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AUTHORS	Nguyen Khac Minh Manh-Hung Nguyen Nguyen Viet Hung
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Nguyen Khac Minh (Vietnam), Manh-Hung Nguyen (France), Nguyen Viet Hung (Vietnam)

Modeling transformation in Vietnam using smooth transitions

Abstract

This study employs a Logistic Smooth Transition Regression to model the impact of economic reforms in Vietnam from 1985 to 2006 in three economic areas: the agricultural sector, industrial sector and service sector. The authors examine the response of both GDP and labor productivity to the reforms in each of these sectors. While our results suggest that allowing for structural breaks in GDP and labor productivity is preferred to either a trend stationary or a unit root process, they also suggest evidence of a positive impact of reforms on GDP growth. Estimated results of parameter γ from three models indicate that the speed of the transition of the agricultural sector between the initial and final states was faster than the others. It implies that reforms in agriculture succeeded in encouraging people to work and also in quickly stabilizing the macro economy. Finally, the results also suggest that the different reform policies undertaken had different impacts on the GDP growth of each sector in Vietnam.

Keywords: smooth transition, agricultural sector, industrial sector, service sector.
JEL Classification: C13, N55, O20, O47.

Introduction

The transition from a planned to market economy began in 1986 after the decision of the Sixth Party Congress. A comprehensive restructuring and renovation process is considered the main point of departure for Vietnam's economic reforms. The reforms introduced economic adjustments including allowing rapid development of private markets for agricultural goods, reforms in land allocation and the land use right system (which formalized the fundamental changes in the agricultural sector), stabilization policies, entry regulations and privatization, state enterprise restructuring, and tax and banking reforms.

The introduction of reform policies differed widely in scope, speed, and sequencing across the industrial, agricultural and service sectors. The reforms adopted have given rise to a number of questions, many of which relate to the impacts of the Land Law and recognition of long-term land use rights in the agricultural sector, combined with price and trade reforms which have contributed to sustained growth in agriculture. Furthermore, the issuance and amendments of laws relating to government budgets, state and non-state enterprises, credit and banking, the expansion of trade and financial relations within the international community, and the new Enterprise Law all have a significant impact on the production and business activities of private enterprises.

A related issue concerns how quickly these economic sectors recovered from the implementation of the reforms in the economy. Furthermore, it is considered whether growth has been higher following the policy reforms or prior to them, and whether any differences across sectors in post-transition performance are related to the speed at which reforms were undertaken. The main focus of this paper concerns this final aforementioned issue. To address this we model GDP and labor productivity using a logistic Smooth Transition Regression (LSTR) and refer to LSTAR, on a sample of three sectors during the period from 1985 to 2006.

There have been two major theoretical issues of importance in time series econometrics over the past two decades. The first is modeling nonlinearity and structural changes in economic series. The second considers the question of whether economic series are best characterized as being stationary processes around a deterministic trend or as having a unit root, a different stationary process.

There are many reasons for nonlinearity in time series such as changing policy regimes; technological changes. There have been many tests of structural change designed to detect discrete shifts in the model parameters. Some of them have considered the possibility of allowing any structural break to occur gradually. In this study, we apply structural change using a smooth transition regression and refer to it as a smooth transition autoregression regression (STAR). There have been numerous papers on the topic. R. Luukkonen et al. (1988) examined a general univariate smooth transition autoregressive model. It was a special case the threshold autoregressive, SETAR, model. They presented three tests for testing linearity against STAR models and discussed their properties. They showed that the power of the tests in small samples would be investigated by simulation when the alternative was the logistic STAR model. They also concluded that the tests were more powerful than the CUSUM test proposed for testing linearity against the SETAR model. T. Terävirta (1994) considered the application of two families of nonlinear autoregressive models, the logistic (LSTAR) and exponential (ESTAR) autoregressive models. He studied the specification of the model based on simple statistical tests, including linearity testing against smooth transition autoregression, determining the delay parameter and choosing between LSTAR and ESTAR models. He also considered estimation by nonlinear least squares and evaluating the properties of the estimated model. Eitrheim et al. (1996) used smooth transition autoregressive models for modeling economic data. This paper contributed to the evaluation stage of a proposed specification, estimation, and evaluation cycle of the models by introducing a Lagrange multiplier (LM) test for the hypothesis of no error autocorrelation, and LM-type tests for the hypothesis of no remaining nonlinearity and parameter constancy. J. Stephen et al. (1999) considered the disinflation experiences of Australia, Canada and New Zealand. Their approach allowed the price of data itself to determine the speed and timing of the reforms using smooth transition analysis. They showed that the process of transition is related to two factors: central bank independence and the general slowdown in economic activity which occurred during the study period in all OECD countries. They found that other reforms to the labor market and fiscal policy had been less influenced. D. Greenaway et al. (2000) have tested whether GDPs in twelve European Union countries are integrated or stationary around a deterministic component that might change gradually and smoothly between two regimes over time. They found that in two-thirds of cases there appears to be a role for modeling with deterministic functions that allows smooth transitions, in some cases standing alone and in others in conjunction with additional integrated regressors. Their findings constituted a challenge to traditional approaches of modeling trend-breaking behavior in GDP. Traditional approaches typically suggested that breaks, when present have to occur instantaneously.

D.G. McMillan (2005) considered whether a series of spot and forward exchange rates exhibited smooth transition nonlinear error-correction dynamic behavior. Their results supported this model. T. Terävirta et al. (2005) examined the forecast accuracy of linear autoregressive, smooth transition autoregressive (STAR), and new network (NN) time series models for 47 monthly macroeconomic variables of the G7 economies. The authors used a single but dynamic specification. They found that the results for NN models were mixed in the sense that at long forecast horizons, an NN model obtained using Bayesian regularization procedures produced more accurate forecasts than a corresponding model specified using the specific to general approach.

M. Koster (2005) addressed the problem of nonlinearity by applying smooth transition autoregressive (STAR) specifications to existing simultaneous macroeconomic model of the South African economy. The results supported the view that non-linear models provide better forecasts than linear specifications of equations. N. Forster and et al. (2007) employed a Logistic Smooth Transition Regression to model economic reforms in CEECs. They allowed for transitions in trends and levels, and then examined the response of both GDP and labor productivity to reforms. They suggested that allowing for structural breaks in most CEECs was preferred to either a trend stationary or a unit root process. They also suggested little evidence of a positive impact of reforms on GDP growth. Examining the response of labor productivity to reforms, they found that labor productivity provided stronger support for an impact from reforms. They suggested that labor supply adjustments have been important in increasing overall efficiency, and that differences in the speed in which reforms were undertaken had an impact on the depth and the length of the transitional recession.

D.G. McMillan (2004) used an exponential smooth transition threshold (ESTR) error-correction model to consider return dynamics in a price dividend cointegration framework from large and small deviations. The empirical results supported the ESTR model over a linear model. N. Aslanidis (2006) applied the idea of regime switching in the analysis of the emission – income relationship using a panel data of US state level sulfur dioxide and nitrogen oxide emissions. They found sulfur dioxide emissions and the nitrogen oxide emission to be different trend to economic growth. Nguyen, K.M and G.T. Long (2008) employed a constant elasticity of substitution function and a non-parametric model to consider the impacts of Vietnamese economic reforms on the productivity and efficiency of the economy. They estimated changes in productivity, technical efficiency and technology across three sectors (the agricultural, industrial and service sectors) in transition (during 1985-2006). They also sought to identify the turning points for productivity growth to see whether it was accompanied by technical change or technical efficiency.

Like study of N. Forster et al. (2007), we try to model the GDP and productivity series of our sample of the industrial, agricultural and service sectors in the Vietnamese economy in transition using the Smooth Transition Regression and Smooth Transition Autoregressive Models to find out whether support to a trend stationary or a unit root process.

The paper is organized as follows. Section 1 is a literature review regarding the methods and empirical studies that relate to this study. Section 2 presents the econometric background and details how to set up the model. A review of economic performance in the Vietnamese economy is presented in Section 3. In Section 4, we present the main results of our estimations. The final Section presents conclusion.

1. The model specification

Switching regression model can be generalized as models in which the transition from one regime to the other is not discrete but smooth, so that there can be a continuum of states between extreme regimes. The speed of adjustment can be the type of nonlinear process. Thus, Smooth Transition Regression Modeling can be illustrated as follows:

$$y_t = \varphi' z_t + \theta' z_t G(\gamma, c, s_t) + u; \quad t = 1,...., T$$

$$= \{\varphi z_t + \theta z_t G(\gamma, c, s_t)\}' z_t + u_t, \qquad (1)$$

where $z_t = (w_t^{'}, x_t^{'})$ is a vector of explanatory variables $w_t^{'} = (1, y_{t-1},...., y_{t-p})'$, and $x_t^{'} = (x_{1t},...., x_{kt})'$, which is a vector of exogenous variables. Furthermore $\phi = (\phi_0, \phi_1,....,\phi_m)'$ and $\theta = (\theta_0, \theta_1,....,\theta_m)'$ are ((*m* + 1) x 1) parameter vectors and u_t~*iid* $(0, \sigma^2)$. The transition function $G(\gamma, c, s_t)$ is a bounded function of the continuous transition variable s_t, continuous everywhere in the parameter space for any value of s_t, γ is the slope parameter, and *c* $(c_1, c_2,..., c_K)'$ is a vector of location parameters, $c_1 \le c_2 \le ...... \le c_K$.

This study assumes that the model allows for a deterministic trend, with u_t a zero mean *I*(0) process. The transition function is a general logistic function, based on sample size *T*, which is given as:

$$G(\gamma, c, s_t) = \left(1 + \exp\left\{-\gamma \prod_{k=1}^{K} (s_t - c_t)\right\}\right)^{-1}, \gamma > 0, \quad (2)$$

where s_t is the transition variable, which in this study will be time, *t*, and c_t is the location parameter.

The most common choices for *K* are *K* = 1 and *K* = 2. For *K* = 1, the parameter $\{\phi z_t + \theta z_t G(\gamma, c, s_t)\}$ change monotonically as a function of s_t from ϕ to $\phi + \theta$. For *K* = 2, they change symmetrically around the midpoint $(c_1+c_2)/2$, where this logistic function attains its minimum value. The minimum lies between zero and 1/2. It reaches zero when $\gamma \to \infty$ and equal 1/2 when $c_1 = c_2$ and $\gamma < \infty$. Slope parameter γ controls the slope and c_1 and c_2 presents the location of the transition function.

The LSTR model with *K* = 1 (LSTR1 model) is capable of characterizing asymmetric behavior. On the other hand, the LSTR2 model (*K* = 2) is appropriate for situations in which the local dynamic behavior of the process is similar at both large and small values of s_t and different in the middle.

When $\gamma = 0$, the transition function $G(\gamma, c, s_t)$ =1/2, and thus the STR model (1) – the linear model. At the other end, when $\gamma \to \infty$ in the LSTR2 model, the result is another switching regression model with three regimes such that the outer regimes are identical and the mid-regime is different from the other two.

1.1. Shift in intercept and trend. The LSTR model allows for gradual changes in both the level and trend of the series of interest. In this study, we allow for shifts in the intercept and trend growth rate of GDP, in both cases allowing the shift to occur over time rather than instantaneously. The model is illustrated as follows:

$$\text{Ln}(y_t) = \alpha_0 + \beta_0 t + \alpha_1 G_t(s_t; \gamma, \tau) + \beta_1 G_t(s_t; \gamma, \tau) + \varepsilon_t,$$

$$t = 1, 2, T, \qquad (1a)$$

where the model allows for a deterministic trend, with ε_t a zero mean *I* (0) process and $G_t(s_t; \gamma, \tau)$ the logistic smooth transition, based on sample size *T*, which is written as

$$G_t(s_t; \gamma, \tau) = \{1 + \exp(-\gamma(s_t - \tau T\}^{-1}, \qquad (2a)$$

where s_t is the transition variable, which in our case will be time, *t*. Under this formulation and assuming that $\gamma > 0$, the model transition occurs smoothly between the initial state

$$\text{Ln}(y_t) = \alpha_0 + \beta_0 t + v, \quad t \to -\infty,$$

and the final state

$$\text{Ln}(y_t) = (\alpha_0 + \alpha_1) + (\beta_0 + \beta_1)t + v, \quad t \to \infty$$

corresponding to $G_{-\infty} = 0$ and $G_{\infty} = 1$, respectively. Hence the growth rate of Ln (y_t). The coefficient on the trend variable changes from β_0 to $\beta_1 + \beta_2$ over time. The model also allows the level to change from α_0 to $\alpha_0 + \alpha_1$.

1.2. Smooth transition autoregressive model (STAR). Smooth transition autoregressive (STAR) models permit the autoregressive parameters to transform slowly. Consider the following special nonlinear autoregressive (NLAR) model:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_1 y_{t-1} G\ (y_{t-1}, \gamma, c) + \varepsilon_t. \quad (3)$$

According to Enders (2004), if *G* (.) is a smooth continuous function, the autoregressive coefficient ($\alpha_1 + \beta_1$) will change smoothly along with the value of y_{t-1}. There are various forms of the STAR model that allow for a changeable degree of autoregressive decay.

In the present study, we employ the logistic transition function, which has the general form

$$G = \left[1 + \exp(-\gamma(y_{t-1} - c)\right]^{-1}. \quad (3a)$$

Equations (3) and (3a) jointly define the LSTAR model, where γ is the smoothness parameter. As γ approaches zero or infinite, the value of θ is constant and the LSTAR model becomes an $AR(p)$ model. For other values of γ the extent of autoregressive decay depends on the value of y_{t-1}. Behavior of y_{t-1} for intermediate values of y in the LSTAR model can be illustrated as follows:

in the initial state

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + ... + \alpha_p y_{t-p} + \varepsilon_t, \qquad y_{t-1} \to -\infty,$$

and in the final state

$$y_t = (\alpha_0 + \beta_0) + (\alpha_1 + \beta_1) y_{t-1} + ... + \varepsilon_t, y_{t-1} \to +\infty$$

corresponding to $G \to 0$ and $G \to 1$, respectively. The intercept and the autoregressive coefficients change smoothly between two extremes as the value of y_{t-1} alters.

LSTAR models are capable of generating asymmetric realization, which make them an interesting tool for modeling macroeconomic time series, exhibiting, such as changes in their dynamic properties over the business cycles.

2. A review of economic performance in the economy

In this paper we use the macroeconomic data collected by Vietnam's General Statistics Office (GSO) over the period of 1985-2006. The reforms included the rapid development of private markets for agricultural goods; adjustments in land allocation, the land use rights system, stabilization policies, entry regulations, and privatization; state enterprise restructuring, and tax, banking reforms.

The reform process in Vietnam has been inherently experimental and gradual given the extremity of the changes. "Doimoi" in Vietnam should be considered a learning process in which the leadership has continually responded to the outcome of economic policies.

Since Vietnam experienced many different economic fluctuations and policy changes during the period of 1985-2006, we can deconstruct the study period into four sub-periods, namely 1985-1988, 1989-1996, 1997-1999, and 2000-2006 (see Table 1 in Appendix).

The first sub-period (1985-1988) was marked by the initial adjustments which aimed at reducing macroeconomic instability and creating new economic incentives. Some of the major reforms included abolishment of internal check points for the free movement of goods, adjustment of prices towards unofficial levels and reducing rationings (such that the Vietnamese Dong (VND) was evaluated in line with the parallel market rates), the approval of the Land Law and recognition of long-term land use rights which encouraged farmers to work (the Communist Party Resolution No.10, issued in April 1988). For example, farmers could no longer be coerced into joining cooperatives and thus also were allowed to sell their products on the open market.

The launch of economic renovation created the good growth performance of the economy. The economy started with a low growth rate of 2.8% in 1986 and then increased in the following two years. The growth rate of the economy reached 6% in 1988. In particular, the positive trend of GDP growth also strengthened the willingness of the government to undertake further reforms.

In the second sub-period (1990-1996), the economy was on a high growth track, peaking in 1995. Fast growth in this phase can be attributed to the effects of several reforms. Some of the major reforms included the issuance and amendments of laws relating to government budgets, state and non-state enterprises, credit and banking. Also important was the encouragement of domestic and foreign investments, and expansion of trade. Take for example the trade agreement signed with the European Union in 1992 for quota allocated garment exports to the European Union and granting tariff preferences on selected imports. There were also increased financial relations with the international community via negotiations and further liberalizations. In particular, Vietnam joined the Association of Southeast Asian Nations (ASEAN) in 1995 and commits to AFTA.

In the third sub-period (1997-1999), the major challenge to Vietnam's young market economy was apparent. The major reforms during this period included temporary prohibitions on imports of a wide range of consumer good and approval of certain foreign investment projects to be decentralized to selected provincial people's committees and industrial zones in 1997. However, the Asian financial crisis led to trade and investment disruptions. The Vietnamese economy was not directly hit by this crisis due to strong capital controls. However, a reduction in foreign direct investment (FDI) and intensified competition in export markets brought about "real blows" to the economy. The economic growth rate declined sharply from 8.2% in 1997 to 5.8 % and 4.8% in 1998 and 1999, respectively (CIEM, 2002).

In the fourth sub-period (2000-2006), when the financial crisis was dying down, the economy resumed its growth momentum. After laying down the fundamental framework in the previous sub-periods, the reform agenda focused on other structural reforms, including the promotion of non-state sector and equitization of the state-owned enterprises (SOEs). The new Enterprise Law enacted in 2000 has helped promote the private sector with more facilitation of business activities for private enterprises. FDI law was amended to streamline procedures clarify land-use right provisions in 2000. The Labor code was amended in 2002 to provide more labor market flexibility. There was rapid growth in the number of newly established enterprises, most of which were private ones.

Table 2 (see Appendix) shows the basic statistics for the output of each of the three economic sectors and the economy as a whole. In general, the contribution of the agricultural sector to the economy gradually decreased over time, while those of industry and services increased significantly. While the output of the services sector increased over time, its contribution as percentage of GDP remained stable over the study period. In recent years, the industrial sector has become the driving force of the economy's growth.

Thus far we have concentrated on the dynamics of the level of GDP in each sector, which is determined by macroeconomic forces such as investment behavior, government consumption, export performance, and monetary policies. However, we may also expect an impact on productivity following economic reforms. The effects on the overall efficiency of each sector may be even stronger and take place faster due to underlying firm-level adjustments like scrapping of inefficient technologies, improving production factors and other general restructuring that has taken place in these sectors.

One way of examining the impact of reforms on productivity is by using the standard accounting framework, including measures of the labor force and capital stock as independent variables. By accounting for the contribution of capital and labor to GDP in each sector this approach would allow one to isolate the impact of reforms on Total Factor Productivity (TFP). However there are a number of problems with this approach. Most importantly, reliable data on the capital stock in each sector in Vietnamese economy are not available. Moreover, constructing capital stocks using the perpetual inventory method assumes a constant depreciation rate is less valid in the case of each sector that was undergoing massive structural changes involving the destruction of capital. As a result we use an alternative measure of productivity defined as GDP to the active labor force. This measure of labor productivity seems to be a useful measure to capture the path of overall efficiency.

In Figure 1 (see Appendix), we plot an index of productivity of labor for our sample of the three sectors. The resulting productivity dynamics of each look rather different. The performance of the industrial sector in terms of productivity has been better and more highly fluctuating than that of other sectors. In the case of the agricultural sector, the productivity of labor experienced a decline in the formative years of transformation but increased over time.

3. Results

We begin by considering the natural log of real GDP as the dependent variable. Table 3 in the Appendix presents results of the ADF test of stationary versus a unit root along with the ADF test.

For GDP series of the three sectors, the results from the ADF test indicate that we can reject the unit root hypothesis in favor of trend stationary in all cases. For the productivity series of three sectors, the results from the ADF test indicate that we cannot reject the unit root hypothesis in favor of trend stationary in all cases. In these cases therefore we find little support for modeling GDP using the LSTR model and as such we have chosen not to report the LSTR results for this series.

3.1. Testing for unit roots in GDP and TFP. We applied the test presented above to the natural logarithm of the real GDP series, measured at 1994 prices, to each of the three sectors. Each series contained 22 observations from the period of 1985 to 2006. We also compute the standard with trend ADF test, here denoted by t^*, to test the same null hypothesis as above, against the alternative that the series is stationary around a fixed intercept and trend. The results are presented in Table 3. For each series, the necessary degree of augmentation is given under p, this being selected by conventional significant tests using 0.05 level critical values from a t distribution. A rejection at the 0.10/0.05/0.01 test size is denoted by */**/***. Even using p-correction critical values for the standard unit root test t^*, the unit root hypothesis is rejected in favor of stationary around a fixed trend. In the case of the GDP of the economy and three sectors, The ADF and KPSS results suggest that we can model GDP using a simple model with trend and intercept.

While considering the impact of economic reforms on the level and growth rate of the GDP in each sector is important, a further question of interest is the extent to which reforms impacted productivity. The way to proceed is analogous to that described above, beginning by calculating the ADF and KPSS tests using the productivity data previously discussed. These results are reported in Table 3, using labor productivity as our dependent variable.

Using these tests we can reject the null hypotheses of a unit root for all cases.

In the case of unit root series the modeling strategy is much different than the LSTR model and requires us to first differencing the series and then building a model on it. We have chosen not to estimate such a model since it adds little to the discussion of the impact of reforms on economic performance. Nevertheless, the finding of a unit root for these series may provide valuable information. From an economic point of view the presence of a unit root implies that the impact of shocks on TFP have permanent effects.

3.2. Testing linearity and choosing the type of the model. Before testing linearity, we fitted a linear model to our data yields

For the industrial sector:

$$\mathrm{Ln}GDP_t = \underset{(0.017)}{10.487} + \underset{(0.001)}{0.035\mathrm{t}} + \tilde{\varepsilon}\ , \ \mathrm{T} = 22.$$

For the service sector:

$$\mathrm{Ln}GDP_t = \underset{(0.015)}{10.575} + \underset{(0.001)}{0.067\mathrm{t}} + \tilde{\varepsilon}\ , \ \mathrm{T} = 22.$$

For the agricultural sector:

$$\mathrm{Ln}GDP_t = \underset{(0.017)}{10.49} + \underset{(0.001)}{0.035\mathrm{t}} + \tilde{\varepsilon}\ , \ \mathrm{T} = 22.$$

The ensuing identification problem in testing linearity can, in the STR context, be circumvented by approximating the transition (2) in (1) by a Taylor expansion around the null hypothesis $\gamma = 0$. We assume $K = 1$ in (2) and use the third-order Taylor approximation. The resulting test has power against both the LSTR1 ($K = 1$) and LSTR2 ($K = 2$) models.

Assume that the transition variable s_t is an element in z_t and let $z_t = (1, \tilde{z}_t^{'})''$, where $\tilde{z}_t$ is an (m x 1) vector. The approximation yields, after merging terms, the following auxiliary regression:

$$y_t = \beta_0^{'} z_t + \sum_{j=1}^{3} \beta_j^{'} \tilde{z}_t s_t^j + u_t^*,\ t = 1,2....,T. \qquad (4)$$

When linearity has been rejected and a transition variable is subsequently selected, the next step is to choose the model type. The variable choices are $K = 1$ and $K = 2$ in (2). When we choose the LSTR1 model, the parameters change monotonically as a function of the transition variable. The choice between these two types of models can be based on the auxiliary regression (4). The coefficient vectors β_j, $j = 1, 2, 3$, in (4) are functions of the parameters in (1). In the special case $c = 0$, it can be shown that $\beta_2 = 0$ when the model is an LSTR1 model, whereas $\beta_1 = \beta_3 = 0$ when the model is LSTR2 or ESTR2 model. Even when $c \# 0$, β_2 is closer to the null vector than β_1 or β_3 when the model is an LSTR1 model, and vice versa for the LSTR2 model. These suggest the following short test sequence:

1. *Test the null hypothesis* H_{04}: $\beta_3 = 0$.
2. *Test* H_{03}*:* $\beta_2 = 0 \,/\, \beta_3 = 0$.
3. *Test* H_{02}*:* $\beta_1 = 0 \,/\, \beta_2 = \beta_3 = 0$.

If the test of H_{03} yields the strongest rejection measured in the p-value, choose the LSTR2 or ESTR model. Otherwise, select the LSTR1 model. All three hypotheses can simultaneously be rejected at a conventional significance level such as 0.05 or 0.01 which is why the strongest rejection counts.

In choosing the STR model type, either one of the two test sequences has proven useful in practice. It is also possible to fit both an LSTR1 and an LSTR2 (or ESTR) model to the data and make the choice between them at the evaluation stage. In practice, this is a sensible way of proceeding if the test sequence does not provide a clear-cut choice between the two alternatives if the p-values of the test of H_{03} and of H_{02} or H_{04} are close to each other.

On the other hand finding support for the LSTR model suggests that shocks have no permanent impact on series, with the exception of the shock captured by the smooth transition.

Where support for the LSTR model was found we proceeded to estimate the single LSTR model. The results for GDP series of the three sectors are reported in Table 4 (see Appendix). The F-statistic testing of the null hypothesis of linearity was carried out using the LM-type test described in Table 4. We suggest that one can reject the null of linearity in all cases at the 1 percent level.

3.3. Estimated results. *4.3.1. Estimated results from LSTR1 model*. The estimate results from LSTR1 model for the three series of GDP are reported in Table 5 (see Appendix). The coefficient α_0, according to the definition of the model is an estimate of the initial logged values of GDP. The coefficient α_1 is an estimate of the change in the intercept following the structural break. As estimated, results of the coefficients on this variable are negative in the case of the agricultural sector, indicating a drop in the level of GDP following reforms in this area. In the two remaining sectors, the results of the coefficients on these variables are positive, indicating an increase in the level of GDP following reforms in these areas.

In terms of size of the coefficient on α_1 we find that there is a great deal of variation across sectors. Meanwhile, the agricultural sector suffered the greatest decline in GDP (estimated coefficient of α_1 was -0.2005 in Table 5).

The coefficient on β_0 provide an estimate of the trend growth rate prior to transition, while the coefficient on β_1 is an estimate of the change in trend growth associated with the transition.

Compared to Forster (2007)'s study applying smooth transition regression to the data set of Bulgaria, Czech Republic, Hungary, Latvia, Romania, and Slovakia, the estimated coefficients of β_0 here are more consistent with the expectation that the trend growth rate prior to the transition would be positive in the three sectors. This suggests a positive growth rate trend prior to transition.

However, the main coefficient of interest for us regarding the impact of reforms on the long-run growth rate trend is that of β_1. The coefficient of β_1 is found to be positive in all models. The results reported here generally suggest that there have been positive impacts on the growth rate trend in all three sectors following reforms undertaken in Vietnam. The reason may be the impact of the initial adjustments on creating new economic incentives for the economy in general and farmers in particular.

The final two coefficients of interest are those of τ and γ, indicating the position of the mid-point and the speed of transition in the three sectors from 1985 to 2006, respectively. This gives a clearer idea of when the estimated transition began in each sector and the speed at which they moved between the initial and the final states.

The coefficient γ provides an estimate of the speed of transition, with larger coefficients signaling a faster speed of transition. The results indicate that the speed of transition was particularly quick in the case of agricultural sector (168.5) and much slower in the service sector (5.964).

The faster speed of transition in the agricultural sector could be explained by the impacts of the adjustments like the Party Resolution No.10, passed in 1988. It provided farmers with property rights, price and trade reforms, thus encouraging farmers (who comprise more than 80% of the country's population) to work on their farms. These not only contributed to sustained growth but explain the faster speed of transition in agricultural sector.

The coefficients of τ indicate the positioning of the mid-point of transition in the three sectors. The mid-points of the process of transition in each sector are calculated as 1993-1994, 1992-1993, and 1991 for industrial sector, service sector and agricultural sector, respectively.

These results suggest that our model tends to capture the impact of transformational reforms on GDP and that there are significant differences in the speed at which sectors moved between economic regimes.

For the three series of GDP for which the LSTR model was supported we proceeded to test for the optimal number of regimes, by testing for any remaining nonlinearities. In practice this involves following the method suggested by Terasvirta (1996) and others who adapted the LM-type linearity test. Although there has only been one fundamental change in regime from a planned economy to a market economy, the Vietnamese government introduced important policies quite late in the transition process, which may reflected by a second transition. The results for the optimal number of transitions are reported in Table 6 (see Appendix). For all case the data suggests that there exists only one transition.

For the economy as a whole and the service sector specially, the data suggest that there is only one transition, and hence the results are identical to those reported in Table 5. For the remaining two sectors we found support for a double LSTR model. However, in the case of the agricultural sector $c_1 = c_2$ and $\gamma < \infty$, the result could not be reported in this table.

In Table 6 the coefficients that correspond closest to the period of transition are presented. We can see that by allowing for a second threshold in the industrial sector the results indicate a significant increase in trend growth following the transition, represented by a negative and significant coefficient of β_1 and a significant increase in the level of GDP (as expected), which is signified by the positive and significant coefficient of α_1. However, the positive effect of the transition on growth (in Table 5) is partially offset by a second structural break, the mid-points of which are calculated as 1990-1991 and 1997-1998. The main reason for this may be the impact of the Asian financial crisis in Asian countries (1997) that led to trade and investment disruptions.

Conclusion

In this paper we used the LSTR model to examine the impact of reforms on the level and growth rate of GDP and productivity of three sectors, namely the industrial, service and agricultural. This model has an advantage over others because it allows for the impact of reforms on economic performance through a smooth transition rather than as a discrete jump. Using this model we considered whether and in what direction the movement towards the market economy affected the growth rate of both GDP and labor productivity in the three sectors of the economy. Given information about the speed in which reforms were implemented, we were also able to consider the impact of the reform strategy on the speed of transformation within each sector. Results indicate that in all cases for the GDP of each sector the LSTR model was preferred over a trend stationary one. In the case of the TFP of each sector we found evidence that supported the unit root hypothesis. From an economic point of view the presence of a unit root in TFP series implies that the impact of shocks on TFP have permanent effects.

The results of estimated smooth transition models for the GDP of each sector indicated that there is evidence of one structural break the service and agricultural sectors but two structural breaks in the industrial sector. Results from the LSTR model suggested that there has been impact from reforms of the early 1990s on the trend growth rate of GDP. It was very interesting to find that the speed of transition was particularly quick in the case of the agricultural sector (168.5) and much slower in the service sector (5.964). The mid-points of the process of transition of each sector are calculated as 1993-1994, 1992-1993 and 1991 for industrial, service and agricultural sectors, respectively. This shows that reforms in agriculture succeeded in encouraging farmers to work on their farms and also succeeded in quickly stabilizing the macro economy. Our results also suggested that the government's policies in economic reform should bring benefit for people in the country in the long term.

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Appendix

1. PKSS test

The integration properties of a series y_t may also be investigated by testing

$$H_0 : y_t \sim I(0)$$
$$H_1 : y_t \sim I(1)$$

that is, the null hypothesis that the DGP is stationary is tested against a unit root. Kwiatkowski, Phillips, Schmidt and Shin (1992) have derived a test for this pair of hypotheses. In there is no trend linear term, it can start from a DGP

$$y_t = x_t + z_t ,$$

where x_t is random walk, $x_t = x_{t-1} + v_t$, $v_t \sim IID(0, \sigma_v^2)$, and z_t is a stationary process. In this framework the foregoing pair of hypotheses is equivalent to the pair

$H_0 : \sigma_v^2 = 0$ and $H_0 : \sigma_v^2 > 0$

The following test statistics was proposed:

$KPSS = \frac{1}{T^2}\sum_{t=1}^{T}\frac{S_t^2}{\hat{\sigma}_\infty^2}$, where $S_t = \sum_{j=1}^{T}\hat{w}_j$ with $\hat{w}_t = y_t - \bar{y}$ and $\hat{\sigma}_\infty^2$ is an estimator of

$$\hat{\sigma}_\infty^2 = \underset{T\to\infty}{Lim}\, T^{-1}\operatorname{var}\left(\sum_{t=1}^{T} z_t\right).$$

That is, $\hat{\sigma}_\infty^2$ is an estimator of the long-run variance of the process z_t. Kwiatkowski, Phillips, Schmidt and Shin (1992) proposed a nonparametric estimator for this quantity based on a Bartlett window with a lag truncation parameter $l_q = q(T/100)^{1/4}$

$$\hat{\sigma}_\infty^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{w}_t^2 + 2\sum_{j=1}^{l_q} w_j\left(\frac{1}{T}\sum_{t=j+1}^{T}\hat{w}_t\hat{w}_{t-j}\right),$$

where $w_j = 1 - \frac{j}{l_q+1}$. Critical values may be found, e.g., in Kwiatkowski, Phillips, Schmidt and Shin (1992). The null hypothesis of stationary is rejected for large values of KPSS.

If a deterministic trend is suspected, the point of departure is a DGP

$$y_t = \mu_1 t + x_t + z_t,$$

and the $\hat{w}_t$ are residuals from a regression

$$y_t = \mu_0 + \mu_1 t + w_t.$$

With these quantities the test statistic is computed in the same way as before. Its limiting distribution under H_0 is different from the case without trend term, however. Critical values for the case with trend are available from them.

Estimated models for three sectors:

LSTR1 models

$$\operatorname{Ln} GDP_I = \underset{(0.0118)}{9.899} + \underset{(0.003)}{0.085}t - \left(\underset{(0.029)}{0.092} - \underset{(0.003)}{0.0084}t\right)\left(1+\exp\left\{-\left(\underset{(1.88)}{7.76/\hat{\sigma}_t^1}\right)(t-0.445)\right\}\right)^{-1}$$

$T = 22,\quad \hat{\sigma} = 0.0135,\quad R^2 = 0.9968$

$$\operatorname{Ln} GDP_S = \underset{(0.0138)}{11.52} + \underset{(0.004)}{0.043}t - \left(\underset{(0.027)}{0.065} - \underset{(0.004)}{0.024}t\right)\left(1+\exp\left\{-\left(\underset{(1.91)}{6.18/\hat{\sigma}_t^1}\right)(t-0.374)\right\}\right)^{-1}$$

$T = 22,\quad \hat{\sigma} = 0.0131,\quad R^2 = 0.9935$

$$\operatorname{Ln} GDP_A = \underset{(0.0064)}{10.61} + \underset{(0.002)}{0.0065}t - \left(\underset{(0.009)}{0.2004} - \underset{(0.004)}{0.0337}t\right)\left(1+\exp\left\{-\left(\underset{(1.91)}{168.51/\hat{\sigma}_t^1}\right)(t-0.318)\right\}\right)^{-1}$$

$T = 22,\quad \hat{\sigma} = 0.0069,\quad R^2 = 0.9932$

Table 1. Growth rates of GDP during the period of 1985-2006

Period	1985-1988	1989-1996	1997-1999	2000-2006
gGDP	0.04	0.08	0.06	0.08
$gGDP_I$	0.1025	0.1126	0.0955	0.1024
$gGDP_S$	0.0463	0.0802	0.0482	0.0692
$gGDP_A$	0.0017	0.0340	0.0436	0.0388

Notes: g*GDP* is growth rate of GDP during the period of studying; subscripts *I*, *S* and *A* denote industrial sector, service sector and agricultural sector, respectively.
Source: Author's estimates using GSO data.

Table 2. Basic statistics for output

	Output (VND billions)				Share of output (%)		
	GDP	GDP_A	GDP_I	GDP_S	$SGDP_A$	$SGDP_I$	$SGDP_S$
Mean	221716.0	55077.55	74200.73	92437.68	27.25455	30.76364	41.99091
Median	204700.0	52448.00	62783.00	89469.00	25.65000	30.60000	41.95000
Maximum	425088.0	79488.00	174210.0	171390.0	38.40000	41.00000	43.80000

Table 2(cont.). Basic statistics for output

	Output (VND billions)				Share of output (%)		
	GDP	GDP_A	GDP	GDP_A	GDP	GDP_A	GDP
Minimum	106176.0	40792.00	21351.00	44033.00	18.70000	20.10000	40.30000
Std. dev.	98689.28	13006.65	46805.67	39049.26	6.071458	6.508496	1.303807
Observations	22	22	22	22	22	22	22

Note: *GDP*, GDP_A, GDP_I, and GDP_S are real *GDP* of the whole economy, the agricultural sector, the industrial sector, and the services sector, respectively. $SGDP_A$, $SGDP_I$, and $SGDP_S$ are the percentage of the agricultural sector, the industrial sector, and the services sector, respectively, in the *GDP*.
Source: Author's estimates using GSO data.

Table 3. Values of unit root test
(natural log of real GDP of the economy and each sector)

	ADF test		KPSS test	
	Value of statistic	p	Value of statistic	p
$LnGDP_I$	-3.48*	4	0.0908	2
$LnGDP_S$	-3.62*	3	0.0954	3
$LnGDP_A$	-3.52*	2	0.1757	2
$LnTFP_I$	-1.912	3		
$LnTFP_S$	-1.706	3		
$LNTFP_A$	-2.787	2		

Note: The first two columns of this table report the trend ADF tests on the log of real GDP. Column (p) refers to the number of lags included in ADF test. The number of lags was determined following the common approach of testing down to find the appropriate number of lags, using t-statistic on the last coefficient as a guide. The final two columns report the KPSS test statistics. Once again number of lags included in the Dickey-Fuller type regression was determined using the t-statistic on the last lag. */**/*** Rejection of the unit-root hypothesis in favor of a trend-stationary or a stationary process around a smooth transition in intercept and trend at the 10%, 5% and 1% levels, respectively.

Table 4. Choosing model type

Sector	Transition variable	F	F4	F3	F2	Suggestion
Whole three sectors	t*	6.7113e-07	6.1250e-05	1.6252e-03	2.5140e-02	LSTR1
I	t*	5.7266e-03	8.1528e-02	2.2070e-03	9.2517e-02	LSTR2
S	t*	2.1884e-06	8.5290e-07	1.5211e-03	2.0316e-02	LSTR1
A	t*	5.7477e-11	3.9339e-02	4.3596e-03	2.7184e-02	LSTR2

Note: F-statistics of null hypothesis H_{04}, H_{03}, H_{02} are denoted by F4, F3, F2. *I* – industrial sector, *S* – service sector, *A* – Agricultural sector.

Table 5. Single transition results (natural log of real GDP) from LSTR model

	α_0	α_1	β_0	β_1	γ	τ	Obs	R^2
$LnGDP_I$	9.89	0.0918	0.085	0.0084	7.76	0.445	22	0.99
SE	(0.118)***	(0.029)***	(0.0028)***	(0.003)***				
$LnGDP_S$	10.61	0.110	0.052	0.0069	5.964	0.374	22	0.98
SE	(0.052)***	(0.047)**	(0.0097)***	0.0095				
GDP_A	10.61	-0.2005	0.0065	0.037	168.5	0.318	22	0.99
SE	(0.006)***	(0.0091)***	(0.0016)***	(0.0017)***			22	

Note: Standard-errors are reported in brackets. Obs. refers to the number of observations for each sector. **/*** Statistical significance at 5%, 1% levels, respectively.

Table 6. Optimal transition results (natural log of real GDP) from LSTR model

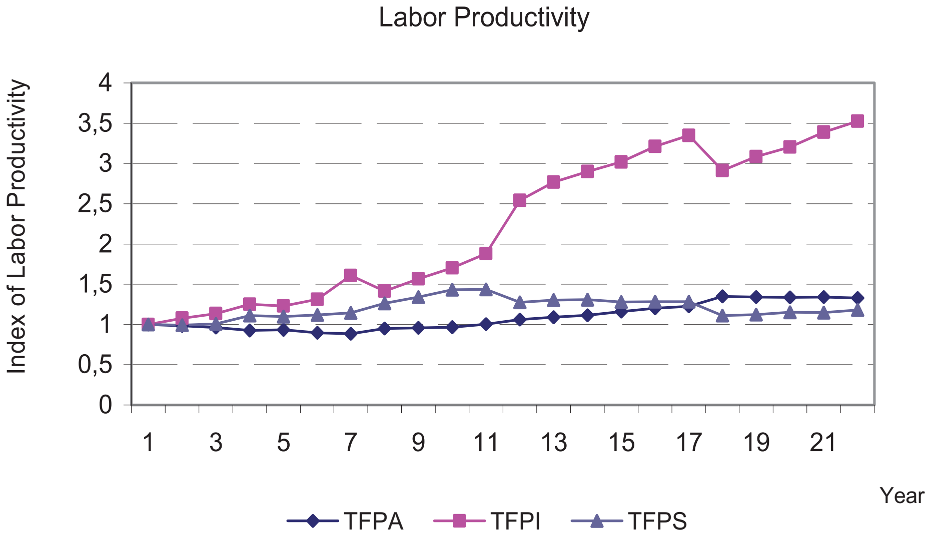
	α_0	α_1	β_0	β_1	γ	τ_1	τ_2	Obs	R^2
$LnGDP_I$	9.476	0.397	0.137	-0.037	5.29	0.289	0.602	22	0.99
SE	(0.082)***	(0.083)***	(0.008)***	(0.008)***					

Note: Standard-errors are reported in brackets. Obs. refers to the number of observations for each sector. **/*** Statistical significance at 5%, 1% levels, respectively.

Table 7. The estimated results from LSTAR model

	α_0	α_1	β_0	β_1	γ	C	Obs	R^2
$LnGDP_I$	0.415		0.976	0.048	107.4	6.89	22	
SE	(0.0108)***		(0.0106)***	(0.0013)***				
$LnGDP_S$	-1.113		1.11	0.00808	9.137	11.58	22	
SE	(0.327)**		(0.03)***	(0.0024)***				
GDP_A	0.265		0.976	0.0397	173	6.01	22	0.99
SE	(0.173)		(0.016)***	(0.0007)***			22	

Note: Standard-errors are reported in brackets. Obs. refers to the number of observations for each sector. **/*** Statistical significance at 5%, 1% levels, respectively.



Note: Labor productivity defined as GDP to the active labor force.

Fig. 1. Labor productivity of three sector overtime (1985=1)