Common and idiosyncratic shocks to labor productivity across sectors and countries:

Is climate relevant?

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ABSTRACT

We use two methodologies, the least square dummy variables approach and the dynamic factor models, to decompose the labor productivity growth rate for a large sample of countries into common, i.e. global, and idiosyncratic, i.e. country, components. We find that country specific effects are much more important than common effects in explaining labor productivity. The interesting result is that, when splitting the sample of countries into those located in temperate zones and those located in tropical zones, we find that the common component plays a larger role in temperate countries. Thus, given the wide gap in labor productivity between the two climatic zones, policy should be targeted on developing technologies for tropical zones and/or on helping them to absorb R&D targeted for temperate countries

Key words: Labor productivity, Decomposition, Dynamic factors, Panel unit roots.

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1. Introduction.

When mapping the world in terms of income per head or labor productivity, we find that rich countries lie in the temperate zones and poor countries in the tropics and semi-tropical areas. [1] These interesting, but until recently neglected, points were fully recognized by John Kenneth Galbraith in 1951, "[If] one marks off a belt a couple of thousand miles in width encircling the earth at the equator one finds within it *no* developed countries… Everywhere the standard of living is low and the span of human life is short." [2] In recent years, a growing body of literature on the effect of physical geography on economic growth has stressed the importance of climatic zones as one of main determinants of productivity across nations and sectors, see among others Gallup et al. (2001), Masters and McMillan (2001); Sachs (2001); Gutierrez and Gutierrez (2003).

We analyze fluctuations in labor productivity for a large sample of countries located in temperate and tropical zones for which annual data are available for the period 1974-1999 and for the three sectors; agriculture, industry and services. Naturally, the countries differ in their institutions, the composition of the GNP, their monetary, fiscal and trade policies and, as previously noted, climate, but the interesting question is whether, despite the previously mentioned differences, they show common patterns, and if these play a major role in explaining the labor productivity variations.

Until now many studies have highlighted the presence of co-movements between a variety of economic variables across sectors and countries, Backus and Kehoe (1992), Bayomi and Prasad (1997), Marimon and Zilibotti (1998). A common explanation is that these are connected with the monetary or fiscal policy that influences variables within a specific country, but can be transmitted rapidly to other countries through trade and financial interdependence. Other research hypothesizes an international impulse, common to all countries, as the cause of the co-movements across countries, connected to global monetary policy McKinnon (1982) or technological shocks Norrbin and Schlagenhauf (1996).

Our work extends previous research in a number of important ways. First, by contrast with previous research, where efforts were concentrated on OCDE countries, our analysis will embrace seventy-three countries and thus, we hope, permit a better understanding of the phenomenon and a consistent estimation of the common and idiosyncratic factors. As is well known from standard panel econometrics, the larger the number of units in the panel, i.e. countries in our case, the higher is the possibility of obtaining a consistent estimation of the common components. Secondly, grouping the countries into temperate and tropical countries will help us to provide evidence on the possible differences and importance of common, country-specific and sector-specific shocks in these two geographical areas. Thirdly, using two statistical estimation approaches will enable us to provide a deeper picture of the presence of common and idiosyncratic patterns in labor productivity. The first method has been widely applied, see among others Stockman (1988) and Marimon and Zilibotti (1998), and consists in using a simple panel least square dummy variable methodology. The second draws from a recent and growing body of literature on panel unit root tests and dynamic factor model estimation methods, see Bai and Ng (2003).

In synthesis, we find that country-specific effects are much more important that common effects in influencing labor productivity. The interesting things is that these results are partially reversed when analyzing the two effects separately for the sample of temperate and tropical countries. The former group of countries are much more influenced by common effects than the latter group. Thus these findings leave open questions for further research, to discover which factors (variables) are likely to be effective in improving labor productivity for the group of tropical countries and which national policy could lead to more effective strategies for improving economic growth.

In the next section, we briefly review the two methods used to decompose labor productivity growth rates. In the third section we present the statistical results. Finally, section four concludes.

2. The statistical decomposition between common and idiosyncratic effects

2.1 The least square dummy variable strategy.

In this section we briefly review the statistical model originally proposed by Stockman (1988) and Costello (1993) to analyze the productivity dynamics in the OCDE countries, which was used by Bayomi and Prasad (1997) to study currency area properties in Europe, by Marimon and Zilibotti (1998) to study European employment dynamics, and by Loayza et al. (2001) to analyze common real value-added patterns for Latin America, East Asia and European countries.

Formally, we assume that the labor productivity growth rate can be decomposed in aggregate international effects associated with the business cycle, sector-specific effects connected, for example, to sectoral technological trends, and country specific factors which can have either an aggregate and/or industry specific nature. If this is the case, in each period *t* the labor productivity growth rate in country *j* and sector *i* can be decomposed as the sum of the following components:

$$\Delta p_{ijt} = h_i + b_t + f_{it} + m_{ij} + g_{jt} + u_{ijt} \tag{1}$$

for sector i=1, 2,..., I, country j=1, 2,..., N and time t=1, 2,..., T, where

- Δp_{ijt} is the labor productivity growth rate of sector i, in country j at time t.
- h_i is a time-invariant component specific for sector i but common to all countries. Its function is to capture the mean growth rate across countries in sector i and represent the international trend of labor productivity in sectoral growth rates.

- m_{ij} is a time-invariant component that identifies deviations across countries from h_i. These differences may be connected to different initial conditions, for example.
- b_t is a time effect common to all N countries and sectors I. The main aim of this term is to capture the international business cycle that influences all countries and sectors.
- f_{it} captures deviations across time from h_i, and deviations across sectors from b_t; the function is to capture differences in cyclical behavior of a specific sector in a country.
- g_{jt} captures country-specific deviations from b_t; for example, transitory national performance with respect to the international business cycle resulting from national economic policies.
- u_{ijt} is an error term orthogonal for all effects.

The previous model is not identified and cannot be estimated without introducing a certain number of restrictions. In this case, we follow the methodology provided by Bayomi and Prasad (1997) and Marinon and Zilibotti (1998), who assume that all the different effects highlighted in equation (1) are orthogonal. Unlike Stockman (1988) and Costello (1993), who choose a specific country and time period as the reference point, assuming orthogonality between all the elements in (1) implies taking as a reference point not a single country, sector or year, but the respective sample averages. [3]

More specifically we assume that

- $\sum_{j=1}^{N} m_{ij} = 0,\ i = 1,\ldots,I,$
- $\sum_{i=1}^{I} f_{it} = 0,\ t = 1,\ldots,T,$
- $\sum_{t=1}^{T} f_{it} = 0,\ i = 1,\ldots,I,$
- $\sum_{t=1}^{T} g_{jt} = 0,\ j = 1,\ldots,N,$
- $\sum_{j=1}^{N} g_{jt} = 0,\ t = 1,\ldots,T,$
- $\sum_{t=1}^{T} b_t = 0$

which give a set of $2T + 2I + N + 1$ restrictions, of which all but two are independent. Thus the model is identified exactly.

A way to analyze the importance of common sectoral effects when influencing long-term labor productivity is to set all countries-specific components (i.e. $m_{ij} = g_{jt} = u_{ijt} = 0$) to zero and define a new labor productivity variable, which is given by the following expression:

$$\Delta p_{it} = h_i + b_t + f_{it}. \qquad (2)$$

Note that in this case labor productivity does not depend on country effects, and that its growth is connected to common factors which influence sectors in all countries by the same amount. In synthesis, expression (2) shows the sector labor productivity growth rate that countries would have experienced in the absence of any “country idiosyncratic” effect.

2.2 The panel unit roots strategy.

Over the last few years, there a lot of attention has been paid to the nonstationary property of panels. As is well known, many studies have examined whether the time series behaviour of economic variables is consistent with a unit root (see for a survey Diebold and Nerlove, 1990; Campbell and Perron 1991). In general, the analysis has been carried out using tests such as the augmented Dickey-Fuller’s (ADF) (Dickey and Fuller, 1981) test or semi-parametric tests, as in the case of the Phillips-Perron tests (Phillips and Perron, 1988). The main problem here is that, in a finite sample, any unit roots process can be approximated by a trend-stationary process. For example, the simple difference stationary process $y_t = f y_{t-1} + e_t$ with $f = 1$ can be arbitrarily well approximated by a stationary process with f less than but close to one. The result is that unit root test statistics have limited power against the alternative.

Recently, starting from the seminal works of Quah (1990, 1994), Breitung and Meyer (1991) Levin and Lin (1992, 1993), Im *et al.* (1997) many tests have been proposed which attempt to introduce unit root tests in panel data. They show that combining the time series information with that from the cross-section, the inference about the existence of unit roots can be made more straightforward and precise, especially when the time series dimension of the data is not very long, and similar data may be obtained across a cross-section of units such as countries or industries. In any case all the panel unit root tests suffer from the serious limitation that the cross-sectional units are uncorrelated. This means for example hypothesizing that European countries’ labor productivities are not correlated either in the short or long term, where it seems clear that high cross-correlations exist and are relevant.

Three papers which have been presented in recent years, Bai and Ng (2003), Moon and Perron (2002) and Phillips and Sul (2002,) take this problem into account. In brief, each of these proposes a dynamic factor model in which the panel data is generated by one or more factors that are common to all the individual units (but which may exert different effects on the individual unit) and by idiosyncratic shocks that are uncorrelated across all the individual units. While Moon and Perron (2002) and Phillips and Sul (2002) state that common factor(s) must be a stationary variable(s), Bai and Ng (2003) include the knowledge obtained from previous works which permit nonstationary (or stationary) common component(s). For this reason we are concentrating our attention on Bai and Ng’s (2003) model.

Assuming that in each sector *i*, the logarithm of labor productivity can be decomposed as

$$p_{jt} = c_{jt} + l_j^{'} F_t + e_{jt} \quad j = 1,...,N \quad t = 1,...,T \tag{3.1}$$

$$\left(I - L\right) F_t = C\left(L\right) u_t \tag{3.2}$$

$$\left(1 - r_j L\right) e_{jt} = B_j\left(L\right) e_{jt} \tag{3.3}$$

where c_{jt} an individual deterministic constant or linear trend, F_t is a $\left(r \times 1\right)$ constant, when $r = 1$, or vector, when $r > 1$, of common factor(s) and l_j is the corresponding vector of factor loadings. The error terms u_t and e_{jt} are mutually independent across *j* and *t*, and $B_j\left(L\right)$ and $C\left(L\right)$ are two polynomial, with a rank of $C\left(1\right) = r_1$. In synthesis, when $r_1 = 0, C\left(1\right) = 0$, and (3.2) is over-differenced, while for $r_1 \geq 1$ the system contains one or more common stochastic trends. Note from (3.3), that the idiosyncratic term e_{jt} is stationary when $\left|r_j\right| < 1$ and non-stationary, or equivalently, integrated of order one $I\left(1\right)$, for $r_j = 1$.

In brief, Bai and Ng’s (2003) model consists of estimating common factor(s), F_t, and idiosyncratic components by applying the method of principal components to the first differenced data $\Delta\boldsymbol{\eth}$ (where now $\boldsymbol{\eth}$ is the observed $\left(T \times N\right)$ matrix of log labor productivities for the *N* countries and over *T* periods), and obtaining the (differenced) common factor(s) as the first r_1 eigenvectors with the largest eigenvalues of the matrix $\Delta\boldsymbol{\eth}\Delta\boldsymbol{\eth}^{'}$. Factor loading l_j can be easily calculated as the product of (transposed) $\Delta\boldsymbol{\eth}$ matrix and common factor(s). Thus, the (differenced) idiosyncratic terms in (3.1) can be calculated as $\Delta p_{jt} - \hat{l}_j^{'} \Delta\hat{F}_t = \Delta\hat{e}_{jt}$. Finally, the estimate of the level of common factor(s) can be obtained simply by integrating $\hat{F}_t = \sum_{k=2}^{T} \Delta\hat{F}_k$, and in the same manner for each unit (sector) *i*, and for each country *j*, the idiosyncratic error term $\hat{e}_{jt}$ can be computed as $\hat{e}_{jt} = \sum_{k=2}^{T} \Delta e_{jk}$.

As in (2), the decomposition between common and idiosyncratic effects can be used to value the importance of the two components in determining the dynamics of labor productivity for each sector *i*. Moreover in this case we can use both the estimated common factor(s) $\hat{F}_t$ and error term $\hat{e}_{jt}$ to analyze the stochastic properties of both components.

3. Statistical results

3.1 Data set

In brief, the data for output comes from the World Bank and are given by the gross value added in the agricultural, industry and service sectors during the period 1974 - 1999. The variables, originally expressed in constant local currency units, were converted to 1985 international dollars by using the corresponding purchase power parity index reported in Penn World Table (Mark 5.6a). Data for labor comes from the ILO database and reflect the economically active population in the agricultural, industrial and service sectors. The availability of data determined which countries were included in the study. We were able to select 73 countries. We do not correct for the effects of changes in the quality of labor. Adjusting labor input for shifting from unskilled to more skilled workers, where the latter have a higher productivity, can result in a lower estimated productivity growth rate. However, in the absence of information, we do not correct productivity measurement for input quality changes and leave these important issues for further research.

Before presenting regression results, it is useful to highlight the sectoral proportion in the total real value added and the average annual labor productivity growth rates during the period 1974-1999.

Table 1 shows the annual average growth rates of labor productivity and the share of each sector in the total real value added for the sample of 73 countries and the two groups of tropical and temperate countries. Analysis of Table 1 reveals important and well known patterns.

Table 1 about here

Firstly, the productivity growth rate was highest in the agricultural sector, and nearly twice that for the industrial sector for the total sample of countries. In the temperate zones there was only a slight difference between the average growth rate for the agricultural and industrial sectors, while in tropical countries the agricultural sector growth rate was far higher than that of the industrial sector. Furthermore, while tropical countries had a negative annual average growth rate for labor productivity in the service sector, in the temperate countries this rate was positive. Secondly although the share of the agricultural sector in the total real value-added decreased in both climate zones during the period of analysis, in 1999 this sector still accounted for 20% of the total product of the tropical countries. Both climate zones showed a marked rise in the service sector's share.

3.2 The least square dummy variable strategy: results.

We are now ready to present the regression results. The model described in (1) was estimated by using a dummy variable regression method for the panel of labor productivity growth rates described in the previous section.

For reasons of brevity we do not report all the estimates, but it is worth mentioning that more than 50% of the labor productivity growth rate variance is explained by the model. The coefficient of determination is R^2=0.51 for the total sample of countries, is R^2=0.56 for the temperate countries and R^2=0.52 for the sample of tropical countries. [4]

In table 2, we report the analysis of long-run and short-run variations of sectoral labor productivity growth rates. As is usual when reporting these values, both components have been normalized to add up to 100 percent.

Table 2 about here

As can be seen from table 2, more than 86% of the total variation in long-run trends for the total sample of countries are explained by the country specific factors m_{ij}. The term h_i, that accounts for sector-specific effects, which are, by definition, country and time independent, explains the remaining variance. When analyzing these components for the sample of temperate and tropical countries some differences emerge. While country-specific factors are wider both for temperate and tropical countries, the sector-specific effects are more relevant for the former countries. In this case more than 20% long-run variance in labor productivity is explained by sector-specific shocks.

The same picture emerges when short-run variations are examined. The country-specific effects g_{jt} plays the major role. International business cycle b_t and sectoral factors f_{it} have a lesser effect. It is noteworthy that while the international business cycle variable b_t roughly explains the same fraction of short-run variance for both temperate and tropical countries, the sector-specific component f_{it} is of more importance in explaining short-run variations of labor productivity for temperate countries.

In synthesis, labor productivity growth rates largely depend on country-specific effects. Sector specific effects, common to all countries, are of less relevance, but it is important to note that their effect is larger in temperate countries than tropical countries. If common sector-specific shocks are related to technological improvements over time, the results may indicate that tropical countries have not succeeded in developing technologies suitable for their climate and/or in adapting R&D targeted for temperate countries to local conditions. [5]

3.3 The panel unit roots strategy: results. [6]

The first task when computing multifactor analysis, as in (3.1), is to specify the number of factors r correctly. We follow Bai and Ng (2002) and we use what they label BIC_3 criterion given by

$$BIC_3(r) = \min_{l} \frac{1}{NT} \sum_{j=1}^{N} \sum_{t=1}^{T} \left(X_{jt} - l_j^{r'} \hat{F}_t^r \right)^2 + r\hat{s}^2 \left(\frac{(N+T-r)\ln(NT)}{NT} \right) \tag{4}$$

where $\hat{s}^2 = 1/(NT) \sum_{j=1}^{N} \sum_{t=1}^{T} E\left(e_{jt}\right)^2$. The number of factors $\hat{r}$ are specified such that $\hat{r} = \arg\min_{0 \le r \le r\max} BIC_3(r)$. Thus, the criteria defines the correct number of factors taking account of the mean squared sum of residuals from (3.1), i.e. the first addend in (4), plus a penalty function for overfitting given by the second term in (4). Bai and Ng (2002) show that this criterion performs well for our sample size of data.

We compute (4) using as maximum number of factors $r\max = 4$. For all the three sectors, the BIC_3 criterion suggests the presence of a single common factor. In table 3, we present some statistics on the relative importance of this factor, as well as of the residual, i.e. idiosyncratic component, in explaining the variance of labor productivity and its stochastic properties.

Table 3 about here

In the first two columns of the table we include the average amount of total variance explained by the two components. Looking at the total sample of countries results, the single common factor explains on average 7% of the total variance. Idiosyncratic effects explain the remaining 93%. Thus the picture that emerges from table 3 confirms the previous least square results: labor productivity is principally influenced by country-specific effects. When looking at the results for temperate and tropical countries, one sees first that that the weight of the common factor is more relevant for temperate countries than for countries located in the tropics. Secondly the impact of the common factor is wider, especially for the industry and service sectors, but less so for the agricultural sector.

The Augmented Dickey Fuller test (when including a constant plus two lags for differenced variables) does not reject the null of unit roots for the common factor $\hat{F}_t$, i.e. the common factor is a non-stationary variable. Different results emerge when testing for unit root the idiosyncratic component. In this case, we adopt the pooled test proposed by Maddala and Wu (1999), which uses the observed significance levels (*p*-values) of the ADF test on each unit of the panel. The results indicate that the null hypothesis of unit root is rejected for the agriculture sector while is not rejected for the industry sector. For the service sector we do not reject the null only for the sample of temperate countries. This means that while a shock to agriculture and service is generally mean-reversed in the long-run, an idiosyncratic shock in the industry sector is long lasting, and can even be said to be long term. Finally in the third column of table we compare the (differenced and standardized) common factors obtained from the dynamic factor model and the (standardized) common labor productivity growth rates obtained from (2). They show a positive correlation coefficient, with values ranging around 0.6 across sectors.

4. Conclusion

This paper provides new evidence about the sources of differences in labor productivity growth rates across a sample of seventy-three countries during the period 1974-1999. We decompose labor productivity growth rates on common and idiosyncratic components by using a well known procedure, the panel least square dummy variable approach, and a new dynamic factor model procedure. We find that labor productivity is mainly influenced by country-specific effects and that the common sector-specific component is of less importance. These results are partially reversed when the total sample of countries is split into two according to their location either in temperate zones or the tropics. In the latter the common component has a greater effect on labor productivity. If common sector specific shocks are related to technological improvements over time, the results indicate that tropical countries have not managed to develop technologies suitable for their climate and/or to adapt R&D targeted for temperate countries to local technologies in a successful way. Thus these results indicate that new efforts and further research are required if we wish to understand which variables are associated with the diffusion of technology, and in this way increase the income of lagged tropical countries more successfully.

Notes

[1] In the *World Development Report 2000/2001* the World Bank defines high income countries as those with Gross National Product per capita in $US of 9,226 ore more. Of these countries, only Hong Kong and Singapore are located in the tropics.

[2] "Conditions for Economic Change in Underdeveloped Countries," *Journal of Farm Economics*, 33, (1951). Cited in Landes (1999) pg. 5.

[3] See Marimon and Zilibotti (1999) for a proof.

[4] The F tests rejects the null hypothesis of zero regression coefficients for all the three sample. The estimates report some marginal evidence of serial correlation of the residuals. The autocorrelation coefficient ranged from –0.16 for the total sample of countries to –0.06 for the sample of tropical countries. When introducing an autoregressive component the results are not altered.

[5] The latter issue have been analyzed in Gutierrez and Gutierrez (2003) who find that countries located in temperate zones benefit more than countries located in tropical zones from technological spillovers.

[6] The GAUSS procedures used in this section are freely available upon request from the author.

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Tables

Table 1. Labor productivity growth rates and sectoral real value-added

Sectors	Annual Average Growth Rates (%)	Share Real Value-Added (% of total)	
		1974	1999
Total Sample of Countries			
Agriculture	1.93	20.4	15.1
Industry	1.11	29.6	30.6
Service	-0.24	50.0	54.3
Total	0.91	100.0	100.0
Temperate Countries (29)			
Agriculture	2.91	13.7	8.0
Industry	2.45	29.0	31.1
Service	0.45	57.3	60.9
Total	1.43	100.0	100.0
Tropical Countries (44)			
Agriculture	1.29	24.8	19.8
Industry	0.22	29.9	30.2
Service	-0.70	45.3	50.0
Total	0.57	100.0	100.0

Sources : author’s calculation on World Bank dataset

Table 2. Analysis of long and short-run variations

Total Sample of Countries			
Components	Analysis of long-run variations		
	% explained	Variance	Correlation
p_L	100.00	0.0006	1.00
h_i	13.75	0.0001	0.37
m_{ij}	86.25	0.0005	0.93
	Analysis of short-run variations		
	% explained	Variance	Correlation
p_S	100.00	0.0024	1.00
b_t	5.17	0.0001	0.23
f_{it}	1.32	0.0000	0.10
g_{jt}	93.51	0.0023	0.97
Temperate Countries (29)			
Components	Analysis of long-run variations		
	% explained	Variance	Correlation
p_L	100.00	0.0005	1.00
h_i	22.35	0.0001	0.47
m_{ij}	77.65	0.0004	0.88
	Analysis of short-run variations		
	% explained	Variance	Correlation
p_S	100.00	0.0023	1.00
b_t	6.43	0.0001	0.25
f_{it}	6.56	0.0001	0.26
g_{jt}	87.01	0.0020	0.93
Tropical Countries (44)			
Components	Analysis of long-run variations		
	% explained	Variance	Correlation
p_L	100.00	0.0005	1.00
h_i	12.58	0.0001	0.35
m_{ij}	87.42	0.0004	0.93
	Analysis of short-run variations		
	% explained	Variance	Correlation
p_S	100.00	0.0028	1.00
b_t	6.33	0.0002	0.25
f_{it}	2.51	0.0001	0.17
g_{jt}	91.16	0.0025	0.96

Sources : author’s calculation based on World Bank and ILO dataset

Table 3. Panel unit roots test results

Sectors	Average $\frac{\text{var}\left(\hat{l}_i'\hat{F}_t\right)}{\text{var}\left(\Delta X_{it}\right)}$	Average $\frac{\text{var}\left(\Delta\hat{e}_{it}\right)}{\text{var}\left(\Delta X_{it}\right)}$	Correlation of $\Delta\hat{F}_t$ with LSDV common trend estimates	ADF test common factor	Pooled ADF test
Total Sample of Countries					
Agriculture	0.073	0.927	0.60	-0.48	-4.58
Industry	0.075	0.925	0.61	0.09	0.74
Service	0.062	0.938	0.62	-1.01	-3.77
Temperate Countries (29)					
Agriculture	0.096	0.904	0.71	-1.35	-4.17
Industry	0.178	0.822	0.78	-1.93	-0.27
Service	0.138	0.862	0.62	-1.59	0.70
Tropical Countries (44)					
Agriculture	0.089	0.911	0.50	0.31	-2.64
Industry	0.058	0.942	0.13	-0.75	-0.92
Service	0.054	0.946	0.71	-1.09	-3.85
5% Critical values				-1.95	-1.65