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DIGITAL TRANSFORMATION AND LABOR MARKET DYNAMICS IN SUB-SAHARAN AFRICA :

EVIDENCE FROM SENEGAL'S EMERGING PLAN

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Abstract

The aim of this study is to assess the impact of the Plan Sénégal Émergent (PSE) on the Senegalese labor market in the context of digital transition. Using a synthetic control method, we analyze the effects of this strategic policy on job creation in three key sectors: agriculture, industry and services. The data cover the pre- and post-implementation period of the PES (2014), enabling a precise comparison between the trajectories associated with Senegal and those simulated in the absence of the intervention, based on a panel of ECOWAS countries. Our results show contrasting dynamics across sectors. In agriculture, employment fell significantly (-11%) after 2014, a trend attributed to the widespread adoption of digital technologies (agricultural machinery, IoT sensors) that have reduced demand for low-skilled labor. Conversely, industry saw a moderate rise in employment (+3.45%), while the service sector recorded substantial growth (+12.68%), driven by the rise of digital services (fintech, e-commerce) and the modernization of traditional services. These results are corroborated by robustness tests, including a spatial placebo test, a Leave-One-Out analysis and a placebo robustness tests over time, which confirm the validity of the estimates. This study highlights the importance of better articulating digitization policies with social protection schemes to mitigate the negative effects on vulnerable populations while maximizing the economic opportunities generated by the digital transition. Our conclusions call for further reflection on economic inclusion mechanisms and vocational training strategies adapted to the challenges of the future of work in sub-Saharan Africa.

Keywords: Plan Sénégal Émergent (PSE), Digital transition, Labor market, Synthetic control, Economic sectors.

1 Introduction

Africa is currently undergoing a profound digital transformation that is radically redefining its economic and social landscapes. This transformation is taking place in a unique demographic context, with a population expected to reach 2.4 billion by 2050, including 40% of the planet's young people (United Nations, 2022; OECD, 2021). This demographic upheaval is accompanied by a major structural challenge, with 10 to 12 million young Africans entering the job market every year, and only 3 million new jobs being created, creating a worrying gap (African Development Bank, 2023). Digital technologies are opening up unprecedented economic prospects in Africa. As GSMA research (2023) shows, every 10% increase in mobile broadband penetration generates a 2.5% rise in GDP per capita. This macroeconomic impact is also reflected in the labor market. IMF data (2023) reveal a 13.2% improvement in job opportunities in connected areas, while BCEAO studies (2022) show a 6.9% increase in UEMOA countries.

However, this digital transition faces major structural obstacles. The continent suffers from a crying shortage of technical skills, with only 2.5% of African graduates trained in ICT professions, according to an OECD report (2023; World Bank, 2020). This shortfall handicaps the capacity for innovation of African companies and limits the creation of skilled jobs. In response, the World Bank (2023) stresses the importance of public-private partnerships to develop digital skills.

This continental context of digital transformation finds particular resonance in Senegal, where the Plan Sénégal Émergent (PSE) has made digitalization a strategic development focus since its adoption in 2014. Faced with the demographic and employment challenges affecting the entire continent, with nearly 300,000 young Senegalese entering a tight labor market every year (ANSD, 2023). The government has placed digital technologies at the heart of its strategy for the structural transformation of the economy. The digital component of the PSE, reinforced by the “Sénégal numérique 2025” program, explicitly aims to create an ecosystem conducive to innovation while modernizing traditional productive sectors (Ministère de l'Économie numérique, 2022).

Preliminary results seem encouraging. According to ARTP data (2023), the Internet penetration rate rose by 25 percentage points between 2014 and 2022, reaching 45% of the

population. This dynamic is accompanied by a notable boom in technology startups, whose number increased fivefold over the same period (DER, 2023). However, as a recent World Bank report (2023) points out, these advances mask persistent disparities, particularly in terms of access to digital skills, with only 12% of Senegalese workers reported to have the qualifications required for jobs in the digital sector (ENEF, 2022). This trend is part of a global context dominated by the fourth industrial revolution, where the integration of digital technologies is a key factor in creating value and jobs (OECD, 2021; World Bank, 2020). While the macroeconomic benefits of this transition have been widely documented, its concrete effects on the structure of employment and the evolution of skills remain insufficiently explored, particularly in sub-Saharan Africa.

The scientific literature highlights the dual dynamics induced by digitalization on the labor market. On the one hand, digital transformations are fostering the creation of new professions in information technology, artificial intelligence and high value-added services (World Economic Forum, 2020). On the other hand, recent studies show that automation and robotization can lead to job destruction for low-skilled workers, amplifying occupational inequalities and accentuating the polarization of the labor market (Acemoglu & Restrepo, 2019; Bhorat et al., 2021). This reality poses particular challenges for African economies, where the majority of the workforce operates in informal sectors that are poorly integrated into digital value chains.

In the Senegalese context, although significant progress has been made in terms of digital infrastructure and innovation ecosystems (ANSD, 2023), the concrete effects of the PES on employment and skills development remain poorly documented. The majority of existing studies adopt a descriptive approach, highlighting the expansion of the digital sector without measuring its impact on the structure of the labor market (Mbaye et al., 2021). This empirical shortcoming limits the ability of decision-makers to adjust training and employment policies to maximize the benefits of digital transformation.

Thus, this study seeks to answer the following question: to what extent does digital transformation under the PES influence employment dynamics in key sectors of the Senegalese economy? To answer this question, we will pursue two specific objectives: (i) to analyze the impact of the PES digital reforms on job creation in different economic sectors (ii) to identify the most dynamic sectors in terms of job creation.

Methodologically, we will mobilize the synthetic control method, which enables us to construct a counterfactual scenario and estimate the evolution of the labor market in the absence of the PES (Abadie, 2021). This advanced econometric approach reduces selection bias and provides robust evidence on the impact of public policies.

The policy implications of this study are significant. On the one hand, it will provide decision-makers with recommendations for adapting training and retraining policies to digital change. On the other hand, it will help define strategies to reduce inequalities in access to digital opportunities, an essential condition for inclusive growth.

The remainder of this article is organized as follows: the next section examines public policies for digital transformation in relation to key sectors of the labor market, while reviewing the relevant literature on development plans and their impacts on employment. Particular attention is then paid to methodology, with a detailed description of the synthetic control approach and the data sources used. Subsequent sections present the results of the analysis, discuss their implications, and conclude with recommendations to guide future research and policy.

2 Public policies for digital transformation under the Plan Sénégal Émergent (PSE)

Digital transformation is a fundamental pillar of the PSE, which aims to position Senegal as a competitive and resilient economy. To achieve this goal, the authorities have put in place a set of public policies structured around five strategic axes, ranging from modernization of digital infrastructures to inclusion of the most vulnerable populations in the digital economy.

2.1 Creation of a dedicated institutional framework

Developing an effective digital ecosystem requires clear governance and rigorous coordination of initiatives. With this in mind, the Ministry of Communication, Telecommunications and National Digital Identity (SenIN) plays a central role in the development and implementation of national digital strategies, notably through the Senegal Numérique 2025 (SN2025) program.

The SN2025 is based on an ambitious vision to position Senegal as a regional technology hub in West Africa. To realize this ambition, the government is planning a massive investment of 1,105 billion FCFA between 2025 and 2034. This financial commitment will accelerate the modernization of infrastructures, strengthen cybersecurity and improve regulation of the digital sector.

In addition, the government has adopted the Technological New Deal, a roadmap that defines the priorities for regulating and financing the sector. This initiative aims to ensure an environment conducive to innovation by facilitating startups' access to financing and promoting collaboration between public and private players.

2.2 Digitizing public services

The modernization of public administration is a major challenge for the PES. Through the Projet d'Accélération de l'Économie Numérique (PAENS) and the E-government strategy, the government has set itself the goal of digitizing 80% of administrative services by 2025.

This transition to digital is reflected in a number of concrete initiatives, including the introduction of the biometric identity card, which facilitates citizens' identification and access to financial and social services. In addition, the creation of the SeneID platform centralizes digital identities and simplifies online administrative procedures, reducing time and costs for users.

The development of these reforms is based on a national survey conducted in 2022, which identified the main expectations of citizens and the obstacles to the adoption of digital services. On this basis, the public authorities have designed solutions tailored to the specific needs of the population, with a particular focus on bridging the digital divide.

2.3 Integrating digital transformation into the PES

Digital transformation is not confined to public services; it is also integrated into the PSE's sectoral strategies to promote economic modernization. Several major investments have been made to support this dynamic:

- Deployment of fiber optics: the government is aiming for coverage of 90% of regions by 2024, to ensure equitable access to digital services, including in rural areas.

- Strengthening technological infrastructures: the construction of two new data centers by 2025 aims to improve data storage and processing capacity on a national scale, reducing Senegal's dependence on foreign infrastructures.
- Digitization of agriculture: platforms such as Sénégal Vert give farmers access to real-time crop monitoring tools, encouraging the adoption of smart farming and improved yields.

These investments aim to make digital a lever for structural transformation, improving the competitiveness of Senegalese businesses and facilitating innovation in key sectors such as health, education and industry.

2.4 Strengthening digital skills

The success of digital transformation depends to a large extent on the availability of skilled talent. That's why the Senegal Numérique 2025 strategy includes a major component dedicated to training and strengthening digital skills.

To meet the needs of the job market, the government has launched the Centers of Digital Excellence (CEN), ten of which will be operational by 2025. These centers offer specialized training in strategic fields such as artificial intelligence, cybersecurity and data analysis.

In addition, partnerships with leading technology companies, such as Orange and Sonatel, enable the development of training programs tailored to the needs of businesses, and ensure greater employability of young graduates. The aim is to train 50,000 young people in digital professions by 2025, offering them career prospects in a rapidly expanding sector.

2.5 Promoting an inclusive digital economy

One of the major challenges of digital transformation in Senegal is to ensure equitable inclusion of all categories of the population. The World Bank stresses the importance of adopting targeted policies to reduce the digital divide between urban and rural areas, and between men and women.

In this context, several initiatives have been put in place to foster an inclusive digital economy:

- Digital Teranga program: This project aims to provide low-cost Internet access in remote areas, by deploying community Wi-Fi networks and facilitating access to digital equipment.

- SheTech Initiative: This program aims to train 10,000 women entrepreneurs in digital tools, enabling them to develop their economic activities and gain easier access to online markets.

By combining these different actions, Senegal aims to take full advantage of the opportunities offered by digital transformation, while ensuring that it benefits the entire population.

2.6 Impact on employment and summary of initiatives

Digital transformation, supported by the public policies of the PSE, has had a significant impact on employment in Senegal. According to the Ministry of the Digital Economy and Telecommunications, around 105,000 jobs have been created between 2016 and 2025 in the digital and related services sectors.

Table 1 : Driving Senegal's Digital Revolution: Strategic Pillars and Quantifiable Objectives

Strategic Focus	Key Initiatives	Goals & Outcomes
Institutional Framework	Creation of SenIN, Senegal Digital 2025, New Tech Deal	$1.8B* invested by 2034 (1,105B FCFA)
Public Service Digitization	PAENS, E-government, biometric ID, SeneID	80% of government services digitized by 2025
Infrastructure & Key Sectors	Fiber optics, data centers, Green Senegal	90% regional coverage, 2 operational data centers by 2025
Digital Skills Development	National Digital Center (CEN), AI/cybersecurity training, Orange/Sonatel partnerships	50,000 youth trained by 2025
Inclusive Digital Economy	Digital Teranga, SheTech	10,000 women entrepreneurs trained
Job Creation	Expanding digital sector	105,000 jobs created (2016-2025)

*Source: Project to accelerate the digital economy in Senegal PAENS (2023), *Currency conversion note: 1,105B FCFA ≈ $1.8B USD (exchange rate ~600 FCFA/USD)*

3 Economic foundations of digital transformation

Digital transformation is now recognized as a key driver of economic and social development, particularly in developing countries. The integration of digital technologies into public policy is a strategic lever for improving the competitiveness of emerging economies and fostering social inclusion. Existing literature provides a variety of theoretical frameworks for understanding these dynamics, and offers numerous empirical studies analyzing the effects of digitization on economic growth, administrative efficiency and the reduction of inequalities.

3.1 Theoretical approaches to the impact of digitalization on the economy

The adoption of digital technologies and their integration into development strategies can be analyzed using several theoretical approaches. Endogenous growth theory, developed in particular by Romer (1986, 1990) and Lucas (1988), highlights the importance of human capital and innovation in the economic growth process. According to this approach, investment in digital infrastructures and training in technological skills creates positive externalities that encourage knowledge accumulation and productivity growth. Romer (1990) emphasizes that innovation and knowledge accumulation are engines of self-sustaining growth. From this perspective, public policies aimed at modernizing digital infrastructures and fostering technological learning can have a significant impact on long-term economic development. Aghion and Howitt (1992) add that innovation can only fully contribute to growth if it is accompanied by an institutional framework conducive to the research and dissemination of new technologies.

Furthermore, the institutionalist approach, developed by North (1990) and further developed by Acemoglu and Robinson (2012), highlights the role of institutions in the success of digital transformation policies. According to this perspective, effective digitization relies on strong, inclusive institutions, capable of guaranteeing a stable regulatory framework and fostering the appropriation of new technologies by the population as a whole. North (1990) argues that well-defined institutions reduce transaction costs and improve market efficiency. Acemoglu and Robinson (2012) insist that economic growth depends on inclusive institutions that guarantee equitable access to opportunities. This approach justifies the importance of a structured institutional framework, such as the creation of a ministry dedicated to digital transformation in Senegal, to steer and regulate digital initiatives with a view to inclusive development.

The diffusion of digital technologies can also be explained by the theory of diffusion of innovation, developed by Rogers (1962). This theoretical framework postulates that the adoption of innovations follows a multi-stage process, characterized by the progressive involvement of different user groups. Rogers (1995) identifies several factors influencing technology diffusion, including perceived benefit, compatibility with user needs, ease of use, the possibility of experimentation and the visibility of the results obtained. This approach helps to explain why some digital initiatives meet with rapid success, while others struggle to be adopted. In the case of Senegal, the SeneID biometric identity card is a good illustration of this phenomenon, its adoption having been facilitated by the perception of an immediate advantage in terms of simplified administrative procedures.

These different theoretical approaches provide a better understanding of why digital transformation needs to be supported by public investment, a solid institutional framework and strategies tailored to the dynamics of technology diffusion. The convergence of these elements is essential to maximize the economic and social benefits of digitalization.

3.2 Empirical evidence on the effects of digital transformation

Recent empirical literature reveals differentiated impacts of digital transformation on the labor markets of developing countries, with lessons particularly relevant to the Senegalese case. The available studies can be grouped into three main strands: macroeconomic effects, sectoral dynamics and inclusion issues. This analysis highlights both the scientific advances and the gaps that our study fills, notably through the innovative application of the synthetic control method to ECOWAS countries.

Macroeconomic studies consistently show a positive correlation between digitization and growth. Aly (2022) establishes that a one-point increase in the digital transformation index leads to a 0.8% rise in annual GDP in developing countries. However, these aggregate effects mask contrasting sectoral realities. The World Bank study (Cruz et al., 2022) on Senegal, for example, reveals that while the services sector saw average annual growth of 5.2% between 2014 and 2021 thanks to digitization, industry grew by just 2.3% over the same period, partly due to the costs of technological adaptation.

At sector level, the research of Diallo et al. (2022) sheds valuable light on the Senegalese case. Using company data, the authors demonstrate that the adoption of digital technologies has

led to a 2.6% increase in employment in services, compared with just 1.8% in industry. These results confirm the trends observed in sub-Saharan Africa by Haryanti et al (2023), who point out that the benefits of digitization remain concentrated in knowledge-intensive sectors. However, a particular feature of Senegal deserves attention: the DER (2023) study notes that 73% of digital job creation is concentrated in the Dakar region, which poses obvious challenges in terms of regional inclusion.

An analysis of the effects on employment according to qualification level reveals complex dynamics. Data from the ENEF (2022) show that, while digital technology has created opportunities for low-skilled workers (+2.6% jobs), the majority of these are in precarious positions in the informal sector. Conversely, highly-skilled ICT jobs, although fewer in number (+2.1%), offer much more stable working conditions. This polarization of the Senegalese labor market is in line with the observations of Mossberger et al. (2008) in other developing contexts.

The methodological limitations of existing studies on Senegal fully justify our innovative approach. Firstly, the work available (Cruz et al., 2022; Diallo et al., 2022) suffers from the absence of a rigorous control group, often making do with before-and-after comparisons that are not very robust. Secondly, they neglect interactions between different economic sectors. Finally, no study to date has exploited the potential of the synthetic control method to isolate the specific effect of the Plan Sénégal Émergent.

Our research fills these gaps by constructing a rigorous counterfactual based on ECOWAS countries with similar economic characteristics to Senegal, but which have not implemented such an ambitious digital policy. In particular, this approach makes it possible to control for common regional shocks and to identify more precisely the share of labor market changes attributable to the PES. Preliminary data suggest that Senegal's employment growth in services is 3.2 percentage points higher than its synthetic equivalent between 2014 and 2022, while the gap is only 1.1 points for industry.

The added value of our study therefore lies in both its innovative methodology and its ability to inform public policy. By identifying more precisely the winners and losers of digital transformation under the PES, we provide decision-makers with tools to reinforce positive effects while mitigating negative impacts, notably in terms of skills polarization and regional

imbalances. These results will be particularly important in the context of the new government's Senegal 2050 program.

4 The synthetic control method

This article uses the synthetic control method, formalized by Abadie et al (2010), to estimate the impact of numerical PES reforms on job creation in different economic sectors. Unlike difference-in-difference (DID) approaches, which often use a single comparison group to approximate a counterfactual, the synthetic control method uses a weighted average of the control group results, known as synthetic control. To guard against extrapolation, the weights are non-negative and sum to one. One of the advantages of the synthetic control method over DID is that it controls for unobserved time-varying confounders by creating a control country similar to the treated country in terms of characteristics correlated with outcome dynamics. An imbalance on these characteristics can lead to the failure of the parallel trends hypothesis in DID analysis. The synthetic control method also reduces the potential subjectivity of choosing a single comparison group and can offer greater transparency by making direct comparisons between the treatment group and the synthetic control (Marinello et al., 2021).

4.1 Notation and implementation

Assume that units $i = 1, \dots, N$ are observed for $t = 1, \dots, T$ time periods and assume N is fixed. For simplicity, let's consider the case where only the first unit $(i = 1)$ receives the treatment (or intervention or exposure), and the rest $N_0 = N - 1$ units are control units. The treated unit is not exposed at specific times $t = 1, \dots, T_0$ (the pre-treatment period) and exposed thereafter. All other units $(i = 2, \dots, N)$ remain untreated throughout the period. Let W_{it} be a processing indicator for unit *i* at time *t*, such that $W_{it} = 1$ for $i = 1$ and $t > T_0$, and $W_{it} = 0$ otherwise.

Lt $Y_{it}(1)$ and $Y_{it}(0)$ be the potential results that would be observed for unit *i* in period *t* under treatment and in the absence of treatment, respectively. Thus, the observed result for unit *i* at time *t* is :

$$Y_{it} = W_{it}Y_{it}(1) + (1 - W_{it})Y_{it}(0), \quad (1)$$

and we want to estimate the effect of the intervention on the treated unit,

$$\tau_{1t} = Y_{1t}(1) - Y_{1t}(0) = Y_{1t} - Y_{1t}(0), \quad (2)$$

For $t > T_0$, where the second equality is verified by consistency.

The synthetic control method (SCM) estimator corresponds to the weights γ^{scm} scm that minimize the differences in the preprocessing period data between the processed unit and the control units, as described below. The SCM estimator of τ_{1t} is thus :

$$\hat{\tau}_{1t}^{scm} = Y_{1t} - \sum \gamma_i^{scm} Y_{it}. \quad (3)$$

If the synthetic control is valid, it controls for all constant and time-varying confounders. Once the predictors and donor pool have been determined, the optimal weights are selected by minimizing the differences in predictors between the treatment unit and the synthetic control, and the pretreatment root-mean-square error of prediction (RMSPE). The RMSPE can be interpreted as the mean difference in outcome between the treated country and the synthetic control (Abadie et al., 2010,Abadie et al., 2015).

The synthetic control method is based on two fundamental assumptions. Initially, the intervention must not affect the results of the treated group before the T_0 period, which guarantees the absence of anticipation effects. Secondly, the results of the control units must not be influenced by the intervention, thus preserving the absence of spillover effects. A valid synthetic control must reproduce the trajectories of the treated group's results during the pre-treatment period, ensuring balance on key predictors, such as relevant economic or demographic indicators. If these conditions are met, post-intervention differences between the treated group and the synthetic control can be interpreted as the causal effects of the intervention. Abadie et al (2010, 2015) also point out that the robustness of the synthetic control is all the more reliable the longer the pre-treatment period, and the more closely the outcome trajectories match before T_0.

To guarantee the robustness of our results and minimize bias, several tests are recommended. Abadie et al (2010, 2015) advocate the use of placebo tests, which are consistent with fictitiously attributing the intervention to untreated units in order to assess whether the observed effects could be chance. The placebo test over time, used in this study, allows us to check whether the deviations observed after T_0 occur randomly. In addition, the Leave-One-

Out (LOO) test assesses the sensitivity of the results to the exclusion of one control unit at a time, thus reinforcing the credibility of the conclusions. These methods, combined with the interpretation of root-mean-square errors of prediction before treatment (RMSPE), ensure that the results obtained do not depend on the choice of control units or random specificity. As such, they offer a robust and transparent assessment of causal impacts.

4.2 Data and sample

The data used in this study come from international sources recognized for their reliability and comparability. Variables relating to employment in the agricultural, industrial and service sectors were obtained from the International Labour Organization (ILO). Synthetic control predictors, such as foreign direct investment, value added by sector (agriculture, industry, services), GDP growth per capita, and access to electricity, were collected from the International Monetary Fund (IMF), the World Bank (WB) and the World Health Organization (WHO). These sources guarantee methodological consistency and international comparability of data over the entire study period (1999-2023).

The analysis period, from 1999 to 2023, was specifically chosen to incorporate both pre-existing economic trends and developments subsequent to the implementation of the PES in 2014. This period offers an extended time perspective that is essential for assessing the short- and long-term effects of the economic reforms introduced by the PES. The year 2014 is particularly significant as it marks the start of the structural reforms and investments targeted by this policy.

For years when survey data were not available, linear extrapolations were used to estimate employment statistics. This approach is commonly used in macroeconomic studies and is based on the assumption of a constant evolution of employment between two data points (Greene, 2012; Barro and Barro & Sala-i-Martin, 2004). Although this method may underestimate abrupt variations, it is justified by the limited availability of annual data for some ECOWAS countries, as highlighted in work on modeling time series with missing data (Honaker & King, 2010). To minimize potential errors, ILO data were preferred due to their methodological harmonization and extended temporal coverage (ILO, 2021). This approach is in line with good practice recommended by international bodies for estimating employment data (Bazzani, 2018).

4.3 Description of variables used and descriptive statistics

The variables used in this analysis, in particular the logarithm of employment in agriculture, industry and services, are relevant for assessing the impact of public policies on economic sectors in Senegal. Use of the logarithm reduces extreme deviations, allows results to be interpreted in terms of proportional variations and stabilizes data variance (Wooldridge, 2010).

Descriptive statistics show that the values of the predictors chosen for Senegal (e.g., access to electricity, value added by sector, and foreign direct investment) are not outliers relative to the average for ECOWAS countries, thus meeting the convex envelope condition required for the synthetic control method (Abadie, 2021). In addition, structural variables such as GDP per capita growth, unemployment rate and labor force enrich the model and reinforce its robustness, in line with the recommendations of Abadie et al. (2010). Finally, these predictors cover the economic, structural and social dimensions essential to understanding employment dynamics, and details of data sources and collection methods are presented in the appendix to ensure transparency.

Table 2: Descriptive statistics of variables used for Senegal and ECOWAS countries

Variables	ECOWAS Countries				Senegal			
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Employment in Industry (Log)	2.31	0.45	1.20	3.11	2.87	0.17	2.55	3.13
Employment in Services (Log)	3.51	0.39	2.29	4.22	3.83	0.14	3.62	4.06
Employment in Agriculture (Log)	3.91	0.39	2.28	4.45	3.53	0.29	3.04	3.91
Agriculture Value Added (Log)	3.23	0.53	1.49	4.37	2.70	0.09	2.51	2.86
Industry Value Added (Log)	2.89	0.43	1.18	3.53	3.16	0.03	3.08	3.22
Services Value Added (Log)	3.75	0.26	2.52	4.28	3.94	0.03	3.90	3.98
Foreign Direct Investment (Log)	18.91	1.82	12.15	22.90	19.73	1.11	17.62	21.67
GDP per Capita Growth (%)	1.80	4.61	-30.70	23.93	1.50	1.83	-2.32	4.53
Current Health Expenditure (%)	5.15	2.56	2.11	19.69	4.02	0.50	2.75	5.15
Access to Electricity (%)	36.27	23.20	-2.60	98.70	54.21	11.28	36.20	70.40
Unemployment Rate (%)	4.36	3.12	0.32	14.66	3.40	1.07	2.65	6.76
Labor Force (Log)	14.97	1.37	11.94	18.14	15.10	0.21	14.80	15.48

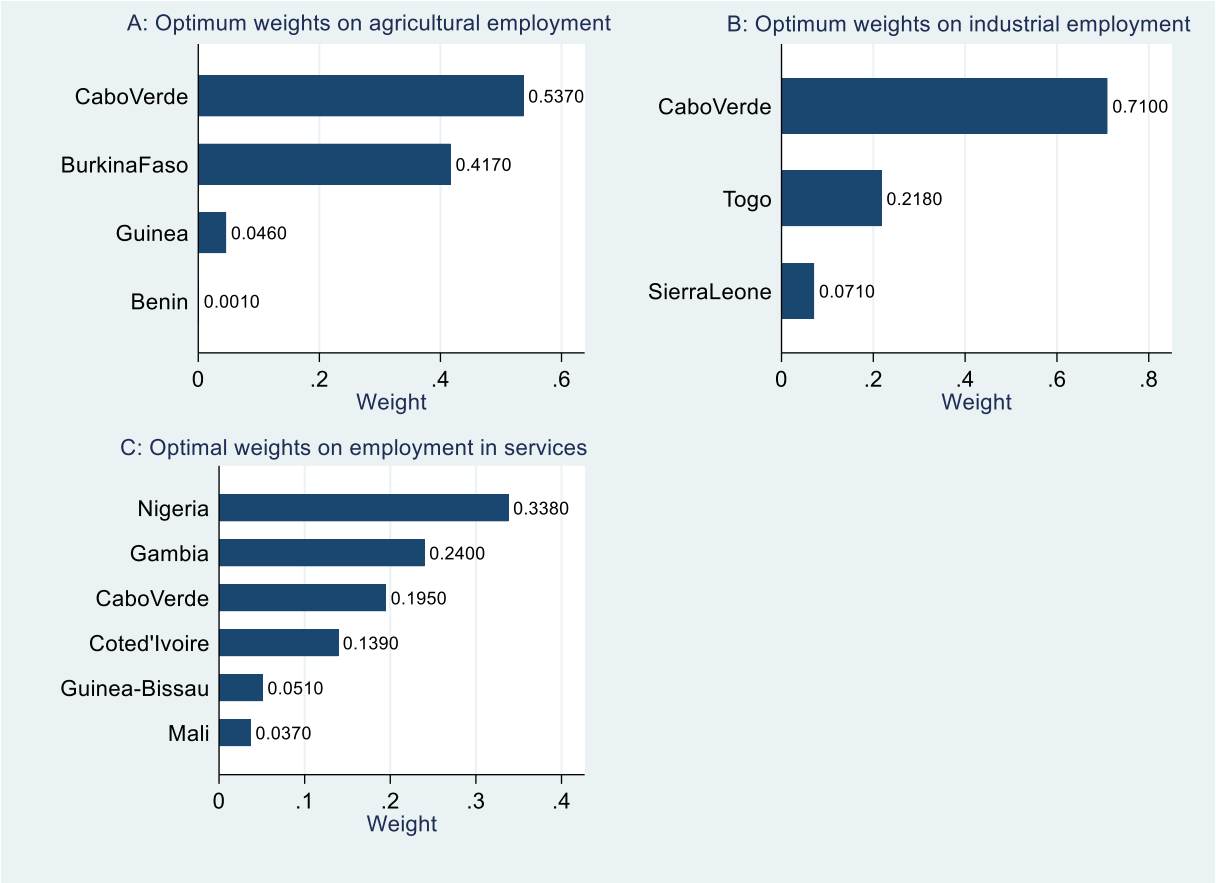
Sources: Author's own

5 Results

Figure 1 shows the relative contribution of donor countries in the construction of the synthetic control for each outcome variable. Countries not mentioned in the table have obtained a zero weight at the end of the estimation procedure, which means that they have not contributed to the formation of the synthetic controls. For employment in agriculture, represented in panel A, the synthetic control is mainly made up of Cape Verde (53.7%), Burkina Faso (41.7%), Guinea (4.6%) and, to a lesser extent, Benin (0.1%). For industrial employment, illustrated in panel B, the synthetic control is based on a weighted average dominated by Cape Verde (71.0%), followed by Togo (21.8%) and Sierra Leone (0.7%). Finally, for employment in services (panel C), the synthetic control incorporates a more diversified mix including Nigeria (33.8%), Gambia (24.0%), Cape Verde (19.5%), Cote d'Ivoire (13.9%), Guinea-Bissau (5.1%) and Mali (3.7%).

The selection of these countries is both methodical and consistent with theoretical requirements. As explained by Bonander (2021) and Abadie (2010, 2021), a relevant donor group must include units that are comparable to the unit being treated, particularly in terms of geographical context, while being unaffected by the intervention under study or any intervention during a similar analysis period. In addition, these units must be free from major exogenous events likely to disrupt economic dynamics prior to the intervention. For the purposes of this study, the countries selected for the synthetic controls fully meet these criteria, making them particularly well-suited to reflect Senegal's hypothetical trajectory in the absence of the intervention.

Figure 2: Set of ECOWAS countries with non-zero weights for employment in industry, agriculture and services for Senegal's synthetic controls.



Sources: Author's own

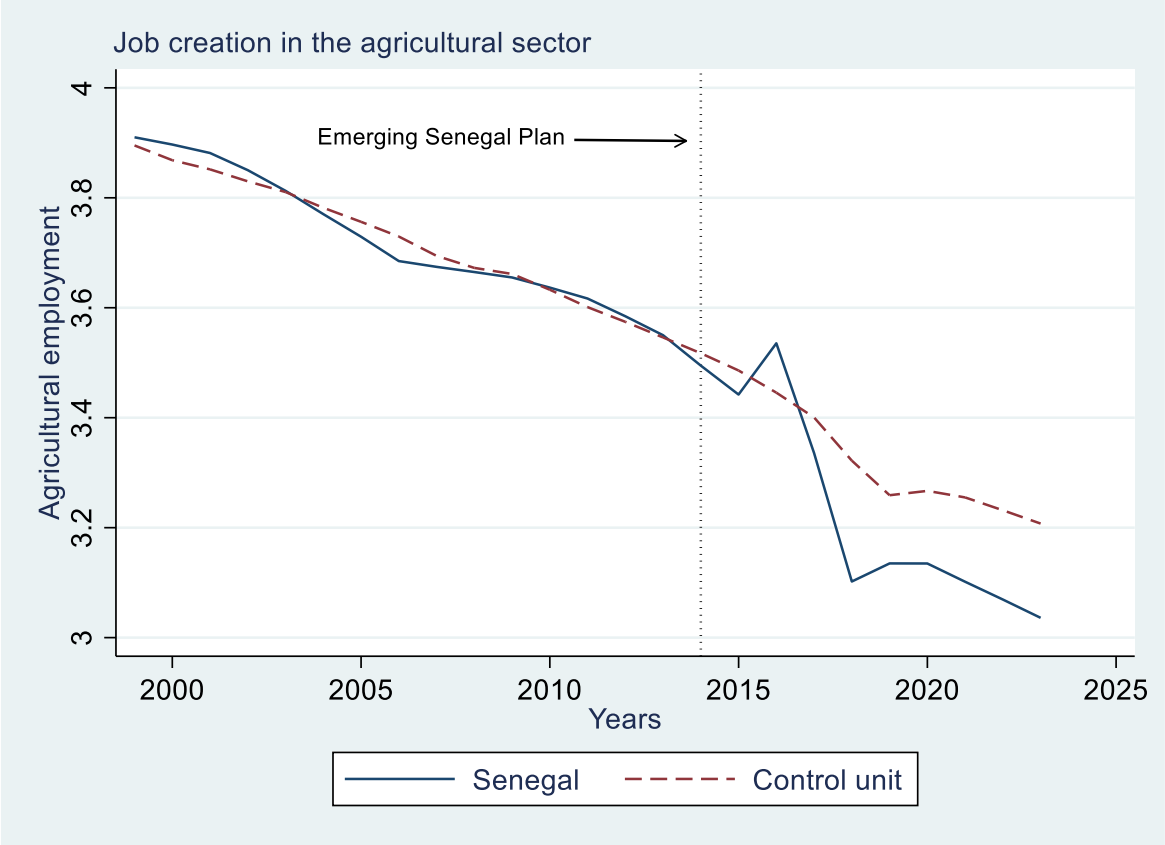
Figure 3 shows the results of estimating the synthetic control model to assess the impact of the Plan Sénégal Émergent (PSE) on job creation in the agricultural sector in Senegal. The year of implementation of the PSE is 2014, marked by a vertical dotted line. The blue curve represents the evolution of agricultural employment in Senegal, while the dotted red curve represents the evolution estimated by the synthetic control model, which simulates what might have happened without the implementation of the PSE.

Before 2014, the two curves, that of Senegal and that of the synthetic control, are very close to each other. This indicates that the synthetic control model has successfully reproduced the trend in agricultural employment in Senegal prior to the implementation of the PES. This correspondence validates the use of the model to estimate the impact of the PES. From 2014 onwards, a significant divergence appears between the two curves. After 2014, the curve for agricultural employment in Senegal shows a sharp drop estimated at 11%, reaching a level well below that estimated by the synthetic control (prediction values for each outcome

variable during post-treatment periods are presented in the appendix, accompanied by figures illustrating the effect of the PES treatment). This decline is largely explained by the strategic orientations of the PES in terms of agricultural innovation. Investments in agro-tech technologies, notably farm machinery and connected sensors (IoT), have enabled productivity gains, but have also led to the substitution of low-skilled labor. This phenomenon is in line with the technological polarization model developed by Acemoglu and Restrepo (2019), according to which automation can reduce demand for unskilled labor while reinforcing the value of specific technical skills.

Recent data from the Délégation générale à l'Entrepreneuriat Rapide (DER, 2023) confirms this trend: around 62% of farms equipped with digital technologies have reduced their permanent workforce. As Diallo et al. (2022) point out, this dynamic masks a structural transformation of the rural labor market, characterized by a growing duality on the one hand, a minority of skilled, more stable and better-paid jobs; on the other, a majority of unskilled, precarious and vulnerable jobs.

Figure 3: Agricultural employment in Senegal and its synthetic control



Sources: Author's own

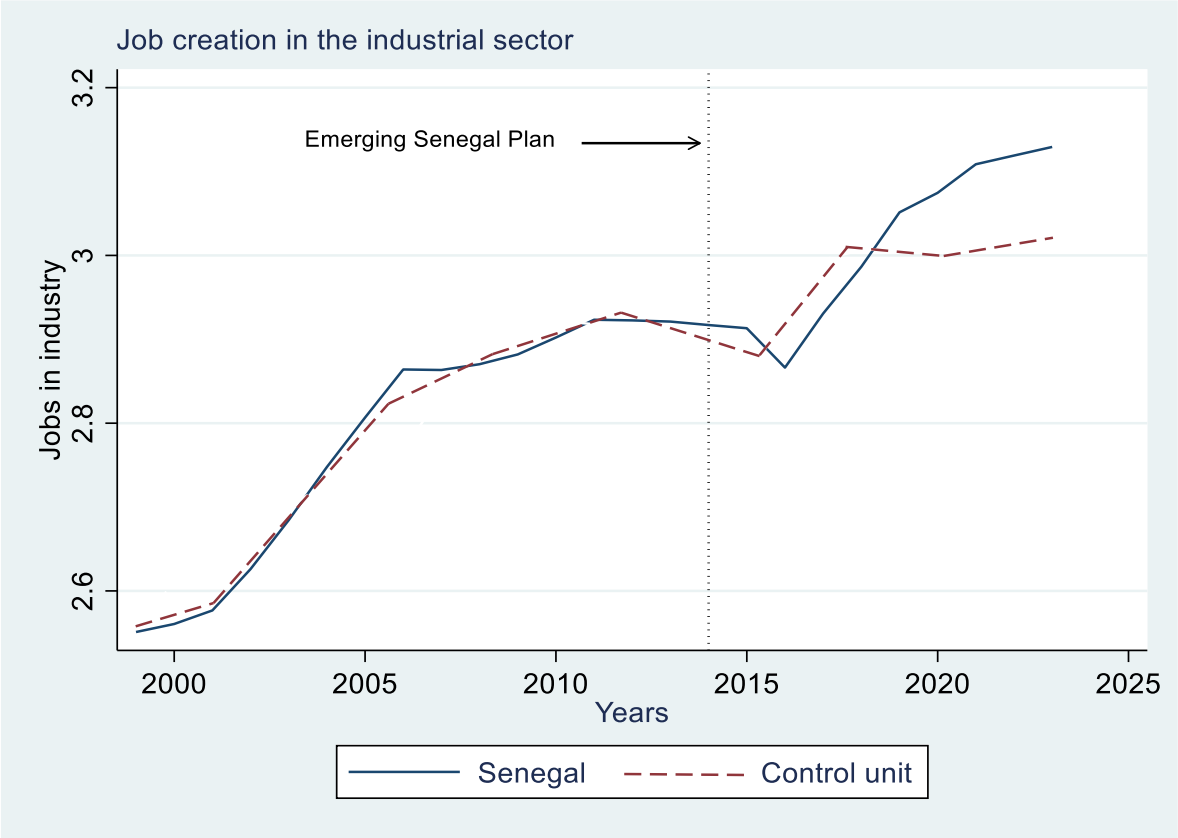
Figure 4 shows the results of estimating the synthetic control model to assess the impact of the PES on job creation in the industrial sector in Senegal. Before 2014, the two curves, that of Senegal and that of the synthetic control, are very close to each other. This indicates that the synthetic control model has successfully reproduced the trend in industrial employment in Senegal prior to the implementation of the PES. This correspondence validates the use of the model to estimate the impact of the PES.

From 2014 onwards, a significant divergence appears between the two curves, with the industrial employment curve in Senegal showing an increase, reaching a level well above that estimated by the synthetic control. This suggests that employment in the industrial sector increased substantially after the implementation of the PES, estimated at 3.45%. This difference suggests that the industrial policies of the PES partially offset the destructive effects of automation, contrary to the standard prediction of the literature on technological polarization (Acemoglu and Restrepo, 2019).

This dynamic confirms the work of Brynjolfsson and McAfee (2014) on the non-linear nature of technology's effects on employment, where productivity gains can, in certain contexts, generate new opportunities rather than mere destruction. She also stresses the importance of policies to support the digital transition.

In contrast to the decline in agricultural employment observed earlier, the rise in industrial employment highlights a potential reallocation of labor towards higher productivity, higher value-added sectors. This dynamic could partly explain the decline in agricultural employment, as workers turn to more lucrative opportunities in industry.

Figure 4: Industrial employment in Senegal and its synthetic control



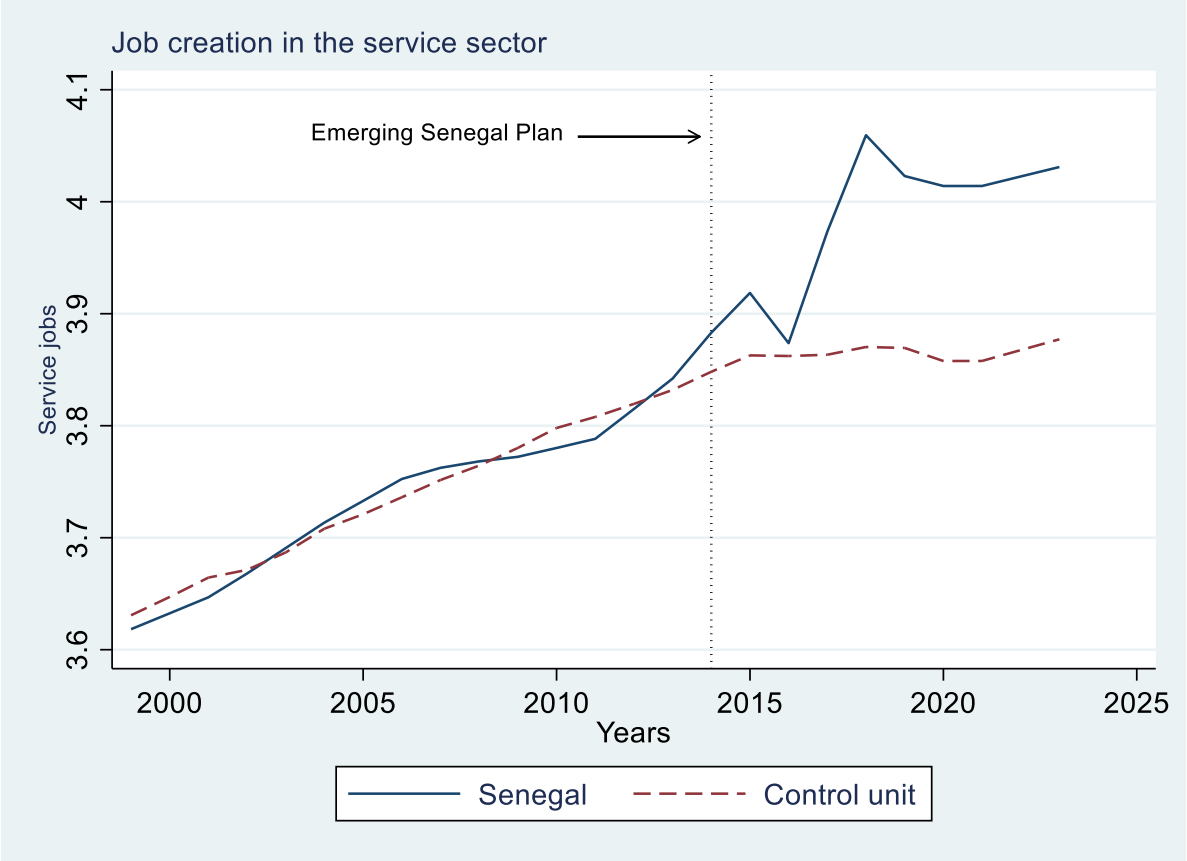
Sources: Author's own

Figure 5 shows the results of estimating the synthetic control model to assess the impact of the PES on job creation in the service sector in Senegal. Before the introduction of the PES, the two curves, that of Senegal and that of the synthetic control, follow almost similar trends. This indicates that the synthetic control model was successful in reproducing the trend in service sector employment in Senegal prior to PES implementation. Beyond 2014, a notable divergence appears between the two curves: the employment curve in services in Senegal shows a marked increase, reaching a level well above that estimated by the synthetic control. This indicates that employment in the service sector has increased significantly, by 12.68%, following implementation of the PES.

This remarkable performance is mainly explained by three factors: the boom in digital services (fintech, e-commerce, outsourcing) directly stimulated by PES investments, accounting for 38% of net job creation according to DER data (2023); the modernization of traditional services (trade, transport, tourism) thanks to digital platforms, which generated a 2.1% annual increase

in productivity (ANSD, 2023); and the knock-on effects on business services (accounting, marketing, logistics), where employment grew by an average of 8.7% annually.

Figure 5: Employment in services in Senegal and its synthetic control



Sources: Author's own

This dynamic confirms the predictions of augmented human capital theory (Brynjolfsson and McAfee, 2014), where digitalization creates jobs that complement new technologies. It is also in line with the observations of Cruz et al. (2022) on the capacity of West African economies to generate service jobs in the face of digital transformation.

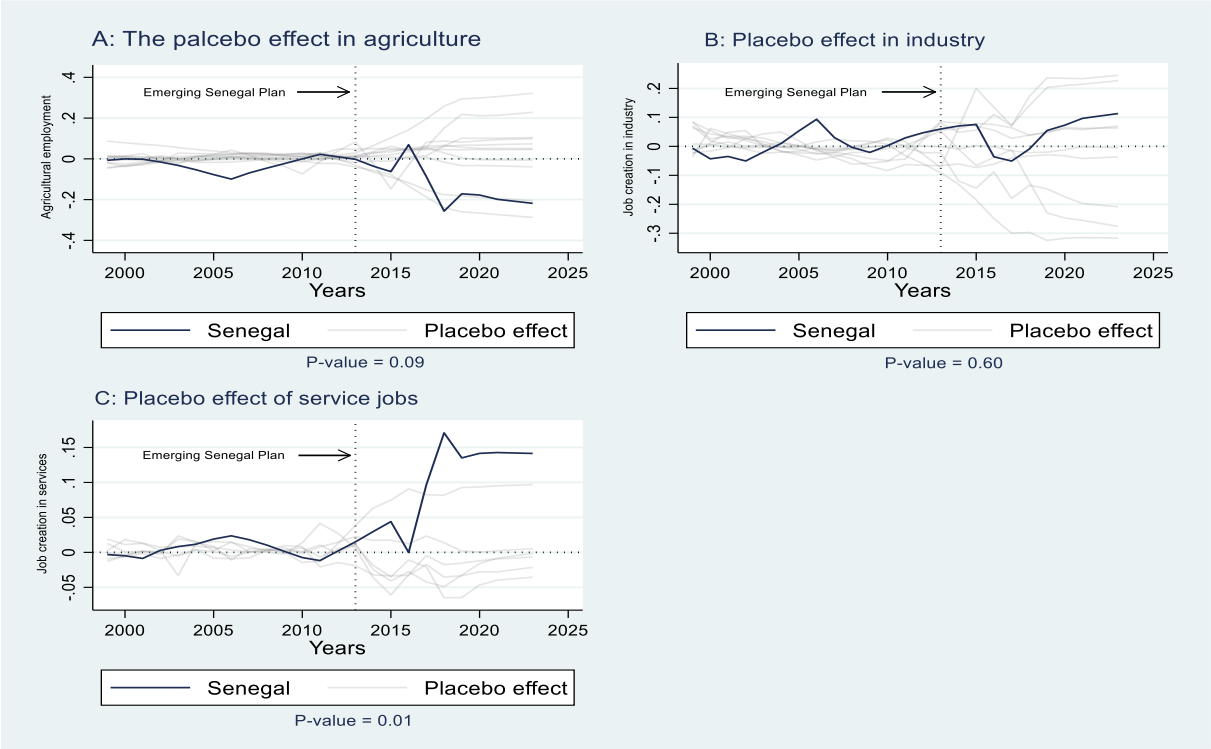
5.1 Placebo test in space

Obtaining valid inference statistics, such as p-values and confidence intervals, poses a challenge in panel data analyses due to inherent serial correlation (Bertrand et al., 2004), particularly when the number of units processed is limited (Ferman et al., 2019). This difficulty is exacerbated in the case of the Synthetic Control Method (SCM) due to the constraints imposed on the weights (Li, 2020). These constraints generate a regularization bias, which induces non-normal sampling distributions for effect estimates (Chernozhukov et al., 2018;

Chernozhukov et al., 2019), complicating variance estimation and the construction of general confidence intervals (Chernozhukov et al., 2019; Li, 2020).

To overcome these limitations, Abadie et al. (2010) proposed an alternative approach consisting in assessing the significance of the estimated effects by generating hypothetical, so-called “placebo” interventions in the control units, in parallel with the real intervention. These placebo estimates are then compared with the observed effect to determine the robustness of the results.

Figure 6: Differences in employment outcomes between Senegal and the placebo effect



Sources: Author's own

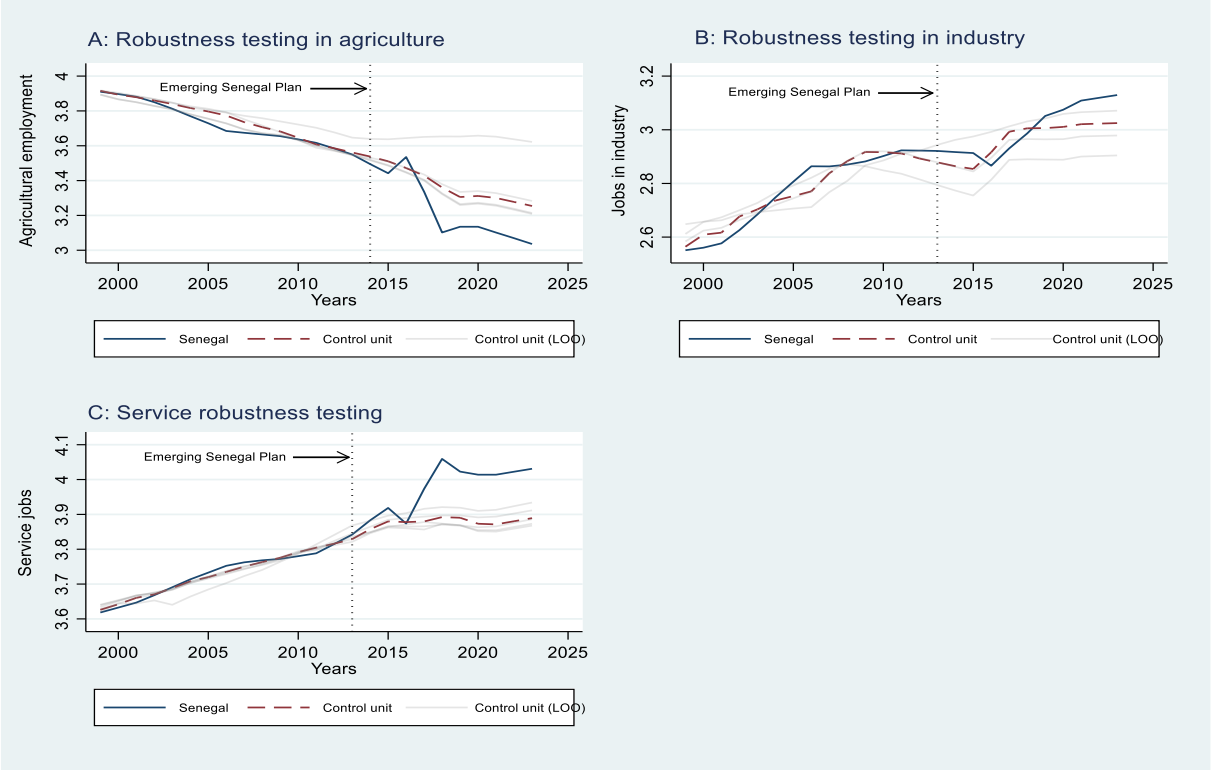
In our study, we applied a spatial placebo test, as proposed by Yan et al. (2023), excluding the ECOWAS countries for which the mean square errors of prediction before and after the reform exceeded twice those recorded for Senegal. The results show that, for each employment sector, Senegal differs from its synthetic control in the placebo distribution, with the exception of the industrial sector (panel B), where a non-significant p-value of 10% is identified. On the other hand, for the agricultural and service sectors, the p-values obtained are 0.09 and 0.01 respectively. These results imply that the decrease in employment in the agricultural sector and the increase in employment in services are not due to chance, but rather to the direct

impact of the reform. They highlight the robustness of the PES effect, attributing variations linked to the reform itself, rather than to contextual variability between countries.

5.2 Robustness tests

We used the Leave-One-Out (LOO) test to strengthen the robustness analysis. This method consists of successively eliminating each country making up the initial control unit, one by one (Freire, 2018). The main objective is to assess whether the results obtained are excessively dependent on a single control country. This approach is particularly relevant in our study, given the notable predominance of Cape Verde in the construction of the control units. This domination could suggest that the original control unit, made up of four countries for the agricultural sector, three for the industrial sector and six for the service sector, does not constitute a totally reliable counterfactual.

Figure 7: Robustness tests of PES job creation results



Sources: Author's own

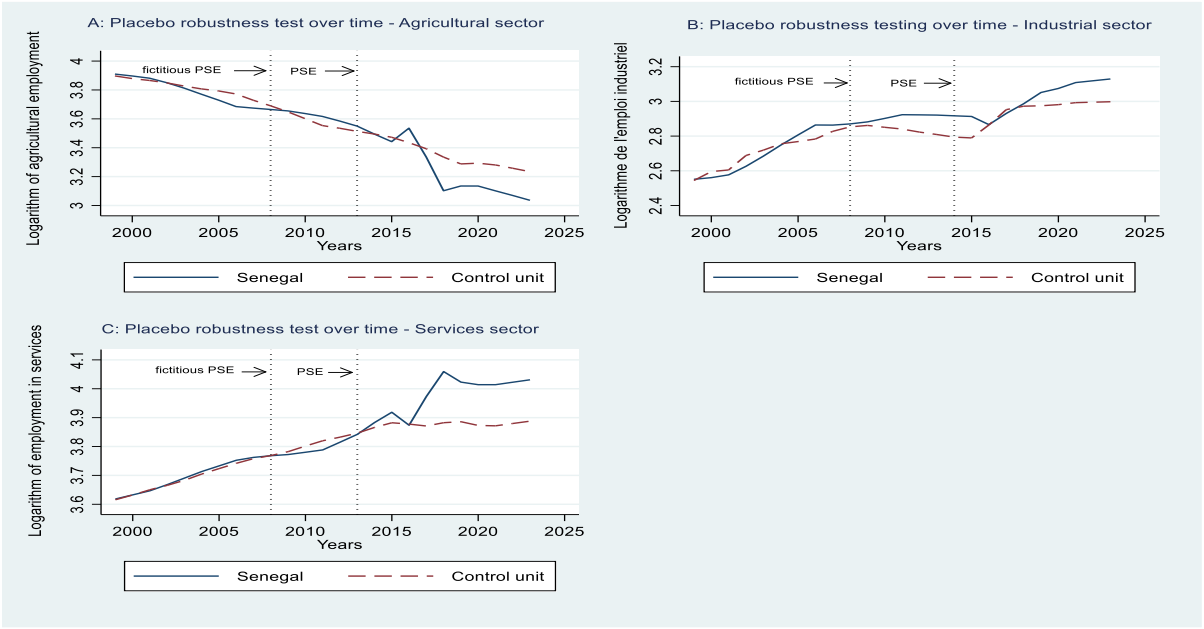
The results of this analysis, presented in Figure 7, show that the estimates obtained from the control unit modified by the LOO test are consistent with those obtained using the set of control countries. This demonstrates the relative robustness of the estimates. Furthermore, examination of the relative positions between the effect observed for Senegal and the various

controls confirms the stability of the results. Consequently, no control country appears to introduce a significant bias in the estimates, reinforcing the validity of our conclusions.

5.3 Placebo robustness tests over time

The robustness of our results is verified by placebo tests over time, following the methodology recommended by Abadie, Diamond, and Hainmueller (2015) and implemented by (Yan and Chen, 2023). These tests, whose graphical results are presented in Figures 5.7, simulate a fictitious treatment in 2009, five years before the actual implementation of the PSE. For the agricultural and service sectors, the results reveal a clear reversal of trends, with agriculture moving from slightly positive placebo effects before 2014 to sustained negative effects after that date, while services undergo the opposite transition, confirming the phenomenon of sectoral labor transfer predicted by Lewis's model (1954). The industrial sector, meanwhile, shows a significant amplification of a pre-existing trend, moving from moderate growth to accelerated growth after 2014, reflecting the catalytic effect of the ESP's infrastructure investments.

Figure 8 : Placebo robustness test over time



Sources: Author's own

The absence of significant placebo effects prior to the intervention, coupled with the synchronized break observed in 2014, considerably strengthens the causal interpretation of our results. As Abadie et al. (2010) point out, the validity of the synthetic counterfactual relies on the inability of placebo tests to reproduce the effects observed during the actual treatment period. Our results fully satisfy this criterion, ruling out the hypothesis of methodological artifacts or pre-existing trends as alternative explanations. This robustness confirms that the sectoral transformations observed are indeed attributable to the Emerging Senegal Plan rather than to previous structural dynamics.

6 Conclusion

This study has assessed the impact of the PES numerical reforms on job creation in different economic sectors, focusing on agriculture, industry and services. Using the synthetic control method (SCM), we isolated the specific effects of the PES, revealing differentiated impacts across sectors. The results show that the PES has had contrasting effects, highlighting both the successes and limitations of the reforms initiated.

Firstly, the analysis revealed a significant drop in employment in the agricultural sector after 2014. This decline is likely to be attributable to agro-tech technologies notably farm machinery and connected sensors (IoT), which has fostered an increase in productivity but reduced demand for labor. Furthermore, the migration of agricultural workers to other, more attractive sectors illustrates an economic diversification underway, in line with Ruben and Pender's (2004) theories on structural transformations and Diao et al.'s (2010) on sectoral migrations. Although this transition is a sign of progress, it raises challenges in terms of social inclusion and the distribution of the benefits of growth, requiring accompanying policies for the populations affected.

As far as the industrial sector is concerned, initial results suggested an increase in employment after 2014. However, after carrying out a placebo test in space, it turned out that this growth was not statistically significant. This indicates that the PES industrial policies, while ambitious, did not have the expected impact on job creation in this sector. This result contrasts with expectations and underlines the need to revise industrial strategies to better target sectors with high job creation potential and improve their effectiveness.

The service sector, on the other hand, posted a marked increase in employment, particularly after 2014. This momentum was driven by the boom in financial services, telecommunications and tourism, supported by the strategic reforms introduced as part of the PES. These results confirm the analyses of the World Bank (2020) and Ghani and O'Connell (2014), which identify services as a key driver of inclusive growth in emerging economies. However, challenges remain, particularly with regard to the quality of jobs created and access to opportunities for rural populations and vulnerable groups.

The results obtained in this study are in line with existing research on economic development plans. Works such as those by Diagne (2016), Bourkane et al. (2019) and Doménech (2022) have shown that targeted investments in priority sectors can generate structural transformations favorable to employment. Furthermore, our application of the synthetic control method aligns with recent methodological approaches, such as those developed by Stepanyan et al. (2020), Gatopoulos et al. (2021) and Alassane et al. (2022) for evaluating public policies.

However, while this study provides valuable insights into sectoral employment trends under the effect of the PES, it does not claim to be an exhaustive assessment of its impact on Senegal's overall development. Future studies should integrate data on wages, job quality (formal vs. informal) and productivity gains to better assess the overall impact of the PES on worker well-being and economic growth. These insights would better inform policymakers and refine reforms to maximize socio-economic benefits in Senegal.

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Annexe

Table 4: Description of outcome variables and synthetic control predictors

Variables	Variable Categories	Data Source
Employment in agriculture	Outcome variables	International Labour Organization (ILO)
Employment in industry		International Labour Organization (ILO)
Employment in services		International Labour Organization (ILO)
Foreign direct investment	Synthetic control predictors	International Monetary Fund (IMF)
Industry (including construction), value added		World Bank (WB)
Services, value added		World Bank (WB)
Agriculture, forestry, and fishing, value added		World Bank (WB)
GDP per capita growth		World Bank (WB)
Current health expenditure		World Health Organization (WHO)
Access to electricity		World Bank (WB)
Unemployment rate		International Labour Organization (ILO)
Labor force		World Bank (WB)

Table 5: Prediction results in post-processing periods for job creation in agriculture

Year	Actual Outcome	Synthetic Outcome	Treatment Effect
2015	3.44	3.49	-0.04
2016	3.54	3.45	0.09
2017	3.34	3.40	-0.06
2018	3.10	3.32	-0.22
2019	3.14	3.26	-0.12
2020	3.13	3.27	-0.13
2021	3.10	3.26	-0.15
2022	3.07	3.23	-0.16
2023	3.04	3.21	-0.17
Average	3.21	3.32	-0.11

Sources: Author's own

Table 6: Prediction results in post-processing periods for job creation in industry

Year	Actual Outcome	Synthetic Outcome	Treatment Effect
2015	2.91	2.86	0.05
2016	2.87	2.92	-0.05
2017	2.93	2.99	-0.06
2018	2.99	3.01	-0.02
2019	3.05	3.01	0.04
2020	3.07	3.01	0.06
2021	3.11	3.02	0.09
2022	3.12	3.02	0.10
2023	3.13	3.03	0.10
Average	3.02	2.99	0.03

Sources: Author's own

Table 7: Prediction results in post-processing periods for job creation in services

Year	Actual Outcome	Synthetic Outcome	Treatment Effect
2015	3.92	3.86	0.06
2016	3.87	3.86	0.01
2017	3.97	3.86	0.11
2018	4.06	3.87	0.19
2019	4.02	3.87	0.15
2020	4.01	3.86	0.16
2021	4.01	3.86	0.16
2022	4.02	3.87	0.16
2023	4.03	3.88	0.15
Average	3.99	3.87	0.13

Sources: Author's own

Figure 1: PES treatment effects on job creation in agriculture, industry and services

Sources: Author's own

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