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Public expenditure, growth, and productivity of Vietnam's provinces

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Abstract

This paper proposes a structural approach to investigate total factor productivity and economic growth of Vietnam's provinces during the 2000-2007 period. TFP is composed of three components: an autonomous technological change, an observed deterministic part depending on external factors, and an unobserved stochastic part. Estimation results do not show any evidence regarding the impacts of national and local public spending on TFP and economic growth of Vietnam's provinces. Human capital and the local economy's structure (shares of industry, services, and agriculture) can play a significant role in explaining the cross-province differences in terms of productivity. Finally, TFP of Vietnam's provinces does not converge in the long run as it displays a polarization feature around two main groups of provinces, a large group with low TFP levels and much smaller group with high TFP levels. This bipolar pattern of TFP distribution helps to explain the competitiveness disparity among the Vietnam's provinces.

Keywords: Structural modeling, national public expenditure; local public expenditure; total factor productivity; Vietnam's provinces

JEL Classification: C23; H50, H70, O40

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1 Introduction

Vietnam, a one-party communist country, initiated a vast economic reform program in 1986 (known as 'Doi Moi' in Vietnamese) to transform its planned economy into a socialist-oriented market economy. Since then, the Vietnam's economy has been recognized as one of the most dynamic emerging economy in the world. It has a long lasting and rapid growth over the last three decades. Decentralization which devolves larger competencies and responsibilities to the provinces is one pillar of this reform. Vietnam was consequently viewed as a relatively highly decentralized country (World Bank, 2014). This decentralization also implies a greater competition among provinces to attract infrastructure projects and foreign direct investment firms. In 2000, the top five provinces which received the highest foreign direct investment (in 2010 prices) are Ho Chi Minh City, Binh Duong, Bac Lieu, Dong Nai (all of them are in the South) and the capital Ha Noi (in the North), and the five provinces which received the least foreign investment are Ha Nam, Nam Dinh, Dien Bien (in the North), Dak Nong (Central Highlands), and Ninh Thuan (Center). In 2007, the top five are almost the same with the exception that Bac Lieu is replaced by Vung Tau (a neighboring province of Ho Chi Minh City). For the same year, the bottom five are Bac Kan (in the North), Quang Binh (Center), Bac Lieu, Tra Vinh, and An Giang (all in the South). The dynamics of foreign investment shows that the locomotive of the Vietnamese economy is Ho Chi Minh City, its neighboring provinces, and in a lesser extent the capital Ha Noi. In this context, the public sector always keeps an utmost importance and public intervention has a primary role to soften the inequality appearing among regions during the development process. Public expenditure at the national and local levels, regardless of its categories (investment, eduction spending, health spending, etc.), is therefore considered as a key factor to achieve the industrialization and modernization of the Vietnam's economy.

Figure 1 displays the rising dynamics of national GDP and median values of provincial GDP over period 2000-2007 (both in 2010 prices). National and local public expenditure (in terms of public investment, also in 2010 prices) in Vietnam also increases during the same period of observation. Figure 2 displays the evolution of these series over period 2000-2007. For local public spending, the plot shows the median values computed yearly for Vietnam's provinces.

Our paper aims to investigate whether this underlying dynamics of local and national public expenditure in Vietnam can have any impact on the local economies, in terms of growth and productivity. Another objective is to assess the difference among Vietnam's provinces in terms of their productivity which appears to be an important determinant of their competitiveness. Such a study has not been done so far, probably due to the lack of reliable data.

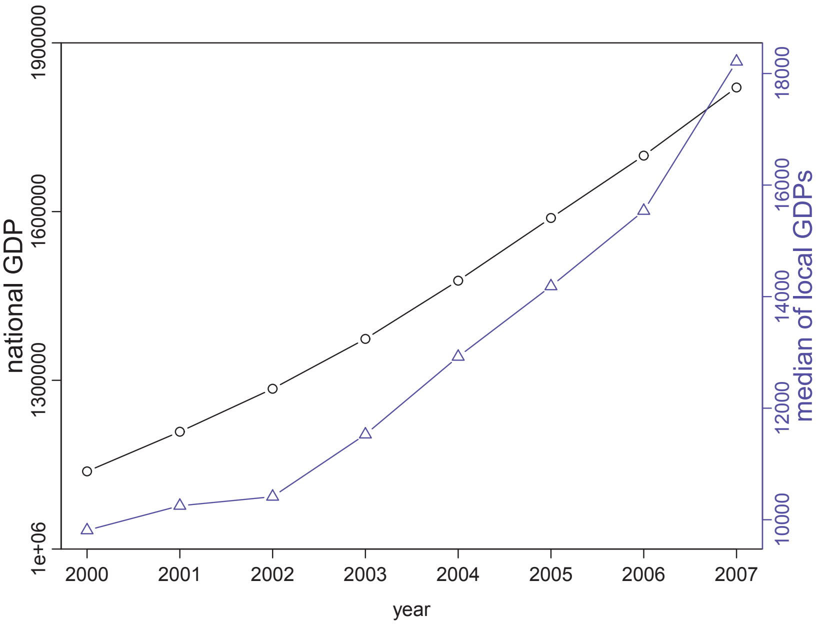

Figure 1: National GDP and median GDP of Vietnam's provinces. The left y-axis corresponds to national GDP (○ symbol). The right y-axis corresponds to the median local GDP (△ symbol). Data sources: World Development Indicators (World Bank), General Statistics Office (Vietnam), and Ministry of Finance (Vietnam).

The question of whether public expenditure has a significant impact on production and economic growth has been the object of a great deal in the growth literature, notably from the seminal paper of Barro (1990). Barro postulated that for countries with a government size lower than an optimal threshold, public spending has a positive impact on growth, while for countries with a government size higher than that threshold, the impact is negative. Several empirical studies focused on this postulate and the results were mixed. For example, Chamorro-Narvaez (2012) considered the case of Latin America countries over the period 1975-2000 and concluded that neither the stock of government spending nor its current spending has any impact on the growth rate of GDP per capita. Bose et al.(2007) rather indicated a significant influence of capital spending. Using a data set of 15 developing countries, Ghosh and Gregoriou (2008) and Gregoriou and Ghosh (2009) suggested that the current component of public spending has a positive impact on growth whereas the capital component has a negative effect. This result confirms that of Devarajian et al. (1996) for a larger group of 43 countries over the period 1970-1990.

Other studies examined whether public expenditure is a key determinant of labor productivity or the technological change (see, e.g., Aschauer, 1989, Lynde and Richmond, 1993, Hansson and Henrekson, 1994, Ramirez, 1998, Ascari and Di Cosmo, 2005, Destefanis and Sena, 2005, Bronzini and Piselli, 2009, etc.). The findings were divergent,

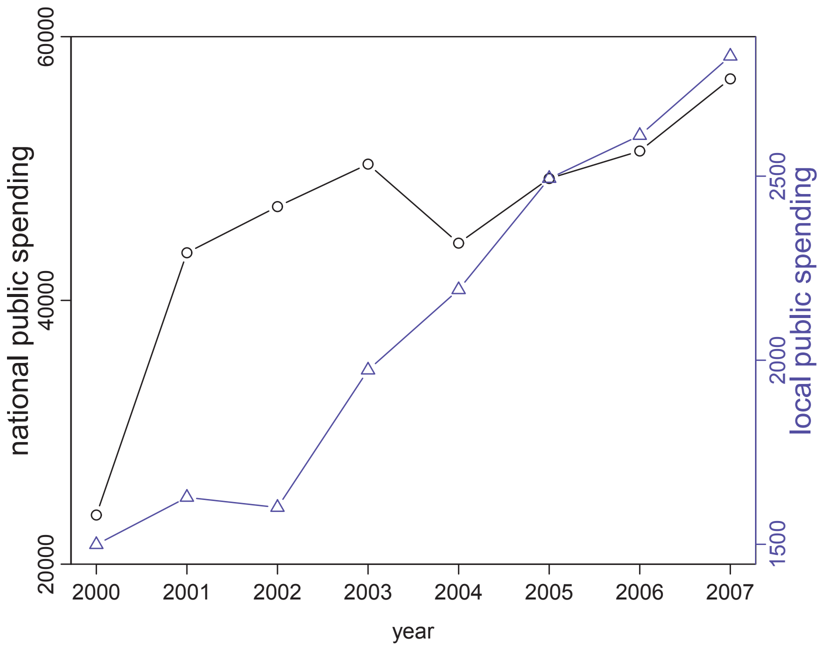

Figure 2: National and provincial public spending. The left y-axis corresponds to national public spending (○ symbol). The right y-axis corresponds to median values of provincial public spending (△ symbol). Data sources: World Development Indicators (World Bank), General Statistics Office (Vietnam), and Ministry of Finance (Vietnam).

depending on data, econometric methodology, public expenditure categories, etc. For instance, by analyzing labor productivity of the Group of Seven industrialized countries (G-7) over the period 1960-1986, Aschauer (1989) found that the elasticity of labor productivity with respect to the share of public capital accumulation in GDP is about 0.73%. Our work also relies on previous studies on regional heterogeneity. Destefanis and Sena (2005) and Ascari and Di Cosmo (2005) stated that among different external factors, the presence of public sector with its expenditure plays a crucial role in the TFP evolution of Italian regions. This positive effect was not found in Hansson and Henrekson (1994) when they examined the influence of government investment for 14 OECD countries over period 1970-1987. They rather obtained a positive impact of educational expenditure on TFP growth. Moreover, public infrastructure of one region may have a positive effect on the neighboring regions' TFP. This geographical spillover (or externality) from public infrastructure was also found across Italian regions during period 1980-2001 by Bronzini and Piselli (2009).

We investigate the impact of public expenditure on productivity of Vietnam's provinces by distinguishing two types of public expenditure at the national and the provincial levels. We estimate the role of provincial and national public expenditure in the production process using a data set of 58 Vietnam's provinces over period 2000-2007. We propose a structural modeling to estimate a stochastic production function with the assumption that the TFP is composed of three parts: (i) an autonomous technological change, (ii) a deterministic technological change depending on provincial external factors such as human capital and local economy's structure (shares of services, industry, and agriculture in the regional GDP), and (iii) an unobservable (stochastic) technological change. Based on the production function estimation, we compute the TFP of Vietnam's provinces and examine its dynamics in order to investigate the long-run distribution of TFP across 58 Vietnam's provinces.

The main results may be summarized as follows. First, among provincial inputs (physical capital, labor force and public expenditure), only labor force has a positive and significant effect on the output growth of Vietnam's provinces. Neither national nor local public expenditure has a significant effect on productivity. Second, our results show that the share of agriculture and that of services in provincial GDP have negative and significant effects on the productivity of Vietnam's provinces whereas the literacy rate (which is a proxy for human capital) has a positive and significant effect. This finding means that these external factors can explain the cross-provincial differences in terms of TFP and income. Finally, when analyzing the dynamics of TFP, we do not find any evidence of convergence between 58 Vietnam's provinces. The long-run distribution of TFP displays a divergence pattern corresponding to a bipolarization phenomenon where provinces are amassed into two groups, one with high TFP levels and another with low TFP levels. This bipolar feature could provide an explanation of the disparity described above regarding the competitiveness between the Vietnam's provinces.

The remainder of the paper is organized as follows. In Section 2, we present a short literature review on TFP, underlying the role of public expenditure. Section 3 presents our proposed structural modeling using a stochastic production function and the potential determinants of TFP for Vietnam's provinces. Section 4 presents data and the econometric specification. Estimation results and an analysis regarding measurement errors are reported in Sections 5 and 6, respectively. Section 7 concludes.

2 On overview on public expenditure, productivity, and economic growth

Several empirical studies underline the influence of public expenditure on the total factor productivity (e.g., Munnell, 1990, Lynde and Richmond, 1993, Hansson, 1994, Destefanis and Sena, 2005, Ascari and Di Cosmo, 2005). For instance, analyzing the labor productivity of the Group of Seven industrialized countries (G-7) over the period 1960-1986, Aschauer (1989) stated that if the share of GDP devoted to public capital accumulation increases by 1%, then labor productivity increases by 0.73%. Lynde and Richmond (1993) explained the American TFP slowdown in the early 1970s by the decline in the public capital-labor ratio. The same argument was advanced by Munnell (1990). This author stressed that besides the fall in the public capital-labor ratio, other factors such as education, rising energy costs, research and development, spending cut, and diversion of funds to pollution abatement are parts of productivity decline in the United States in the early 1970s. Hansson and Henrekson (1994) analyzed the effects of different public expenditure categories in a sample of 14 OECD countries for the 1970-1987 period. Not surprisingly, they found that consumption expenditure and transfers exert a negative influence while educational expenditure has a positive effect on the TFP growth. However, the authors did not find any significant effect of government investment on the TFP growth. This study did not find any nexus between government spending and the marginal productivities of capital and labor.[1]

Bayraktar and Moreno-Dodson (2012) underlined that there is no agreement on which components of public spending that can enhance growth. The impact of public spending through its components on economic growth is strong only for countries where there exist fast growth dynamics, a macroeconomic stability, and a strong openness to the private sector. In the same vein, Baldacci et al. (2008) indicated that with the presence of control for governance, both education and health spending promote higher growth in developing countries.

It should be noted that the impacts of local and national government expenditure on growth are not necessarily identical. The implementation of policies in infrastructure and human capital by the local government is more likely to foster economic growth. This may be explained by the fact that the central government's policies ignore the geographical difference between regions. Besides, the local government is supposed to be nearer to individual preferences (Oates, 1972, 1993). Empirical findings in Iimi (2005), Thieben (2003), Enikolopo and Zhuravskaya (2007), among others, corroborated this observation. However, in a cross-country study for the period 1970-1989, Davoodi and Zou (1998) found the opposite result. These authors indicated that if the decentralization of expenditure (i.e. local expenditure) increases by 10%, it reduces economic growth by 0.7-0.8% in developing countries. Similarly, using a data on 23 developing countries and for the period 1974-1991, Woller and Philipps (1998) showed no evidence of a significant effect of local expenditure on growth.

At the regional level, Destefanis and Sena (2005) and Ascari and Di Cosmo (2005) also highlighted the role of infrastructure and public capital in explaining the TFP's heterogeneity between Italian regions. Indeed, Ascari and Di Cosmo (2005) concluded

[1]In this respect, Mastromarco and Zago (2012) also concluded that public infrastructure has no significant effect on TFP of Italian manufacturing firms.

that the Italian regions's TFP is mainly determined by research activity, human capital, social capital, infrastructure, and agglomeration spillovers. For the period 1970-1998, Destefanis and Sena (2005) found a positive and significant effect of public capital on the evolution of TFP, particularly in the Italian Southern regions. In another study, Bronzini and Piselli (2009) highlighted significant effects of human capital and neighboring regions' public infrastructure on the long-run TFP across Italian regions over period 1980-2001. This finding corresponds to the existence of a geographical spillover following which an Italian region' productivity benefits from the R&D activity and public infrastructure in its neighboring regions.[2]

TFP heterogeneity between regions may be found in studies using Chinese data (Chen et al., 2009, Li, 2009, Li and Liu, 2011, among others). For the case of China's regions, one of main element explaining this heterogeneity relates to technological change. Chen et al. (2009) analyzed the dynamics of China's productivity over period 1996-2004 and found out an increase in regional productivity, which is explained by technological change or an adjustment in the production scale. Their analysis also underlined the persistence of productivity inequality between coastal and non-coastal regions. Li (2009) gave the same conclusion concerning the difference in regional productivity for the 1984-2006 period. In addition, the author concluded that TFP growth does considerably contribute to regional economic growth. Using a stochastic frontier model and a decomposition of productivity growth in three components (adjusted scale effect, technological progress and growth of technical efficiency), Li and Liu (2011) estimated the TFP growth of China's regions for the post-reform period (i.e. after 1978). As in Chen et al. (2009), the authors indicated that the major determinant of the TFP growth is technological progress. They recommended the use of a productive investment policy promoting embodied technological change in order to sustain the China's post-reform economy.

Regarding the Vietnam's regions, empirical studies on the relationship between government expenditure, growth and productivity are rare. This is probably due to the lack of reliable data. Anh (2008) analyzed the effects of different components of government expenditure on economic growth for the 2001-2005 period. The author found that investment expenditure has a positive impact on economic growth while current expenditure (such as salary, administration, culture and information, etc.) has no significant impact on economic growth. Nguyen and Giang (2008) indicated that TFP of the Viet-

[2]At the country level, the international transmission of R&D knowledge may be implemented through the channel of trade and its contribution to TFP growth has been found in several studies (Del Barrio-Castro et al., 2002, Madsen, 2007, etc.). The underlying idea is that one economy's TFP depends on its R&D activity and R&D of foreign economies that spill over into the world economy by mean of trade. Trade partners benefit from technological spillovers, which increase their TFP, leading to economic growth. In this regard, the magnitude of international R&D spillovers may depend on human capital of an economy.

nam's economy during the 1985-2006 period was driven by 45.8% by capital, 34.5% by labor, and 19.7% by technological progress. The authors also found that the productivity growth rates of industry, agriculture, and services sectors are 6.3%, 1.6%, and -4.7%, respectively. In a recent analysis, Nguyen et al. (2015) applied a spatial econometric approach to investigate the dynamics of industrial labor productivity among 60 provinces over period 1998-2011. The result showed that the spacial dependance among regions, i.e. labor productivity in a province depends on neighboring regions' productivity, affects the labor productivity convergence.

In the next section, we present a structural econometric model to investigate the determinants of output growth and TFP of Vietnam's regions.

3 A model for productivity of Vietnam's provinces

3.1 Production function

We consider the following stochastic production function of province i ($i = 1, 2, ..., N$) at year t ($t = 1, 2, ..., T$):

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} G_{it}^{\gamma} \tilde{G}_t^{\theta} \exp(\varepsilon_{it}). \tag{1}$$

where Y_{it}, A_{it}, K_{it}, L_{it}, G_{it} are production output, technological level (or total factor productivity), local private capital, local labor, and local government expenditure, respectively. $\tilde{G}_t$ is national public expenditure corresponding to a positive externality in the province's production. The error terms ε_{it} represent the unobserved random residuals associated to the production process. Coefficients α, β, and γ correspond to output elasticities of local production factors. Moreover, we do not assume that $\alpha + \beta + \gamma = 1$, i.e. there is not necessarily a constant returns to scale production function.

For local and national public expenditure, we only consider public investment spending (or productive spending), which include (national and provincial) expenditure on roads, highways, airports, etc. that directly relate to the production process. We remark that national public spending may be subject to congestion as it is nonexclusive, but partially nonrival. Hence, we can write $\tilde{G}_t$ as:

$$\tilde{G}_t = \frac{G_t}{K_t^{\varphi} L_t^{\psi}}, \tag{2}$$

where K_t^{φ} and L_t^{ϕ} represent congestion linked to the use of stock of physical capital and labor force at the national level. If $\varphi = \phi = 0$ there is no congestion. In other words, the parameters φ and ϕ represent the degree of nonrivalty of national public spending.

The technological level or total factor productivity A_{it} is defined by

$$A_{it} = A_0 \exp(\lambda t + Z_{it}' \eta + \omega_{it}). \tag{3}$$

In this formulation, A_0 is a constant technological level, λt represents autonomous technological change, and $Z'_{it}\eta$ corresponds to observed factors that can impact the TFP. For instance, in the context of our data, Z_{it} includes provincial literacy rate as a measure of human capital and the shares of agriculture and services in provincial production (the industry share is considered as the reference category). The remaining term, ω_{it}, is the unobserved stochastic TFP.

By plugging equations (3) and (2) into equation (1), we obtain the production function of each province as follow:

$$Y_{it} = A_0 \exp\left(\lambda t + Z'_{it}\eta + \omega_{it}\right) \frac{G_t^{\theta}}{K_t^{\theta\varphi} L_t^{\theta\psi}} K_{it}^{\alpha} L_{it}^{\beta} G_{it}^{\gamma} \exp(\varepsilon_{it}). \tag{4}$$

Taking logarithmic transformation of equation (4) gives the following expression

$$y_{it} = a_0 + \lambda t + Z'_{it}\eta + \omega_{it} + b_K k_t + b_L l_t + \theta g_t + \alpha k_{it} + \beta l_{it} + \gamma g_{it} + \varepsilon_{it} \tag{5}$$

where the lowercase letters represent variables measured in logs, i.e. $x \equiv \ln X$ with $X = Y_{it}, K_{it}, L_{it}, G_{it}, K_t, L_t, G_t$. Furthermore, the coefficients of the model are $a_0 \equiv \ln A_0$, $b_K \equiv -\theta\varphi$, and $b_L \equiv -\theta\psi$.

It should be noted that at the local level, we can observe the quantities of output and inputs $(y_{it}, k_{it}, l_{it}, g_{it})$, the quantities of variables at the national level (k_t, l_t, g_t), the autonomous technological change (relative to t), and the deterministic technological change (relative to Z_{it}). However, we cannot observed the stochastic productivity, ω_{it}. Without any restriction on the productivity level ω_{it}, the model cannot be estimated. Hence, in order to have a tractable model, we assume that ω_{it} is a non-specified function of input choices at the local level, i.e. $\omega_{it} = m(k_{it}, l_{it}, g_{it})$. It results that ω_{it} is not separately identified from $\alpha k_{it} + \beta l_{it} + \gamma g_{it}$. Moreover, because the nonparametric nature of m, i.e. it is identified up to an additive constant, the regression intercept a_0 is subsumed into m. Equation (5) can be rewritten as

$$y_{it} = \lambda t + Z'_{it}\eta + \Psi\left(k_{it}, l_{it}, g_{it}\right) + b_K k_t + b_L l_t + \theta g_t + \varepsilon_{it} \tag{6}$$

where $\Psi\left(k_{it}, l_{it}, g_{it}\right) \equiv m(k_{it}, l_{it}, g_{it}) + \alpha k_{it} + \beta l_{it} + \gamma g_{it}$.

Estimation of the model can rely on the method developed by Olley and Pakes (1996), Levinsohn and Petrin (2003), and Ackerberg et al. (2015), which can be briefly sketched as follows.[3] The first step is to estimate λ, η, b_K, b_L, θ, and function Ψ by using the Robinson's (1988) method. When estimates for b_K, b_L and θ are available, φ and ψ can be estimated by the delta method.

In the second step, it is assumed that ω_{it} follows a first-order Markov chain, i.e.

$$\omega_{it} = E(\omega_{it} \mid \omega_{i,t-1}) + \zeta_{it}, \tag{7}$$

[3] See also van Beveren (2012) for a literature survey.

where ζ_{it} is the white noise. By using a first set of estimates for α, β, and γ, denoted as α^0, β^0, and γ^0, we can compute $\tilde{\omega}_{it} = \hat{\Psi}\left(k_{it}, l_{it}, g_{it}\right) - (\alpha_K^0 k_{it} + \beta_L^0 l_{it} + \gamma^0 g_{it})$, which can be used in the nonparametric regression $E(\tilde{\omega}_{it} \mid \tilde{\omega}_{i,t-1})$. The next operation is to compute the innovation term $\tilde{\zeta}_{it}(\alpha_K^0, \beta_L^0, \gamma^0) = \tilde{\omega}_{it} - E(\tilde{\omega}_{it} \mid \tilde{\omega}_{i,t-1})$, which evidently depends on $(\alpha^0, \beta^0, \gamma^0)$. Finally, we obtain the following moment conditions

$$E\left[\tilde{\zeta}_{it}(\alpha^0, \beta^0, \gamma^0)\begin{pmatrix} k_{i,t-1} \\ l_{i,t-1} \\ g_{i,t-1} \end{pmatrix}\right] = 0. \tag{8}$$

Finally, the optimization over $(\alpha^0, \beta^0, \gamma^0)$ provides a GMM estimation for (α, β, γ).[4] The bootstrap procedure can be employed to compute the standard errors for all the parameters of the model.

After obtaining the estimates of the model, total factor productivity (net of autonomous technological change λt and deterministic factors $Z'\eta$) of province i at year t can by computed as (from equation (6)):

$$\hat{\omega}_{it} = y_{it} - \hat{\lambda} t - Z_{it}'\hat{\eta} - \hat{b}_K k_t - \hat{b}_L l_t - \hat{\theta} g_t - \hat{\alpha} k_{it} - \hat{\beta} l_{it} - \hat{\gamma} g_{it}. \tag{9}$$

3.2 Dynamics of total factor productivity

With the series on TFP in hands, we can analyze its distribution dynamics in order to shed light on the convergence/divergence process. The main question is whether a convergence in terms of TFP has taken place among 58 Vietnam provinces during the period of study.

Let $f_t\left(\omega_{it}\right)$ and $f_{t-1}\left(\omega_{i,t-1}\right)$ denote the distribution of TFP at time t and $t-1$, respectively. We assume that the process describing the evolution of the TFP distribution is time-invariant and of first-order in between t and $t-1$ (see Johnson, 2000, 2005), hence the relationship between the two distributions is given by

$$f_t\left(\omega_{it}\right) = \int_{-\infty}^{+\infty} f\left(\omega_{it} \mid \omega_{i,t-1}\right) f_{t-1}\left(\omega_{i,t-1}\right) \mathrm{d}\omega_{i,t-1}, \tag{10}$$

where $f\left(\omega_{it} \mid \omega_{i,t-1}\right)$ is the conditional density of current TFP given past values of TFP.

[4] We can also use the moment conditions

$$E\left[(\tilde{\zeta}_{it} + \tilde{\varepsilon}_{it})\begin{pmatrix} k_{i,t-1} \\ l_{i,t-1} \\ g_{i,t-1} \end{pmatrix}\right] = 0$$

because equation (6) becomes

$$y_{it} = \hat{\lambda} t + Z_{it}'\hat{\eta} + \hat{a}_K k_t + \hat{a}_L l_t + \hat{\theta} g_t + \alpha_K k_{it} + \beta_L l_{it} + \gamma g_{it} + E(\tilde{\omega}_{it} \mid \tilde{\omega}_{i,t-1}) + \tilde{\zeta}_{it} + \tilde{\varepsilon}_{it}.$$

where estimates were plugged.

It should be noted that $f(\omega_{it} \mid \omega_{i,t-1})$ represents the distribution dynamics of TFP between $t-1$ and t. This function represents the continuous version of the transition matrix in a discrete space. Let $f_{t-1,t}(\omega_{i,t-1}, \omega_{it})$ denote the joint distribution of $(\omega_{i,t-1}, \omega_{it})$. The joint distribution at point (x^0, y^0) can be estimated by

$$f_{t-1,t}\left(x^0, y^0\right) = \frac{1}{NTh^2} \sum_{i=1}^{N} \sum_{t=1}^{T} K\left(\frac{x^0 - \omega_{i,t-1}}{h}\right) K\left(\frac{y^0 - \omega_{it}}{h}\right), \tag{11}$$

where $K(.)$ is the univariate kernel function and h is the bandwidth. We use the Gaussian kernel and the optimal bandwidth proposed by Silverman (1986).

We obtain $f_{t-1}(\omega_{i,t-1}) = \int_{-\infty}^{+\infty} f_{t-1,t}(\omega_{i,t-1}, \omega_{it}) \mathrm{d}\omega_{it}$ and

$$f(\omega_{it} \mid \omega_{i,t-1}) = \frac{f_{t-1,t}(\omega_{i,t-1}, \omega_{it})}{f_{t-1}(\omega_{i,t-1})}. \tag{12}$$

By using the conditional distribution $f(\omega_{it} \mid \omega_{i,t-1})$, we can calculate the ergodic density for TFP as

$$f_{\infty}(\omega) = \int_{-\infty}^{+\infty} f(\omega_{it} \mid \omega_{i,t-1}) f_{\infty}(\omega) \, \mathrm{d}\omega. \tag{13}$$

This density represents the long-run behavior of provincial productivity.

4 Data

The data used in this paper cover 58 provinces and municipalities of Vietnam and are provided by the General Statistics Office of Vietnam (GSO).[5] They include series at the provincial level such as provincial GDP, provincial public expenditure, provincial total investment in physical capital, provincial labor force, shares of agriculture, services and industry in provincial GDP, and ratio of people able to read and write in provincial population. All these series, except ratio of people able to read and write, cover the period 2000-2007. The literacy rate is only observed in 2006. This database for a period of 8 years is so far the best we can obtain at the provincial level.[6]

Data at the national level are extracted from the World Development Indicators database of the World Bank. They correspond to GDP, national public expenditure, gross fixed capital formation, national labor force, GDP deflator and gross national expenditure deflator for the period 2000-2007. Table 1 reports the list of 58 provinces and

[5] See Appendix for a map of Vietnam's provinces.

[6] Official data at the provincial level, usually provided by the General Statistics Office for a longer period are not available. Vietnam has in total 58 provinces and 5 municipalities. However, five provinces (Ha Giang, Hau Giang, Kon Tum, Dong Thap, and Tra Vinh) were excluded from our data sample due to missing data. Ha Tay was merged into the capital Ha Noi in 2008.

Table 1: List of provinces and municipalities

Name	Period	Name	Period	Name	Period
Ha Noi*	2000-2007	Hai Phong*	2000-2007	Vinh Phuc	2000-2007
Bac Ninh	2000-2007	Hai Duong	2000-2007	Hung Yen	2000-2007
Nam Dinh	2000-2007	Ninh Binh	2003-2007	Ben Tre	2000-2007
Lao Cai	2000-2007	Bac Kan	2000-2007	Lang Son	2000-2007
Yen Bai	2000-2007	Thai Nguyen	2000-2007	Phu Tho	2000-2007
Quang Ninh	2000-2007	Lai Chau	2000-2007	Dien Bien	2000-2007
Hoa Binh	2001-2007	Thanh Hoa	2000-2007	Nghe An	2000-2007
Quang Binh	2005-2007	Quang Tri	2000-2007	Thua Thien-Hue	2005-2007
Quang Nam	2000-2007	Quang Ngai	2000-2007	Binh Dinh	2000-2007
Khanh Hoa	2000-2007	Dong Nai	2000-2007	Gia Lai	2000-2007
Dak Nong	2000-2007	Lam Dong	2000-2007	Ho Chi Minh city*	2000-2007
Binh Phuoc	2000-2007	Tay Ninh	2000-2007	Binh Duong	2001-2007
Binh Thuan	2000-2007	Ba Ria-Vung Tau	2000-2007	Long An	2000-2007
An Giang	2000-2007	Tien Giang	2000-2007	VinhLong	2000-2007
Kien Giang	2000-2007	Can Tho*	2000-2007	Ninh Thuan	2000-2007
Soc Trang	2005-2007	Bac Lieu	2002-2007	Cau Mau	2000-2007
Ha Tay	2000-2007	Ha Nam	2000-2007	Cao Bang	2000-2007
Tuyen Quang	2005-2007	Bac Giang	2000-2007	Son La	2000-2007
Ha Tinh	2000-2007	Da Nang*	2000-2007	Phu Yen	2000-2007
Dak Lak	2000-2007				

Notes. There are 53 provinces and 5 municipalities (stared).

municipalities and Table 2 summarizes the definition and the sources of variables used in estimations. Table 3 reports some main statistics for the series employed in this study.

Concerning variables at the provincial level, there are two types of investment in physical capital: private investment (PI) and foreign direct investment (FDI). These variables are expressed in billion VND and in 2010 prices using the GDP deflator series available from the WDI database. Then, we use the perpetual inventory method (PIM) to compute the series on physical capital stock for each type of investment, i.e. K_{it}^{PI} and K_{it}^{FDI}.[7] Finally, the stock of total private physical capital at the local level is given by

[7]The equation characterizing the PIM is $K_{it}^{\tau} = S_{it}^{\tau} + (1-\delta)K_{i,t-1}^{\tau}$ where S_{it}^{τ} is the flow of investment of type τ ($\tau = PI$ or FDI), K_{it}^{τ} is the capital stock of type τ at time t, and δ is the depreciation rate. The initial capital stock is given by $K_{i0}^{\tau} = S_{i0}^{\tau}/(g_S^{\tau}+\delta)$ where g_S^{τ} is the average geometric growth rate of investment of type τ for the period of study. Usually the depreciation rate is set between 4% and 6%.

Table 2: Variable definition

Variable	Description	Source*
National level		
K_t	National physical capital stock, 2010 prices, billion VND	our calculations
L_t	National labor force, thousands people	WDI
G_t	National public expenditure, 2010 prices, billion VND	MOF
Local level		
Y_{it}	Provincial GDP, 2010 prices, billion VND	GSO
K_{it}	Provincial physical capital stock, 2010 prices, billion VND	our calculations
L_{it}	Provincial labor force, thousands people	GSO
G_{it}	Provincial public expenditure, 2010 prices, billion VND	GSO
S_{it}^{PI}	Private investment, 2010 prices, billion VND	GSO
S_{it}^{FDI}	Foreign direct investment, 2010 prices, billion VND	GSO
Ind_{it}	Share of industry in provincial GDP (reference)	GSO
Agr_{it}	Share of agriculture in provincial GDP	GSO
Ser_{it}	Share of service in provincial GDP	GSO
H_i	Ratio of people able to read and write in population, 2006	GSO

Notes. * WDI: World Development Indicators, MOF: Vietnam Ministry of Finance, GSO: General Statistics Office.

the sum between these two stocks of capital, i.e. $K_{it} = K_{it}^{PI} + K_{it}^{FDI}$.

Concerning public expenditure at the national and the provincial levels (G_t and G_{it}), we use data on public investment expenditure which is often considered as a productive spending. These variables and provincial GDP (Y_{it}) are measured in billion VND and in 2010 prices (using the GDP deflator). We observe that the data for some variables at the provincial level such as private and FDI investments (S_{it}^{PI} and S_{it}^{FDI}), provincial GDP, provincial public spending, and provincial labor force (L_{it}) are missing in 2004. Thus, we compute the average geometric growth rates of these series to interpolate the missing values for each of the 58 provinces and municipalities included in the data sample.[8] This interpolation aims to complete the data. However, this operation may exacerbate the potential measurement error relative to data collection and affects the quality of

In this paper, changing δ from 4% to 6% does not modify the qualitative results.

[8]Let g_x denote the average geometric growth rate of a series x. Hence, the relation between the initial value (period 0) and the value of this variable at time t is $x_t = x_0(1 + g_x)^t$. Thus, the average growth rate of x between 0 and t is approximately calculated as $g_x = \ln(x_t/x_0)/t$. Equivalently, this growth rate can be computed as $g_x = \exp(b) - 1$ where b is the slope coefficient of the ordinary least squares regression $\ln x_t = a + bt + \upsilon_t$, $t = 1, 2, ..., T$.

Table 3: Descriptive statistics

Variable	Mean	Std.Dev.	Min.	Max.
K_t	584223.51	198453.55	310483.31	919427.91
L_t	44950.95	2241.10	41324.12	48166.10
G_t	46366.11	8921.28	23725.57	56800.15
Y_{it}	23121.40	40988.93	1155.76	334111.21
K_{it}	10765.26	198453.55	170.95	177912.82
L_{it}	685.27	534.60	47.8	3340.03
G_{it}	3736.54	5323.40	53.25	42116.90
S_{it}^{PI}	3718.66	7388.06	20.94	62899.12
S_{it}^{FDI}	1457.61	3754.54	0	22929.91
Ind_{it}	0.30	0.14	0.06	0.91
Agr_{it}	0.36	0.16	0.01	0.75
Ser_{it}	0.33	0.08	0.07	0.59
H_i	0.92	0.07	0.60	0.98

Notes. Number of observations: 425 (58 provinces and municipalities, period 2000-2007).

estimation. This issue will be addressed in Section 6.

Regarding variables at the national level, the stock of national physical capital K_t is defined as the sum of stocks of local physical capital, i.e. $K_t = \sum_i^N K_{it}$. Data on national labor force are obtained from the WDI and are expressed in thousands people. For national public spending G_t, we use the series on central government expenditure on investment from the Vietnam Ministry of Finance (MOF) database and compute its corresponding values in 2010 prices (in billion VND) using the GDP deflator (from the WDI).

The data at the local level show a huge heterogeneity among 58 provinces considered. Three most dynamic regions in the country can be identified: (i) Ho Chi Minh City and the neighboring provinces in Southern Vietnam, (ii) Da Nang in the Center, and (iii) Hanoi (the capital) and Hai Phong in the North. The data on local production include Lai Chau (one of the poorest provinces, located at the Vietnam-China border) which only produced 1155.76 billion VND in 2000 (the smallest value in the sample) and Ho Chi Minh City which produced an amount of about 290 times higher, i.e. 334111.21 billion VND in 2007. It is also Ho Chi Minh City which has the maximum value of local physical capital stock (i.e. 177912.82 billion VND in 2007), more than one thousand times higher than the physical capital stock of Bac Giang (another province closed to

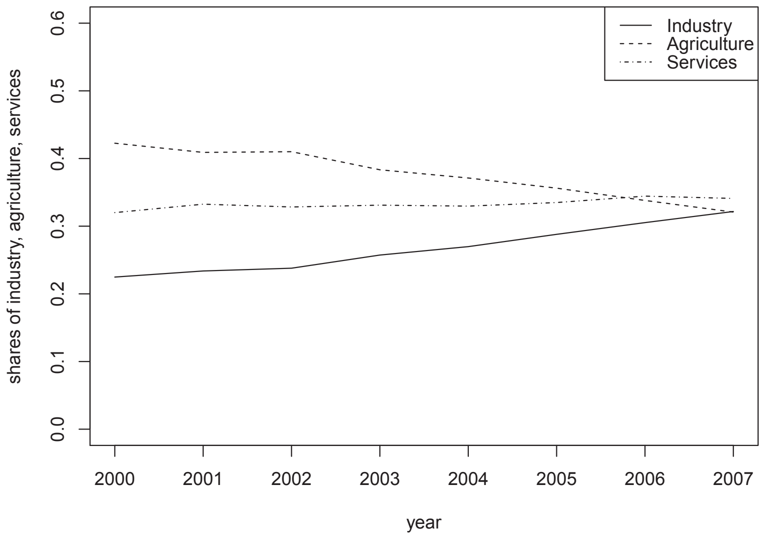

Figure 3: Evolution of shares of industry, agriculture, and services in provincial GDP. The curves correspond to the yearly median values. Source: General Statistic Office of Vietnam, Ministry of Finance, and the World Bank.

the northern border with China, only 170.95 billion VND in 2000). Ho Chi Minh City, Binh Duong, Dong Nai, Vung Tau, and Ha Noi are among the provinces which attract the highest amounts of foreign direct investment. Lai Chau is one of the provinces that cumulate handicaps, including the lowest amount of local public spending and the lowest ratio of people who are able to read and write (60%). On the contrary, Ha Noi has the highest amount of local public spending and the highest value of human capital (98% of population are able to read and write). The capital also possesses the most important labor force (more than 3.34 million people).

Concerning the economic structure of the country, Figure 3 shows that industry is the most dynamic sector compared to agriculture and services. Indeed, the industry share in GDP increases more rapidly than the services share while the agriculture share decreases over the period of study. The discrepancy among the three sectors observed at the beginning of the sample (the median values of these shares vary between 30%-36% in 2000) vanishes over time, leading to an almost equal distribution in 2007 (the median values for each of the three shares are around 32%-34%). Table 3 completes the picture. We observe that industry share in the local GDP is highest in Vung Tau (91%) while it attains its lowest value in Dac Nong (only 6%), which is also the most agricultural province (its agriculture share in GDP is about 75%). Ha Noi has the highest services share in its local economy (about 59%).

Table 4: Estimation results

Variable	Coefficient	Estimate	Bootstrap Std.Err.
Production inputs			
Provincial physical capital	α	-0.116	0.110
Provincial labor	β	0.819**	0.315
Provincial public spending	γ	-0.144	0.307
National physical capital	b_K	0.201	3.708
National labor	b_L	-10.922	20.441
National public spending	θ	-0.037	0.323
Congestion effects			
Capital related	φ	5.400	110.026
Labor related	ψ	-293.218	2598.676
Determinants of TFP			
Agricultural share	η_{Agr}	-0.894**	0.385
Services share	η_{Ser}	-2.019**	0.607
Human capital	η_H	1.365*	0.751
Time trend	λ	0.201	0.740

Notes. Number of observations: 425 (58 provinces and municipalities, period 2000-2007). Standard errors are obtained by bootstrap (99 replications). Significance levels: * 10%, **: 5%.

In the next section, we discuss the estimation results of our structural modeling which takes into account the heterogeneity described above to address the issue of productivity of Vietnam's provinces.

5 Results and discussion

We aim to estimate the production function as well as the three components of the TFP of 58 Vietnam provinces. We first present the estimation of the model, including the coefficients associated to autonomous technological change (λ), deterministic term of technological change explained by the share of agriculture in provincial production (η_{Agr}), the share of service in provincial production (η_{Ser}), the literacy rate at the provincial level in 2006 (η_H), the effects of production inputs (α, β, γ, b_K, b_L, γ), and the congestion effects related to national public spending (φ, ψ). Next, we compute the unobserved stochastic part of TFP, i.e. TFP net of autonomous technological change and deterministic factors, as shown by equation (9).

Estimation results are presented in the Table 4. We observe that among different production inputs, only local labor has a positive and significant effect on the provincial production. The estimated parameter associated to this variable shows that in response to a rise of 1% in labor force, the provincial output increases about at 0.8%. There is no evidence of significant impact of local and national public expenditure on provincial output. In other words, all government spending in investment during period 2000-2007 are not effective in terms of provincial growth and productivity. This result might be explained by the lack of control for provincial governance as underlined by Bayraktar and Moreno-Dodson (2012) and Baldacci et al. (2008).[9] These author showed in their cross-country studies that the significant effect of public spending depends on the governance quality and macroeconomic stability.

Concerning the deterministic (observable) TFP, our findings shed light the role of agriculture and services shares in GDP, and human capital in explaining provincial differences in terms of productivity and output. Indeed, it is shown that agriculture and services shares (compared to industry share which is the reference category) exert a negative influence on the TFP and output. This result is not surprising for industry is recognized as the most dynamic sector in the Vietnam's economy (see also Figure 3). Moreover, human capital (proxied by the literacy rate) has a positive and significant effect. This result is consistent with existing empirical works (for example, Ascari and Di Cosmo, 2005, and Bronzilli and Piselli, 2009, with data on Italian regions, and Lynde and Richmond (1993) with American data, etc.). Our estimation results suggest that the production process in Vietnam's provinces is essentially based on labor and human capital and that public spending (both at the local and national levels) are not effective during the period of study.

Provided the estimated coefficients of the model, we can obtain the series on TFP and analyze its distribution. Figure 4 displays the distribution of this component of TFP in 2000, 2003, 2007. We observe that provincial TFP increases over time thanks to a parallel movement of the curve to the right.

The growth rate of TFP is given by

$$\frac{\dot{A}_{it}}{A_{it}} = \lambda + \dot{Z}'_{it}\eta + \dot{\omega}_{it}. \tag{14}$$

Hence, the variation of TFP comes from three components: a constant corresponding to autonomous technological change λ and two varying quantities, one is the variation of the observed deterministic component ($\dot{Z}'_{it}\eta$) while the other is the variation of the unobserved stochastic component ($\dot{\omega}_{it}$).

As the autonomous and the deterministic parts are easily predictable (following the corresponding estimated parameters of λ and η), we only focus on the growth rate of TFP which is due the variation of the stochastic part, i.e. $\dot{\omega}_{it}$. The latter is displayed in

[9]However, information on provincial governance is not available.

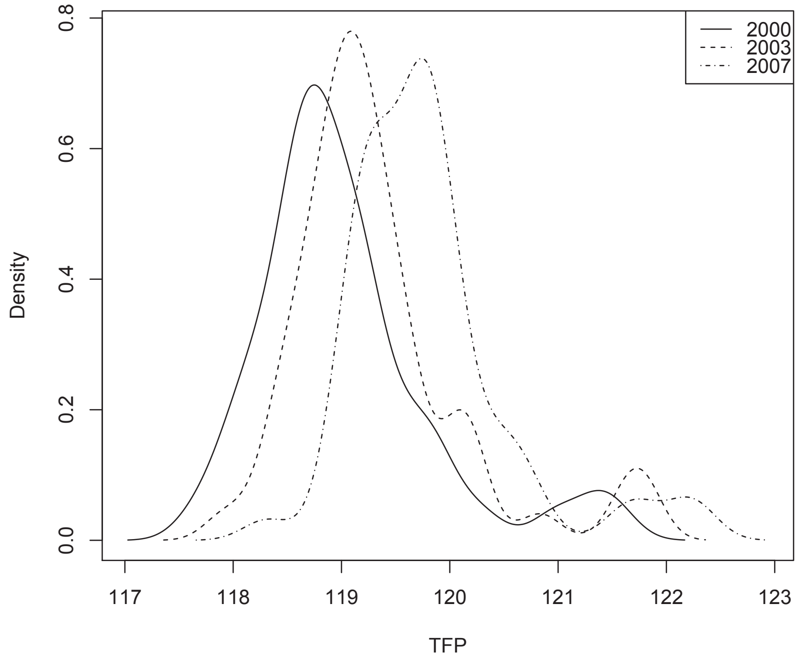

Figure 4: Distribution of the unobserved stochastic part of TFP (ω_{it}) in 2000, 2003, and 2007.

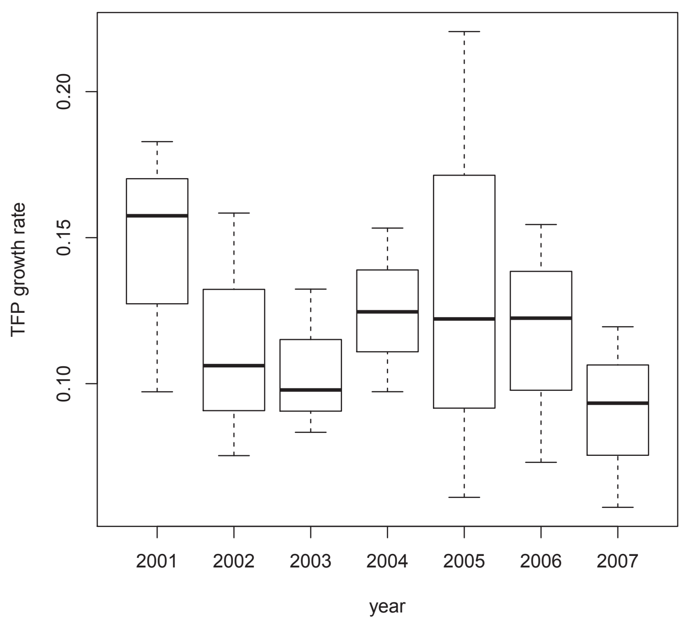

Figure 5: Growth rate of TFP related to the unobserved stochastic part, $\dot{\omega}_{it}$, period 2001-2007.

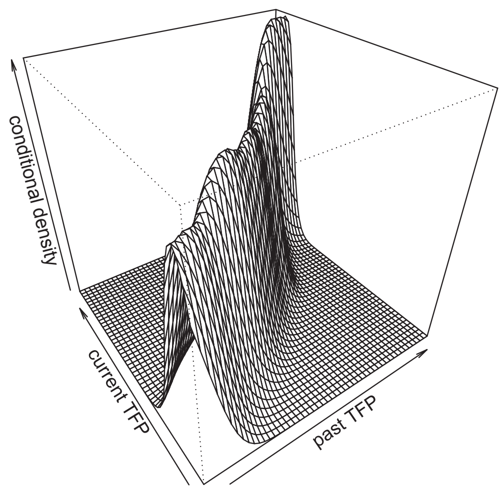

Figure 6: Surface of conditional density of stochastic TFP of Vietnam's provinces, $f(\text{current TFP} \mid \text{past TFP})$.

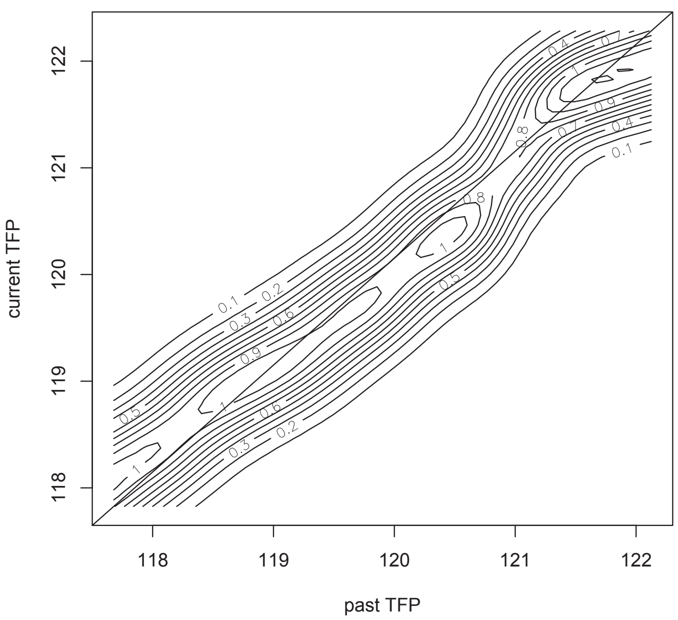

Figure 7: Contour plot of conditional density of stochastic TFP of Vietnam's provinces, $f(\text{current TFP} \mid \text{past TFP})$.

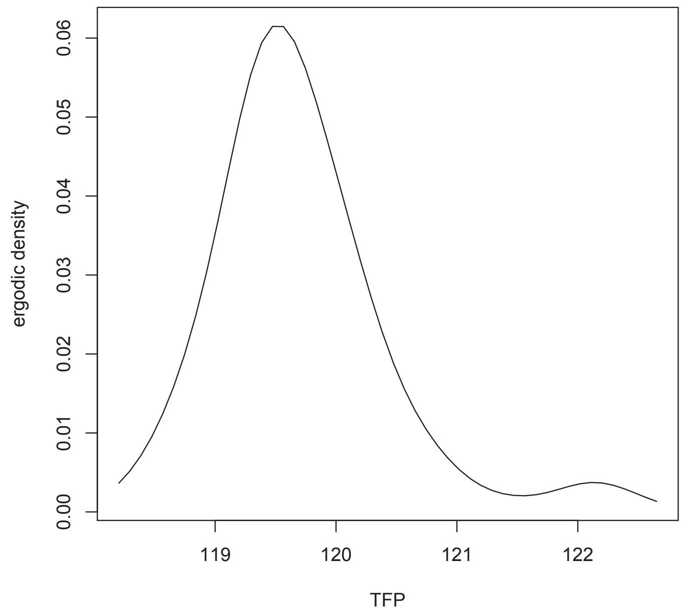

Figure 8: Ergodic distribution of stochastic TFP of Vietnam's provinces.

Figure 5. Some remarks are in order. First, the box sizes of different years are different as we have a unbalanced panel data. Second, the bold line indicates the median value of TFP growth rate. We observe that the growth rate of TFP due to the unobserved stochastic part during the period 2001-2007 has no clear evolution. Most of its values fall into the interval (0.05, 0.17). The median value of TFP growth rate is found between 0.1 and 0.15. These results represent then a big heterogeneity among the 58 provinces.

Figure 6 represents the distribution dynamics of the stochastic TFP ω between two years, t and $t-1$. It shows the conditional density of current TFP given past values of TFP. The conditional density for 58 provinces shows a multimodal distribution and contour plot in Figure 7 makes clear this observation by giving three peaks around the 45° line. Two peaks on the 45° line (with low TFP values for the first one and with high TFP values for the second one) and one peak below the 45° line. This result indicates a weak decrease of TFP over time for provinces with medium TFP values. However, regions with a low or high TFP value stay at their initial position.

In the long run, the ergodic distribution of stochastic TFP, presented in Figure 8, illustrates the existence of two groups of provincial TFP – a large group with a low TFP and a much smaller one with a high TFP. This result underpins the lack of convergence in the long run, characterized by a polarization phenomenon, among the 58 Vietnam provinces. We think that the bipolar pattern of TFP distribution can help to explain

Table 5: Estimation results, accounting for *measurement errors*

Variable	Coefficient	Estimate	Bootstrap Std.Err.
Production inputs			
Provincial physical capital	α	-0.041	0.281
Provincial labor	β	0.229	1.236
Provincial public spending	γ	-0.093	0.362
National physical capital	b_K	-0.388	4.909
National labor	b_L	-12.271	40.059
National public spending	θ	-0.051	1.419
Congestion effects			
Capital related	φ	-7.592	231.809
Labor related	ψ	-240.290	6722.220
Determinants of TFP			
Agricultural share	η_{Agr}	-0.583	0.503
Services share	η_{Ser}	-1.582*	0.847
Human capital	η_H	1.421*	0.807
Time trend	λ	0.320	1.091

Notes. Number of observations: 367 (58 provinces and municipalities, period 2000-2007). Standard errors are obtained by bootstrap (99 replications). Significance levels: * 10%, ** 5%.

the disparity in terms of competitiveness among the Vietnam's provinces. Indeed, the high TFP group (TFP higher than 121.5) includes the only four provinces: Ho Chi Minh City, Khanh Hoa, Vung Tau (two neighboring provinces of Ho Chi Minh City), and the capital Ha Noi. Moreover, if we look at the upper tail of the low TFP group, i.e. for TFP comprised between 121 and 121.5, it corresponds to four additional provinces: Can Tho, Dong Nai (two provinces very close to Ho Chi Minh City), and Hai Phong (a neighboring province of Ha Noi), and Da Nang (a city in the Center). These 8 provinces and cities have the highest productivities in the sample. They are also among the most dynamic and competitive provinces of Vietnam (see Malesky et al., 2015).[10]

6 Measurement errors

Data at the provincial level may contain unobserved measurement errors which can alter the quality of estimation. While measurement errors relative to local GDP y_{it} are not a

[10]Following the the provincial competitiveness index computed by Malesky et al. (2014), these provinces are ranked between mid-high to excellent (other categories being mid-low, low, and very low).

serious problem (as they are automatically plugged into the regression residual terms), measurement errors concerning local capital stock k_{it}, local labor force l_{it} and local public spending g_{it} can induce important consequences with regard to the quality of parameter estimates. Indeed, in this situation, the residual terms in equation (6) becomes correlated with regressors, resulting in an inconsistent estimation for λ, η, b_K, b_L, θ, and function Ψ obtained at the first step.[11]

To deal with this issue, we propose to modify the estimation procedure applied to equation (6). We suppose that each of the three variables k_{it}, l_{it}, g_{it} has an instrument set w_{it}^x so that we can write

$$x_{it} = \sum_{j}^{J} \pi_j(w_{jit}^x) + u_{it}^x, \quad x_{it} = k_{it}, l_{it}, g_{it}, \tag{15}$$

where π_j is the univariate nonparametric function for the jth component of the set of instruments w_{it}^x for x_{it}. In the context of our data, we think that a reasonable instrument set for x_{it} should correspond to its lagged value ($x_{i,t-1}$) and other local variables, including Z_{it} in equation (6).[12] The additive structure here allows us to keep the flexibility of nonparametric modeling and to avoid the curse of dimensionality when a nonparametric function contains a high number of arguments.

The model with measurement errors in local variables is composed of equation (6) and equations (15) and the assumptions $E(\varepsilon_{it} \mid u_{it}^x, w_{it}^x) = E(\varepsilon_{it} \mid u_{it}^x) \neq 0$ and $E(u_{it}^x \mid w_{it}^x) = 0$. The method developed by Newey et al. (1999) can be adapted to estimate this model. Following Newey et al. (1999), we need an additional assumption that $E(\varepsilon_{it} \mid u_{it}^x) = \rho_x u_{it}^x$ with $x_{it} = k_{it}, l_{it}, g_{it}$. Hence, estimation for λ, η, b_K, b_L, θ, and function Ψ in equation (6) can be obtained as previously described (see Section 3.1) but with a preliminary step. More precisely, we first implement the nonparametric estimation of the additive model in equation (15) for $x_{it} = k_{it}, l_{it}, g_{it}$ to compute the residuals $\hat{u}_{it}^x$. Secondly, we apply the Robinson's (1988) method, as described in Section 3.1, to equation (6), which now includes three additional regressors, $\hat{u}_{it}^k$, $\hat{u}_{it}^l$, and $\hat{u}_{it}^g$. This step gives the estimates for λ, η, b_K, b_L, and θ. Finally, estimation for α, β, and γ can be obtained as described above in Section 3.1.

Table 6 displays estimation results when measurement errors in local variables are taken into account. We can observe that considering these errors do not significantly change the results given in Table 4 as the signs of estimated coefficients remain unchanged. Most of qualitative conclusions presented in the previous section still remain valid with some exceptions. In particular, compared to previous results, labor force is no longer

[11] More precisely, if $x_{it} = x_{it}^* + \varepsilon_{it}^x$ where x_{it}^* is the unobserved true value of x_{it}, $x_{it} = k_{it}, l_{it}, g_{it}$, and ε_{it}^x is the corresponding measurement error, the new residual terms of equation (6) becomes $\vartheta_{it} \equiv \varepsilon_{it} + \varepsilon_{it}^k + \varepsilon_{it}^l + \varepsilon_{it}^g$. Hence, $E(\vartheta_{it} \mid k_{it}, l_{it}, g_{it}) = E(\vartheta_{it} \mid k_{it}^* + \varepsilon_{it}^k, l_{it}^* + \varepsilon_{it}^l, g_{it}^* + \varepsilon_{it}^g) = E(\vartheta_{it} \mid \varepsilon_{it}^k, \varepsilon_{it}^l, \varepsilon_{it}^g) \neq 0$.

[12] Using lagged values $x_{i,t-1}$ reduces the sample size from 423 observations to 364 observations.

determinant for the provincial output. The same remark applies to the agricultural share which now has no significant impact on productivity. Concerning other significant factors, the observed effect of services share on the provincial TFP is less important while that of human capital is stronger in the new estimation.

7 Conclusion

This paper aims to analyze the determinants and the dynamics of the TFP of Vietnam's provinces and their economic growth using panel data for 58 Vietnam's provinces during the 2000-2007 period. In a context of Vietnam's economy, which has an important public intervention (both at the local and national levels) and a large decentralization in favor of provinces, our study indicates that while private factors such as labor force and human capital are key factors, both local and national government expenditure seem to play no significant role in explaining the TFP growth and production of Vietnam's provinces. Moreover, when analyzing the dynamics of TFP, we observe a heterogeneity of TFP across 58 Vietnam's provinces. The analysis points out a polarization phenomena with two groups of TFP, one large group with high TFP values and one small group with low TFP values. In other words, the convergence process is not observed for productivity of Vietnam's provinces, i.e. provinces with low TFP do not necessarily grow more quickly than provinces with high TFP. The bipolar feature of TFP distribution could provide an explanation for the disparity in terms of competitiveness among the Vietnam's provinces.

Our study can be interestingly extended in several ways. The analysis can include a control for national and local governance allowing for a deeper discussion about the effect of public expenditure. Unfortunately, while such a variable can be found at the national level, it is not available at the provincial level. It is also interesting to extend our analysis to cope with other economies where both the national and local factors compete in the development process. Another extension is to employ a more flexible specifications for the production function.

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Appendix

Figure A: Map of Vietnam's provinces. Source: Vietnam Ministry of Natural Resources and Environment.