 2.5).

These are analyses of variance-type estimators of the variance components and are minimum variance-unbiased under normality of the disturbances (see Graybill, 1961). The true disturbances are not known and therefore (2.21) and (2.22) are not feasible. Wallace and Hussain (1969) suggest substituting OLS residual  $\hat{u}_{OLS}$  instead of the true  $u$ . After all, under the random effects model, the OLS estimates are still unbiased and consistent, but no longer efficient. Amemiya (1971) shows that these estimators of the variance components have a different asymptotic distribution from that knowing the true disturbances. He suggests using the LSDV residuals instead of the OLS residuals. In this case  $\tilde{u} = y - \tilde{\alpha} \iota_{NT} - X\tilde{\beta}$  where and  $\tilde{X}'$  is a  $1 \times K$

vector of averages of all regressors. Substituting these  $\hat{u}$  for  $u$  in (2.21) and (2.22) we get the Amemiya-type estimators of the variance components. The resulting estimates of the variance components have the same asymptotic distribution as that knowing the true disturbances:

$$\begin{pmatrix} \sqrt{NT}(\hat{\sigma}_v^2 - \sigma_v^2) \\ \sqrt{N}(\hat{\sigma}_\mu^2 - \sigma_\mu^2) \end{pmatrix} \sim N \left( 0, \begin{pmatrix} 2\sigma_v^4 & 0 \\ 0 & 2\sigma_\mu^4 \end{pmatrix} \right) \quad (4.7)$$

where  $\hat{\sigma}_\mu^2 = (\hat{\sigma}_1^2 - \hat{\sigma}_v^2)/T$ .<sup>3</sup>

Swamy and Arora (1972) suggest running two regressions to get estimates of the variance components from the corresponding mean square errors of these regressions. The first regression is the Within regression, given in (2.10), which yields the following  $s^2$ :

$$\hat{\sigma}_v^2 = [y'Qy - y'QX(X'QX)^{-1}X'Qy] / [N(T-1) - K] \quad (4.8)$$

The second regression is the Between regression which runs the regression of averages across time, i.e.

$$\bar{y}_i = \alpha + \bar{X}_i' \beta + \bar{u}_i \quad i = 1, \dots, N \quad (4.9)$$

(2.25)

This is equivalent to premultiplying the model in (2.5) by  $P$  and running OLS. The only caution is that the latter regression has  $NT$  observations because it repeats the averages  $T$  times for each individual,

while the cross-section regression in (2.25) is based on  $N$  observations. To remedy this, one can run the cross-section regression

$$\sqrt{T}\bar{y}_i = \alpha\sqrt{T} + \sqrt{T}\bar{X}'_i\beta + \sqrt{T}\bar{u}_i. \quad (4.10)$$

where one can easily verify that  $\text{var}(\sqrt{T}\bar{u}_i) = \sigma_1^2$ . This regression will yield an  $s^2$  given by

$$\hat{\sigma}_1^2 = (y'Py - y'PZ(Z'PZ)^{-1}Z'Py) / (N - K - 1) \quad (4.11)$$

Note that stacking the following two transformed regressions we just performed yields

$$\begin{pmatrix} Qy \\ Py \end{pmatrix} = \begin{pmatrix} QZ \\ PZ \end{pmatrix} \delta + \begin{pmatrix} Qu \\ Pu \end{pmatrix} \quad (4.12)$$

and the transformed error has mean 0 and variance-covariance matrix given by

$$\begin{pmatrix} \sigma_v^2 Q & 0 \\ 0 & \sigma_1^2 P \end{pmatrix}$$

Problem 2.7 asks the reader to verify that OLS on this system of 2NT observations yields OLS on the pooled model (2.3). Also, GLS on this system yields GLS on (2.3). Alternatively, one could get rid of the constant by running the following stacked regressions:

$$\begin{pmatrix} Qy \\ (P - \bar{J}_{NT})y \end{pmatrix} = \begin{pmatrix} QX \\ (P - \bar{J}_{NT})X \end{pmatrix} \beta + \begin{pmatrix} Qu \\ (P - \bar{J}_{NT})u \end{pmatrix} \quad (4.13)$$

This follows from the fact that  $QNT = 0$  and  $(P - \bar{J}_{NT})NT = 0$ . The transformed error has zero mean and variance-covariance matrix

$$\begin{pmatrix} \sigma_v^2 Q & 0 \\ 0 & \sigma_1^2 (P - \bar{J}_{NT}) \end{pmatrix}$$

OLS on this system yields OLS on (2.3) and GLS on (2.29) yields GLS on (2.3). In fact,

$$\begin{aligned} \hat{\beta}_{\text{GLS}} &= [(X'QX/\sigma_v^2) + X'(P - \bar{J}_{NT})X/\sigma_1^2]^{-1} [(X'Qy/\sigma_v^2) \\ &\quad + X'(P - \bar{J}_{NT})y/\sigma_1^2] \\ &= [W_{XX} + \phi^2 B_{XX}]^{-1} [W_{Xy} + \phi^2 B_{Xy}] \end{aligned} \quad (4.14)$$

(2.30)

with  $\text{var}(\hat{\beta}_{\text{GLS}}) = \sigma_v^2 [W_{XX} + \phi^2 B_{XX}]^{-1}$ . Note that  $W_{XX} = X'QX$ ,  $B_{XX} = X'(P - \bar{J}_{NT})X$  and  $\phi^2 = \sigma_v^2/\sigma_1^2$ . Also, the Within estimator of  $\beta$  is  $\hat{\beta}_{\text{Within}} = W_{XX}^{-1}W_{Xy}$  and the Between estimator of  $\beta$  is  $\hat{\beta}_{\text{Between}} = B_{XX}^{-1}B_{Xy}$ . This shows that  $\hat{\beta}_{\text{GLS}}$  is a matrix weighted average of  $\hat{\beta}_{\text{Within}}$  and  $\hat{\beta}_{\text{Between}}$  weighing each estimate by the inverse of its corresponding variance. In fact

$$\hat{\beta}_{\text{GLS}} = W_1 \hat{\beta}_{\text{Within}} + W_2 \hat{\beta}_{\text{Between}} \quad (4.15)$$

(2.31) where

$$W_1 = [W_{XX} + \phi^2 B_{XX}]^{-1} W_{XX}$$

and

$$W_2 = [W_{XX} + \phi^2 B_{XX}]^{-1} (\phi^2 B_{XX}) = I - W_1$$

This was demonstrated by Maddala (1971). Note that (i) if  $\sigma_\mu^2 = 0$  then  $\phi^2 = 1$  and  $\hat{\beta}_{\text{GLS}}$  reduces to  $\hat{\beta}_{\text{OLS}}$ . (ii) If  $T \rightarrow \infty$ , then  $\phi^2 \rightarrow 0$  and  $\hat{\beta}_{\text{GLS}}$  tends to  $\tilde{\beta}_{\text{Within}}$ . Also, if  $W_{XX}$  is huge compared to  $B_{XX}$  then  $\hat{\beta}_{\text{GLS}}$  will be close to  $\tilde{\beta}_{\text{Within}}$ . However, if  $B_{XX}$  dominates  $W_{XX}$  then  $\hat{\beta}_{\text{GLS}}$  tends to  $\hat{\beta}_{\text{Between}}$ . In other words, the Within estimator ignores the Between variation, and the Between estimator ignores the Within variation. The OLS estimator gives equal weight to the Between and Within variations. From (2.30), it is clear that  $\text{var}(\tilde{\beta}_{\text{Within}}) - \text{var}(\hat{\beta}_{\text{GLS}})$  is a positive semidefinite matrix, since  $\phi^2$  is positive. However, as  $T \rightarrow \infty$  for any fixed  $N$ ,  $\phi^2 \rightarrow 0$  and both  $\hat{\beta}_{\text{GLS}}$  and  $\tilde{\beta}_{\text{Within}}$  have the same asymptotic variance.

Another estimator of the variance components was suggested by Nerlove (1971a). His suggestion is to estimate  $\sigma^2$  as  $\sum^N (\hat{u} \cdot -\hat{\pi})^2 / (N - 1)$  where  $\hat{u}$  are the dummy coefficients estimates from the LSDV regression.  $\sigma_v^2$  is estimated from the Within residual sums of squares divided by  $NT$  without correction for degrees of freedom.<sup>4</sup>

Note that, except for Nerlove's (1971a) method, one has to retrieve  $\hat{\sigma}_\mu^2$  as  $(\hat{\sigma}_1^2 - \hat{\sigma}_v^2) / T$ . In this case, there is no guarantee that the estimate of  $\hat{\sigma}_\mu^2$  would be nonnegative. Searle (1971) has an extensive discussion of the problem of negative estimates of the variance components in the biometrics literature. One solution is to replace these negative estimates by zero. This in fact is the suggestion of the Monte Carlo study by Maddala and Mount (1973). This study finds that negative estimates occurred only when the true  $\sigma_\mu^2$  was small and close to zero. In these cases OLS is still a viable estimator. Therefore, replacing negative  $\hat{\sigma}_\mu^2$  by zero is not a bad sin after all, and the problem is dismissed as not being serious.<sup>5</sup>

How about the properties of the various feasible GLS estimators of  $\beta$  Under the random effects model, GLS based on the true variance components is BLUE, and all the feasible GLS estimators considered are asymptotically efficient as either  $N$  or  $\$N \rightarrow \infty$ . Maddala and Mount (1973) compared OLS, Within, Between, feasible GLS methods, MINQUE, Henderson's method III, true GLS and maximum likelihood estimation using their Monte Carlo study. They found little to choose among the various feasible GLS estimators in small samples and argued in favor of methods that were easier to compute. MINQUE was dismissed as more difficult to compute and the applied researcher given one shot at the data was warned to compute at least two methods of estimation, like an ANOVA feasible GLS and maximum likelihood to ensure that they do not yield drastically different results. If they do give different results, the authors diagnose misspecification.

Taylor (1980) derived exact finite sample results for the one-way error component model. He compared the Within estimator with the Swamy-Arora feasible GLS estimator. He found the following important results:

- (1) Feasible GLS is more efficient than LSDV for all but the fewest degrees of freedom.
- (2) The variance of feasible GLS is never more than 17% above the Cramer-Rao lower bound.
- (3) More efficient estimators of the variance components do not necessarily yield more efficient feasible GLS estimators.

These finite sample results are confirmed by the Monte Carlo experiments carried out by Maddala and Mount (1973) and Baltagi (1981a).

Bellmann, Breitung and Wagner (1989) consider the bias in estimating the variance components using the Wallace and Hussain (1969) method due to the replacement of the true disturbances by OLS residuals, also the bias in the regression coefficients due to the use of estimated variance components rather than the true variance components. The magnitude of this bias is estimated using bootstrap methods for

two economic applications. The first application relates product innovations, import pressure and factor inputs using a panel at the industry level. The second application estimates the earnings of 936 full-time working German males based on the first and second wave of the German Socio-Economic Panel. Only the first application revealed considerable bias in estimating  $\sigma^2_\epsilon$ . However, this did not affect the bias much in the corresponding regression coefficients

### 4.3.1 Fixed vs Random

Having discussed the fixed effects and the random effects models and the assumptions underlying them, the reader is left with the daunting question, which one to choose? This is not as easy a choice as it might seem. In fact, the fixed versus random effects issue has generated a hot debate in the biometrics and statistics literature which has spilled over into the panel data econometrics literature. Mundlak (1961) and Wallace and Hussain (1969) were early proponents of the fixed effects model and Balestra and Nerlove (1966) were advocates of the random error component model. In Chapter 4, we will study a specification test proposed by Hausman (1978) which is based on the difference between the fixed and random effects estimators. Unfortunately, applied researchers have interpreted a rejection as an adoption of the fixed effects model and nonrejection as an adoption of the random effects model.<sup>6</sup> Chamberlain (1984) showed that the fixed effects model imposes testable restrictions on the parameters of the reduced form model and one should check the validity of these restrictions before adopting the fixed effects model (see Chapter 4). Mundlak (1978) argued that the random effects model assumes exogeneity of all the regressors with the random individual effects. In contrast, the fixed effects model allows for endogeneity of all the regressors with these individual effects. So, it is an “all” or “nothing” choice of exogeneity of the regressors and the individual effects, see Chapter 7 for a more formal discussion of this subject.

Hausman and Taylor (1981) allowed for some of the regressors to be correlated with the individual effects, as opposed to the all or nothing choice. These over-identification restrictions are testable using a Hausman-type test (see Chapter 7). For the applied researcher, performing fixed effects and random effects and the associated Hausman test reported in standard packages like Stata, LIMDEP, TSP, etc., the message is clear: Do not stop here. Test the restrictions implied by the fixed effects model derived by Chamberlain (1984) (see Chapter 4) and check whether a Hausman and Taylor (1981) specification might be a viable alternative (see Chapter 7).



## Chapter 5

# The Two-way Error Component Regression Model

### 5.1 INTRODUCTION

Wallace and Hussain (1969), Nerlove (1971b) and Amemiya (1971), among others, the regression model given by (2.1), but with two-way error components disturbances:

$$u_{it} = \mu_i + \lambda_t + v_{it} \quad i = 1, \dots, N; t = 1, \dots, T \quad (5.1)$$

(3.1)

where  $\mu_i$  denotes the unobservable individual effect discussed in Chapter 2,  $\lambda_t$  denotes the unobservable time effect and  $v_{it}$  is the remainder stochastic disturbance term. Note that  $\lambda_t$  is individual-invariant and it accounts for any time-specific effect that is not included in the regression. For example, it could account for strike year effects that disrupt production; oil embargo effects that disrupt the supply of oil and affect its price; Surgeon General reports on the ill-effects of smoking, or government laws restricting smoking in public places, all of which could affect consumption behavior. In vector form, (3.1) can be written as

$$u = Z_\mu \mu + Z_\lambda \lambda + v \quad (5.2)$$

(3.2)

where  $Z_\mu$ ,  $\mu$  and  $v$  were defined earlier.  $Z_\lambda = i_N \otimes I_T$  is the matrix of time dummies that one may include in the regression to estimate the  $\lambda_t$  if they are fixed parameters, and  $\lambda' = (\lambda_1, \dots, \lambda_T)$ . Note that

$$Z_\lambda Z_\lambda' = J_N \otimes I_T$$

and the projection on  $Z_\lambda$  is

$$Z_\lambda (Z_\lambda' Z_\lambda)^{-1} Z_\lambda' = \bar{J}_N \otimes I_T$$

This last matrix averages the data over individuals, i.e., if we regress  $y$  on  $Z_\lambda$ , the predicted values are given by

$$(\bar{J}_N \otimes I_T)y$$

which has typical element  $\bar{y}_{.t} = \sum_{i=1}^N y_{it}/N$ .

## 5.2 THE FIXED EFFECTS MODEL

If the  $\mu_i$  and  $\lambda_t$  are assumed to be fixed parameters to be estimated and the remainder disturbances stochastic with  $v_{it} \sim \text{IID}(0, \sigma_v^2)$ , then (3.1) represents a two-way fixed effects error component model. The  $X_{it}$  are assumed independent of the  $v_{it}$  for all  $i$  and  $t$ . Inference in this case is conditional on the particular  $N$  individuals and over the specific time periods observed. Recall that  $Z_\lambda$ , the matrix of time dummies, is  $NT \times T$ . If  $N$  or  $T$  is large, there will be too many dummy variables in the regression  $\{(N-1) + (T-1)\}$  of them, and this causes an enormous loss in degrees of freedom. In addition, this attenuates the problem of multicollinearity among the regressors. Rather than invert a large  $(N+T+K-1)$  matrix, one can obtain the fixed effects estimates of  $\beta$  by performing the following Within transformation given by Wallace and Hussain (1969):

$$Q = E_N \otimes E_T = I_N \otimes I_T - I_N \otimes \bar{J}_T - \bar{J}_N \otimes I_T + \bar{J}_N \otimes \bar{J}_T \quad (5.3)$$

(3.3)

where  $E_N = I_N - \bar{J}_N$  and  $E_T = I_T - \bar{J}_T$ . This transformation “sweeps” the  $\mu_i$  and  $\lambda_t$  effects. In fact,  $\tilde{y} = Qy$  has a typical element  $\tilde{y}_{it} = (y_{it} - \bar{y}_{i.} - \bar{y}_{.t} + \bar{y}_{..})$  where  $\bar{y}_{..} = \sum_i \sum_t y_{it} / NT$ , and one would perform the regression of  $\tilde{y} = Qy$  on  $\tilde{X} = QX$  to get the Within estimator  $\tilde{\beta} = (X'QX)^{-1} X'Qy$

Note that by averaging the simple regression given in (2.8) over individuals, we get

$$\bar{y}_{.t} = \alpha + \beta \bar{x}_{.t} + \lambda_t + \bar{v}_{.t} \quad (5.4)$$

(3.4)

where we have utilized the restriction that  $\sum_i \mu_i = 0$  to avoid the dummy variable trap. Similarly the averages defined in (2.9) and (2.11) still hold using  $\sum_t \lambda_t = 0$  and one can deduce that

$$(y_{it} - \bar{y}_{i.} - \bar{y}_{.t} + \bar{y}_{..}) = (x_{it} - \bar{x}_{i.} - \bar{x}_{.t} + \bar{x}_{..})\beta + (v_{it} - \bar{v}_{i.} - \bar{v}_{.t} + \bar{v}_{..}) \quad (5.5)$$

(3.5)

OLS on this model gives  $\tilde{\beta}$  the Within estimator for the two-way model. Once again, the Within estimate of the intercept can be deduced from

$$\tilde{\alpha} = \bar{y}_{..} - \tilde{\beta} \bar{x}_{..}$$

and those of  $\mu_i$  and  $\lambda_t$  are given by

$$\tilde{\mu}_i = (\bar{y}_{i.} - \bar{y}_{..}) - \tilde{\beta} (\bar{x}_{i.} - \bar{x}_{..}) \quad (5.6)$$

(3.6)

$$\tilde{\lambda}_t = (\bar{y}_{.t} - \bar{y}_{..}) - \tilde{\beta} (\bar{x}_{.t} - \bar{x}_{..}) \quad (5.7)$$

(3.7)

Note that the Within estimator cannot estimate the effect of time-invariant and individualinvariant variables because the Q transformation wipes out these variables. If the true model is a two-way fixed effects model as in (3.2), then OLS on (2.1) yields biased and inconsistent estimates of the regression coefficients. OLS ignores both sets of dummy variables, whereas the one-way fixed effects estimator considered in Chapter 2 ignores only the time dummies. If these time dummies are statistically significant, the one-way fixed effects estimator will also suffer from omission bias.



### 5.2.1 Testing for Fixed Effects

As in the one-way error component model case, one can test for joint significance of the dummy variables:

$$H_0 : \mu_1 = \dots = \mu_{N-1} = 0 \quad \text{and} \quad \lambda_1 = \dots = \lambda_{T-1} = 0$$

The restricted residual sums of squares (RRSS) is that of pooled OLS and the unrestricted residual sums of squares (URSS) is that from the Within regression in (3.5). In this case,

$$F_1 = \frac{(\text{RRSS} - \text{URSS}) / (N + T - 2)}{\text{URSS} / ((N - 1)(T - 1) - K)} \stackrel{H_0}{\sim} F_{(N+T-2), (N-1)(T-1)-K} \quad (5.8)$$

(3.8)

Next, one can test for the existence of individual effects allowing for time effects, i.e.  $H_2 : \mu_1 = \dots = \mu_N = 0$  allowing  $\lambda \neq 0$  for  $t = 1 \dots T - 1$

The URSS is still the Within residual sum of squares. However, the RRSS is the regression with time-series dummies only, or the regression based upon

$$(y_{it} - \bar{y}_{.t}) = (x_{it} - \bar{x}_{.t}) \beta + (u_{it} - \bar{u}_{.t}) \quad (5.9)$$

(3.9)

In this case the resulting  $F$ -statistic is  $F_2 \stackrel{H_0}{\sim} F_{(N-1), (N-1)(T-1)-K}$ . Note that  $F_2$  differs from  $F_0$  in (2.12) in testing for  $\mu_i = 0$ . The latter tests  $H_0 : \mu_i = 0$  assuming that  $\lambda_t = 0$ , whereas the former tests  $H_2 : \mu_i = 0$  allowing  $\lambda_t \neq 0$  for  $t = 1, \dots, T - 1$ . Similarly, one can test for the existence of time effects allowing for individual effects, i.e.

$$H_3 : \lambda_1 = \dots = \lambda_{T-1} = 0 \quad \text{allowing} \quad \mu_i \neq 0; i = 1, \dots, (N - 1) \quad (5.10)$$

The RRSS is given by the regression in (2.10), while the URSS is obtained from the regression (3.5). In this case, the resulting F-statistic is  $F_3 \stackrel{H_0}{\sim} F_{(T-1), (N-1)(T-1)-K}$ .

#### Computational Warning

As in the one-way model,  $s^2$  from the regression in (3.5) as obtained from any standard regression package has to be adjusted for loss of degrees of freedom. In this case, one divides by  $(N - 1)(T - 1) - K$  and multiplies by  $(NT - K)$  to get the proper variance-covariance matrix of the Within estimator.

## 5.3 THE RANDOM EFFECTS MODEL

If  $\mu_i \sim \text{IID}(0, \sigma_\mu^2)$ ,  $\lambda_t \sim \text{IID}(0, \sigma_\lambda^2)$  and  $v_{it} \sim \text{IID}(0, \sigma_v^2)$  independent of each other, then this is the two-way random effects model. In addition,  $X_{it}$  is independent of  $\mu_i, \lambda_t$  and  $v_{it}$  for all  $i$  and  $t$ . Inference in this case pertains to the large population from which this sample was randomly drawn. From (3.2), one can compute the variance-covariance matrix

$$\begin{aligned} \Omega &= E(uu') = Z_\mu E(\mu\mu') Z_\mu' + Z_\lambda E(\lambda\lambda') Z_\lambda' + \sigma_v^2 I_{NT} \\ &= \sigma_\mu^2 (I_N \otimes J_T) + \sigma_\lambda^2 (J_N \otimes I_T) + \sigma_v^2 (I_N \otimes I_T) \end{aligned} \quad (5.11)$$

(3.10)

The disturbances are homoskedastic with  $\text{var}(u_{it}) = \sigma_\mu^2 + \sigma_\lambda^2 + \sigma_v^2$  for all  $i$  and  $t$ ,

$$\begin{aligned} \text{cov}(u_{it}, u_{js}) &= \sigma_\mu^2 & i = j, t \neq s \\ &= \sigma_\lambda^2 & i \neq j, t = s \end{aligned} \quad (5.12)$$

(3.11)

and zero otherwise. This means that the correlation coefficient

$$\begin{aligned} \text{correl}(u_{it}, u_{js}) &= \sigma_\mu^2 / (\sigma_\mu^2 + \sigma_\lambda^2 + \sigma_v^2) & i = j, t \neq s \\ &= \sigma_\lambda^2 / (\sigma_\mu^2 + \sigma_\lambda^2 + \sigma_v^2) & i \neq j, t = s \\ &= 1 & i = j, t = s \\ &= 0 & i \neq j, t \neq s \end{aligned} \quad (5.13)$$

(3.12)

In order to get  $\Omega^{-1}$ , we replace  $J_N$  by  $N\bar{J}_N$ ,  $I_N$  by  $E_N + \bar{J}_N$ ,  $J_T$  by  $T\bar{J}_T$  and  $I_T$  by  $E_T + \bar{J}_T$  and collect terms with the same matrices. This gives

$$\Omega = \sum_{i=1}^4 \lambda_i Q_i \quad (5.14)$$

(3.13)

where  $\lambda_1 = \sigma_v^2$ ,  $\lambda_2 = T\sigma_\mu^2 + \sigma_v^2$ ,  $\lambda_3 = N\sigma_\lambda^2 + \sigma_v^2$  and  $\lambda_4 = T\sigma_\mu^2 + N\sigma_\lambda^2 + \sigma_v^2$ . Correspondingly,  $Q_1 = E_N \otimes E_T$ ,  $Q_2 = E_N \otimes \bar{J}_T$ ,  $Q_3 = \bar{J}_N \otimes E_T$  and  $Q_4 = \bar{J}_N \otimes \bar{J}_T$ , respectively. The  $\lambda_i$  are the distinct characteristic roots of  $\Omega$  and the  $Q_i$  are the corresponding matrices of eigenprojectors.  $\lambda_1$  is of multiplicity  $(N-1)(T-1)$ ,  $\lambda_2$  is of multiplicity  $(N-1)$ ,  $\lambda_3$  is of multiplicity  $(T-1)$  and  $\lambda_4$  is of multiplicity 1.<sup>1</sup> Each  $Q_i$  is symmetric and idempotent with its rank equal to its trace. Moreover, the  $Q_i$  are pairwise orthogonal and sum to the identity matrix. The advantages of this spectral decomposition are that

$$\Omega^r = \sum_{i=1}^4 \lambda_i^r Q_i \quad (5.15)$$

(3.14)

where  $r$  is an arbitrary scalar so that

$$\sigma_v \Omega^{-1/2} = \sum_{i=1}^4 (\sigma_v / \lambda_i^{1/2}) Q_i \quad (5.16)$$

(3.15)

and the typical element of  $y^* = \sigma_v \Omega^{-1/2} y$  is given by

$$y_{it}^* = y_{it} - \theta_1 \bar{y}_{i.} - \theta_2 \bar{y}_{.t} + \theta_3 \bar{y}_{..} \quad (5.17)$$

(3.16)

where  $\theta_1 = 1 - (\sigma_v / \lambda_2^{1/2})$ ,  $\theta_2 = 1 - (\sigma_v / \lambda_3^{1/2})$  and  $\theta_3 = \theta_1 + \theta_2 + (\sigma_v / \lambda_4^{1/2}) - 1$ . As a result, GLS can be obtained as OLS of  $y^*$  on  $Z^*$ , where  $Z^* = \sigma_v \Omega^{-1/2} Z$ . This transformation was first derived by Fuller and Battese (1974), see also Baltagi (1993).

The best quadratic unbiased (BQU) estimators of the variance components arise naturally from the fact that  $Q_i u \sim (0, \lambda_i Q_i)$ . Hence,

$$\hat{\lambda}_i = u' Q_i u / \text{tr}(Q_i) \quad (5.18)$$

(3.17)

is the BQU estimator of  $\lambda_i$  for  $i = 1, 2, 3$ . These ANOVA estimators are minimum variance unbiased (MVU) under normality of the disturbances (see Graybill, 1961). As in the one-way error component model, one can obtain feasible estimates of the variance components by replacing the true disturbances by OLS residuals (see Wallace and Hussain, 1969). OLS is still an unbiased and consistent estimator under the random effects model, but it is inefficient and results in biased standard errors and  $t$ -statistics. Alternatively, one could substitute the Within residuals with  $\tilde{u} = y - \tilde{\alpha} \iota_{NT} - X\tilde{\beta}$ , where  $\tilde{\alpha} = \bar{y}_{..} - \bar{X}'_{..}\tilde{\beta}$  and  $\tilde{\beta}$  is obtained by the regression in (3.5). This is the method proposed by Amemiya (1971). In fact, Amemiya (1971) shows that the Wallace and Hussain (1969) estimates of the variance components have a different asymptotic distribution from that knowing the true disturbances, while the Amemiya (1971) estimates of the variance components have the same asymptotic distribution as that knowing the true disturbances:

$$\begin{pmatrix} \sqrt{NT}(\hat{\sigma}_v^2 - \sigma_v^2) \\ \sqrt{N}(\hat{\sigma}_\mu^2 - \sigma_\mu^2) \\ \sqrt{T}(\hat{\sigma}^2 - \sigma_\mu^2) \end{pmatrix} \sim N \left( 0, \begin{pmatrix} 2\sigma_v^4 & 0 & 0 \\ 0 & 2\sigma_\mu^4 & 0 \\ 0 & 0 & 2\sigma^4 \end{pmatrix} \right) \quad (5.19)$$

(3.18)

Substituting OLS or Within residuals instead of the true disturbances in (3.17) introduces bias in the corresponding estimates of the variance components. The degrees of freedom corrections that make these estimates unbiased depend upon traces of matrices that involve the matrix of regressors  $X$ . These corrections are given in Wallace and Hussain (1969) and Amemiya (1971), respectively. Alternatively, one can infer these correction terms from the more general unbalanced error component model considered in Chapter 9. Swamy and Arora (1972) suggest running three least squares regressions and estimating the variance components from the corresponding mean square errors of these regressions. The first regression corresponds to the Within regression which transforms the original model by  $Q_1 = E_N \otimes E_T$ . This is equivalent to the regression in (3.5), and yields the following estimate of  $\sigma_v^2$ :

$$\hat{\lambda}_1 = \hat{\sigma}_v^2 = [y' Q_1 y - y' Q_1 X (X' Q_1 X)^{-1} X' Q_1 y] / [(N-1)(T-1) - K] \quad (5.20)$$

(3.19)

(\hat{\alpha} \text{ arranger})

The second regression is the Between individuals regression which transforms the original model by

$$Q_2 = E_N \otimes \bar{J}_T$$

This is equivalent to the regression of

$$(\bar{y}_{i.} - \bar{y}_{i..})$$

on

$$(\bar{X}_{i.} - \bar{X}_{i..})$$

and yields the following estimate of  $\sigma_v^2$ :

$$\hat{\lambda}_2 = [y' Q_2 y - y' Q_2 X (X' Q_2 X)^{-1} X' Q_2 y] / [(N-1) - K] \quad (5.21)$$

(3.20)

from which one obtains  $\hat{\sigma}_\mu^2 = (\hat{\lambda}_2 - \hat{\sigma}_v^2) / T$ . The third regression is the Between time-periods regression which transforms the original model by  $Q_3 = \bar{J}_N \otimes E_T$ . This is equivalent to the regression of  $(\bar{y}_{.t} - \bar{y}_{..})$  on  $(\bar{X}_{.t} - \bar{X}_{..})$  and yields the following estimate of  $\lambda_3 = N\sigma_\lambda^2 + \sigma_v^2$

$$\hat{\lambda}_3 = [y'Q_3y - y'Q_3X(X'Q_3X)^{-1}X'Q_3y] / [(T-1) - K] \quad (5.22)$$

(3.21)

from which one obtains

$$\widehat{(\sigma_\lambda^2)} = \hat{\lambda}_3 - \hat{\lambda}_v) / N$$

Stacking the three transformed regressions just performed yields

$$\begin{pmatrix} Q_1y \\ Q_2y \\ Q_3y \end{pmatrix} = \begin{pmatrix} Q_1X \\ Q_2X \\ Q_3X \end{pmatrix} \beta + \begin{pmatrix} Q_1u \\ Q_2u \\ Q_3u \end{pmatrix} \quad (5.23)$$

(3.22)

since  $Q_i t_{NT} = 0$  for  $i = 1, 2, 3$ , and the transformed error has mean 0 and variance-covariance matrix given by  $\text{diag}[\lambda_i Q_i]$  with  $i = 1, 2, 3$ . Problem 3.4 asks the reader to show that OLS on this system of  $3NT$  observations yields the same estimator of  $\beta$  as OLS on the pooled model (2.3). Also, GLS on this system of equations (3.22) yields the same estimator of  $\beta$  as GLS on (2.3). In fact,

$$\begin{aligned} \hat{\beta}_{\text{GLS}} &= [(X'Q_1X) / \sigma_v^2 + (X'Q_2X) / \lambda_2 + (X'Q_3X) / \lambda_3]^{-1} \\ &\quad \times [(X'Q_1y) / \sigma_v^2 + (X'Q_2y) / \lambda_2 + (X'Q_3y) / \lambda_3] \\ &= [W_{XX} + \phi_2^2 B_{XX} + \phi_3^2 C_{XX}]^{-1} [W_{Xy} + \phi_2^2 B_{Xy} + \phi_3^2 C_{Xy}] \end{aligned} \quad (5.24)$$

(3.23)

with  $\text{var}(\hat{\beta}_{\text{GLS}}) = \sigma_v^2 [W_{XX} + \phi_2^2 B_{XX} + \phi_3^2 C_{XX}]^{-1}$ . Note that  $W_{XX} = X'Q_1X$ ,  $B_{XX} = X'Q_2X$  and  $C_{XX} = X'Q_3X$  with  $\phi_2^2 = \sigma_v^2 / \lambda_2$ ,  $\phi_3^2 = \sigma_v^2 / \lambda_3$ . Also, the Within estimator of  $\beta$  is  $\tilde{\beta}_W = W_{XX}^{-1} W_{Xy}$ , the Between individuals estimator of  $\beta$  is  $\hat{\beta}_B = B_{XX}^{-1} B_{Xy}$  and the Between timeperiods estimator of  $\beta$  is  $\hat{\beta}_C = C_{XX}^{-1} C_{Xy}$ . This shows that  $\hat{\beta}_{\text{GLS}}$  is a matrix-weighted average of  $\tilde{\beta}_W$ ,  $\hat{\beta}_B$  and  $\hat{\beta}_C$ . In fact,

$$\hat{\beta}_{\text{GLS}} = W_1 \tilde{\beta}_W + W_2 \hat{\beta}_B + W_3 \hat{\beta}_C \quad (5.25)$$

(3.24)

where

$$\begin{aligned} W_1 &= [W_{XX} + \phi_2^2 B_{XX} + \phi_3^2 C_{XX}]^{-1} W_{XX} \\ W_2 &= [W_{XX} + \phi_2^2 B_{XX} + \phi_3^2 C_{XX}]^{-1} (\phi_2^2 B_{XX}) \\ W_3 &= [W_{XX} + \phi_2^2 B_{XX} + \phi_3^2 C_{XX}]^{-1} (\phi_3^2 C_{XX}) \end{aligned} \quad (5.26)$$

This was demonstrated by Maddala (1971). Note that (i) if  $\sigma_\mu^2 = \sigma_\lambda^2 = 0$ ,  $\phi_2^2 = \phi_3^2 = 1$  and  $\hat{\beta}_{\text{GLS}}$  reduces to  $\hat{\beta}_{\text{OLS}}$ ; (ii) as  $T$  and  $N \rightarrow \infty$ ,  $\phi_2^2$  and  $\phi_3^2 \rightarrow 0$  and  $\hat{\beta}_{\text{GLS}}$  tends to  $\tilde{\beta}_W$ ; (iii) if  $\phi_2^2 \rightarrow \infty$  with  $\phi_3^2$  finite, then  $\hat{\beta}_{\text{GLS}}$  tends to  $\hat{\beta}_B$ ; (iv) if  $\phi_3^2 \rightarrow \infty$  with  $\phi_2^2$  finite, then  $\hat{\beta}_{\text{GLS}}$  tends to  $\hat{\beta}_C$ . Wallace and Hussain (1969) compare  $\hat{\beta}_{\text{GLS}}$  and  $\tilde{\beta}_{\text{Within}}$  in the case of nonstochastic (repetitive)  $X$  and find that both are (i) asymptotically normal, (ii) consistent and unbiased and that

- (iii)  $\hat{\beta}_{\text{GLS}}$  has a smaller generalized variance (i.e. more efficient) in finite samples. In the case of non-stochastic (nonrepetitive)  $X$  they find that both  $\hat{\beta}_{\text{GLS}}$  and  $\tilde{\beta}_{\text{Within}}$  are consistent, asymptotically unbiased and have equivalent asymptotic variance-covariance matrices, as both  $N$  and  $T \rightarrow \infty$ . The last statement can be proved as follows: the limiting variance of the GLS estimator is

$$\frac{1}{NT} \lim_{\substack{N \rightarrow \infty \\ T \rightarrow \infty}} (X' \Omega^{-1} X / NT)^{-1} = \frac{1}{NT} \lim_{\substack{N \rightarrow \infty \\ T \rightarrow \infty}} \left[ \sum_{i=1}^3 \frac{1}{\lambda_i} (X' Q_i X / NT) \right]^{-1} \quad (5.27)$$

(3.25)

but the limit of the inverse is the inverse of the limit, and

$$\lim_{\substack{N \rightarrow \infty \\ T \rightarrow \infty}} \frac{X' Q_i X}{NT} \quad \text{for } i = 1, 2, 3 \quad (5.28)$$

(3.26)

all exist and are positive semidefinite, since

$$\lim_{\substack{N \rightarrow \infty \\ T \rightarrow \infty}} (X' X / NT)$$

is assumed finite and positive definite. Hence

$$\lim_{\substack{N \rightarrow \infty \\ T \rightarrow \infty}} \frac{1}{(N\sigma_\lambda^2 + \sigma_v^2)} \left( \frac{X' Q_3 X}{NT} \right) = 0$$

and

$$\lim_{\substack{N \rightarrow \infty \\ T \rightarrow \infty}} \frac{1}{(T\sigma_\mu^2 + \sigma_v^2)} \left( \frac{X' Q_2 X}{NT} \right) = 0$$

Therefore the limiting variance of the GLS estimator becomes

$$\frac{1}{NT} \lim_{\substack{N \rightarrow \infty \\ T \rightarrow \infty}} \sigma_v^2 \left( \frac{X' Q_1 X}{NT} \right)^{-1}$$

which is the limiting variance of the Within estimator. One can extend Nerlove's (1971a) method for the one-way model, by estimating  $\sigma_\mu^2$  as  $\sum_{i=1}^N (\hat{\mu}_i - \bar{\mu})^2 / (N - 1)$  and  $\sigma_\lambda^2$  as  $\sum_{t=1}^T (\hat{\lambda}_t - \bar{\lambda})^2 / (T - 1)$  where the  $\hat{\mu}_i$  and  $\hat{\lambda}_t$  are obtained as coefficients from the least squares dummy variables regression (LSDV).  $\sigma_v^2$  is estimated from the Within residual sums of squares divided by  $NT$ . Baltagi (1995, appendix 3) develops two other methods of estimating the variance components. The first is Rao's (1970) minimum norm quadratic unbiased estimation (MINQUE) and the second is Henderson's method III as described by Fuller and Battese (1973). These methods require more notation and development and may be skipped in a brief course on this subject. Chapter 9 studies these estimation methods in the context of an unbalanced error component model.

Baltagi (1981a) performed a Monte Carlo study on a simple regression equation with twoway error component disturbances and studied the properties of the following estimators: OLS, the Within estimator and six feasible GLS estimators denoted by WALHUS, AMEMIYA, SWAR, MINQUE, FUBA and NERLOVE corresponding to the methods developed by Wallace and Hussain (1969), Amemiya (1971), Swamy and Arora (1972), Rao (1972), Fuller and Battese (1974) and Nerlove (1971a), respectively. The mean square error of these estimators was computed relative to that of true GLS, i.e. GLS knowing the true variance components. To review some of the properties of these estimators: OLS is unbiased, but asymptotically

inefficient, and its standard errors are biased; see Moulton (1986) for the extent of this bias in empirical applications. In contrast, the Within estimator is unbiased whether or not prior

information about the variance components is available. It is also asymptotically equivalent to the GLS estimator in case of weakly nonstochastic exogenous variables. Early in the literature, Wallace and Hussain (1969) recommended the Within estimator for the practical researcher, based on theoretical considerations but more importantly for its ease of computation. In Wallace and Hussain's (1969, p. 66) words the "covariance estimators come off with a surprisingly clear bill of health". True GLS is BLUE, but the variance components are usually not known and have to be estimated. All of the feasible GLS estimators considered are asymptotically efficient. In fact, Prucha (1984) showed that as long as the estimate of  $\sigma_v^2$  is consistent, and the probability limits of the estimates  $\sigma_\mu^2$  and  $\sigma_\lambda^2$  are finite, the corresponding feasible GLS estimator is asymptotically efficient. Also, Swamy and Arora (1972) proved the existence of a family of asymptotically efficient two-stage feasible GLS estimators of the regression coefficients. Therefore, based on asymptotics only, one cannot differentiate among these twostage GLS estimators. This leaves undecided the question of which estimator is the best to use. Some analytical results were obtained by Swamy (1971) and Swamy and Arora (1972). These studies derived the relative efficiencies of (i) SWAR with respect to OLS, (ii) SWAR with respect to Within and (iii) Within with respect to OLS. Then, for various values of  $N, T$ , the variance components, the Between groups, Between time-periods and Within groups sums of squares of the independent variable, they tabulated these relative efficiency values (see Swamy, 1971, chapters II and III; Swamy and Arora, 1972, p. 272). Among their basic findings is the fact that, for small samples, SWAR is less efficient than OLS if  $\sigma_\mu^2$  and  $\sigma_\lambda^2$  are small. Also, SWAR is less efficient than Within if  $\sigma_\mu^2$  and  $\sigma_\lambda^2$  are large. The latter result is disconcerting, since Within, which uses only a part of the available data, is more efficient than SWAR, a feasible GLS estimator, which uses all of the available data.

## Chapter 6

# Test of Hypotheses with Panel Data

### 6.1 REFERENCES





# Chapter 7

## Methods

We describe our methods in this chapter.

Les données de panel, ou données longitudinales possèdent les deux dimensions précédentes (individuelle et temporelle). En effet, il est souvent intéressant d'identifier l'effet associé à chaque individu (un effet qui ne varie pas dans le temps, mais qui varie d'un individu à un autre). Cet effet peut être fixe ou aléatoire.

Par conséquent, le modèle en données de panel s'écrit comme un modèle à double indice qui prend la forme suivante :

$$Y_{it} = \alpha_i \sum_k \beta_{ki} x_{ki} + \epsilon_{it}$$

avec

$$i : 1 \rightarrow N$$

et

$$t : 1 \rightarrow T$$

La double dimension qu'offrent les données de panel est un atout majeur. En effet, si les données en séries temporelles permettent d'étudier l'évolution des relations dans le temps, elles ne permettent pas de contrôler l'hétérogénéité entre les individus. A l'inverse, les données en coupes transversales permettent d'analyser l'hétérogénéité entre les individus mais elles ne peuvent pas tenir compte des comportements dynamiques, puisque la dimension temporelle est exclue du champ d'analyse.

Ainsi, en utilisant des données de panel, on pourra exploiter les deux sources de variation de l'information statistique : - Temporelle où variabilité intra-individuelle (within) - et individuelle ou variabilité inter-individuelle (Between).



## Chapter 8

# Analyses

Nous faisons *application* des méthodes présentées dans le chapitre précédant pour l'analyse des données de pannel

Avant de passer à la modélisation, nous ferons une description de nos variables d'intérêt d'une manière statique : nos prédicteurs et les variables réponses

### 8.1 Netoyage de la base des données

Apperçue globale des données

Voici la structure de la base des données

```
## Rows: 3,310
## Columns: 6
## $ `N°` <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 1~
## $ `Country/destination` <chr> "AFRIQUE DU SUD", "AFRIQUE DU SUD", "AFRIQUE DU ~
## $ Year <dbl> 2011, 2011, 2011, 2013, 2013, 2013, 2013, 2013, ~
## $ Goods <fct> "GRUES SUR PNEUMATIQUE", "CAMION FAMIL", "CAMION~
## $ Weight <dbl> 13500, 12000, 24000, 183, 19520, 19520, 19520, 1~
## $ Taxe <dbl> 0, 0, 0, 0, 264771, 272817, 283220, 264142, 0, 0~
```

Table 8.1: Echantillon de la base des données

N°	Country/destination	Year	Goods	Weight	Taxe
1	AFRIQUE DU SUD	2011	GRUES SUR PNEUMATIQUE	13500	0
2	AFRIQUE DU SUD	2011	CAMION FAMIL	12000	0
3	AFRIQUE DU SUD	2011	CAMION SOMUL	24000	0
4	AFRIQUE DU SUD	2013	Café vert arabica k4	183	0
5	AFRIQUE DU SUD	2013	Café vert arabica k4	19520	264771
6	AFRIQUE DU SUD	2013	Café vert arabica k4	19520	272817
7	AFRIQUE DU SUD	2013	Café vert arabica k4	19520	283220
8	AFRIQUE DU SUD	2013	Café vert arabica k4	19520	264142
9	AFRIQUE DU SUD	2013	CAMION	24000	0
10	AFRIQUE DU SUD	2017	Instruments et appareils du n°90.15	654	0

Voici les modalités de la variable **Goods** qui signifie **Marchandises**

Table 8.2: Modalités de la variable Goods à l'importation des données

x
0
3Café vert arabica, en feve K3
Abats comestibles,congeles,de chevaux,anes,mulets,ovins ou caprins
ABATS COMESTIBLES;CONGELES;DE CHEVAUX;ANES;MULETS;OVINS
Accessoires de radio diffusion
Accessoires de vehicules
Accumulateurs electriques
Acide acetique
ages de 5 ans ou moins
ages de plus de 5 ans
Agés de plus de 5 ans ou moins
Alcaloides du quinquina et leurs derives;
ALCOOL ETYLIQUE NON DENATURE
ambulance d'une cylindree excedant 2500 cm3
Antennes
Antennes et reflecteurs d'antennes
antennes et refleteurs
Appareils d'eclairage electriques
Appareils d'eclairage non electriques
Appareils d'eclairages electriques
Appareils du n°84.14
Appareils electrothermiques pour la
appareils pour la reception,la conversion et la transmission
Art et materiel d'athletisme
Articles confectionnes en textiles
Articles d'economie domestique,en
Articles de bureau
ARTICLES DE BUREAU
Articles de bureau ou de la papeterie
Articles de friperie
ARTICLES DE FRIPERIE
Articles et materiel d'athletisme
Ashok Layland
ASPIRATEUR ET ACCESSOIRES
Autes bois sciés
AUTRE MACHINE ET APPAREIL A IMPRIMER
AUTRE MINERAIS DE TITANE (Coltant)
AUTRE PARTIE DE PLANTE
AUTRE PEAUX
AUTRE PREP ALIMENTAIRE
Autre vehicules automobiles a usages speciaux
Autres

## AUTRES

Autres bois scies

Autres abats comestibles frais ou réfrigérés de chevaux,ânes,mulets,ovins,caprins

Autres abats comestibles,congelés,de chevaux,ânes,mulets,ovins ou caprins

Autres accessoires de tuyauterie en fonte

Autres accumulateurs électriques

Autres appareils éleveurs, à action continue pour marchandises

Autres armes

Autres art de bureau ou de papeterie en papier

Autres Art de ménage

Autres articles d'économie domestique, en

autres articles de bureau

## AUTRES ARTICLES DE BUREAU OU D PAPETERIE EN PAPIER OU CARTON

Autres articles de bureau ou de papeterie en

Autres articles de campement

Autres articles de friperie

Autres articles de ménage ou d'économie en aluminium

Autres articles de transport ou d'emballage

Autres articles en toles emailles

Autres babeurre,lait et creme

Autres babeurre,lait et creme caillés,yoghourt

autres baies fraîches

Autres bois

Autres bois plaques ou stratifiés

## AUTRES BOIS TROPICAUX SCIES LONG

Autres bois sciées

Autres bois scies

## AUTRES BOIS SCIES

autres bois sciés

Autres bois sciés

Autres bois tropicaux, à scies long, sciages d'1 avives d'1 épaisseur supérieure à 50mm

Autres bois tropicaux, scies lon, sciages avives d'1 épaisseur supérieure à 50mm

Autres bois tropicaux,scies long

## AUTRES BOIS TROPICAUX,SCIES LONG-SCIAGES AVIVESD'1 EPAISSEUR SUPERIEURE A 50MM

Autres bois tropicaux,scies long,sciages avivées

Autres bois tropicaux,scies long,sciages avives

Autres bois tropicaux,sciés long...sciages avives

Autres bois tropicauxmscies long

Autres Caoutchouc

Autres cassiterites

Autres chariots y.c. chariots tracteurs,sans

Autres chaussures

Autres coltan

Autres coltans

Autres constructions

Autres couvertures non chauffantes

Autres déchets et débris

Autres déchets et débris d'aciers alliés

Autres déchets et débris d'aciers alliés  
 Autres dechets et debris d aciers  
 autres eaux, y compris l'eau douce  
 Autres engins du n84 29  
 AUTRES EQUIPEMENTS DE PROTECTION

Autres et debris de bois  
 Autres etiquettes de tous genres, en papier  
 Autres fours industriels ou de laboratoires  
 Autres fours, cuisinieres, rechauds, grils  
 Autres fours,cuisinières,rechauds

AUTRES GROUPES ELECT  
 Autres groupes electrogenes  
 Autres haut-parleurs  
 Autres huiles de paliste ou babassu  
 Autres instrument et appareils du n°90,18

Autres instruments de musique a vent  
 Autres instruments et appareils  
 Autres instruments et appareils du n 90.18  
 Autres jus de tout autres fruit ou legume  
 Autres legumes ¿ cosse secs, ¿coss¿s, m¿me

Autres legumes, frais ou refrigeres  
 Autres lunettes  
 autres machines  
 Autres machines  
 Autres machines electriques a laver la

Autres machines et appareils  
 Autres machines et appareils de manutention du n,8428  
 Autres machines et appareils du n 8515  
 Autres medicaments  
 AUTRES MEDICAMENTS

Autres mélanges d'épices  
 Autres meubles et leurs parties  
 AUTRES MINERAIS DE TANTALE  
 AUTRES MINERALS DE TANTALE (Coltan)  
 Autres montres (y.c. compteur de temps)

Autres moteurs diésel  
 Autres moteurs diésels  
 Autres nattes en matières vegetales  
 autres outils  
 Autres outils agricoles

Autres ouvrages en plomb  
 Autres papiers non denommes ni compris ailleurs  
 AUTRES PAPIERS NON DENOMMES NI COMPRIS AILLEURS  
 Autres papiers non nommés ni compris ailleurs  
 Autres parties d'avions ou d'helicopteres

Autres parties de lampes portatives  
 AUTRES PARTIES DE PLANTES EN MEDECINE  
 AUTRES PARTIES DE PLANTES UTILISEES PRINCIPALEMENT EN MEDECINE

Autres parties de plantes utilisés en medecine

Autres parties des appareils des n 88.01 ou

Autres parties des plantes utilisées principalement en medecine

Autres parties et accessoires des vehicules

Autres parties et accessoires de

AUTRES PARTIES ET ACCESSOIRES DE VEHICULES DES n87.01 a 87.05

AUTRES PARTIES ET ACCESSOIRES DES VEHICULES

autres parties et accessoires des vehicules des 8701 a 8705

Autres parties et accessoires des vehicules des 8701 a 8705

AUTRES PARTIES ET ACCESSOIRES DES VEHICULES DES N 87.01 A 87.05

Autres parties et accessoires des vehicules des n 8701 à 8705

Autres parties et accessoires des vehicules n 8701 à 8705

AUTRES PEAUX

AUTRES PEAUX DES BOVINS

Autres pierres

autres piles et batteries

Autres plantes

Autres plantes, parties de plantes,

AUTRES PLAQUES

Autres plaques, feuilles,bandes en polymeres

Autres pneumat autres qu'a crpn,a chvn en autr etc synt

Autres pneumatiques neuf en autres mat que les mat synth de type pour voiture tourisme

AUTRES POMPES A DISPOSITIF MESUREUR OU CONCUES POUR EN COMPORTER UN

Autres préparations alimentaires

Autres preparations alimentaires n d c a

Autres preparations homogenisees

AUTRES PRODUITS DE BEAUTE

Autres produits de beaute,de

Autres produits du no 33.07,contenant de

Autres recepteurs fixes de radiodiffusion

AUTRES RECERVOIRS

Autres refrigerateurs menagers

Autres sacs,sachets,pochettes

Autres salmonides entiers,

Autres savons

AUTRES TENTES

Autres tissus de coton imprimé,200 g/m2 et

Autres tracteurs

Autres unites de machines automatiques de

Autres vehicules autom a usages speciaux

Autres vehicules automobiles a usages

Autres vehicules automobiles a usages speciaux

Autres vetements de dessous en coton, pour

Autres vetements en bonneterie d'autres

Autres, en couleurs

Babeurre,lait et creme cailles,yoghourt ou avec fruits ou cacao

BACHES

Baches et stores d'exterieur de fibres

Baches et stores d'exterieur de fibres synth

Baies fraîches

bières de malt titrant moins de 6°

BISCUIT

Biscuits additionnes d'edulcorants

BITUMES

Bois ciés

BOIS RABOTES OU PONCES

Bois scies

BOIS SCIES

Bois sciés

Bois scies longitudinalement

Bois tropicaux, scie long..sciages avives d'1 epaisseur supérieur à 50mm

Bois tropicaux

Bois tropicaux scies

Bois tropicaux scies long,sciages avives d'un epaisseur superieur à 50 mm

Bois tropicaux,scies

Bois tropicaux,scies long

Bois tropicaux,scies long,sciages avives

Bois tropicaux,scies long,sciages vives d'un epaisseur supérieure à 50 mm

Boites et cartonnages,pliants,en papier ou carton non ondulé

Boites et caisses en papier ou carton ondule

Boites et caisses en papier ou carton ondulé

Boites et cartonnages,pliants en papier ou carton non ondule

Boites et cartonnages pliants en papier ou carton non ondule

Boites et cartonnages, en papier ou carton non ondule

Boites et cartonnages, pliants, en papier ou

Boites et cartonnages, pliants, en papier ou caton non ondule

Boites et cartonnages,pliants

Boites et cartonnages,pliants , en papier ou carton

Boites et cartonnages,pliants en papier ou carton non ondule

BOITES ET CARTONNAGES,PLIANTS EN PAPIER OU CARTON NON ONDULE

Boites et cartonnages,pliants,en papier

Boites et cartonnages,pliants,en papier ou carton non ondule

Boites et cartonnages,pliants,en papier ou carton non ondulé

Boites et cartonnages,pliants,en papier ou carton non ondules

Boites et cartonnagesmpliantsmen papier ou carton non ondule

Boites et cartonnages

Boites et catonnages, pliants, en papier ou carton non ondule

Boites, caisses et similaires en matieres plastiques

Boites,caisses,casiers et similaires en matières plastiques

Boites,caisses,casiers et similaires plastiques

Brosses a dents y compris les brosses a

Cables coaxiaux

Cadres et conteneurs

Cadres et conteneurs multimodaux y.c.conteneurs citernes et reservoirs

CAF Vert arabica, en feves K4, Est

Caf? vert arabica, en feves K4, Est



Caf<sub>i</sub> vert arabica, en feves K3, Est  
 CAFE  
 Cafe arabica  
 CAFE ARABICA  
 Café arabica  
 Café Arabica  
  
 Café arabica k4  
 Café arabica k7  
 Café arabica, en feve K4  
 Café arabica,en feves k3,est  
 Cafe arabica,en feves k4  
  
 Café arabica,en feves k4,est  
 Cafe arabica,en feves k7  
 Café cert, en feves k4 (kivu4)  
 Cafe non torrefie, non decaféiné  
 Café non torrifié  
  
 Café ver arabica k4  
 CAFE VERT  
 Café vert  
 Café vert arabica  
 CAFE VERT AFRICA;EN FEVES K4  
  
 CAFE VERT ARAB K4  
 Cafe vert arabica  
 CAFE VERT ARABICA  
 Café vert arabica  
 Café vert Arabica  
  
 CAFE VERT ARABICA ;EN FEVES  
 Cafe vert arabica en feves k4  
 café vert arabica en feve k4 Est  
 Cafe vert arabica en feves  
 café vert arabica en feves  
  
 Cafe vert arabica en fèves  
 Café vert arabica en fèves  
 CAFE VERT ARABICA EN FEVES DE K4  
 Cafe vert arabica en feves k3  
 CAFE vert arabica en feves k3  
  
 Café vert arabica en feves k3  
 Café vert arabica en fèves K3  
 café vert arabica en feves k3 est  
 Cafe vert arabica en fèves K3(kivu)  
 cafe vert arabica en feves k4  
  
 Cafe vert arabica en feves k4  
 CAFE VERT ARABICA EN FEVES K4  
 Café vert arabica en feves k4  
 Café vert arabica en fèves K4  
 Cafe vert arabica en feves k4 est  
  
 café vert arabica en feves k4 est  
 Cafe vert arabica en fèves K4(kivu4)

Cafe vert arabica en fèves k4,Est  
 Cafe vert arabica en feves k7  
 Café vert arabica en feves,k3  
 Café vert arabica en feves,k4  
 Cafe vert arabica en fevesk4  
 Cafe vert arabica en fevres  
 Cafe vert arabica feves k4  
 café vert arabica k  
 Café vert arabica k'  
 CAFE VERT ARABICA K3  
 café vert arabica k3  
 Café vert arabica k3  
 Cafe vert arabica k4  
 CAFE VERT ARABICA k4  
 CAFE VERT ARABICA K4  
 café vert arabica k4  
 Café vert arabica k4  
 Café vert Arabica K4  
 Cafe vert arabica k7  
 CAFE VERT ARABICA K7  
 café vert arabica k7  
 Café vert arabica k7  
 Café vert arabica k8  
 Café vert arabica, en faves k4  
 Cafe vert arabica, en faveurs k4  
 Cafe vert arabica, en feve K3  
 Café vert arabica, en feve K3  
 Café vert arabica, en feve k3, est  
 Cafe vert arabica, en feve k4  
 café vert arabica, en feve K4  
 Café vert arabica, en feve k4  
 Café vert arabica, en feve K4  
 Cafe vert arabica, en feves k3  
 Café vert arabica, en feves k3  
 Café vert arabica, en feves K3 (KIVU 3 )  
 Cafe vert arabica, en feves k3 (kivu 3)  
 Cafe vert arabica, en feves k3 (kivu3)  
 café vert arabica, en feves k3, Est  
 Café vert arabica, en feves k3, Est  
 Café vert arabica, en fèves K3, EST  
 Cafe vert arabica, en feves k4  
 Café vert arabica, en feves k4  
 Cafe vert arabica, en feves k4 (kivu 4)  
 Café vert arabica, en feves k4 (kivu 4)  
 Café vert arabica, en feves K4 (KIVU 4)  
 Cafe vert arabica, en feves k4 (kivu4)  
 Café vert arabica, en feves K4 (KIVU4)  
 Café vert arabica, en feves k4 est

Cafe vert arabica, en feves K4, Est  
 Café vert arabica, en feves k4, Est  
 Café vert arabica, en feves K4, Est  
 Café vert arabica, en fèves K4, EST  
 Cafe vert arabica, en feves k5 (kivu 5)  
 Cafe vert arabica, en feves k6 (kivu 6)  
 Cafe vert arabica, en feves k7 (kivu 7)  
 Café vert arabica, en feves K7 (KIVU7)  
 Café vert arabica, en feves k7, Est  
 Café vert arabica,en feve k4 est  
 Café vert arabica,en feve k7 est  
 Café vert arabica,en feves  
 café vert arabica,en feves 4,est  
 cafe vert arabica,en feves k3  
 Cafe vert arabica,en feves k3  
 Café vert arabica,en feves K3  
 café vert arabica,en feves k3  
 Café vert arabica,en feves k3  
 café vert arabica,en fèves k3  
 CAFE VERT ARABICA,EN FEVES K3(kivu)  
 Café vert arabica,en feves K3, Est  
 café vert arabica,en feves k3,Est  
 Café vert arabica,en feves k3,Est  
 Café vert arabica,en feves K3,Est  
 cafe vert arabica,en feves k4  
 Cafe vert arabica,en feves k4  
 Café vert arabica,en feves k4  
 café vert arabica,en fèves k4  
 café vert arabica,en feves k4 est  
 Café vert arabica,en feves k4 est  
 Café vert arabica,en feves K4 EST  
 CAFE VERT ARABICA,EN FEVES K4(kivi)  
 CAFE VERT ARABICA,EN FEVES K4(kivu4)  
 Café vert arabica,en feves k4(kivu4)  
 Cafe vert arabica,en feves k4,est  
 café vert arabica,en feves k4,Est  
 café vert arabica,en feves K4,est  
 Café vert arabica,en feves k4,est  
 Café vert arabica,en feves K4,Est  
 cafe vert arabica,en feves k5  
 Cafe vert arabica,en feves k7  
 Café vert arabica,en feves k7,est  
 Café vert arabica,en feves k7,Est  
 cafe vert arabira,en feves k3  
 CAFE VERT EN FEVE  
 Cafe vert en fèves k4  
 Cafe vert en feves,k3  
 CAFE VERT K4

## CAFE VERTS

Cafévert arabica,en feves K4,Est

cameras

## CAMION

Camion Ben d'occasion

Camion Citerne d'occasion

## CAMION FAMIL

Camion renault kerax

## CAMION SOMUL

## CAOUTCHOU

## CAOUTCHOUC NATUREL

## CAOUTHOUX NATUREL

Cartons vide

Cartons vides

## CARTONS VIDES USAGES POUR RE-EMPLOIES

## CARTONS VIDES USAGES POUR RE-EMPLOIS

casseroles en aluminium

Casseterite

Cassitérie

Cassiteriet oxyde d'étain, 60-64% de Sn

cassiterite

Cassiterite

## CASSITERITE

Cassitérite

CASSITERITE DE 55-65 % DE SNO<sub>2</sub>

Cassiterite (oxyde d'étain) de 55-65% de

Cassiterite de 55-65%

Cassiterite de 55% - 65 %

Cassiterite oxyde

Cassiterite oxyde d'étain

Cassiterite oxyde d'étain 55-65%

Cassiterite oxyde d'étain de 55-59% de sn

Cassitérite oxyde d'étain de 55-59% de Sn

Cassiterite oxyde d'étain de 65-69

Cassiterite oxyde d'étain de 66-69% de Sn

Cassitérite oxyde d'étain de 55-59% de sn

Cassiterite oxyde d'étain de 65-69% de sn

cassiterites

Cassiterites

Cassitérites oxyde d'étain de 55-59% de sn

Cassiterites oxyde d'étain de 65-69% de Sn

Cassiterites oxyde d'étain de 55-59

## CASSITERTE

## CASSITTERITTES

## CEFE VERT ARABICA

Cerceuil

Cereales autre que semences

Cereales autres que semences

Chargeurs autopropulsés à chargement frontal  
 Chars et automobiles blindées de combat et  
 Chassis d'autres véhicules automobiles des n 8701 à 8705 avec moteur  
 CHAUDIERE ET SES ACCESSOIRES

Chaudières  
 Chocolat et préparations alimentaires du cacao  
 Cigares (même à bouts coupés) et  
 CIMENT  
 CITERNES EN ACIER

coltan  
 Coltan  
 COLTAN  
 Coltan-scorie stannique 20-25% Ta<sub>2</sub>O<sub>5</sub>  
 Coltan & scorie stannique (concentrés de

Coltan et scorie stannique de 26-30%  
 COLTANS  
 COLTN

Compacteurs autopropulsés  
 COMPACTEURS, NIVELEUSES

compresseurs  
 Conditionneur d'air de mur ...puis. < ou =  
 Conserves de sprats et esprots entiers ou en morceaux non hachés  
 construction prefabriquées  
 Constructions et parties de constructions en aluminium autre que 761010

Constructions prefabriquées  
 Constructions prefabriques  
 CONTAINER  
 CUISINIÈRES

Déchets et brisures de café vert arabica

DECHETS ET BRISURES DE CAFÉ VERT ROBUSTA

Déchets et brisures de café vert robusta  
 Déchets et débris d'aciers alliés  
 Déchets et débris de bois  
 Déchets et débris de fer ou d'acier

Déchets et débris de zirconium et ouvrages  
 Démareurs, même fonctionnant comme génératrice  
 Désinfectant  
 Désinfectants  
 Dispositifs de fermeture

Eaux conditionnées pour la table  
 Eaux de vie de vin ou de marc de raisin

EAUX MINÉRALES  
 EAUX MINÉRALES ET EAUX GAZEIFIÉES  
 Eaux minérales et eaux gazeifiées

ECAUSSINE ET AUTRES PIERRES CALCAIRES DE TAILLE OU CONSTRUCTION, ALBATRE  
 ÉCHANTILLONS DES MATÉRIAUX GÉOLOGIQUEs  
 ECORCE QUINQUINA  
 ECORCE QUINQUINNA

ECORCES DE QUINQUINA

ECORCES QUINKINA

ECORCES QUINQUINA

EFFETS PERSONNELS

Engins du n°84.29

Engrais du chapitre31 en tablettes ou emballages n'excedant pas 10 kg brut

equipement concus pour la protection individuelles

Equipements de sport

ESCALIERS MECANQUES ET TROTTOIRS ROULANTS

Etais,ecrins et similaires à surface exterieure en plastique ou textile

Extincteurs meme charges

Farine de froment (ble) ou de meteil

Farine de froment ou de meteil

FARINE DE MAIS

Farine de moutarde et moutarde préparée

Farine de moutarde preparée

FARINES DE MAIS

FILS D'ACETATE

FILS D'ACETATE DE CELLULOSE

FOURS, CUISINIERS, RECHAUDS, GRILS ET ROTISSOIRS ELECTRIQUES

Goupes electrogene (diesel, semi- disiel)

Groupes electrogene

Groupes electrogene(diesel,semi-diesel)de puissance n'excedant pas 75kva

Groupes electrogenes(diesel,semi-diesel) de

GRUES SUR PNEUMATIQUE

HARICOTS

Haricots communs:de semences

HUILE DE GRAISSAGE

Huile de palme brute

HUILES VEGETALES

Huiles,graissages et fractions,non chimiquement modifiées

Insecticides

Instruments et appareils de photographie

Instruments et appareils du n°90.15

IVECO TRAKKER D OCCAS

LAIT EN POUDRE

Lampes -reclames

LAND CRUISER

LAND CRUISER PRADO

LAND ROVER

Land rover defender 90

Levures vivantes

limes,rapes et outils similaires

Liqueurs titrant moins de 25°

MACHINE A MELANGER

MACHINE A RABOTER ET ACCESSOIRES

MACHINE A SCIER ET ACCESSOIRES

Machine et appareil pour la fabrication du tabac

## MACHINE POUR PREPARATION DU TABAC

## MACHINE POUR PREPARER DU TABAC

## MACHINE POUR TRANS DE TABAC

Machines à meuler,poncer ou polir les matières du n°84.65

MACHINES A PERCER OU MORTAISER LES MATIRES DU N° 84.65

Machines et appareil

Machines et appareils du n° 84.30

## MACHINES ET APPAREILS POUR LA PREP OU TRANSFORMATION DU TABAC

Machines et appareils pour le brochage ou la

Machines geneatrices à courant alternatif de 75 kva

Machines generatrices a courant alternatif

Machines pr la transformation du tabac

Machines qui assurent au moins deux des fonctions suivantes

Machines qui assurent au moins deux des fonctions suivantes impression,copie ou transm

Maghony,scies longitudinalement,sciages avives

Mahogany, scies lingitudinalement, sciage avices d'une epaisseur superieur a 50mm

Mahogany, scies longitudinalement, sciage avives d'une epaisseur inferieur à 50mm

Mahogaany, scies lingitudinalement, sciagaes avives d'une epaisseur superieur a 50mm

Mahogany, scies lingitudianlement, sciages avives d'une epaisseur superieure a 50mm

Mahogany,scies lingitudinalement,sciages avives

Mahogany,scies lingitudinalement,sciages avives d une epaisseur superieure a 50 mm

Mahogany,scies longitudinalement

Mahogany,sciés longitudinalement

Mahogany,scies longitudinalement,sciages avives

Mahogany,scies longitudinalement,sciages avives d'une epaisseur

Mahogany,scies longitudinalement,sciages avives d'une épaisseur inf à 50 mm

Mahogany,scies longitudinalement,sciages avives d'une epaisseur inférieure à 50 mm

Mahogany,scies longitudinalement,sciages avives d une epaisseur inferieure à 50 mm

Malles,valises,mallettes à surface exter en plastique

Margarine, a l'exclusion de la margarine

Margarine,a l exclusion de la margarine liquide

marteaux et masses

Matériel d'échafaudage,de coffrage ou d'étayage

Materiel d'échafaudage,de coffrage ou d'etayge en fonte,fer ou acier

## MATERIEL POUR LA GYMNASTIQUE

Materiels d'échafaudage,de coffrage ou d'etayage en fonte,fer ou acier

## MATIERES COLORANTES

Matières colorantes

## MEDICAMENTS

Melanges d'epices

## MEUBLES ET LEURS PARTIES

## MIERAI DE COLTAN ET SCORIE STANIQUE DE 26-30%TA05

Minerais autres que ceux des n 26171000 a 26179091

## MINERAIS CASSITERITES

Minerais d'étain et leurs concentré

Minerais d'étain et leurs concentré d'une teneur de 55 à 65 % en etain

Minerais d'étain et leurs concentres

minerais d'étain et leurs concentres d'une teneur de 55 à 65

Minerais d'étain et leurs concentrés d'une teneur de 55 à 65% en étain/cassiterite

Minerais d'étain et leurs concentrés d'une teneur de 55 à 65% en étain

Minerais d'étain et leurs concentrés d'une teneur de 55% à 65%

MINERAIS DE COLTA & SCORIE STANIQUE DE 26-30% TaO<sub>5</sub>

Minerais de coltan

MINERAIS DE COLTAN

Minerais de coltan

Minerais de coltan & scorie de 26-30 % TaO<sub>5</sub>

Minerais de coltan & scorie stannique

Minerais de coltan & scorie stannique de

Minerais de Coltan & scorie stannique de

Minerais de coltan & scorie stannique de 26-30 % TaO<sub>5</sub>

MINERAIS DE COLTAN & SCORIE STANIQUE DE 26-30%

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de Coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan & scorie stannique de 4-14% TaO<sub>5</sub>

Minerais de coltan & scories stannique de 26-30%

MINERAIS DE COLTAN & SCORIE STANIQUE DE 26-30 % TaO<sub>5</sub>

MINERAIS DE COLTAN & SCORIE STANIQUE DE 26-30%

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan et scorie

Minerais de coltan et scorie stannique

MINERAIS DE COLTAN ET SCORIE STANIQUE

Minerais de coltan et scorie stannique de 26-30%

Minerais de coltan et scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan et scorie stannique de 26-30% TaO<sub>5</sub>

Minerais de coltan et scorie stannique de 4-14% TaO<sub>5</sub>

Minerais de coltan et scories

MINERAIS DE COLTAN & SCORIE STANIQUE

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

MINERAIS DE TANTALE

Minerais de tantale

Minerais de tantale et leurs concentrés

Minerais de tantale teneur 26-30%

Minerais de tantale teneur 26-30% tantale et 40-59% oxyde niobium ou colombite

MINERAIS DE TANTALE TENEUR 26-30% TANTALE ET 40-59% OXYDE NIOBIUM OU COLOMBITE

Minerais de tantale teneur 26-30% tantale et 40-59% oxyde niobium ou colombite

Minerais de tantale teneur 26-30% et 40-59% oxyde niobium ou colombite

Minerais et leurs concentrés

Minerais et leurs concentrés d'une teneur de 55 à 65% en étain/cassiterite

Minerais de coltan & scorie stannique de 26-30% TaO<sub>5</sub>

Mitraille de fer

Mitrailles de fer

Mitrailles de fer



Mohogany, scies longitudinalement, sciages avives d'une epaisseur inferieur à 50mm  
 Moteur Aviation

Moteurs à explosion pour vehicule du chapitre 87  
 Moteurs universels de puissance excedant 37,5w

MOTOCYCLES

Motos et lubrifiant

Navets,betteraves,celeris-raves et similaires frais refrigeres

NISSAN VANETTE

Niveleuses autopropulsées

Non decafeine

OBJET DE DEMEN

OBJET DE DEMENAGEMENT

Œufs

Or a usages non monetaires d'exploitation

OR ARTISANAL

Oxygene

Palettes simples, palettes-caisses et autres

PAPIER A CIGARETTE EN ROULEAUX D'UNE LARGEUR N'EXCEDANT PAS 5 CM

Papier a cigarettes en rouleaux d'une

Papiers ndnca

Papiers non denommes ni compris ailleurs

Parfuns et eaux de toilette titrant - de 50

Parties de machines

PARTIES DES MACHINES ET APPAREILS DU N 84.74

Parties des machines et appareils du n° 84.53

PARTIES ET ACC VEHICULE

Parties et accessoires

PARTIES ET ACCESSOIRES DES MACHINES

Parties et accessoires des vehicules des 87.01 à 87,05

Parties et accessoires des vehicules des n° 87.11 à 87.13

Parties et accessoires des vehicules des n°87.01 à 87.05

PARTIES RECONNAISSABLES DES MACHINES DES N°85.01 OU 85.02

PC

PEAUX

PEAUX DE BETTES

Peaux de bovins

PEAUX DES BEBES

Peaux des betes

PEAUX DES BETTES

Petrol lampant sans biodiesel

photocopie

Pieres synthétiques ou reconstituees

Pieres synthetiques ou reconstituées

Pierres de couleur

Pierres de taille ou construction

Pierres synth ou reconstituées

PIOCHES,PICS,HOUES,BINETTES,RATEAUX ET RACLOIRS

Plantes medecinales

Plantes medicales  
 Plaques,feuilles,bandes,rubans,pellicules  
 Pneumatiques  
 Pneumatiques rechapés pour auto-bus ou camion  
 Poivre non broyé ni pulvérisé  
 Pompe à vide  
 pompes à carburant  
 Pompes à injection pour moteurs à explosion  
 PREPARATIONS ALIMENTAIRES NDCA  
 Préparations alimentaires ndca  
 Preparations pour enfants,conditionnées pour  
 Préparations soufflées ou grillées à base de céréales  
 Préparations,pour sauces,saucisses,condiments et assaisonnements  
 PRODUIT DE BEAUTE  
 Produits de beauté  
 Produits de beauté,de maquillage,solaires ou pour la peau  
 propulseurs à réaction autres que les turboreacteurs  
 quinquina  
 Quinquina  
 QUINQUINA  
 Recipients pour gaz comprimés,liquéfiés,en fonte,fer ou acier  
 REFRIGERATEUR  
 Réservoirs, fûts, tambours, bidons, d'une  
 Réservoirs,foudres,cuves et autres(+300)en matières plastiques  
 Riz semi-blanchi ou blanchi, même poli ou  
 Sacs et sachets d'emballage en autres synthétiques ou articles  
 Sacs et sachets d'emballage en autres synthétiques ou artificiels  
 Sacs et sachets en bonneterie de jute ou autres fibres  
 Sacs,sachets,pochettes,cornets en polyéthylène  
 Salmonides entiers,congelés  
 SCORIE  
 Scorpio 4x4 Mihindra  
 Sel  
 SEL IODE  
 Slips et caleçons pour hommes ou garçonnets en bonneterie de coton  
 Sucres de canne  
 Sucs et extraits végétaux de houblon  
 Tabac partiellement écotés  
 TABACS  
 TABACS ECOTES  
 TABACS PARTIELLEMENT ECOTES  
 The noir (fermente...), en emballage  
 TILAPIAS  
 Tissus Imprimés  
 Tours et pylones en fontes  
 Toyota ambulance  
 TOYOTA DINA Agés de plus de 5 ans  
 Toyota Hilux

Toyota hilux surf  
 TOYOTA ID  
 Toyota Land cruiser  
 TOYOTA LAND CRUISER  
 Toyota pick up  
 Toyota Prado tx  
 TOYOTA RAV4 D'OCCASION  
 Treuils cabestans  
 Treuils cabestants  
 TROTTINETTES(CHUKUDU)  
 Tungstene  
 vaisselle et art de tables et de cuisine en mat plastiques  
 Vaisselle et art de tables et de cuisine en matières plast  
 Véhicule  
 VEHICULE AUTO  
 Vehicule automobile  
 VEHICULE KIA SORENTO  
 VEHICULE LAND ROVER  
 Vehicules automobiles a usages speciaux  
 Vetements neuf  
 vetements usage  
 Vis et boulons filetes en fonte,fer ou acier  
 WOLFRAM  
 WOLFRAMI  
 Wolframite  
 WOLFRAMITE

---

La variables **Goods** a 740 modalités

Faisons la caractérisation des niveaux des marchandises dont l'encodage fait défaut

```
class(taxe_df$Goods)
```

```
## [1] "character"
```

Usage de tm et Stringr

```
## Warning: Unknown levels in `f`: equipements protection
```

```

## [1] "Autres Marchandises"
## [2] "Bois"
## [3] "Machines et appareils domestique"
## [4] "Médicaments et plantes médicinales"
## [5] "Poissons, viande et oeufs"
## [6] "Matériels de construction"
## [7] "Matériel Informatique et Electroniques"
## [8] "Véhicules, camions, Motos et acc"
## [9] "Vêtements, tissus et acc et chaussure"
## [10] "boissons, bières et limonades"
## [11] "Machine us Industriel"
## [12] "Article Menage et Campement"
## [13] "sacs, sachets et emballages"

```

```

## [14] "Papiers et fournitures de bureaux"
## [15] "Produits alimentaires,prep et huiles"
## [16] "caféarabica"
## [17] "Minéraux et dérivés"
## [18] "engins et tracteurs"
## [19] "Cigarette et papier cigarettes et tabac"
## [20] "constructionprefabriquees"
## [21] "cadreset conteneurs"
## [22] "Pièces de Réchange appareils"
## [23] "Générateurs,batterie et piles"
## [24] "etuis en plastique ou textile"
## [25] "Pétrole et dérivées et huile de graissage"
## [26] "boissons, bières,liqueurs et limonades"
## [27] "produits beaute"
## [28] "peauxdes betes"

##              n      % val%
## Autres Marchandises      160  4.8  4.8
## Bois                      140  4.2  4.2
## Machines et appareils domestique      30  0.9  0.9
## Médicaments et plantes médicinales     34  1.0  1.0
## Poissons, viande et oeufs              12  0.4  0.4
## Matériels de construction              27  0.8  0.8
## Materiel Informatique et Electroniques  32  1.0  1.0
## Véhicules,camions,Motos et acc        113  3.4  3.4
## Vetements,tissus et acc et chaussure   100  3.0  3.0
## boissons, bières et limonades          15  0.5  0.5
## Machine us Ingsutriiel                 54  1.6  1.6
## Article Menange et Campement           37  1.1  1.1
## sacs, sachetsn emballages              6   0.2  0.2
## Papiers et fournitures de bureaux       24  0.7  0.7
## Produits alimentaires,prep et huiles    68  2.1  2.1
## caféarabica                       1303 39.4 39.5
## Minéraux et dérivés                  1053 31.8 31.9
## engins et tracteurs                   18   0.5  0.5
## Cigarette et papier cigarettes et tabac  14   0.4  0.4
## constructionprefabriquees              7   0.2  0.2
## cadreset conteneurs                   1   0.0  0.0
## Pièces de Réchange appareils           6   0.2  0.2
## Générateurs,batterie et piles          15  0.5  0.5
## etuis en plastique ou textile           1  0.0  0.0
## Pétrole et dérivées et huile de graissage  4  0.1  0.1
## boissons, bières,liqueurs et limonades   2  0.1  0.1
## produits beaute                       10  0.3  0.3
## peauxdes betes                        14  0.4  0.4
## NA                                    10  0.3  NA

```

netoyage de la variable `country_desti` qui est un facteur dans le quel nous retrouvons les niveaux rédon-  
dants (sur l'identifiant des pays)

```

## [1] "AFRIQUE DU SUD"
## [2] "ALGERIE"
## [3] "ALLEMAGNE"

```

```
## [4] "AMERIQUE LATINE"
## [5] "ANGLETERRE"
## [6] "ANGOLA"
## [7] "ARABIE"
## [8] "ASIE"
## [9] "AUSTRALIE"
## [10] "BELGIQUE"
## [11] "BURUNDI"
## [12] "CANADA"
## [13] "CHINE"
## [14] "CHYPRE"
## [15] "CONGO BRAZA"
## [16] "CZECH REP"
## [17] "DOMBASI SIMBA"
## [18] "EMIRATES ARABES UNIES"
## [19] "ESPAGNE"
## [20] "FRANCE"
## [21] "GABON"
## [22] "GRANDE BRATAGNE"
## [23] "GRECE"
## [24] "HONG KONG"
## [25] "ILE MAURICE"
## [26] "INDE"
## [27] "ITALIE"
## [28] "J WOLFF"
## [29] "JAPON"
## [30] "KENYA"
## [31] "KP - Corée, République Populaire démocra"
## [32] "LIBAN"
## [33] "LUXEMBOURG"
## [34] "MADRID"
## [35] "MALAISIE"
## [36] "MAROC"
## [37] "NERLAND"
## [38] "NERETHERLAND"
## [39] "NIGERIA"
## [40] "NOUVELLE ZELANDE"
## [41] "OUGANDA"
## [42] "PANAMA"
## [43] "PAYS BAS"
## [44] "PHILLIPINE"
## [45] "POLOGNE"
## [46] "PORTUGAL"
## [47] "R-U"
## [48] "RDC"
## [49] "RDC/BELGIQUE"
## [50] "RDC/BUNIA"
## [51] "RDC/CHINE"
## [52] "RDC/ETATS UNIS"
## [53] "RDC/FRANCE"
## [54] "RDC/MALAISIE"
## [55] "RDC/OUGANDA"
```

```

## [56] "RDC/R-U"
## [57] "RDC/RWANDA"
## [58] "RDC/SINGAPOUR"
## [59] "RDC/SUISSE"
## [60] "REP TCHEQUE"
## [61] "ROYAUME UNI"
## [62] "RWANDA"
## [63] "SENEGAL"
## [64] "SINGAPOUR"
## [65] "SKN"
## [66] "SOMALIE"
## [67] "SOUDAN"
## [68] "SUCAFINA"
## [69] "SUD SOUDAN"
## [70] "SUEDE"
## [71] "SUISSE"
## [72] "SUITZERLAND"
## [73] "Swaziland"
## [74] "SWEDEN"
## [75] "SWITZERLAND"
## [76] "TANZANIE"
## [77] "TCHAD"
## [78] "THAILANDE"
## [79] "TWIN TRADING"
## [80] "TZ"
## [81] "UAE"
## [82] "UNION EUROPEENNE"
## [83] "USA"
## [84] "WALTER MATTER"
## [85] "ZAMBIE"

## [1] "AFRIQUE DU SUD"      "ALGERIE"      "ALLEMAGNE"
## [4] "AMERIQUE LATINE"    "GRANDE BRATAGNE" "ANGOLA"
## [7] "ARABIE"             "ASIE"         "AUSTRALIE"
## [10] "BELGIQUE"           "BURUNDI"      "CANADA"
## [13] "CHINE"              "CHYPRE"       "CONGO BRAZA"
## [16] "REP TCHEQUE"        "NA"           "EMIRATES ARABES UNIES"
## [19] "ESPAGNE"            "FRANCE"       "GABON"
## [22] "GRECE"              "HONG KONG"    "ILE MAURICE"
## [25] "INDE"               "ITALIE"       "JAPON"
## [28] "KENYA"              "KP - Corée"   "LIBAN"
## [31] "LUXEMBOURG"         "MALAISIE"     "MAROC"
## [34] "NERLAND"            "PAYS BAS"     "NIGERIA"
## [37] "NOUVELLE ZELANDE"   "OUGANDA"     "PANAMA"
## [40] "PHILLIPINE"         "POLOGNE"     "PORTUGAL"
## [43] "ROYAUME UNI"        "RDC"         "USA"
## [46] "RWANDA"             "SINGAPOUR"    "SUISSE"
## [49] "SENEGAL"            "SOMALIE"     "SOUDAN"
## [52] "SUD SOUDAN"         "SUEDE"       "Swaziland"
## [55] "TANZANIE"           "TCHAD"       "THAILANDE"
## [58] "UNION EUROPEENNE"   "ZAMBIE"

```

Dans la base des données il y a des entreprises que l'on a enregistré à la place des pays. ces genre des

Table 8.3: Table de corrélation entre les variables quantitatives

var1	var2	coef_corr
Weight	Year	-0.1727414
Taxe	Year	-0.1965648
Year	Weight	-0.1727414
Taxe	Weight	0.6699457
Year	Taxe	-0.1965648
Weight	Taxe	0.6699457

cas ont été traité par remplacement avec le *NA* pour **Not Available** et ces dernier on été élargués de la base des données, car nous avons jugé qu' aucune méthode d'imputation n'est applicable pour ce genre de situation. Nous avons fait la même chose pour les variables tels que **Les marchandises**.

### 8.1.1 Nouvelle base de données pour les analyses

Regroupement des variables pour la synthèse pour rendre la base des données simple à exploiter, éliminer les NA dans les observations telsque les pays et les valeurs pour les marchandises et les taxes.

```
DBase <- taxe_df %>%
  select(Year,Country_dest,Goods,Weight,Taxe) %>%
  group_by(Year,Country_dest,Goods) %>%
  summarise(Weight=sum(Weight),Taxe=sum(Taxe),.groups = "drop") %>% drop_na()

correlate(DBase) %>% kable(caption = "Table de corrélation entre les variables quantitatives")

#plot_correlate(DBase)

df <- pdata.frame(DBase,index = c("Year","Country_dest"))

## Warning in pdata.frame(DBase, index = c("Year", "Country_dest")): duplicate couples (id-time) in r
## to find out which, use, e.g., table(index(your_pdataframe), useNA = "ifany")

DF <- df %>% pivot_wider(names_from = Goods,values_from = c(Taxe,Weight))

DB <- pdata.frame(DBase,index=c("Year","Goods"))

## Warning in pdata.frame(DBase, index = c("Year", "Goods")): duplicate couples (id-time) in resultin
## to find out which, use, e.g., table(index(your_pdataframe), useNA = "ifany")
```

## 8.2 Analyse descriptive des Varariales

Conversion des données en modèle des panels des données





## Chapter 9

# Final Words

We have finished a nice book.