Patterns of Specialization and (Un)conditional Convergence: The Cases of Brazil, China and India

Marine Hadengue

Ph.D Student, Department of Mathematics and Industrial Engineering, Polytechnique Montreal (Canada)

Thierry Warin[1]

Associate professor, Department of Mathematics and Industrial Engineering, Polytechnique Montreal (Canada)

Vice-President at Cirano (Canada)

Abstract:

The purpose of this paper is to highlight the Balassa-Samuelson effect for emerging countries with new data. More than the catching-up effect, we will measure the convergence for three emerging countries: Brazil/China/India. We will compare the convergence between these countries and the productivity frontier represented by the US over the pas ten years. A first contribution is that as the distance between the level of labor productivity in Brazil (China, India) and the United States decreased, the growth rate of labor productivity within the country decreases. In other words, the higher the level of productivity in an industry, the lower its growth rate, showing a convergence to the productivity frontier. A second contribution is that there is unconditional convergence as measured at the industry level.

JEL Classification: O40, O41, O43, O47, O53
Keywords: economic convergence, endogenous growth, China, India, labor productivity

[1] Corresponding author: thierry.warin@polymtl.ca. We would like to thank Cirano and the GMT Lab (Polytechnique Montreal) for their support. Our thanks go to the participants of the IFBAE conference in Tours, the usual caveats apply.

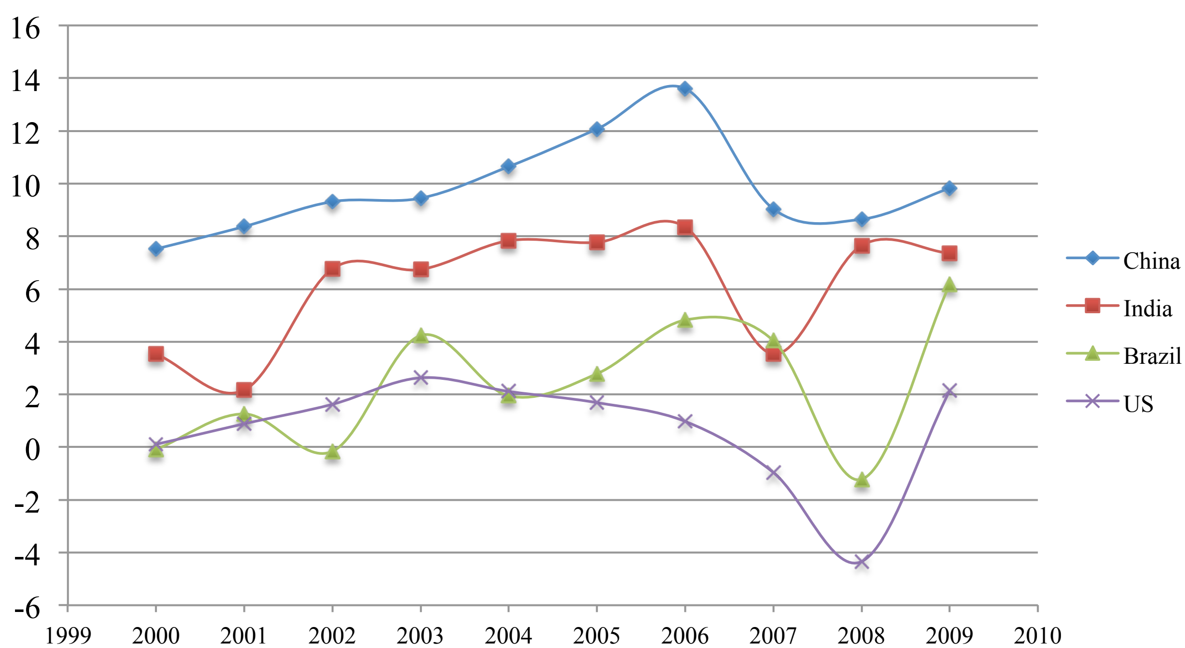
1 Introduction

Emerging and developing countries represent roughly half of the world GDP and are the main contributors to the bulk of world growth (Builter & Rahbari, 2011). This paper aims at revisiting the models of growth and more specifically the convergence of growth between emerging and developed countries. In the midst of a globalisation of the value chains, measuring the world based on data, whose geographical scope is political, does not help capture the new world economic reality. This is why we need to work on the right data to collect as well as use the right methodology to understand these data. The present does not pretend to provide all the answers, but our aim is to be part of this conversation.

The goal of this paper is twofold: (1) based on a large dataset built around industrial sectors in each country (China, India, Brazil, USA), we study the notion of convergence based on a pooled approach at the industry level first, and (2) we study the convergence at some industry level. Clearly, this work does not intend to be exhaustive, indeed the limitations we have with the data prevent us from being too definitive. Nevertheless, we hope that the approach we design here lays out the path for further interesting research.

The current study focuses on Brazil, China and India. In 2010, populations of these three countries represented more than 45% of the world population.[2] According to Builter and Rahbari (2011), China will even become the largest economy in the world by 2030 and will itself be second to India by 2050. The following graph (Figure 1) gives us some interesting information about the economic evolution of Brazil, China and India in the past two decades.

Figure 1 – GDP Per Capita, Annual Growth in % (constant 2005 international $)



Source: Author's calculations using World Bank 2011 data

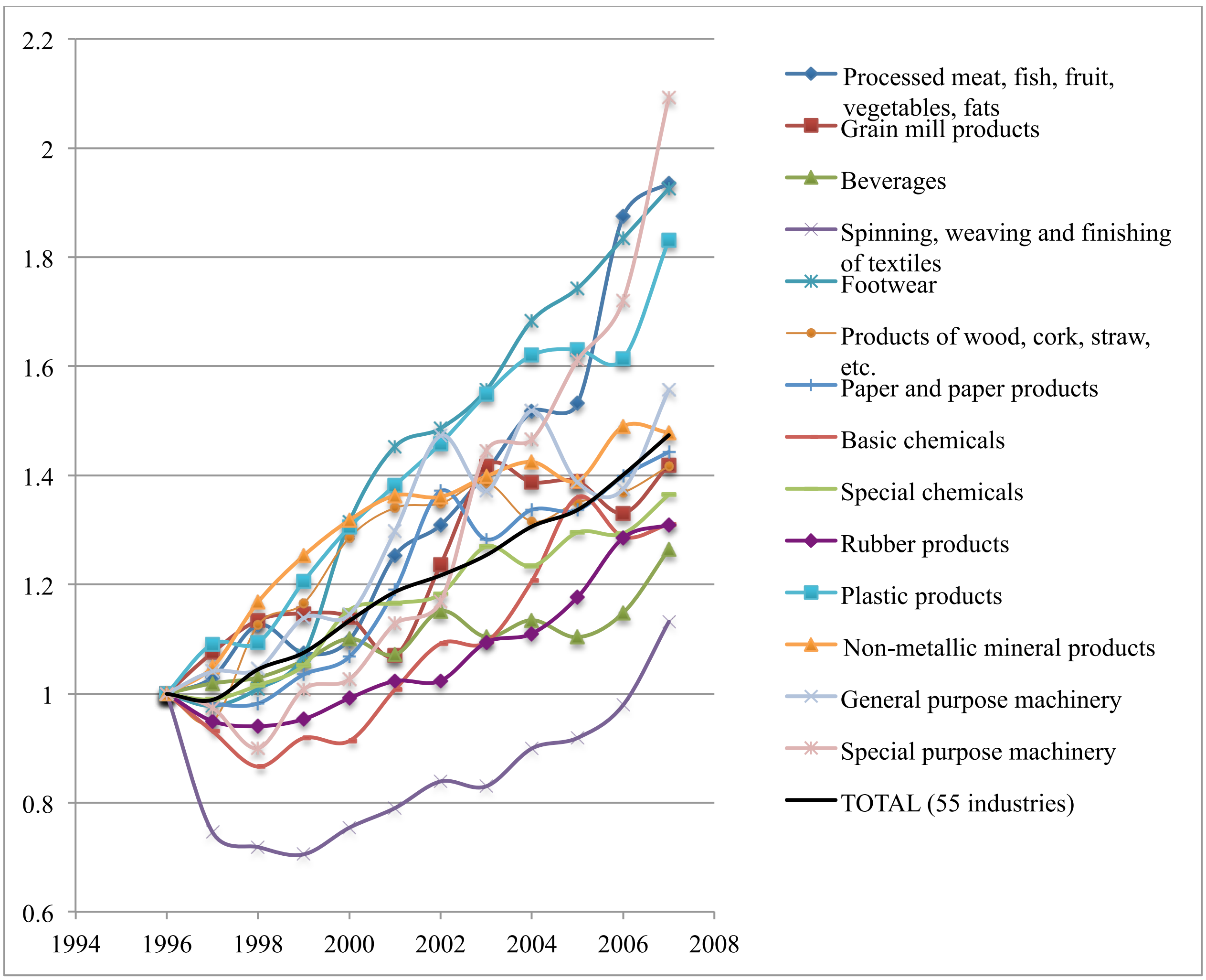
Before the crisis, the high annual growth of Brazil, China and India compared to the United States (which is even negative between 2007 and 2009) is already an indicator of convergence between these emerging economies and the U.S. economy. Brazil, China and India are very interesting case studies in this regard. But instead of looking at this convergence at the aggregate level, our study relies on a more micro level approach. Indeed, industrial firms play an important role in emergent countries. Exports have drastically

[2] According to autor's calculation from World Bank data.

increased over the years to levels of 24%, 30% and 25% of the GDP in Brazil, China and India in 2011 (compared for example to 12% in the U.S.). And what is more interesting than overall convergence is to look at which industrial sectors are actually converging.

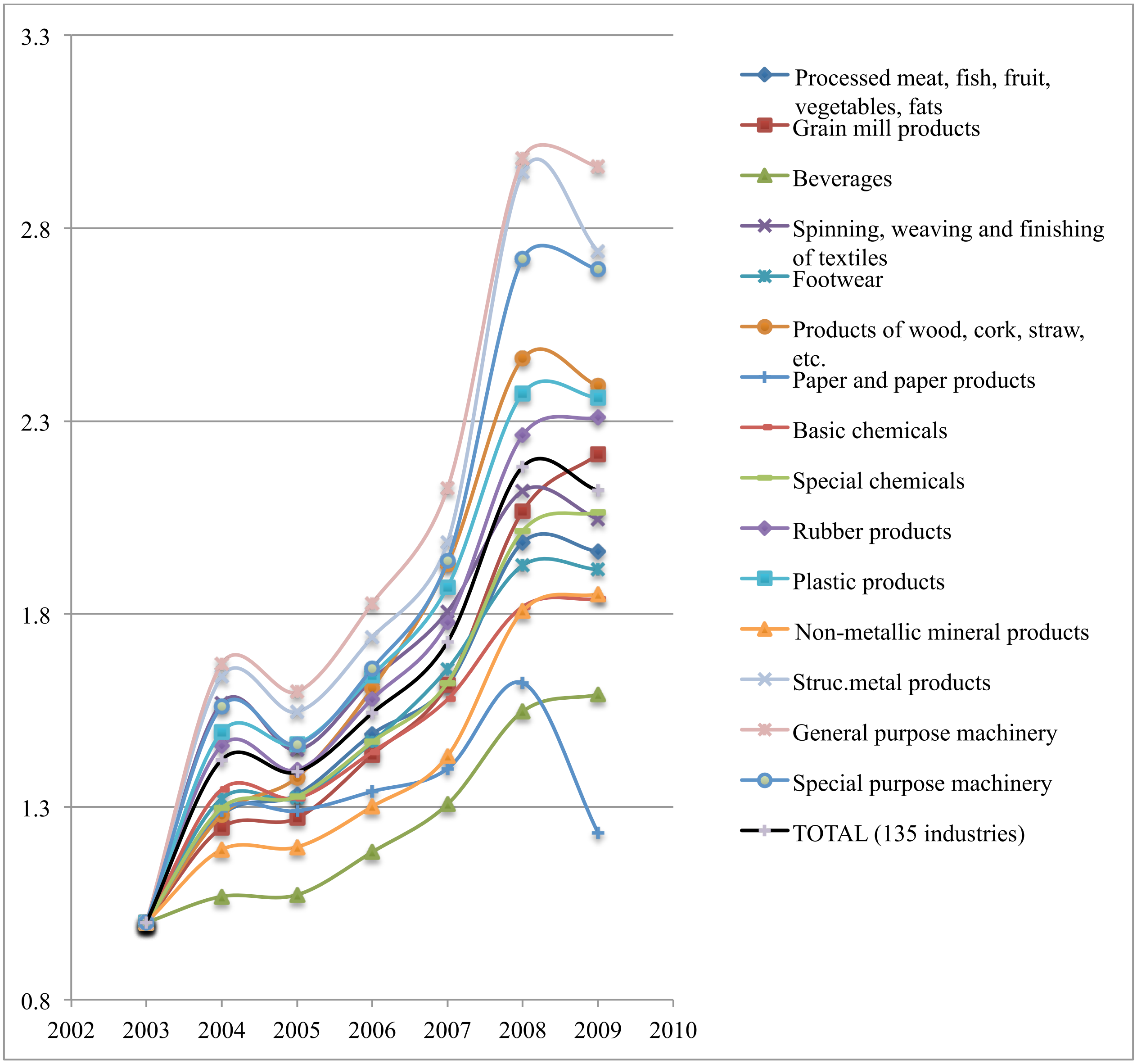
As the manufacturing sector accounts for respectively 60%, 93% and 64% of Brazilian, Chinese and Indian exports in 2010 (World Bank, 2010), we should look more closely at the evolution of this sector. Despite a slowdown, the number of manufacturing establishments in China has tripled in less than 10 years. Brazil has also experienced an important increase of every industry in general. India's manufacturing sector has stayed stable or increased too. In comparison with the U.S., we observe that almost every sector has experienced a slowdown (except for beverages, non-metallic mineral products and structure metal products), although the global industry sector has slightly increased. Unfortunately, we do not have the data from 2006 onwards for the U.S. However we can assume that the economic crisis has not helped and that the number of establishments has continued to fall at least until 2009. This big picture shows that the advantage goes to Brazil, China and India.

Figures 2 - Normalized evolution of the number of establishments in the manufacturing sector for major industry types in Brazil.



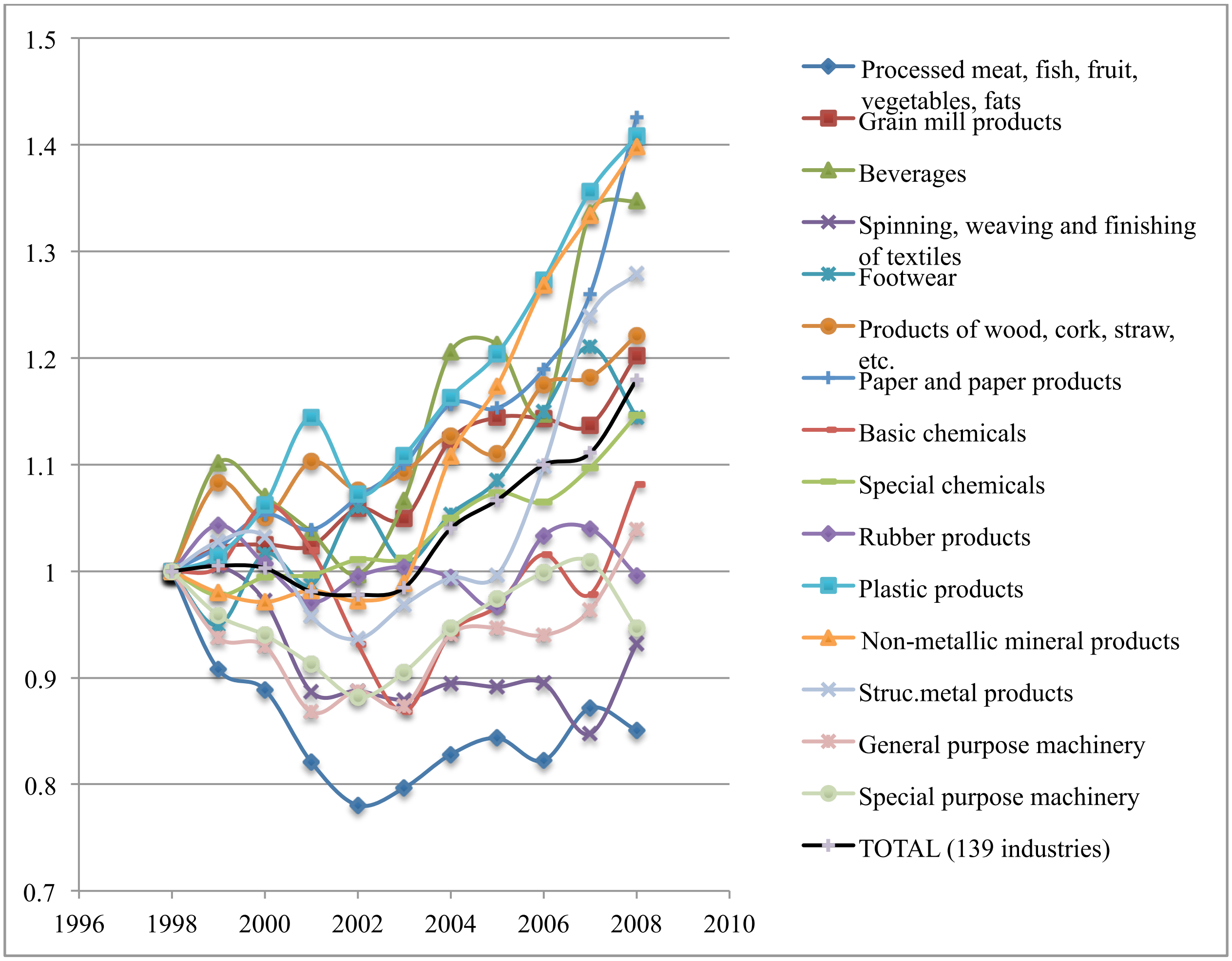
Source: UNIDO database, 2011

Figures 3 - Normalized evolution of the number of establishments in the manufacturing sector for major industry types in China.



Source: UNIDO database, 2011

Figures 4 - Normalized evolution of the number of establishments in the manufacturing sector for major industry types in India.



Source: UNIDO database, 2011

In this regard, it might be very interesting to look at the evolution of labor productivity in these countries. Indeed, considering their active population and the recent fast-pace development of the manufacturing sector, we assume that these emerging countries may start having important absolute comparative advantages. Moreover, it is important to emphasize that the size of their own population provides them with a huge domestic market. Independently of any other control variable (political measures, economic measures etc.), we could eventually find unconditional convergence for these two countries.

It is in this context that this paper tests whether the convergence hypothesis can be validated for these three countries. We will try to identify labor productivity convergence in the manufacturing sector between these countries and the United States. This type of convergence is different from the well-known β-convergence, which checks convergence of an entire country or region. It is also different from the σ-convergence, which is particularly interested in the shape of the variance in growth rate. For the sake of a name and clarity, we modestly decided to name it: δ-convergence. The choice of the U.S. as the country of reference is not a coincidence, as it remains up to four times the more productive country at the manufacturing level before Germany or France in the main sectors.[3] In what follows, we present a brief literature review on the types of convergence. Then the data and models are described in section 3. In section 4, these models are tested (for all industries and by industry) for each country and the results are presented.

2 Literature review

This study is inspired by Rodrik (2011a) who finds unconditional convergence measured through labor productivity in manufacturing (detailed by type of industry according to the Industrial Statistics Database at the 4 - digit level) over ten years for a total of forty countries. The results are interesting insofar as they oppose the conclusions of recent works on convergence. Indeed, if unconditional convergence was verified for all sectors, then developing countries should have almost caught up with developed countries in terms of labor productivity. Moreover, according to the factor price equalization theorem, ratios of wages over cost of capital in developing countries should evolve towards ratios of wages over cost of capital in developed countries. If two countries met the conditions of the H-O model[4] and their inputs do not differ "too much", then the free exchange of goods leads to an equalization of factor prices even if "there is no mobility of these factors" (Mundell, 1957; Samuelson, 1948). In other words, since international trade leads to the equalization of ratios of final goods prices between countries, then the factors prices (including wages) should also be adjusted. However, some new theories of international trade came to change the assumptions of the old traditional models. The configuration of international trade, the diffusion of ideas, the elimination of duplication in research were also studied in the literature (Aghion & Howitt, 1992, Grossman & Helpman, 1990, Rivera-Batiz & Romer, 1991, Segerstrom, Anant, and Dinopoulos, 1990). These phenomena have an impact on the production factors. Moreover, the factor price equalization theorem has been questioned in the literature (Leamer & Levinsohn, 1994; Repetto & Ventura, 1997; L. Rivera-Batiz & Oliva, 2003; Trefler, 1995) and unconditional convergence of labor productivity does not automatically imply a convergence of the global economy, which has been widely validated empirically in the literature (Rodrik, 2011a).

This paper is part of this literature on economic growth and most particularly on labor productivity convergence. An important part of the economic growth literature is dedicated to the convergence concept. Convergence is defined in two ways: (1) when countries (or regions) converge to a steady state, which is the same for all. (2) But it can also be if countries (or regions) are considered to converge each to their own steady state (Barro & Sala-i-Martin, 2004). Generally, convergence is measured through per capita income (GDP per capita) or labor productivity. It can be conditional or unconditional.

In the case of **unconditional β-convergence**, there is a correlation between growth and the initial value, and this, without adding control variables in the following regression:

$$\hat{y}_T = \alpha_0 + \beta \times y_0 + \varepsilon \tag{1}$$

$\hat{y}_T$ is the annual growth rate and the initial value is y_0 (initial income, or the distance between the income of rich and poor countries). The coefficient of interest β has a negative value. The first work on the subject was done by Baumol (1986) and covers a sample of 16 OECD countries. In the case of **conditional β-convergence**, Pritchett (1997) shows that while rapid gains in productivity are possible, this is not what is observed empirically. Since the industrial revolution, developing countries have had an experience of divergence rather than convergence with rich countries (Pritchett, 1997). The β-convergence then becomes conditional:

[3] According to Author's calculation and using UNIDO data : the productivity is obtained by dividing each sector added value by the number of employees at the time.

[4] For more details on the hypothesis, see (Mundell, 1957; Ohlin, 1933; Rybczynski, 1955; Samuelson, 1948, 1949)

$$\hat{y}_T = \alpha_0 + \beta \times y_0 + \Upsilon' \times \Phi + \varepsilon \quad (2)$$

with Φ a vector of control variables such as, for example, human capital, savings rate, population growth, technology or the rate of capital depreciation. All this literature is of course linked with the neoclassical growth model from Solow (1956), which implies that countries with similar production functions at a given time should see their incomes converge to their steady state through time. In short, it is conditional convergence (Mankiw G., Phelps, & Romer, 1995). The growth rate is regressed on the initial income with other control variables determining the steady state (variables in the vector Φ of equation 2). In the case of **σ-convergence**, it emerges in response to criticisms (Friedman, 1992; Quah, 1993) who consider that a negative value of the coefficient is not sufficient to prove convergence and an assessment of the standard deviation of the distribution of the dependent variable (growth rate of per capita income or productivity) in cross section is required to validate the hypothesis (Islam, 2003). Also according to Islam (2003), the literature about σ-convergence is divided in two branches: (1) one that maintains and tries to explain the relationship between σ and β-convergences and (2) one that emphasizes the limitations of the latter. Indeed, σ-convergence has the advantage of indicating whether the distribution of income across economies is becoming more equitable (Friedman, 1992; Quah, 1993).

The debate is far from being over and researchers continue to be interested in the β-convergence since it is still necessary, although not sufficient, for the σ-convergence (Islam, 2003; Andrew Young, Higgins, & Levy, 2005). To our knowledge, there is no work evaluating the δ-convergence. Indeed, rather than focusing on the convergence of income or productivity of an entire country or region compared to a steady state (shared or not), the δ-convergence analyses convergence between the level of labor productivity of the manufacturing industries of a country and the productivity frontier of that industry at time *t* in the world. In the case of δ-convergence, the equilibrium state is associated with the productivity frontier and other variables specific to the national growth model (savings rate, growth population, technology or capital depreciation rate etc…) are not appropriate.

In 1991, Barro studied the β-convergence of income in 98 countries between 1960 and 1985. He finds that the latter is conditional on the initial level of human capital (positive correlation) and government expenditures relative to GDP (negative correlation) (Barro, 1991). Mankiw, Romer and Weil (1992) have studied β-convergence in income between 1960 and 1985 on three different samples of countries (those with a developed oil industry, those for whom data were unreliable and finally the OECD countries) and found unconditional convergence for the OECD countries, and conditional convergence for the two other groups. Barro and Sala-i-Martin focused on 48 States in the U.S. between 1880 and 1988 and found unconditional β-convergence (Barro & Sala-i Martin, 1992). More recently, Dawson and Sen (2007) showed an unconditional β-convergence in income for a sample of 29 countries (selected according to availability of data provided by Maddison) between 1900 and 2001. In response to the work of Barro and Sala-i-Martin (1992), Young, Levy and Higgins (2005) reaffirmed β-convergence and studied the σ-convergence across U.S. states. They found a significant σ-divergence in most cases (Andrew Young et al., 2005). In the same vein, Wang (2004) found a discrepancy in income across Chinese provinces between 1991 and 1999, thus questioning the initial results of Choi and Li (2001) who found a conditional β-convergence between 1978 and 1994. Kaitila, Alho and Nikula (2007) found unconditional β-convergence of 21 emerging economies of Central Europe and Eastern Europe. Finally in a recent study, Rodrik (2011a) used data from the Penn World Tables Data compiled by Maddison and found β-convergence in income for a very large set of countries between 1990 and 2007 periods by regressing 10 years.

Other authors are more focused on the convergence of productivity including labor productivity. Bernard and Jones (1996) examined the unconditional β-convergence based on productivity for 14 OECD countries between 1970 and 1987. Their main results was a lack of convergence in the manufacturing sector as opposed to unconditional convergence in services. Other authors such as Carree, Klomp and Thurik (1999), working on 18 OECD countries between 1972 and 1992, found that convergence varies greatly by industry. They explained this phenomenon by the existence of substantial differences in knowledge and capital. However, Landesmann and Stehrer (2000) found an unconditional β-convergence in a sample of 33 countries between 1963 and 1997 for the manufacturing sector. They also showed that it seemed faster for medium and high technologies. Castellacci, and Los Vries (2010) tried to see whether Bernard and Jones (1996)'s conclusions were valid for a larger set of countries. Their sample included 49 countries between 1970 and 2004 for six major industrial sectors. Overall, they confirmed Bernard and Jones' results for a small group of countries. Finally, in a recent study, Rodrik (2011a) found unconditional β-convergence in labor productivity at a highly disaggregated level (more than a hundred manufacturing industry category) for a set of 72 countries between 1990 and 2007. Hwang (2007) showed that poor countries actually converge towards rich countries unconditionally for all manufactured goods they produce and export. Indeed, Hwang showed that there was a large force of "vertical" convergence: the countries furthest from the technological frontier were those who showdc the greatest unconditional economic growth (Hwang, 2007). Levchenko and Zhang (2011) assessed the trend in productivity in 19 manufacturing sectors from 1960 to 2000 and showdc that there was some convergence across countries: the areas farthest from the technological frontier were those who saw their productivity grow the fastest (Levchenko & Zhang, 2011). At the regional level, Jefferson Rawski and Zhang (2008) studied β-convergence among Chinese provinces based on productivity (of labor, capital and multifactor) at the industry level between 1998 and 2005. They found unconditional convergence. Similarly, Marti, and Fernandez Puertas (2011) studied the β and σ-convergences in labor productivity of industrial sectors in the Chinese provinces and found that they were weak. For India, works on convergence were made including the σ and β-convergence of regional growth in agriculture between 1971 and 2007 (Somasekharan, Prasad, & Roy, 2011) and the growth of services (services per capita) between 1980 and 2006 (Shingal, 2010). The results are respectively a divergence in agriculture and convergence in services. Several econometric issues were also raised in the literature of convergence with a panel based approach. From a methodological perspective, Islam (2003) concluded that the inclusion of least squares with dummies (LSDV), the minimum distance estimator of Chamberlain (MD) and GMM estimators are among the most reasonable estimators for such models, unless the time frame was not long enough.

3 Model

The data used in this paper are from the United Nations Industrial Development Organization (INDSTAT4 ISIC Rev.3). For non-OECD members, they were collected from national statistical offices of UNIDO. The database provides the value added (in current U.S. dollars) and the number of employees for 151 manufacturing industries in 127 countries between 1990 and 2008 for the most part. In this paper, we use the data for Brazil, China, India and the United States. The data are available respectively between 1997 and 2007, 2003 and 2007, 1998 and 2007 and 1997 and 2007. The data cover respectively 55, 135 and 139 out of the 151 industries for Brazil, China and India. Annual labor productivity is calculated by dividing the value added by the number of employees for each industry and each year. To measure this productivity in real terms, we deflate values by using the consumer price index. Different models are used in the literature to assess the convergence of labor productivity. Some authors regress the growth rate of labor productivity on the initial labor productivity, others regress the growth rate of labor productivity - or the growth rate of the difference in labor productivity between a country and the leading country - on the gap between labor productivity and the country's initial leader of the country.

In our case, data for the labor productivity frontier are the United States's. Indeed, the U.S. remains the most productive in manufacturing according to UNIDO. We will regress the growth rate (biannual) of labor productivity on the ratio of the distance between the labor productivity of industry i at time t and the data in the same industry i at time t in the U.S. The δ-convergence model is specified as follows:

$$\hat{y}_{it} = \beta_0 + \beta_1 \times RATIO_{it} + \mathcal{E}_{it} \quad (3)$$

$\hat{y}_{it}$ is the absolute growth of labor productivity between time *t* and time t_{+2} and $RATIO_{it}$ the distance to the labor productivity frontier for industry *i* at time *t*.

$$\hat{y}_{it} = \frac{v_{it+2}}{v_{it}} \qquad \text{with} \quad v_{it} = \frac{Added\ Value_{it}}{Number\ of\ Employees_{it}}$$

$$RATIO_{it} = \frac{y_{it}}{y_{it}^{US}}$$

This functional forms can be tested to approximate the trend:

$$\log(\hat{y}_{it}) = \beta_0 + \beta_1 \log(RATIO_{it}) + \mathcal{E}_{it} \qquad (4)$$

To check the convergence hypothesis, β_1 should be significant and negative: the growth rate of labor productivity decreases as the distance to the productivity frontier decreases (and thus increases the variable *RATIO*).

The logarithmic form implies that although there is a positive correlation between the growth rate and a long distance to the productivity frontier, the magnitude of this relationship diminishes as the frontier expands (Equation 4).

Regarding the estimator, the ordinary least squares (OLS) could not be optimal for evaluating this type of data. Indeed, it seems reasonable to assume that there is a positive correlation between distance and the error term, which includes unobserved variables specific to each industry (Ci). These variables might be positively correlated with the regressor, which automatically induces a positive bias on β_1. Since the expected sign of β_1 is negative, then the value estimated by OLS will tend to be less negative than it could be, which will minimize the estimated convergence. Formerly:

$$E(\mathcal{E}_{it} | RATIO_{it}, C_i) = 0 \qquad (7)$$

Hence:

$$\hat{y}_{it} = \beta_0 + \beta_1 \times \text{RATIO}_{it} + C_i + V_{it} \qquad (8)$$

with:

$$Corr\ (RATIO_{it}, \mathcal{E}_{it}) \neq 0 \qquad (9)$$

A Hausman test was performed showing that a fixed effects model is superior to a random effects model, which is consistent with the literature (Islam, 2003; G. Mankiw et al., 1995). Therefore we will use the fixed effects method (LSDV).

To further check for robustness, we used the Beck-Katz, Kmenta-Parks and GMM estimation techniques. Indeed, the presence of serial correlation and panel heteroscedasticity were of key concern in our estimation of this model. If there is autocorrelation, the option would be fourfold: (1) a dynamic panel model (two-way random effect model or error component model) with first differences, sometimes known as a Prais-Winston transformation or a Cochrane-Orcutt transformation; (2) a dynamic model with lagged dependent variables with two slightly different approaches known as one or two step general methods of moments (GMM) estimators as in Arellano and Bond (1991) or Arellano and Bover (1995); (3) a weight-adjusted combination of the White and Newey-West estimator to handle both the heteroskedasticity and the autocorrelation in the model; or (4) a feasible generalized least squares procedure (FGLS, or a two-state generalized least squares model) as in Parks (1967) and Kmenta (1997) in which the model assumes an autoregressive error structure of the first order AR(1), along with contemporaneous correlation among cross-sections. Unlike a pooled OLS estimation, the Kmenta-Parks method employed here accounts for heteroskedasticity and serial correlation when present. Our choice of estimation method is not immune to criticism, such as those found in Beck and Katz (1995). One of the main criticisms of the Kmenta-Parks estimates is the possibility of underestimation of standard errors and consequently resulting in an artificially inflated statistical significance. This is why we decided to use both estimators to validate the robustness of our results. Nevertheless, these two estimators should be considered cautiously considering the short time-frame of the dataset. This is why we also used the GMM estimator.

As a consequence, we will focus more on the consistency of the statistical significance across the different methods and the sign of the coefficients than the size of the coefficients. Our aim here is to provide a preliminary set of guidelines to study convergence with this new database more than providing the exact impact in absolute terms.

The second step in our analysis will be to regress by industry by separating them into 10 groups representing the available data.[5] Thus, we will have used the dataset in two ways and extracted as much information as we could for these two countries. In a couple of years, when the dataset will have a longer time frame, the econometric results will be a little more robust.

4 Results

The results are presented separately for the three countries: Brazil, China and India. We evaluate each of the proposed models (equations 4, 5 and 6). These results allow us to determine whether there has been convergence between these countries and the United States during the last decade in terms of labor productivity for the manufacturing sector. Finally, in a second step, we focus at the industry level to analyze the areas of convergence during this period. Several elements can be identified in light of these estimations.

First, with ordinary least squares, the coefficient is significant for the three countries. However, and as predicted, this method of estimation produces positively biased coefficients, which therefore tend to minimize the convergence phenomenon.

These results are actually very interesting as they highlight unconditional convergence of the labor productivity in the manufacturing sector (by the OLS) and that this convergence relies on conditions/variables proper to each industry type (introduced in the model by the fixed effects dummies). In other words, the difference in the coefficient intensity implies that even if there is a convergence phenomenon independently of the context, this convergence will be more important considering specific attributes from the different industries.

It proves that convergence is even more important if factors - for example technology transfer through learning-by-doing - are taken into account. Indeed, technology transfer could be easier in certain types of manufacturing industries than others.

The associated R^2 are not very high. It may be considered as reasonable insofar as the only variable RATIO is not expected to fully explain the variation in growth rate of labor productivity. Standard deviations are reasonable, especially since they are corrected for heteroscedasticity.

Finally, it is possible to remark that the convergence phenomenon seems to be faster in India and Brazil than in China.

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[5] See groups in appendix

Table 1- Results for Brazil

	BRAZIL							
Estimation	**OLS**	**Beck & Katz**	**Kmenta-Parks**	**GMM System**	**OLS**	**Beck & Katz**	**Kmenta-Parks**	**GMM System**
Dependant variable: ln(yt)	without industry fixed effects				with industry fixed effects			
Independant variable								
ln(RATIOit)	-0.659***	-0.659***	-0.528***	-0.640***	-0.299***	-0.463***	-0.590***	-0.660***
	(0.0233)	(0.0233)	(0.0244)	(0.0796)	(0.0217)	(0.0939)	(0.0246)	(0.0717)
Industry fixed effects:								
I1					-0.00458	-0.00865	0.00142	0.0263
					(0.0330)	(0.0170)	(0.0483)	(0.0834)
I2					0.0152	0.0295*	0.0394	0.0765
					(0.0330)	(0.0164)	(0.0466)	(0.0734)
I3					0.136***	0.179***	0.206***	0.270
					(0.0337)	(0.0397)	(0.0509)	(0.165)
I4					0.0805**	0.114***	0.187***	0.177
					(0.0372)	(0.0376)	(0.0545)	(0.125)
I5					0.0882***	0.117***	0.103**	0.208**
					(0.0319)	(0.0284)	(0.0466)	(0.0917)
I6					0.0679*	0.101***	0.128***	0.146***
					(0.0372)	(0.0306)	(0.0497)	(0.0523)
I7					0.0611*	0.0936***	0.127***	0.176**
					(0.0317)	(0.0295)	(0.0464)	(0.0700)
I8					0.0397	0.0742***	0.107**	0.116
					(0.0376)	(0.0202)	(0.0533)	(0.0799)
I9					0.117***	0.172***	0.212***	0.252***
					(0.0332)	(0.0366)	(0.0475)	(0.0602)
I10								
Constant	-0.435***	-0.435***	-0.365***	-0.397***	-0.290***	-0.408***	-0.515***	-0.571***
	(0.0143)	(0.0143)	(0.0166)	(0.0586)	(0.0332)	(0.0750)	(0.0461)	(0.0700)
N	493	493	493	493	493	493	493	493
Groups	55	55	55	55	55	55	55	55
R-squared	0.647	0.647				0.408		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2- Results for China

	CHINA							
Estimation	**OLS**	**Beck & Katz**	**Kmenta-Parks**	**GMM System**	**OLS**	**Beck & Katz**	**Kmenta-Parks**	**GMM System**
Dependant variable: ln(yt)	without industry fixed effects				with industry fixed effects			
Independant variable								
ln(RATIOit)	-0.192***	-0.0840***	-0.0989***	0.135	-0.106***	-0.101***	-0.107***	0.149
	(0.0466)	(0.0211)	(0.00612)	(0.106)	(0.0214)	(0.0187)	(0.00736)	(0.0973)
Industry fixed effects:								
I1					0.0552***	0.0302	0.0564***	0.0457
					(0.0208)	(0.0244)	(0.0118)	(0.0343)
I2					0.0501**	0.0232	0.0474***	0.0164
					(0.0223)	(0.0277)	(0.0127)	(0.0375)
I3					0.0559**	0.0300	0.0496***	0.0108
					(0.0221)	(0.0398)	(0.0136)	(0.0411)
I4					0.0378	0.0152	0.0469***	0.0405
					(0.0231)	(0.0324)	(0.0127)	(0.0358)
I5					0.0911***	0.0643**	0.0921***	0.0490
					(0.0205)	(0.0285)	(0.0126)	(0.0354)
I6					0.0761***	0.0505*	0.0746***	0.0379
					(0.0223)	(0.0299)	(0.0125)	(0.0371)
I7					0.00858	-0.0195	-0.00104	-0.0478
					(0.0240)	(0.0191)	(0.0151)	(0.0472)
I8					0.0384	0.0135	0.0560***	0.0257
					(0.0271)	(0.0193)	(0.0138)	(0.0398)
I9					0.0724***	0.0475*	0.0549***	0.0128
					(0.0239)	(0.0259)	(0.0148)	(0.0465)
I10						-0.0264		
						(0.0320)		
Constant	-0.0772	0.0513*	0.0309***	0.314**	-0.0317		-0.0365**	0.303**
	(0.0560)	(0.0305)	(0.00822)	(0.126)	(0.0334)		(0.0156)	(0.127)
N	403	403	402	403	403	403	402	403
Groups	135	135	134	135	135	135	134	135
R-squared	0.060					0.121		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3- Results for India

INDIA								
Estimation	**OLS**	**Beck & Katz**	**Kmenta-Parks**	**GMM System**	**OLS**	**Beck & Katz**	**Kmenta-Parks**	**GMM System**
Dependant variable: ln(yt)	without industry fixed effects				with industry fixed effects			
Independant variable								
ln(RATIOit)	-0.864***	-0.232***	-0.282***	-0.689***	-0.183***	-0.303***	-0.375***	-0.764***
	(0.0310)	(0.0847)	(0.0185)	(0.101)	(0.0179)	(0.0915)	(0.0204)	(0.0938)
Industry fixed effects:								
I1					-0.0112	-0.137***	-0.0802***	-0.187*
					(0.0237)	(0.0407)	(0.0231)	(0.102)
I2					0.0157	-0.0755**	-0.00937	0.0287
					(0.0244)	(0.0305)	(0.0204)	(0.0464)
I3					0.0389	-0.0574*	-0.0206	-0.00907
					(0.0241)	(0.0304)	(0.0209)	(0.0867)
I4					0.0290	-0.0566	-0.0161	0.0893
					(0.0254)	(0.0402)	(0.0208)	(0.0939)
I5					0.0612***	-0.0218	0.0313	0.101*
					(0.0223)	(0.0296)	(0.0192)	(0.0599)
I6					0.0890***	0.0109	0.0703***	0.148**
					(0.0238)	(0.0285)	(0.0209)	(0.0590)
I7					0.0827***	0.00982	0.0935***	0.201**
					(0.0260)	(0.0349)	(0.0235)	(0.0817)
I8					0.0746**		0.0688***	0.0973
					(0.0296)		(0.0226)	(0.0607)
I9					0.0861***	0.0108	0.0771***	0.167***
					(0.0260)	(0.0413)	(0.0227)	(0.0583)
I10						-0.0887**		
						(0.0400)		
Constant	-1.146***	-0.285**	-0.352***	-0.914***	-0.263***	-0.336***	-0.493***	-1.058***
	(0.0423)	(0.115)	(0.0246)	(0.145)	(0.0309)	(0.122)	(0.0318)	(0.132)
N	1100	1100	1100	1100	1100	1100	1100	1100
Groups	139	139	139	139	139	139	139	139
R-squared	0.447	0.116				0.167		

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Again, the goal of this paper is essentially to lay out a new way of measuring convergence benefitting from the availability of a new database. We can nevertheless conclude about convergence of labor productivity between Brazil/China/India and the United States in the manufacturing sector. In other words, the greater the gap between the level of labor productivity between Brazil, China or India and the United States in an industry, the greater the rate of productivity growth in Brazil, Chinaor India. As the distance between the two levels of productivity decreases, the growth rate decreases.

Visually, the following graph represents the logarithm of the growth rate of labor productivity in Brazil, China and India against the logarithm of the distance to the border (the variable RATIO). Industries therefore appear, at most, three times (for three time are evaluated 2003-2005, 2004-2006 and 2005-2007) in the case of China and six times in the case of Brazil and India (1998 - 2000, 1999-2001, 2000-2002, 2003-2005, 2004-2006, 2005-2007). The negative slope of the straight lines serves to illustrate the results of the previous regressions.

Figure 3 - Growth rate of labor productivity (in log format) in function of the ratio of the labor productivity distance between Brazil and the U.S.

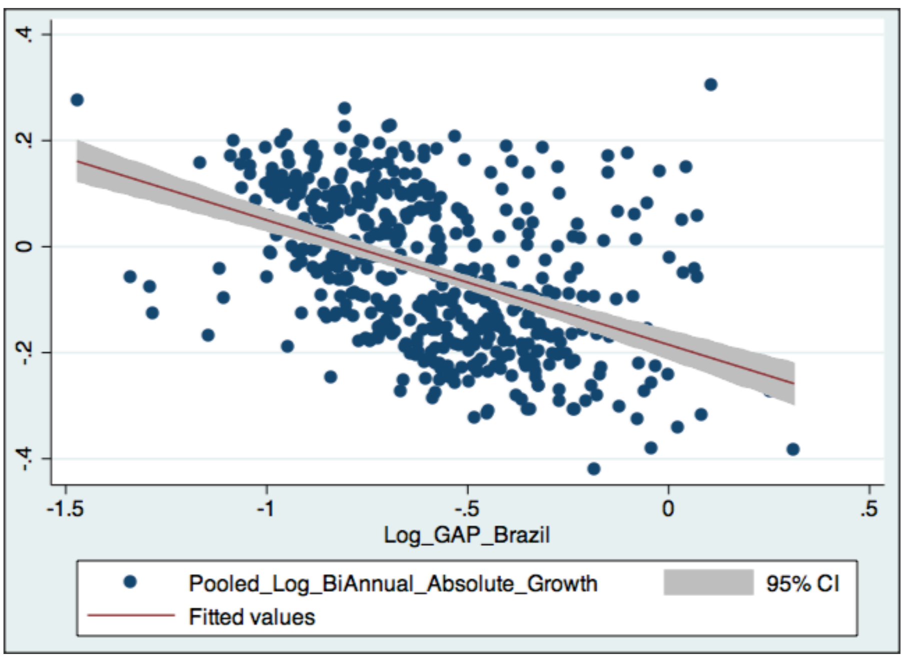


Figure 4 - Growth rate of labor productivity (in log format) in function of the ratio of the labor productivity distance between China and the U.S.

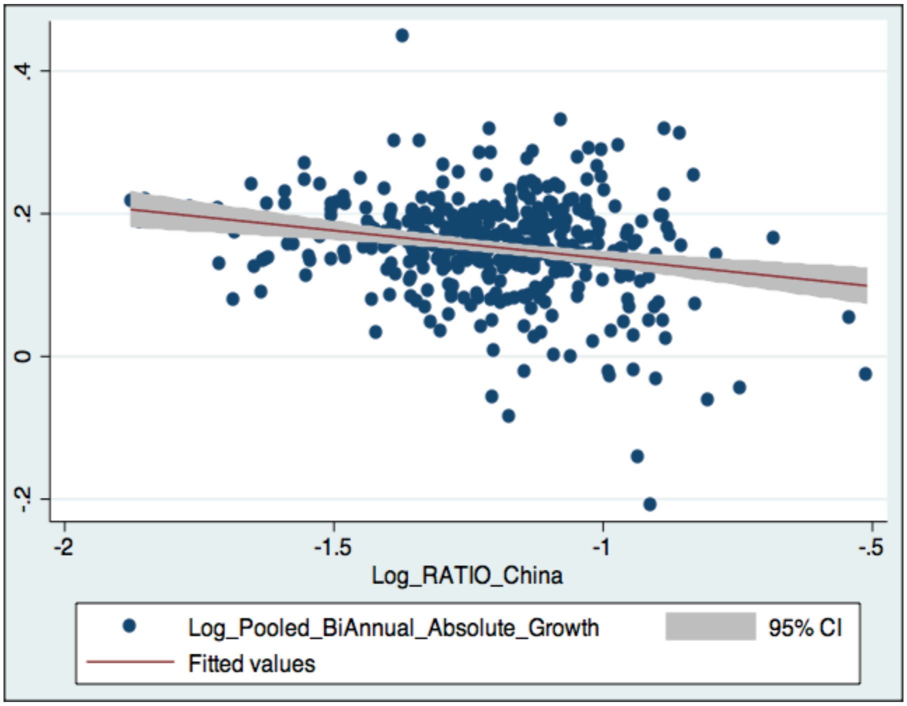
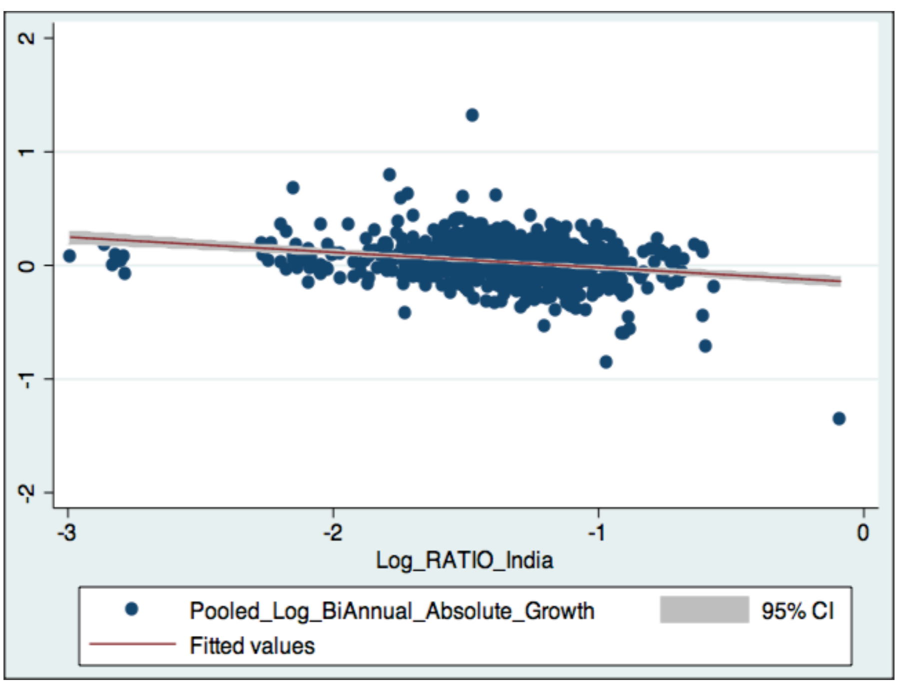


Figure 5 - Growth rate of labor productivity (in log format) in function of the ratio of the labor productivity distance between India and the U.S.



What connection can be made between the convergence of labor productivity and the recent emergence of these countries? As already stated in the introduction, it is important to remember that the manufacturing sector accounts for respectively 60%, 93% and 64% of Brazilian, Chinese and Indian exports in 2010 (World Bank, 2010). These three economies have been largely open to international trade during the last decade, particularly with their entry in the World Trade Organization (1995 for Brazil and India and 2001 for China). The general intuition, often used in the literature is: the opening of the economy generates higher revenues and faster growth if the sectors stimulated generate technological changes and gains through "learning-by-doing" (Young, 1991)[6]. In the case of Brazil, China and India, the manufacturing sector, which represents the majority of exports, may be considered the most stimulated. Obviously, some further research should assess this point.

Now, for our second step, we could analyze the dataset at the industry level. The following tables refer to the regression results for different types of manufacturing industries. Although the small temporal dimension of the data limits the interpretation of these results, they nevertheless provide us with an overview of levels of convergence of the different industries. It is possible to note that almost all industries seem to converge, which is consistent with our previous results. However, the small sample size could also be the cause of this result. For Brazil, except for wood & paper, all industries seem to converge really fast with heavy machinary, transport and textiles in head. For China, the areas of medical equipment, wood & paper and heavy machinary seem to converge faster. In India, we note transport, medical equipment and textiles.

[6] Other elements as returns to scale, ideas diffusion, elimination of research duplication or enforcement of creative destruction have also been reported by literature as vectors of sustainable growth (Aghion & Howitt, 1992; Grossman & Helpman, 1990; L. A. Rivera-Batiz & Romer, 1991; Segerstrom, Anant, & Dinopoulos, 1990).

Table 2- Log-log, Brazil: OLS estimation by industry

Dependant variable: ln(yt)	**BRAZIL**									
	Consommables	**Textiles**	**Wood & Paper**	**Chimical & Pharmaceutical**	**Metals and Plastics**	**Heavy Machinary**	**Electrical Machines**	**Medical Equipment**	**Transport**	**Others**
ln(RATIOit)	-0.299***	-0.417***	-0.082	-0.331***	-0.227***	-0.690***	-0.352***	-0.398***	-0.474***	-0.584***
	0.059	0.052	0.067	0.067	0.05	0.063	0.048	0.079	0.089	0.081
Constant	-0.294***	-0.357***	-0.054	-0.227***	-0.161***	-0.440***	-0.258***	-0.313***	-0.251***	-0.513***
	0.044	0.034	0.045	0.042	0.033	0.035	0.03	0.053	0.049	0.065
N	54	54	54	27	81	27	90	25	63	18
R-squared	0.37	0.5	0.04	0.32	0.17	0.74	0.33	0.53	0.44	0.73

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3- Log-log, China: OLS estimation by industry

Dependant variable: ln(yt)	**CHINA**									
	Consommables	**Textiles**	**Wood & Paper**	**Chimical & Pharmaceutical**	**Metals and Plastics**	**Heavy Machinary**	**Electrical Machines**	**Medical Equipment**	**Transport**	**Others**
ln(RATIOit)	-0.120***	-0.094**	-0.184**	-0.131***	-0.015	-0.152***	-0.125	0.196**	-0.136*	-0.060
	0.028	0.041	0.081	0.048	0.032	0.052	0.098	0.071	0.079	0.063
Constant	0.007	0.033	-0.066	-0.029	0.164***	-0.01	-0.043	0.387***	0.008	0.029
	0.036	0.048	0.099	0.073	0.038	0.061	0.114	0.095	0.099	0.088
N	63	42	45	33	81	42	30	16	30	21
R-squared	0.27	0.1	0.13	0.21	0	0.14	0.06	0.22	0.08	0.04

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4- Log-log, India: OLS estimation by industry

Dependant variable: ln(yt)	INDIA									
	Consommables	**Textiles**	**Wood & Paper**	**Chimical & Pharmaceutical**	**Metals and Plastics**	**Heavy Machinary**	**Electrical Machines**	**Medical Equipment**	**Transport**	**Others**
ln(RATIOit)	-0.11***	-0.307***	-0.161*	-0.095**	-0.071	-0.289***	-0.094	-0.424***	-0.743***	-0.426***
	0.032	0.068	0.088	0.038	0.046	0.083	0.059	0.152	0.174	0.115
Constant	-0.154***	-0.417***	-0.193	-0.12**	-0.054	-0.308***	-0.074	-0.488**	-0.872***	-0.583***
	0.056	0.094	0.132	0.054	0.061	0.103	0.074	0.193	0.219	0.156
N	173	112	120	88	216	130	80	46	79	56
R-squared	0.07	0.17	0.05	0.08	0.01	0.14	0.02	0.19	0.41	0.31

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5 Conclusion

At a time when the western world is still struggling with the aftermath of the financial crisis, it is interesting to look at the adjustments operated in the emerging countries. In the past, when the western world would slow down, world demand would cause the emerging countries to slow down as well. It is no longer the case. Demand in the new global players can help sustain their own economy, but moreover, the supply chain is productive enough to keep attracting foreign direct investments. This is probably the time of a paradigm shift.

In this context, the purpose of this paper was to highlight the convergence between Brazil/China/India and the U.S. labor productivity in manufacturing over the past ten years. We tried to make it original in two ways: (1) the study of convergence was done at the industrial sector level and not at a more aggregated level as previous studies. This allowed us to complement these studies by designing a map of which industrial sectors are catching-up with the productivity frontier. (2) We also proposed a new approach to convergence. To the extent that this study is original and differs from the classical studies of convergence, we named it δ-convergence. We tested several different models and estimation methods and found that there was indeed δ-convergence: as the distance between the level of labor productivity in Brazil (or China/India) and the United States decreased, the growth rate of labor productivity within the country, in Brazil, China and India decreases. Also, we showed that there are reasons to be convinced by the unconditional convergence explanation. We recognize that the temporal dimension of our study is its main limitation.

While data availability does not allow deeper investigation currently, this work gives a brief overview of what should be further investigated. Indeed, future studies should concentrate at the industry level in order to understand what are the conditions and the mechanisms required to accelerate the convergence phenomenon and through that, the economic growth. Although study fields of convergence and technology transfer have always been macroeconomic topics, the new globalized world yells for change in our old models and beliefs.

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7 Appendix

Industry groups

I1= Consumables	151 Processed meat, fish, fruit, vegetables, fats 1511 Processing/preserving of meat 1512 Processing/preserving of fish 1513 Processing/preserving of fruit & vegetables 1514 Vegetable and animal oils and fats 1520 Dairy products 153 Grain mill products; starches; animal feeds 1531 Grain mill products 1532 Starches and starch products 1533 Prepared animal feeds 154 Other food products 1541 Bakery products 1542 Sugar 1543 Cocoa, chocolate and sugar confectionery 1544 Macaroni, noodles & similar products 1549 Other food products n.e.c. 155 Beverages 1551 Distilling, rectifying & blending of spirits 1552 Wines 1553 Malt liquors and malt 1554 Soft drinks; mineral waters 1600 Tobacco products
I2= Textiles	171 Spinning, weaving and finishing of textiles 1711 Textile fibre preparation; textile weaving 1712 Finishing of textiles 172 Other textiles 1721 Made-up textile articles, except apparel 1722 Carpets and rugs 1723 Cordage, rope, twine and netting 1729 Other textiles n.e.c. 1730 Knitted and crocheted fabrics and articles 1810 Wearing apparel, except fur apparel 1820 Dressing & dyeing of fur; processing of fur 191 Tanning, dressing and processing of leather 1911 Tanning and dressing of leather 1912 Luggage, handbags, etc.; saddler & harness 1920 Footwear
I3=Wood and paper	2010 Sawmilling and planning of wood 202 Products of wood, cork, straw, etc. 2021 Veneer sheets, plywood, particle board, etc. 2022 Builders' carpentry and joinery 2023 Wooden containers 2029 Other wood products; articles of cork/straw 210 Paper and paper products 2101 Pulp, paper and paperboard 2102 Corrugated paper and paperboard 2109 Other articles of paper and paperboard 221 Publishing 2211 Publishing of books and other publications 2212 Publishing of newspapers, journals, etc. 2213 Publishing of recorded media 2219 Other publishing 222 Printing and related service activities

	2221 Printing 2222 Service activities related to printing 2230 Reproduction of recorded media
I4: Chemicals and pharmaceuticals	241 Basic chemicals 2411 Basic chemicals, except fertilizers 2412 Fertilizers and nitrogen compounds 2413 Plastics in primary forms; synthetic rubber 242 Other chemicals 2421 Pesticides and other agro-chemical products 2422 Paints, varnishes, printing ink and mastics 2423 Pharmaceuticals, medicinal chemicals, etc. 2424 Soap, cleaning & cosmetic preparations 2429 Other chemical products n.e.c. 2430 Man-made fibres
I5: Metals and plastics	251 Rubber products 2511 Rubber tyres and tubes 2519 Other rubber products 2520 Plastic products 2610 Glass and glass products 269 Non-metallic mineral products n.e.c. 2691 Pottery, china and earthenware 2692 Refractory ceramic products 2693 Struct.non-refractory clay; ceramic products 2694 Cement, lime and plaster 2695 Articles of concrete, cement and plaster 2696 Cutting, shaping & finishing of stone 2699 Other non-metallic mineral products n.e.c. 2710 Basic iron and steel 2720 Basic precious and non-ferrous metals 273 Casting of metals 2731 Casting of iron and steel 2732 Casting of non-ferrous metals 281 Struct.metal products;tanks;steam generators 2811 Structural metal products 2812 Tanks, reservoirs and containers of metal 2813 Steam generators 289 Other metal products; metal working services 2891 Metal forging/pressing/stamping/roll-forming 2892 Treatment & coating of metals 2893 Cutlery, hand tools and general hardware 2899 Other fabricated metal products n.e.c.
I6: Heavy machinery	291 General purpose machinery 2911 Engines & turbines (not for transport equipment) 2912 Pumps, compressors, taps and valves 2913 Bearings, gears, gearing & driving elements 2914 Ovens, furnaces and furnace burners 2915 Lifting and handling equipment 2919 Other general purpose machinery 292 Special purpose machinery 2921 Agricultural and forestry machinery 2922 Machine tools 2923 Machinery for metallurgy 2924 Machinery for mining & construction 2925 Food/beverage/tobacco processing machinery 2926 Machinery for textile, apparel and leather 2927 Weapons and ammunition 2929 Other special purpose machinery

	2930 Domestic appliances n.e.c.
I7: Electrical machines	3000 Office, accounting and computing machinery 3110 Electric motors, generators and transformers 3120 Electricity distribution & control apparatus 3130 Insulated wire and cable 3140 Accumulators, primary cells and batteries 3150 Lighting equipment and electric lamps 3190 Other electrical equipment n.e.c. 3210 Electronic valves, tubes, etc. 3220 TV/radio transmitters; line comm. apparatus 3230 TV and radio receivers and associated goods
I8: Medical Equipment	331 Medical, measuring, testing appliances, etc. 3311 Medical, surgical and orthopaedic equipment 3312 Measuring/testing/navigating appliances,etc. 3313 Industrial process control equipment 3320 Optical instruments & photographic equipment 3330 Watches and clocks
I9: Transports	3410 Motor vehicles 3420 Automobile bodies, trailers & semi-trailers 3430 Parts/accessories for automobiles 351 Building and repairing of ships and boats 3511 Building and repairing of ships 3512 Building/repairing of pleasure/sport. boats 3520 Railway/tramway locomotives & rolling stock 3530 Aircraft and spacecraft 359 Transport equipment n.e.c. 3591 Motorcycles 3592 Bicycles and invalid carriages 3599 Other transport equipment n.e.c.
I10: Others	3610 Furniture 369 Manufacturing n.e.c. 3691 Jewellery and related articles 3692 Musical instruments 3693 Sports goods 3694 Games and toys 3699 Other manufacturing n.e.c. 3710 Recycling of metal waste and scrap 3720 Recycling of non-metal waste and scrap