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Case Study of Senegal

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Askar Mukashov, Christian Henning, Richard Robertson, and Manfred Wiebelt

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ABSTRACT

THE ROLE OF GLOBAL CLIMATE CHANGE IN STRUCTURAL TRANSFORMATION OF SUB-SAHARAN AFRICA: CASE STUDY OF SENEGAL

Askar Mukashov, Christian Henning, Richard Robertson, and Manfred Wiebelt

With increasing evidence that rural households in Sub-Saharan Africa (SSA) opt for deagrarianization as an adaptation strategy to climate change, it is becoming important to understand the role of Global Climate Change (GCC) in ongoing structural transformation processes in these countries. We use Senegal as a case study country and analyze how various GCC scenarios affect the country's economic sectors, households' welfare, and structural transformation patterns. Our simulation results suggest that GCC can increase the country's deagrarianization pace, with industrial and service sectors in the capital Dakar being the most important destinations of the former agricultural labor force. Although unplanned urbanization smoothes the overall negative impact of GCC and decreases spatial income disparities, uncontrolled deagrarianization is also associated with negative externalities. Previous growth-focused studies suggest that services partaking in Senegal's deagrarianization can hamper its long-term growth prospects, and our results suggest that productivity increase of services can redirect part of the former agricultural labor force towards industrial sectors.

Keywords: CGE modeling; climate change; deagrarianization; urbanization.

JEL classification: D58, C68, Q54.

Corresponding Author

Askar Mukashov
Kiel Institute for the World Economy
Kiellinie 66
D-24105 Kiel, Germany
Email:
askar.mukashov@ifw-kiel.de
www.ifw-kiel.de

Christian Henning
Institute for Agricultural Economics, the University of Kiel
Wilhelm-Seelig-Platz 7,
D-24118 Kiel, Germany
Email:
chenning@agric-econ.uni-kiel.de
https://www.agrarpol.uni-kiel.de/de

Richard Robertson
International Food Policy Research Institute
Eye Street, 1201 I St NW,
Washington, DC 20005,
USA
Email:
r.robertson@cgiar.org
https://www.ifpri.org/

Manfred Wiebelt
Kiel Institute for the World Economy
Kiellinie 66
D-24105 Kiel, Germany
Email:
manfred.wiebelt@ifw-kiel.de
www.ifw-kiel.de

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1. Introduction

With the growing confidence in Global Climate Change (GCC) projections and scenarios, quantification of GCC-associated economic and social consequences is becoming a top priority of researchers and policymakers worldwide. Due to the natural relationship of climate characteristics and agriculture (Dell et al., 2014), vulnerable agriculture-dependent countries and regions receive particular attention (Mertz et al., 2009). Significant efforts have been made to quantify GCC scenarios' impact and explore agriculture-focused adaptation strategies in various developing countries and regions (e. g. Kurukulasuriya et al. 2006; Mendelsohn 2008; Calzadilla et al. 2013; Arndt and Thurlow 2014; Wiebelt et al. 2015; Siddig et al. 2020). While these studies provide important insights on GCC-associated economic and social consequences, surprisingly, less attention has been given to climate change in the context of ongoing structural transformation processes in developing countries.

GCC-associated challenges in Sub-Saharan Africa (SSA) represent particular research interests. For decades it has been observed that SSA countries do not follow classic structural transformation patterns[1]. Bryceson (1996) is among the first to cite statistical evidence and notes that SSA is becoming less rural in character despite poor industrialization. She emphasizes that the industrial sector, being easily outcompeted by developed countries, is not the primary driver of rural exodus and urbanization in SSA. She suggests applying the distinct concept of 'deagrarianization' for SSA and using a sectoral perspective to analyze off-farm

[1] *See Syrquin (1988); Herrendorf et al. (2014) for overviews on the topic.*

activity diversification of rural households. With increasing evidence that rural households in SSA opt for deagrarianization and rural outmigration as adaptation strategies to GCC (Mertz et al., 2008; Connolly-Boutin and Smit, 2015), the sectoral focus suggested by Bryceson (1996) thus becomes particularly relevant in understanding the development path of these countries. How can various GCC scenarios affect fundamental economic structure and labor reallocation? Which economic regions and sectors suffer, and which might eventually benefit from the structural transformation? What policies might be necessary to influence these processes? This paper attempts to answer these and related questions based on the case study of GCC in Senegal.

Like many other SSA countries, Senegal is characterized by very uneven economic and social development, with the capital Dakar being more developed and wealthier than other provinces. The country has been experiencing a rural exodus since the 1960s, with most of the provincial migrants joining the non-official urban sectors (Goldsmith, 2004; WB, 2018). Although historical evidence suggests that rural outmigration decisions are more complex and might include non-income factors (e. g. Brockerhoff 1990), the search for a better job and income remains the self-declared primary driver of rural exodus in Senegal (FAO, 2018, 2020). In the context of the lingering significance of agriculture for most of Senegal's rural population (USAID, 2017), GCC thus can be expected to trigger the country's deagrarianization and affect the fundamental structure of its economy.

To model GCC's impact on the Senegalese economy, we use biophysical and economical workhorse models developed by the International Food Policy Research Institute (IFPRI). We use the IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model to produce GCC scenarios that affect the country through agricultural productivity and world market prices. Then IMPACT GCC scenarios are passed on to the IFPRI-type Computable General Equilibrium (CGE) model designed for the Senegalese economy.

Our simulation results demonstrate that although GCC's overall impact is expected to be relatively moderate, it can still impact economic structure and contribute to existing regional

imbalances. Agriculture, which is directly exposed to the GCC-associated productivity shocks, becomes even more ineffective, and we expect labor to be pushed out of agriculture and into both industry and services. This effect is the most significant for uneducated labor, which is intensively employed in Senegalese agriculture. Rural households are expected to deagrarianize either by joining nonagricultural sectors in their provinces or, depending on the interregional mobility, offer their labor in the other regions with higher wages. The most developed and the least agricultural, the Dakar region suffers only from the indirect, general income losses, and its activities are expected to be the most attractive destinations for the former agricultural labor force. Provincial industrial and service activities that could have grown due to local deagrarianization, with increasing interregional labor mobility, become less attractive than wealthier Dakarian counterparts. As a result, the already underdeveloped provinces may find their gap with the capital widening as Dakar becomes even more economically important at other regions' expense.

Although urbanization resulting from non-interventional policy smoothes the overall negative impact of GCC and decreases spatial income disparities, previous growth-focused studies suggest that policy interventions should be considered too. McMillan et al. (2014) and Rodrik (2015, 2016) argue that in SSA rural labor movements towards unproductive and informal urban services is growth reducing phenomenon that blocks off rapid industry-led growth and transformation similar to South Asian countries. In this context, services partaking in Senegal’s deagrarianization can hamper its long-term growth prospects, and we additionally conduct simulations to analyze potential policies to influence these processes. Our results suggest that productivity increase of services can redirect part of the agricultural labor force towards industrial sectors. Although not being optimal policy in terms of immediate growth effects (compared to a productivity increase of industrial sectors themselves), productivity boost of services can reduce factor demand and push uneducated labor towards industry, paving the way for rapid growth through industrialization.

The rest of this paper proceeds as follows. Section 2 provides an overview of the existing economic and social status quo and outlines GCC scenarios' major shock transmission channels that impact the Senegalese economy. Section 3 presents simulation results and analyzes scenarios of Senegal's economic transformation. Section 4 highlights the potential policy implications and concludes.

2. Vulnerability of the Senegalese economy to GCC

2.1 Economic and social status-quo

We begin our analysis by investigating pre-existing vulnerabilities of the Senegalese economy to GCC. As our primary data input, we use the Social Accounting Matrix (SAM)[2] constructed by Randriamamonjy and Thurlow (2019). The SAM represents the state of the Senegalese economy in 2015, and, unlike standard national SAMs, it represents activities, households, and factors on the regional level (Table 1). Thus, our SAM allows us to account for each region's economic and social specifics and conduct our analysis on both regional and national levels.

Table 1. Mapping between administrative and SAM regions

Source: Wikimedia Commons

Administrative	SAM
Dakar	Dakar
Thies & Diourbel	Thi_Dio
Louga, Kaolack, Fatick & Kaffrine	Center
Saint-Louis & Matam	North
Ziguinchor, Sedhiou, Kolda, Kedougou & Tambacounda	South

Senegal has features that characterize the least developed economies (Schwab and Sala-i Martin, 2015). In particular, the country has a high share of primary sectors (18.7% of GDP is primary agriculture and mining, see Table 2), low industrialization (14% of GDP), and high

[2] *The SAM (available from the authors upon request.) uses macro- and micro-level data such as national accounts, input-output tables, household surveys and consistently represents a detailed snapshot of the economy for selected year. See Breisinger et al. (2009) for detailed explanation of the concept.*

reliance on imported industrial products (33% of consumption, of which one third is imported). At the same time, on the regional level, these patterns are not homogeneous. In particular, our SAM captures the more developed status of the capital Dakar, and its neighboring regions (Thi_Dio), where most of the economic activity is represented by the secondary and tertiary sectors. Other regions (Center, North, and South) heavily rely on primary agriculture (GDP share of agriculture varies from 40 to 60%) and are underdeveloped even by the national standards.

Table 2. Economic structure (based on Randriamamonjy and Thurlow 2019)

	Total, %	of which (within), %						
		crops	oagr	mini	agpr	oind	serv	padm
National GDP	100.00	9.26	6.20	3.17	9.38	14.08	52.34	5.57
Dakar	55.34	0.73	0.44	2.18	8.68	16.86	63.91	7.21
Thi_Dio	17.22	5.49	5.10	5.24	10.15	16.59	53.99	3.44
Center	9.05	38.47	20.48	1.70	5.26	6.21	26.14	1.73
North	10.10	21.03	18.58	6.56	16.57	8.67	23.12	5.47
South	8.29	27.76	16.23	2.97	8.19	5.58	35.86	3.41
Export in output	10.27	7.36	2.38	23.84	15.83	14.15	7.65	-
Consumption	100.00	7.68	4.20	2.86	14.35	32.74	34.51	3.66
of which import	18.21	19.52	0.37	38.51	14.05	32.60	8.42	-

Note: crops = crops production; oagr = other agriculture (livestock, fishery, forestry); mini=mining; agpr = agroprocessing; oind = (other) industry; serv = services; padm = public administration

Similar developmental disparities can be observed in the regional breakdown of the household types (Table 3). The share of non-urban residents is significantly higher in the rural provinces (Center, North, and South), where the households involved in farming activities vary from 48.8 to 71.5%. The latest FAO survey conducted in 2020 reveals that most of these households are small-scale subsistence farmers who rely on informal family labor (FAO 2020). As a result, already in 2015, Senegal is characterized by significant income disparities across its regions. The poverty line in Dakar is almost two times higher than in rural areas, and even

with that, the (weighted) average poverty incidence among farmers is 64% compared to only 26% in Dakar (ANSD 2013).

Table 3. Households (based on Randriamamonjy and Thurlow 2019; ANSD 2013)

	Population				% below the poverty line			
	% of tot	of which, %			Tot	URB	FAR	NFR
		URB	FAR	NFR				
National	100.00	43.79	46.04	10.16	46.71	33.03	64.42	36.91
Dakar	23.68	100.00	0.00	0.00	26.10	26.10	-	-
Thi_Dio	24.65	28.26	55.80	15.94	45.04	31.15	64.01	31.40
Center	10.78	35.83	48.83	15.35	41.60	50.10	41.00	28.23
North	21.36	19.09	71.44	9.46	54.19	31.09	63.46	41.52
South	19.53	26.67	60.24	13.09	68.45	55.94	74.62	61.96

Note 1: URB = urban households; FAR = rural farm households; NFR = rural non-farm households.
Note 2: Poverty lines (yearly per-capita consumption per adult equivalent in 2015 thousand CFA franks): Dakar: 370; other urban: 295; rural: 221.

2.2 Modeling GCC shocks and economic transformation

To produce the GCC scenarios that can affect the Senegalese economy, we use the IMPACT model developed by the IFPRI. For each of the three climate model scenarios used here, the IMPACT model produces estimates of region-specific crop productivity shocks and world market prices (detailed description of the model can be found in Calzadilla et al., 2013; Robinson et al., 2015).

Given our focus on the whole economy's structural transformation, we have to extrapolate beyond IMPACT's basic outputs. The IMPACT model focuses on the most common crops, and it does not produce GCC impact estimates for livestock and fishery, which constitute 40% of the primary agriculture in Senegal (see Table 2). At the same time, climate experts emphasize that these two agricultural sub-sectors will also be directly affected by GCC in Senegal. For the livestock, the impact is expected via heat stress and reduced productivity through reduced water and forage resources; for the fishery, the impact is expected via rising surface water temperatures and ocean acidification, altering species' reproduction migration

(USAID, 2017). Furthermore, the IMPACT model does consider region-specific crops (e. g., cassava and other local fruits and vegetables). Therefore, given our focus on the fundamental structural transformation of the economy, we use the rule of thumb and produce region-specific GCC productivity shocks for the whole primary agriculture based on the weighted average IMPACT crop projections.

Table 4. GCC scenarios (total % change over 2015-50)

Scenario	Agricultural productivity					Prices (world)	
	Dakar	Thi_Dio	Center	North	South	crops	oagr
No GCC	0.00	0.00	0.00	0.00	0.00	17.66	11.29
GFDL	-15.01	-15.01	-11.59	-4.56	-4.84	28.31	11.94
IPSL	-23.60	-23.60	-28.37	-14.41	-17.32	30.03	12.42
HADGEM	-31.15	-31.15	-34.64	-15.81	-10.71	31.28	12.39

Note: No GCC = no-global-climate-change scenario; GFDL = Geophysical Fluid Dynamics Laboratory Climate Model; IPSL = Institut Pierre Simon Laplace Earth System Model; HADGEM = Hadley Centre Global Environment Model.

Then we use GCC scenarios (Table 4) and supply them into the IFPRI-type CGE model of the Senegalese economy (Table 5)[3]. Similar to Wiebelt et al. (2013, 2015); Arndt et al. (2015); Siddig et al. (2020), and other authors who measure economywide repercussions of agricultural GCC shocks, we model GCC scenarios through the factor productivity parameters in the value-added production functions and model parameters that define the world market prices in the trade block of model equations. At the same time, our study is distinct from the literature strands because we focus on the country's fundamental economic transformation resulting from GCC. We assume that deagrarianization will be the primary GCC adaptation strategy of rural households and suppose that sectoral and regional income differentials resulting from the agricultural productivity decline will shape the country's economic transformation.

[3] *The model is based on the standard recursive-dynamic CGE model of the IFPRI, which we tailor to reflect country-specific adjustment mechanisms. A detailed description of the IFPRI-type CGE model and its equations can be found in Löfgren et al. (2002) and Diao and Thurlow (2012).*

Table 5. Specification of the primary CGE model

Block	Category	Form / closure (endogenous variables)
Production (regions)	Value-added	Constant Elasticity of Substitution (CES). Elasticities: crops=0.24; oagr=0.24; mini=0.2; agpr= 1.12; oind=1.26; serv and padm=1.68. Source: Aguiar et al. (2016).
	Intermediate	Leontief
	Top of technology	Leontief
National market	Output by each region	CES
Trade	Import	CES
	Export	Constant Elasticity of Transformation (CET)
Households	Consumption	Linear Expenditure System (LES)
Closures	Numeraire	The exchange rate is the model numeraire[4]; Consumer Price Index and domestic producers' price level are flexible;
	Rest of the World	the current account balance and world market prices are given exogenously;
	Government	Fixed government tax rates; (dis)savings adjust to available net revenues;
	Savings/Investment	Neoclassical: fixed savings rate, endogenous investment
	Factors	Capital: 'putty clay: newly generated capital is mobile, and its distribution depends on the rents (↑ rents ⇒ ↑ new capital, see Diao and Thurlow 2012 for more details); Labor and land: fully employed and mobile (within regions); interregional labor transformation via CET (below)

Note: Model code (written in GAMS), parameters, and other materials available from the authors.

The shock transmission channel is modeled as follows. First, we assume that GCC productivity decline in agriculture will affect non-labor production factors only. This assumption is justified because, unlike specific land and capital production factors, the most significant agricultural labor is noneducated (see Table 6), meaning that it is relatively homogeneous, and its productivity losses due to intersectoral (or interregional) mobility are relatively low.

[4] *The exchange rate of the CFA franc to the French franc (and later Euro) is fixed since 1994. See Boogaerde and Tsangarides (2005) for more details.*

Table 6. Contribution of agricultural factors to GDP, % (Randriamamonjy and Thurlow 2019)

	FLND	FCAP-c	FCAP-l	FLAB-n	FLAB-p	FLAB-s	FLAB-t	Total agriculture
Dakar	0.36	0.34	0.14	0.28	0.04	0.01	0.00	1.17
Thi_Dio	2.81	3.97	1.08	2.22	0.38	0.12	0.01	10.59
Center	18.21	10.93	11.75	16.04	1.35	0.66	0.00	58.95
North	8.54	10.84	9.43	8.98	1.37	0.44	0.02	39.61
South	12.79	10.74	8.30	10.57	1.12	0.45	0.01	43.99
National	4.25	3.85	2.97	3.77	0.44	0.17	0.01	15.45

Note: FLND = agricultural land; FCAP-c=crops capital; FCAP-l=livestock capital; FLAB-n=non-educated labor; FLAB-p=primary educated labor; FLAB-s=secondary educated labor; FLAB-t=tertiary educated labor

Then, agricultural assets' reduced productivity implies that agriculture receives less investment than other sectors (see 'putty clay' closure in Table 5). Given its rigid production function (very low CES elasticities, see Table 5), labor cannot substitute scarce land and capital. Therefore, being relatively abundant, agricultural labor is devalued and pushed out of agricultural activities. As other sectors with higher wages can employ released agricultural labor force, this shock transmission channel allows us to model the economic transformation.

The beneficiaries of labor deagrarianization can be either nonagricultural activities within the region or, conditional on the interregional mobility, activities in other regions with higher wages. For the sake of simplicity, we assume that the labor can be reallocated across the activities within their regions without any frictions (full employment and mobility assumption for region-specific labor factor, see Table 5). To model the interregional mobility of labor, we use a relatively straightforward approach and apply (volume-preserving) the CET function (see Dixon and Rimmer 2003, 2006; van der Mensbrugghe and Peters 2016). Under this approach, regions with higher wages attract more labor, and household costs associated with reallocating labor from one region to another are represented through exogenously specified elasticity parameters (the higher the elasticity, the higher is the mobility to regions with higher wages)[5]. Furthermore, as our model separates households and factors, we assume that households stay

[5] *It should be mentioned that upon the data availability, the interregional mobility of labor can be modeled based on the econometric estimates of migration gravity equations, where besides wage/income differentials, the attractiveness of the region depends on distance, demography, and other non-monetary factors (see Borgy et al. 2010; Luo et al. 2016 for details).*

in their provinces, but they can receive factor income earned in the other regions. This mechanism can be interpreted as remittances sent to the family by internal labor migrants, and it allows us to take into account positive welfare effects for migrant-sending regions.

3. Scenarios of country's transformation

Our simulation results demonstrate that GCC's overall economic impact is expected to be relatively low, with GDP losses reaching 2.08% under the worst-case HADGEM scenario (Table 7). At the same time, these losses are unevenly distributed across sectors and regions of the country. On a sectoral level, due to direct productivity losses, agriculture is expected to experience the worst economic decline. In turn, although not directly hit, downstream agroprocessing also shrinks because its most essential intermediates - agricultural commodities - get more expensive due to domestic and world market price increase. With increasing GCC severity, the whole agribusiness sector becomes less effective and loses in the competition for production factors to other economic sectors. Under the assumption of interregional immobility of labor, the industrial sector is expected to be the primary beneficiary of the country's GCC-induced deagrarianization (Table 7). Compared to income-dependent services, the less elastic industrial sector additionally benefits from the depreciated real exchange rate[6] and pulls production factors to itself. Consequently, besides GCC shocks, the regional losses largely depend on their economic structure. The most severe GDP losses are expected in the rural region Center, whose underdeveloped industrial sector cannot absorb the deagrarianized labor force and cushion GCC shocks. At the same time, Dakar and neighboring Thies & Diourbel are the most industrialized and the least agrarian regions in the country, and despite having comparable shocks as Center (see Table 4), they are expected to be the most resilient to GCC.

[6] *Real exchange rate in % vs No GCC by 2050 (no interregional mobility): GFDL-0.7; IPSL -1.56; HADGEM -1.8.*

Table 7. GDP losses (% vs. No GCC by 2050, no interregional mobility)

Scenario	Total	by sectors						by regions				
		crops	oagr	mini	agpr	oind	serv	Dakar	Thi_Dio	Center	North	South
GFDL	-0.74	-8.03	-3.89	2.62	-4.77	1.33	-0.40	-0.22	-0.90	-3.69	-0.89	-1.13
IPSI	-1.86	-20.80	-9.62	5.59	-9.35	2.47	-0.89	-0.56	-1.52	-9.37	-2.75	-3.98
HADGEM	-2.08	-22.88	-10.90	6.29	-10.61	2.75	-0.99	-0.67	-2.01	-11.77	-2.99	-2.13

However, the economic loss distribution is not fully mirrored in the households' welfare (Table 8). Like other case-country studies (e. g. Breisinger et al. 2013; Wiebelt et al. 2015), we find that farmers (households who own agricultural land) are not the main cost-bearers of GCC. Although all households suffer from increased agricultural prices and reduce real consumption, farmers are expected to be less affected than urban and rural non-farm households. Despite reduced productivity, we expect factor remuneration of agricultural land to increase, especially in regions with a relatively mild productivity decrease (North and South). Land becomes a scarce and expensive production factor that cannot be easily substituted (very low CES elasticities, see Table 5). Therefore, landowners (farmers), unlike urban and landless rural households, can partly compensate for their consumption losses. However, because significant income disparities already characterize the country, residents of industrialized regions (Dakar, Thies & Diourbel) are projected to be still much wealthier than their rural provincial compatriots.

Table 8. Households' losses (by 2050, no interregional mobility)

Indicator	Scenario	National	URB	FAR	NFR	Dakar	Thi_Dio	Center	North	South
Real per capita consumption (vs. No GCC)	GFDL	-1.78	-2.30	0.29	-3.65	-1.94	-2.66	-1.89	-0.70	-0.15
	IPSI	-4.01	-4.22	-2.74	-7.31	-3.34	-4.90	-7.74	-3.38	-3.14
	HADGEM	-4.53	-4.77	-3.13	-7.99	-3.78	-5.78	-10.08	-3.79	-1.45
% below the poverty line	No GCC	36.14	23.80	53.72	22.66	11.82	27.49	38.83	45.49	64.85
	GFDL	37.64	25.66	54.11	26.29	12.14	31.07	41.74	45.86	65.62
	IPSI	40.67	27.81	57.59	30.66	12.14	34.98	48.13	49.23	68.95
	HADGEM	40.85	28.31	57.41	30.90	12.14	36.32	49.90	49.59	66.80

GCC's uneven impact on the regional economies and persisting regional income disparities can facilitate interregional labor mobility. We expect that poorer households of rural

provinces, especially owners of the noneducated labor, will offer their labor in the provinces with higher wages. To model these processes, we assume that each labor type's supply across the regions is distributed via the CET function with the elasticity values of 0.5 and 2. Given data absence, we assume that these arbitrarily chosen elasticity parameters represent scenarios of rigid and flexible responses to wage differentials across the regions (rigid=0.5; flexible=2). Due to this paper's size restrictions, we present the interregional labor mobility scenarios only for the most severe 'HADGEM' GCC scenario.

According to our simulations, interregional labor mobility allows smoothing the GCC's overall negative economic impact (Table 9). This effect, however, is associated with growing economic imbalances across the country. With its highest wages, Dakar is expected to be the most significant labor-pulling region, and compared to the interregional labor immobility, the inflow of cheap labor boosts its economy. In contrast, the provincial economies become even more non-competitive and plummet. As a result, we expect Dakar to gain economic weight at the expense of other provinces and be the only region with positive growth rates.

Table 9. Interregional labor mobility - regional GDP (HADGEM, % vs. No GCC by 2050)

Region	GDP changes			GDP shares		
	no	low	high	no	low	high
National	-2.08	-1.75	-1.69	100.00	100.00	100.00
Dakar	-0.67	1.11	1.55	59.08	59.94	60.16
Thi_Dio	-2.01	-1.37	-1.30	17.38	17.43	17.44
Center	-11.77	-16.85	-18.05	6.92	6.50	6.41
North	-2.99	-5.09	-5.66	9.31	9.07	9.01
South	-2.13	-5.23	-6.15	7.31	7.05	6.98

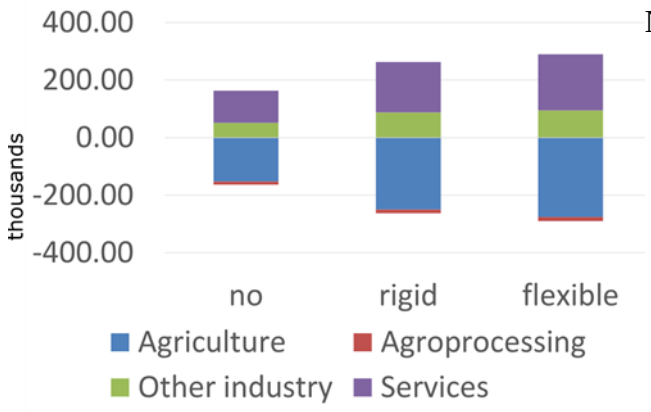
Redistribution analysis on a sectoral level (Table 10) reveals further important details. Provincial industrial and service sectors that could have benefited from the local deagrarianization, with increasing interregional labor mobility, are losing competitiveness to Dakar, where services and industrial sectors are expected to be the most important destinations for the former agricultural labor force. With increasing 'Dakarization', the pace of the country's

deagrarianization can be almost doubled. Under the HADGEM GCC scenario with no interregional mobility, only 9.8% (152.95 thousand, see Figure 1) of the noneducated labor force is leaving agricultural activities; however, with increasing interregional mobility, Dakarian industry and services absorb the former agricultural labor force at a larger scale, and agriculture is losing 18% (275.85 thousand, see Figure 1) of its most crucial labor factor.

Table 10:Interregional labor mobility - sectoral GDP (HADGEM, % vs. No GCC by 2050)

Sector	no	low	high	Sector	no	low	high
Agriculture	-15.87	-16.95	-17.32	Other industry	3.38	4.21	4.41
Dakar	-23.86	-21.96	-21.19	Dakar	3.63	5.24	5.65
Thi_Dio	-23.48	-22.23	-21.78	Thi_Dio	3.31	4.10	4.26
Center	-27.12	-29.93	-30.90	Center	2.06	-1.02	-1.77
North	-7.62	-8.08	-8.26	North	3.21	2.07	1.74
South	-3.93	-4.90	-5.25	South	1.65	-0.49	-1.20
Agroprocessing	-10.61	-11.82	-12.22	Services	-0.91	-0.34	-0.21
Dakar	-9.60	-10.25	-10.54	Dakar	-1.33	0.78	1.30
Thi_Dio	-9.70	-10.28	-10.50	Thi_Dio	-1.35	-0.74	-0.74
Center	-13.19	-16.90	-17.75	Center	4.28	-4.99	-6.75
North	-13.04	-15.48	-16.12	North	0.64	-3.84	-4.98
South	-14.00	-17.18	-18.09	South	-0.35	-5.38	-6.82

Figure 1. Deagrarization of noneducated labor (HADGEM, diff vs. No GCC by 2050)



Notes:

- using nationwide estimates of the labor force by the ILO (2020) (noneducated labor in 2015: 2,171.20 thousand);
- assuming 2.37% of yearly growth rate (based on population growth projections by the UN (2020) and assuming proportional growth of labor factors).

'Dakarization' of the country is also expected to smooth spatial income disparities (Table 11). In particular, poor rural households can improve their well-being by offering their labor factors in rich Dakar and repatriating profits back home. Rural regions can also benefit because

the outflow of the labor to Dakar eases the pressure on local wages (e. g., almost a quarter of labor factor income of the region 'Center' is expected to be earned in Dakar). However, the massive inflow of labor from the provinces to Dakar can suppress the Dakarian wages and, thus, negatively affect the income growth of Dakarian households. Nevertheless, even in this case, Dakar will be the richest in the country, with significantly lower poverty rates than in other regions.

Table 11. Interregional labor mobility - welfare (HADGEM by 2050)

Region	Real per capita consumption (% diff. vs. No GCC)			% below the poverty line (level)			Share of `foreign' labor income	
	no	rigid	flexible	no	rigid	flexible	rigid	flexible
Dakar	-3.78	-5.23	-5.62	12.14	12.54	12.54	0	0
Thi_Dio	-5.78	-5.66	-5.56	36.32	35.65	35.65	0.00	0.22
Center	-10.08	-4.26	-3.21	49.90	40.83	39.05	19.68	22.01
North	-3.79	-0.95	-0.24	49.59	44.90	44.44	8.06	9.91
South	-1.45	2.26	3.20	66.80	63.42	62.61	12.43	15.11

Although urbanization and 'Dakarization' of the country resulting from non-interventional policy smooth the overall negative impact of GCC and decrease spatial income disparities, adjacent studies suggest that further consideration of policy interventions is necessary. In particular, the most recent growth-focused literature strands argue that uncontrolled labor movement in the SSA can have long-term growth repercussions that cannot be directly accounted for in our model. For instance, McMillan et al. (2014) find that, unlike in Asian countries, structural change in SSA from 1990 to 2000 was growth reducing, with labor moving towards mostly informal urban services. The authors find evidence about potential turnaround after 2000 and express cautious optimism about African growth prospects through industry-led structural change. Similarly, Rodrik (2016) emphasizes that unproductive and informal urban services are major destinations for rural-urban migrants in SSA. He analyzes various growth options, and in the context of poor industrialization pace, expects mediocre long-term growth rates in SSA of a maximum of 2% per capita p. a.

Given this context, the expected deagrarianization of Senegal towards the services can be concerning. Being the largest sector in the country (almost 58% of the country's GDP in 2015, see Table 2), the services sector can absorb more agricultural labor than the industry (in absolute numbers, see Figure 1). More important, however, is that the lion's share of mostly uneducated agricultural labor is likely to join trade and transport services that are notoriously known for their informality (depending on interregional flexibility, the share of the labor force absorbed by these subsectors varies from 73 to 83% of the total labor force absorbed by services). Given this context, we also conduct a brief analysis of the potential policy interventions that can reduce services' partaking in the country's deagrarianization.

As a set of potential policy interventions, we consider TFP (Total Factor Productivity) growth of the nonagricultural sectors (aggregate nonagricultural industry and aggregate services on the regional level). We assume that considered sectors are technologically homogenous and have equal costs of TFP increase (for the same money, sectors of the same size should receive an equal TFP boost). This is a somewhat strong assumption, but it allows us to conduct coarse comparisons of policy interventions at least on an aggregated level. To set values of TFP policy parameters, we assume that an additional 1% of TFP growth of the whole economy is achieved only by respective sectors and treat obtained results as comparable sectoral policy elasticities. As a set of policy outcomes, we focus on noneducated labor employment and the overall impact on real per-capita consumption for all households.

Table 12. TFP sectoral elasticities (% diff. vs. HADGEM flexible by 2050)

	TFP boost of the industrial sector in				
	Dakar	Thi_Dio	Center	South	North
Noneducated labor, total industry	-1.96	-2.04	-1.77	-2.01	-2.01
Noneducated labor, total services	1.12	1.06	0.61	0.66	0.74
Real per-capita consumption (total households)	2.08	2.11	1.06	0.92	1.36
	TFP boost of the services sector in				
	Dakar	Thi_Dio	Center	South	North
Noneducated labor, total industry	1.17	1.09	1.38	1.05	1.36
Noneducated labor, total services	-0.74	-0.77	-0.92	-0.70	-0.90
Real per-capita consumption (total households)	1.40	1.14	1.10	1.10	1.10

Note: yearly TFP growth rates:
Industry (non agricultural): Dakar=0.29; Thi_Dio= 0.86; Center=3.34; North= 2.20; South=3.34;
Services: Dakar=0.08; Thi_Dio= 0.29; Center=1.01; North= 1.02; South=0.83;

Our simulation results (Table 12) demonstrate that increasing productivity of the respective sector leads to own factor demand reduction and diverts noneducated labor to competing sectors (increased productivity of industrial sectors will push noneducated labor towards services and vice versa). In terms of immediately observable income growth, investing in raising the productivity of Dakar's industrial sectors seems to deliver the highest policy return. At the same time, this policy is also associated with the highest increase of undesirable services' absorption of noneducated labor.

All in all, these findings align with the recently emerged Rodrik's concept of `premature deindustrialization.' Rodrik (2015) investigates transformation patterns of modern economies and shows that increased industrial productivity leads to low-skill employment reduction, which is part of the broader growth-reducing phenomenon of `premature deindustrialization' in modern developing countries. In this context, although our CGE model is not a growth-focused model[7], our outcome variables still serve as proxies to reflect an unavoidable trade-off between short and long-term growth prospects faced by the policymakers in the context of forthcoming labor deagrarization. From one side, the immediately observable multiplicative effect of boosting the productivity of industrial sectors appears to be higher than that of services, but the

[7] Our model has endogenized capital accumption, but other growth determinants such TFP growth are given exogenously (Hicks neutral rate of technical change, see Löfgren et al. 2002 and Diao and Thurlow 2012 for details).

consequent push of uneducated labor towards services can have long-term growth repercussions. On the other side, boosting the productivity of services, although less effective in the short run, pushes uneducated labor towards industry, paving the way for rapid future growth through industrialization. Nevertheless, it must also be noted that our findings on policy interventions should be treated cautiously because of the coarse and ad-hoc nature of our simulations and corresponding assumptions. A more nuanced analysis of policy interventions (such as detailization on a sub-sectoral level) and consideration of other important factors (such as trade or budgeting[8]) might be necessary in future elaborations and extensions.

4. Conclusion

In this paper, we investigate the potential role of GCC in the structural transformation processes in SSA. We use Senegal as a case study country and analyze how various GCC scenarios might affect its economy, household welfare, and labor reallocation across sectors and regions.

Our simulation results suggest that although GCC's overall impact is expected to be moderate, it can significantly impact its economic structure and increase existing regional imbalances. As directly hit agriculture becomes less efficient and non-competitive, uneducated labor that constitutes the lion's share of the agricultural labor force will deagrarianize and join other economic activities. The most developed and the least rural Dakar region is the most resilient to GCC shocks, and its economy is expected to outcompete provincial nonagricultural sectors and attract former agricultural labor from all provinces. The pulling power of a large Dakarian economy, with increasing interregional mobility, can significantly increase the pace of the country's deagrarianization and contribute to internal migration.

Although expected urbanization and 'Dakarization' of the country allow smoothing negative consequences of GCC, nonintervention policy is also associated with potentially

[8] *For instance, in the recent work, Diao and McMillan (2018) adjust the Lewis Model to explain the SSA's growth patterns. They find that structural transformation, besides agricultural and nonagricultural productivity, depends on the terms of trade and sources of public investment to enhance productivity growth. The authors show that when TFP growth is financed through foreign inflows, it can cause significant real exchange rate appreciation leading to an undesirable boom of less tradable sectors and contraction of more tradable sectors.*

negative repercussions. In particular, the urban services' absorption of mostly uneducated agricultural labor can slow industrialization and hamper the country's long-term growth prospects. One of the policy options that can push the former agricultural labor force from the services to the industry can be a productivity boost that reduces services demand for unskilled labor. This option, however, appears to be not an optimal policy in terms of short-term policy returns, as boosting the productivity of Dakar's industrial sectors is likely to outperform similar policies in any service sector across the country.

In the context of forthcoming labor deagrarization in SSA, our approach and finding pave the way for future consideration of necessary policies. Besides the more refined approach to the potential policy instruments themselves, future work in this direction might also require considering the multidimensional nature of the national goals, which besides standard growth and poverty reduction targets, can distinctly highlight such aspects as regional development, inclusive provincial growth, or internal migration reduction.

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