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The main obstacles to firms' growth in Senegal

Implications for the long run

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Abstract: Productivity gains are the prime engine of economic growth. This paper uses a rich amount of firms' accounting information from the Single Information Collecting Centre in Senegal over the period 1998-2011. To investigate the two main obstacles to growth, poor education and poor access to electricity supply, we aggregate the firms' data at the sectoral level. Our findings corroborate the conclusion of a recent report by the African Development Bank suggesting the importance of primary and vocational education. Another key conclusion drawn in the AfDB report is that the main obstacle to production is the poor access to electricity and the low quality of infrastructure. Based upon a World Bank indicator of access and some strong but reasonable assumptions regarding the sectoral demand for electricity, we estimate the impact of the electricity access on firms' total factor productivity.

Keywords: productivity dynamics, total factor productivity, education, electricity supply
JEL classification: O11, O44, C33

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The World Institute for Development Economics Research (WIDER) was established by the United Nations University (UNU) as its first research and training centre and started work in Helsinki, Finland in 1985. The Institute undertakes applied research and policy analysis on structural changes affecting the developing and transitional economies, provides a forum for the advocacy of policies leading to robust, equitable and environmentally sustainable growth, and promotes capacity strengthening and training in the field of economic and social policy-making. Work is carried out by staff researchers and visiting scholars in Helsinki and through networks of collaborating scholars and institutions around the world.

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1 Introduction

Several decades ago, Africa's economic growth was similar to that of South Asia (Collier and Gunning 1999). However, the decades of the 1970s and 1980s were characterized by a lack of growth, average growth rates being insufficient to deliver a sustainable pattern of growth and catching-up (Berthélemy and Söderling 2001). In Sub-Saharan Africa (SSA), Senegal has suffered from this lack of growth. The 1990s were marked by a change in its growth strategy: the currency devaluation in 1994 and the step-by-step liberalization of the economy in the two decades after. For several years, Senegal has experienced annual growth above 5 per cent as a result of the reforms embarked upon in the 1990s. Is this trend sustainable? How can Senegal keep growing? What are the key policies to facilitate this growth trajectory?

This paper aims to shed light on these questions using micro-data from firms. A country's growth must be based upon its comparative advantage, but recent theoretical and empirical analysis (Rodrik 2006) also emphasises the importance for developing countries of producing and exporting more complex products in the manufacturing industries. In order to be able to update the technological frontiers, education matters, be it for innovation in more developed and pioneering countries (Aghion and Howitt 2004; Aghion et al. 2006), or for imitation purposes in less developed countries that do not drive the technological frontier. For Senegal, this implies the development of industries that do not require an overly high capital-labour ratio, and the implementation of an appropriate educational policy. To evidence the importance of educated labour within an industry, we compute total factor productivity (TFP) across industrial sectors and we show that differences in the share of educated labour do matter.

For van Biesebroeck (2005), Bigsten et al. (2004), or Mengistae and Patillo (2004), economic performance can essentially be explained by exports. In that vein, many economists advocate that developing export capacity is the key policy to circumvent the small market size and the numerous problems surrounding the business environment in developing countries. In this paper we adopt a different but complementary approach, which is illustrated in a recent paper by Harrison et al. (2013). In this paper the authors list all possible explanatory factors driving labour productivity, sales growth, labour growth, export intensity, and the rate of investment. The list is long, ranging from geography, political risks, ownership, competition and infrastructure to crime and violence, labour flexibility, and access to more formal and informal finance. Given the limited capacity of reformers and policy makers, the objective is to identify the key constraints for growth.

We focus on a selection of those different explanations, relying upon an identification method proposed by Hausmann et al. (2008). This method was used recently to identify the main obstacles to growth in Senegal (AfDB 2012). The report reaches the following conclusions: the main obstacles are the size of the informal sector and the dualism which characterizes the economy. Electric power supply and quality appear to be the main obstacles to industrialization; finally, spending on education and infrastructure must be improved. Those conclusions constitute the starting point of our analysis, which illustrate the importance of skilled labour and access to electricity in explaining cross sectoral differences in TFP in Senegal.

We take advantage of two unique panel datasets from the Single Information Collecting Centre (CUCI) (Senegalese National Statistic and Demography Agency, ANSD). The first dataset contains the balance sheets of all registered Senegalese firms, over the period 1998-2011. The second panel gives the percentages of low-skilled, intermediate-skilled, and highly skilled labour at the sector level. We construct a proxy for the quality of access to electricity by multiplying the World Bank Indicator at the country level by an estimate of the sectoral industrial electricity consumption drawn from the dataset. Our analysis is based on 23 sectors over the period 1998-2011.

In Section 2 we describe the main features of the two main obstacles to productivity and growth: education and electricity supply. Taking advantage of the panel structure of our datasets, we propose in Section 4 a methodology to quantify the impact in both the short and long run of education and electricity. This section is preceded by a description of our data and methodology used to proxy the quality of access to electricity. The final section draws our main conclusions.

2 Education and access to electricity in Senegal

A recent diagnosis of growth conducted for Senegal by the African Development Bank (2012) has identified two key obstacles to productivity improvement; the mismatch between labour demand and supply and the insufficient level of educational stock, and the poor level of infrastructure development, namely of electricity. The first calls for more investment in the primary sector, for higher enrolment, notably in rural areas, and for a better fit between market needs and skills. The latter is widely discussed in the literature (Ghosh 2002 for India; Wolde-Rufael 2005, 2006 and 2009 for Africa; Ferguson et al. 2000 for a more general sample), with a special emphasis on the causality between energy consumption and growth, but no consensus emerging from the debate.

2.1 Inadequate education

According to the Human Development Index, Senegal is not only one of the poorest countries in terms of GDP per capita, but also in terms of its human development. Education is one pillar of human development, and because of its low level over the long run Senegal has devoted considerable effort to education over the past 15 years. Between 2000 and 2009, education expenditure rose from 3 per cent to 6 per cent of GDP, i.e. 40 per cent of the total budget (AEO 2009). In 2009, 47 per cent of total education expenditure was allocated to primary education, 27 per cent to secondary education and 24 per cent to higher education. This breakdown reflects the belief that primary and secondary schooling are more important than tertiary education for poverty reduction, and has been encouraged by the international development community. From 1985 to 1989, 17 per cent of the World Bank's worldwide education sector spending was on higher education. But from 1995 to 1999, the proportion allotted to higher education declined to just 7 per cent. In Senegal, one main concern is illiteracy, which affected half of the population in 2009, a much higher level than that observed in SSA, where an average of 37.7 per cent of the people are illiterate.

The efficiency of education is assessed according to two criteria. Internal efficiency depends on the ability to retain the maximum number of pupils in school (average number of years at school and gross enrolment rates), and the results obtained by the pupils (that can be measured by the proportion of pupils repeating years) as well as by available resources (teachers, classes, equipment, etc.). External efficiency corresponds to the match between the provision of education and market needs. External efficiency is key for this paper, as it evidences that a certain kind of education is key for improving the economic performance of the country.

Despite recent progress, there is room for improving internal efficiency. The average number of years of schooling (for people aged 15 or older) in 2009 was 4.05. Close to the average for SSAn countries, this rate is low when compared to those of Latin America or East Asia or even some other SSAn countries (Ghana, Kenya and Zambia). Gross enrolment rates in primary education rose from 68 per cent in 1998 to 86 per cent in 2009. These primary enrolment rates are below the average rates for SSA (78 per cent in 1998 and 102 per cent in 2009). It is also worth noting that the proportion of children completing primary education is rising more slowly than the enrolment rates (58.4 per cent in 2008). The rate attained in 2008 falls far short of the 2015 target rate of 83 per cent set by the World Bank, and is considerably lower than the rates recorded by West African countries (Ghana: 73 per cent; the Gambia: 91 per cent; Mali: 79 per cent; and Cape Verde: 85 per cent). This situation implies that the results obtained by the pupils could be improved. The secondary education enrolment rate is much lower – 31.4 per cent in 2008 – while enrolment in higher education did not exceed 8.3 per cent in 2008. These rates are considered low even though they are close to the average of rates for SSA (34.8 per cent for secondary education and 6 per cent for higher education).

Table 1: Secondary and higher education enrolment rates, 2008, in %

	Gross secondary enrolment rate			Gross higher education enrolment rate		
	Total	Male	Women	Total	Male	Female
Senegal	31.4	34.9	27.7	8.3	10.5	6
Sub-Saharan Africa	34.8	39	30.5	6	7.6	4.8

Source: Authors' elaboration based on data from UNESCO-BREDA (2007).

A recent report by Pôle de Dakar UNESCO-BREDA (2007) has assessed external efficiency by computing the rates of return to education according to the level achieved, as reported in Table 2. An interesting pattern emerges: the most profitable investments are at primary level (24 per cent), and the return on technical education is higher than that of middle education. Moreover, the efficiency of higher education is not proved. These findings echo a core debate about the social utility of spending in higher education (see Bigsten et al. 2000), from Pritchett (2001) arguing that educated individuals in developing countries may prefer piracy (rent-seeking activities), or that the supply of education is too high compared with a stagnant demand, to Teal (2010) who asks whether Africa can produce labour that is more highly skilled to effect a growth revolution in the service sector.

Table 2: Rates of return to education in Senegal, in %

Level of education	Social	Private	
		Formal sector	Informal sector
CFEE / NONE	24	11	29
BFEM / CFEE	16	18	27
CAP / CFEE	17	20	38
BAC / BFEM	11	14	29
LICENCE / BAC	NPV<0	0,1	-0,2

Notes: NONE: no diploma; CFEE: Primary School Certificate; BFEM: Secondary School Diploma; CAP: Technical/Vocational Education Diploma; BAC: Baccalauréat (A-level equivalent); LICENCE: Bachelor's Degree or above.

Source: Authors' elaboration based on data from Pôle de Dakar UNESCO-BREDA (2007).

As in many places in Africa, the current situation in Senegal reflects the excess supply of graduates and competition for formal jobs requires some of them to turn to unemployment, or even to emigrate. This is a real sign of the external inefficiency of education or of an imbalance between job supply and demand. The unemployment rate depends on the level of education, reaching its highest level for those who left high school without basic knowledge, followed by those who have a higher level of education. Young graduates are hardest hit by unemployment and are motivated to emigrate. According to the 2001 Senegalese Household Survey (Enquête Sénégalaise auprès des Ménages –ESAM II), skilled workers represent 24.1 per cent of the migrant stock. In 2001, around 17.7 per cent of the population with a higher education level emigrated from Senegal (Docquier and Marfouk 2005). Clemens and Pettersson (2008) confirm the 'brain drain' diagnosis: 51 per cent of Senegalese doctors and 27 per cent of nurses emigrated over the 1995-2005 period, mainly to France.

The external efficiency of education depends on the balance between supply and demand. In one way, the relative weakness of tertiary education enrolment is due to the fact that the job market in Senegal is more open to job seekers with primary, secondary or vocational levels of education. The consequences of the imbalance between supply and demand (too many overqualified graduates) are a high unemployment rate and a brain drain. The Senegalese educational system is sub-optimal in that it proposes training, which does not correspond to the requirements of the labour market. The problem is not new. Berthélemy et al. (1996) already considered that the quality of education in Senegal was inadequate, which, according to the authors, raised the question of its legitimacy.

2.2 Access to electricity

Despite the immense energy potential Africa possesses, the second main obstacle to firms' growth is poor access to electricity and a low level of energy consumption (Karekezi and Kimani 2002; ECA 2004). The average African is still using less energy than the average person used in England more than a century ago (Davidson and Sokona 2002).

In this general framework, Senegal is almost at the level of African middle-income countries and well above other low-income countries. According to Table 3, about 47 per cent of the population had access to electricity in the 2000s, but this figure hides a wide disparity: it includes over 80 per cent of people in urban areas, while almost 85 per cent of rural households do not have access to electricity. Those figures resemble the situation in middle-income countries, with rural electricity access and growth in access both being much lower than the national and urban figures: 15.8 per cent in Senegal as compared with 26.3 per cent in middle-income countries for the former, and 2.7 as compared with 12.1 per cent for the latter.

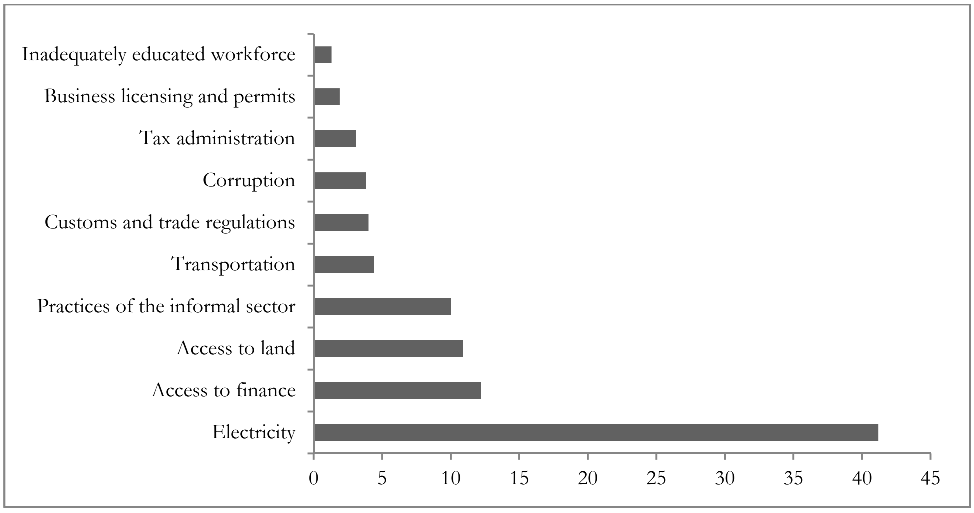
Table 3: Indicators on access to electricity in Senegal

		Low-income countries	Senegal		Middle-income countries
		Mid-2000s	Late 1990s	Mid-2000s	Mid-2000s
Indicator	Unit				
National access to electricity	% pop	32.8	36.2	47.1	49.5
Urban access to electricity	% pop	72.8	72.8	80.4	74.4
Rural access to electricity	% pop	12.7	7.8	15.8	26.3
Growth in access to electricity	% pop / year	4.4	-	2.7	12.1

Source: Authors' elaboration based on data from Eberhard et al. (2008).

However, the quality of the electricity supply, as proxied by the number of outages per month, is too low and represents a major obstacle to firms' productivity. According to the latest World Bank enterprise survey (World Bank 2007), 50 per cent of the firms surveyed, represented in Figure 1 by sector, consider that electricity is a major or very serious obstacle and 85 per cent of enterprises stated they had experienced at least one power outage in the preceding month. They also report at least ten power outages per month. Only 16 of the 835 enterprises surveyed reported that they had experienced no power outages in the preceding month. The average duration of power outages reported was eight hours, which means that every three days firms experience a power outage, and that 12.5 per cent of the time allocated to work is lost.

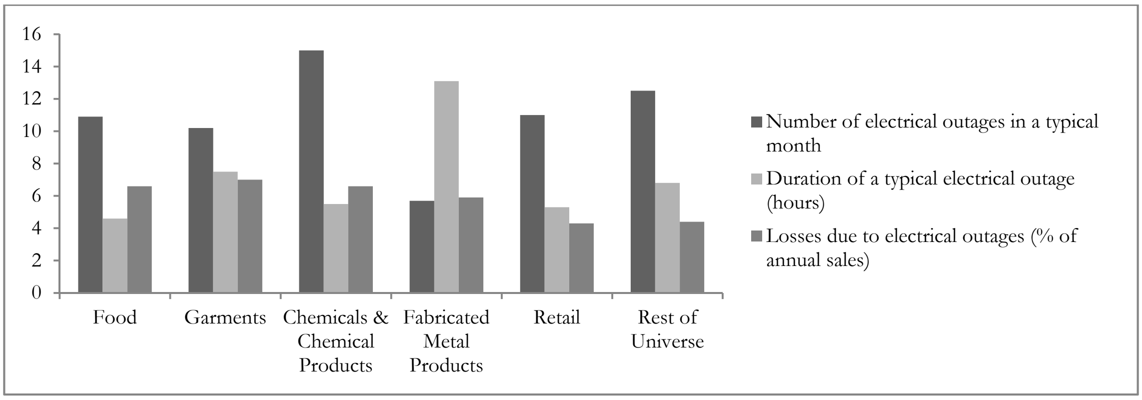
Figure 1: Electricity, a major and serious constraint for firms, by sector



Source: Authors' elaboration based on data from the World Bank (2007).

Figure 2 gives the percentage of annual sales lost as a result of a power outages by sector of activity. The average loss is 4.8 per cent, with 4.5 per cent for medium enterprises and 5.4 per cent for large enterprises. The worst-affected firms are in the garment and chemical sectors. Successive power outages and cuts lead to the installation of electric generators, which are much more expensive than grid-supplied electricity. To offset the shortfall in electricity, over 55 per cent of manufacturing enterprises in Senegal (compared with 35.3 per cent in Uganda and 38.2 per cent in Zambia) have had to acquire generators.

Figure 2: Loss of sales as a result of power outages by sector



Source: Authors' elaboration based on data from the World Bank (2007).

This statistical information provides preliminary evidence of the importance of both education and electricity in hindering firms' productivity. We turn now to the data description and exposition of the methodology that allows us to identify the exact contribution of those two factors to the loss of TFP.

3 Data

The raw dataset comes from CUCI (ANSD) which provides accounting information for industrial firms from 1998 to 2011. Some data is available at the sectoral level whereas other variables are available at the firm level. Therefore, the company level observations have been aggregated into

23 sectors within the broader manufacturing industry. This allows each sector to have different production technologies, which seems reasonable since there are differences in the amount of labour and capital used in different industries as well as the level of technology used.

For the estimation of TFP, time series data on value added, capital stock and labour are required. Some of these variables are directly reported in the datasets while others have been calculated. The value added output measure used is gross profit, which is defined as operating revenue minus costs of goods sold. The capital measure used is tangible fixed assets, which covers assets such as machinery, building and equipment.[1] The measure for labour is the number of employees.

The determinants of productivity identified in this paper are human capital and physical infrastructure. Human capital is measured by the sectoral shares of employees with different qualification levels. The CUCI database distinguishes between four categories of employee: (i) senior managers, (ii) skilled technicians, (iii) supervisors and skilled workers and (iv) unskilled workers. The first two skill levels are supposed to be acquired via investment in education and training, whereas the last two are mainly acquired by learning-by-doing. Therefore, the stock of senior managers and skilled technicians represents the accumulated stock of past investment in education and training. These indications are available for all the 23 sectors from 1998 to 2011. Appendix Figure 1 gives the average employee qualification level across the sectors.

Physical infrastructures are approximated by the quality of electricity access. The World Development Indicators (WDI) provide series data on electricity access only at the country level. Based on the WDI indicators and the CUCI database, we construct a proxy variable for electricity access at the sectoral level. Indeed, the accounting database provides data on tangible fixed assets by sector and we make the assumption of a proportional relationship between the size of tangible fixed assets and electricity access.

4 Methodology and results

The model that we propose below aims at explaining the determinants of productivity growth across sectors over the period 1998 to 2011. We focus on the main constraints identified in the Senegalese context, namely education and electricity supply, and we estimate the long-run relationship between TFP, human capital and electricity access.

4.1 TFP estimation

The first step of our analysis is the estimation of TFP at the sector level. The functional form that we use to estimate TFP is a Cobb-Douglas function. We run 23 equations for each of the 23 industry groups. They have the following form:

$$Y_{it} = A_{it}\, F(K_{it}\, L_{it}) \tag{1}$$

Where the *i* subscript varying from 1 to 23 allows identification of the industry group and the *t* subscript refers to the year. Y_{it}, K_{it} and $L_{it}$are, respectively, value added, capital and labour and A_{it} refers to *TFP*.

[1] We deflate value added and capital with the GDP deflator.

Imposing the constraint of constant returns to scale in private inputs, and dividing both sides of equation (1) by L yields the following equation:

$$\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha} \tag{2}$$

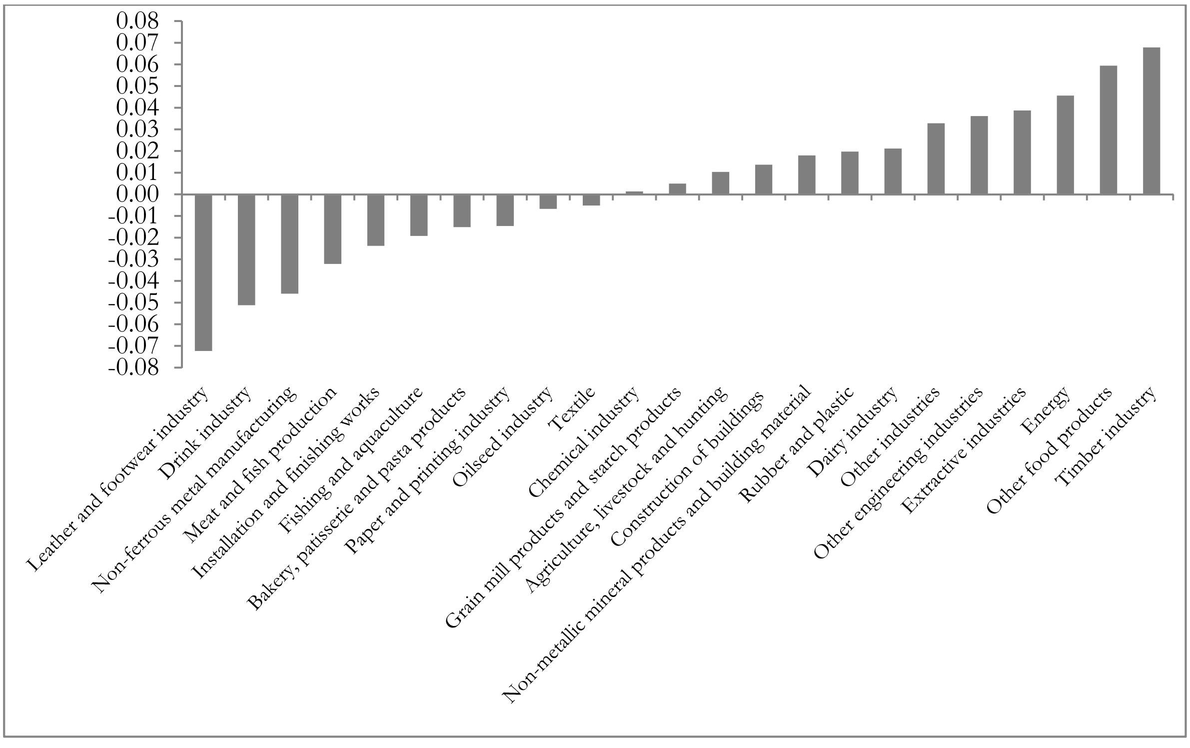
Finally, taking the natural logarithm yields the regression equation that is typically employed in empirical studies relying on the production function approach:

$$(y_{it} - l_{it}) = \beta_0 + \beta_1 t + \alpha(k_{it} - l_{it}) \; and \; \ln(A_{it}) = \beta_0 + \beta_1 t \tag{3}$$

where A_{it} represents the level of technology, TFP.

We find an elasticity of output with respect to capital, which is statistically significant and equal to 0.46. Figure 3 gives the corresponding TFP annual average growth rate from 1998 to 2011 for each sector. Over the period considered, about 10 out of 23 sectors recorded, on average, a decrease in productivity. By contrast, the other sectors registered an increase in TFP over the period 1998-2011.

Figure 3: TFP annual average growth rate by sector from 1998 to 2011



Source: Authors' calculations based on data from ANSD (various years).

4.2 Estimation and testing of the long-run relationship

In the second step we assess empirically the linkages between TFP, human capital and electricity access. Our focus is on two main determinants:

1. *Education:* Vandenbussche et al. (2006) distinguish two sources of increase in TFP, namely imitation and innovation, both being driven by education. Their model predicts that the cross sectoral differences in TFP growth can largely be understood as the consequence of differences in human capital endowment and the ability to both introduce innovations

and/or replicate best practices. Our prior hypothesis is that there is more scope in Senegal for imitation than for pure innovation.

2. *Access to electricity:* We also introduce in our model the quality of access to electricity. As emphasised in the previous section, electricity shortages have been identified as being the main obstacle to growth in several surveys conducted by the World Bank. By correlating TFP at the sectoral level with a proxy for the quality of access to electricity in the different sectors, we test whether any change in the quality of electricity access can produce positive spillover effects and translate into improved TFP.

A growing number of studies (Funk 2001; Guellec and van Pottelsberghe de la Potterie 2004; Lee 2006, Apergis et al. 2008) have resorted recently to dynamic panel-based cointegration to study such linkages. Following this literature, we conduct our examination of the relationship between TFP, human capital and electricity access in three steps. First, we test for cross section dependence and the order of integration of the variables. Second, we employ panel cointegration tests to examine whether a long-run relationship exists between the variables. Third, we estimate long-run parameters using adequate methodology (Dynamic Ordinary Least Squares (DOLS). Finally, we use the Pooled Mean Group (PMG) method, developed by Pesaran et al. (1999) to distinguish between the short-run and the long-run effects of human capital and electricity access on TFP.

First of all, we test for cross section dependence in order to avoid spurious results. Cross section dependence may arise due to unobserved common factors, externalities, regional linkages and unaccounted residual interdependence. We implement two tests: Pesaran (2004) and Friedman (1937). The tests, reported in Table 1 (in the Appendix), strongly reject the null hypothesis of no cross-sectional dependence at the 1 per cent level of significance. This indicates that our panel is cross-sectionally correlated, which may reflect the presence of similar regulations in various sectors.

Then, we can test the order of integration of the series. For this purpose, we implement three unit root tests, namely: the Im et al. (2003) unit root test, and the Maddala and Wu (1999) test. Neither of these take into account the cross section dependence between sectors. The third one, the Pesaran (2007) test, allows for cross-sectional dependence and thus controls for the common factor proxied by the cross section averages of lags and differences in the individual series. Results reported in Table (4) show that all the variables of interest are integrated of order one.

Table 4: Panel unit root tests and results

	Im et al.(2003)		Maddala and Wu (1999)		Pesaran (2007)	
	Statistic	P-values	Statistic	P-values	Statistic	P-values
TFP	-1.238	0.108	54.380	0.186	2.396	0.992
Δ(TFP)	-8.485	0.000	375.07	0.000	-8.115	0.000
Senior managers	0.467	0.680	169.051	0.000	2.853	0.998
Δ(Senior managers)	-16.48	0.000	460.00	0.000	-9.815	0.000
Skilled technicians	2.014	0.978	55.200	0.166	0.939	0.826
Δ(Skilled technicians)	-16.83	0.000	554.27	0.000	-9.640	0.000
Electricity access	1.776	0.962	36.102	0.852	0.676	0.750
Δ(Electricity access)	-11.06	0.000	274.87	0.000	-3.212	0.000

Source: Authors' calculations based on data from CUCI (ANSD various years).

Once the order of integration of our series has been defined, we test whether there exists a long-run relationship among these variables. Since we have cross section dependence in the unit root of our series, cross section dependence in cointegration vectors is likely to occur. Therefore, we perform the Westerlund (2007) cointegration test with the bootstrap approach, computable under the assumption of cross section dependence. The results, reported in Appendix Table 2, show that all the statistics reject the hypothesis of no cointegration between productivity, human capital and electricity access.

The cointegration tests allow assessment of whether there is a long-run equilibrium relationship. Nevertheless, they do not provide parameter estimates either for the long run or the short run. To estimate the long-run vector, we consider two estimators with error correction: the PMG and the DOLS estimator.

The DOLS estimator, proposed by Kao and Chiang (2000), corrects the standard pooled OLS for the serial correlation and endogeneity of regressors that are normally present in long-run relationships. Therefore we use this estimator to estimate the long-run relationship between total factor productivity, human capital and electricity access. In order to obtain an unbiased estimator of the long-run parameters, the DOLS estimator uses parametric adjustment to the errors by including lead and lags of the differenced I(1) regressors. The DOLS estimator is obtained from the following equation:

$$TFP_{it} = \alpha_i + \beta X'_{it} + \sum_{j=-q_1}^{j=q_2} c_{ij} \Delta X_{i,t+j} + v_{it} \qquad (4)$$

where c_{ij} is the coefficient of lead or lag of the first explanatory variables X_{it}. Table 5 reports the results of this estimation.

In order to test the robustness of the previous results, we use an alternative methodology, the PMG estimator, to estimate the cointegration relationship between TFP, human capital and electricity access. The main advantage of the PMG estimator over the DOLS model is that it can allow the short-run dynamic specification to differ from sector to sector while the long-run coefficients are constrained to be the same.

Assuming an autoregressive distributive lag (ARDL) ($p,q_1 \ldots q_k$) dynamic panel specification of the form:

$$TFP_{it} = \sum_{j=1}^{p} \gamma_{ij} \Delta TFP_{i,t-j} + \sum_{j=0}^{q} \delta_{ij} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (5)$$

Hence, the error-correction re-parametrization of equation (5) is given by:

$$\Delta TFP_{it} = \emptyset_i (TFP_{i,t-1} - \theta_i X_{it}) \sum_{j=1}^{p-1} \gamma_{ij} \Delta TFP_{i,t-1} + \sum_{j=0}^{q-1} \delta_{ij} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (6)$$

where the number of sectors i=1,2,...,N; the number of periods t=1,2,…,T; X_{it} refers to explanatory variables (namely human capital and electricity access); δ_{ij} are the coefficients of explanatory variables; μ_i is the sector-specific effect. θ_i is the vector which contains the long-run relationships between the variables and finally $\emptyset_i$ is the error-correcting speed of adjustment term. If $\emptyset_i$<0, there is a long-run relationship between TFP_{it} and X_{it} defined by:

$$TFP_{it} = -\left(\frac{\theta_i}{\emptyset_i}\right) X_{it} + \tau_{it} \qquad (7)$$

for each i, where τ_{it} is a stationary process. The parameter $\emptyset_i$ represents the speed of adjustment at which the values of TFP, human capital and electricity access return to their long-run equilibrium levels once they have deviated from the long-run equilibrium relationship. The negative sign of the estimated speed of adjustment coefficients are in accordance with the convergence toward the long-run equilibrium.

Results are reported in Tables 5 and 6. They are consistent with the TFP literature. As regards PMG estimates, the error correction term is significantly negative, meaning that productivity responds to deviations from the long-run equilibrium. The estimated speed of adjustment of TFP is around (-0.5) and is statistically significant at the 1 per cent level. Moreover, the results with the DOLS and the PMG procedures are convergent.

Table 5: Long parameter estimation: DOLS

	Senior managers	Skilled technicians	Electricity access
Coefficients	-0.195(1.506)***	0.242(1.345)***	0.210(1.775)***

Notes: *** significant at the 1% level; ** at the 5% level; * at the 10% level. Standard errors are given in parentheses. The dependent variable is TFP.

Source: Authors' calculations based on data from CUCI (ANSD various years).

Table 6: Long parameter estimation: PMG

	Senior managers	Skilled technicians	Electricity access
Short run	0.064(0.023)***	-0.004(0.019)	0.128(0.060)**
Error correction term	-0.500(0.010)***		
Long run	-0.100(0.024)***	0.053(0.026)**	0.295(0.023)***

Notes: *** significant at the 1% level; ** at the 5% level; * at the 10% level. Standard errors are given in parentheses. The dependent variable is TFP.

Source: Authors' calculations based on data from CUCI (ANSD various years).

The role of electricity is to expand productive capacity by increasing resources and improving the productivity of private capital. In both the long run and the short run, electricity access has a significant positive impact on economic performance. A 1 per cent increase in electricity access increases total productivity factor by 29 per cent (PMG) and 21 per cent (DOLS) in the long run and by 12 per cent (PMG) in the short run. These results have to be put in line with Wolde-Rufael (2009), who presents the latest evidence regarding Granger causality relationships between energy consumption and growth in a sample of 17 African countries. Regarding Senegal, Wolde-Rufael's paper finds that there is a unidirectional causality running from economic growth to energy consumption, implying that reducing energy consumption may be implemented with little or no adverse effect on economic growth. Using a different methodology and relying upon sectoral data, our results emphasize that improving the quantity and quality of electricity supply could indeed alleviate obstacles to productivity improvement and unleash firms' TFP.

Human capital is also a robust determinant of TFP. While low-skilled workers do not correlate with productivity,[2] skilled workers play a key role in improving firms' TFP. Our results allow two categories of skilled workers to be distinguished: senior managers and skilled technicians. Only for the latter category does the long-run relationship highlight a positive effect on TFP. A 1 per cent increase in the proportion of skilled technicians increases TFP by 5 per cent (PMG) and by 24 per cent (DOLS). For the senior managers category, the effect is in fact negative. These findings are

[2] Results available upon request.

in line with the diagnostics made by Pôle de Dakar UNESCO-BREDA (2007), which pointed out the low external efficiency of tertiary education enrolment and the higher efficiency of technical education.

5 Conclusion

This paper analysed the dynamics of TFP growth, exploiting sectoral information for a rich set of Senegalese manufacturing firms over the period 1998-2013, borrowed from the Single Information Collecting Centre (CUCI) (Senegalese National Statistic and Demography Agency-ANSD). We perform a careful analysis of the time series properties of our dataset, and we compute two sets of estimates, PMG and DOLS.

We found significant differences across sectoral TFP. By taking advantage of growth diagnostics recently published by the AfDB (2012), we propose two factors to explain these differences: education on one hand and the quality of electricity on the other hand. Both are shown to contribute substantially to the explanation of heterogeneity in TFP across different sectors. A 1 per cent increase in the proportion of skilled technicians increases TFP by 5 per cent (PMG) and by 24 per cent (DOLS). For the senior managers category, the effect is negative. Our proxy for electricity supply is based upon the WDI, available at the country level, and we assume that the demand for electricity is proportional to the size of tangible fixed assets, data on which is available at both the firm and sector level. A 1 per cent increase in electricity access increases total factor productivity by 29 per cent (PMG) and 21 per cent (DOLS) in the long run and by 12 per cent (PMG) in the short run.

Important policy implications can be drawn. The educational drive should focus on primary education, and technical training, the returns to which are higher. As emphasized in Section 2, the job market in Senegal is more open to job seekers with primary, secondary and technical levels of education than to university graduates. This is confirmed by our empirical analysis, showing that returns to TFP of technical levels of education, but not of the highest skill levels, are positive in the long run.

Efforts by Senegal – 11 per cent of GDP is spent on the infrastructure sector – are not negligible. The problem is that an insufficient amount is allocated to electricity, which is the main impediment to industrial growth. Between 2000 and 2009, generation capacity grew from 365 MW to 510 MW while demand kept growing at a rate of 25-30 MW per year. This was undoubtedly a significant increase in generation achieved by SENELEC but it still does not meet ever-rising demand. In addition to the problem of high demand for electricity that SENELEC cannot meet, the company is faced with other problems. Its power generation and transmission facilities are obsolete and consequently this prevents it from effectively addressing growing demand and power disruptions.

Our conclusion is corroborated by the World Bank Enterprise Surveys, which identify weak supply and frequent outages as the main obstacles to the development of the country's industrial activities and economic growth. This paper shows that better access to electricity could result in considerable improvement in TFP.

Appendix

Appendix Table 1: Cross section dependence results.

	Statistic	P-value
Pesaran	6.649	0.000
Friedman	51.01	0.000

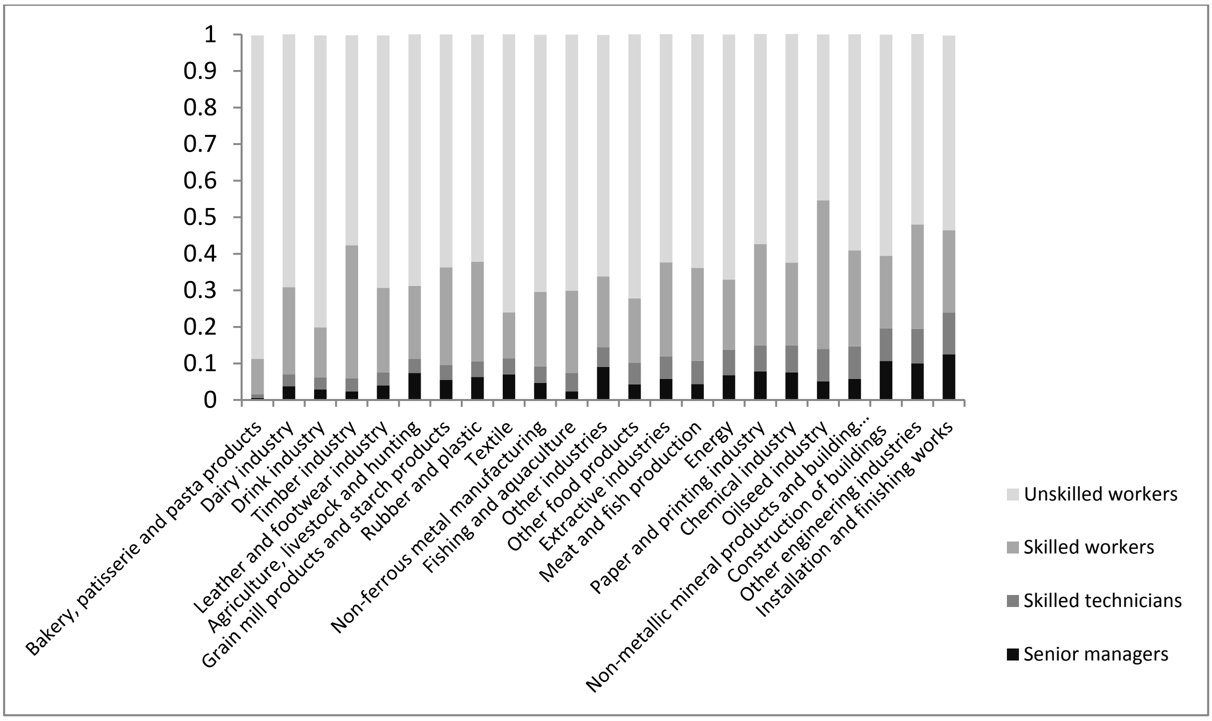
Source: Authors' calculations based on data from ANSD (various years).

Appendix Table 2: Westerlund (2007) panel cointegration test results.

Statistic	Value	Robust P-value
Gt	-2.614	0.080
Ga	-6.016	0.000
Pt	-10.68	0.055
Pa	-6.176	0.025

Source: Authors' calculations based on data from ANSD (various years).

Appendix Figure 1: Average proportions of employees by skill level across sectors



Source: Authors' calculations based on data from ANSD (various years).

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