Institution and decomposition of natural-disaster impact on growth

Yamamura, Eiji

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INSTITUTION AND DECOMPOSITION OF NATURAL-DISASTER IMPACT ON GROWTH

We investigated whether natural disasters enhance efficiency improvement, capital accumulation, and technological progress. Furthermore, we examined whether the influence of natural disasters depends on the legal origin. By using long-term panel data, this paper decomposes productivity growth measured by the growth of output per labor unit into three components: efficiency improvement, capital accumulation, and technological progress. After controlling for countries' specific unobservable characteristics and year-specific effects, we found that the impacts of natural disasters vary according to specifications. Natural disasters enhance capital accumulation and technological progress in non-French-civil-law countries, but have no effect in these areas in French-civil-law countries. (JEL : E25, O4, O15)

I. INTRODUCTION

External shocks have a tremendous effect on economic activity, and natural disasters are considered one such shock. Improvements in disaster-prevention technology would appear to reduce the influence of natural disasters in modern society. However, recent natural disasters, such as Hurricane Katrina in the United States and the Great East Japan Earthquake, have revealed that major disasters continue to have a profound effect on human society even in the most developed countries in the twenty-first century. Recently, there has been increasing interest in the economic consequences of natural disasters (Cavallo and Noy, 2009): for example, the impact of disasters on economic loss and death (e.g., Anbarci et al., 2005, Kahn, 2005, Escaleras et al., 2007; Toya and Skidmore, 2007; Cavallo et al., 2010; Yamamura, 2010), foreign direct investment (e.g., Escaleras and Register 2011), and economic growth (e.g., Skidmore and Toya, 2002; Crespo-Cuaresma et al., 2008; Strobl 2011; Escaleras and Register 2012).

There are various channels through which natural disasters influence economic growth (Skidmore and Toya 2002; Crespo-Cuaresma et al., 2008). It has been argued that natural disasters lead to destruction of capital stock and so reduce output. Disaster risk reduces the expected return on physical capital, and so investment in physical capital falls (Skidmore and Toya, 2002). On the other hand, as asserted in the seminal work of Skidmore and Toya (2002), "disasters also provide an opportunity to update the capital stock, thus encouraging the adoption of new technologies" (Skidmore and Toya 2002, 665)[1]. That is, natural disasters appear to have both negative and positive effects

[1] More recent work of Crespo-Cuaresma et al. (2008) demonstrated that the level of a country's development influences the benefit from capital upgrading.

on economic growth[2].

Skidmore and Toya (2002) pointed out the importance of the insurance market when the impact of natural disasters on growth is considered. Thus, they noted that "our study takes no account of the differential ability to insure against hazard" (Skidmore and Toya 2002, 682). The development of markets is believed to depend on institutional conditions. Institutions are considered to play an important role in reducing the impact of an economic crisis (Johnson et al., 2000; Acemoglu et al., 2003). As suggested by Cavallo and Cavallo (2010), the impact of an economic crisis, such as a banking crisis, on long-term economic growth depends on political institutions. In a similar way, the "net effect" of disasters on growth is thought to depend on such factors as the institutional background[3]. This is because long-term institutions are known to have a great effect on economic outcomes (e.g., Acemoglu et al., 2002; 2001; Du 2010) [4]. For example, a good deal of evidence suggests that legal origin is profoundly associated with incentives to economic agents and, therefore, economic performance (e.g., La Porta et al., 1997, 1998, 1999, 2008). Countries with better-developed financial systems show superior growth in capital-intensive sectors (Rajan and Zingales 1998). Furthermore, legal origin is considered to exogenously determine the degree of financial development that promotes economic growth (Levine 1998). According to evidence provided by La Porta et al. (1998), French civil-law countries offer the weakest legal protection to investors. It seems plausible therefore to assume that the insurance market

[2] In a similar vein, there are contradictory views about the impact of economic crises on growth (Cavallo and Cavallo, 2011). Crises increase uncertainty and reduce investment, resulting in impeded economic growth (Ramey and Ramey 1995). Conversely, crises enhance institutional improvements, leading to a rise in economic performance (Drazen 2002; Bordo 2007).

[3] However, an economic crisis appears to be an endogenous variable. Natural disasters are considered exogenous rather than endogenous shocks.

[4] The size of the aggregate price shock needed to alter financial conditions depends on the institutional environment (Bordo et al., 2002).

is less developed in French civil-law countries. In response to destruction of physical capital by natural disasters considered as a kind of external shock, investment in physical capital plays an important role in recovery from disaster damage and subsequent growth. After a natural disaster has occurred, investment in physical capital is, however, likely to be low in a country that offers poor legal protection to investors and thus has a less-developed insurance market. Consequently, natural disasters would be expected to hamper capital accumulation in French civil-law countries, impeding economic growth. However, the extent to which the impact of natural disasters on capital accumulation depends on institutions has hitherto received insufficient attention[5]. The aim of this paper is to remedy that.

In addition to capital accumulation, technological progress is a key factor in economic development. As asserted by Schumpeter (1912), creative destruction is the engine of technological progress, leading to economic growth. Natural disasters can be considered a catalyst of creative destruction (Skidmore and Toya 2002). It is important to decompose economic growth into various factors and then to examine the impact that natural disasters exert on them. Data envelopment analysis (DEA) allows the construction of a production frontier and the decomposition of labor-productivity growth into three components: efficiency improvement, capital accumulation, and technological progress (Banker et al. 1984; Cooper et al., 2000). Previous reports (Yamamura 2011, Yamamura and Shin 2007a, 2007b, 2008, Zheng et al., 1998; 2003) have used DEA to decompose labor-productivity growth so as to investigate economic growth more closely. Through regression analysis, these studies have examined how

[5] Skidmore and Toya (2002) found that natural disasters increased human capital accumulation rather than physical accumulation. However, they did not explore the relationship between natural disasters and human capital accumulation in terms of different institutional conditions.

various key independent variables have an effect on these three components. Adopting this approach, the present paper attempts to examine how natural disasters affect not only economic growth but also capital accumulation, efficiency improvement, and technological progress. Furthermore, the degree of influence of natural disasters on these factors depends on institutional settings, such as a country's legal origin, and that is also addressed in the present study.

Using panel data from 57 countries over a 25-year period from 1965 to 1989, the present study controls for year-specific and unobservable country-specific effects[6]. The main findings here provide evidence as follows: the effects of natural disasters on labor-productivity growth vary according to specifications and are thus inconclusive. However, natural disasters enhance capital accumulation and technological progress for non-French-civil-law countries, though disasters have no such effect in French-civil-law countries.

This paper is organized as follows. Section II explains briefly the strategy of the method used in the present paper and describes data sources. Subsequently, regression functions are presented. Section III discusses the results of the estimations. The final section offers concluding observations.

II. METHODOLOGY

[6] Skidmore and Toya (2002) did not control for the unobserved time-invariant features of countries when they examined the impact of natural disasters on growth; this was probably because they used a cross-sectional dataset. In addition to cross-country data, Crespo-Cuaresma et al. (2008) used panel data to examine the impact of natural disasters on growth. They did not control for the unobserved time-invariant features of countries, although regional dummies were included. Hence, institutional factors were not controlled for in these studies.

Data

Table I presents the independent-variable definitions, means, and the standard deviations of the analyzed data. The data relating to capital stock, per capita GDP, and population were collected from the Penn World Table (pwt 6.3), spanning the years 1965 to 1990 for 57 countries[7]. Apart from dependent variables, the variables were as follows. The key variable is the number of natural disasters, represented as NATDIS, which is predicted to affect economic growth. NATDIS was gathered from the Emergency Events Database (EM-DAT), which is constructed by the Center for Research on the Epidemiology of Disasters (CRED). Government size is a critical determinant of economic growth (Yamamura 2011). To capture government size, the rate of general government final consumption expenditure over GDP, which is represented as GOVSIZ, was included as an independent variable and was gathered from the World Bank (2010). The degree of international trade is believed to influence productivity. Economic openness, represented as OPEN, was captured by the rate of trade over GDP, which was collected from the Penn World Table (pwt 6.3). The proxy of human capital was schooling years, represented as SCHOOL. Schooling years for 1960, 1970, and 1980 were collected from Easterly and Levine (1997). Schooling years were unavailable for some years and so were insufficient for constructing panel data. Therefore, additional data were generated by interpolation, based on the assumption of constant changes in rates to make up for this deficiency[8]. The Gini coefficient of income, represented as GINI, was collected from the Standardized Income Distribution Database

[7] The data are available from the Center of International Comparisons at the University of Pennsylvania. http://pwt.econ.upenn.edu/ (accessed May 1, 2007).
[8] It must be noted that these data may suffer from measurement errors when interpolation is conducted. Caution should thus be exercised when interpreting the estimation results.

(SIDD) constructed by Salvatore (2008)[9].

Method

Kumar and Russell (2002) used DEA to construct a cross-country dataset by decomposing labor-productivity growth into three components. They conducted a simple, ordinary least squares (OLS) regression model, where the independent variable was the output per worker (labor-productivity) in 1965; the dependent variables were the percentage change between 1965 and 1990 for output per worker (labor-productivity growth), technological change, efficiency index, and capital accumulation index.

Following the approach of Kumar and Russell (2002)[10], the DEA method can decompose labor-productivity growth into efficiency improvement, capital accumulation, and technological progress, based on the Penn World Table (Färe et al., 1994, 1996)[11]. This approach has an advantage over the growth accounting approach in that we can further decompose total factor productivity growth, thereby obtaining more detailed information. I take these variables as dependent variables. This method allows an assessment of how and to what extent natural disasters have an effect on productivity growth through capital accumulation, efficiency improvement, and technological progress. (1) Capital accumulation can be regarded as a contribution of investment in physical capital to labor-productivity growth. (2) Efficiency improvement can be

[9] SIDD is based on a comprehensive collection of income-distribution data from the World Income Inequality Database (WIID), which is compiled by the United Nations University's World Institute for Development Economics Research. SIDD adjusts the raw WIID data for differences in scope of coverage, income definition, and reference unit to a nationally representative gross-income household per capita standard. There are various versions of SIDD, such as SIDD-1, SIDD-2, and SIDD-3. The present paper used SIDD-3, which is an interpolated and extrapolated version of SIDD-2.

[10] Kumar and Russell (2002) admitted that their method includes the possibility of an implosion of the technological frontier. Henderson and Russell (2005) precluded an implosion of this frontier over time. In the present paper, it is also precluded.

[11] This decomposed dataset is also used in Yamamura and Shin (2007a) and Yamamura (2011).

considered the contribution of technology (knowledge) spillovers to labor-productivity growth. (3) Technological progress can be considered the contribution of technology replacement, capturing Schumpeterian-type creative destruction to labor-productivity growth.

Using the above method, it is possible to examine whether and to what degree natural disasters—in determining productivity growth—affect investment in physical capital, technology (knowledge) spillover, and technology replacement.

Specification of the regression function

I would now like to formulate a regression function, which takes growth of labor productivity, growth of the level of efficiency, growth of the level of per capita capital, and change in the level of technology as dependent variables, denoted as GY_{it}. GY_{it}, is LY_{it1}–LY_{it0}. To estimate their determinants, the following equation is postulated:

$$LY_{it} = \alpha_1 LY_{it0} + \alpha_2 NATDIS_{it0} + \alpha_3 GOVSIZ_{it0} + \alpha_4 OPEN_{it0} + \alpha_5 SCHOOL_{it0} + \alpha_6 GINI_{it0} + \varepsilon_i + \nu_t + u_{it} ,$$

ε_t, ν_i, u_{it} represent the following unobservable effects, t's year-specific effects, the i'"s prefecture-specific effects, and the error term, respectively. $t0$ is the lagged year of the t's year. ν_i represents the time-invariant feature. The dataset used in this study has a panel structure. I incorporate a lagged-dependent variable, LY_{it0}, to control for the initial level. I employed a fixed-effects model with year dummies as the two-way fixed-effects model. The definition of each independent variable is presented in Table I. NATDIS represents the number of natural disasters, and it consists of various type of disasters. Previous works have divided these into climatic and geologic disasters and examined their effects on economic growth (Skidmore and Toya 2002; Crespo-Cuaresma et al., 2008). In addition to NATDIS, their effects were also examined. The effects of climatic disasters are almost the same as those of NATDIS, while geologic disasters have no effect on dependent variables. This is consistent with the argument that "climatic disasters are more reasonably proxy for physical capital-related catastrophic risk than geologic disasters since they tend to impact larger economic areas and occur periodically" (Crespo-Cuaresma et al., 2008, p.221). The results of climatic and geologic disasters are not reported here although they are available upon request. The frequency of natural disasters varies according to geographic factors. For instance, the probability of natural disasters depends on the location of a country with respect to plate tectonic fault lines. Furthermore, countries with a greater land surface area have a greater tendency to experience natural disasters even if other geographic conditions are the same. That is, the land mass is positively associated with the probability that natural disasters may take place in a country, which leads to estimation bias. To control for this, the number of disaster events is normalized by the land area (Skidmore and Toya 2002; Crespo-Cuaresma et al., 2008). The size of the land area is considered a time-invariant country-specific effect. Hence, the fixed-effects estimation control for this, and thus the unadjusted total number of natural disasters, is used in this paper.

The level of disaster-prevention technology is believed to improve over time, leading to a reduction in damage produced by natural disasters. Furthermore, climate changes around the world influence the frequency of natural disasters. These effects can be covered in ε_t, which is controlled by incorporating year dummies.

Apart from the key variable NATDIS, the initial level of income (LY_1) seems to be related to damage caused by natural disasters (e.g., Kahn 2005; Toya and Skidmore 2007; Kellenberg and Mobarak 2008; Yamamura 2010). Government size, represented as GOVSIZ, appears to be associated with economic growth since governments influence the allocation of resources and therefore impede economic activity (Yamamura 2011). Economic openness (OPEN) appears to enhance the introduction of new technologies to help prevent disasters. Schooling years (SCHOOL) captured human capital effects, which are widely known to be one of the key determinants of economic growth. Income inequality, measured by Gini coefficients, is also considered to be associated with economic growth.

III. ESTIMATION RESULTS

The estimation results of the fixed-effects model with a year dummy, which can be considered a two-way fixed-effects model for labor-productivity growth, capital accumulation, efficiency improvement, and technological progress, are presented, respectively, in Tables II, III, IV, and V. In each table, the results of the whole sample, the sample of non-French-civil-law countries, and those of French-civil-law countries are displayed as (a), (b), and (c). Each table indicates the results of five specifications for checking whether the data are robust to alternative specifications. The sample size was reduced when independent variables were added because additional independent variables were not available for some countries. This paper focuses on the effect of natural disasters on each dependent variable.

Labor-productivity growth

Table II shows the results concerning the determinants of labor-productivity growth. NATDIS yields a positive sign in all estimations in Table IIa, b, and c. However, it is statistically significant only in columns 1 and 2 of Table IIa and c, and in columns 2 and 5 of Table IIb. Thus, by using the whole sample, it is not conclusive whether NATDIS has a positive effect on labor-productivity growth. Furthermore, the impact of natural disasters shows no difference between non-French- and French-civil-law countries. At least, it can be argued that natural disasters do not reduce labor-productivity growth, which is in line with the findings reported using cross-country data (Skidmore and Toya, 2002).

Capital accumulation

From Table IIIa, it is evident that NATDIS produced a positive sign in all columns, while being statistically significant in columns 1 and 2. Therefore, the positive effects of natural disasters on capital accumulation are not robust to alternative specifications. The results presented in Table IIIb indicate that the coefficients of NATDIS take a significant positive sign in all estimations. This demonstrates that natural disasters enhanced capital accumulation in non-French-civil-law countries. Conversely, Table IIIc indicates that the coefficients of NATDIS take a positive sign in columns 1, 4, and 5 though they take a negative sign in columns 2 and 3. From this, it can be concluded that natural disasters have a positive impact on capital accumulation in non-French-civil-law countries but not in French-civil-law countries.

Skidmore and Toya (2002) argued that natural disasters reduce investment in physical capital because the expected rate of return to physical capital is reduced. Conversely, Skidmore and Toya (2002) also pointed out the possibility that "the potential increase in human capital induced by natural disasters may increase the return to physical capital, leading to an increase in physical capital investment. Also, some resources are used for disaster management and physical capital replacement following a disaster so that physical capital investment would increase" (Skidmore and Toya 2002, 677). Furthermore, "some countries may have highly developed insurance markets and therefore may be able to reduce the risks associated with disasters" (Skidmore and Toya 2002, 682). In French-civil-law countries, where legal protection for investors is weak, the insurance market is considered to be less developed (La Porta et al., 1998; 2008). The findings of the present paper indicate that the legal protection for investors increases the benefit following natural disasters on investments in physical capital. Consequently, the positive effects of natural disasters on investment outweigh the negative ones, leading to an increase in investment in physical capital in non-French-civil-law countries.

Efficiency improvement

I now turn to the results of Table IV. In Table IVa and c, the coefficient of NATDIS yields a positive sign in all columns. Conversely, it is evident in Table IVb that the coefficient of NATIDS produces a negative sign except in column 5. NATDIS, however, is not statistically significant in all estimations in Table IV a, b, and c. This means that natural disasters do not influence efficiency improvement at all, regardless of legal origin. I interpret this as suggesting that natural disasters do not enhance technology spillover, which is unaffected by legal origin.

Technological progress

Table Va indicates that NATDIS produces a positive sign in all columns and is statistically significant, with the exception of column 5. Therefore, the positive effects of natural disasters on technological progress are, to a certain extent, robust to alternative specifications. The results of Table Vb are similar to those in Table III a. It is clear from Table Vb that the coefficient of NATDIS takes a positive sign in all estimations and is statistically significant, with the exception of column 5. Conversely, Table Vc indicates that the coefficients of NATDIS take a positive sign in all columns, though this is not statistically significant in all estimations. Hence, natural disasters do not influence technological progress in French-civil-law countries. This confirms that natural disasters stimulate technological progress, resulting in Schumpeterian creative destruction. This effect of natural disaster is observed for non-French-civil-law countries but not for-civil-law countries. Put another way, Schumpeterian creative destruction takes place in response to an exogenous shock, such as a natural disaster. This, however, relies on institutional conditions to capture the legal protection for investors. The above findings can be interpreted as follows: The rate of return from investment in research and development (R&D) is low when the legal protection for investors is weak. Consequently, investment in R&D in response to natural disasters decreased in French-civil-law countries, which of course had a negative effect on technological progress.

IV. CONCLUSION

In response to an upsurge in interest in the outcomes of natural disasters from an economic point of view, an increasing number of studies have recently been devoted to investigating how such disasters affect economic growth. Little is known, however, regarding the channels through which natural disasters exert an effect on productivity growth. It is open to question whether the influences of natural disasters on capital accumulation, technology spillover, and technology progress are different. Accordingly, rather than putting an emphasis just on labor-productivity growth, this paper decomposes such growth into several components and closely examines them.

It is increasingly acknowledged that long-term institutional factors, such as the legal origin, have an effect on economic outcomes. As shown by Cavallo and Cavallo (2010), the impact of an economic crisis, such as a banking crisis, on growth varies according to institutional conditions. A natural disaster exerts a different type of shock to that of an economic crisis in that a natural disaster has a direct destructive impact on physical capital. In addition, natural disasters are thought to be a kind of exogenous shock; thus, examining the effect of natural disasters can be undertaken in the form of a natural experiment, although the occurrence of natural disasters, to a certain extent, can be predicted. Thus far, no researcher, however, has explored the impact of natural disasters on growth and institutional conditions. Hence, this paper attempts to examine how and to what extent the effect of natural disasters differs between different legal origins. To this end, this paper employs the DEA method for examination, using panel data from countries during the period 1960–89.

This paper compares the effect of natural disasters between French- and non-French-civil-law countries after controlling for year-specific and country-specific characteristics. This allows geographic characteristics of different countries to be controlled for. Accordingly, the effects of a country's land area and location can be controlled for and thereby exert no influence on the estimation results. Hence, variations in the frequency of disasters between French- and non-French-civil-law countries do not affect the estimation results. The key findings derived from empirical estimates are as follows: based on the whole sample of countries, the effects of natural disaster on capital accumulation, efficiency improvement, and technological progress are ambiguous. Once the sample is divided into non-French- and French-civil-law countries, natural disasters are seen to enhance capital accumulation and technological progress in non-French-civil-law countries, whereas such disasters have no effect in these areas in French-civil-law countries.

From the above findings, it can be plausibly pointed out that legal protection of investors is important in enhancing capital accumulation and thereby aiding recovery from the damage caused to physical capital stock after natural disasters. What is more, legal protection triggers Schumpeterian creative destruction through technological progress, whereas legal protection does not have an influence on knowledge spillovers captured by efficiency improvement. From this, I derived the argument that the role played by natural disasters on capital accumulation and Schumpeterian creative destruction depends on historical institutional conditions. Hence, it is important to consider the interaction between exogenous shock and institutions when examining economic growth.

It should be noted that legal origin possibly captures other factors, such as religious and cultural backgrounds. Furthermore, the effect of legal origin possibly reflects the level of economic development even if the level of output per worker is controlled for. If these points hold true, a different interpretation of the results of this paper may be made. For a closer examination of the legal origin effect, a micro-level dataset should be used to control for the level of a country's development and various institutional and individual characteristics. This is a major issue that remains to be addressed in future studies.

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TABLE I

DEFINITION OF VARIABLES, SOURCES, AND DESCRIPTIVE STATISTICS

Variables	Definition	Source	Mean	Standard deviation
LY_1	Output per worker in log form	Penn World Table. 5.6.	1.18	0.55
NATDIS	Total number of disasters	Emergency Events Database (EM-DAT)[a]	$0.01*10^{-2}$	$4.88*10^{-2}$
GOVSIZ	General government final consumption expenditure (% of GDP)	Penn World Table . 5.6.	$1.24*10^{-2}$	$2.04*10^{-2}$
OPEN	Trade (% of GDP)	World Development Indicators 2010	$0.76*10^{-2}$	$1.53*10^{-2}$
SCHOOL	Schooling years	Easterly and Levine (1997)	0.39	0.08
GINI	Income Gini coefficients	Standardized Income Distribution Database (SIDD)[c]	0.38	0.37

Notes: Sample is the same as that used for estimation results shown in column (5) in Tables II–V.

a. Data obtained from http://www.emdat.be. (accessed on June 1, 2011).

b. Data is available from http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:20700002~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html (access at June 2, 2011).

c. Data is available from http://salvatorebabones.com/data-downloads (accessed on June 2, 2011).

Data of French-civil-law countries is available from http://www.economics.harvard.edu/faculty/shleifer/dataset (accessed on June 1, 2011).

TABLE II

Determinants of productivity growth (fixed-effects model)

(a) Whole sample

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.05***	-0.04***	-0.06***	-0.04***	-0.03***
	(-2.79)	(-2.74)	(-3.43)	(-2.82)	(-2.83)
NATDIS	0.001**	0.001**	0.001	0.001	0.001
	(2.56)	(2.84)	(1.37)	(1.36)	(1.21)
GOVSIZ	-0.001	-0.001	-0.001*	-0.0009	
	(-1.37)	(-1.28)	(-1.70)	(-0.97)	
OPEN	0.0007**	0.0006**	0.0006***		
	(2.61)	(2.58)	(3.30)		
SCHOOL	-0.04	-0.03			
	(-1.49)	(-1.24)			
GINI	0.0001				
	(0.48)				
R-square(within)	0.16	0.15	0.13	0.12	0.12
Sample	1046	1121	1312	1312	1425
Groups	44	47	55	55	57

(b) Sample of non-French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.05*	-0.03	-0.04**	-0.03**	-0.02
	(-1.92)	(-1.63)	(-2.23)	(-2.19)	(-1.64)
NATDIS	0.001	0.001*	0.001	0.001	0.001**
	(1.37)	(1.84)	(1.68)	(1.65)	(2.31)
GOVSIZ	-0.003**	-0.003**	-0.003***	-0.003**	
	(-2.31)	(-2.75)	(-3.02)	(-2.67)	
OPEN	0.0006*	0.0004	0.0004		
	(1.89)	(1.56)	(1.56)		
SCHOOL	-0.07*	-0.06*			
	(-1.85)	(-1.82)			
GINI	0.0007				
	(0.56)				
R-square(within)	0.13	0.12	0.12	0.11	0.11
Sample	513	563	638	638	700
Groups	21	23	26	26	28

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

TABLE II

Determinants of productivity growth (fixed-effects model)

(c) Sample of French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.07***	-0.09***	-0.11***	-0.07***	-0.06***
	(-4.83)	(-4.17)	(-4.98)	(-3.60)	(-4.67)
NATDIS	0.002*	0.002*	0.0005	0.0007	0.0002
	(2.01)	(1.99)	(0.33)	(0.43)	(0.15)
GOVSIZ	0.0004	0.001	0.0008	0.001	
	(0.28)	(0.93)	(0.52)	(1.08)	
OPEN	0.001***	0.001***	0.0008***		
	(3.30)	(3.85)	(3.37)		
SCHOOL	0.01	0.04			
	(0.74)	(1.23)			
GINI	0.0001				
	(0.43)				
R-square(within)	0.30	0.28	0.21	0.18	0.17
Sample	533	558	674	674	725
Groups	23	24	29	29	29

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

TABLE III

Determinants of capital deepening (fixed-effects model)

(a) Whole sample

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.001	0.009	0.011	0.017*	0.015**
	(-0.15)	(0.96)	(1.13)	(1.98)	(2.10)
NATDIS	0.0006**	0.0005*	0.0004	0.0004	0.0004
	(2.34)	(1.99)	(1.27)	(1.21)	(1.35)
GOVSIZ	-0.001**	-0.0009**	-0.0009**	-0.0006*	
	(-2.47)	(-2.08)	(-2.11)	(-1.70)	
OPEN	0.0003***	0.0002**	0.0002**		
	(2.74)	(2.14)	(2.14)		
SCHOOL	0.02	0.03			
	(1.19)	(1.62)			
GINI	0.0004*				
	(1.76)				
R-square(within)	0.16	0.15	0.13	0.12	0.12
Sample	1046	1121	1312	1312	1425
Groups	44	47	55	55	57

(b) Sample of non-French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.004	0.0005	0.009	0.012	0.013
	(-0.34)	(0.05)	(0.71)	(0.89)	(1.14)
NATDIS	0.0007**	0.0009***	0.0007**	0.0007*	0.0007*
	(2.45)	(3.04)	(2.09)	(2.00)	(2.04)
GOVSIZ	-0.0005	-0.0006	-0.0007	-0.0005	
	(-1.24)	(-1.09)	(-1.30)	(-1.06)	
OPEN	0.0001	0.0001	0.0001		
	(1.30)	(0.43)	(1.11)		
SCHOOL	0.0006	-0.017			
	(0.02)	(-0.51)			
GINI	0.002***				
	(3.68)				
R-square(within)	0.13	0.12	0.12	0.11	0.11
Sample	513	563	638	638	700
Groups	21	23	26	26	28

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

TABLE III

Determinants of capital deepening (fixed-effects model)

(c) Sample of French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	0.007	0.019	0.012	0.023*	0.018*
	(0.69)	(1.48)	(0.87)	(1.92)	(1.76)
NATDIS	0.0001	-0.0004	-0.0004	0.0003*10^{-2}	0.0001
	(0.21)	(-0.11)	(-0.09)	(0.01)	(0.31)
GOVSIZ	-0.001***	-0.001**	-0.001	-0.0009	
	(-2.98)	(-2.35)	(-1.65)	(-1.40)	
OPEN	0.0007***	0.0006***	0.0002		
	(3.62)	(3.30)	(1.59)		
SCHOOL	0.05***	0.07***			
	(3.06)	(2.80)			
GINI	0.0002				
	(1.18)				
R-square(within)	0.30	0.28	0.21	0.18	0.17
Sample	533	558	674	674	725
Groups	23	24	29	29	29

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

TABLE IV

Determinants of efficiency improvement (fixed-effects model)

(a) Whole sample

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.04*	-0.05**	-0.07***	-0.06**	-0.05**
	(-1.74)	(-2.48)	(-2.98)	(-2.67)	(-2.65)
NATDIS	0.0004	0.0006	0.0003	0.0002	0.0002
	(0.77)	(0.95)	(0.38)	(0.38)	(0.33)
GOVSIZ	-0.0004	-0.0003	-0.0007	-0.0003	
	(-0.40)	(-0.33)	(-0.70)	(-0.33)	
OPEN	0.0001	0.0003	0.0003*		
	(0.70)	(1.14)	(1.76)		
SCHOOL	-0.054	-0.058			
	(-1.22)	(-1.35)			
GINI	-0.0002				
	(-0.97)				
R-square(within)	0.07	0.08	0.08	0.07	0.07
Sample	1046	1121	1312	1312	1425
Groups	44	47	55	55	57

(b) Sample of non-French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.03	-0.03	-0.05*	-0.04	-0.03
	(-0.99)	(-1.36)	(-1.74)	(-1.56)	(-1.33)
NATDIS	-0.0001	-0.0001	-0.0001	-0.0001	0.0004
	(-0.14)	(-0.17)	(-0.09)	(-0.15)	(0.60)
GOVSIZ	-0.002*	-0.002**	-0.003**	-0.002**	
	(-2.02)	(-2.39)	(-2.37)	(-2.18)	
OPEN	0.0002	0.0002	0.0002		
	(0.76)	(1.08)	(0.74)		
SCHOOL	-0.10	-0.08			
	(-1.60)	(-1.40)			
GINI	-0.002*				
	(-1.82)				
R-square(within)	0.10	0.10	0.09	0.09	0.08
Sample	513	563	638	638	700
Groups	21	23	26	26	28

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

TABLE IV

Determinants of efficiency improvement (fixed-effects model)

(c) Sample of French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.08***	-0.11***	-0.12***	-0.10***	-0.08***
	(-2.93)	(-2.97)	(-3.96)	(-3.60)	(-3.63)
NATDIS	0.001	0.001	0.0003	0.0004	-0.0001
	(1.45)	(1.56)	(0.19)	(0.24)	(-0.03)
GOVSIZ	0.002	0.003*	0.002	0.002	
	(1.39)	(1.88)	(1.20)	(1.54)	
OPEN	0.0003	0.0005	0.0004**		
	(1.01)	(1.49)	(2.41)		
SCHOOL	0.001	0.009			
	(0.02)	(0.17)			
GINI	-0.0002				
	(-0.09)				
R-square(within)	0.16	0.17	0.13	0.12	0.10
Sample	533	558	674	674	725
Groups	23	24	29	29	29

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

TABLE V

Determinants of technological progress (fixed-effects model)

(a) Whole sample

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.008	-0.001	0.001	0.004	0.002
	(-1.08)	(-0.22)	(0.20)	(0.70)	(0.49)
NATDIS	0.0005**	0.0005**	0.0003*	0.0003*	0.0003
	(2.26)	(2.64)	(1.80)	(1.80)	(1.66)
GOVSIZ	0.0003	-0.0001	-0.0002	0.0001	
	(0.10)	(-0.37)	(-0.06)	(0.21)	
OPEN	0.0001*	0.0001	0.0001		
	(1.77)	(1.09)	(1.30)		
SCHOOL	-0.012	-0.008			
	(-0.53)	(-0.42)			
GINI	0.00001				
	(0.08)				
R-square(within)	0.33	0.35	0.28	0.27	0.29
Sample	1046	1121	1312	1312	1425
Groups	44	47	55	55	57

(b) Sample of non-French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	-0.015**	-0.002	0.001	0.004	-0.0007
	(-2.36)	(-0.26)	(0.17)	(0.48)	(-0.08)
NATDIS	0.0004*	0.0006**	0.0004*	0.0004*	0.0004
	(1.75)	(2.73)	(1.81)	(1.77)	(1.63)
GOVSIZ	-0.0001	-0.0001	-0.0004	0.0001	
	(-0.13)	(-0.40)	(-0.10)	(0.12)	
OPEN	0.0002*	0.0001	0.0001		
	(2.01)	(0.77)	(0.88)		
SCHOOL	0.034	0.041			
	(1.49)	(1.66)			
GINI	0.0007				
	(1.40)				
R-square(within)	0.31	0.33	0.26	0.26	0.26
Sample	513	563	638	638	700
Groups	21	23	26	26	28

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

TABLE V
Determinants of technological progress (fixed-effects model)

(c) Sample of French legal origin

	(1)	(2)	(3)	(4)	(5)
LY_1	0.002	0.004	-0.0002	0.002	0.006
	(0.20)	(0.33)	(-0.02)	(0.31)	(0.71)
NATDIS	0.0005	0.0004	0.0002	0.0002	0.0002
	(1.69)	(1.57)	(0.85)	(0.89)	(0.65)
GOVSIZ	-0.0002	-0.0001	0.00002	0.0001	
	(-0.48)	(-0.37)	(0.06)	(0.20)	
OPEN	0.0001	0.0001	0.0001		
	(0.81)	(0.89)	(0.87)		
SCHOOL	-0.037	-0.036			
	(-1.55)	(-1.61)			
GINI	-0.0001				
	(-0.21)				
R-square(within)	0.41	0.44	0.30	0.30	0.33
Sample	533	558	674	674	725
Groups	23	24	29	29	29

Notes: Numbers in parentheses are t-statistics calculated using robust standard error. *,**, and *** indicate significance at 10-, 5-, and 1-percent levels, respectively. For each estimate, year dummies are included but are not reported to save space. In each column, the sample size may vary across different specifications owing to data availability.

Appendix

TABLE A1
LIST OF COUNTRIES

	Sample in column (1)	Sample in column (2)	Sample in column (3)-(4)	Sample in column (5)
1	ARGENTINA	ARGENTINA	ARGENTINA	ARGENTINA
2	AUSTRALIA	AUSTRALIA	AUSTRALIA	AUSTRALIA
3	AUSTRIA	AUSTRIA	AUSTRIA	AUSTRIA
4	BELGIUM	BELGIUM	BELGIUM	BELGIUM
5	BOLIVIA	BOLIVIA	BOLIVIA	BOLIVIA
6	CANADA	CANADA	CANADA	CANADA
7	CHILE	CHILE	CHILE	CHILE
8	COLOMBIA	COLOMBIA	COLOMBIA	COLOMBIA
9			COTE D'IVOIRE	COTE D'IVOIRE
10	.	.	DENMARK	DENMARK
11	DOMINICAN REPUBLIC	DOMINICAN REPUBLIC	DOMINICAN REPUBLIC	DOMINICAN REPUBLIC
12	ECUADOR	ECUADOR	ECUADOR	ECUADOR
13	FRANCE	FRANCE	FRANCE	FRANCE
14	GERMANY WEST	GERMANY WEST	GERMANY WEST	GERMANY WEST
15	GREECE	GREECE	GREECE	GREECE
16	GUATEMALA	GUATEMALA	GUATEMALA	GUATEMALA
17	HONDURAS	HONDURAS	HONDURAS	HONDURAS
18	HONG KONG	HONG KONG	HONG KONG	HONG KONG
19	.	ICELAND	ICELAND	ICELAND
20	INDIA	INDIA	INDIA	INDIA
21	.	.	IRAN	IRAN
22	IRELAND	IRELAND	IRELAND	IRELAND
23	ISRAEL	ISRAEL	ISRAEL	ISRAEL
24	ITALY	ITALY	ITALY	ITALY
25	.	JAMAICA	JAMAICA	JAMAICA
26	JAPAN	JAPAN	JAPAN	JAPAN
27	KENYA	KENYA	KENYA	KENYA
28	SOUTH KOREA	SOUTH KOREA	SOUTH KOREA	SOUTH KOREA
29	.	.	LUXEMBOURG	LUXEMBOURG
30	.	.	MADAGASCAR	MADAGASCAR
31	MALAWI	MALAWI	MALAWI	MALAWI
32	MAURITIUS	MAURITIUS	MAURITIUS	MAURITIUS
33	MEXICO	MEXICO	MEXICO	MEXICO
34	.	.	MOROCCO	MOROCCO
35	NETHERLANDS	NETHERLANDS	NETHERLANDS	NETHERLANDS
36	NEW ZEALAND	NEW ZEALAND	NEW ZEALAND	NEW ZEALAND
37	.	.	NIGERIA	NIGERIA
38	PANAMA	PANAMA	PANAMA	PANAMA
39	PARAGUAY	PARAGUAY	PARAGUAY	PARAGUAY

40	PERU	PERU	PERU	PERU
41	PHILIPPINES	PHILIPPINES	PHILIPPINES	PHILIPPINES
42	PORTUGAL	PORTUGAL	PORTUGAL	PORTUGAL
43	SIERRA LEONE	SIERRA LEONE	SIERRA LEONE	SIERRA LEONE
44	SPAIN	SPAIN	SPAIN	SPAIN
45	SRI LANKA	SRI LANKA	SRI LANKA	SRI LANKA
46	SWEDEN	SWEDEN	SWEDEN	SWEDEN
47	.	.	SWITZERLAND	SWITZERLAND
48	.	SYRIA	SYRIA	SYRIA
49	.	.	.	TAIWAN
50	THAILAND	THAILAND	THAILAND	THAILAND
51	TURKEY	TURKEY	TURKEY	TURKEY
52	UNITED KINGDOM	UNITED KINGDOM	UNITED KINGDOM	UNITED KINGDOM
53	UNITED STATES	UNITED STATES	UNITED STATES	UNITED STATES
54	VENEZUELA	VENEZUELA	VENEZUELA	VENEZUELA
55	.	.	.	YUGOSLAVIA
56	ZAMBIA	ZAMBIA	ZAMBIA	ZAMBIA
57	ZIMBABWE	ZIMBABWE	ZIMBABWE	ZIMBABWE

Note: List shows countries used for estimations in each column of Tables II, III, IV and V.