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SPATIAL CONVERGENCE AND CONGESTION*

ABSTRACT: This paper analyses how several spatial variables coming from cities and transportation system can affect money market, specially the income velocity of circulation, assuming one-elastic aggregate demand function and considering money velocity as a variable. Fluctuations in velocity caused by some spatial variables, under certain conditions, affect also the aggregate demand curve. Specification of the main relation-ship is found in the Baumol-Tobin model for transaction money demand, and in Christaller-Lösch central place theory. The estimation of the model has been based on panel data techniques and applied across 61 countries during 14 years in the 1978-1991 period. Theoretical and econometric results indicates that seven spatial variables like the country's first city population, the population density, the passenger-kilometers transported by railways, and several ratios referred to some geographical variables, can provokes fluctuations on aggregate demand curve in the short run. In the long run, aggregate supply can be also affected by means of these variables; in order to checking this question, considering that these spatial variables are not product factor, we propose to observe if these variables can affect the technological coefficient A of an aggregate production function according to a neo-classical growth model. Results by mean of the Mankiw, Romer and Weil method, and also mean of an endogenous growth model of technology diffusion, indicates that some spatial variables affect the speed of convergence in per head income across these 61 countries. Moreover, certain amount in some of these variables generates a congestion process in some countries. For to check it, we utilize a Barro and Sala i Martin endogenous growth model which reflects government activities; concluding remarks indicates that some of these spatial variables above mentioned increases the speed of convergence but generates congestion. These spatial variables affect the aggregate supply, and hence the price and output levels.

Key words: transportation, regional growth, convergence, congestion.
JEL Class.: R41

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1. INTRODUCTION

Spatial issues are generally neglected in conventional macroeconomic modeling, because the goods market is usually assumed to be in perfect competition. In fact, most spatial models are microeconomic, and do not embody the money market. Incorporating space into macroeconomic models implies to consider product differentiation, and hence imperfect competition in goods market, as indicate in Gabszewicz and Thisse (1980), and in Thisse (1993). New Keynesian economics seems the framework in which space can be embodied in macroeconomic modeling. So, real rigidities due to agglomeration economies which lead to increasing returns to scale and hence coordination failures, together with the probable existence of nominal friction due to near-rationality, cost-based prices and externalities coming from aggregate demand fluctuations, can cause nominal rigidities and hence can provoke that money would not be neutral and output fluctuates, according to Nishimura (1992). Not only there are a great difficulty to include the space in a macroeconomic model, but also in reverse, is not still possible to introduce the money market in a spatial model. The best microeconomic model which incorporates the money in a framework of imperfect competition is the model of Blanchard and Kiyotaki (1987), which consider monopolistic competition with product differentiation in Dixit-Stiglitz (1977) sense. In this model, households choice between a composite good and money. Following the Dixit-Stiglitz approach, each household has a CES utility function and faces a usual budget constraint. The household problem is to maximize the utility function subject to the budget constraint and, as result of this optimization, we have the individual demand function. In this framework, if the aggregate demand function considered is the typically one-elastic as Lucas (1973) or Corden (1979) and Mankiw (1994) case: $P.y = M.V$, fluctuations in the amount of money (M) can affect output (y) in a Keynesian framework. In a Classical framework, fluctuations in the amount of money affect level of prices (P) only because money velocity (V) is constant in this model. In a conventional Keynesian model income velocity of circulation is not a relevant variable because the aggregate demand function is not generally unielastic, and V results a erratic variable. One important question that we are worried about is: If income velocity of circulation is neither constant nor a erratic ratio but it is a conventional variable, can then V affect output or prices? Maybe income velocity of circulation (V) was a variable neither so erratic as some authors say, nor a short-run constant as others say. The fact that V was identically equal to the ratio of two macroeconomic variables such as nominal income and the stock of money, both measured in nominal terms, means that V was only measurable as a real figure. Surely, it should be somewhat more considered Irving Fisher's (1911) observation, in the sense of velocity being a variable also depending on the state of transports and communications' infrastructure, as well as institutional factors and the well-known macroeconomic variables such as the price level, real income, the interest rate, the inflation rate or, conversely, the stock of money. A preliminary attempt in this direction has been made by Mulligan and Sala i Martin (1992). These authors estimate a money demand function using data for 48 US states covering the 1929-1990 period, where population density is included as an additional explanatory variable. They find a significant role for this variable in the explanation of US money demand patterns during that period. The main aim of this paper is to analyze whether several space variables stemming from the cities and transportation systems would affect the quantity of money demanded in equilibrium, and hence income velocity of circulation. In this model, the income velocity of circulation is theoretically not constant but it is a variable incorporated in some unielastic aggregate demand functions such as the Corden case. We study the possible relationship between money velocity (as a proxy for money demand), and several space variables, fundamentally derived from the Baumol-Tobin model of transactions demand for money. The specification of this model is in section 2 of this paper and section 3 contains an application. In section 4 and 5 we study the conditional convergence among countries in per capita income, and the possible congestion process, and finally some conclusions are in section 6.

2. SPATIAL EFFECTS ON AGGREGATE DEMAND

In this section, we will study the possible existence of a relationship between some economic-geographical variables and velocity and, in such a case, to specify a model that embodies some of the considerations made previously. As a starting point for this analysis, we will establish some previous hypotheses. First, with the aim of simplifying the process, we will assume that money is only demanded for transactional purposes. This restriction does not mean any loss of generality regarding the results, and might be relaxed by including the precautionary and speculative motives in the equation of the demand for money. Second, we assume that money market is in equilibrium. Third, we will use as money stock the M1 money aggregate, that is, currency in the hands of the public plus sight deposits. The specification of the model will be based in the three following points: i) Some expansion on the Baumol-Tobin model for transaction money demand. ii) A unielastic aggregate demand MV, where V is considered as a conventional variable. iii) The spatial central places theory starting from Christaller and Lösch. Under these assumptions, we will follow, first, the transactions demand for money approach due to Baumol (1952) and Tobin (1956). This is a Keynesian-type approach in which the optimum number of exchanges between bonds and money made by an individual agent, is related with individual nominal income. Other additional restriction is given by the consideration of a representative agent, which obtains with a monthly frequency a certain level of nominal income (Y_m).

The income velocity of circulation is defined as $V = I/M$, and after substituting we have:

$$V = (24rI/PO.b)^{1/2} \quad \{1\}$$

and separating the nominal interest rate:

$$V = (24(\rho + \pi)I / PO.b)^{1/2} \quad \{2\}$$

where p is the inflation rate and r the real interest rate. The last expression explains V as a function of some conventional macroeconomic variables, except for PO. The total number of optimal exchanges that the total population of the country made during a year is:

$$N = 12n.PO = (6rI.PO/b)^{1/2} \qquad \{3\}$$

and hence:

$$V = (24rI/(b.PO))^{1/2} = (2/PO)(6rI.PO/b)^{1/2} = 2N/PO \qquad \{4\}$$

which is a result similar to that obtained in Barro (1990). N is the total number of annual exchanges in the country but also means the number of journeys for changing money to make annual transactions. Perhaps there exists some correlation between the number of exchanges made within a certain area during a year, and the total number of journeys made during that time in that area for made several transactions. These journeys are made by several transport systems. We only consider two of them ir our model: road and railway transport but not air, sea and walking transportation, because the impact on land of these last systems is small. At the same time, there are, as usually passenger and freight transportation. The application of the model which we try to specify is going to take place in the context of the so-called metropolitan areas, in a broad sense. The basic configuration of these ones comes from the analysis by Christaller (1933) and Lösch (1954), who in a simplified way, infer that in the center of the area there exist a central place, which is the most important center of population. Approximately in the middle of the central place there is the so-called central business district, which usually includes the markets for consumption and investment goods being the most important in that area, and where some goods non existing in any other place of the area can be purchased. Surrounding the central place and at a certain distance, there are usually six important, and similar, population centers, smaller than the central place. Each of these second-order centers is surrounded by approximately six other third-order centers, including markets for basic goods.

We consider for the analysis of the number of journeys the simplest cities system of W. Christaller: A metropolitan area with a central place and six small similar cities around. The Christaller's system assumes monopolistic competition in partial equilibrium with vertical product differentiation in Chamberlin sense. Our preference for this type of differentiation versus the horizontal differentiation from Hotelling (1929) until Fujita and Krugman (1992) is due to reasons of simplicity, and because there are not fall in the generality of this problem. Following this simple model, if population of the central place is PC , and the population of each satellite city is P_i , the number of journeys generated between central place and one satellite city can be expressed according to a gravity model:

$$n_c = \beta. \; PC.P_i \; / \; d^{\alpha} \qquad \{5\}$$

where b and a are constants to be estimated, and (d) is the distance between cities. If we consider that PO is the total area population, then total journeys generated in the area will be:

$$Ncs = (\beta/6d^{\alpha})((PO)^2 + 4\ PC.PO - 5(PC)^2) \quad \{6\}$$

In the same sense, and remembering that in our model we consider only the road and railways transportation, we can try now to calculate the number of journeys made into a metropolitan area by both transportation systems. Following Thomas (1993), Valdés (1988) and Button et al.(1993) for road transportation, the generation and attraction of traffic by road is a function of cars and trucks stock and the cars / trucks ratio in the area. Considering that the greater part of this traffic is by cars, a possible function of road traffic's generation- attraction is:

$$Nrd = k.(AUT).\phi_1(CAM, AUT/CAM) \quad \{7\}$$

where (*Nrd*) is the total number of road journeys, by cars and trucks, into the area, *AUT* is cars' stock, *CAM* is trucks' stock, both in circulation, k is a constant and f_1 is a function. The total journeys by road system *per head* are:

$$Nrd / PO = k(PC / PO)(AUT/ PC).\phi_1(CAM, AUT/CAM) \quad \{8\}$$

In the same way, following Izquierdo (1982), Oliveros (1983) and Friedlaender et al.(1993) for railways transportation system , the total journeys during a year by train are dependent basically on passenger-kilometer (*PASKM*) and net ton-kilometer (*TNKM*) carried and *PASKM/TNKM* ratio. Passengers-kilometer is defined as the sum of kilometers traveled by each passenger per year. Net ton-kilometer is the sum of kilometers that each ton is carried per year. Considering that the greater part of traffic's volume by railways are freight, a possible function for the volume of traffic is:

$$Nrw = k.(TNKM).\phi_2(PASKM, PASKM / TNKM) \quad \{9\}$$

where (*Nrw*) are journeys by railway, passengers and freight, into the area during a year, *k* is some constant and f_2 is a certain deterrence function. The railway traffic volume per inhabitant will be:

$$Nrw/PO = k(PC/PO)(TNKM / PC).\phi_2(PASKM, PASKM / TNKM) \quad \{10\}$$

The total number of journeys (Nts) due to the transportation system into the area during a year is Nts = Nrd + +Nrw. Both systems (transportation and cities) provide different variables for explaining the same problem that is the total individual journeys made during a year within an area. Hence, it must exist a certain probability that journeys' explanatory variables will be a composition, probably non linear, of these two systems.

By simplifying explanatory variable names, we will call *PCPO* to *PC/PO* ; *AUTPC* to *AUT/PC* ; *AUTCAM* to *AUT/CAM*; *PKMTKM* to *PASKM/TNKM* ; and *TKMPC* to *TNKM/PC*. With these considerations, total journeys *per head* (*N*/PO*) can be expressed as a function as follows, if we consider that $N^* = f\,(Nts, Ncs)$:

N*/PO = f (PO, PC, PCPO, CAM, PASKM, AUTPC, TKMPC, AUTCAM, PKMTKM) {11}

If there exists some correlation between the total journeys and the journeys for exchanges between bonds an money, we will have:

$$N / PO = \varphi(N^*/ PO) \quad \{12\}$$

but remembering equation (4): *V(money velocity) = 2N / PO = 2j (N*/ PO)*, we have the final specification of the income velocity of circulation model as follows:

V = F (PO, PC, PCPO, CAM, PASKM, AUTPC, TKMPC, AUTCAM, PKMTKM). {13}

where income velocity (*V*) is made dependent on the population of the main city of the concerned country (*PC*), the country's total population (*PO*), the ratio of *PC* to the country's total population (*PCPO*), the number of road passenger vehicles located into the country divided by population of country's first city (*AUTPC*), the number of trucks located into the country (*CAM*), the number of passenger-kilometer transported by railways (*PASKM*), the passengers-kilometer/ net ton-kilometer railways ratio (*PKMTKM*), the cars/trucks road ratio (*AUTCAM*), and the number of net ton-kilometer transported by railways divided by population of country's first city (*TKMPC*). All the variables are referred to a particular year.

3. EMPIRICAL MODEL

The specification of the theoretical model embody probably a non linear model, but following the standard formulation of panel techniques and again for simplicity, the model which was finally estimated was a linear one such as:

$$V_{it} = \alpha_{it} + \mu_i + B_1(PCPO)_{it} + B_2(PC)_{it} + B_3(PKMTKM)_{it} + B_4(AUTCAM)_{it} + B_5(PASKM)_{it} + B_6(AUTPC)_{it} + B_7(PO)_{it} + B_8(CAM)_{it} + B_9 (TKMPC)_{it} + \xi_{it} \quad \{14\}$$

where *V* is the endogenous variable and the rest are the explanatory variables. Although the specification of the model according to Christaller is expected to be applied to metropolitan areas, there exist several difficulties to collect some of the data. Specifically there are not generally M1 data for regions and even less for metropolitan areas. Moreover, the area's surface do not appear into the specification of the theoretical model. In the specification of the model, the central place theory is applied to calculate the total journeys into a metropolitan area, but the total population of one country is basically the addition of the populations of all metropolitan areas in the country. The total number of journeys made into the country are the addition of journeys into each metropolitan area plus the journeys among these areas. Total number of journeys in a country is a linear function of the journeys made into a metropolitan area. These are the reasons to try the application of the model to several countries. The variables are measured as follows: *V* is the ratio between GDP at market prices and M1 monetary aggregate, both in national currency units; *PC* and *PO* are measured in millions inhabitants; The ratio *PCPO* is an agglomeration index measured as *100(PC/PO);* the ratios *AUTCAM* and *PKMTKM* are directly *AUT/CAM* and *PASKM / TNKM*, respectively; *AUT* and *CAM* are measured in thousands units; *PASKM* and *TNKM* are both measured in millions, and *AUTPC* and *TKMPC* are directly *AUT/PC* and *TNKM/PC* respectively. Velocity (*V*) and the *AUTCAM* and *PKMTKM* are real numbers; the *AUTPC* ratio is measured in physical quantities divided by physical quantities, and the rest of variables are measured in physical quantities. All variables are, hence, deflated.

The data set includes yearly variables for 64 countries (19 European, 17 Asian, 14 African, and 14 American), and the period of 14 years (1978 to 1991). All countries of the sample have road and railways transportation system, and only a small group of countries with railways transportation are excluded from the sample because of incomplete data In Figure 1, we can observer some spatial correlation in the endogenous variable, income velocity of circulation, among several countries as say Anselin and Florax (1995). The data are collected basically from several sources, mainly: National Accounts Statistics, Tables 1992. United Nations Statistical Year Book, 37-38-39 issues; United Nations. International Financial Statistics Yearbook, (1994); International Monetary Fund. Statistical Trends in Transport, (1965-1989); E.C.M.T. World Tables, (1991). World Bank and The Europe Year Book, (1989). E.P.L. The former model has been estimated using panel data techniques, following the basic references of Hsiao (1986) and Green (1995). This is the way to take advantage when time series data are few and control country specific heterogeneity which states constant over time. How there are not multicolinearity among explanatory variables, we make the estimation using basic panel data techniques, i.e. OLS, between groups, within-groups and GLS. Afterwards, we test the hypotheses embodied amongst these methods. We present in Table 4 the results after dropping the non-significant regressors.

Under the hypothesis of absence of correlation in the residuals, method III provides the best results. This is so, because the Hausman test detects the presence of correlation between the effects and the explanatory variables which make all other set of estimates inconsistent. Under the hypothesis of first order serial correlation in the residuals, we choose model VII because of several reasons: i) the Lagrange multiplier test rejects the homogeneous OLS. ii) the Hausman test rejects the fixed effects or within-groups results in favor of this random effects specification, despite its low predictive capability.

On the other hand, in the specification of the theoretical model appear the distance (*d*) as a variable that we do not finally consider. However, Fotheringham and O'Kelly (1989) obtain some formulations linking distance and surface. Calling surface (*SF*), becomes: *Ncs/PO = a PO/SF)+b (PC/SF)+g (PC/SF)(PC/PO)*, where *a*, *b* and *g* are parameters. It is necessary to note that (*PO/SF*) is the population density which now appears in model' specification. Mulligan and Sala i Martin (1992) introduce population density in their model as explanatory variable of money demand in the U.S. Surface (*SF*) is measured in thousands of squared kilometers. Population density is defined by *1000(PO/SF)* and called *DENSID* in our model , and the other new variable called *PCSS* is defined by *1000(PC/SF).* Thus, we add these new variables to our specification. The omitted variables being non-significant are surface (*SF*) and (*PCSS*). Population density (*DENSID*) is significant in some models. As regards the explanatory variables, all have significant coefficients. Population density appears only in the random effects model, but the rest of regressors are the same in both models and with same sign, positive for *PCPO*, *PC*, *AUTCAM*, and *PKMTKM*, and negative for *PASKM*, and *AUTPC*. Country's surface is non-significant in any relevant model and hence we can, probably, extend the analysis beyond metropolitan areas; only seven of these explanatory variables are significant.

The second empirical model links the quantity of money in equilibrium and the identical significant explanatory variables of money velocity. These explanatory variables may be to explain also the quantity money on circulation according to the following model:

$$M_{it} = \beta_{it} + \mu_i + A_1(PCPO)_{it} + A_2(PC)_{it} + A_3(PKMTKM)_{it} + A_4(AUTCAM)_{it} + A_5(PASKM)_{it} + A_6(AUTPC)_{it} + A_7(DENSID) + \xi_{it} \quad \{15\}$$

where *M* is the quantity of money on circulation in equilibrium and is measured in US dollars in power purchasing parity terms, following the PWT data base developed by Summers and Heston (1991). The correlation among the endogenous variable and spatial explanatory variables is not a spurious one because from equation (3) we have the following specification: *M = (b.PO/24.r)V* and hence the explanatory variables of *V* can theoretically to explain *M*. In this formulation appears the nominal interest rate, but under the hypothesis of Mundell-Fleming model for small economies, we can assume that it is almost constant among economies because them accept the interest rate of rest of the world, which is the interest rate of developed countries, as say in Mundell (1963). The estimation of this model is reported in Table 5.

We can observe that the best method of estimation is 2SLS (column XIII), with all explanatory variables being significantly different from zero. The spatial explanatory variables of Income Velocity of circulation can also explain the quantity of money in circulation, an hence, the aggregate unielastic demand. According to results in Tables 4 for Velocity, and 5 for Money in equilibrium, we can deduce that *PCPO*, *PC* and *PKMTKM* affect the endogenous variables *V* and *M* in same sense, and hence affect the unielastic aggregate demand. The another four explanatory variables affect the two endogenous variables in contradictory sense.

4. SPATIAL EFFECTS ON GROWTH AND CONVERGENCE

The target of this section is to analyze if the seven explanatory variables above mentioned in sections 2 and 3 can affect the economic growth and the real per capita income. For to analyze this question, we suppose now an economy with a neoclassical growth process where, in a first moment with one constant technical progress; then, the product grow in the following exponential form in the steady-state:

$$y = y_0.e^{nt} \qquad \{16\}$$

If we increasing this relationship we will have:

$$dy = n. \ y_0.e^{nt}.dt = y - y_0. \qquad \{17\}$$

and divided it into the initial income (y_0):

$$(y - y_0)/ \ y_0 = n.e^{nt}.dt \qquad \{18\}$$

this formulation tends in discrete time, for example annual data, to the following formulation:

$$dy / y = n.e^{nt}.dt \qquad \{19\}$$

and integrating:

$$\ln y = C. \ .e^{nt} \qquad \{20\}$$

where C is a integration constant; if $t=0$, then $y=y_0$, and substituting t by zero we obtains that $C = ln\ y_0$:

$$\ln y = (ln \ y_0).e^{nt} \qquad \{21\}$$

this equation, in discrete time, can be approached by mean of a neoclassical growth process in y when y tends takes high values. If by simplicity to denote e^{nt} as b, then the relationship {21} under the above conditions is now converted in: $y = y_0{}^{b}$, in form that when $t = T$ this relation will be now:

$$y_T = y_o{}^{b} \qquad \{22\}$$

where b is a coefficient depending of time $[b(t)]$; and y_o and y_T are the initial and final real incomes respectively. The growth process of labor level L in the neoclassic model is: $L = L_0.e^{nt}$, but mean of similar process, we can it expressed as:

$$L_T = L_0{}^{b} \qquad \{23\}$$

where L_0 is the initial level of employment; the model also supposes decreasing returns in phisical capital factor. Supposing now in a neoclassic form that employment is related with the total population of country (PO) as follows: $L = l.PO,$ by mean of a certain ratio (l), substituting it in {23} we have that:

$$l.PO_T = (l.PO_0)^{b} \qquad \{24\}$$

If Y_m is the average of real per capita income in this country and calling as B the coefficient $(l/Y_m)^{1-b}$, which is supposed constant and probably related with a constant technical progress when it exists, the growth process of the per capita real income respect to average of per capita income can be expressed as follows:

$$Y_T = B\,(Y_0)^{b} \qquad \{25\}$$

where b is a coefficient depending of time t. The growth rate of real per capita income respect to average of per capita income accumulated during the period $(0,T)$ will be $\sum_{t=0}^{t=T} \frac{\Delta Y_t}{Y_t}$; and in the limit we have that:

$$\int_o^T \frac{dY}{Y} = \ln Y_T - \ln Y_o = \ln \frac{Y_T}{Y_o} \qquad \{26\}$$

Taking logarithms in expression {25}:

$$\ln Y_T = \ln B + b \,.\, \ln Y_o \qquad \{27\}$$

and rearranging:

$$\ln Y_T - \ln Y_o = \ln B - (1-b) \ln Y_o \qquad \{28\}$$

Relating the expressions {26} and {28}, we obtain that the growth rate of per capita real income relative in the (0,T) period is:

$$\ln \frac{Y_T}{Y_o} = \ln B - (1-b)\ln Y_o \qquad \{29\}$$

where b is a parameter related with time by mean of one expression as following: $b = e^{-b.T}$, where β is, in the dynamic transition toward the steady-state, a coefficient which indicates the speed of convergence of the real per capita income towards the steady state. Then, the average rate of per capita real income in relative terms will be:

$$\frac{1}{T} \cdot \ln \frac{Y_T}{Y_o} = a - \left[\frac{1 - e^{-b \cdot T}}{T} \right] \cdot \ln Y_o \qquad \{30\}$$

where a is (ln B)/T. This expression denote how the growth rate of relative real per capita income is related negatively with the logarithm of the initial level of relative real per capita income ($\ln Y_o$). That is, for a determined level of interaction parameter (a) related with each steady state, as more high is the per capita income in a country the growth rate of this will be below. If the value of b is positive, and (a) is the same in all countries of the sample, then exists absolute convergence; if it is zero or negative will exists divergence.

The coefficient b mean the speed of convergence; if $b \geq 0$ and the interaction term (a) is the same for all countries, then the poor economies grew more quickly that rich, and will exists absolute convergence. The absolute convergence concept can not be utilized among economies which have different steady states. For this last and more common situation must be utilized the conditional convergence concept. The conditional convergence concept implicates that in each country the speed of convergence is inversely related with the distance to each steady state.

When exists technical progress, denoted as A, the neoclassical model assumes that this coefficient is the same for all countries, and the model supposes that this coefficient is exogenous and grow at one constant rate (g); then the growth rate of the per capita income beyond steady state will be:

$$\frac{1}{T} \int_{Y^x}^{Y_T} \frac{dY}{Y} = \frac{1}{T} \cdot \ln \frac{Y_T}{Y^x} = g = a - \left(\frac{1 - e^{-bT}}{T} \right) \ln Y^* \qquad \{31\}$$

and hence the interaction term (a), that now is related with the exogenous technical progress, tends to the following value:

$$a = g + \left(\frac{1 - e^{bT}}{T} \right) \cdot \ln Y^* \qquad \{32\}$$

Substituting this term in the convergence equation (30) we have that:

$$\frac{1}{T} \int_{Y_0}^{Y_T} \frac{dY}{Y} = g + \left(\frac{1 - e^{-bT}}{T} \right) \ln Y^* - \left(\frac{1 - e^{-bT}}{T} \right) \ln Y_0 \qquad \{33\}$$

and hence:

$$\frac{1}{T} \ln \frac{Y_T}{Y_0} = g + \left(\frac{1 - e^{-bT}}{T} \right) \left(\ln Y^* - \ln Y_0 \right) \qquad \{34\}$$

where real income is in per capita terms.

The problem now is the estimation of per capita income in the steady state (Y^*). For this, we suppose that countries grow by mean of a neoclassical model with a technical progress neutral in Harrod sense, at an exogenous rate fixed (g). Besides, and following Mankiw, Romer and Weil (1992), this growth model embodies the capital factor in a broad sense for to include the human capital factor. For to keep the neoclassical hypothesis is necessary to consider constant returns to scale and the marginal productivity of physical capital incorporates diminishing return. The growth model can be expressed as following:

$$y = K^a \cdot H^g \cdot \left[A \cdot L \right]^{1-a-g} \qquad \{35\}$$

where A denotes the technical progress; in per capita terms, we have then:

$$Y = \frac{y}{L} = K^a \cdot H^g \cdot A^{1-a-g} \cdot L^{-(a+g)} \qquad \{36\}$$

Taking logarithms in this expression we have that:

$$\ln Y = \ln \left(\frac{y}{L} \right) = \boldsymbol{a} \cdot \ln K + g \ln H + \left(1 - \boldsymbol{a} - g \right) \cdot \ln A - \left(\boldsymbol{a} + g \right) \ln L \qquad \{37\}$$

In one time period the investment (*I*) have an expression as following in the goods market equilibrium:

$$I = dK = S_K \cdot y - \boldsymbol{d} \cdot K \qquad \{38\}$$

where S_K is the saving rate and d is the depreciation rate of physical capital (*K*).

Divided into *K* the last expression, we can wrote the growth rate of physical capital:

$$\frac{dK}{K} = S_K \cdot \left(\frac{y}{K} \right) - \boldsymbol{d} \qquad \{39\}$$

But in the steady state under a growth rate (g) of technological progress, the physical capital grew at one rate: $\frac{dK}{K} = n + g$, whereas this rate, in per capita terms grew dk/k = g; and substituting now this in the last formulation (39) we have one condition for steady state:

$$S_K \cdot y = \left(n + g + \boldsymbol{d} \right) K \qquad \{40\}$$

In the same sense for the human capital factor, we have that:

$$S_H \cdot y = \left(n + g + \boldsymbol{d} \right) H \qquad \{41\}$$

where H is the human capital and S_H is a proxy of them. Rearranging these two equations and taking logarithms we have the following expressions:

$$\left.\begin{aligned}\ln K &= \ln y^* + \ln S_K - \ln(n+g+\delta)\\ \ln H &= \ln y^* + \ln S_H - \ln(n+g+\delta)\end{aligned}\right\} \qquad \{42\}$$

and substituting these two equations, which concerning to steady state, in the expression {37} we will have a measure of income in this steady state:

$$\ln Y^* = \ln\left(\frac{y^*}{L}\right) = \ln y^* - \ln L = \alpha[\ln y^* + \ln S_K - \ln(n+g+\delta)] +$$
$$+\gamma[\ln y^* + \ln S_H - \ln(n+g+\delta)] + (1+\alpha+\gamma)\ln A - (\alpha+\gamma)\ln L$$
$$\{43\}$$

and rearranging this last equation:

$$(1-\alpha-\gamma)\ln y^* - (1-\alpha-\gamma)\ln L = \alpha[\ln S_K - \ln(n+g+\delta)] + \gamma[\ln S_H - \ln(n+g+\delta)] +$$
$$+(1-\alpha-\gamma)\ln A$$
$$\{44\}$$

Hence:

$$(1-\alpha-\gamma)\ln\left(\frac{y^*}{L}\right) = \alpha\cdot\ln S_K + \gamma\ln S_H + (1-\alpha-\gamma)\ln A - (\alpha+\gamma)\ln(n+g+\delta) \qquad \{45\}$$

And finally we have the estimation of per capita income at steady state:

$$\ln Y^* = \ln\left(\frac{y^*}{L}\right) = \ln A + \left(\frac{\alpha}{1-\alpha-\gamma}\right)\ln S_K + \left(\frac{\gamma}{1-\alpha-\gamma}\right)\ln S_H - \left(\frac{\alpha+\gamma}{1-\alpha-\gamma}\right)\ln(n+g+\delta)$$
$$\{46\}$$

Normally is assumed that the value of (g+δ) is 0.05. The estimation of average growth rate of per capita income yield when substituting the above equation of per capita income at the steady state into the expression (34); and hence:

$$\frac{1}{T}\int_{Y_0}^{Y_T}\frac{dY}{Y} = \frac{1}{T}\ln\frac{Y_T}{Y_0} = g + \left(\frac{1-e^{-bT}}{T}\right)\Bigg[\ln A + \left(\frac{\alpha}{1-\alpha-\gamma}\right)\ln S_K\left(\frac{\gamma}{1-\alpha-\gamma}\right)\ln S_H -$$
$$\{47\}$$
$$-\left(\frac{\alpha+\gamma}{1-\alpha-\gamma}\right)\ln(n+g+\delta) - \ln Y_0\Bigg]$$

and of this formulation we can know the coefficients of ln S_K, and ln S_H; in non logarithms terms we have that, calling to $\left(1-e^{-bT}\right)$ as (1-*b*):

$$Y_T = e^{gT}\cdot(n+g+\delta)^{\left[\frac{(b-1)(\alpha+\gamma)}{1-\alpha-\gamma}\right]}\cdot A^{(1-b)}.S_K^{\left[\frac{(1-b)\alpha}{1-\alpha-\gamma}\right]}\cdot S_H^{\left[\frac{(1-b)\gamma}{1-\alpha-\gamma}\right]}\cdot Y_o^b \qquad \{48\}$$

but considering that (dA/dt)/A = g, and integrating it we have that: $e^{gT} = A/A_0$, where A_0 is the initial level of technology; moreover, with the aim of to avoid the initial technical progress A_0, we will estimate the following form of equation (48) for to estimate the global *b* parameter:

$$Y_T = e^{gT}A^{(1-b)}(n+g+\delta)^{-(\lambda+\nu)}\cdot S_K^{\lambda}\cdot S_H^{\nu}\cdot Y_0^b \qquad \{49\}$$

where S_K and S_H reflects hold fixed levels of physical and human capital. As results of this estimation we can obtain the coefficient β conditional among global countries.

If we suppose now that each economy is an open economy then is possible that technological progress be diffused among all countries supposing a certain number of leading countries technology diffusers. If the diffusion of technology occurs gradually the model above analyzed became in an endogenous growth model which predict a pattern of convergence across economies.

The early versions of endogenous growth theories no longer predict conditional convergence, but the diffusion models predict a forum of conditional convergence that resembles the predictions of the neoclassical growth model.

If one economy follows an innovator process that produces a number N_1 of intermediate goods (x_j) that have been discovered by this leader economy, then the growth process can be expressed as following:

$$y_1 = A_1 \cdot L^{1-a} \sum_{j=1}^{N_1} \left(x_{ij}\right)^a \qquad \{50\}$$

where y_1 is the quantity of final goods produced by a representative firm in a country technologically leader; A_1 can represent here various aspects of government policy, such as taxation, provision of public services, and mainly the level of technology. For simplicity we suppose that the intermediate goods can be measured in a common physical unit, and that are employed in the same quantity. Then, the quantity of output will be give by the following expression:

$$y_1 = A_1 \cdot L^{1-a} \cdot N_1 \cdot \left(x_j\right)^a \qquad \{51\}$$

This productive process can be assimilated to one which incorporate human capital and labor augmenting technology similar to $y = K^a H^g \left[AL\right]^{1-a-g}$ above mentioned, if the productive process of intermediate inputs x_j follows certain production function such:

$$x_j = \frac{K}{A \cdot N_1^{1/a}} \left[\frac{H}{AL}\right]^{\frac{g}{a}} \qquad \{52\}$$

where physical capital incorporates non diminishing returns to scale, and hence generates and endogenous process of accumulation. Moreover globally all goods x_j incorporates in the production function of y_1 embodies diminishing returns on physical capital.

The diffusion of technology process must incorporate imperfect competition in final goods market (y_1) when individual's innovations spread only gradually to follower countries, and at same time producing endogenous growth making endogenous the rate of technological progress. In this model, technological progress shows up as an expansion of the number of varieties of producer and consumer products; if this number of capital goods augmenting is considered as a basic innovation because opening up a new industry.

The process of production of new technologies begins in the R & D sector where researchers produce designs for new intermediate inputs. They then sale these designs to monopolistically competitive firms who produce them with the price of the design determined by the flow of monopoly profits generated by the purchasing firm. The output of the R & D sector, in terms of new designs for intermediate inputs is determined by a different technology define as:

$$(dA/dt)/A = \tau H \qquad \{53\}$$

such in Romer (1990) and Grossman and Helpman (1992), where τH is the human capital used in research. In the case of follower economies which imitates leader countries the production function for the representative firm will be:

$$y_2 = A_2 \cdot L^{1-a} \cdot N_2 \left(x_j\right)^a \qquad \{54\}$$

where N_2 £ N_1. y_2 is the output of the representative firm in the follower countries, and N_2 is the number of products that are available for use in these imitator countries. If assuming that cost of imitation pay by follower countries (n) is an increasing function of the ratio N_2 / N_1, following Mansfield, Schwartz, and Wagner (1981), and Barro, R. and Sala i Martin, X. (1995), the model delivers to a kind of conditional convergence behavior similar to come from neoclassical labor augmenting model of growth. Then, the relationship between the growth rates in follower and leader countries be yield by the following expression:

$$\frac{1}{T}\int_0^T \frac{dy_2}{y_2} \cong \frac{1}{T}\int_0^T \frac{dy_1}{y_1} - \frac{b}{T} \cdot \ln\left[\frac{N_2 / N_1}{\left(N_2 / N_1\right)^*}\right] \qquad \{55\}$$

where y_i are in no per capita terms. But considering the expressions (54) and (51) and divides both, we can related, for two types of countries the real per capita incomes measured in efficiency units, ($Y^o = y / AL$), for both types of countries, with respects both levels of varieties of intermediate goods (N) produced in each country, and it can be expressed as: $(Y_2^o/Y_1^o)=(A_2/A_1)^{(\alpha/1-\alpha)}$ (N_2/N_1), following Barro and Sala i Martin (1995); at same time, supposing the real per capita income measured in not efficiency units, we have that: $(Y_2/Y_1)=(A_2/A_1)^{(1/1-\alpha)}$ (N_2/N_1). Using these expressions we can substitute them in relation (55) and then this last formulation can be write as follows:

$$\int_0^T \frac{dy_2}{y_2} \cong \int_0^T \frac{dy_1}{y_1} - b \cdot \ln\left[\frac{Y_2 / Y_1}{\left(Y^\circ_2 / Y^\circ_1\right)^*}\left(\frac{A_1}{A_2}\right)\right] \qquad \{56\}$$

where Y_2 is the real per capita income of each country, and Y_1 is the average of per capita real income in the leader countries; in this equation all terms are observable because we can substitute the ratio $(Y_2^o/Y_1^o)^*$ by their estimation in relationship (46); with the aim of to make disappear A, this equation (46) can be expressed in efficiency terms as follows:

$$\ln Y^{o}* = \ln\left(\frac{y*}{AL}\right) = \left(\frac{a}{1-a-g}\right)\ln S_K + \left(\frac{g}{1-a-g}\right)\ln S_H - \left(\frac{a+g}{1-a-g}\right)\ln\left(n+g+d\right) \qquad \{57\}$$

and in this equation do not appear the coefficient of technical progress A. In the relationship (56) A_1 and A_2 are the technological matrix concerning to leader and follower countries respectively. With respect to follower countries, we assuming that they do not have the same access to the technology come from leader countries; in this sense, and looking our countries' sample, we consider two types of technology for the follower countries: A_2 for the developed, but not technologically leader countries, and A_3 concerning to less-developed and the poor countries. We suppose one A_2 technology for the following 21 countries contains in the sample: Algeria, Tunisia, Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Uruguay, Venezuela, Iran, Jordan, Malaysia, Syria, South Korea, Thailand, Turkey, Greece, Poland, Portugal, and Yugoslavia. The A_3 technology concerns to the followings 21 countries: Cameroon, Congo, Egypt, Ethiopia, Kenya, Madagascar, Malawi, Morocco, Tanzania, Zaire, Zambia, Bolivia, Paraguay, Peru, Bangladesh, Philippines, India, Indonesia, Myanmar, Pakistan, and Sry Lanka. The countries technologically leaders considered in this analysis, with A_1 technology, are: Canada, USA, Japan, South Korea, Israel, Germany, Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Netherlands, Ireland, Italy, Norway, United Kingdom, Spain, Sweden and Swiss, in total 19 technological leader countries.

In a single cross-section analysis, the speed of conditional convergence (b) is identical in both models, neoclassical with exogenous growth, and endogenous with diffusion of technology; but in a panel data both models furnishes different speed of conditional convergence. The problem now in the relation (56) is to calculate the term (A_1/A_2); moreover, if we consider the equation (53), and remembering also that $(dA/dt)/A = g$, we can concluding that: $gT = tHT$, and substituting this in formulation (49) using ln (S_H) as a proxi of H, we will have the following model:

$$Y_T = A^{(1-b)}(n+g+d)^{r} \cdot S_K^{l} \cdot S_H^{m} \cdot Y_0^{b} \qquad \{58\}$$

This model not assumes in necessary form the neoclassical hypotheses formulated about model (49) by Mankiw, Romer and Weil, including the exogenous growth rate of A, and that technological progress must be the same for all countries; it is results an endogenous growth model, that is not sure predicts convergence. But form model (58) is very easy to obtain the A coefficient, by mean of to regress this equation for each group of countries. Once known the coefficients A_1, A_2 and A_3, substituting them in the relation (56), we can obtain the particulars speeds of conditional convergence β's for each country. The values of β coefficients are shown in the first column of table 1. Substituting now this values of β's in the relation (30), henceforth that both models, neoclassical and technological diffusion furnishes the same values of β's, we can obtain the interaction parameters (a_i) for each country, corresponding to each steady state.

At same time we can consider now the role of infrastructures and other spatial variables in the growth and convergence process. These variables, coming from of public infrastructures are not exactly a factor input, as assumed in Aschauer (1989) and in Barro (1990), but it affect the growth process as a factor productivity externalities; the infrastructure factor productivity externality is incorporated into the production process as follows: $A^* = AS^{\eta}$, where S is a ratio referred to spatial variables which are related with infrastructures; we assuming that these variables hold fixed, being η is a certain coefficient of elasticity. The measure of spatial ratio S_i, following Bradley, Gerald y Kearney (1992) is made as (S_T/S_o), that is the ratio between the final and initial values of an absolute and general spatial variable. The general form of a production function in this growth process could be write as following: y = A*f(N,K). The factor productivity externality is associated with improved supply conditions in the economy as a result of the investment in human capital and public infrastructure; these last variables are incorporated in the model by endogenising the scale parameter A provoking, hence, an endogenous growth model, as say in Barro(1990). The growth process generated by this model, once calculated the growth income rates in per capita terms are as the following:

$$\frac{1}{T}\cdot\ln\frac{Y_T}{Y_o}=a-\left[\frac{1-b'}{T}\right]\cdot\ln Y_o+\frac{h}{T}.\ln\left(\frac{S_T}{S_0}\right) \qquad \{59\}$$

where h is a certain elasticity coefficient, and a is the intersection parameter, related with the steady state position. In the Barro (1990) model of endogenous growth, which incorporate shocks and factor productivity externalities provoked by mean of human and public capital, during the dynamic transition toward steady state, once we are away from the optimal ratio between human to physical capital there is a higher return to the factor which is relatively scarce, and hence the optimal policy is to accumulate only that factor; as more of this factor is accumulated, the rate of return on it declines and we return to steady state growth path. During the transition we observe the growth rate declining towards the steady state rate. This means that an economy is from the optimal ratio H/K the higher is its rate of growth. The early endogenous growth model do not generates convergence, but under the above conditions can exist some possibilities of generates a convergence form from Barro (1990) model; in this situation,b' is $e^{-b'T}$ being b' the speed of conditional convergence resulting of to introduce the spatial variables S_i in the growth process. From equation (59), we obtain:

$$h=\frac{\partial\ln\left(\frac{Y_T}{Y_0}\right)}{\partial\ln\left(\frac{S_T}{S_0}\right)} \qquad \{60\}$$

where η is the effect caused by the spatial variable on real per capita income growth rate. At same time from the non linear regression of real income in absolute terms (y) on all spatial explanatory variables for to estimate the explanation power of these on output level, we obtain:

$$\ln y_{i,t}=a_{it}+e\cdot\ln S_{it}+u_{it} \qquad \{61\}$$

where $e = e_{y,S}$ is the elasticity coefficient of (y) relative to S variable. Estimated this equation, we have:

$$\hat{e}_{y,S}=\frac{d\ln y}{d\ln S}=\frac{\ln y_T-\ln y_o}{\ln S_T-\ln S_o}=\frac{\ln\left(\frac{y_T}{y_S}\right)}{\ln\left(\frac{S_T}{S_o}\right)}=\frac{\frac{\Delta y}{y}}{\frac{\Delta S}{S}} \qquad \{62\}$$

and we can deduced that: $\ln\left(\frac{y_T}{y_o}\right)=\hat{e}\cdot\ln\left(\frac{S_T}{S_o}\right)$, and hence:

$$y_T = \left(\frac{S_T}{S_o}\right)^{\hat{e}} \cdot y_o \; . \qquad \{63\}$$

If now we divided this equation into labor, thinking that $L_T = L_0 \,.\, e^n$, we will have that,

$$Y_T = e^{-n} \cdot \left[\frac{S_T}{S_0}\right]^{\hat{e}} \cdot Y_0 \qquad \{64\}$$

taking logarithms in this expression we have:

$$\ln Y_T = -n + \hat{e} \cdot \ln\left(\frac{S_T}{S_0}\right) + \ln Y_0 \qquad \{65\}$$

and hence:

$$\hat{e} = \frac{\partial \ln \frac{Y_T}{Y_0}}{\partial \ln \frac{S_T}{S_0}} \qquad \{66\}$$

hence we can reduced the problem to: $h \cong \hat{e}$.

Substituting it and considering now T annuals periods the convergence equations related with the average rate of growth is the following:

$$\frac{1}{T} \cdot \ln\left(\frac{Y_T}{Y_o}\right) = a + \frac{\hat{e}}{T} \cdot \ln\left(\frac{S_T}{S_o}\right) - \left(\frac{1 - e^{-b_s \cdot T}}{T}\right) \cdot \ln Y_o \qquad \{67\}$$

that is:

$$\ln\left(\frac{Y_T}{Y_o}\right) = a \cdot T + \hat{e} \cdot \ln\left(\frac{S_T}{S_o}\right) - \left(1 - e^{-b_s \cdot T}\right) \cdot \ln Y_o \qquad \{68\}$$

where:

$$e^{-b_s \cdot T} = \frac{\ln Y_T - a \cdot T - \hat{e} \ln\left(\frac{S_T}{S_o}\right)}{\ln Y_o} \qquad \{69\}$$

and substituting the term a by each a_i, we have the particular spatial speed of convergence:

$$b_s = \frac{1}{T} \cdot \ln\left[\frac{\ln Y_o}{\ln Y_T - a_i \cdot T - \hat{e} \cdot \ln\left(\frac{S_T}{S_o}\right)}\right] \qquad \{70\}$$

where a_i denotes the interaction terms for each steady states corresponding with each country before estimated in the equations (56) and (30); b_S is the speed of conditional converge concerning to each country when the variable S affect the growth process of real per capita income. These coefficients β_S are shown in table 1 for each spatial variable and each country.

5. CONGESTION PROCESS

A great number of the spatial variables above mentioned not should available without the existence of certain infrastructures, as in the case of transportation and cities system infrastructures, in general provides by Government, playing a role as public goods and hence may be generates a congestion process.

For analyzing this process we suppose an aggregate production function without diminishing returns in physical capital that furnishes an endogenous growth process with *AK* technologies modified mean of inclusion by a term that reflects the activities of Government. The production process can be as following:

$$Y = A \cdot K \cdot f\left({}^{G}\!/_{y} \right) \qquad \{71\}$$

where *(G/y)* is considered constant an equal to t. Besides with supposing that $f_t^{'} > 0$ and $f_{tt}^{''} < 0$, being $A>0$. For simplicity we will supposes that Government have a budget balances in equilibrium, in maner that $G=t\ y=T$, being T the total volume of direct taxes. In this model consumers and producers maximize theirs utilities and profits respectively. Moreover the Government is also an economic agent which will maximize a certain social welfare function. In this function the most important component is the per capita real income growth rate. Following Barro and Sala-i-Martin (1995) the results of this maximization process are identical to maximize the following function:

$$g(t) = (1-t) \cdot f(t) \qquad \{72\}$$

The results of this maximization furnishes the optimum sizes of Government sector face to congestion problem. The equation that yields this optimum size is the following:

$$\frac{\partial y}{\partial G} = \frac{f'(t)}{f(t) + t \cdot f'(t)} = \frac{f'(t)}{f'(t)} = 1 \qquad \{73\}$$

And this condition is so-called the efficiency condition of the Government Sector.

If we suppose now that generally the Governments are efficient in the congestion problem, then the income elasticity with respect to the public expenditure must be for each country the following:

$$e_{y,G} = \left(\frac{\partial y}{\partial G} \right) \cdot \left(\frac{G}{y} \right) = 1 \cdot t = t \qquad \{74\}$$

where $0 < t < 1$, and hence this elasticity must be <1. When the growth rate of spatial variables be more high that infrastructures rates corresponding, then will appears congestion. Supposing that S is a generically spatial variable, the income elasticity with respect this variable become:

$$e_{y,S} = \left(\frac{\partial y}{\partial S} \right) \cdot \left(\frac{S}{y} \right) \qquad \{75\}$$

And dividing the formulation {75} into the {74} we have:

$$e_{G,S} = \frac{e_{y,S}}{e_{y,G}} = \frac{\left(\frac{\partial y}{\partial S} \right) \cdot \left(\frac{S}{y} \right)}{\left(\frac{\partial y}{\partial G} \right) \cdot \left(\frac{G}{y} \right)} = \left(\frac{\partial G}{\partial S} \right) \cdot \left(\frac{S}{G} \right) = \frac{\left(\frac{dG}{G} \right)}{\left(\frac{dS}{S} \right)} = \frac{e_{y,S}}{t} \qquad \{76\}$$

Supposing the efficiency condition and like we know that $t < 1$, we can deduce that if $e_{y,S}$ ³ 1 , then:

$$e_{G,S} > 1. \qquad \{77\}$$

That is:

$$e_{G,S} = \frac{\frac{dG}{G}}{\frac{dS}{S}} > 1 \qquad \{78\}$$

and hence:

$$\frac{dG}{G} > \frac{dS}{S} \qquad \{79\}$$

When the growth rate of public expenditures in infrastructures be more high that the growth rate of the spatial variable corresponding, then implicates not congestion. In abstract the congestion process is submitted in the following framework:

If $e_{y,S} \geq 1$ do not exists congestion

If $e_{y,S} < 1$, should be congestion : If $e_{y,S} \geq t$ there are not congestion

If $e_{y,S} < t$ produces congestion

These coefficients of elasticity $e_{y,S}$ are shown for each country and each spatial variable in table 2.

6. CONCLUDING REMARKS

The main results of this analysis are shown in table 2, denoting that if increase the value of any spatial variables affect positively (+) the growth rate of real per capita income, or negatively (-) depending of sign that take each spatial variable in each country. At same time the table 1 show the speed of conditional convergence particular β of each country, and at same time, the speed of convergence when the spatial variables affect separately the coefficient of technical progress. In the table 3 we can observer what policy on each spatial variable in each country is good for aumenting the speed of conditional convergence in real per capita income, depending of the sign of the values. How we can observer in some countries for some spatial variables may appear infrastructure congestion (CG), following the explanation furnishes in section 5 of this paper.

Table 1. SPEEDS OF CONDITIONAL CONVERGENCE (1978-1990)

Countries	β	β-PC	β-PCPO	β-AUTCAM	β-PASKM	β-AUTPC	β-PKMTKM	β-DENSID
Algeria	0.001901	0.001901	0.001901	0.001901	-0.03608	0.001901	0.026826	0.001901
Cameroon	0.004240	0.004240	0.004240	-0.00724	-0.00447	0.004240	0.004240	0.004240
Congo	0.013908	-0.02269	0.013908	0.013908	0.013908	0.018916	0.019699	0.013908
Egypt	0.014068	0.014068	0.008316	0.014068	0.014068	-0.00157	0.014068	0.014068
Ethiopia	0.004877	0.004877	0.004877	0.007744	0.004877	-0.00339	0.004877	0.004877
Kenya	0.002675	-0.00579	0.002675	-0.00053	-0.00319	0.002675	0.009756	0.002675
Madagascar	-0.0002	-0.00022	-0.00022	-0.00041	-0.00022	0.015396	-0.00022	-0.00022
Malawi	0.001306	-0.30148	-	0.001306	-0.00214	-0.00075	0.001306	-
Morocco	0.005095	0.005095	0.005095	0.005095	-0.00412	-0.00099	0.005095	0.005095
Tanzania	0.002723	0.002723	0.002723	0.002723	0.005524	-0.00434	0.002723	0.002723
Tunisia	-0.00343	-0.00343	-0.00343	-0.00343	0.006078	-0.00343	-0.00484	-0.02471
Zaire	-0.00113	-	-	-0.00065	-0.00113	-0.00113	0.001745	-0.27518
Zambia	-0.00822	-	-0.23926	-0.00822	-0.00505	-0.02215	-0.00735	-0.28006
Argentina	-0.07131	-	-	-0.07131	-0.06506	-0.07131	-0.07131	-0.46296
Bolivia	-0.01249	-0.35611	-	-0.01249	-0.01256	-0.01249	-0.01249	-
Brazil	-0.01858	-0.01858	-0.05091	-0.01500	-0.01858	0.027184	-0.03470	-0.01858
Canada	0.019115	-0.30016	-	0.019115	0.012033	0.019115	0.019115	-
Chile	0.007759	-0.28807	-0.20630	0.012495	-0.00167	0.007759	0.007759	-
Colombia	0.003448	0.003448	0.003448	0.003448	0.003448	-0.00852	0.003448	0.003448
Ecuador	-0.00285	-0.00285	-0.00285	-0.00806	-0.00285	-0.00594	-0.00285	-0.00285
U.S.A.	0.024878	0.024878	0.024878	0.024878	0.070773	0.024878	0.052521	0.024878
Mexico	-0.00793	-	-0.28274	-0.00616	-0.00799	-0.01667	-0.00793	-0.28909
Paraguay	0.003196	0.003196	0.003196	-0.00773	0.003196	0.003196	0.003196	0.003196
Peru	-0.02432	-0.02432	-0.02432	-0.05436	-0.03102	-0.02432	-0.01506	-0.02432
Uruguay	-0.00589	-0.00589	-0.00589	-0.00589	-0.00589	-0.00589	-0.00589	-0.00589
Venezuela	-0.03599	-	-	-0.03599	-0.03716	-0.03599	-0.03621	-0.43615
Bangla Desh	0.006121	0.006121	0.006121	0.006121	0.006267	0.000037	0.006121	0.006121
South Korea	0.062264	0.062264	0.062264	0.062264	0.002368	-0.00317	0.134479	0.062264
Philippines	-0.00103	-0.00103	-0.00103	-0.01191	-0.00103	0.005902	-0.00207	-0.00103
India	0.010426	0.010426	0.004421	0.010426	0.010426	0.002668	0.010426	0.010426
Indonesia	0.013480	0.013480	0.013480	0.008818	0.008799	0.007457	0.011258	0.013480
Iran	-0.08554	-0.08554	-0.08554	-0.08554	-0.10221	-0.08554	-0.10419	-0.08554
Israel	0.004237	-0.52612	-	0.004237	0.004237	0.004237	0.004237	-
Japan	0.002477	-0.35121	-	0.002477	0.002477	0.001453	0.002477	-
Jordan	0.002888	-0.01074	0.002888	0.002888	0.002888	0.002888	0.002888	0.002888
Malaysia	0.015543	-0.00546	0.015543	0.010999	0.004151	0.015543	0.015543	0.015543
Myanmar	0.007794	0.007794	0.007794	0.054660	0.004367	-0.00616	0.007794	0.007794
Pakistan	0.011359	-0.01207	0.017763	0.011123	0.011359	0.014447	0.011359	0.011359
Syria	-0.01001	-	-0.32930	0.014341	-0.01001	-0.00837	-0.00658	-0.35548
Sri Lanka	0.005809	-0.14716	-0.19125	0.005809	0.005809	0.005809	0.005809	-
Thailand	0.023000	-0.11147	-	0.022632	0.003068	0.023000	0.023000	0.023000
Turkey	0.004314	-0.38425	-	0.039164	0.004314	-0.02353	-0.00005	-
W.Germany.	0.017013	-0.20983	-	0.020963	0.017013	0.029107	0.014820	-
Austria	0.016970	-	-0.23719	0.023041	0.024171	0.022291	0.017804	-0.09895
Belgium	0.017635	-	-0.17886	0.017727	0.017635	0.030300	0.017635	0.031411
Czechoslov.	0.002672	-0.23586	-	0.008171	0.002672	0.002672	0.005731	-
Denmark	0.017591	-0.02696	-	0.018662	0.034289	0.024854	0.008718	-0.02557
Spain	0.025309	0.025309	0.035014	0.030948	0.020428	0.102048	0.049553	0.025309
Finland	0.006830	-	-0.14908	0.006830	0.007273	0.036290	0.008367	-0.07299
France	0.019884	0.020979	0.019884	0.030282	0.022570	0.056990	0.004864	0.019884
Greece	-0.05994	-	-0.35619	-0.05633	-0.04112	-0.05994	-0.05994	-0.34627
Netherlands	0.026283	-	-0.30321	0.031915	0.033511	0.062660	0.026283	-
Ireland	0.002625	0.002625	0.002625	0.236934	-0.00901	0.041681	0.002625	0.002625
Italy	0.014891	0.048990	0.014891	0.006891	0.024963	-0.00640	0.014891	0.052747
Norway	0.013280	0.023478	0.013280	0.022424	0.013280	0.021918	0.013280	0.013280
Poland	0.038077	-0.28866	-0.12528	-0.01147	0.040637	0.250140	0.038077	-
Portugal	0.016523	0.016523	0.016523	0.016523	0.016523	-0.03990	0.038216	0.016523
U.Kingdom	0.020776	0.020776	0.020776	0.021513	0.026144	0.061049	0.017462	0.020776
Sweden	0.017322	0.017322	0.029725	0.017322	0.018336	0.019333	0.017707	0.021237
Switzerland	0.016734	-	-0.05871	0.016734	0.028515	0.015537	0.016609	0.016734
Yugoslavia	-0.01424	-0.01424	-0.01424	-0.01424	-0.01424	-0.01424	-0.01424	-0.02912

Table 2. REAL INCOME-SPATIAL VARIABLES ELASTICITIES (1978-1990)
(Spatial effects on real per capita income growth rate)

Countries	ε-PC	ε-PCPO	ε-AUTCAM	ε-PASKM	ε-AUTPC	ε-PKMTKM	ε-DENSID	$\ln y_{o\,i}$	$\ln y_{Ti}$
Algeria	0	0	0	1.56004	0	-1.30521	0	-1.30927	-1.13463
Cameroon	0	0	1.20215	0.388574	0	0	0	-1.93998	-1.77410
Congo	3.04068	0	0	0	0.478421	-0.30533	0	-2.09284	-1.67193
Egypt	0	1017311	0	0	0.752358	0	0	-2.52429	-2.07912
Ethiopia	0	0	0.310142	0	-1.03655	0	0	-4.07312	-4.04862
Kenya	0.524	0	-0.27925	0.309295	0	-0.33899	0	-2.93265	-2.91481
Madagascar	0	0	1.23427	0	1.40992	0	0	-3.06102	-3.18694
Malawi	388.841	-393.616	0	0.262827	-0.30605	0	-387.614	-3.17685	-3.24786
Morocco	0	0	0	0.295528	1.39316	0	0	-2.04318	-1.86144
Tanzania	0	0	0	-0.59302	-0.65413	0	0	-4.10520	-4.20834
Tunisia	0	0	0	-0.56911	0	0.424193	2.02856	-1.50553	-1.47459
Zaire	-425.31	426.3	0.046599	0	0	0.912296	426.093	-3.86728	-4.16508
Zambia	-244.994	244.026	0	-0.09861	-0.85118	-0.04084	244.809	-2.24688	-2.53484
Argentina	-724.082	724.291	0	0.382568	0	0	723.998	-0.25853	-0.42040
Bolivia	447.336	-446.478	0	-0.09267	0	0	-447.734	-1.86771	-2.18742
Brazil	0	2.10361	0.90473	0	3.08767	-0.50208	0	-0.73819	-0.74848
Canada	-245.334	246.044	0	0.173311	0	0	250.082	0.94192	1.16853
Chile	437.247	-419.175	-0.67749	-0.29899	0	0	-430.839	-1.34765	-1.06714
Colombia	0	0	0	0	0.512681	0	0	-1.84916	-1.69645
Ecuador	0	0	0.3839	0	0.230495	0	0	-1.88348	-1.91006
U.S.A.	0	0	0	0.338894	0	-0.37109	0	1.03989	1.18899
Mexico	-163.309	163.549	0.373445	0.46572	0.722122	0	163.971	0.93149	-0.85468
Paraguay	0	0	0.148211	0	0	0	0	-1.83615	-1.68882
Peru	0	0	-6.03851	0.692583	0	-0.67867	0	-1.06351	-1.34273
Uruguay	0	0	0	0	0	0	0	0.00400	-0.91327
Venezuela	-738.408	734.519	0	0.042651	0	-0.04230	740.336	-0.09192	-0.97403
Bangla Desh	0	0	0	-0.56574	-0.37279	0	0	-3.58486	-3.46225
South Korea	0	0	0	1.42987	0.348044	-1.67906	0	-0.95052	-0.15678
Philippines	0	0	-0.39539	0	0.236084	0.283186	0	-2.20382	-2.22934
India	0	1.29689	0	0	0.469651	0	0	-3.22792	-2.89915
Indonesia	0	0	-0.38630	0.299145	0.476032	-0.17618	0	-2.85311	-2.41350
Iran	0	0	0	0.74499	0	-0.60762	0	-0.37843	-0.98971
Israel	-658.021	655.527	0	0	0	0	661.826	0.22065	0.56659
Japan	-180.923	182.175	0	0	0.740642	0	180.368	0.85112	1.27095
Jordan	1.45589	0	0	0	0	0	0	-2.04916	-1.93175
Malaysia	0.619989	0	0.215313	0.578053	0	0	0	-1.43633	-1.01585
Myanmar	0	0	-4.70149	0.544827	3.38318	0	0	-4.09318	-3.90654
Pakistan	2.24274	-1.9682	0.10984	0	-0.23849	0	0	-3.12897	-2.76255
Syria	-340.198	338.97	-1.49553	0	1.26129	0.170686	343.289	-2.81200	-2.65729
Sri Lanka	305.897	-301.09	0	0	0	0	-301.075	-1.18436	-1.21672
Thailand	15.8891	-25.5658	0.024558	0.816659	0	0	0	-2.12542	-1.47670
Turkey	404.836	-398.828	-0.60629	0	1.04818	-0.33755	-407.838	-1.14539	-0.91210
W.Germany.	-157.555	158.985	-0.51251	0	0.526269	-0.23144	156.928	1.02839	1.27117
Austria	92.5716	-92.1748	0.627033	0.334836	0.409051	-0.09662	-92.2965	0.85756	1.11487
Belgium	-123.736	121.608	-0.35570	0	0.324115	0	120.805	0.82304	1007667
Czechoslov.	250.838	-250.627	-0.89364	0	0	-0.29064	-239.265	-1.04387	-0.82661
Denmark	110.011	-106.922	0.445526	0.446955	0.685035	-0.28931	-96.8155	1.10355	1.33257
Spain	0	2.81696	-0.43881	0.256798	0.368524	-0.37979	0	0.37871	0.63951
Finland	38.4184	-37.6519	0	0.056967	1.1115	-0.12892	-40.4204	1.04349	1.42056
France	-1.04596	0	-0.93175	0.157962	1.0023	-0.38022	0	0.92965	1.12932
Greece	-171.79	172.467	0.74645	-0.30529	0	0	174.782	-0.13549	-0.01057
Netherlands	-393.435	395.51	-0.21488	0.210626	0.794842	0	395.074	0.88406	1.04664
Ireland	0	0	-0.50270	-0.22270	0.997405	0	0	0.29366	0.65242
Italy	-15.1782	0	0.523808	0.593044	-0.42844	0	10.4094	0.76358	1.04778
Norway	1.62941	0	-0.27232	0	0.39603	0	0	1.02872	1.31842
Poland	1552.79	-1561.71	3.71321	-0.75250	-1.66263	0	-1536.3	-2.48333	-1.40529
Portugal	0	0	0	0	0.612714	0.206321	0	-0.45913	-0.09645
U.Kingdom	0	0	-0.05356	0.403388	0.557265	-0.08059	0	0.70309	0.94188
Sweden	0	1.11531	0	0.188403	0.47812	-0.03006	1.57887	1.15802	1.38586
Switzerland	4.31966	-4.57124	0	0.589671	0.133233	-0.19158	0	1.40462	1.62108
Yugoslavia	0	0	0	0	0	0	2.04598	-0.56243	-0.44728

Table 3. CONGESTION AND SPATIAL POLICIES ON SPEED OF CONDITIONAL CONVERGENCE (1978-1990)

Countries	Δ-PC	Δ-PCPO	Δ-AUTCAM	Δ-PASKM	Δ-AUTPC	Δ-PKMTKM	Δ-DENSID
Algeria	0, CG	0	0	-	-, CG	+, CG	0, CG
Cameroon	0, CG	0	-, CG	-	0	0	0, CG
Congo	-	0	0	0	-, CG	+, CG	0, CG
Egypt	0, CG	-	0	0	-, CG	0	0, CG
Ethiopia	0, CG	0	-, CG	0	+, CG	0	0, CG
Kenya	-, CG	0	+, CG	-	0	+, CG	0, CG
Madagascar	0, CG	0	-, CG	0	-, CG	0	0, CG
Malawi	-	+, CG	0	-	+, CG	0	+, CG
Morocco	0, CG	0	0	-	-, CG	0	0, CG
Tanzania	0, CG	0	0	+, CG	+, CG	0	0, CG
Tunisia	0, CG	0	0	+, CG	0	-, CG	-, CG
Zaire	0, CG	-	-, CG	0	0	-, CG	-, CG
Zambia	0, CG	-	0	+, CG	+, CG	+	-, CG
Argentina	+, CG	-	0	-	0	0	-, CG
Bolivia	-	+, CG	0	+, CG	0	0	+, CG
Brazil	0, CG	-	-, CG	0	-, CG	+, CG	0, CG
Canada	-	+	0	+	0	0	+
Chile	-	+, CG	+, CG	+, CG	0	0	+, CG
Colombia	0, CG	0	0	0	-, CG	0	0, CG
Ecuador	0, CG	0	-, CG	0	-	0	0, CG
U.S.A.	0, CG	0	0	+	0	-	0, CG
Mexico	+, CG	-	-, CG	-	-, CG	0	-, CG
Paraguay	0, CG	0	-, CG	0	0	0	0, CG
Peru	0, CG	0	+, CG	-	0	+, CG	0, CG
Uruguay	0, CG	0	0	0	0	0	0, CG
Venezuela	+, CG	-	0	-, CG	0	+	-, CG
Bangla Desh	0, CG	0	0	+, CG	+, CG	0	0, CG
South Korea	0, CG	0	0	-	-	+, CG	0, CG
Philippines	0, CG	0	+, CG	0	-	-, CG	0, CG
India	0, CG	-	0	0	-, CG	0	0, CG
Indonesia	0, CG	0	+, CG	-	-, CG	+, CG	0, CG
Iran	0, CG	0	0	-	0	+, CG	0, CG
Israel	-	+	0	0	0	0	+
Japan	-, CG	+	0	0	+	0	+
Jordan	-	0	0	0	0	0	0, CG
Malaysia	-, CG	0	-, CG	-	0	0	0, CG
Myanmar	0, CG	0	+, CG	-	-, CG	0	0, CG
Pakistan	-	+, CG	-, CG	0	+, CG	0	0, CG
Syria	+, CG	-	+, CG	0	-, CG	-, CG	-, CG
Sri Lanka	-	+, CG	0	0	0	0	+, CG
Thailand	-	+, CG	-, CG	-	0	0	0, CG
Turkey	-	+, CG	+, CG	0	-, CG	+, CG	+, CG
W.Germany.	-, CG	+	-	0	+	-	+
Austria	-	-	+	+	+, CG	-	-
Belgium	-	+	-	0	+, CG	0	+
Czechoslov.	-	+, CG	+, CG	0	0	+, CG	+, CG
Denmark	-	-	+	+	+	-	-
Spain	0, CG	+	-	+	+, CG	-	0, CG
Finland	0	-	0	+, CG	+	-	-
France	-, CG	0	-	+	+	-	0, CG
Greece	+, CG	-	-, CG	+, CG	0	0	-, CG
Netherlands	0, CG	+	-	+	+	0	+
Ireland	0, CG	0	-, CG	-, CG	+	0	0, CG
Italy	-, CG	0	+	+	-	0	+

Norway	+	0	-	0	+, CG	0	0, CG
Poland	-	+, CG	-, CG	+, CG	+, CG	0	+, CG
Portugal	0, CG	0	0	0	-, CG	-	0, CG
U.Kingdom	0, CG	0	-, CG	+	+	-	0, CG
Sweden	0, CG	+	0	+	+	-, CG	+
Switzerland	-	-	0	+	+, CG	-	0, CG
Yugoslavia	0, CG	0	0	0	0	0	-, CG

Table 4. Empirical results of income Velocity of Circulation. Panel (1978-91)

Method:	I	II	III	IV	V	VI	VII
Endog.Var: VELOCID	**Between**	**OLS**	**Within**	**Random**	**OLS-AR1**	**Within-AR1**	**Random -AR1**
Expl.Varia:							
PCPO	0.1552 (3.199)	0.1529 (11.22)	0.1109 (1.797)	0.1293 (3.621)	0.1540 (10.41)	0.1270 (4.896)	0.1283 (5.630)
PC	0.2779 (1.921)	0.2885 (7.202)	0.5763 (4.818)	0.4160 (5.134)	0.2630 (6.234)	0.1145 (1.856)	0.1507 (2.691)
PKMTKM	0.0273 (0.160)	0.0264 (0.588)	-0.207 (-0.38)	-0.397 (-0.07)	0.5558 (1.244)	0.1018 (2.291)	0.0981 (2.289)
AUTCAM	-0.783 (-0.39)	-0.505 (-0.94)	0.3339 (4.020)	0.2120 (2.889)	-0.135 (-0.02)	0.2604 (3.530)	0.2165 (3.241)
PASKM	-0.198 (-1.98)	-0.200 (-7.12)	-0.386 (-3.33)	-0.259 (-3.47)	-0.193 (-6.51)	-0.143 (-2.91)	-0.155 (-3.53)
AUTPC	-0.120 (-0.43)	-0.148 (-1.93)	0.1883 (1.051)	-0.163 (-1.21)	-0.186 (-2.33)	-0.256 (-2.38)	-0.268 (-2.73)
DENSID	0.5242 (1.231)	0.5154 (4.324)	-0.693 (-1.07)	0.2157 (0.667)	0.4967 (3.872)	0.4497 (1.825)	0.4402 (2.093)
Constant	3.8766 (3.307)	3.8123 (11.79)	Fixed Effects	3.1304 (4.222)	6.0706 (27.65)	Fixed Effects	5.9242 (5.688)
Tests:							
R^2	0.2940	0.2630	0.8837	0.0979	0.2484	0.8159	0.2081
R^2-adjusted	0.2008	0.2564	0.8730	0.0145	0.2411	0.7974	
DW			0.7638			2.0636	2.0676
Lagrang.M							2107.0
Hausman				21.508			0.0001

Note: t ratios in brackets.

Table 5. Estimation results of Money in equilibrium. Panel (1978-91)

Method	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
Endog var: **MPPP**	**Betwee n**	**OLS**	**Within**	**Random Effects**	**2SLS Panel**	**2SLS AR1**	**OLS AR1**	**Within AR1**	**Random AR1**
Expl var.:									
PCPO	1.07565 (0.92)	1.07 (2.6)	0.0374 (0.025)	0.8177 (0.970)	1.1529 (2.875)	0.8323 (1.85)	0.94 (2.1)	-0.025 (-0.04)	0.2471 (0.473)
PC	12.9693 (3.94)	12.6 (11.)	6.598 (2.018)	7.7081 (3.801)	12.736 (11.24)	12.791 (11.15)	13.0 (10.)	12.257 (8.53)	12.23 (9.289)
PKMTKM	6.34367 (1.65)	5.80 (4.5)	0.7769 (0.623)	1.3014 (1.107)	6.2529 (4.718)	6.5904 (5.619)	5.22 (4.0)	3.3013 (2.98)	3.5153 (3.32)
AUTCAM	-4.8277 (-0.97)	-5.42 (-3.2)	-3.464 (-1.72)	-8.492 (-4.94)	-5.637 (-3.34)	-17.03 (-8.01)	-7.20 (-3.)	-13.62 (-6.90)	-12.508 (-6.804)
PASKM	0.00077 (3.35)	.7E-3 (9.8)	0.00149 (5.531)	0.00116 (6.803)	0.0007 (9.762)	0.0007 (9.157)	.8E-3 (9.3)	0.0008 (8.09)	0.00085 (8.95)
AUTPC	0.03416 (5.33)	0.03 (16.)	0.07837 (15.57)	0.05256 (16.034)	0.0352 (16.11)	0.0414 (19.06)	0.03 (15.)	0.0384 (15.44)	0.03864 (16.71)
DENSID	- 0.17479 (-1.79)	-0.17 (-5.0)	-0.2587 (-1.44)	-0.2314 (-2.962)	-0.174 (-5.17)	-0.117 (-2.88)	-0.16 (-4.)	-0.140 (-2.65)	-0.1441 (-3.095)
Constant	- 54.8014 (-1.92)	-51.8 (-5.3)	Effects Fixed	-32.462 (-1.761)	-53.27 (-5.43)	-16.77 (-0.86)	-75.9 (-10)	Effects Fixed	-22.68 (-0.82)
Tests:									
R^2	0.705	.689	0.97918	0.57389	0.6916	0.691	.696	0.9466	0.6855
R^2-adjusted	0.666	.685	0.97586		0.6871	0.687	.691	0.9367	
DW			0.76321	0.75365	2.0761	1.905		2.8828	2.8869
F.		152.	294.95		153.81	153.8	137.	95.16	

Lagrang.M				1387.93					791.46
Hausman				57.2138					3.3956

Note: t ratios in brackets.

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