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Exploring the role of technology, tourism and financial development: an empirical study of Vietnam

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Abstract Vietnam is one of the emerging and industrializing developing countries in East Asia that has experienced a growth in tourism, information and communications technology (ICT) and financial development over the last three decades largely supported by significant structural reforms to escalate its path towards modernization and industrialization by 2020. In this paper, we explore the short-run and long-run effects of tourism, ICT and financial development over the period 1980–2010. Further, we examine the causation between these contemporary drivers of growth. The results show tourism has a positive and statistically significant effect in the short-run whereas ICT and financial development have a momentous positive and significant effect in the long-run. The causality results show unidirectional causation from capital per worker, ICT and financial development to output per worker; from ICT and financial development to capital per worker; and from capital per worker to tourism. Further, we also note a bi-directional causation between tourism and output per worker indicating their mutually reinforcing effect in the economy.

Keywords ICT · Technology · Tourism · Financial development · ARDL approach · Granger causality · Vietnam

1 Introduction

Vietnam is considered one of the emerging and industrializing developing countries in East Asia which is making significant efforts to modernize by 2020. Vietnam's financial sector was poised to liberalize in 1984 which resulted in signs of healthy competition in the financial sector.

Further, the Communist Government of Vietnam launched the *Doi Moi*, or Renovation as a policy to reform the economy in 1986. It is after these reforms that the economy put its foot

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on the accelerator of growth thereby experiencing greater inflow of foreign direct investment which spanned financial sector development, tourism and later technology growth. Moreover, during these periods, the role international migration and tourism also gained momentum in the development process (Athukorala 2009; Haley and Haley 1997).

In this study, we explore the plausible effects of ICT, financial development and international tourism on economic growth in Vietnam. The study is motivated by the fact that the economy of Vietnam has undergone significant reforms and is gearing to become a modern and industrialized economy. Therefore, considering the mutual role of tourism, financial development and technology amidst these developments are vital. Moreover, we also noted a significant gap in the literature in this regard and therefore, attempt to provide a macro level study based on these contemporary drivers of growth to modestly contribute to the debate on sustainable development and growth of the economy. We advance our study using the augmented Solow framework (Solow 1956) with insights from the pioneers (Schumpeter 1933; Domar 1952, 1961; Harrod 1959) and contemporary literature (Acemoglu 2009) on growth theories. The balance of the paper is set out as follows. A brief literature survey is provided in Sect. 2, followed by a discussion on the framework, method and data in Sect. 3. In Sect. 4, we present the results. Finally, conclusion follows in Sect. 5.

2 Literature survey

2.1 Tourism

The literature on tourism development and its consequent impact on growth and development process dates back to the pioneering work of Sheldon (1997) which duly spurred a plethora of studies in this direction. For instance, Durbarry (2004) explored the impact of tourism on Mauritius where he used real gross domestic investment as a proxy for investment, secondary school enrolment as a proxy for human capital, and disaggregated exports such as sugar, manufactured exports and tourism receipts, and found that tourism contributed about 0.8 percent to growth in the long-run. Nowak et al. (2007) studied the Spanish economy where he showed that tourism exports when used to finance imports of capital goods had a growth enhancing effect. Lee and Chang (2008) used a heterogeneous panel cointegration technique for Organization for Economic Co-operation and Development (OECD) and non-OECD countries. They found that tourism had a greater impact on GDP in non-OECD countries than in the OECD countries. Brida et al. (2008) investigated the plausible causal relationships among tourism expenditure, real exchange rate and economic growth on a quarterly data in Mexico using the Johansen cointegration technique. Their results confirmed the tourism-led growth (TLG) hypothesis and showed a unidirectional causation from tourism to real GDP. Fayissa et al. (2008) used a panel of 42 African countries within the conventional neoclassical framework to explore the potential contributions of tourism to growth. Their results showed that tourism receipts contributed to the current level of output and economic growth of the selected SSA countries.

Further, Holzner (2010) studied 134 countries and explored the Dutch disease effect of tourism. He found that there was no significant danger of beach (Dutch) disease effect and that tourism dependent countries benefited from higher economic growth as a result of tourism. Seetanah (2011) used a panel of 19 island economies and the generalized method of moments (GMM) technique over the period 1990–2007 within the conventional augmented Solow growth model to examine the contribution of tourism to growth. He found that tourism significantly contributed to economic growth and that there was a plausible bi-directional causality between tourism and growth. In another study, Seetanah et al. (2011) studied 40 African countries over the period 1990–2006 and found, *inter alia*, a bi-causal and reinforcing relationship between tourism and output. Kumar and Kumar (2012) explored the nexus between tourism and technology in Fiji's growth using the autoregressive distributed lag (ARDL) model within the augmented Solow framework of Rao (2010) which formally accounted for labour and capital stock. They showed that tourism contributed about 0.23 % in the long-run and 0.19 % in the short-run. A similar study by Kumar and Kumar (2013) on Fiji explored the impact of tourism with other contemporary drivers such as financial development and urbanization. They found that tourism contributed about 0.12 % to per worker output in the long-run. Chang et al. (2012) used instrument variable (IV) estimation in a panel threshold model to investigate the importance of tourism specialization in economic development for 159 countries and found a positive relationship between growth and tourism. In another study, Kumar (2013b) studied the Kenyan economy and found a unidirectional causation from output per worker to tourism and that tourism has a positive effect on growth in the long-run.

While the aforesaid studies unequivocally advocate the TLG hypothesis, there are few studies which have noted contrary views. For instances, Oh (2005) examined the causal relationship between tourism and economic expansion for the Korean economy by using the Engle and Granger two-stage approach and a bi-variate vector autoregression (VAR) model. Oh showed there was no long-run equilibrium relationship between tourism and output, and the evidence of only a unidirectional causality from output to tourism. Katircioglu (2009) investigated the TLG hypothesis in Turkey using the ARDL bounds test and Johansen approach to cointegration and found there was no evidence of any cointegration relationship between international tourism and economic growth. Similarly, Kumar et al. (2011) examined the impact of tourism and remittances on per worker output in a small island economy of Vanuatu using the ARDL procedure. Their finding showed that tourism (measured by visitor arrivals) although positive, was not statistically significant.

2.2 Information and communications technology (ICT)

The pervasive nature of technology has resulted in enhanced productivity and growth (Solow 1956; Romer 1990; Katz 2009; Minghetti and Buhalis 2010), besides lowering cost of production and streamlining supply chain processes, providing access to information thus aiding consumers in decision making, and providing quality products at competitive prices (Porter 2001; Buhalis and Law 2008). Quite a lot of studies, particularly focusing on developed countries, have examined the effects of technology at various levels, i.e. firm-industry, national, cross-country and regional levels (Cole 1986; Mody and Dahlman 1992; Indjikian and Siegel 2005). For instance, at a firm level, Lehr and Lichtenberg (1999) examined firms in service industries in Canada and found that personal computers made a positive contribution to productivity growth. Stiroh (2002) investigated 57 major US industries and found a strong link between ICT and productivity. Similarly, Brynjolfsson and Hitt (2003) found that firms that invested in computer technology were able to realize greater productivity (output per unit of input). O'Mahony and Vecchi (2005) used a pooled data at the industry level for the US and the UK. They found a positive effect of ICT on output growth and excess returns relative to the non-ICT assets.

At a country level, various studies have supported ICT or technology-led growth hypothesis. Among these include: Jorgenson and Stiroh (2000), Jorgenson (2001), and Oliner and Sichel (2000) for the United States of America (US); Oulton (2002) for the United Kingdom (UK); Jalava and Pohjola (2002, 2008) for Finland; Daveri (2002) for European Union

(EU) economies; Jorgenson and Motohashi (2007) for Japan; Jorgenson (2003) for the G-7 economies; Jorgenson and Vu (2007) for 110 countries; Kuppusamy et al. (2009) for Malaysia; Venturini (2009) for the US and 15 EU countries; Kumar (2011) for Nepal, Kumar and Kumar (2012, 2013) and Kumar and Singh (2013) for Fiji; Kumar (2012) for Sub-Saharan Africa (SSA), and Kumar (2013a) for the Philippines.

Another strand of literature has focused on the technology–growth relationship using cross-country regression techniques. For instance, Hardy (1980) analyzed the data for 60 nations over the 1968–1976 period and found strong evidence that telephones contributed to the economic development. Madden and Savage (1998) examined a sample of 27 Central and Eastern European (CEE) countries during the period 1990–1995 and found a positive relationship between investment in telecommunication infrastructure and economic growth. Similarly, Roller and Waverman (2001) used data on 21 Organisation for Economic Co-operation and Development (OECD) countries over a 20-year period (1970–1990) and found a positive causal relationship between investment in telecommunication infrastructure and subsequent economic performance. Thompson and Garbacz (2007) examined a panel of 93 countries for the period 1995–2003 and found that penetration rates of telecommunication services improved the productive efficiency of the world as a whole and particularly in some subsets of low income countries. Seo et al. (2009), analyzed a panel of 29 countries in the 1990s and concluded that ICT investment has positive impacts on GDP growth. Koutroumpis (2009) used the model introduced by Roller and Waverman (2001) for 22 OECD countries over the period 2002–2007 and found that broadband penetration had a positive causal link with economic growth in the presence of critical mass and infrastructure. Gruber and Koutroumpis (2010) used the data from 192 countries for the period 1990–2007 and found a significant effect of mobile telecommunications diffusion on GDP and productivity growth. Vu (2011) investigated the effect of ICT on growth for a sample of 102 countries for the period 1996–2005 and found *inter alia*: (a) a substantial improvement of growth in the sample period relative to previous years; (b) a statistically significant relationship between growth and ICT; and (c) that penetration of personal computers, mobile phones, and internet users had a significant causal effect on growth.

On the other spectrum, there are some studies which have found inconclusive evidence on the growth effects of investment in technology. Among these include: Dewan and Kraemer (2000), which analyzed 36 countries over the 1985–1993 period and found that returns from capital investments in ICT, although positive and significant for developed countries, were not statistically significant for the developing countries. Pohjola (2002) examined a sample of 43 countries over the period 1985–1999 and found no statistically significant correlation between ICT investment and economic growth.

2.3 Financial sector development

A growing body of literature has acknowledged the important and dynamic role of financial sectors, particularly in reallocating and mobilizing resources to the most productive investments, diversifying risks, and supporting growth of other sectors, which in turn lead to higher economic growth (Beck et al. 2000; Greenwood and Jovanovic 1990; King and Levine 1993a, King and Levine 1993b; Levine and Zervos 1998; McKinnon 1973). Further, the discussion on financial and banking sector development has been linked to the advancement in technology as well as the need for stable sources of capital inflows.

Anga (2009) examined the nexus between FDI and economic growth of Malaysia by controlling for the level of financial development over the period 1965–2004. Anga found that FDI and financial development were positively related to the output in the long-run, and hence the impact of FDI was enhanced through financial development. Fung (2009) tested for the convergence in financial development and economic growth by incorporating the interaction between real and financial sectors. He found that mutually reinforcing relationship between financial development and economic growth was stronger in the early stages of economic development and this relationship diminished as growth become more sustainable. Subsequently, it was concluded that low income countries with a relatively well-developed financial sector are more likely to catch up to their middle- and high-income counterparts and those with a relatively under-developed financial sector are more likely to be trapped in poverty.

Hassan et al. (2009) used panel data on Chinese provinces to study the role of legal institutions, financial deepening and political pluralism on growth rates. They concluded that the development of financial markets, legal environment, awareness of property rights and political pluralism are linked to stronger growth. Further, Chiou Weia et al. (2010) investigated the influences of financial development on economic growth for South Korea using an error-correction model and a nonlinear smooth transition error correction technique. They found a long-run equilibrium relationship among financial development and economic growth and that the short-run effect of financial development on economic growth was unstable despite the positive long-term effect. Hassan et al. (2011) found the existence of a positive association between finance and economic growth for developing countries but contradictory results for high-income countries. In another study, Anwar and Nguyen (2011) used a panel data covering 61 provinces of Vietnam over the period 1997–2006 and found that financial development has contributed to economic growth.

Onoa (2012) examined the relationship between financial development and economic growth where he used money supply and loans relative to gross domestic product (GDP) as measures of financial development. Onoa found that money supply led to economic growth and the latter supported greater loans. Arizalaa et al. (2013) estimated the impact of financial development on industry level total factor productivity (TFP) growth using 77 countries with data for 26 manufacturing industries for the years 1965–2003. They found a significant relationship between financial development and industry-level TFP growth when controlling for country-time and industry-time fixed effects.

On the contrary, Kar et al. (2011) investigated the direction of causality between financial development and economic growth in the Middle East and North African (MENA) countries using panel causality approach based on the seemingly unrelated regressions (SUR) and Wald tests with the country specific bootstrap critical value for the period 1980–2007. Their results showed no clear consensus on the direction of causality between financial development and economic growth and the effects also differed for each country. Similarly, Kumar (2012) explored the interactive effects of remittances, financial development and ICT on economic growth in Sub-Saharan Africa over the period 1970–2010 using the ARDL bounds approach. He found that financial development per se was not significant. However, a positive effect was noted by the interaction of financial development with remittances and technology. In another study, Kumar and Kumar (2013) examined Fiji's economy and found that financial development is not statistically significant in the short-run, however is positive and significant in the long-run. Ahmed (2013) investigated the role of financial liberalization in promoting financial deepening and economic growth for 21 Sub-Saharan countries (SSA) by using GMM estimator in dynamic panel data that combines first difference and original specification to deal with the problems of weak instruments over the period 1981–2009. His results showed that financial liberalization is negatively associated with income growth in SSA region, however supports financial deepening and resource mobilization. Overall, the general consensus of various other studies (Khan and Senhadji 2003; Odhiambo 2010; Savvides 1995; Schubert et al. 2011) is that there is a positive correlation between financial development and economic growth despite mixed views on the direction of causality between the two.

3 Method, model and sample data

3.1 Framework and model

We used the conventional Cobb–Douglas type production function within the augmented Solow framework (Solow 1956). The extended Solow model is often used to explore the plausibility of various economic factors affecting growth, where factors besides capital and labor are treated as shift variables (Rao 2010). Starting with the conventional Solow model:

$$Y = A_t K_t^{\alpha} L_t^{\beta}, \tag{1}$$

where α and β are capital and labor shares respectively and $\alpha + \beta = 1$, thus assuming constant returns to scale. Hence, the per worker output (y_t) equation is defined as:

$$y_t = A_t k_t^{\alpha}, \quad \alpha > 0, \tag{2}$$

where $A =$ stock of technology and $k=$ capital per worker. The Solow model assumes that the evolution of technology is given by:

$$A_t = A_o e^{gT}, \tag{3}$$

where A_0 is the initial stock of knowledge and T is time.

Augmenting the model with tourism, telecommunications and financial development, we define the stock of technology as:

$$A_t = f(TUR, ICT, FIN), \tag{4}$$

where:

- *TUR* refers to tourism receipts (% GDP), a proxy for tourism,
- *ICT* refers to telecommunication lines (% population), a proxy for technology development,
- *FIN* refers to domestic credit (% GDP), a proxy for financial development.

Subsequently,

$$A_t = A_o e^{gT} TUR_t^{\phi} ICT_t^{\theta} FIN_t^{\gamma}, \tag{5}$$

and

$$y_t = (A_o e^{gT} TUR_t^{\phi} ICT_t^{\theta} FIN_t^{\gamma}) k_t^{\alpha}. \tag{6}$$

The above can be formulated as:

$$\Delta L y^{*} = g + \phi \Delta LTUR + \theta \Delta LICT + \gamma \Delta LFIN, \tag{7}$$

where ΔL denotes the partial differential of logs of respective variables, and the intercept term, g, is the *TFP*, compactly defined.

Table 1 Summarized data on key variables

Year	Output per worker in constant VND, ('000) (*y*)	Capital per worker in constant VND, ('000) (*k*)	Tourism receipts (% GDP) (*TUR*)	Telecommunications lines (% population) (*ICT*)	Domestic credit (% GDP) (FIN)
1980–1985	2118.3	3005.7	0.1	4.6	1.8
1986–1990	2448.7	3694.7	0.1	8.7	3.2
1991–1995	3109.5	4935.9	0.5	15.9	4.2
1996–2000	4223.8	7227.5	2.3	24.4	3.1
2001–2005	5508.3	10826.3	8.2	51.1	3.7
2006	6677.6	13911.8	10.2	71.2	4.7
2007	7164.2	15482.1	13.1	93.4	5.3
2008	7535.7	16991.2	17.2	90.2	4.3
2009	7853.6	18586.2	20.1	112.7	3.1
2010	8299.3	20343.9	16.4	125	3.9

Source WorldBank (2012)

3.2 Data and method

We examined the annual data for Vietnam over the periods 1980–2010. Data on capital stocks is built using the perpetual inventory method, where the gross fixed capital formation at 2000 constant Vietnamese Dong (VND) is used as a proxy for investment.[1] The output is defined as GDP at 2000 constant VND. Annual labour stock data is estimated using the average employment ratio times the respective year of population. The ICT is proxied with annual telecommunication lines as a percent of total population. Tourism receipts as a percent of GDP is used as a proxy for tourism development.[2] All data on key variables were sourced from *World Development Indicators and Global Development Finance* database (WorldBank 2012). A summary of the data is provided in Table 1. The variables used in the analysis were duly transformed into natural log form.

Next we use the autoregressive distributed lag (ARDL) procedure developed by Pesaran et al. (2001) to test the existence of a long-run relationship between output per worker, capital per worker, tourism, ICT and financial development. The ARDL approach is used because this procedure is relatively simple and easy to implement with a relatively small sample size (Pesaran et al. 2001; Ghatak and Siddiki 2001). Moreover, in this approach, one is not required to test for unit roots and it is possible to investigate cointegration irrespective of the order of integration. In other words, the variables can be either I(0), I(1) or a combination of both. However, we emphasize the need to conduct the unit root tests to justify using ARDL approach instead of other approaches, such as ordinary least squares (OLS) method which is not recommended for variables in the presence of unit root. Further, the information on the maximum order of integration is useful should one decide to pursue the Toda and Yamamoto (1995) procedure for testing causality. With the aforesaid motivations, we carried out the

[1] Capital stock, K_t, is defined as $K_t = (1 - \delta)K_{t-1} + I_t$, where δ is the depreciation rate and I_t is the investment in constant US dollars. Labour stock is estimated from employment to population ratio. We used $\delta = 0.08$; and initial K_0 is set as 1.5 times the 1980 GDP in constant 2000 prices.

[2] The data on tourism receipts reported by the WorldBank (2012) was 2003–2010 periods. However, to ensure we have consistent data available for analysis, we used the growth of visitor arrival to estimate data for tourism receipts from 1980–2002.

Table 2 Results of unit root tests

Variables in log form	ADF		Phillips and Perron	
	Level	First difference	Level	First difference
Ly	-4.041^b	-2.889^c	-3.887^b	-7.040^a
Lk	-1.711	-3.919^a	-6.382^a	-3.605^b
LTUR	-3.564^c	-4.918^a	-2.096	-5.626^a
LICT	-2.837	-3.789^a	-1.886	-3.811^a
LFIN	-2.307	-5.931^a	-2.307	-6.454^a

The ADF critical values are based on Mackinnon (1996). The optimal lag is chosen on the basis of Akaike Information Criterion (AIC). The null hypothesis for both ADF and Phillips–Perron tests is a series has a unit root (non-stationary)

[a,b,c] Rejection of the null hypothesis of unit root at 1, 5 and 10 % level of significance, respectively

unit-root test. In doing so, we used the ADF and Phillips–Perron tests to examine the time series properties of the variables and computed the unit root statistics. We found that all variables were stationary at most in their first differences (Table 2) hence confirming the maximum order of integration is one.

3.3 Cointegration results

At the outset, we do not have information about the direction of the long-run relationship between output per worker (*Ly*), capital per worker (*Lk*), tourism (*LTUR*), technology (*LICT*), and financial development (*LFIN*). Therefore, we constructed the following ARDL equations to investigate the long-run cointegration relationship:

$$\begin{aligned}\Delta Ly_t =\; & \beta_{10} + \beta_{11} Ly_{t-1} + \beta_{12} Lk_{t-1} + \beta_{13} LTUR_{t-1} + \beta_{14} LICT_{t-1} + \beta_{14} LFIN_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{11i} \Delta Ly_{t-i} + \sum_{i=0}^{p} \alpha_{12i} \Delta Lk_{t-i} + \sum_{i=0}^{p} \alpha_{13i} \Delta LTUR_{t-i} + \sum_{i=0}^{p} \alpha_{13i} \Delta LICT_{t-i} \\ & + \sum_{i=0}^{p} \alpha_{13i} \Delta LFIN_{t-i} + \varepsilon_{1t}, \end{aligned} \tag{8}$$

$$\begin{aligned}\Delta Lk_t =\; & \beta_{20} + \beta_{21} Ly_{t-1} + \beta_{22} Lk_{t-1} + \beta_{23} LTUR_{t-1} + \beta_{24} LICT_{t-1} + \beta_{24} LFIN_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{21i} \Delta Ly_{t-i} + \sum_{i=0}^{p} \alpha_{22i} \Delta Lk_{t-i} + \sum_{i=0}^{p} \alpha_{23i} \Delta LTUR_{t-i} + \sum_{i=0}^{p} \alpha_{23i} \Delta LICT_{t-i} \\ & + \sum_{i=0}^{p} \alpha_{23i} \Delta LFIN_{t-i} \varepsilon_{2t}, \end{aligned} \tag{9}$$

$$\begin{aligned}\Delta LTUR_t =\; & \beta_{30} + \beta_{31} Ly_{t-1} + \beta_{32} Lk_{t-1} + \beta_{33} LTUR_{t-1} + \beta_{34} LICT_{t-1} + \beta_{34} LFIN_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{31i} \Delta Ly_{t-i} + \sum_{i=0}^{p} \alpha_{32i} \Delta Lk_{t-i} + \sum_{i=0}^{p} \alpha_{33i} \Delta LTUR_{t-i} \\ & + \sum_{i=0}^{p} \alpha_{33i} \Delta LICT_{t-i} + \sum_{i=0}^{p} \alpha_{33i} \Delta LFIN_{t-i} + \varepsilon_{3t}, \end{aligned} \tag{10}$$

Table 3 Results of bound tests

Dependent variable		Computed F-statistic
Ly		12.58[a]
Lk		2.12
LTUR		1.93
LICT		1.39
LFIN		2.92
Critical value (%)	Lower bound value	Upper bound value
1	3.74	5.61
5	2.86	4.01
10	2.45	3.52

Critical values are obtained from Pesaran et al. (2001), k = 4; Table CI.iv: Case IV with unrestricted intercept and no restricted trend, p. 300. NB: [a] indicates significance at 1% level

$$\begin{aligned}\Delta LICT_t = {} & \beta_{40}+\beta_{41}Ly_{t-1}+\beta_{42}Lk_{t-1}+\beta_{43}LTUR_{t-1}+\beta_{44}LICT_{t-1}+\beta_{44}LFIN_{t-1}\\ & +\sum_{i=1}^{p}\alpha_{41i}\Delta Ly_{t-i}+\sum_{i=0}^{p}\alpha_{42i}\Delta Lk_{t-i}+\sum_{i=0}^{p}\alpha_{43i}\Delta LTUR_{t-i}\\ & +\sum_{i=0}^{p}\alpha_{43i}\Delta LICT_{t-i}+\sum_{i=0}^{p}\alpha_{43i}\Delta LFIN_{t-i}+\varepsilon_{4t},\end{aligned} \tag{11}$$

$$\begin{aligned}\Delta LFIN_t = {} & \beta_{50}+\beta_{51}Ly_{t-1}+\beta_{52}Lk_{t-1}+\beta_{53}LTUR_{t-1}+\beta_{54}LICT_{t-1}+\beta_{55}LFIN_{t-1}\\ & +\sum_{i=1}^{p}\alpha_{51i}\Delta Ly_{t-i}+\sum_{i=0}^{p}\alpha_{52i}\Delta Lk_{t-i}+\sum_{i=0}^{p}\alpha_{53i}\Delta LTUR_{t-i}\\ & +\sum_{i=0}^{p}\alpha_{53i}\Delta LICT_{t-i}+\sum_{i=0}^{p}\alpha_{53i}\Delta LFIN_{t-i}+\varepsilon_{5t}.\end{aligned} \tag{12}$$

In examining the cointegration relationship, there are two steps involved: First, equations (8)–(12) are estimated separately by OLS techniques. Second, the existence of a long-run relationship is traced by imposing a restriction on all estimated coefficients of lagged level variables equating to zero for each equation. Hence, in essence, bounds test is based on the F-statistics (or Wald statistics) with the null hypothesis of no cointegration ($H_0 : \beta_{i1} = \beta_{i2} = \beta_{i3} = \beta_{i4} == \beta_{i5}$) against the alternative hypothesis of existence of long-run cointegration ($H_1 : \beta_{i1} \neq 0; \beta_{i2} \neq 0; \beta_{i3} \neq 0; \beta_{i4} \neq 0; \beta_{i5} \neq 0$). If the computed F-statistics falls above the upper critical bound, then the null hypothesis of no conintegration is rejected at the given levels of significance. Alternatively, if the test statistics falls below the lower bounds, then the null hypothesis is accepted at the given level of significance. In case when the F-statistics falls within the upper and lower bounds, the outcome is inconclusive. The results of the bounds tests confirmed the presence of a long run relationship at 1 % level of significance when only real output per worker (*Ly*) was set as the dependent variable (F-statistics = 12.58) (Table 3).

Next, we examined the diagnostic tests from the lag estimates of the ARDL regression results where we consider the (a) Lagrange multiplier test of residual serial correlation (I), (b) Ramsey's RESET test using the square of the fitted values for correct functional form

Table 4 Diagnostic tests—from the ARDL approach: ARDL (1,1,0,1,1)

Test types	LM version	*p* value	F version	*p* Value
(I) Serial correlation	$\chi 2$ (1) = 5.0647[b]	0.024	F(1,19) = 3.8592	0.064[b]
(II) Functional form	$\chi^2(1) = 1.7019$[a]	0.192	F(1,19) = 1.1427	0.298[a]
(III) Normality	$\chi^2(2) = 0.5684$[a]	0.753	Not applicable	
(IV) Heteroscedasticity	$\chi^2(1) = 0.5430$[a]	0.461	F(1, 28) = 0.5161	0.478[a]

ADL lag estimates test statistics

R-squared	0.9997	R-bar-squared	0.9996
SE of regression	0.0090	F-stat. F(9, 20)	8176.0
Mean of dependent cariable	15.140	SD of dependent variable	0.4532
Residual sum of squares	0.0016	Equation log-likelihood	104.85
Akaike info. criterion	94.847	Schwarz Bayesian criterion	87.841
DW-statistic	1.3036	Durbin's h-statistic	2.4557

[a,b] Rejection of null hypothesis of the presence of (I)–(IV) at 1 and 5 % level of significance

(II), (c) normality test based on a test of skewness and kurtosis of residuals (III), and (d) heteroscedasticity test based on the regression of squared residuals on squared fitted values (IV). The results (Table 4) showed the cointegrated equation performed well as the disturbance terms are normally distributed and serially uncorrelated with homoscedasticity of residuals duly confirming the model has a correct functional form. Moreover, the CUSUM and CUSUM of squares plot showed the parameters of the model are relatively stable over time (Fig. 1a, b).

4 Regression results

4.1 Short-run

The short-run results show that per worker capital contributes about 1.57 % ($\Delta Lk = 1.5653$) to the output per worker, which is statistically significant at 1 % level (Table 5). Moreover, tourism receipts ($\Delta LTUR = 0.0132$), which is statistically significant at 5 % level contributes about 0.01 % to the per worker output. The positive effect from tourism is marginal in the short-run, however, is important given that most of the provinces in Vietnam heavily depend on tourism sector. However, the short-run effects of telecommunications ($\Delta LICT = 0.0131$ − proxy for ICT) and domestic credit ($\Delta LFIN = 0.0315$ − proxy for financial development), although positive, are not statistically significant within the conventional level of significance. This is plausible since the financial and ICT sectors are relatively young and emerging on one hand and the heavy investment that is required in these sectors with benefits and spillovers that materialize in the long-run. Moreover, the banking sector in Vietnam is characterized with high non-performing loans (NPLs) estimated to be somewhere between 4.9 and 8.8 % (Mishra and Dinh 2012) which is likely to create a weakening effect in the short-run. In the same vein, although the penetration of mobile and cellular technology is growing, it remains relatively less accessible in remote areas where the necessary technology infrastructure remains undeveloped.

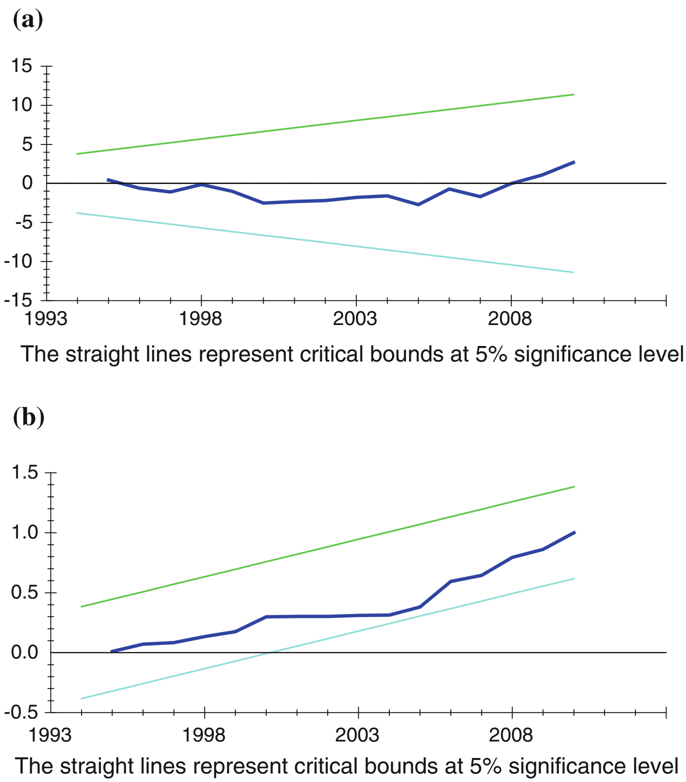

Fig. 1 **a** Cumulative sum of recursive residuals: Vietnam. **b** Cumulative sum of squares of recursive residuals: Vietnam

The error correction term ($ect_{t-1}= -0.4189$), which measures the speed at which prior deviations from equilibrium are corrected, has correct (negative) sign and is significant at 1 % level duly indicating a relatively speedy convergence to long-run equilibrium. In other words, about 42 % of the previous period deviations are corrected in the current period.

4.2 Long-run

In the long-run (Table 5), we find that per worker capital share is 0.39 ($Lk = 0.3871$), indicates that per worker output increases by 0.39 % given a 1 % increase in capital productivity. Telecommunications ($LICT = 0.1045$) and domestic credit ($LFIN = 0.2102$), which are proxies for ICT and financial development respectively, indicate a positive and statistically significant effect within the 1–10 % level of significance. In other words, ICT contributed about 0.10 % and financial development about 0.21 % to the long-run per worker output. Further, we find that tourism receipts, [although positive ($LTUR = 0.0316$)] is not statistically significant within the conventional level, in the long-run. The short-run effects of tourism indicate the plausibility that most of the tourism receipts are being predominantly diverted to consumption expenditure, hence does not permeate to investment oriented initiatives which are critical to long-run growth.

In both periods (short-run and long-run), we noted the trend coefficients are negative ($Trend = -0.0132$ in the short-run and $Trend = -0.0316$ in the long-run). The trend

Table 5 Estimated long run coefficients and error correction representation

Long-run: Dependent variable Ly_t				Short-run: Dependent variable ΔLy_t			
Regressor	Coefficient	Standard error	t-Ratio	Regressor	Coefficient	Standard error	t-Ratio
Lk	0.3871	0.1083	3.574[a]	ΔLk	1.5653	0.4739	3.303[a]
LTUR	0.0316	0.0191	1.650	$\Delta LTUR$	0.0132	0.0056	2.366[b]
LICT	0.1045	0.0267	3.911[a]	$\Delta LICT$	0.0131	0.0086	1.519
LFIN	0.2102	0.0998	2.106[b]	$\Delta LFIN$	0.0315	0.0303	1.040
Constant	8.7947	1.5918	5.525[a]	*Constant*	3.6842	0.9207	4.002[a]
Trend	−0.0316	0.0147	−2.149[b]	*Trend*	−0.0132	0.0044	−2.994[a]
				ect_{t-1}	−0.4189	0.1150	−3.642[a]

Short-run dynamics test statistics			
R-squared	0.8339	R-bar-squared	0.7591
SE of regression	0.0090	F-stat. F(6, 23)	16.733
Mean of dependent variable	0.0494	SD of dependent Variable	0.0183
Residual sum of squares	0.0016	Equation log-likelihood	104.85
Akaike info. criterion	94.847	Schwarz Bayesian criterion	87.841
DW-statistic	1.3036	ARDL(1,1,0,1,1)	$N = 31$

[a,b] 1 and 5 % level of significance, respectively

variable can be used as a proxy for the effectiveness (or the lack of it) of structural and institutional factors influencing growth. However, identifying these factors is beyond the scope of this study. In this case, it is evident that certain structural factors are having a ‘pull-back’ or ‘growth-retarding’ effect. Therefore, it is incumbent that while obvious policies (such as those targeting ICT, tourism and financial development) towards improving growth are promoted, other plausible (negative) factors are addressed simultaneously in order to expedite the scale-up effect of ICT and financial development, whilst creating the supporting environment to boost tourism effects.

4.3 The Toda–Yamamoto (T–Y) approach to Granger non-causality test

Next, to give further merit to the cointegration results and the estimations of short-run and long-run results, the Granger causality test using the Toda and Yamamoto (1995) approach is carried out. This approach is suitable when the economic series are either integrated of different orders, not cointegrated, or both. In these cases, the error-correction model (ECM) cannot be applied for Granger causality tests and the standard (pair-wise) Granger causality test may not give robust results. Hence, Toda and Yamamoto (1995) provides a method to test for the presence of non-causality, irrespective of whether the variables are I(0), I(1) or I(2), not cointegrated or cointegrated of an arbitrary order. Moreover, using this procedure, one can also examine the ‘combined effects’ of the parameters (excluded variables) on the target variable. In order to carry out the Granger non-causality test, the model is presented in the following vector autoregression (VAR) system:

$$\begin{aligned} Ly_t &= \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} Ly_{t-i} + \sum_{j=k+1}^{d\max} \alpha_{2j} Ly_{t-j} + \sum_{i=1}^{k} \eta_{1i} Lk_{t-i} + \sum_{j=k+1}^{d\max} \eta_{2j} Lk_{t-j} \\ &+ \sum_{i=1}^{k} \phi_{1i} LTUR_{t-i} + \sum_{j=k+1}^{d\max} \phi_{2j} LTUR_{t-j} + \sum_{i=1}^{k} \delta_{1i} LICT_{t-i} + \sum_{j=k+1}^{d\max} \delta_{2j} LICT_{t-j} \\ &+ \sum_{i=1}^{k} \varsigma_{1i} LFIN_{t-i} + \sum_{j=k+1}^{d\max} \varsigma_{2j} LFIN_{t-j} \lambda_{1t}, \end{aligned} \tag{13}$$

$$\begin{aligned} Lk_t &= \beta_0 + \sum_{i=1}^{k} \beta_{1i} Lk_{t-i} + \sum_{j=k+1}^{d\max} \beta_{2j} Lk_{t-j} + \sum_{i=1}^{k} \theta_{1i} Ly_{t-i} + \sum_{j=k+1}^{d\max} \theta_{2j} Ly_{t-j} \\ &+ \sum_{i=1}^{k} \vartheta_{1i} LTUR_{t-i} + \sum_{j=k+1}^{d\max} \vartheta_{2j} LTUR_{t-j} + \sum_{i=1}^{k} \nu_{1i} LICT_{t-i} + \sum_{j=k+1}^{d\max} \nu_{2j} LICT_{t-j} \\ &+ \sum_{i=1}^{k} \xi_{1i} LFIN_{t-i} + \sum_{j=k+1}^{d\max} \xi_{2j} LFIN_{t-j} + \lambda_{2t}, \end{aligned} \tag{14}$$

$$\begin{aligned} LTUR_t &= \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} LTUR_{t-i} + \sum_{j=k+1}^{d\max} \gamma_{2j} LTUR_{t-j} + \sum_{i=1}^{k} \phi_{1i} Ly_{t-i} + \sum_{j=k+1}^{d\max} \phi_{2j} Ly_{t-j} \\ &+ \sum_{i=1}^{k} \mu_{1i} Lk_{t-i} + \sum_{j=k+1}^{d\max} \mu_{2j} Lk_{t-j} + \sum_{i=1}^{k} \kappa_{1i} LICT_{t-i} + \sum_{j=k+1}^{d\max} \kappa_{2j} LICT_{t-j} \\ &+ \sum_{i=1}^{k} \chi_{1i} LFIN_{t-i} + \sum_{j=k+1}^{d\max} \chi_{2j} LFIN_{t-j} + \lambda_{3t}, \end{aligned} \tag{15}$$

$$\begin{aligned} LICT_t &= \pi_0 + \sum_{i=1}^{k} \pi_{1i} LICT_{t-i} + \sum_{j=k+1}^{d\max} \pi_{2j} LICT_{t-j} + \sum_{i=1}^{k} \rho_{1i} Ly_{t-i} + \sum_{j=k+1}^{d\max} \rho_{2j} Ly_{t-j} \\ &+ \sum_{i=1}^{k} \omega_{1i} Lk_{t-i} + \sum_{j=k+1}^{d\max} \omega_{2j} Lk_{t-j} + \sum_{i=1}^{k} \psi_{1i} LFIN_{t-i} + \sum_{j=k+1}^{d\max} \psi_{2j} LFIN_{t-j} \\ &+ \sum_{i=1}^{k} \upsilon_{1i} LTUR_{t-i} + \sum_{j=k+1}^{d\max} \upsilon_{2j} LTUR_{t-j} + \lambda_{4t}, \end{aligned} \tag{16}$$

$$\begin{aligned} LFIN_t &= \sigma_0 + \sum_{i=1}^{k} \sigma_{1i} LFIN_{t-i} + \sum_{j=k+1}^{d\max} \sigma_{2j} LFIN_{t-j} + \sum_{i=1}^{k} o_{1i} Ly_{t-i} + \sum_{j=k+1}^{d\max} o_{2j} Ly_{t-j} \\ &+ \sum_{i=1}^{\upsilon} \iota_{1i} Lk_{t-i} + \sum_{j=k+1}^{d\max} \iota_{2j} Lk_{t-j} + \sum_{i=1}^{k} \varpi_{1i} LICT_{t-i} + \sum_{j=k+1}^{d\max} \varpi_{2j} LICT_{t-j} \\ &+ \sum_{i=1}^{k} \tau_{1i} LTUR_{t-i} + \sum_{j=k+1}^{d\max} \tau_{2j} LTUR_{t-j} + \lambda_{4t}, \end{aligned} \tag{17}$$

Table 6 Granger non-causality test

Excluded variable	Dependent variable: χ^2				
	Ly	*Lk*	*LTUR*	*LICT*	*LFIN*
Ly	–	1.4284 (0.4896)	9.982 (0.0068)[a]	2.145 (0.3422)	4.097 (0.1289)
Lk	8.411 (0.0149)[b]	–	6.501 (0.0388)[b]	1.367 (0.5048)	0.466 (0.7921)
LTUR	7.427 (0.0244)[b]	1.0215 (0.6000)	–	0.462 (0.7937)	2.864 (0.2389)
LICT	11.659 (0.0029)[a]	6.833 (0.0328)[b]	1.947 (0.3778)	–	1.451 (0.4840)
LFIN	14.573 (0.0007)[a]	17.502 (0.0002)[a]	2.239 (0.3264)	0.180 (0.9141)	–
Combined	45.880 (0.0000)[a]	28.223 (0.0004)[a]	20.211 (0.0096)[a]	9.295 (0.3181)	10.911 (0.2068)

[a,b] 1 and 5 %, level of significance, respectively, for causation; df = 2; *p* values in the parenthesis

where the series are defined in (13)–(17). The null hypothesis of no-causality is rejected when the *p* values falls within the conventional 1–10 % of level of significance. Hence, in (13), Granger causality from Lk_t to Ly_t, $LTUR_t$ to Ly_t, $LICT_t$ to Ly_t and $LFIN_t$ to Ly_t implies $\eta_{1i} \neq 0 \forall i$, $\phi_{1i} \neq 0 \forall i$, $\delta_{1i} \neq 0 \forall i$, and $\zeta_{1i} \neq 0 \forall i$, respectively. Similarly, in (14), Ly_t, $LTUR_t$, $LICT_t$ and $LFIN_t$ Granger causes Lk_t if $\theta_{1i} \neq 0 \forall i$, $\vartheta_{1i} \neq 0 \forall i$, $\nu_{1i} \neq 0 \forall i$, and $\xi_{1i} \neq 0 \forall i$, respectively; from (15) Ly_t, Lk_t, $LICT_t$ and $LFIN_t$ Granger causes $LTUR_t$ if $\varphi_{1i} \neq 0 \forall i$,$\mu_{1i} \neq 0 \forall i$, $\kappa_{1i} \neq 0 \forall i$, and $\chi_{1i} \neq 0 \forall i$, respectively, and from (16), Ly_t, Lk_t, $LFIN_t$ and $LTUR_t$ Granger causes $LICT_t$ if $\rho_{1i} \neq 0 \forall i$, $\omega_{1i} \neq 0 \forall i$, $\psi_{1i} \neq 0 \forall i$, and $\upsilon_{1i} \neq 0 \forall i$, respectively. Finally, from (17), Ly_t, Lk_t, $LICT_t$ and $LTUR_t$ Granger causes $LFIN_t$ if $o_{1i} \neq 0 \forall i$, $\iota_{1i} \neq 0 \forall i$, $\varpi_{1i} \neq 0 \forall i$, and $\tau_{1i} \neq 0 \forall i$, respectively. From the unit root results (Table 2) where the maximum order of integration is 1 (m = 1), and the optimal lag length chosen from ARDL estimates using the Akaike information and Schwarz Bayesian criteria ($p = 1$), the maximum lags needed to carry out the non-causality tests is 2 (p + m). The results of the causality tests are presented in Table 6.

From what follows, the non-causality results (Table 6), based on the chi-square (χ^2) values indicates a unidirectional causation from: capital per worker (*Lk*→*Ly*) (χ^2 = 8.411), ICT (*LICT*→*Ly*) (χ^2 = 11.659), and financial development (*LFIN*→*Ly*) ($\chi^2 = 14.573$), to output per worker within 1–5 % level of significance, respectively. Moreover, we also note a unidirectional causation from ICT (*LICT*→*Lk*) ($\chi^2 = 6.833$), and financial development (*LFIN*→*Lk*) ($\chi^2 = 17.502$) to capital per worker within 1–5 % level of significance, respectively. A bi-directional causation is noted between tourism and output per worker (*LTUR* ←→*Ly*) ($\chi^2 = 7.427$ and $\chi^2 = 9.982$). Further, in terms of joint causation, where the respective excluded variables 'combined effects' are considered (the combined effects capture the interactive causality effects on output), it is shown that excluded variables have a combined causation on output per worker ($\chi^2 = 45.880$), capital per worker ($\chi^2 = 28.223$) and tourism receipts ($\chi^2 = 20.211$).

5 Conclusion

In this paper, we set out to explore the short-run and long-run effects of tourism, ICT and financial development on economic growth in Vietnam over the period 1980–2010 using the augmented Solow framework and the ARDL bounds procedure. We also used the Toda–Yamamoto non-causality test to examine the direction of causality between these variables.

The results from the ARDL procedure revealed that tourism has a short-run effect only, whereas ICT and financial development has a long-run effect on output per worker. From what follows, the Toda–Yamamoto non-causality test revealed a unidirectional causality from capital per worker, ICT, and financial development to output per worker; and from ICT and financial development to capital per worker. A bi-directional causation was noted between tourism and output per worker indicating that both tourism and output per worker are mutually *reinforcing* each other.

Our results, at minimum, highlighted that capital productivity is the key driver of economic growth. In regards to the effects of shift parameters (tourism, ICT and financial development), ICT and financial development plays a relatively momentous and permeating role in the growth process, the latter coinciding with Anwar and Nguyen (2011). Further, the (short-term) effects of tourism are also worth exploiting to make in more inclusive to sustainable development agenda (Haley and Haley 1997). The long-run policies need to target greater technology and financial inclusion in the economy. Further, aggressively promoting the diffusion and investment in ICT will scale-up technology and enable a pervasive and permeating effect on virtually all sectors of the economy (Vu 2011).

Although we have empirically showed the pivotal role of tourism, ICT and financial development in enhancing growth in Vietnam, our findings are not without caveats. Firstly, data on tourism receipts as well as visitor arrival are relatively small and inconsistent (c.f. WorldBank 2012) and therefore we had to impute the missing data using the growth rate of visitor arrival (which was available for a relatively longer time horizon) as the next best guide. Secondly, the capital share is slightly higher than the stylized value of one-third which is not uncommon for developing countries for a couple of reasons: (a) when labor inputs tends to grow at a relatively slower rate than the capital; (b) when an economy has large numbers of self-employed persons who derive income from both capital and their own labor (Gollin 2002), thus making it difficult to obtain meaningful measures of income shares; (c) the plausibility of omitted variable biasness; and (d) because of the poor quality of data and the small sample size which is not uncommon among developing countries (Bosworth and Collins 2008). Thirdly, although a internet penetration and computer usage will be a relatively better measure of technology, data on these variables are not available. Similarly, data on access to mobile phones or subscriptions were scant. Against these limitations, the empirical study provides insights into the short-run and long-run effects and causation, and indicates the crucial role of tourism, ICT and financial development, besides capital productivity in meeting the ambition of becoming a modern and industrialized Vietnam by 2020.

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