Determinants of Judicial Efficiency Change: Evidence from Brazil

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Abstract

Judicial efficiency matters for economic development. Nevertheless, the determinants of judicial productivity growth are not entirely understood in the literature. Using data of Brazil's state courts for the period of 2009 to 2014, this paper analyses judicial productivity change and its possible determinants over time in a two stage approach. First, data envelopment analysis is used to calculate Malmquist productivity measures which are decomposed in: technical change (frontier-shift effect) and efficiency change which is composed of pure efficiency change (catch-up effect) and scale efficiency change (size effect). In the second stage, fixed effect models are estimated to evaluate the determinants of judicial productivity growth. The first stage results show a slight improvement in judicial productivity trend, which is defined mainly by efficiency change, since technical change deteriorated in the period. While the second stage findings suggest the inexistence of a trade-off between judicial quality and efficiency improvement, while judges remuneration, legal complexity and technology use affect judicial productivity, however not always in the expected direction.

Keywords: Judicial Efficiency, Malmquist Index, Productivity, Brazilian Courts

Resumo

A eficiência judicial é importante para o desenvolvimento econômico, contudo os determinantes do crescimento da produtividade da justiça não são totalmente compreendidos na literatura. Usando dados de tribunais estaduais do Brasil para o período de 2009-2014, este artigo analisa a mudança da produtividade judicial e seus possíveis determinantes ao longo do tempo em uma abordagem de dois estágios. Primeiro, a análise envoltória de dados é usada para calcular medidas de produtividade de Malmquist que são decompostas em: mudança tecnológica (*frontier-shift effect*) e mudança de eficiência, sendo esta dividida em mudança pura de eficiência (*catch-up effect*) e mudança de eficiência de escala (*size effect*). Na segunda etapa, modelos de efeitos fixos são estimados para avaliar os determinantes do crescimento da produtividade judicial. Os resultados do primeiro estágio mostram uma ligeira melhoria na evolução da produtividade judicial, definida principalmente pela variação da eficiência, uma vez que a mudança tecnológica se deteriorou no período. Por sua vez, os resultados encontrados no segundo estágio sugerem a inexistência de um *trade-off* entre a qualidade judicial e a melhoria da eficiência, enquanto que a remuneração do judiciário, a complexidade criminal e o uso de tecnologia afetam a produtividade judicial, no entanto, nem sempre na direção esperada.

Palavras-chave: Eficiência Judicial, Índice de Malmquist, Produtividade, Tribunais Brasileiros

Área 6: Crescimento, Desenvolvimento Econômico e Instituições

JEL Code: K40, C23, H11

1. Introduction

Legal system effectiveness relies on efficient courts. An unenforceable law is no different than an inexistent rule. Economic agents react to incentives and the legal system is the basic society's formal incentive framework.

However, an inducement mechanism only works if the incentives are credible, otherwise a rational agent would be indifferent between following or not the norm. Law's credibility derives mainly from its enforceability to which the judiciary plays a central role.

As the New Institutional Economics has been showing, institutional design and performance are key factors for economic development. The firmly establishment of the rule of law is essential to generate a stable and predictable environment in developing countries. In addition to directly improve doing business conditions, it is also crucial to overcome other social problems that affect these nations, such as corruption and human rights violations. In this sense, since the nineties, the World Bank has been supporting justice reforms in emerging economies. Initially, those programs were focused on legislation reforms. However, quickly the Bank realized that laws alone would not be enough to achieve the reforms goals (World Bank, 2002). Therefore, it started to encourage and provide assistance to develop the institutions responsible to implement and enforce the law in these countries, thus mainly judicial reforms programs.

This new approach stimulated the creation of judicial statistics databases in several countries which favoured the development of empirical studies on judicial efficiency[1]. Indeed, some research has been conducted even on cross country basis (Buscaglia and Ulen, 1997, Dakolias, 1999, Blank et al., 2004). Although it is undeniably important to assess legal institutions's quality in a comparative perspective, cross nation judiciary efficiency analyses are affected by the diversity of legislations which lessen their ability to reveal the managerial determinants of court efficiency. Consequently, since at national level several factors that cannot be controlled by the courts (such as the legislation) but can affect their efficiency are intrinsically controlled by the data, within-country assessments have been more common (Pedraja-Chaparro and Salinas-Jimenez, 1996, Rosales-López, 2008, Yeung and Azevedo, 2011, Elbialy and García-Rubio, 2011, Dalton and Singer, 2013). However, most of those studies are cross-section analysis which neglect the time variable. Time is the dimension in which institutions evolve (North, 1994), thus it is crucial to reveal the determinants of judicial efficiency growth.

This paper analyses changes in judiciary efficiency and its determinants in a two stages approach. First, data envelopment analysis (DEA) is used to calculate the Malmquist index (a measure of productivity growth). The use of a productivity change index is preferable since it allows an analysis of the judicial performance evolution over time, including technical (innovation aspects) and efficiency variations. On the second stage, fixed effects models are estimated to assess the role of relevant variables, such as decision quality, courts' and external factors on productivity growth. As done by Posner (2000), Rosales-López (2008), Mitsopoulos and Pelagidis (2010), Dimitrova-Grajzl et al. (2016), reversal rate is used as a proxy for judicial decisions quality. The data used is from the 27 Brazil's state courts for the period of 2009 to 2014. This country's particularities, especially its continental dimensions, population and cultural diversity[2], combined with its relatively uniform legislation provide a singular database. Moreover, the covered period did not register any major legislation change (especially procedural law) while it encompasses different economic performances[3].

The remainder of this paper is structured as follows. The second section presents a discussion about the importance of judiciary efficiency. Section 3 briefly describes the structure of the Brazilian judiciary. Sections 4 and 5 present the methodology and the data used. Section 6 reports the results while section 7 concludes.

2. Judicial efficiency matters

Institutions play a central role in the economic development process. They are the incentives framework of a society. How individuals will and should behave, thus shaping economic outcome, as it has been demonstrated

[1] For a literature survey on this topic see Voigt (2016).

[2] Cultural traits might affect court efficiency, especially through the demand side (Landes, 1971, Vereeck and Muhl, 2000). However, in this paper those issues are controlled using fixed effects regressions, admitting that these features do not have an abrupt change in the short time.

[3] Since a 7.5% GDP growth (2010) until a 0.1% GDP stagnation (2014).

by the new New Institutional Economics (North, 1991, Acemoglu et al., 2005). The legal system is an obvious example of an institution. It represents the formal constraints that aim to frame people's behavior, consequently it must affect society's economic performance as Law and Economics scholars have been revealing in the last decades (Friedman, 2000, Ginsburg, 2000, Glaeser and Shleifer, 2002). However, a good legal system can only make a difference if enforcement does exist, since without it individuals might not have incentives to obey the rules of the game [4].

Adopting a Weberian concept[5], the State is the ultimate law enforcer in a society. Indeed, as soon as it took over the monopoly of the legitimate use of physical force, it also dragged the obligation to protect its citizens' rights. A modern state performs this duty through three branches: Legislative, Executive and Judiciary. The first one is responsible to enact the rules within a society. While the Executive's task is to execute and enforce the law, it can only well accomplish its mission if the law is interpreted and applied that are the functions of the third one. In fact, the main function of the Judiciary is to exercise the State's monopoly over jurisdiction (from the Latin *iuris*, "law", and *dicere*, "to speak"). Indeed, considering that the emergence of the State itself is related to dispute resolution[6] (Hobbes, 1968), the judiciary is a fundamental institution in any modern society. Its primary role is to assure society's members that there is an ultimate impartial third party which will resolve their disputes according to publicly available principles and rules, thus in a generally predictable manner Saez Garcia (1998). Hence it reduces uncertainty, consequently fosters economic growth.

As stated by Ronald Coase (1960), transaction costs are a major obstacle for market efficiency. Among them, enforcement costs are crucial. Contracts can only be efficiently concluded if the parties believe that the counterpart will comply with the agreement's clauses and if the promisor eventually breaches the contract, the promisee will be able to take an appropriate action against him to resolve the dispute. However, this action is not costless. To force a contractor to perform his promise (or to pay damages), in a modern society, means to use the Judiciary[7]. Consequently, the cost of a lawsuit is essentially a transaction cost, thus the higher it is, the less efficiently allocated the resources will be within a society.

Lawsuit's costs can be classified as direct and indirect. The direct costs of a lawsuit are the amount of money that the parties must spend to use the courts (lawyers' remuneration, courts' fees and so on). Indeed, those expenses might even affect the access to justice, especially in developing economies (Fauvrelle and Almeida, 2013). Whereas indirect costs can be defined as the nonmonetary ones (the time it takes, the decision's quality and so forth). Henceforth, the indirect costs of a lawsuit are intrinsically correlated to judiciary efficiency.

As defined by Landes and Posner (1979), the judiciary produces both a private and a public good. The decision taken by the court ends the parties' dispute, thus it is a private good for the plaintiff and the defendant. Nevertheless, at the same time, the decision creates also a precedent, an information which can be useful for every society's member that is facing (or will face) a situation similar to the one decided by the court, therefore it is also a public good. In this sense, efficient courts are in the best interest not only of the lawsuit's parties, but also in the interest of the entire community.

An efficient judicial system might also indirectly enhance economic development. Expectations play a central role in the economy. The belief that your property will be respected is a vital incentive to invest. Indeed, as demonstrated by Torstensson (1994), Dincer (2007) and Besley and Ghatak (2010) property rights do affect economic performance. In the case of developing countries, property rights' definition and protection might have an even stronger role (Sherwood et al., 1994). As found in Field (2005), strengthening property

[4] Indeed, Bhattacharya and Daouk (2009) suggest that in some situations a good law not enforced might lead to an equilibrium situation worse than a no law state.

[5] "A human community that (successfully) claims the monopoly of the legitimate use of the physical force within a given territory" (Weber, 1946, p. 78).

[6] According to Hobbes, the State would emerge to establish social peace among human beings that are naturally bellicose.

[7] Although Alternative Dispute Resolution (ADR) options might exist, the State, thus the Judiciary, is still the ultimate monopolist of the legitimate use of physical force.

rights in urban slums increases residential investment. This is critical in order to overcome the favelas' conditions in which a large part of their population lives. Furthermore, as shown by Lichand and Soares (2014) using Brazilian data, by securing property rights and enforcing contracts, the judiciary might also incentivize entrepreneurship which is fundamental for long-term growth and aggregate productivity.

Judiciary efficiency is also important in crime deterrence. Considering Becker (1968), the crime level in a society would be a function of, among other factors, the probability to be apprehended and convicted. Briefly, rational criminals balance the utility they can get by committing a wrongful act and the expected disutility of its punishment. Since the expected penalty depends on the probability to be arrested and sentenced, an efficient judiciary should discourage crimes, hence decreases crime level, thus fosters social welfare. Moreover, as the literature on drug prohibition has shown (Rasmussen et al., 1993, Cooney, 1997, Fryer et al., 2005), the unavailability of non-violent dispute resolution mechanisms (mainly courts) is associated with criminality. Concisely, since drugs are illicit, dealers and consumers cannot use official institutions (police, judiciary and so on) to resolve their disputes. Hence, they need to use their own methods, mainly violence, to overcome their problems. Analogically, it is straightforward to suppose a correlation between inefficient judicial systems and crime rates, since the extreme case (a completely inefficient judiciary) would be no different than courts unavailability.

Judicial inefficiency can also indirectly influence social welfare through human rights protection and corruption. Excessive pretrial detention is a clear example of how courts backlogs can directly violate individuals' fundamental rights. Additionally, it also contributes to prison overcrowding, deteriorating the conditions of the entire penitentiary system (Hafetz, 2002). Moreover, an weak judicial system is a condition to corruption (Jain, 2001). Indeed, corruption can be both cause and consequence of judicial inefficiency (Damania et al., 2004, Ismail and Rashid, 2014).

3. Summary of the Brazilian Judiciary structure

Brazil is a civil law jurisdiction composed by 27 federal unities. Although the Federal Constitution provides some autonomy in the law making process for the states (as well as for the federal district and the municipalities), most of the Brazilian legislation is made on the Federal level. For instance, the civil and criminal codes (together with the civil and procedure codes) are both federal laws. Consequently, the Federal Republic of Brazil has a relatively uniform legislation, if compared to other federal states, such as the United States of America.

The Federal Constitution also sets the guidelines for the organization of the judiciary. At the top of the system is the Supreme Court which deals mainly only with constitutional cases (mostly appeals of lower Courts decisions on constitutional matters). Below it, there are the specialized (Superior Labour Court, Superior Military Court and Superior Electoral Court) and the general (Superior Court of Justice) superior courts, all located in Brazil's capital city (Brasilia). The specialized tribunals have also lower courts (regional court of labour, regional electoral court and so on), usually one for each state, which are the second instance for the first level specialized judges. Since Brazil is a federation, it has Federal and State courts, both of them have the Superior Court of Justice as the third level tribunal. The Federal judiciary has its competence specified by the Constitution (basically cases involving the Federal State itself, indigenous communities, international cases and other specific proceedings).

Henceforth, the state courts' competence is residual: everything that the Constitution does not specify to another judiciary branch must be judged by them. Consequently, the majority[8] of the cases in Brazil are handled by the state courts. Every federal unit (26 states and the federal district which is considered in this work as a state) has its own first instance (state judges) and appellate courts. Although, the federal law (Federal Constitution and the National Judiciary Organic Law) provides the general guidelines for their framework, the

[8]For instance, in 2014, the state courts received about 70% of the new cases filled in the entire Brazilian judicial system.

states are responsible for the organization of their own judiciary. As a consequence, each state has a different structure: the quantity of judges and public servants, their remuneration, the number and specialization degree of the judicial districts, the budget and so forth. Therefore, considering that the legislation applied by the courts is basically the same across the country, the differences among courts' productivities should be influenced by their own factors.

4. Methodology

To achieve the goals set, this empirical analysis is comprised by two stages. The first builds a productivity index of the courts using nonparametric efficiency measures. The second stage evaluates the relationship between productivity growth and relevant factors that might affect it, as set by the literature.

4.1. Stage 1: Malmquist Index

According to Färe et al. (1994b) and Färe and Grosskopf (1996), the Malmquist index measures the total factor productivity (TFP) change over time, where this indicator can be decomposed into two main components: efficiency change (EC) and technical change (TC). The former, also known as catch-up effect, measures relative efficiency over time, indicating whether production converges or diverges to the frontier. If EC>1, we have a convergence process, in which courts with initial low productivity levels adopt more efficient techniques already implemented by the other courts. The TC, alias frontier-shift effect, captures the change in productivity which is due to innovation. This index based on input and output data using Data Envelopment Analysis (DEA) was developed by Färe et al. (1994b).

Färe et al. (1994b) calculate the Malmquist productivity index using a geometric mean of two reasons: the first uses as a reference the frontier of the period t and then the frontier of the period $t+1$. This indicator is a geometric mean of two ratios of function distance[9], considering the technical frontier at different moments and the relationship between outputs ($\mathbf{y}$) and inputs ($\mathbf{x}$). Equation 1 expresses the Malmquist index:

$$m(\mathbf{x}_{t+1}, \mathbf{y}_{t+1}, \mathbf{x}_t, \mathbf{y}_t) = m = \left[\frac{d^t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{d^t(\mathbf{x}_t, \mathbf{y}_t)} \times \frac{d^{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{d^{t+1}(\mathbf{x}_t, \mathbf{y}_t)}\right]^{1/2}. \tag{1}$$

Note that $m > 1$ reveals an improvement in the judicial productivity between periods t and $t+1$, while $m < 1$ indicates a decline in TFP. Equation 2 shows the Malmquist index decomposed into change of TC (or frontier-shift effect) and EC (or catch-up effect):

$$m(\mathbf{x}_{t+1}, \mathbf{y}_{t+1}, \mathbf{x}_t, \mathbf{y}_t) = TC \times EC, \tag{2}$$

where: $EC = \dfrac{d^{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{d^t(\mathbf{x}_t, \mathbf{y}_t)}$ and $TC = \left[\dfrac{d^t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})}{d^{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})} \times \dfrac{d^t(\mathbf{x}_t, \mathbf{y}_t)}{d^{t+1}(\mathbf{x}_t, \mathbf{y}_t)}\right]^{1/2}$. The TC is calculated as geometric mean of two shifts.

The DEA approach calculates the functions distance $d(\cdot)$. In short, to calculate m it is necessary to resolve four linear programming problems. In all cases, we have: $\lambda \geq 0$.
where: x and y represent a given input and output used in t and $t-1$, X and Y indicate the vectors of inputs and outputs, λ is a weight, ϕ is the efficiency score $\in [1, \infty]$ and $\theta = (\phi)^{-1}$ represent the efficiency score $\in [0, 1]$.

In two problems (A, B), the functions distance evaluate the decision making units (DMUs) with the corresponding technology available (contemporary frontier), and others evaluate the production plans in a given period with the technology of another moment in time (C, D). In this work, following Färe et al. (1994b), we

[9]The function distance shows the degree of efficiency of the decision making unit (DMU) in relation to the frontier technical reference.

$$
\begin{array}{ll}
\begin{array}{c}\theta = [d^t(\mathbf{x}_t, \mathbf{y}_t)]^{-1} = \max_{\phi,\lambda} \phi \\ \text{s.t. } -\phi y_{it} + Y_t\lambda \geq 0 \\ x_{it} - X_t\lambda \geq 0\end{array} \quad \text{(A)} &
\begin{array}{c}\theta = [d^{t+1}(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})]^{-1} = \max_{\phi,\lambda} \phi \\ \text{s.t. } -\phi y_{it+1} + Y_{t+1}\lambda \geq 0 \\ x_{it+1} - X_{t+1}\lambda \geq 0\end{array} \quad \text{(B)} \\
\begin{array}{c}\theta = [d^t(\mathbf{x}_{t+1}, \mathbf{y}_{t+1})]^{-1} = \max_{\phi,\lambda} \phi \\ \text{s.t. } -\phi y_{it+1} + Y_t\lambda \geq 0 \\ x_{it+1} - X_t\lambda \geq 0\end{array} \quad \text{(C)} &
\begin{array}{c}\theta = [d^{t+1}(\mathbf{x}_t, \mathbf{y}_t)]^{-1} = \max_{\phi,\lambda} \phi \\ \text{s.t. } -\phi y_{it} + Y_{t+1}\lambda \geq 0 \\ x_{it} - X_{t+1}\lambda \geq 0,\end{array} \quad \text{(D)}
\end{array}
$$

use the output-based Malmquist index with $\mathbf{x}_t \in \mathbb{R}_+^N$ and $\mathbf{y}_t \in \mathbb{R}_+^M$. The efficiency change (EC) and technical change component are calculated under constant returns to scale (CRS), while the pure efficiency change (PEC) is obtained by variable returns to scale (VRS) in order to evaluate the scale effect.

To calculate the rate of productivity growth between 2009 and 2014, we adopt the Malmquist method of assessment with adjacent periods, i.e.:

$$m(\mathbf{x}_{t+1}, \mathbf{y}_{t+1}, \mathbf{x}_t, \mathbf{y}_t), m(\mathbf{x}_{t+2}, \mathbf{y}_{t+2}, \mathbf{x}_{t+1}, \mathbf{y}_{t+1}), ..., m(\mathbf{x}_{t+n}, \mathbf{y}_{t+n}, \mathbf{x}_{t+n-1}, \mathbf{y}_{t+n-1}).$$

In the VRS model the constraint $\sum \lambda_i = 1$ is included in $d(\cdot)$ equations. When calculating the efficiency scores, we can project the optimal level of inputs and outputs. Thus, we compute the goals projected by the DEA model in order to make each DMU efficient using Equation 3.

$$x_{m0}^* = x_{m0} - s_{m0}^- = x_{m0} - X_m\lambda \tag{3}$$
$$y_{n0}^* = \theta^{-1}y_{n0} + s_{n0}^+ = \theta^{-1}y_{n0} + Y_n\lambda \tag{4}$$

where: x_{m0}^* and y_{n0}^* are targets for inputs and output; s^- and s^+ are negative (reduction of inputs) and positive slacks (shortage of outputs). A DMU is considered efficient if, and only if, $s^- = s^+ = 0$.

We identify the type of returns to scale from the following inequality: if $\theta_{VRS} = \theta_{CRS}$, the DMU operates with optimal scale; if $\theta_{VRS} \neq \theta_{CRS}$ and the scores calculated under decreasing returns ($\sum \lambda_i > 1$) and VRS are equal, the DMU operates with excess of inputs (decreasing scale); otherwise, the DMU operates with increasing scales (Färe et al., 1994a, Ramanathan, 2003).

The changes in scale efficiency (SC), based on Färe et al. (1994b), is defined by: $SC = \dfrac{EC}{PEC}$, where EC and PEC respectively are calculated by DEA-CRS and DEA-VRS. Therefore, we can verify in Malmquist index the scale effect over time:

$$m = TC \times EC = TC \times (PEC \times SC) \tag{5}$$

4.2. Stage 2: Econometrics with panel data

The procedures described in the first stage allow the calculation of the judicial productivity growth rates for the period under analysis. Then, to assert the impact of its possible determinants, a panel data with fixed effects model is estimated according to the Equation 6:

$$\ln Y_{it}^j = \beta_0 + \beta_1 RR_{it} + \mathbf{CF}_{it}^{'}\mathbf{\Gamma} + \mathbf{EF}_{it}^{'}\boldsymbol{\alpha} + \gamma_t + a_i + \epsilon_{it} \tag{6}$$

where: $\ln Y_{it}$ represents the indicator j of the State Court i in period t, with j ={Malmquist index (m), efficiency change (EC), technical change (TC)}; RR is Reversal rate, used as proxy for judicial decision quality; $\mathbf{CF}$ is a vector with information about courts factors, including remuneration of jugdes and judicial staff, investment rate, technology resources used by each court (investment and electronic filing); $\mathbf{EF}$ is a vector that include external factors to the courts such as gross domestic product (GDP) per capita and a index for legal particularities (rate of criminal cases); a_i is the fixed effect involving the environment conditions of each Courts i

(such as cultural diversity, moral aspects etc.); γ_t captures the fixed effect of time in the year t; ϵ_{it} is the random error term.

A main concern about improving judicial productivity is if it would not be caused by a decrease in the quality of the decisions. For instance, a system in which, instead of analyzing the cases, the judges just flip a coin to decide a case would be tremendously efficient from a quantitative perspective. However, as discussed in section two, the judiciary's primary role is to reduce uncertainty, resolving disputes in a predictable manner. Consequently, quality is as important as quantitative efficiency. The result of the parameter β_1 aims to capture if the quality of the decisions is related to judicial productivity growth. The percentage of sentences reversed by the upper court is used as a proxy for judicial output quality, as done by Posner (2000), Rosales-López (2008), Mitsopoulos and Pelagidis (2010), Dimitrova-Grajzl et al. (2016). Will the courts with higher quality index (lower reversal rate) have productivity losses? The estimation of the β_1 coefficient aims to answer this question.

According to the fair wage-effort hypothesis (Akerlof and Yellen, 1990), salary and effort, thus productivity, are positively correlated. Moreover, the public choice model of judicial decision making predicts that judges[10], as everybody else, follow self interest rules (Shepherd, 2011). Indeed, as Posner (1993) proposed, judges are rational agents and utility maximizers. Furthermore, Deyneli (2012) highlights that higher remuneration might incentivize productivity and reduce the chances of corruption. Additionally to the incentives-effort effect, higher remuneration can also make the judge's career more attractive for high quality workers. However, Choi et al. (2009) suggest that higher wages would only affect judicial efficiency if judges could be sanctioned due to bad performance (mainly facing termination risk) and if the judge's selection process is sophisticated enough to screen out low-ability candidates.

Investment is, by definition, an expenditure related to an expected increase on the future production, thus it should affect productivity growth. Specifically, technology investment rate is expected to positively influence the dependent variable since it improves the degree of informatisation. As Palumbo et al. (2013) suggested, spending on computerisation should smooth court functioning and improve its efficiency, mainly by promoting new case-flow management techniques. Indeed, a good degree of informatisation permits the introduction of better procedures to monitor and enforce judicial deadlines. Furthermore, it can contribute to improve courts accountability and transparency (Kourlis and Gagel, 2008).

Electronic filing is a proxy for the diffusion of information and communication technologies (ICT) among courts. As discussed above, the use of new technologies should increase courts efficiency, thus a higher percentage of new cases filed electronically is expected to positively affect the court productivity.

GDP per capita and the rate of criminal cases are the external factors, in the sense that they might influence the courts' efficiency, but cannot be controlled by the court. The former is used to estimate the impacts of socioeconomic factors on judicial productivity, as done by Djankov et al. (2003), Gorman and Ruggiero (2009). The latter is used as a proxy for particularities of the substantive/procedural law. In a cross-country analysis, Djankov et al. (2003) found that legal formalism might affect judicial efficiency. Criminal and civil cases are formally distinct, following a different path in the judiciary. For instance, since criminal and non criminal cases have diverse burden of proof standards (Fleming Jr., 1961), they have different complexity levels. In this sense, the rate of criminal cases tries to capture the effects of the legislation on judicial productivity.

5. Data

The data used in this paper was extracted from the database of the Courts in Figures which is an annual report developed by the Brazilian National Council of Justice (Conselho Nacional de Justiça). It covers all the

[10]Due to data limitation, the remuneration of judges and justice staff is used as a proxy for judges' wages. Indeed, notwithstanding the fact that the judge is the main decision maker, it is plausible to assume that the court's output is a result of the judge's and his staff's efforts combined.

27 Brazilian states courts for the period 2009-2014. The monetary variables were deflated using the National Consumer Price Index (Índice Nacional de Preços ao Consumidor) calculated by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística).

Table 1 shows the set of variables selected to compose the productivity index. The selection of inputs and output was based on previous published studies on judiciary efficiency, such as Beer (2006), CNJ (2015), Deyneli (2012), Elbialy and García-Rubio (2011), Kittelsen and Forsund (1992), Yeung and Azevedo (2011). The input variables are represented by human, material and monetary resources, while the output captures the number of resolved cases in each court.

Table 1: Variables selected to evaluate judicial productivity in Brazil – 2009 to 2014

Variable	Description	Mean	SD	Min	Max
Inputs					
Court expenditures	Total expenditure of the State Courts in R$ millions, except expenses with retired staff and investment				
	overall	1156.6	1466.2	100.0	8093.4
	between		1476.6		
	within		192.5		
Judges	Total number of judges				
	overall	422.5	482.4	32.0	2566.0
	between		489.3		
	within		27.2		
Judicial staff	Civil servants, servants requested from other government agencies or entities, employees without formal affiliation to public service				
	overall	9274.2	12102.3	985.0	66365.0
	between		12237.4		
	within		1167.3		
Workload	Total of cases being processed (new cases plus pending cases)				
	overall	2709823.0	4875838.0	103676.0	26500000.0
	between		4936199.0		
	within		405508.0		
Output					
Judgments	Total of resolved cases				
	overall	691103.2	1042959.0	33789.0	5937348.0
	between		1051163.0		
	within		130902.7		
Observations	overall	162			
	between	27			
	within	6			

Source: Authors' elaboration from Courts in Figures, CNJ (2015)

The variables used in the second stage are reported in Table 2. According to Posner (2000), Rosales-López (2008), Mitsopoulos and Pelagidis (2010), Deyneli (2012), the selected variables aim to identify the role of decision's quality (measures by reversal rate), courts' factors (remuneration, investment rate, technology rate and electronic filing) and external factors (GDP per capita and rate of criminal cases) on growth of judicial productivity.

Since the goal is to study the determinants of productivity growth rate and its components (efficiency change and technical change), the regression model is made for 5 periods. Given the existence of missing values in reversal rate, we estimate a panel data model with fixed effects to an unbalanced panel which made the total number of observations drop from 135 to 131.

Table 2: Explanatory variables used in the regression models

Variable	Description	Mean	SD	Min	Max
Reversal rate	Rate of appeals reversed by the upper court				
	overall	0.37	0.14	0.00	0.94
	between		0.12		
	within		0.09		
Remuneration	Average remuneration of judges and justice staff				
	overall	104,575.10	22,498.10	70,709.28	161,867.10
	between		20,745.04		
	within		9,415.66		
Investment rate	Percentage of investment in relation to total expenditure				
	overall	4.69	3.89	0.04	17.35
	between		2.88		
	within		2.65		
Technology investment rate	Percentage of spending on information technology in relation to the total expenditure				
	overall	3.97	2.01	0.00	12.04
	between		1.32		
	within		1.53		
Electronic filing	Percentage of new electronic cases over total filed cases				
	overall	30.44	26.48	0.00	1.00
	between		19.83		
	within		17.88		
GDP per capita	Gross domestic product per capita				
	overall	20,032.89	12,145.01	6,888.60	75,466.46
	between		12,021.13		
	within		2,703.24		
Rate of criminal cases	Percentage of criminal cases in relation to total cases				
	overall	4.03	2,13	0.81	11.20
	between		2.02		
	within		0.76		
Observations	overall	131			
	between	27			
	within	4.9			

Source: Authors' elaboration from Courts in Figures, CNJ (2015)

6. Results

6.1. Judicial Efficiency

Productivity growth and its components were calculated for the 27 Brazilian state courts over the period 2009-2014. As one of the basic components of the Malmquist index is the efficiency change, Table 3 reports the evolution of pure technical efficiency over time for each Brazilian state court.

Under the assumption of variable returns to scale (VRS), Table 3 shows that most Brazilian State courts were technically inefficient between 2009 and 2014. On average, the overall level of pure efficiency was 0.83, indicating that the number of judgments (output indicator) could increase by about 20% per year.

Between 2009 and 2014, the courts of Rio de Janeiro (RJ), Roraima (RR), Rio Grande do Sul (RS), Sao Paulo (SP) and Acre (AC) show the best performance in terms of higher production results with lower input use. Among the most efficient units there are courts located in both more (RJ, RS and SP) and less (RR and AC) developed states in Brazil.

At the bottom of the rank, the courts of Piaui (PI) and Mato Grosso (MT) have the worst technical performance over time. For example, Court of PI in 2009, given the resources used, should increase its judicial production by 2.33 times. On global average (2009-2014), considering the score of 0.44 and taking into account the benchmarks units, the Court of PI would need to increase its production by 127.3% per year to optimize the input-output relationship.

Table 3: Technical efficiency (VRS) in Brazilian Courts – 2009 to 2014

	year						Total (2009-2014)				
Court	2009	2010	2011	2012	2013	2014	Mean	SD	Min	Max	Count Eff*
Rio de Janeiro (RJ)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	6
Roraima (RR)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	6
Rio Grande do Sul (RS)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	6
Sao Paulo (SP)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	6
Acre (AC)	1.00	1.00	1.00	1.00	1.00	0.95	0.99	0.02	0.95	1.00	5
Mato Grosso do Sul (MS)	1.00	1.00	1.00	1.00	0.81	0.85	0.94	0.08	0.81	1.00	3
Rondonia (RO)	0.76	0.94	1.00	1.00	0.92	0.93	0.92	0.08	0.76	1.00	1
Distrito Federal (DF)	0.82	0.77	0.95	0.91	1.00	1.00	0.91	0.09	0.77	1.00	2
Minas Gerais (MG)	0.93	1.00	0.83	0.85	0.88	0.93	0.90	0.06	0.83	1.00	1
Para (PA)	1.00	0.93	0.78	0.84	0.90	0.96	0.90	0.07	0.78	1.00	1
Parana (PR)	0.87	0.86	0.97	0.78	0.84	0.99	0.89	0.07	0.78	0.99	0
Amazonas (AM)	0.77	0.77	0.88	1.00	1.00	0.86	0.88	0.09	0.77	1.00	2
Goias (GO)	0.90	0.75	0.73	0.92	0.98	1.00	0.88	0.11	0.73	1.00	1
Amapa (AP)	1.00	0.57	0.81	0.89	1.00	1.00	0.88	0.16	0.57	1.00	3
Sergipe (SE)	0.87	0.95	0.82	0.77	1.00	0.81	0.87	0.08	0.77	1.00	1
Maranhao (MA)	0.76	0.71	0.99	0.86	0.97	0.87	0.86	0.10	0.71	0.99	0
Alagoas (AL)	0.44	0.92	0.94	0.96	0.88	0.90	0.84	0.18	0.44	0.96	0
Rio Grande do Norte (RN)	1.00	0.74	0.82	0.88	0.76	0.72	0.82	0.10	0.72	1.00	1
Ceara (CE)	0.91	0.58	0.63	0.81	0.77	0.93	0.77	0.13	0.58	0.93	0
Tocantins (TO)	1.00	0.48	0.71	0.68	0.79	0.87	0.76	0.16	0.48	1.00	1
Santa Catarina (SC)	0.77	0.70	0.76	0.76	0.78	0.60	0.73	0.06	0.60	0.78	0
Bahia (BA)	0.96	0.84	0.60	0.69	0.57	0.62	0.71	0.14	0.57	0.96	0
Paraiba (PB)	0.54	0.52	0.77	0.61	0.91	0.87	0.70	0.15	0.52	0.91	0
Pernambuco (PE)	0.72	0.63	0.53	0.47	0.80	0.66	0.63	0.11	0.47	0.80	0
Espirito Santo (ES)	0.68	0.46	0.55	0.53	0.60	0.69	0.58	0.08	0.46	0.69	0
Mato Grosso (MT)	0.46	0.36	0.44	0.46	0.62	0.77	0.52	0.13	0.36	0.77	0
Piuai (PI)	0.30	0.36	0.30	0.38	0.55	0.77	0.44	0.17	0.30	0.77	0
Total	0.83	0.77	0.81	0.82	0.86	0.87	0.83	0.03	0.77	0.87	-

Source: Authors' elaboration from Courts in Figures, CNJ (2015).
Note: SD = standard deviation; *Count Eff = amount of times that the DMU was efficient in the period.

A relevant literature on judicial efficiency (Finocchiaro Castro and Guccio, 2012, Schneider, 2005, Yeung and Azevedo, 2011, Deyneli, 2012) relies on the assumption that courts operate with constant returns to scale (CRS) which implies that the courts' sizes are optimal. However, as Voigt (2016) discusses, this is not always the case. Courts may operate with variable returns to scale (VRS). Some judicial units might have increasing return to scale, while others can be already too big.

Table 4 shows the scale efficiency of the courts in the period, including the dominant scale types of the court in each period. These results complement the previous analysis, because the courts may be technically efficient and operate in an incorrect production scale or be doubly inefficient (in technical and scale terms). And yet, the DMU can operate on an optimal scale of production and have technical efficiency.

Most State Courts of Brazil operate with increasing returns to scale over time (see Table 4), indicating that in addition to pure technical inefficiency the courts have problems related to incorrect scale functioning. Among the technically efficient Courts, only Rio de Janeiro (RJ) and Rio Grande do Sul (RS) do not have scale problems between 2009 and 2014, operating at optimal scale of production. On the other hand, Roraima (RR) and Sao Paulo (SP) feature scale inefficiency, the first of which operates with increasing returns and the second works basically with decreasing returns.

Table 4: Scale efficiency in Brazilian Courts – 2009 to 2014

		year						**Total**
Court	**Scale***	2009	2010	2011	2012	2013	2014	2009-2014
AC		0.85	1.00	1.00	1.00	1.00	0.92	0.96
	constant	increasing	constant	constant	constant	constant	increasing	
AL		0.74	0.71	0.68	0.68	0.87	0.83	0.75
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
AM		0.80	0.79	0.72	0.88	1.00	0.76	0.83
	increasing	increasing	increasing	increasing	increasing	constant	increasing	
AP		1.00	0.98	0.92	0.98	1.00	1.00	0.98
	undefined	constant	increasing	increasing	increasing	constant	constant	
BA		0.73	0.85	0.92	0.88	0.90	0.99	0.88
	undefined	increasing	increasing	decreasing	decreasing	increasing	decreasing	
CE		0.99	0.97	0.97	0.97	0.99	0.95	0.98
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
DF		0.83	0.89	0.83	0.83	0.78	0.85	0.84
	decreasing	decreasing	increasing	increasing	decreasing	decreasing	decreasing	
ES		0.93	0.94	0.98	0.98	0.96	0.95	0.96
	increasing	decreasing	decreasing	increasing	increasing	increasing	increasing	
GO		0.94	1.00	0.99	0.96	1.00	1.00	0.98
	increasing	increasing	increasing	increasing	decreasing	increasing	constant	
MA		0.86	0.80	0.85	0.83	0.80	0.84	0.83
	increasing	increasing	decreasing	increasing	increasing	decreasing	increasing	
MG		0.81	0.77	0.86	0.86	0.83	0.86	0.83
	decreasing	decreasing	decreasing	increasing	increasing	decreasing	decreasing	
MS		1.00	1.00	0.99	1.00	0.99	1.00	0.99
	constant	constant	constant	increasing	constant	decreasing	increasing	
MT		0.93	0.95	0.99	0.99	1.00	0.99	0.98
	undefined	decreasing	increasing	decreasing	decreasing	increasing	increasing	
PA		1.00	0.95	1.00	0.99	0.88	0.87	0.95
	increasing	constant	increasing	increasing	increasing	increasing	increasing	
PB		1.00	0.98	0.99	0.99	0.88	0.93	0.96
	decreasing	decreasing	decreasing	increasing	increasing	decreasing	decreasing	
PE		0.99	0.97	0.96	0.97	1.00	1.00	0.98
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
PI		1.00	0.93	0.90	0.93	0.96	0.80	0.92
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
PR		0.99	0.98	0.98	1.00	0.99	0.98	0.99
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
RJ		1.00	1.00	1.00	1.00	1.00	1.00	1.00
	constant	constant	constant	constant	constant	constant	constant	
RN		0.98	0.95	0.96	0.97	0.95	0.99	0.96
	decreasing	decreasing	decreasing	increasing	decreasing	decreasing	decreasing	
RO		0.98	0.91	1.00	0.97	0.91	0.99	0.96
	increasing	increasing	increasing	constant	increasing	increasing	increasing	
RR		0.63	0.62	0.53	0.67	0.55	0.90	0.65
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
RS		1.00	1.00	1.00	1.00	1.00	1.00	1.00
	constant	constant	constant	constant	constant	constant	constant	
SC		0.99	0.96	0.99	0.99	1.00	1.00	0.99
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
SE		0.97	0.99	0.89	0.99	0.96	0.97	0.96
	increasing	increasing	decreasing	decreasing	increasing	increasing	increasing	
SP		1.00	0.66	0.83	0.85	0.79	0.84	0.83
	decreasing	constant	decreasing	decreasing	decreasing	decreasing	decreasing	
TO		0.70	0.90	0.85	0.90	0.95	0.93	0.87
	increasing	increasing	increasing	increasing	increasing	increasing	increasing	
Total		0.91	0.91	0.91	0.93	0.92	0.93	0.92

Authors' elaboration from Courts in Figures, CNJ (2015).
Note: *Return to scale dominant over time.

Table 5 reports a basic description (average information) about efficiency scores, inputs and output of the Brazilian courts by type of returns to scale.

Table 5: Description of inputs, output and scores of judicial efficiency in Brazil by type of returns to scale (2009-2014)

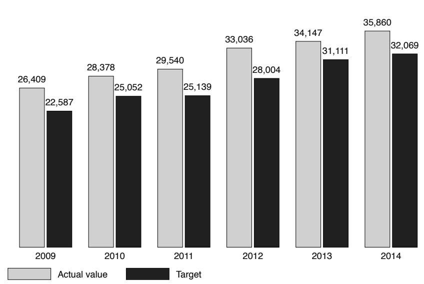
	Returns to scale			
Variable	**Increasing**	**Constant**	**Decreasing**	**Total**
Efficiency				
Technical (VRS)	0.79	1.00	0.81	0.83
Scale	0.91	1.00	0.89	0.92
Inputs				
Expenditure (constant 2014 R$ millions)	714.79	1,575.71	2,057.25	1,156.60
Judges	301	511	691	423
Staff	5,746	12,839	16,302	9,274
Workload	1,406,513	4,602,358	4,874,524	2,709,823
Output				
Judgements	381,670	1,253,334	1,120,370	691,103

Source: Authors' elaboration from Courts in Figures, CNJ (2015).

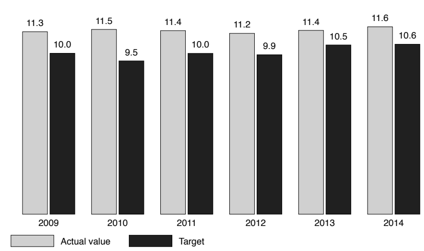
The courts with increasing and decreasing returns present more problems in the input-output relationship (technical efficiency problem) than in incorrect scale production. Evaluating the production, the units with optimal scale of production have an output, on average, higher in 11.9% than those operating with decreasing returns. While in the inputs, these differences are even more pronounced, reflecting the DMUs with decreasing returns also work with excess human and financial resources – particularly in the number of judges and the courts expenditures.

Figure 1: Comparison of actual values for inputs and output with its targets by DEA-VRS model in Brazilian Courts (2009-2014)

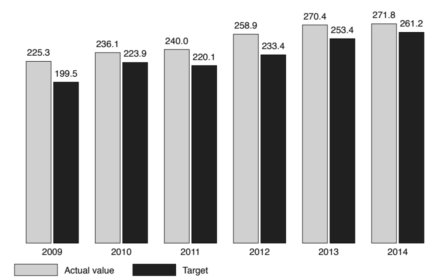
(a) Expenditures - Input (R$ millions)



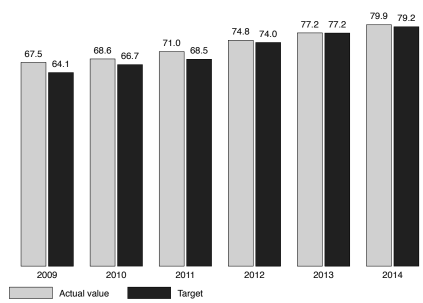
(b) Judges - Input (in thousands)



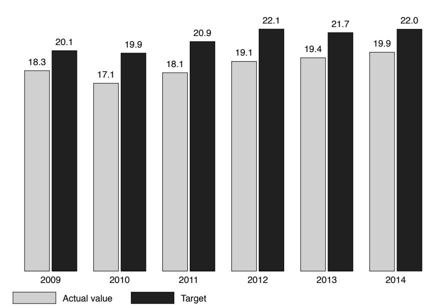
(c) Staff - Input (in thousands)



(d) Workload - Input (millions)



(e) Judgements - Output (millions)



Source: Authors' elaboration from Courts in Figures, CNJ (2015). The expenditures were adjusted for inflation (base period: 2014).

What would be the adjustments in inputs and output in the aggregate to transform technically inefficient units into efficient ones? To answer this question, Figure 1 shows the cumulative adjustments, based on DEA-VRS model, to the inputs and outputs to increase judicial efficiency. Therefore, this illustration presents accumulated actual values of inputs and outputs, as well as its values projected by the DEA results for each year.

Although the efficiency model is output-oriented, DMUs exhibit excess in the use of inputs, such that assuming the possibility of all courts adjusting their inputs and outputs, we would have globally reductions in all considered inputs and an average expansion of output in 13.26%. Among the inputs, those with higher slacks were the court expenditures and the number of judges, which on average would need to be reduced respectively by 12.6 % and 11.7% in the period. What is noticeable regarding these results is that in order to achieve technical efficiency, inefficient courts should increase their relative production and necessarily minimize the use of financial and human resources.

In practical terms, given contractual rigidity in the Brazilian public sector (specially with human resources), adjustments should primarily occur in the output level of courts and/or by frontier shifting up (improvements in technological change). Thus, for a better evaluation of the judicial productivity over time, also taking into account the technical changes, Table 6 presents the Malmquist index and its components for each state court. Note that the Malmquist index can be obtained by two approaches: $m = TC \times EC$ or $m = TC \times PEC \times SC$. In the last approach, we detail the changes in scale efficiency.

The results presented in Table 6 are summarized by the global average which demonstrates that Brazilian courts showed a slight tendency to improve their productivity in the period. The average productivity growth by Malmquist index was 1.5% per year. This productivity growth, on average, can be attributed more to the efficiency component than to innovation (technological change). We observe, globally, that 57.8% of the State courts during the study period present a progress in net productivity. This information confirms the trend of a slight improvement in judicial productivity over time.

Table 6: Malmquist index, Technical change, Efficiency change, Pure efficiency change and Scale efficiency change (Average annual changes, 2009-2014)

				EC = PEC × SC	
Court	Malmquist index	Technical change	Efficiency change (EC)	Pure efficiency change (PEC)	Scale efficiency change (SC)
AC	1,007	0,993	1,010	0,989	1,021
AL	1,211	0,984	1,228	1,211	1,015
AM	1,032	0,986	1,039	1,026	1,013
AP	1,041	0,993	1,042	1,044	0,999
BA	0,956	0,971	0,984	0,929	1,059
CE	0,994	0,971	1,028	1,036	0,993
DF	1,046	0,999	1,049	1,046	1,002
ES	0,990	0,974	1,026	1,022	1,004
GO	1,023	0,986	1,040	1,031	1,009
MA	1,029	0,975	1,047	1,045	1,002
MG	1,001	0,986	1,013	1,004	1,009
MS	0,952	0,979	0,971	0,972	1,000
MT	1,111	0,985	1,139	1,127	1,011
PA	0,940	0,971	0,969	0,997	0,972
PB	1,087	0,981	1,112	1,134	0,980
PE	1,012	0,991	1,029	1,024	1,005
PI	1,143	0,967	1,179	1,230	0,958
PR	1,009	0,980	1,032	1,035	0,997
RJ	1,023	1,023	1,000	1,000	1,000
RN	0,915	0,961	0,954	0,948	1,006
RO	1,033	0,983	1,051	1,046	1,004
RR	1,091	0,992	1,114	1,000	1,114
RS	0,983	0,983	1,000	1,000	1,000
SC	0,945	0,984	0,962	0,958	1,003
SE	0,992	0,988	1,003	1,000	1,004
SP	0,978	0,996	0,986	1,000	0,986
TO	1,029	0,971	1,068	1,038	1,029
Mean	1,015	0,983	1,040	1,033	1,007

Authors' elaboration from Courts in Figures, CNJ (2015).

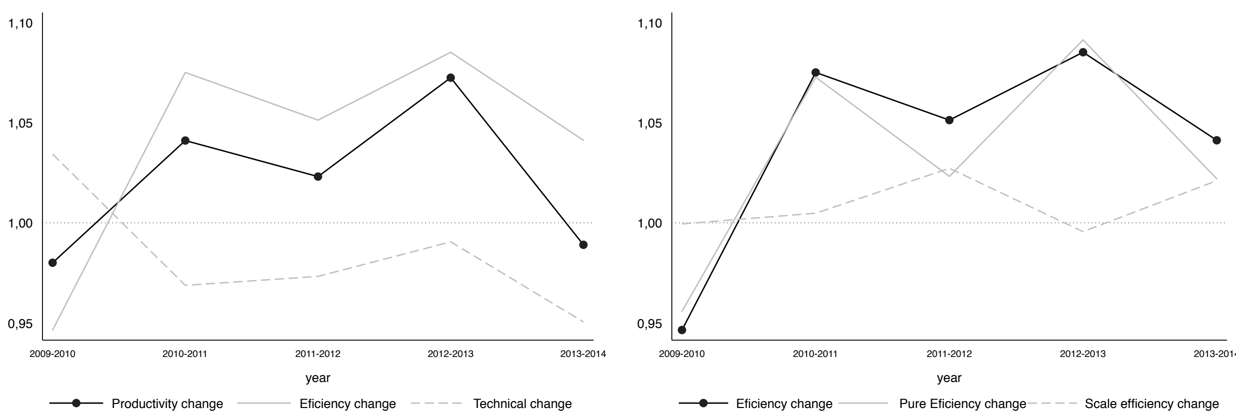
Note: Pure efficiency change is calculated using DEA-VRS and efficiency change by DEA-CRS. Scale efficiency change (SC), based on Färe et al. (1994b), is defined by: $SC = \frac{EC}{PEC}$.

As it can be seen more clearly in Figure 2a, the evolution of judicial productivity in Brazil occurs unsteadily, being basically defined by efficiency changes over time. With the exception of 2009-2010, throughout the designated period the technical change evolved under EC and Malmquist index, with a downward trend in the period.

Decomposing the efficiency change over time, we note from Figure 2b that pure efficiency change has superimposed the effects of changes in efficiency scale. Globally, the EC has a growth of 4%, with 82.5% of which is due to the catch-up effect (pure efficiency change). Despite the average annual growth, changes in scale effect contribute only 17.5% with EC growth over time.

Figure 2: Evolution of Malmquist index and its components for Brazilian State Courts (2009-2014)

(a) Productivity change (b) Efficiency change



Source: Authors' elaboration from Courts in Figures, CNJ (2015).

Indeed, among all courts only RJ, with an average annual technical change of 2.3%, progressed from a technological perspective (positive frontier effect). All the other tribunals faced a decrease in the technical change indicator (negative frontier effect). The courts with higher rates of productivity growth per year were, respectively, Alagoas (AL, 21.1%), Piaui (PI, 14.3%) and Mato Grosso (MT, 11.1%). Decomposing the productivity indicator, we find that the key to achieving growth for these courts was due to better input-output ratio (pure efficiency change) obtained by these courts.

As seen in Table 3, these courts (AL, PI and MT) have the lowest technical efficiency indicators. Considering the hypothesis of diminishing marginal returns, the most inefficient units tend to have a higher relative evolution in time.

6.2. Econometric Results

Table 7 evidences the econometric results of the relationship between judicial productivity change (Malmquist index) and the variables discussed in the methodology (decision quality, courts' and external factors). The estimations are made by fixed effect model with cluster-robust standard errors.

Table 7: Determinants of judicial productivity change (Malmquist index) from regression with fixed effect model (Dependent variable in growth rate)

Variable	**(1)**		**(2)**		**(3)**		**(4)**	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Decision quality								
Reversal rate	-0.4260	0.359	-0.4107	0.362	-0.3724	0.355	-0.3522	0.309
Courts' factors								
Remuneration (log)			0.3499*	0.197	0.4938**	0.203	0.4994**	0.212
Investment rate					-0.0106	0.008	-0.0089	0.009
Technology investment rate					0.0081	0.015	0.0081	0.014
Electronic filing					-0.0018**	0.001	-0.0020**	0.001
External factors								
GDP per capita (log)							0.5289	0.689
Rate of criminal cases							0.0022	0.009
Year								
2011							0.0350	0.095
2012							-0.0362	0.102
2013							-0.0417	0.182
2014							-0.1511	0.221
Intercept	0.1635	0.133	-3.8797*	2.257	-5.4822**	2.290	-10.7271*	6.023
σ_u	0.0918		0.1214		0.1627		0.3209	
σ_e	0.2056		0.2040		0.2026		0.2033	
ρ	0.1662		0.2616		0.3922		0.7136	
R^2	0.0447		0.0690		0.1089		0.1567	
Adjusted R^2	0.0373		0.0544		0.0732		0.0787	
Observations	131		131		131		131	
Groups	27		27		27		27	

Authors' elaboration from Courts in Figures, CNJ (2015).
Note: ***p-value<0.01, **p-value<0.05, *p-value<0.10. Cluster-robust standard errors.

The statistical insignificance of the reversal rate on judicial efficiency improvement, in all the models, suggests that the productivity improvement is not a result of a decrease in judicial decisions quality, which is in line with the results found by Rosales-López (2008), Dimitrova-Grajzl et al. (2016). Consequently, it supports the assumption that judicial efficiency and quality maximization are not mutually exclusive.

The positive effect of remuneration on judicial productivity change is in line with the public choice model of judicial decision-making and also with the findings of Deyneli (2012). Considering the coefficient in model (4), which presents the best fit and specification, a change of 1% in remuneration increases the productivity growth by 0.53%. This evidence can support the assumption that well paid judges are more motivated, thus more productive. It also suggests that courts which pay the highest salaries attract the most productive workers. Considering Choi et al. (2009) and that, in Brazil, judges are protected by life tenure, the second interpretation seems more plausible.

Both general and technological investment rates are not statistically significant. This result can suggest that either the courts are badly investing or that their investment returns do not affect the same year output[11]. GDP per capita also does not affect judicial productivity, in any of the models, suggesting that judicial productivity growth does not depend on social-economic factors.

The negative and statistically significant estimate of the new cases electronically filed might seem counter-intuitive, since more paperless lawsuits were expected to result in more efficient courts. The model shows that a marginal change in the percentage of electronic filing generates, on average, a reduction of approximately 0.22% in judicial productivity growth. However, a possible explanation for this issue is the fact that electronic filing systems are a relatively new technology and the employees would need time to adapt to this new technique. Moreover, the technology itself changed over the years which might support the adaption hypothesis. Indeed, in the beginning (late 00's), there was no uniformity in the electronic cases technology which means that several different kinds of paperless systems were adopted by the courts. It was only in 2011 that the Na-

[11]This hypothesis could be tested introducing a lag on those variables. However, the database time series length analysed in this paper is too short to perform this task.

tional Council of Justice decided to release an uniform system ("Processo Judicial Eletrônico-PJe") which has been gradually implemented by the courts. This explanation is reinforced by the result of this coefficient in the TC(1) model in Table 8 which shows that this variable contributes to induce a negative frontier-shift effect.

Table 8 reports the role of explanatory variables considered on the decomposition of productivity measures change (EC and TC). These relationships aim to complement the previous analysis, because we can see if there are differences between the determinants of the EC (efficiency) and TC (technological) growth.

Table 8: Determinants of judicial efficiency and technical changes (decomposition of Malmquist index) from regression with fixed effect model (Dependent variables in growth rate)

Variable	EC(1)		EC(2)		TC(1)		TC(2)	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Decision quality								
Reversal rate	-0.3424	0.329	-0.2915	0.276	-0.0301	0.050	-0.0608	0.057
Courts' factors								
Remuneration (log)	0.5078**	0.191	0.4539**	0.203	-0.0139	0.062	0.0454	0.050
Investment rate	-0.0105	0.007	-0.0070	0.008	-0.0001	0.001	-0.0018	0.002
Technology investment rate	0.0096	0.014	0.0094	0.011	-0.0015	0.003	-0.0012	0.004
Electronic filing	-0.0011	0.001	-0.0019**	0.001	-0.0008***	0.000	-0.0001	0.000
External factors								
GDP per capita (log)			0.4776	0.732			0.0514	0.081
Rate of criminal cases			0.0054	0.009			-0.0032**	0.001
Year								
2011			0.1092	0.091			-0.0742***	0.016
2012			0.0358	0.104			-0.0720***	0.014
2013			0.0198	0.185			-0.0616**	0.025
2014			-0.0426	0.230			-0.1085***	0.028
Intercept	-5.6649**	2.157	-98.442	6.458	0.1827	0.711	-0.8829	1.111
σ_u	0.1566		0.2904		0.0171		0.0346	
σ_e	0.2050		0.2016		0.0514		0.0430	
ρ	0.3685		0.6748		0.0997		0.3932	
R^2	0.1017		0.1841		0.1042		0.4097	
Adjusted R^2	0.0657		0.1087		0.0683		0.3551	
Observations	131		131		131		131	
Groups	27		27		27		27	

Authors' elaboration from Courts in Figures, CNJ (2015).
Note: ***p-value<0.01, **p-value<0.05, *p-value<0.10. Cluster-robust standard errors.

Basically, the main results of EC(2) model, such as monetary incentives and null statistical effect of the reversal rate, replicate the signals observed on the determinants of productivity growth. This replication finding was expected, since the behavior of the Malmquist index, as done in the previous subsection, is defined over time by efficiency change. Thus, estimates of the determinants of technological change (frontier effect) are differentiated information exhibited in Table 8.

The negative coefficient of the criminal cases rate on the TC(2) model is interesting from a Law and Economics perspective. It suggests that particularities of the substantive/procedural law do affect judicial productivity through a reduction in the technical component, which is in line with the findings of Djankov et al. (2003). Indeed, combining the results of that variable with the years' coefficients (which capture the conjuncture variables that affect all the courts) in this model might suggest that the legislation in Brazil evolved in a manner that decreased the innovation growth of the courts.

7. Concluding remarks

The New Institutional Economics states that institutions matter for economic growth since they form the incentives framework of a society. Among them, the legal system is an important element for the economy's performance, as the Law and Economics have established. However, the laws' effectiveness relies on judicial efficiency. Hence, efficient courts are a key factor for society's welfare maximization.

In this work, we provide evidence that Brazilian courts globally had an average slight improvement in judicial productivity between 2009 and 2014. Thus, the initiatives developed by the courts are generating progress in terms of efficiency change, however this development has not occurred equally among all state courts and the speed of change is still slow (about 1.5% per year). An important result observed is that the evolution of total productivity is being defined by gains in efficiency scale and, specially, pure efficiency change. Despite the relative improvement of the input-output relationship, the Brazil's state courts technical frontier declined on average by 1.7% per year over time, with the exception of Rio de Janeiro's court. Consequently, the productivity trend of the courts in the analyzed period can be seen as a consequence of the convergence process in which the tribunals with low initial efficiency levels recover their productivity gap in relation to the most efficiency courts instead of being an innovation result.

Finally, the regression analysis revealed the determinants of judicial productivity growth. It suggested the nonexistence of a trade-off between judicial decisions' quality and efficiency improvement. Among the courts' factors, the model confirmed the assumption that wages and productivity are positively correlated. Nevertheless, it also shown that technology introduction might not always produce the expected results, at least in the short run. Furthermore, the model results confirmed the assumption that Law particularities matters for judicial performance, which is in line with the Law and Economics literature.

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