

# Hidden Treasures in the Comoros

## The Impact of Inter-Island Connectivity Improvement on Agricultural Production

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## Abstract

The paper revisits the traditional transport-agricultural growth nexus. Connectivity is particularly challenging for small island developing states, such as the Comoros, where domestic markets are limited and transport and transaction costs tend to be high. Using household survey data from Comoros, the paper shows that significant untapped economic potential exists in the domestic market. The analysis shows that better transport connectivity increases

crop production and market sales. Accessibility to Moroni, the primary market in the country, and inter-island connectivity are of particular importance. Not only transport infrastructure, but also services are important. Access to intermediary services, such as cooperatives and collectors, is also found to have a positive impact on crop production and market sales.

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**Hidden Treasures in the Comoros:  
The Impact of Inter-Island Connectivity Improvement on Agricultural Production**

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Africa Infrastructure, Transport Global Practice  
World Bank Group

Key words: Agricultural production; Market accessibility; Inter-island connectivity; Value chain analysis; Instrumental variable tobit regression.

JEL classification: C34, C36, O13, R41

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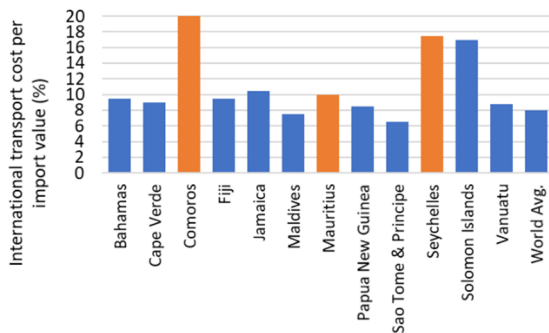
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## I. INTRODUCTION

1. Agriculture is an important sector in Africa. A large share of the labor force is still engaged in agricultural production, and agricultural exports often contribute to foreign exchange earnings significantly. However, the region’s agriculture sector largely remains small-scale subsistence farming with few advanced inputs used, with little produce sold in the market. Among others, transport connectivity has long been a crucial constraint particularly in rural areas. In general, the literature suggests improved transport connectivity can increase agricultural productivity (e.g., Khandker, Bakht, and Koolwal, 2009; Bell and Van Dillen, 2012) and eventually alleviate poverty (Dercon et al., 2008; Khandker and Koolwal, 2011).

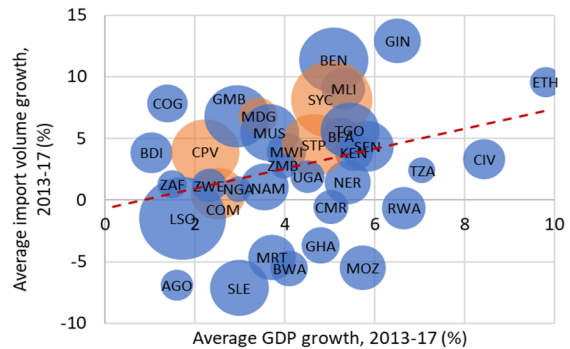
2. Small island developing states (SIDS), such as the Comoros, are faced with particularly difficult challenges. Because of their physical isolation from the global market and limited domestic absorption capacity, transport and trade costs tend to be high (Figure 1). Maritime transportation, port operations and international trade exhibit significant economies of scale (UNCTAD 2014). Small countries, including SIDS, tend to depend on imports for feeding their people. In general, many African countries are importing economies. That is, as the economies grow, they import more (Figure 2). For SIDS, inter-island connectivity within a country is an additional burden.

Figure 1. Transport costs for international trade



Source: UNCTAD (2014)

Figure 2. Growth, imports and food imports in Africa



Bubble size = Food imports per GDP (%)  
Source: WDI.

3. Africa has untapped great potential for agriculture. Agriculture and agribusiness currently generate US\$313 billion of commodities and products every year, which is projected to increase to US\$1 trillion by 2030 (World Bank 2013). Significant potential remains to be developed. African farmers are normally disconnected from available technologies and market opportunities, and the current yields are far below potential levels (e.g., World Bank 2012).

4. The current paper aims at exploring the potential impacts of market accessibility on agricultural growth in the Comoros, with particular attention paid to different types of connectivity, i.e., within- and inter-island connectivity. The country comprises three major islands, Grande Comore, Anjouan and Moheli. While the country's primary market, Moroni, is located in Grande Comore, the other two islands are more fertile. Land transportation within each island is already a challenge, but inter-island connectivity is even more difficult. The hypothesis tested by the paper is that the country could feed itself more by better connecting the agricultural production and consumption areas.

5. The rest of the paper is organized as follows: Section II provides an overview of the Comoros, with particular focus on transport connectivity. Section III discusses our empirical strategy and data. Section IV presents our main results and policy implications. Then, Section V concludes.

## **II. OVERVIEW OF THE COMOROS**

6. The Comoros is an island country in the Indian Ocean. The total population is about 830,000. The country comprises three main islands: Grande Comore, Anjouan and Moheli, of which the regional populations are about 430,000, 350,000 and 50,000, respectively. The largest city, Moroni, which is the national capital, is located at the western coast of Grande Comore. The other two islands have the regional capitals, Mutsamudu and Fomboni, respectively.

7. Generally, Comoros owns basic transport infrastructure, namely, about 800 km of roads, one international airport and two regional airports, and three major ports (one for each island) (Figure 3). However, the quality of transport services remains to be improved. About 45 percent of the road network is in poor condition (Figure 4). Maritime transport is also unreliable and unsafe. Port operations are inefficient, and port handling fees and local taxes are high. As the result, the passenger and freight traffic among the islands has been stagnant in recent years (Figure 5). Since Port Fomboni cannot serve large international vessels, Moheli depends on cabotage, mostly through Port Moroni, for its imports and exports.<sup>1</sup> Despite natural growth of the island economies, the port traffic at Fomboni has been declining (Figure 6).

Figure 3. Transport network in Comoros

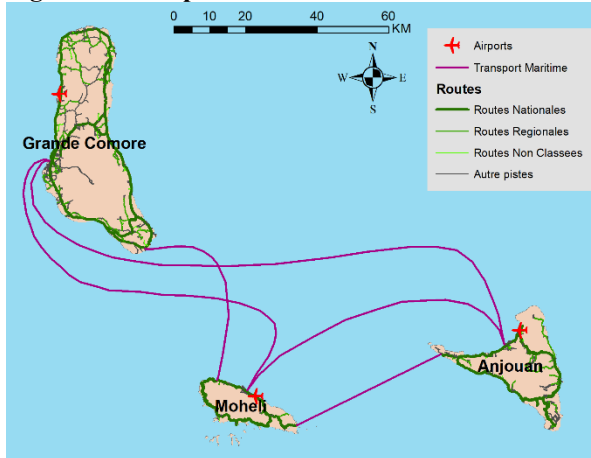
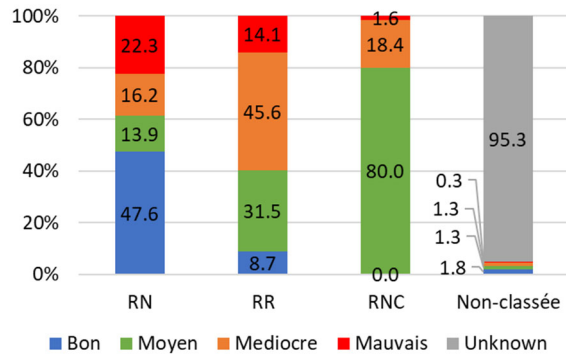
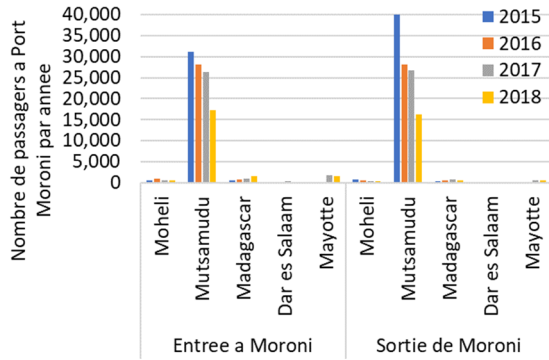


Figure 4. Road condition by road class, 2018

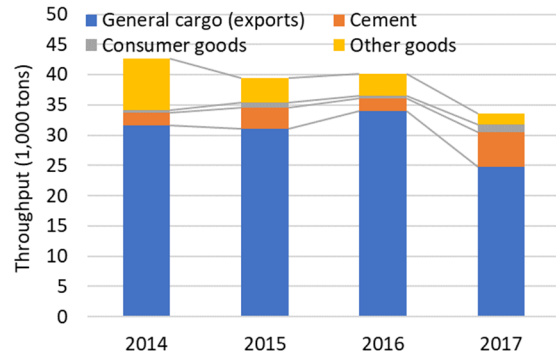


<sup>1</sup> Thus, the cargo handled by Port Fomboni is actually entirely the domestic traffic.

**Figure 5. Passenger traffic at Port Moroni**

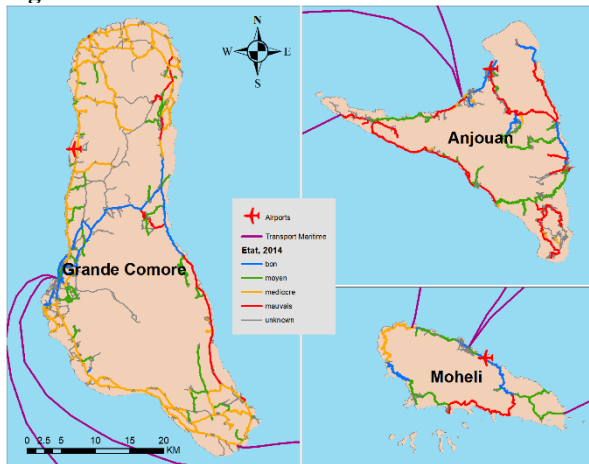


**Figure 6. Freight throughput at Port Fomboni**

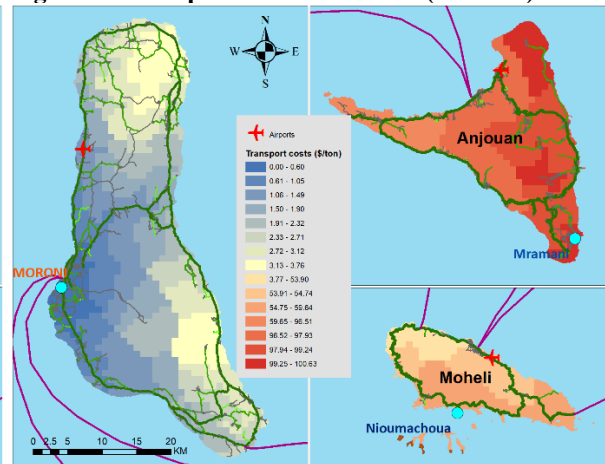


8. Because of the poor condition of the road network (Figure 7) as well as the costly and unreliable inter-island connectivity, the primary market, Moroni, is far from many parts of the country, especially from Anjouan and Moheli. With the road user and maritime transport costs taken into account, the total transport costs to bring goods to Moroni are estimated (Figure 8). It is estimated to cost US\$55.6 per ton from Nioumachoua, Moheli, and US\$99.6 per ton from Mramani, Anjouan, respectively. Significant costs are incurred to inter-island transportation.

**Figure 7. Road network and conditions**



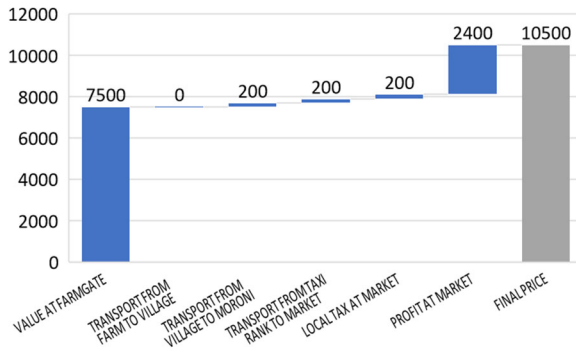
**Figure 8. Transport costs to Moroni (US\$/ton)**



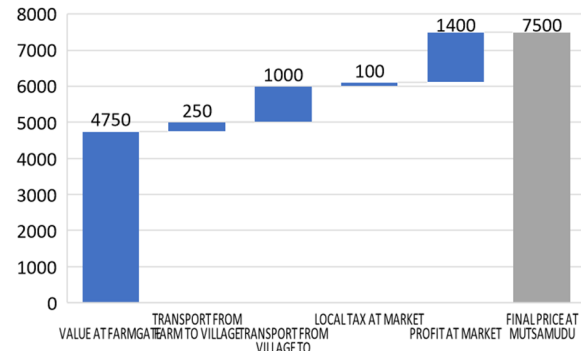
9. When the actual production and distribution costs as well as transport costs were tracked, it turned out that transport-related costs accounted for about 25 to 50 percent of the final market prices at the Volo Volo market in Moroni. For example, the farmgate price of banana (25 kg) is KMF7,500 at Nioumachoua, which is increased to KMF15,000 at Moroni

(Figure 9). From Anjouan, agricultural produce may not even be brought to Moroni despite the existing large price disparity between the islands. Notably, profit margins for retailers are quite high in all cases. The limited supply of agricultural commodities seems to allow them to raise their retail prices considerably.

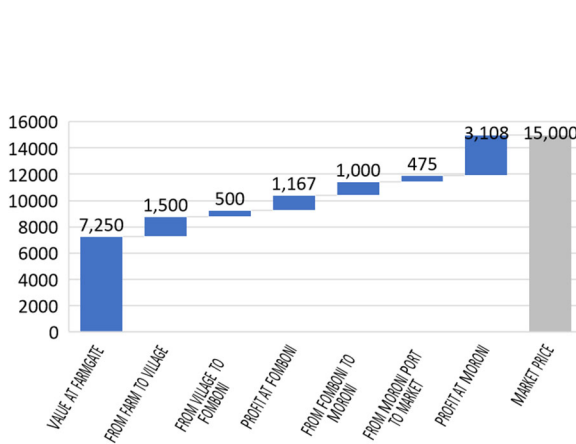
**Figure 9. Transportation value chain analysis on banana (25kg)**  
**(from Mitsamiouli to Volo volo, Moroni)**



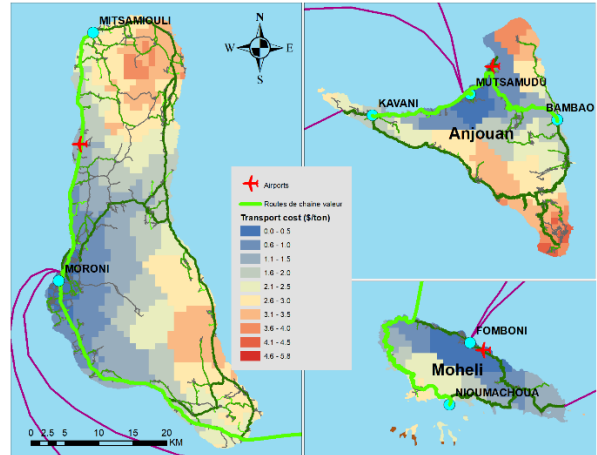
**(from Kavani to Mutsamudu, Anjouan)**



**(from Nioumachoua, Moheli to Volo Volo, Moroni)**



**(Origin-destination and lowest cost routes)**



10. This indicates that significant untapped economic gains exist in the country. With cheaper and more efficient transport connectivity, both farmers and consumers could benefit from more production and more consumption at lower equilibrium prices. Currently, the Comoros is losing significant economic opportunities in the agriculture sector, because of poor transport connectivity. The following analysis aims at quantifying the possible impacts of better transport connectivity on agricultural production. Of particular note, such potential

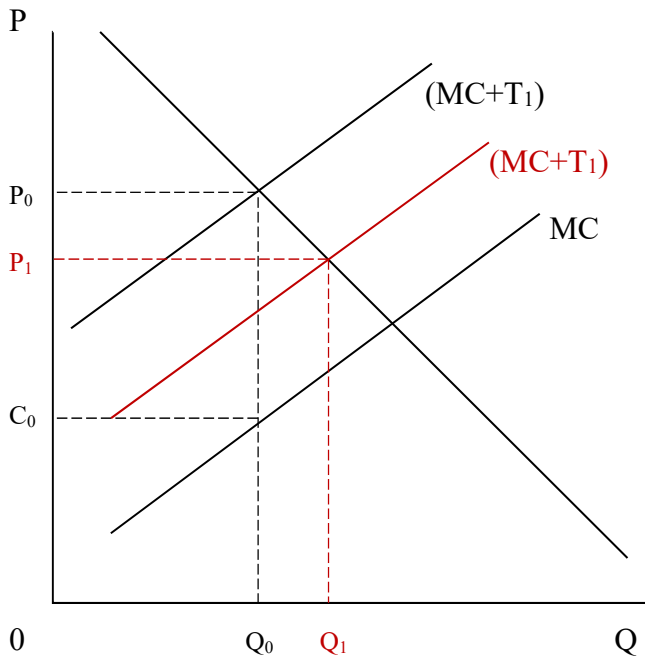


economic gains can be achieved through the domestic markets in the Comoros. Improving connectivity is also expected to contribute to deepening the economic integration among the three regions.

### III. EMPIRICAL STRATEGY AND DATA

11. Basic economic theory tells that lowered transport costs can increase agricultural production (Figure 10). With a positive transport cost,  $T_0 = P_0 - C_0$ , the equilibrium price is currently high at  $P_0$  with a limited amount of supply,  $Q_0$ . Suppose that the transportation cost is reduced to  $T_1 = P_1 - C_0$ . Then, the supply curve shifts downwards. In a new equilibrium, the market price declines to  $P_1$  and the supply or production increases to  $Q_1$ . Therefore, both consumer and producer surplus increase. That is, both groups can benefit from lowered transportation costs.

Figure 10. Demand, supply and transport costs



12. To empirically estimate the impact of transport connectivity on agricultural production, a simple crop production function is considered:

$$\ln Q_{ij} = X_{ij}'\beta_1 + M_i'\beta_2 + Z_i'\beta_3 + c_j + \varepsilon_{ij} \quad (1)$$

where  $Q_{ij}$  is the amount of crop  $j$  produced by household  $i$ , using production inputs  $X_{ij}$ . Although our household data are not comprehensive in terms of input variables,  $X$ , four types of inputs are included following the agricultural economics literature (e.g., Gyimah-Brempong, 1987; Bravo-Ortega and Lederman, 2004): labor, fertilizer, improved seeds, and intermediary services.

13. As usual, the production levels may also depend on household characteristics,  $Z_i$ , for example, the age of the head of household and ownership of certain assets, such as vehicles and motorcycles. The crop-specific fixed-effects,  $c_j$ , are also included to control for unobservables across different crops.  $\varepsilon$  is an idiosyncratic error distributed independently and identically under the cluster-robust variance-covariance assumption.

14. The main hypothesis of the paper is that the level of production is affected by the market accessibility,  $M_i$ . This contains a set of locational characteristics of household  $i$ , which is common across crops. The impact of transport connectivity is supposed to be captured by  $\beta_2$ . This specification implicitly rules out subsistence farming with few advanced inputs used, which is in fact the case in the Comoros. As will be shown below, only 10 percent of the surveyed households used some advanced inputs in our sample. On the output side, on the other hand, about half were involved in some market transactions. In our model, the accessibility variable therefore captures the generic impact of access to input and output markets.<sup>2</sup>

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<sup>2</sup> The paper will also examine the market sales equation, in which the accessibility variable may be able to more explicitly capture the impact of access to output markets. See below.

15. Three connectivity variables are constructed using spatial software based on road user costs and maritime transport costs: The first is transport costs to bring goods to Moroni, denoted by  $COST_{MORONI}$ . This measures the accessibility to the primary market. The second variable is transport costs to bring goods to a large city with a population of 7,500 or more ( $COST_{CITY}$ ). Major towns in each island are taken into account.<sup>3</sup> This is expected to represent the market accessibility at a more local level within each island.

16. Finally, the Market Access Index ( $MAI$ ) is computed as an integral measure of all kinds of market accessibility. Formally, it is often defined by the average market size inversely weighted by transport difficulties. The idea basically follows Tobler's first law of geography: "everything is related to everything else, but near things are more related than distant things (Tobler 1970)."

$$MAI_i = (\sum_m Y_m / d_{im}) / \max MAI \quad (2)$$

where  $Y_m$  represents the size of market at  $m$ , which is measured by the population that does not engage in agricultural production.<sup>4</sup>  $d_{im}$  measures transportation costs between location  $i$  and destination  $m$ . The index is normalized to zero to one. It is clear that Moheli is particularly disconnected from the rest of the country, while Grande Comore, especially around Moroni, has relatively good market accessibility (**Figure 11**). Not surprisingly, poverty is highly correlated with the MAI: The poor tend to be less connected to the markets (**Figure 12**).

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<sup>3</sup> Twenty-one cities and towns were identified among a total of 302 populated areas: Adda Daoueni, Barakani, Bazimini, Dindri, Domoni, Fomboni, Iconi, Jimlime, Koni Djodjo, Mbeni, Mirontsi, Moroni, Moya, Mremani, Mutsamudu, Ngadzale, Ongodjou, Ouani, Ounkazi, Sima and Tsembehou.

<sup>4</sup> It is estimated by the population multiplied by the share of non-agricultural households, which is calculated by subregion, using the same household survey.

Figure 11. Market Access Index (0 to 1)

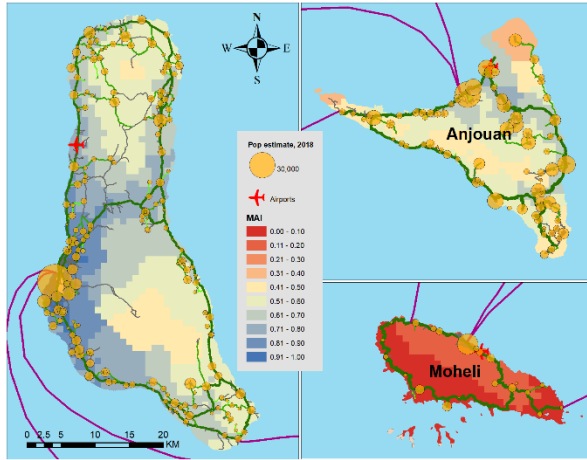
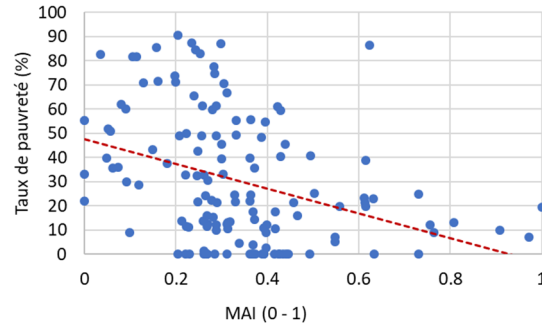


Figure 12. Poverty rate and MAI at town level



17. One empirical challenge to estimate Equation (1) is that the transport connectivity variables,  $Z$ , are potentially endogenous (e.g., Banerjee et al. 2012; Datta, 2012; Jedwab and Moradi, 2012). While transport infrastructure is essential to increase economic productivity, governments tend to invest more in transport infrastructure where productivity is inherently high. Therefore, ordinary least squares (OLS) is likely to generate biased estimates.

18. To deal with this problem, the instrumental variable technique is used. Four instruments are constructed: (i) elevation at each location (meters),  $ELEV$ , (ii) slope of the terrain (degrees),  $SLOP$ , (iii) longitude,  $LONG$ , and (iv) latitude,  $LAT$ . The idea behind the first two variables is that if the land is hilly or mountainous, the transport costs are likely to be high. The poor road conditions raise vehicle operating costs and reduce fuel efficiency. The coordinate data are considered to be fairly exogenous. The validity of the instruments needs to be examined empirically and will be in the following sections.

19. The paper also examines how the transport connectivity impacts on the farmers' market participation to sell their produce. The same framework as Equation (1) is used, however, many farmers in the Comoros may not sell any produce at the market, as in rural areas of

other African countries. Thus, the dependent variable, which is the quantity of crops sold,  $S_{ij}$ , is censored:

$$\ln S_{ij} = \begin{cases} \ln S_{ij}^* = X_{ij}'\gamma_1 + M_i'\gamma_2 + Z_i'\gamma_3 + c_j + \varepsilon_{ij} & \text{if } S_{ij}^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

Since  $M$  is potentially endogenous, the instrumental variable tobit (IVTOBIT) model is used to estimate the equation. Unlike Equation (1), this specification allows to measure the impact of output market connectivity because the dependent variable is a precise measurement representing output market participation, explicitly ruling out subsistence production.

20. Similarly, an alternative specification is this:

$$SHR_{ij} = X_{ij}'\gamma_1 + M_i'\gamma_2 + Z_i'\gamma_3 + c_j + \varepsilon_{ij} \quad (4)$$

where  $SHR_{ij}$  is the share of market sales of crop  $j$  for household  $i$ . This can be estimated consistently by the instrumental variable (IV) regression.

21. The current paper relies on a household expenditure and consumption survey that was carried by the Comorian National Institute of Statistics and Economic and Demographic Studies (INSEED) in 2014. The survey has an agricultural module, in which households were asked how many crops were produced in monetary terms. In total, 36 crops were identified. For each crop, households were also asked whether they used fertilizer and improved seeds. The availability of intermediary services to sell produce was also interviewed. Three types of services were itemized: (i) Aggregation at the cooperative level (denoted by *COOP*), (ii) Direct access to large markets (*MKT*), and (iii) Collection of crops by intermediate traders, i.e., collectors (*TRAD*). Note that these data are available at the crop level. In addition, households were asked whether they sold some of their produce, and how much.

22. A particular challenge lies to use this data set: It is an expenditure survey. Therefore, all data were recorded in monetary terms, i.e., Comorian francs (KMF). For example, the data may show that household  $X$  produced KFM100,000 of crop  $Y$ , not 100 kg. The monetary data of production or market sales are not particularly useful for the analysis, because the crop prices are significantly different across the islands. To convert the monetary data into real terms, the average crop prices were calculated for four subregions (i.e., Moroni, other areas than Moroni in Grande Comore, Anjouan and Moheli), using the consumption data, which include both spending and consumption (quantity) for each crop. As expected, there are substantial price differentials (Figure 13). This is partly attributed to high transport costs among the islands, as discussed above. It is also clear that Anjouan and Moheli produce a lot of agricultural products in the Comoros (Figure 14).

Figure 13. Average crop prices by subregion

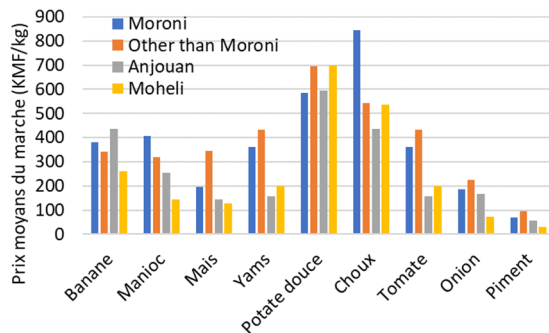
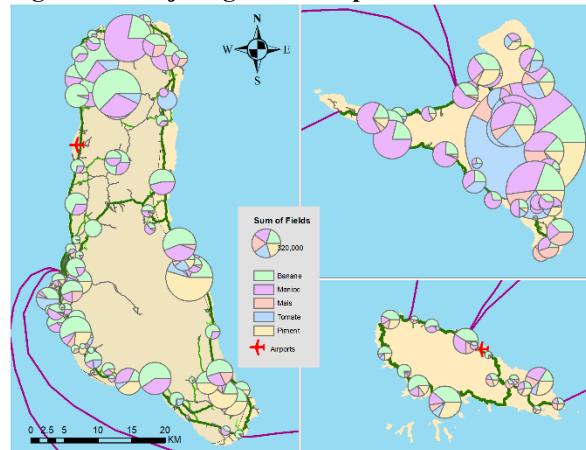


Figure 14. Major agricultural production areas



23. The summary statistics are shown in (Table 1). The original sample comprises a total of 3,110 households who lived in 338 local zones. The agriculture module covers 36 crops. Since not everyone produces all crops, the sample has 3,680 and 1,899 data entries for  $q$  and  $s$ , respectively. A number of outliers were found through the data conversion from monetary to real terms. Especially, small-volume production and sales data are sensitive to the conversion. With such outliers excluded, the following analysis only uses 2,587 observations. Of those, there are 1,340 cases where produced crops were partly sold at the markets.

24. Agricultural producers are quite heterogenous. The amount of crops produced ranges from 2 kg to over 50 tons, with an average of 280 kg. The market sales are also different, from 2 kg to 9,100 kg. Labor force is measured by the number of household members aged 16 to 60. The use of advanced inputs, such as fertilizer and improved seeds, remains minimal in the Comoros. Only 12 and 11 percent of households used them, respectively. Intermediary services by cooperatives or traders also seem to be unavailable in most places. It is also noteworthy that farmers often do not have any transport means in the Comoros.

**Table 1. Summary statistics**

Variable	Abb.	Obs	Mean	Std. Dev.	Min	Max
Quantity of crop produced (kg)	<i>Q</i>	2,587	280.26	1104.56	1.98	51613
Volume of crop sold (kg)	<i>S</i>	1,340	225.11	419.88	2.30	9133
Transport costs to bring produce to Moroni (US\$/ton)	<i>COST<sub>MORONI</sub></i>	2,587	55.43	42.88	0.08	100.54
Transport costs to bring produce to a large city (US\$/ton)	<i>COST<sub>CITY</sub></i>	2,587	0.89	0.83	0.03	2.89
Market Access Index (0 to 1)	<i>MAI</i>	2,587	0.60	0.27	0.08	1.00
Labor force (age 16 to 60)	<i>L</i>	2,587	2.63	1.32	1	10
Use of improved seeds	<i>SEED</i>	2,587	0.12	0.32	0	1
Use of fertilizer	<i>FERT</i>	2,587	0.11	0.32	0	1
Access to intermediary services:						
Crop collection by cooperatives	<i>COOP</i>	2,587	0.02	0.14	0	1
Direct access to large market	<i>MKT</i>	2,587	0.16	0.37	0	1
Crop collection by intermediate traders	<i>TRAD</i>	2,587	0.01	0.10	0	1
Household size	<i>SIZE</i>	2,587	5.41	2.37	1	15
Dummy variable for male household head	<i>MALE</i>	2,587	0.80	0.40	0	1
Age of household head	<i>AGE</i>	2,587	45.93	13.82	16	90
Ownership of transport means:						
Vehicle	<i>CAR</i>	2,587	0.06	0.24	0	1
Motorcycle	<i>MOTR</i>	2,587	0.04	0.20	0	1
Bicycle	<i>BICY</i>	2,587	0.01	0.09	0	1
Instrumental variables:						
Slope (degree)		2,587	6.48	3.69	0.17	16.70
Elevation (meter)		2,587	305.83	246.00	2.00	881.00
Longitude (degree)		2,587	43.92	0.51	43.23	44.53
Latitude (degree)		2,587	-12.05	0.31	-12.38	-11.37

#### IV. ESTIMATION RESULTS

25. First, OLS regression was performed. The results are broadly consistent with prior expectation (Table 2). The transport cost variables have negative coefficients, and *MAI* has a positive coefficient. Thus, improved transport connectivity to markets would likely enhance crop production in the Comoros. As discussed, however, the results may be biased because of the potential endogeneity associated with transport investments.

26. To deal with this problem, the instrumental variable (IV) estimator was used. The results are shown in Table 3 and found to be broadly consistent with the above: Improved market accessibility increased crop production. The endogeneity test results are mixed: Two variables, *COST<sub>CITY</sub>*, and *MAI*, seem to be able to be treated exogenously. In the first and the last column models, the exogeneity hypothesis can be rejected with test statistics of 23.8 and 28.8, respectively. The overidentifying restriction test statistics are estimated at 3.81 and 2.68. Thus, our instruments are considered to be valid in these cases.

27. The table indicates that crop production was increased by improving the market accessibility in general. Particularly, the accessibility to Moroni is essential. When all accessibility variables are included, the coefficient of *COST<sub>MORONI</sub>* is only found to be significantly positive. The impact of *MAI*, which also essentially measures the proximity to Moroni, may be captured by the coefficient of *COST<sub>MORONI</sub>*. Policy implications are clear: The access to the primary market is critical to stimulate agricultural production in the Comoros.

28. With respect to other variables, the measured productivity impacts of labor force, improved seeds or fertilizer are inconclusive. All the coefficients are statistically insignificant. It was found that access to intermediary services is important. The coefficient of *COOP* is always positive: Cooperatives play an important role to collect and consolidate crops that are produced. *MKT* also has a significantly positive coefficient. It means that farmers produced more when they had good and direct access to a large market.



**Table 2. OLS estimation results for crop production**

	lnQ	lnQ	lnQ	lnQ
lnCOST <sub>MORONI</sub>	-0.209 (0.136)			-0.0003 (0.147)
lnCOST <sub>CITY</sub>		-0.126 (0.036) ***		-0.079 (0.037) **
lnMAI			1.240 (0.287) ***	0.941 (0.316) ***
lnL	0.077 (0.069)	0.055 (0.068)	0.067 (0.067)	0.053 (0.067)
SEED	0.077 (0.084)	0.070 (0.081)	0.059 (0.083)	0.057 (0.082)
FERT	0.034 (0.095)	0.018 (0.097)	0.029 (0.097)	0.014 (0.094)
COOP	0.540 (0.200) ***	0.561 (0.185) ***	0.527 (0.193) ***	0.548 (0.185) ***
MKT	0.434 (0.068) ***	0.421 (0.068) ***	0.439 (0.068) ***	0.431 (0.068) ***
TRAD	0.091 (0.239)	0.104 (0.242)	0.116 (0.249)	0.110 (0.253)
MALE	0.050 (0.063)	0.023 (0.064)	0.025 (0.061)	0.015 (0.062)
SIZE	-0.063 (0.068)	-0.057 (0.068)	-0.059 (0.068)	-0.051 (0.067)
AGE	0.023 (0.081)	0.010 (0.078)	0.006 (0.080)	0.003 (0.078)
CAR	-0.242 (0.109) **	-0.249 (0.111) **	-0.230 (0.112) **	-0.242 (0.113) **
MOTR	-0.170 (0.158)	-0.178 (0.162)	-0.186 (0.166)	-0.184 (0.166)
BICY	0.244 (0.340)	0.279 (0.332)	0.158 (0.332)	0.200 (0.329)
Constant	5.497 (0.400) ***	5.586 (0.382) ***	5.889 (0.388) ***	5.788 (0.399) ***
Obs.	2587	2587	2587	2587
R-squared	0.365	0.371	0.373	0.3748
F-stat	22.79	23.25	24.03	23.14
Dummy variables:				0.3777
Crops	Yes	Yes	Yes	Yes
Prefectures	Yes	Yes	Yes	Yes

**Table 3. IV estimation results for crop production**

	lnQ	lnQ	lnQ	lnQ
lnCOST <sub>MORONI</sub>	-0.854 (0.226) ***			-1.046 (0.307) ***
lnCOST <sub>CITY</sub>		-0.209 (0.100) **		0.057 (0.135)
lnMAI			2.931 (1.271) **	-1.240 (1.708)
lnL	0.064 (0.068)	0.050 (0.069)	0.048 (0.066)	0.085 (0.077)
SEED	0.024 (0.084)	0.034 (0.082)	-0.002 (0.084)	0.049 (0.090)
FERT	-0.014 (0.095)	-0.040 (0.096)	-0.048 (0.097)	0.012 (0.104)
COOP	0.564 (0.203) ***	0.568 (0.181) ***	0.478 (0.192) **	0.559 (0.220) **
MKT	0.437 (0.066) ***	0.432 (0.068) ***	0.431 (0.068) ***	0.440 (0.067) ***
TRAD	0.011 (0.262)	0.103 (0.246)	0.114 (0.271)	-0.006 (0.254)
MALE	0.062 (0.062)	0.017 (0.069)	0.007 (0.065)	0.100 (0.080)
SIZE	-0.039 (0.068)	-0.041 (0.068)	-0.031 (0.068)	-0.051 (0.073)
AGE	0.055 (0.080)	0.033 (0.078)	0.018 (0.081)	0.065 (0.089)
CAR	-0.313 (0.120) ***	-0.251 (0.114) **	-0.278 (0.119) **	-0.308 (0.119) ***
MOTR	-0.137 (0.155)	-0.163 (0.164)	-0.168 (0.181)	-0.126 (0.152)

<i>BICY</i>	0.235 (0.333)	0.304 (0.325)	0.072 (0.337)	0.318 (0.377)
Constant	5.007 (0.412) ***	5.497 (0.373) ***	6.202 (0.458) ***	4.707 (0.587) ***
Obs.	2587	2587	2587	2587
R-squared	0.347	0.364	0.351	0.317
Wald chi2	1490.0	1490.0	1471.9	1408.8
Dummy variables:				
Crops	Yes	Yes	Yes	Yes
Prefectures	Yes	Yes	Yes	Yes
Endogeneity test:				
C stat. chi2	23.808 ***	1.219	1.968	28.808 ***
Overidentifying restriction test:				
Hansen's J stat. chi2	3.817	20.235 ***	19.150 ***	2.689

29. To estimate the market sales equation, the IVTOBIT model was applied: The results are presented in **Table 4**. The market accessibility variables to Moroni and a regional city are again found to be significant. The coefficient is estimated at -1.95 when  $COST_{MORONI}$  is only included in the equation. The coefficient is also significant at -0.95 when  $COST_{CITY}$  is used. Thus, the crop sales have a higher elasticity with respect to the costs to Moroni. The statistical significance looks relatively weak when  $MAI$  is used.

30. When all three variables are included, the accessibility to Moroni remained statistically significant. In this model, the endogeneity test statistic is estimated at 20.09, which implies that the connectivity variables are likely endogenous. Thus, the result can be interpreted to mean that the connectivity to Moroni is particularly important to support agricultural market transactions. The finding may not be surprising because Moroni is the primary market in the Comoros. All the indications are that improved market accessibility can boost agricultural growth. Especially given the current distribution of population (see **Figure 11**) and agricultural production areas (**Figure 14**), inter-island connectivity is an important challenge to the country.

31. The results also suggest that the accessibility to intermediary services, such as cooperatives and collectors, are instrumental to facilitating the farmers' market participation to sell their produce. All the coefficients of  $COOP$ ,  $MKT$  and  $TRAD$  are estimated to be

significantly positive. This looks consistent with the fact that the vast majority of farmers do not own their own transport means. The result indicates that not only transport infrastructure but also transport and trade services are important. Interestingly, the size of household also has a positive impact on the market participation. The coefficient of *SIZE* is always positive and significant. It may be interpreted to mean that the market participation is time-consuming, requiring extra labor force, for example, to bring their produce to the markets or the places where their produce is consolidated.

32. Since the exogeneity hypothesis cannot be rejected in the two cases, the tobit regression was also performed (Table 5). The results just confirm the above findings. The accessibility to the large city in the islands has a negative and significant coefficient.

**Table 4. IVTOBIT estimation results for market sales**

	lnS	lnS	lnS	lnS
<i>lnCOST<sub>MORONI</sub></i>	-1.950 (0.804) **			-2.022 (1.062) *
<i>lnCOST<sub>CITY</sub></i>		-0.952 (0.342) ***		-0.623 (0.437)
<i>lnMAI</i>			2.501 (7.588)	-9.701 (5.997)
<i>lnL</i>	-0.286 (0.243)	-0.444 (0.249) *	-0.254 (0.255)	-0.314 (0.285)
<i>SEED</i>	-0.127 (0.263)	-0.148 (0.243)	-0.102 (0.288)	0.001 (0.283)
<i>FERT</i>	0.035 (0.319)	-0.031 (0.294)	0.160 (0.313)	0.039 (0.321)
<i>COOP</i>	3.515 (0.396) ***	3.651 (0.418) ***	3.397 (0.375) ***	3.693 (0.406) ***
<i>MKT</i>	3.582 (0.203) ***	3.485 (0.203) ***	3.587 (0.199) ***	3.471 (0.204) ***
<i>TRAD</i>	3.542 (0.400) ***	3.679 (0.356) ***	3.757 (0.348) ***	3.450 (0.463) ***
<i>MALE</i>	-0.069 (0.229)	-0.271 (0.237)	-0.147 (0.258)	-0.003 (0.305)
<i>SIZE</i>	0.599 (0.232) **	0.623 (0.241) ***	0.514 (0.243) **	0.577 (0.241) **
<i>AGE</i>	0.374 (0.295)	0.277 (0.292)	0.321 (0.296)	0.436 (0.318)
<i>CAR</i>	-0.930 (0.426) **	-0.958 (0.451) **	-0.807 (0.416) *	-1.013 (0.418) **
<i>MOTR</i>	0.289 (0.551)	0.203 (0.554)	0.193 (0.561)	0.354 (0.560)
<i>BICY</i>	-0.949 (0.816)	-0.631 (0.935)	-1.067 (0.941)	-0.092 (1.024)
Constant	0.664 (1.343)	1.597 (1.255)	2.597 (1.841)	-1.563 (2.057)
Obs.	2587	2587	2587	2587
Obs.	1247	1,265	1,265	1,265
Censored				
Wald chi2	1174.4	1195.0	1192.7	1108.7
Dummy variables:				
Crops	Yes	Yes	Yes	Yes
Prefectures	Yes	Yes	Yes	Yes
Endogeneity test:				
Wald chi2	11.90 ***	4.66	0.06	20.09 ***

**Table 5. TOBIT estimation results for market sales**

	lnS		lnS	
ln <i>COST</i> <sub>CITY</sub>	-0.283	(0.129) **		
ln <i>MAI</i>			0.660	(0.988)
ln <i>L</i>	-0.292	(0.237)	-0.231	(0.239)
<i>SEED</i>	-0.078	(0.246)	-0.065	(0.252)
<i>FERT</i>	0.133	(0.283)	0.192	(0.285)
<i>COOP</i>	3.471	(0.371) ***	3.399	(0.379) ***
<i>MKT</i>	3.545	(0.194) ***	3.578	(0.194) ***
<i>TRAD</i>	3.727	(0.352) ***	3.750	(0.362) ***
<i>MALE</i>	-0.149	(0.223)	-0.115	(0.225)
<i>SIZE</i>	0.526	(0.223) **	0.492	(0.223) **
<i>AGE</i>	0.330	(0.285)	0.340	(0.288)
<i>CAR</i>	-0.845	(0.417) **	-0.805	(0.410) **
<i>MOTR</i>	0.209	(0.545)	0.206	(0.546)
<i>BICY</i>	-0.810	(0.857)	-0.932	(0.822)
Constant	1.964	(1.215)	2.251	(1.240) *
Obs.	2587		2587	
Obs. Censored	1247		1247	
F stat	18.57		18.44	
Dummy variables:				
Crops	Yes		Yes	
Prefectures	Yes		Yes	

33. The IV regression on market sales shares shows similar results (Table 6). Transport connectivity to cities is important. Of particular note, the coefficients of *COST*<sub>CITY</sub> and *MAI* are statistically significant in this case. Market accessibility is no doubt essential to promote farmers' output market participation. In addition, it is confirmed once again that not only transport infrastructure but also transport and trade services are equally important: *COOP*, *MKT* and *TRAD* systematically have positive and significant coefficients. Other household characteristics do not seem to play an important role in determining households' decision to be involved in market transactions, which is also broadly consistent with the above.

**Table 6. IV regression results for market sales share**

	<i>SHR</i>	<i>SHR</i>	<i>SHR</i>	<i>SHR</i>
$\ln COST_{MORONI}$	-0.531 (0.400)			-0.778 (1.955)
$\ln COST_{CITY}$		-0.374 (0.211) *		-0.378 (0.292)
$\ln MAI$			2.089 (1.285) *	-1.654 (6.953)
$\ln L$	0.242 (0.159)	0.322 (0.181) *	0.138 (0.112)	0.504 (0.556)
<i>SEED</i>	0.507 (0.247) **	0.720 (0.312) **	0.381 (0.178) **	0.978 (0.814)
<i>FERT</i>	0.262 (0.159) *	0.283 (0.186)	0.257 (0.149) *	0.310 (0.241)
<i>COOP</i>	0.367 (0.134) ***	0.421 (0.155) ***	0.340 (0.117) ***	0.447 (0.207)
<i>MKT</i>	0.973 (0.238) ***	1.114 (0.265) ***	0.901 (0.188) ***	1.311 (0.586)
<i>TRAD</i>	1.127 (0.726)	0.869 (0.764)	1.128 (0.686) ***	0.750 (0.942)
<i>MALE</i>	-0.252 (0.183)	-0.510 (0.269) *	-0.207 (0.143)	-0.671 (0.540)
<i>SIZE</i>	0.102 (0.092)	0.167 (0.119)	0.086 (0.078)	0.229 (0.204)
<i>AGE</i>	-0.182 (0.198)	-0.475 (0.303)	-0.105 (0.138)	-0.682 (0.680)
<i>CAR</i>	-0.054 (0.136)	-0.158 (0.163)	-0.017 (0.109)	-0.237 (0.322)
<i>MOTR</i>	-0.010 (0.085)	-0.034 (0.120)	-0.022 (0.089)	-0.024 (0.154)
<i>BICY</i>	-0.454 (0.238) *	-0.363 (0.337)	-0.590 (0.233) **	-0.254 (0.635)
Constant	0.779 (0.587)	1.929 (1.003) *	1.145 (0.628) *	1.933 (1.186)
Obs.	2587	2587	2587	2587
R-squared	0.040	0.048	0.032	0.050
Wald chi2	298.1	131.2	241.7	108.9
Dummy variables:				
Crops	Yes	Yes	Yes	Yes
Prefectures	Yes	Yes	Yes	Yes
Endogeneity test:				
C stat. chi2	1.454	3.6056 **	1.353	3.948
Overidentifying restriction test:				
Hansen's J stat. chi2	2.637	0.3487	1.790	0.000

## V. CONCLUSION

34. Agriculture is an important sector in Africa. However, the region's production system remains small-scale subsistence farming with few advanced inputs used with little produce sold in the market. The paper revisited the traditional transport-agricultural growth nexus. Even if the existing literature is substantially rich, this is still an important question, particularly for small island developing states, such as the Comoros, where the domestic markets are limited, and the transport and transaction costs are often prohibitively high.

35. Using household survey data in the Comoros, the paper examined the potential impacts of transport connectivity on crop production and market sales. Different types of connectivity, i.e., within- and inter-island connectivity, were considered. By the value chain analysis, first, it was found that in the country, there are significant price differentials among the islands, indicating disconnection among the regional economies in the country. In addition, the differences were found to be attributed largely to high inland and maritime transport costs.

36. More formally, second, regression analysis was carried out. The results indicate that significant untapped economic potential exists in the domestic market. The accessibility to Moroni, the primary market in the country, was found to be of particular importance, indicating the importance of inter-island connectivity among the islands. The crop production can be increased by reducing the transport costs to Moroni or improving the market accessibility in general. The connectivity to Moroni is also essential to encourage farmers to participate in market transactions, stimulating agricultural market sales.

37. The estimation results also show that not only transport infrastructure but also transport and trade services are important. The accessibility to intermediary services, such as cooperatives and collectors, plays an important role to increase crop production and market sales. Thus, it is important to not only invest in transport infrastructure but also promote private sector development in the transport and/or agrobusiness industries.

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