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THE IMPACT OF INTERNATIONAL TRADE FLOWS ON THE GROWTH OF BRAZILIAN STATES[1]

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Abstract

The aim of this paper is to explore the impact of Brazil's trade openness on regional inequalities by estimating the effect of international trade flows on growth of Brazilian states, depending on their income level. For this purpose, we run dynamic growth regressions, using the system GMM estimator, on a panel data set including 26 Brazilian states for the 1989 - 2002 period. Growth rates of Brazilian states are regressed on control variables and on Brazilian states' trade openness variables. All variables vary across both states and year. The results indicate that trade openness benefits more the Brazilian states with higher levels of per capita income, thereby tending to increase regional inequalities in Brazil. Besides, we find that trade openness advantages more the states with a good level of human capital as well as the industrialized states rather than the states whose main activity is agriculture. The problem that this study reveals is that international trade seems to provide additional advantages to already well developed Brazilian states while one of the priorities of the Brazilian federal government is to achieve a better territorial balance in Brazil.

Key words : International trade, growth equation, GMM estimator, Brazilian states.

Résumé

Ce travail a pour objectif d'estimer l'impact des flux de commerce international sur la croissance des Etats brésiliens. A l'aide de l'estimateur GMM, le taux de croissance des Etats brésiliens est régressé sur divers déterminants de la croissance et sur leur taux d'ouverture commerciale. La base de données en panel contient les 26 Etats brésiliens sur la période 1989 - 2002. Les estimations de l'équation de croissance montrent que les flux de commerce international des Etats favorisent davantage la croissance des Etats riches que celle des Etats les moins développés. Nous montrons également qu'il existe au Brésil une convergence conditionnelle. Les Etats pauvres ont un taux de croissance plus élevé que les Etats riches mais il semble que leurs états stationnaires soient très différents les uns des autres, ce qui nous amène à penser que les inégalités régionales resteront importantes dans l'avenir.

Mots clés : Commerce international, équation de croissance, estimateur GMM, Etats brésiliens.

JEL Classification : F43, R11

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1 Introduction

Regional inequalities have always been very large in Brazil : the per capita GDP of the Southeast region is more than three times that of the North (see Figure 3 in the Appendix). There is a growing consensus among Brazilian political parties that addressing regional inequalities is a priority for the country, as they expose the country to the risk of fragmentation. On his election in 2002, president Lula da Silva underlined that efforts to combat regional inequalities in Brazil would be one of his priorities. Brazil has undergone trade liberalization in the beginning of the 90s. A strategy of outward orientation led to reductions in tariffs and removal of other trade barriers. The aim of our paper is to determine whether there is a link between Brazil's trade openness and the regional inequalities of the country. One hypothesis is that international trade might affect Brazil's regional inequality through its impact on the growth of the Brazilian states. For instance, if Brazil's trade openness benefits more the growth of richer states, then Brazil's international trade is likely to aggravate regional inequality of the country. This paper aims to test this hypothesis.

The effect of trade openness on growth is found to be ambiguous in the growth literature. The theoretical arguments in favor of openness are well known : In the Heckscher-Ohlin-Samuelson model, trade openness can promote higher levels of output and growth by exploiting comparative advantages and promoting an efficient allocation of ressources. Trade openness can also push the national government to implement virtuous macroeconomic policies (Wacziarg, 2001), because of international agreements for instance or because an open country requires policy against inflation. International trade fosters innovation, the dissemination of technological progress through exposure to new goods and imports of high-tech inputs, and efficient production. New imported goods are important in the development of new products by domestic firms. For instance, Goldberg and alii. (2008) show that, in the case of India, input tariff liberalization in 1991 increased domestic product growth of Indian firms by making available imported inputs cheaper and by giving access to new imported input varieties that were not available prior to the liberalization. One of the theoretical arguments against openness is that trade liberalization may push a country towards a specialization in extractive and natural-ressources sectors with low propensity for technological change and new varieties, which can reduce long-term growth (Young, 1991).

The first empirical papers on the links between growth and trade such as Sachs and Warner (1995) or Frankel and Romer (1999) provide evidence for the growth effect of international trade. Sachs and Warner (1995) examine the impact of trade liberalization on the growth of countries in a data set of 122 countries. They use a binary variable to indicate if a country is open or closed to trade, according to many criteria such as average tariff rates above 40% or a socialist economic system. They show that open countries enjoy better growth rates than closed countries. Frankel and Romer (1999) study the impact of trade openness after constructing instrumental variables for trade openness by using countries' geographic characteristics. Their estimations are cross-country regressions for the year 1985. Their results show that trade has a large positive impact on income.

But there has been criticism of the robustness of these results. Rodriguez and Rodrik (2000), for example, reconsider the growth benefits of trade openness by criticizing the empirical methodology of these studies. The endogeneity of trade to growth or the omitted-variable bias due to the exclusion of relevant control variables (institutions, geography) correlated with trade would lead to a biased estimation of the growth effect of trade. They explain that the first empirical papers have used inappropriate openness indicators. These indicators would be in fact correlated to economic institutions or geographic characteristics, such as the trade volume that would depend partly on geography, that are also growth determinants. Rodrik and al. (2004) estimate the impact of institutions, geography and trade on income of countries on a 140-country sample for year 1995. Their results indicate that the growth effect of trade is not significant, once institutions are controlled for.

However, Wacziarg (2001)'s results suggest a positive impact of openness on economic growth. Most recent studies such as Calderón, Fajnzylber and Loayza (2004) that control for invariant omitted variables and endogeneity of trade by using the Generalized Method of Moments estimator on panel data report significant and robust positive effects of trade openness on growth. Dollar and Kray (2004) and Calderón, Fajnzylber and Loayza (2004) find that higher trade openness leads to higher growth. Both papers use trade volumes as a measure of trade openness and control for their endogeneity. Actually, studies that rely on within-country variation usually report robust growth benefits of trade liberalization.

Another debate has been emerging about the links between trade openness and growth. Some authors such as Chang and alii. (2005) claim that the impact of trade on growth may not be homogeneous across countries. The growth effect of trade openness may depend on national specificities such as the level of development. Chang and alii. (2005) examine how the impact of trade on per capita income depends on structural characteristics. They interact trade openness with education, inflation, level of infrastructure, governance and so on, and find that trade impacts positively on economic growth only in certain conditions. For instance, trade has a positive effect on growth only when labor markets in the country are enough flexible. Calderón, Loayza and Schmidt-Hebbel (2004) show that the growth effect is zero for countries with low levels of per capita income and positive for countries with a high level of development. According to this point of view, trade openness might be beneficial to more developed Brazilian states and detrimental to the other ones, thereby tending to increase regional disparities.

Concerning case studies, Gonzales Rivas (2007) studies the effect of Mexico's trade openness on growth of Mexican states. She estimates a growth model where growth rates of Mexican states are regressed, among others, on Mexico's trade openness in interaction with income level and finds that Mexico's trade openness benefits more the Mexican states with higher levels of income.

The empirical strategy consists here in estimating the impact of Brazilian states' trade openness on their growth rate, depending on their income level. This study tries to answer the following questions : What is the impact of higher trade openness on growth rate of Brazilian states ? Does the growth effect of trade openness depend on the state's level of per capita income ? To our knowledge, no studies have been performed so far to explore the causal link between Brazilian states' trade openness and states' growth. It is the first time that this question is empirically addressed, for Brazil, with a growth model and the system GMM (Generalized Method of Moments) estimator. In order to explore the impact of states' trade openness on growth, we build panel-data growth regressions estimated with the system GMM estimator. The GMM procedure controls for endogeneity of some growth determinants and controls for invariant omitted variables. The data set includes 26 Brazilian states over the period 1989-2002. Per capita GDP of Brazilian states is regressed on the initial level of income, on control variables, on Brazilian states' trade openness (volume of trade / GDP) and on an interaction term between trade openness and per capita income level so that openness may have an effect on growth that depends on income level of the Brazilian states. All these explanatory variables vary across both states and year. The results indicate that trade openness benefits more the Brazilian states with higher levels of per capita income. We also show that there is a conditional convergence effect in Brazil. Poorer Brazilian states tend to grow faster than richer ones. Higher initial GDP per capita is associated with lower growth rates.

The paper is organized as follows. Section 2 describes the empirical methodology, the used growth model, the data and the system GMM estimator. Then, section 3 presents the panel-data regression results on the effect of trade openness on growth of Brazilian states. Section 4 concludes.

2 Methodology and data

The basic idea of this work is to determine the impact of Brazilian states' trade openness on their growth rate. The sample consists of a balanced panel dataset that comprises 26 Brazilian states over the period 1989-2002. We follow the most common growth specification and methodology used in the growth literature. Calderón, Fajnzylber and Loayza (2004) and Chang and alii. (2005) for instance use the Generalized Method of Moments (GMM) estimator developed for dynamic models of panel data. We will then extend this specification to account for an interaction term between the openness measure and the level of income of states to allow the growth effect of openness to vary with the income level. Further details on the methodology are given below.

2.1 Specification of the empirical growth equation

The standard growth regression usually estimated in the growth literature and that we estimate for Brazilian states is the following :

$$(1) \qquad lnY_{it} = a_0 + \delta lnY_{it-1} + \beta' X_{it} + \lambda_i + \lambda_t + \epsilon_{it}$$

The dependent variable Y_{it} is the per capita real GDP of each Brazilian state i at time t. The explanatory variables are lnY_{it-1} that is the initial per capita GDP and X that is a set of control variables, determinants of economic growth, that vary across both states and year ; the terms λ_i represent the unobserved state-specific effects such as geography or institutions that may be invariant factors of growth ; λ_t is an unobserved time-specific effect and ϵ_{it} is the time-varying regression residual. The subscripts i and t represent Brazilian state and time period respectively. The term *ln* is log. Note that the dependent variable could also be the growth rate. In that case, results and estimated coefficients on explanatory variables would be exactly the same ones as those estimated in Eq.(1). Only the coefficient on lnY_{it-1} would be different.

In Eq.(1) are included determinants of growth typically employed in growth regressions.[1] The determinants of growth of Brazilian states that vary across both states and year are the following : the initial per capita income of the Brazilian state i, an indicator of trade openness, private investment in physical capital, private physical capital, the human capital stock and the growth of the work force (economically active population). These variables are widely accepted in the empirical growth literature as determinants of growth. The initial per capita income is included to capture the convergence effect. The growth of workforce, human capital, the private and public capital are expected to have a positive impact on growth. Many studies also include trade openness and trade volumes as determinants of growth.

The empirical equation with an interaction term is the following :

$$\begin{aligned}(2) \qquad lnY_{it} = {} & a_0 + a_1 lnY_{it-1} + a_2 lnOpenness_{it} + a_3(lnOpenness_{it} * lnY_{it-1}) \\ & + a_3 lnPrivateCapital_{it} + a_4 lnPublicCapital_{it} + a_5 lnHumanCapital_{it} \\ & + a_6 lnActivePopulation_{it} + \lambda_i + \lambda_t + \epsilon_{it}\end{aligned}$$

[1] Eq.(1) is the autoregressive form of the augmented Solow growth model that has been presented by Mankiw and al. (1992). The growth determinants are the investment rate (that can be proxied by public and private capital), the population growth rate and human capital

The explanatory variable of interest is trade openness, $lnOpenness_{it}$. This is the openness measure of each Brazilian state for each year between 1989 and 2002. We use the conventional measure of trade volume (exports + imports) in percentage of GDP. To explore the possibility that the effect of openness on growth may depend on the level of income, we allow the growth effect of openness to vary with the initial level of income of Brazilian states at period t-1. Therefore, an interaction term between the openness variable and the per capita income of Brazilian states, $(lnOpenness_{it} * lnY_{it-1})$, is included.

As the objective is to estimate the impact of trade openness on growth, the challenge is to include all determinants of growth potentially correlated with trade openness in order to avoid a biased estimation of the coefficient on the openness variable. Some omitted variables such as geography that drive both growth and trade do not change or change very little over time. They are controlled by the states' fixed effects λ_i. The term λ_i represents all growth determinants specific to a state i that do not change over time. Here, it captures invariant heterogeneity across Brazilian states that has an impact on growth, such as states' geographical characteristics, natural ressoures, to be landlocked or not etc.

The real challenge is to include all growth determinants that vary across states and year and that could be correlated with Brazilian states' trade openness. Human capital, public infrastructures and private industrial capital have potentially an impact on trade performance of the Brazilian states. Then, it was essential to include them in the growth regression. The terms λ_t controls for unobserved time-specific effects and for shocks that are common to all Brazilian states, such as the period of high inflation in 1992, the Plan Real in 1994 and the national economic crisis in 1999.

2.2 Data description

It is always difficult to work at a subnational level with panel data because it requires to have data that vary by year and by state. Fortunately, Brazil is a country that provides relatively good data at a subnational level, certainly because it is a federal country. Below are given the description and the source of the used data.

The dependent variable of Eq.(2) is the **state GDP per capita**. Per capita GDP data by state are taken from IBGE (Instituto Brasileiro de Geografia e Estatística) and are in constant prices (base 2000) in local currency, Real. IBGE provides annual data for the period 1985-2004 only. Data are not available for 2005 and 2006.

The variable of interest is **trade openness** that is proxied by the volume of imports plus exports in percentage of GDP. The international trade flow data of Brazilian states are provided by the AliceWeb system maintained by SECEX, the Foreign Trade Secretariat of the Brazilian Ministry of Development. From 1989 to 2007, exports and imports by Brazilian state and by year are provided in current US dollars. Figure 1 reports trade openness by Brazilian state for the year 2000. Total trade has to be divided by GDP in current US dollars. IPEA (Instituto de Pesquisa Econômica Aplicada) provides GDP by Brazilian state in current local currency from 1985 to 2004. We use the World Bank exchange rates to convert it into current US dollars.

Table 5 in the Appendix reports some descriptive statistics of trade data. We observe that the Brazilian states are in average more open to international trade in 2002 than in 1989, which is consistent with the strategy of outward orientation in trade policy introduced in 1989 by the Brazilian government. More precisely, we find in the data that all Brazilian states excepted 2 are more open in 2002 than in 1989. For instance, the state of Maranhão has a trade openness ratio equal to 15.1% in 1989. The equivalent figure is 38.7% in 2002 (see Table 7 in the Appendix for data about Maranhão). We also observe that there is a high heterogenity among states in terms of trade openness : some are very open while others are closed to international trade. For instance, in 2002, trade volume in percentage of GDP ranges from 0.96% for the state of Acre to 60% for the state of Espirito Santo (see Figure 2 in the Appendix).

To account for human capital stock, we include the average years of schooling of population over 25 years of age. Data are provided by IPEA until 2005. For example, in 2002, the average years of schooling is 7 in the state of São Paulo and is 4 in the state of Alagoas.

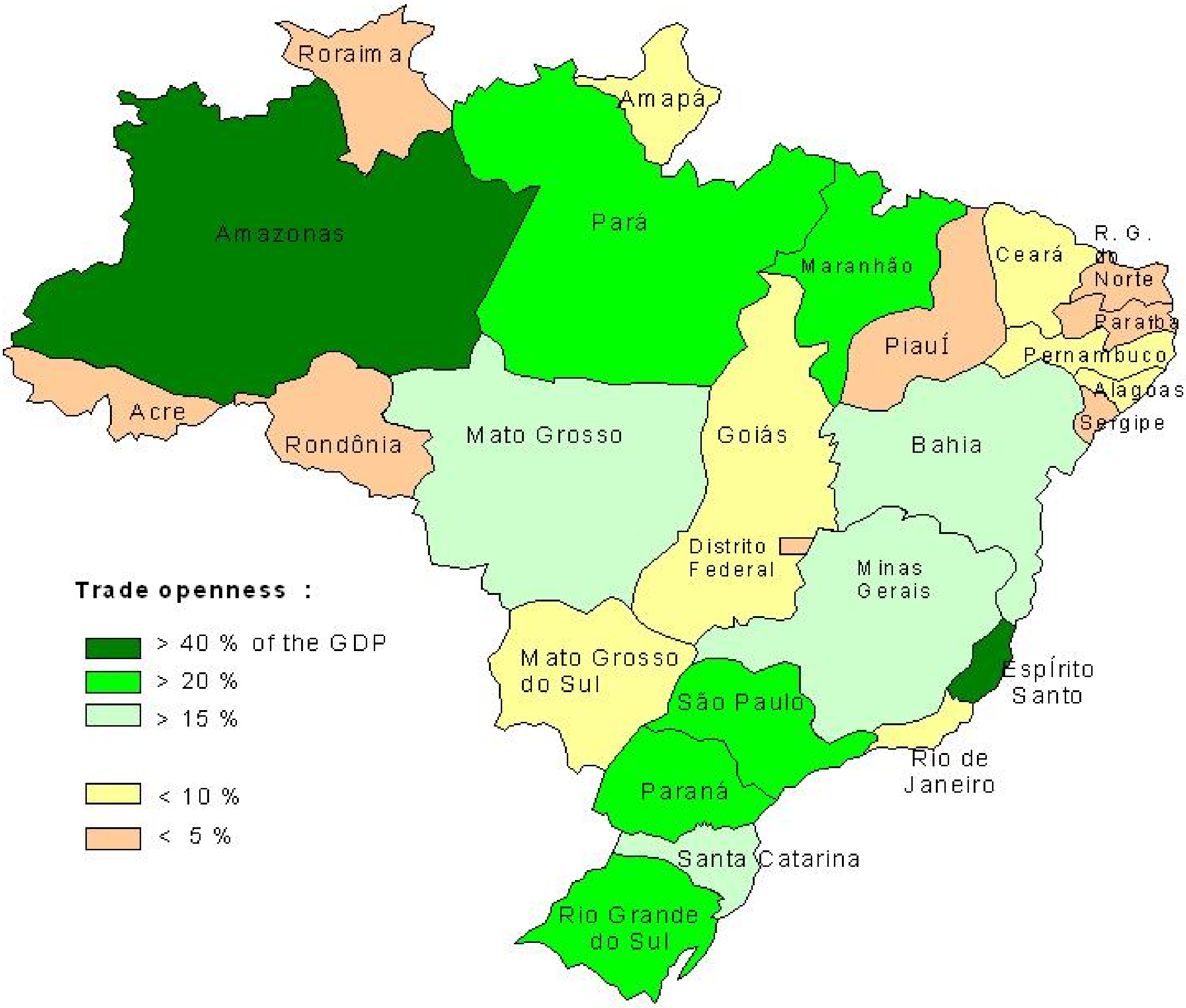
Public investment in physical capital (equipment, public real estate and building construction) is employed as an indicator of public physical capital. These data are provided by the Ministry of Finance of Brazil (Ministério da Fazenda, Secretaria do Tesouro Nacional) in local currency by state and by year, until the year 2005. The ratio public investment in physical capital to GDP is included in Equation (2). For each state and each year, public investment in physical capital is thus divided by states' GDP. Both are in constant local currency. GDP data are taken from IBGE.

There is no available data for **private physical capital** at the subnational level in Brazil. Therefore, we use the industrial consumption of electrical energy as proxy of industrial capital. The idea is that more industrial equipment, appliance or machine imply more industrial consumption of energy. This should be a reasonable proxy of capital for production. Data come from IPEA and are available until 2002 only. In the equation, the ratio private capital to GDP is included. Then, by state and by year, industrial consumption of electrical energy is divided by the states' GDP in constant local currency.

Growth of work force is also taken into account and is measured by change in active population. Data on active population (População ocupada) are from IPEA and are available until 2002, which explains the studied period 1989-2002.

In Table 3 in the appendix, the correlation between the explanatory variables of Eq. (2) is reported. The correlation between trade openness and per capita income of the same year is only equal to 0.27. Besides, Figure 2 in the appendix reports the trade openness ratio of states with their per capita income for the year 2002. We can observe that the richest states are the

FIG. 1 - Trade openness by Brazilian state in 2000
Source : Map of the authors. Trade openness is the volume of exports plus imports in percentage of GDP. Data on trade are from Aliceweb system.



most open. But the states whose per capita income is in the average are very heterogenous in terms of trade openness. Acre is not open at all while Para which has the same per capita income is very open. There is an outlier on the graph : the state of Maranhão which is the poorest state is very open to international trade.

2.3 Econometric methodology : the one-step system GMM estimator

Regressions of Eq.(2) are made using a panel data set of 26 Brazilian states between 1989 and 2002. The one-step system GMM estimator is used for many reasons explained below. There are well-known problems with estimating dynamic growth regressions that have been widely discussed in the growth literature (Caselli, Esquivel and Lefort, 1996, Chang and alii., 2005 or Dollar and Kray, 2004). This subsection outlines these econometric problems.

First, the regression of Eq. (2) is dynamic in the sense that it includes the lagged dependent variable, initial level of per capita GDP, as an explanatory variable. The presence of the lagged dependent variable combined with that of the fixed effects λ_i renders the OLS estimator inconsistent, given that the lagged variable lnY_{it-1} is by construction correlated with the error term ϵ_{it} and that other explanatory variables might be correlated with fixed effects. In that case, every coefficient could be potentially biased. In consequence, the first step to estimate correctly dynamic growth equation is to eliminate the fixed effects. However, the Within OLS estimator that eliminates fixed effects is not appropriate either since, in the equation in difference, the new error term $(\epsilon_{it} - \epsilon_{it-1})$ is by construction correlated with the lagged dependent variable $(lnY_{it-1} - lnY_{it-2})$, (cf. Eq. (3)). Besides, the Within method has the drawback to eliminate the inter-indidivual information. Neither the OLS estimator nor the Within estimator are appropriate to estimate dynamic growth equations.

The second problem is that of omitted variables. These omitted variables can be variant or invariant. The inclusion of the fixed effects λ_i permits to control for invariant omitted variables. Moreover, one would like to deal with the likely endogeneity of all the explanatory variables. Some determinants of growth may be endogenous to growth. For example, trade openness may be endogenous with respect to economic growth : faster growing Brazilian states become more open. A shock to the growth rate of a Brazilian state may have an effect on its level of openness. Many studies in the empirical growth literature address all these econometric problems by relying on the system Generalized Method of Moments (GGM) estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998). Indeed, the system GMM estimator controls for omitted invariant variables and corrects for the potential endogeneity of some explanatory variables by using internal instruments. This estimator involves estimating growth equation as a system of two equations, one in first difference[2], Eq. (3), and one in level, Eq. (1).

The GMM estimation procedure controls and eliminates the unobserved individual-specific effects λ_i by first-differencing the growth equation :

$$(3) \qquad lnY_{it} - lnY_{it-1} = a_0 + \alpha(lnY_{it-1} - lnY_{it-2}) + \beta'(X_{it} - X_{it-1}) \\ +(\lambda_i - \lambda_i) + (\lambda_t - \lambda_{t-1}) + (\epsilon_{it} - \epsilon_{it-1})$$

In the framework of the system GMM estimation, the right-hand side variables assumed endogenous or predetermined can be instrumented and the validity of the instruments can be tested. To adress the problem of endogeneity of some explanatory variables, the system GMM procedure uses lagged values of the corresponding endogenous variables as internal instruments. Lagged first differences are used as instruments for equation in levels and lagged levels of explanatory variables are used as instruments for equation in first difference, which, besides, deals with the problem of correlation between the error term and the lagged dependent variable. More precisely, an endogenous variable is instrumented by lags from at least two periods and deeper and a pre-determined variable is instrumented by lags from at least one period and deeper. In consequence, we have to do some assumptions on the endogeneity or exogeneity of the explanatory variables included in growth equation 2. The explanatory variables can be strictly exogenous to growth or predetermined or endogenous.
The growth of the work force, human capital and public physical capital are treated as predetermined variables. The idea is that shocks to economic growth in period t-1 could affect the level of active population, human capital and public capital in period t. Private capital, proxied by consumption in energy, and trade openness are assumed to be endogenous to growth. Here, we follow Dollar and Kray (2004) who treat trade openness as an endogenous variable. Contemporaneous shocks to GDP growth in period t may affect the level of trade openness in period t as well as industrial consumption in energy.
The GMM estimation is consistent if lagged values of explanatory variables are valid instruments. The Sargan test that tests the overall validity of the instruments is reported to determine whether lagged and first-differenced values of endogenous or predetermined explanatory variables are valid instruments. Another specification test examines whether the residual of the regression in differences is second-order serially correlated. First-order serial correlation is expected. Second-order serial correlation must be rejected to confirm the correct specification of the regression. Besides, according to Roodman (2005), the instrument count should not ex-

[2] There also exists the first-difference GMM estimator that estimates only the equation in first-difference but it is less appropriate in this application because the Between (inter-individual) variance of the used data here is larger than the Within (intra-individual) variance for most variables such as trade openness, per capita income and private capital. And only the system GMM method allows the use of the Between information.

ceed N, the number of individuals (here 26 states). If it does, it weakens the power of the Sargan-Hansen test. The instrument count is reported for each regression of Table 1. To limit the instrument count, we follow Roodman (2005) by using the option *collapse* that reduces the size of the instruments matrix. If this option is not used here, the number of instruments is too close to the number of observations (364) and much larger than the number of groups (26). Collapsing means that GMM estimator creates one instrument per variable instead of one instrument for each variable at each period. This gives a smaller set of instruments without a loss of lags (Roodman, 2005). Finally, year dummies are treated as exogenous variables.

3 Empirical estimation of the growth effect of trade

3.1 Empirical results

The econometric results based on system GMM estimates[3] of Eq.(2) are presented in Table 1. Column 1 reports the estimation of Eq.(2) without the interaction term between openness and income level and column 2 with the interaction term, which is the preferred specification commented here. Column 3 reports the estimation without the detected outliers. Column 4 reports the estimation of column 2 but using the first-difference GMM estimator rather than the system GMM in order to provide robustness test. Column 5 is the pooled estimation and column 6 is the Within (Fixed Effects estimator) estimation.

Impact of trade openness on growth of Brazilian states

In column 2, trade openness is a significant explanatory variable of growth of Brazilian states. The coefficient on the trade openness variable is significant and negative, equal to - 0.17. When an interaction term is significant, one can not say anything about the *main* effects of terms in the interaction, since these main effects lose meaning in the context of an interaction. The coefficient for the interaction term between trade openness and per capita income is significantly positive equal to + 0.11. These results reveal that the growth effect of trade openness is a function of the level of per capita income of the Brazilian states or, broadly, on their overall level of development. Thus, the positive effect of more trade openness declines as the level of income of Brazilian states decreases.

More precisely, we calculate that the net effect of international trade on growth is positive if the per capita income of the Brazilian state is above 6700 real (in constant 2000 real) or above 5450 dollars (in constant 2000 US dollars). The poorer Brazilian states (Piaui, Acre, Alagoas, Rio Grande do Norte for instance) are below this threshold. Trade openness might be

[3]Estimations are computed with the xtabond2 stata command provided by Roodman (2005)

beneficial to already well developed states and detrimental to poorer Brazilian states. Besides, this opposite effect of openness on growth may be the explanation for the non significance of the trade openness variable in column 1. In column 1, the trade openness variable carries a positive but non significant coefficient equal to 0.03.

This result is similar to that of Calderón, Loayza and Schmidt-Hebbel (2004) whose empirical estimation is based on 76 countries over the period 1970-2000. They find a negative coefficient on the trade openness variable and a positive one on the interaction term between trade openness and level of income. They show that the growth effect is zero for countries with low levels of per capita income and positive for countries with a high level of development. This result is also similar to that found by Gonzales Rivas (2007) for Mexican states. She estimates a growth model where growth rates of Mexican states are regressed, among others, on Mexico's trade openness (and not on Mexican states' trade openness) in interaction with income level. She finds a positive coefficient on the interaction term between trade openness and states' per capita income : Mexico's trade openness benefits more the Mexican states with a high level of income.

To check the robustness of this result, Eq. (2) is estimated in column 3 without the outlier observations detected by the Hadi's (1994) method.[4] Results are similar for trade openness variable and the interaction term. Column 4 estimates growth equation using the first-difference GMM estimator rather than the system GMM estimator as in column 2.[5] Results are not good. Coefficients on trade openness and on interaction term have the wrong sign and are not significant, which is annoying for the robustness of the results found in column 2. This problem is mentionned in sub-section 3.3. In column 7, regression is performed, with the system GMM estimator, on the same data set but including 7 observations consisting of 2-year averages spanning the 1989-2002 period. Coefficients on trade openness and on the interaction term are very similar to those of column 2.

Conditonnal convergence across Brazilian states

In column 2 of Table 1, initial GDP per capita, lnY_{it-1}, carries a significant and positive coefficient, equal to +0.63, which is commonly interpreted in the empirical growth literature as a sign of conditionnal convergence. Actually, when the dependent variable is the growth rate, the coefficient is equal to -0.37. This means that poorer Brazilian states tend to grow faster than richer ones. But Brazilian states are probably converging towards different levels of per capita income since other explanatory variables controll for structural differences between states. The

[4]The *hadimvo* program identifies multiple outliers, creating a variable equal to 1 if an observation is an outlier and 0 otherwise. We estimate growth equation of column 2 using in Stata the command hadimvo, generate(odd) p(0.01). Then, we estimate Eq.(2) without the three outlier observations detected by the program.

[5]First-difference GMM estimator only uses the regression in differences while the system GMM estimator combines the regression in differences and the regression in levels into one system

TAB. 1 – Panel data estimation of the impact of trade openness on growth of Brazilian states using the system GMM estimator. The data set includes 26 Brazilian states from 1989 to 2002.

	Dependent Variable : lnY_{it}, per capita income						
	(1) (gmm)	(2) (gmm)	(3) (gmm)	(4) (fd gmm)	(5) (OLS)	(6) (Within)	(7) (gmm) span 2
$\ln Y_{it-1}$	.87 (.088)***	.63 (.148)***	.63 (.157)***	.45 (.250)*	.97 (.027)***	.64 (.050)***	.68 (.207)***
$\ln Openness_{it}$ (Trade in % of GDP)	.03 (.030)	-.17 (.097)*	-.17 (.108)*	.10 (.143)	.01 (.014)	-.0004 (.027)	-.15 (.088)*
$\ln Openness_{it}$ * $\ln Y_{it-1}$		.11 (.057)**	.11 (.059)*	-.08 (.106)	-.007 (.009)	-.01 (.017)	.09 (.053)*
$\ln HumanCapital_{it}$ (years of schooling)	.49 (.220)**	.66 (.250)***	.66 (.299)**	.20 (.221)	.05 (.043)	.09 (.070)	.12 (.225)
$\ln PublicCapital_{it}$ (capital to GDP ratio)	.008 (.012)	.003 (.016)	.004 (.015)	.02 (.013)	-.01 (.005)**	.002 (.005)	-.01 (.015)
$\ln PrivateCapital_{it}$ (capital to GDP ratio)	.03 (.039)	.09 (.037)**	.10 (.049)**	.08 (.384)	-.004 (.006)	-.003 (.012)	.10 (.060)*
$ActivePopulation_{it}$ (growth of work force)	.10 (.045)**	.07 (.057)	-.03 (.164)	.07 (.043)*	.03 (.041)	.06 (.047)	-.007 (.072)
constant	-.45 (.213)**	-.33 (.337)	-.29 (.410)		-.02 (.068)	.41 (.117)***	.56 (.278)**
N. of observations	364	364	361	338	364	364	182
Time dummies	yes	yes	yes	yes	yes	yes	yes
Fixed effects	yes	yes	yes	yes	no	yes	yes
Instrument count	28	29	29	25			24
R^2					0.98	0.96	
Sargan test, p-level	0.90	0.97	0.97	0.70			0.35
AR(1) test, p-level	0.00	0.01	0.00	0.45			0.00
AR(2) test, p-level	0.32	0.17	0.16	0.54			0.97

Note : Robust standard errors in parentheses : ***, ** and * represent respectively statistical significance at the 1%, 5% and 10% levels. Column 3 is the regression without the outliers. Column 4 is the regression with the first-difference GMM estimator.

findings on the growth effect of trade also means that increasing trade openness reduces the overall convergence effect in Brazil since trade openness is found to foster richer states' growth. The result on initial GDP per capita is very robust across all regressions of Table 1.

The speed of transitional convergence, called s for instance, can be calculated from the coefficient δ on initial income per capita. According to the theoretical growth model, $\delta = exp[-st]$ where t is the time interval between the two observations and is 1 here (Ferreira, 2000). Given that the coefficient δ is equal to +0.87 in column 1, the speed of convergence is equal to 13%. We use this coefficient rather than the coefficient of 0.63 in column 2 because, when an interaction term is included, the main effects of the constitutive terms of this interaction term (here openness and initial income) lose meaning in the context of an interaction. In consequence, it is better to use the coefficient of column 1 where no interaction term is included.

The speed of convergence is found to be 13% : 13% of the gap between per capita income of a state and its steady state is filled in each year. This is a high rate of convergence, which implies that Brazilian states are close to their respective steady state value. This result is in line with Ferreira's (2000) result that shows that, in 1995, poor Brazilian states are very close to their steady-state values. This is a problem for Brazil because it means, since regional inequalities are high, that poor Brazilian states have steady state very different from richer states and that regional disparities would remain large across states.

Ferreira (2000) and Nakabashi and Salvato (2007) also find a convergence effect in Brazil. Ferreira (2000) examines states' per capita income between 1970 and 1995 and finds that the poorer the Brazilian state in 1970, the higher tended to be its growth of income per capita in the following 25 years. He finds a speed of convergence of around 1.8%. But his speed of convergence is not really comparable with ours. Ferreira does not control for structural differences across states through the inclusion of other explanatory variables. When there is only the initial per capita income in the growth regression, the steady state of each Brazilian state is assumed to be the same. In consequence, the speed of absolute convergence is very slow. Poorer states will need a long time to catch up the level of wealth of richer states. On the contrary, the more are included explanatory variables in the growth regression, the more disperse the steady states of Brazilian states are allowed to be. In that case, poorer Brazilian states need less time to catch up their respective steady state, which explains that the speed of convergence is much higher. Azzoni (2001) also finds convergence over the period 1939-1995. In the case of absolute convergence, he finds a speed of 0.68% per year.

Finally, columns 5 and 6 of Table 1 report the results of the pooling (OLS) and Within (FE) estimations. Bond and al. (2001) argue that pooled and within estimations of dynamic growth models, although they are not appropriate estimators, provide the upper and lower bounds for the autoregressive parameter lnY_{it-1}. In view of the pooling and within results, the coefficient on the lnY_{it-1} variable must fall between these bounds, between 0.97 in column 5 and 0.64 in column 6. The result on convergence should be robust since the coefficient, equal to +0.63 in column 2, is at the limit of the lower bound.

As expected, the proxy for human capital has a significant and positive coefficient, equal to +0.66, in column 2. Nakabashi and Salvato (2007) who estimate a growth equation with Brazilian states for the years 1970, 1980, 1991, and 2000 also find for Brazil a positive effect of human capital on growth. They show that disparities in quality of human capital among Brazilian states states significantly explain the disparity in income level across states.
The coefficient for the public capital variable is close to zero and not significant. The non-significance is a bit disappointing. Brazilian states with high level of public investment in capital were expected to grow faster than the other ones unless fiscal burden linked to public investment hinders growth. The proxy for private capital reports a positive and significant coefficient equal to 0.09 in column 2. Nakabashi and Salvato (2007) who also use industrial energy consumption as proxy for private capital find significant and positive coefficients for this variable as well. Surprisingly, the growth of work force is only significant in column 1. In columns 2 and 3, the Sargan and serial-correlation specification tests do not reject the null hypothesis of correct specification, giving support to the results. The Sargan test also confirms the validity of the used instruments.

3.2 Channels between trade and economic growth of Brazilian states

The aim is now to explore the specific mechanisms through which trade openness has an effect on economic growth of Brazilian states. The idea is that the positive benefits of trade openness might depend on a state's endowments or specialization.

Interacting trade openness with human capital
First, the specification is extended to incorporate how states' endowments in human capital may mediate the relationship between trade openness and economic growth. In the traditionnal Solow growth model, economic growth depends directly on the level of technology, physical capital, human capital and labor. Trade openness may affect one of these determinants and especially the level of technology. As it has been said in the introduction, international trade may foster innovation and the dissemination of technological progress (Grossman and Helpman, 1991). However, Ben-David (1999) argues that trade with foreign countries will not transfer knowledge to countries with low levels of human capital. Thus, the diffusion of technology within a state may be dependent on its stock of human capital.
To test this idea, we include in growth equation an interaction term between trade openness and the variable of human capital. Column 2 of Table 2 reports the results. Interaction term

between openness and initial income is omitted. Indeed, interactions between openness and other variables will be considered one at a time to avoid problem of multicollenarity between trade openness and interaction terms[6], and to simplify the interpretation of the results. The coefficient on the interaction term "lnOpenness$_{it}$ * lnHumanCapital$_{it}$" is significant (although at the limit with a p-value of 0.11) and positive, +0.11. This confirms the idea that trade openness is more beneficial to Brazilian states with a high level of human capital. This result is consistent with the hypothesis on the links between technology and human capital.

Interacting trade openness with primary and industrial sectors

Secondly, we want to determine whether trade openness is beneficial to growth depending on the specialization of the Brazilian states. Rodriguez and Rodrik (2000) and Chang and alii. (2005), for example, review some arguments as to why trade openness can be detrimental to growth. This is the case when trade openness, through an initial comparative advantage in "non-dynamic" sectors, pushes the country's ressources in the activities that do not generate long-run growth (via innovation and technological progress, expanding product variety or quality). In the Heckscher-Ohlin-Samuelson (HOS) model, trade affects the level and the composition of output by promoting specialization. Specialization in non-dynamic sectors implies for instance a low propensity for technological change, for new varieties and productivity improvement. Besides, access to new imported input varieties and to new imported technology will be more useful for manufacturing states than for traditionnal agricultural states.

Following that idea, one can imagine that Brazilian states that have initial comparative advantage in non-dynamic sectors such as basic agricultural products might not benefit from advantages of trade openness.[7] After trade liberalization, they will be even more specialized in their non-dynamic agricultural sector, thus hindering growth in long-term. In Brazil, one must distinguish agribusiness in industrialized states in the South-East of the country and traditionnal agriculture in Northern and Amazonian states for which agriculture is often the main activity. In the state of São Paulo, agriculture represents 2% of GDP in 2001 and the industrial sector 40% while the economic activity of the Northeast is mainly based on the production of sugar, cocoa and cotton. The opening of these economies to the global market (but also to Brazilian market) could imprison and confine them to these non-dynamic sectors.

We construct the variable *Primary sector*$_{it}$ that is the percentage of agricultural sector in the total GDP of state i at year t. The higher this variable, the higher the state is specialized in

[6]For instance, when interaction term with income is included in column 2 in addition to interaction term with human capital, the problem of collinearity becomes severe with VIF values of 130 (interaction with human capital) and of 34 (interaction with initial income). When only one interaction term is included, collinearity is far less important : interaction terms have VIF values of 14 in column 1, of 72 in column 2, of 11 in column 3 and of 90 in column 4.

[7]It is probably true in the eighties and in the nineties. But, in the future, things could change. Prices of agricultural goods have been increasing on the world market and developed countries could open in the future their national market to agricultural goods.

Tab. 2 – Channels between trade openness and economic growth. Panel data estimation of the impact of trade openness on growth of Brazilian states using the system GMM estimator. The data set includes 26 Brazilian states from 1989 to 2002.

	Dependent Variable : lnY_{it}, Per capita income			
	(1)	(2)	(3)	(4)
$\ln Y_{it-1}$	.62 (.148)***	.82 (.101)***	.91 (.091)***	.91 (.095)***
$\ln Openness_{it}$	-.17 (.097)*	-.19 (.115)*	.06 (.031)**	-.39 (.229)*
$\ln HumanCapital_{it}$	.66 (.250)***	.45 (.237)*	.61 (.197)***	.21 (.263)
Primary $sector_{it}$, % of GDP (in log)			.06 (.030)**	
Industrial $sector_{it}$, % of GDP (in log)				-.27 (.156)*
Interaction terms				
$\ln Openness_{it}$ * $\ln Y_{it-1}$	.11 (.057)**			
$\ln Openness_{it}$ * $\ln HumanCapital_{it}$		.11 (.069)*		
$\ln Openness_{it}$ * Primary $sector_{it}$			-.02 (.013)*	
$\ln Openness_{it}$ * Industrial $sector_{it}$				.15 (.090)*
constant	-.33 (.337)	-.30 (.331)	-.99 (.308)***	.33 (.652)
N. of observations	364	364	364	364
Time dummies	yes	yes	yes	yes
Fixed effects	yes	yes	yes	yes
Sargan test, p-level	0.97	0.99	0.85	0.92
AR(1) test, p-level	0.00	0.00	0.00	0.00
AR(2) test, p-level	0.17	0.21	0.51	0.96

Note : Robust standard errors in parentheses : ***, ** and * represent respectively statistical significance at the 1%, 5% and 10% levels. The variables Private Capital, Public Capital and ActivePopulation reported in Table 1 are included in regressions of Table 2 but are not reported for space reasons. The Sargan test confirms the validity of the set of instruments. Correlation between per capita income, human capital and economic sectors are reported in Table 4 in the Appendix.

agriculture. Data come from IPEA that provides agricultural GDP by state and by year in constant local currency (base 2000). We then divide agricultural GDP by state's GDP that is also in constant local currency (base 2000). For instance, in Rondonia, the agricultural sector accounts for 20% of the total GDP in 1990. The state of Para is the most agricultural state with a percentage of 40% in 1993.
The variable *Primary* $sector_{it}$ and the interaction term between trade openness and *Primary* $sector_{it}$ are included in column 3 of Table 2. The interaction term yields a significant and negative coefficient of -0.02, which indicates that trade openness can be detrimental when primary sector is an important component of the state economic activity. We calculate that trade openness has a negative effect on economic growth if the primary sector accounts for more than 20% of the state GDP.

On the contrary, states specialized in manufacturing products could benefit from trade openness because innovation and technological progress that may come from foreign trade are more prominent in these sectors. To test this idea, the variable *Industrial* $sector_{it}$ and the interaction term between trade openness and *Industrial* $sector_{it}$ are included in column 4 of Table 2. This variable has been constructed with data from IPEA that provides industrial GDP by state and by year in constant local currency (base 2000). *Industrial* $sector_{it}$ represents the percentage of industrial GDP in percentage of total GDP. The coefficient on the interaction term is positive (+0.15) and significant, which indicates that trade openness benefits more the Brazilian industrialized states. Actually, trade openness is found to have a positive impact on economic growth if industrial sector accounts for more than 14% of the state's GDP. The most industrialized states in Brazil are the state of Amazonas and the Southern states of São Paulo, Santa Catarina and Sergipe with more than 40%. The less industrialized states are the Federal District, Rondonia, Roraima and Amapa whose industrial sector represents less than 14% of the GDP for some years.

To illustrate the idea of bad specialization, we consider the state of Maranhão (data reported in Table 7 in the Appendix). The per capita income of this state has slightly increased from 1520 (in constant real) in 1989 to 1646 in 2002, while its trade openness ratio has highly increased from 15.1% in 1989 to 38.7% in 2002. One cannot say that this state has benefited from its higher trade openness. Actually, in 1989, Maranhão exports aluminium (84% of its total exports), chemistry goods (11%) and iron (4%). These data come from Aliceweb system. In 1989, Maranhão is a state specialized in primary and extractive goods. In 1989, the state imports from outside fuels and oil (50% of the imports) and some boats (35% of the imports). Actually, the structure of its exports and imports are nearly the same in 2002 : it still exports aluminum and iron and still imports fuels and oil (90% of the imports). The new thing is that in 2002 the state imports mechanical devices (10% of the imports). The idea behind this description is that Maranhão's trade openness hasn't changed anything to its specialization and structure of production. Or worse, international trade pushes the state to be even more specialized in these non-dynamic sectors. Maranhão does not benefit from imported technological progress because the state does not import technology, and it does not really benefit from its exports because they push it in a specialization with low propensity for technological change and new varieties, which can reduce long-term growth.

3.3 Possibilities to extend work in future

Actually, the main concern regarding this study is the robustness of the results regarding trade openness variable and its interaction term with income.

On the one hand, results in column 2 of Table 1, indicating that states' trade flows benefit the growth of richer Brazilian states, seem good : the coefficients on interest variables are significant and the Sargan test confirms the validity of the used instruments. Besides, as recommended by Roodman (2005), the instrument count is not too high, close to the number of individuals, which should make the Sargan test reliable.

On the other hand, this result has not been confirmed in column 4 of Table 1 by the estimation using the first-difference GMM estimator, which is annoying although Blundell and Bond (1998) argue that the system GMM estimator is more efficient than the first-difference GMM method.[8] The GMM estimator is now used in most empirical papers on growth using panel data (Dollar and Kray, 2004, Chang and alii., 2005, Ackah and Morissey, 2001, Calderon and alli., 2004, Dejong and Ripoll, 2006, among others) because this is the prominent solution to address the problems of estimating dynamic growth regressions. However, although broadly used, the GMM estimator may have a big drawback : it may provide unstable results (Roodman, 2005). Indeed, in many cases, estimated coefficients on explanatory variables are unstable and depend on the specific instrumentation chosen by the researcher. For instance, we estimate Eq.(2) assuming now that all variables of equation (human capital, private and public capital, work force) are endogenous instead of being only pre-determined as in column 2 of Table 1. Results change a bit : the trade openness variable has still a negative coefficient, equal to -0.10, but it is no longer significant. Result remains the same for the interaction term between openness and income that carries a significant coefficient of +0.09. In consequence, specific instrumentation may give specific results.[9]

[8] Moreover, with the used data set here, the first-difference GMM should be less efficient than the system GMM estimator since the Between (inter-individual) variance is larger than the Within (intra-individual) variance for most variables such as trade openness, per capita income and private capital. Unlike the first-difference GMM estimator, the system GMM method estimates the equation in level, which allows the use of the Between information.

[9] A same drawback can be observed in the Hausman-Taylor method. Instrumentation of the endogenous

In conclusion, to confirm the robustness of our finding "Brazil's trade openness favors only richer Brazilian states", the ideal would be to test it in another way. All the challenge is now to find it. There is a need for further investigation to find a second methodology to estimate the impact of trade on growth of Brazilian states.

4 Conclusion

The goal of this study is to estimate the impact of states' trade openness on their economic growth. For this purpose, non-linear growth regressions are run using the system GMM estimator on a panel data set spanning 26 Brazilian states for the 1989-2002 period. Econometric results show that trade openness benefits more the growth of richer Brazilian states than that of poorer states. This is a new and important result because one of the priorities of the Brazilian federal government is to achieve a better territorial balance in Brazil and trade openness could counteract this national objective through the channel of growth. Besides, we show that trade openness advantages more the states with a good level of human capital and the industrialized states rather than the agricultural states. The problem that this study reveals is that international trade seems to provide additional advantages to already well developed Brazilian states. International trade is probably an additional factor that pushes poorer Brazilian states to specialize even more in traditional goods that do not generate technological progress and long-run growths.

Results also show that there is a conditional convergence effect in Brazil and a speed of conditionnal convergence of 13%. This is quite a high rate of convergence, which could indicate that Brazilian states are close to their respective steady-state value. This result is in line with Ferreira (2000) who shows that, in 1995, poor Brazilian states are very close to their steady-state values. This situation is a problem for Brazil because it means that poor Brazilian states are close to their respective steady state that is very different from that of richer states, which implies that regional disparities will remain large in Brazil.

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Appendix

Tab. 3 – Correlation matrix between explanatory variables of growth equation 2 and Table 1

	lnY_{it-1}	Openness	O* lnY_{it-1}	Human capital	Public capital	Private capital	Growth of workforce
lnY_{it-1}	1.00						
Openness	0.28	1.00					
Openness * lnY_{it-1}	0.68	0.85	1.00				
Human capital	0.76	-0.00	0.37	1.00			
Public capital	-0.24	-0.24	-0.30	0.09	1.00		
Private capital	-0.10	0.68	0.39	-0.39	-0.26	1.00	
Growth of workforce	-0.02	-0.06	-0.05	0.03	0.06	-0.08	1.00

Note : Public capital and private capital are ratios to GDP

Tab. 4 – Correlation matrix between per capita income, human capital and economic sectors. Variables of regression in Table 2.

	lnY_{it-1}	Human capital	Primary $sector_{it}$	Industrial $sector_{it}$
lnY_{it-1}	1.00			
Human capital	0.76	1.00		
Primary $sector_{it}$	-0.44	-0.53	1.00	
Industrial $sector_{it}$	0.12	-0.22	0.16	1.00

Tab. 5 – Statistics on the trade openness ratio ((export+imports)/GDP) of Brazilian states in 1989 and 2002

	Mean	standard-error	Min	Max
Year 2002	18%	14	0.96%	54%
Year 1989	7.7%	6.82	0.04%	29%

Note : in 2002, the closest state to international trade has a trade openness ratio equal to 0.96% and the more open state has it equal to 54%. Mean is the mean of all trade openness ratios of the Brazilian states (not weighted by their GDP).

Tab. 6 – Statistics on GDP per capita (in Real constant) of Brazilian states in 1989 and 2002

	Mean	standard-error	Min	Max
Year 2002	5287	2850	1646	13822
Year 1989	5081	2713	1390	11580

Tab. 7 – Case study : State of Maranhão, trade openness ratio and GDP per capita from 1989 to 2002

Year	GDP per capita (in constant real)	Export in % of GDP	Import in % of GDP
1989	1520	12.8	2.3
1990	1369	12	2.7
1991	1384	14.3	6.7
1992	1346	13.6	4.7
1993	1348	13.5	4.8
1994	1479	12.9	3.9
1995	1454	12.2	3.6
1996	1660	10	6
1997	1632	11	6
1998	1498	10.3	5
1999	1527	15.2	8.4
2000	1615	15.1	9.7
2001	1658	12.5	19
2002	1646	16.7	22

FIG. 2 - Trade openness and GDP per capita of Brazilian states, Year 2002
Source : Trade openness is exports plus imports in percentage of GDP. Trade openness and GDP per capita are in log.

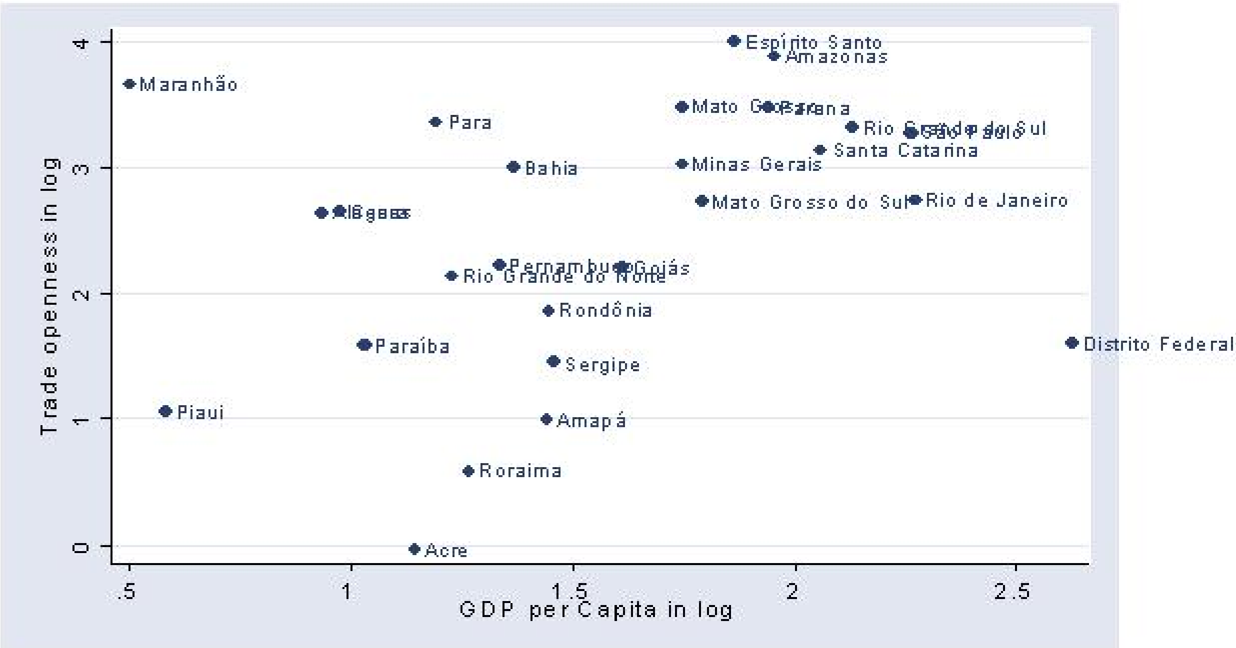

FIG. 3 - Regional Inequality in Brazil. Per Capita Income of Brazilian States in 2001
Source : map of the author. Per capita income is in PPP current dollars.