Agricultural production, road rehabilitation and conflicts: evidence from the Western Growth Poles Development project in Bas-Congo

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This paper

Research objective: Investigate the impact of PDPC project on agricultural market participation in Bas-Congo province (DRC).

- How: Household-level survey data, with a DiD approach.

Main findings: PDPC project has *positive* impact on the commercialization of agricultural output.

- Mechanism: road rehabilitation as a source of exogenous variation.

Additional results: Local level impact of PDPC.

- Nexus between agricultural output commercialization and violence.
- Rural road rehabilitation interventions mitigate surplus-induced violence.

Western Growth Pole Development (PDPC) Project

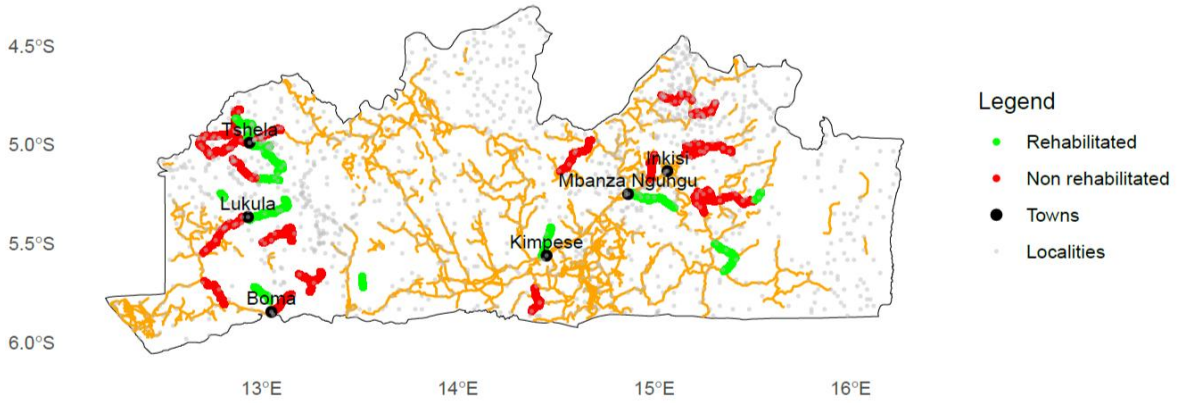


Table A.2: **Themes of delivered PDPC training, by territory of Bas-Congo**

Territory	Production	Disease	Harvest	Transformation	Production costs
Lukula	6,239	3,253	4,565	3,085	3,085
Madimba	4,092	3,145	2,799	673	2,283
Mbanza Ngungu	1,347	1,291	1,356	30	2,080
Muanda	9,497	9,497	9,497	0	8,996
Songololo	759	759	759	759	759
Tshela	10,132	10,132	10,132	10,132	10,062

Source: Author based on PDPC Project (2019).
Note: All variables in the Table refer to the number of households who received the training about the indicated theme.

- **Component 1:** strengthening agricultural value chain of cassava, rice and palm oil in Bas-Congo.
  - Infrastructure rehabilitation: rural road rehabilitation to ease the provision of inputs and ease the access to local markets.
  - Producer capacity development: agricultural extension services provisions.
- **Component 2**: support the industrial business development of private operators (Kinshasa province).
- **Component 3**: improve business environment and promoting investments in productive activities of targeted value chains.

Agricultural production and infrastructures

Improved connectivity is associated with a reduction in poverty (Gibson and Rozelle, 2003, Lokshin and Yemtsov, 2005; Dercon et al., 2009; Khander et al. 2009; Qin and Zhang, 2016).

Agricultural sector

Better connectivity eases the access to agricultural inputs and technologies (Shamdani, 2021), increasing the share of harvested production sold to the market (Nakamura et al 2020). This impact strengthens when combined with agricultural extension services (Gebresilasse, 2023).

Other Mechanisms

- Crops: mixed effects have been detected on crop prices, production and yields (Ludwing, 2016).
- Consumption: improvements in consumption (Anega and Alemu, 2023), linked to lower local market prices (Casaburi et al. 2013), o increased availability of goods (Aggarwal, 2018). However, higher consumption might not be translated into higher savings (Escobal and Ponce, 2002).
- Non-agricultural income: rural road rehabilitation increases off-farm wage employment (Ahser and Novosad, 2020) and reduce self-employment in agriculture (Akee, 2006), for poorer and more vulnerable households (Nakamura et al. 2020).

Agricultural production and violence

The nexus between agricultural production and violence is not *a priori* univocal.

- Production scarcity, food insecurity or uneven distribution of agricultural output → deprivation effect (Hendrix and Haggard, 2015).
- Presence (or nonhomogeneous) distribution of agricultural surplus → rapacity effect (i.e. violent appropriation of the surplus) (Dube and Vargas, 2013; Berman et al., 2017; McGuirk and Burke, 2020, Berman et al. 2021).
- Commercialization of exceeding production as a source of income → opportunity-cost effect (Bazzi and Blattman, 2014).

Context

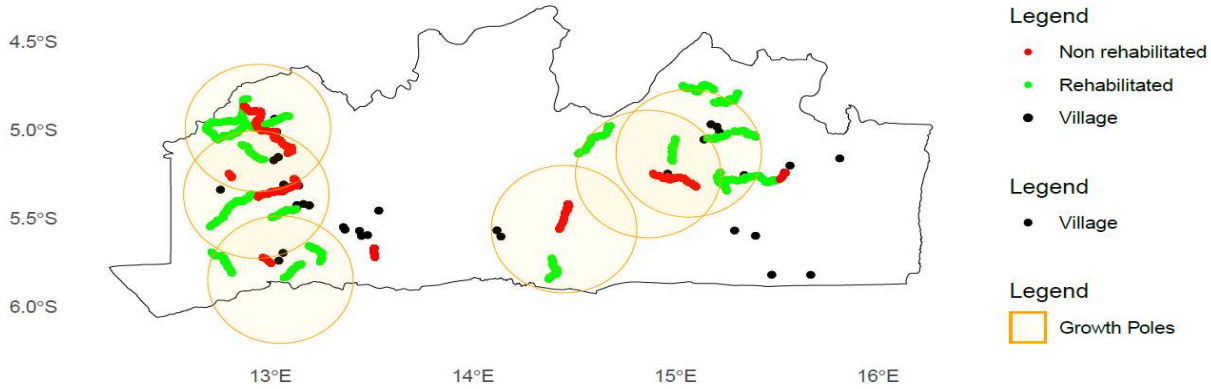
- DRC is fragile and conflict-affected, but Western provinces (including Bas-Congo) are consistently less affected than North-Eastern provinces.
- Agriculture is the main source of income in Bas-Congo (extraction activities are concentrated in the Eastern provinces).
- From 2015, there is a generalized increase in violence in Bas-Congo, driven by protests, riots and incidents targeting civilians (Raleigh and Carlsen, 2019).

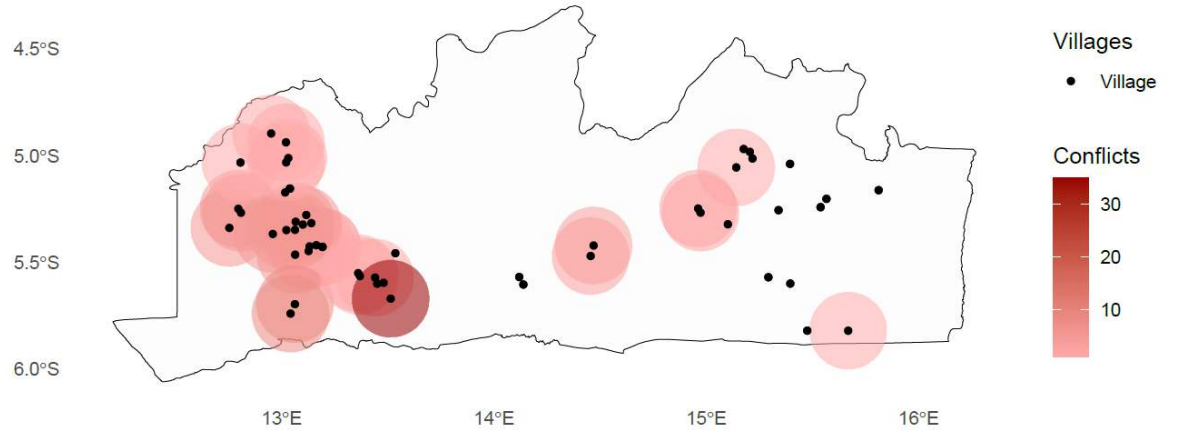
Data sources

- **Households:** panel survey data from PDPC, conducted in pre and post treatment (December 2015, July 2019). GPS coordinates are provided at village level.
  - *Production sold* → structural transformation of the agricultural production.
  - *Input accessibility* → mechanism of transmission.

- **Roads**: 31 feeder roads, connecting 7 territories in Bas-Congo (DVDA and PDPC). Cross-sectional data providing post-rehabilitation information.

- **Violence and conflict**: geo-localised violent events (ACLED) occurring in a 20 km radius around villages' centroids in the period Dec-2015/July-2019. Selected categories: "Protests", "Riots", "Violence against civilians".





Sample

Original sample

- Two-stage sampling procedure: 61 villages, 20 household per village.
- Stratification: 10 female, 10 male lead farmers.

Only households cultivating target crops as main crop.

Final sample: 2, 203 households observed before and after the treatment (4,406 observations), distributed across 8 territories.

- Around 40% purchase at least one type of agricultural input.
- Each household sells on average 56.6% of their production.
- Every household has been exposed on average to 1.53 violent events during the period Dec2015-Jul2019.

Variable	Observations	Mean	Std. Dev.	Min	Max
		Main characteristics			
Inputs accessibility$_{i,t}$	4,406	0.41	0.49	0.00	1.00
Production sold$_{i,t}$	4,406	56.16	48.47	0.00	100.0
Conflict$_{i,t}$	4,406	1.53	5.31	0.00	42.00
		Additional characteristics			
Car access month$_{i,t}$	4,406	4.59	5.16	0.00	12.00
Market distance$_{i,t}$	4,406	13.51	125.92	0.00	3,744.8
Road speed$_{i,t}$	4,406	4.49	1.21	2.93	9.45

Source: Author based on PDPC project baseline and follow-up survey (2019) & ACLED (2024)

Note: $Production\ sold_{i,t}$ is the logarithm of the share of harvested production over the total harvest s by households to the local market. $Conflict_{i,t}$ is the number of violent events registered by ACLE a 20km radius around each village location. Among all the categories, we selected events classifie "Protest", "Riots" or "Violence against civilians". $Input\ accessibility_{i,t}$ is a dummy variable assum value 1 if the household reported having purchased at least on input in the local market and 0 otherw $Road\ speed_{i,t}$ is the average road speed (m/s) recorded for each road track.

Treatment identification

Treatment and control groups

Households living in the project intervention area, defined as 40 km around the center of the GP.

- A ***treated unit*** is every household who received the PDPC package of extension services and inputs.
- A ***control unit*** is any other household in the sample.

- **Road rehabilitation** is not considered as part of the treatment:
  - Road rehabilitation have been implemented in a different phase, earlier than the rest of PDPC interventions and not simultaneously to all households.
  - Road data are in a cross-sectional form, so there are not pre-treatment information.
- **40.20%** of households are treated.

Treatment measurement

Capture the variation attributable to PDPC treatment, isolating treated households in post-treatment period.

$$Treatment_{i,t} = PDPC_{i,t} * Final\ Survey\ Indicator_{i,t}$$

Regression model – main model

To investigate the impact of treatment on commercialization of agricultural output:

- Difference-in-Difference (DiD) approach.
- OLS regression.

$$Production\ sold_{i,t} = \alpha + \beta Treatment_{i,t} + \gamma Final\ Survey\ Indicator_{i,t} + u_{i,t}$$

where, $Production\ sold_{i,t}$ is the logarithm of harvested output sold to the local market over the total harvested area output. $Treatment_{i,t}$ is the treatment indicator, $Final\ Survey\ Indicator_{i,t}$ is a dummy variable to isolate treated units in post-treatment.

β can be interpreted as the percentage variation of the share of commercialized output associated with the causal impact of PDPC on production commercialization.

Results – main model

Table 1: **Impact of treatment on production commercialization in Bas-Congo province (2016-2019)**

	Production sold$_{i,t}$		
	(1)	(2)	(3)
Treatment$_{i,t}$	2.917***	2.771***	3.008***
	(0.202)	(0.306)	(0.275)
Final survey indicator $_{i,t}$	0.055	0.437	−0.109
	(0.711)	(0.343)	(0.057)
Sample	Full	Close RR	Close NR
Additional controls	YES	YES	YES
Observations	1,824	600	1,224

Notes.(* p-value< 0.1; ** p-value<0.05; *** p-value<0.01) The unite of observation is the household. Standard errors in parenthesis, are robust and clustered at village level. The dependent variable $Production\ sold_{i,t}$ is the logarithm of the share of harvested output sold to the local market over total harvested output. $Treatment_{i,t}$ is the treatment indicator defined as in equation 1. $Final\ Survey\ Indicator_{i,t}$ is a dummy variable assuming value 1 to indicate the post-treatment period, while 0 to indicate the period before the treatment The sample of households close to a RR includes all the treated and untreated households which closes road has been rehabilitated. The sample of households to a NR includes all the treated and untreated households which closes road has not been rehabilitated. **Controls**: $Distance\ from\ market_{i,t}$ is the distance (in walking minutes) from the local market of reference. $Car\ access_{i,t}$ is the number of times per month a car accessed the village. The initial sample is the original sample of all households. The final sample is the households reporting to cultivate at least one of the target crops (cassa, rice, palm oil).

Results of the main model

- Large and positive effect of PDPC on commercialization of agricultural output (column 1).

- Stratification by proximity to a rehabilitated road (columns 2-3):
  - The large and positive impact of PDPC on selling of agricultural output remains robust and stable for both households close to a rehabilitated road or to a non-rehabilitated road.

Results – gender dis-aggregation

Gender dis-aggregated analysis

- By plot manager:
  - Plots both male and female managers benefit from the treatment.
  - The slight difference is not significant.
  - Stratification: the proximity to a rehabilitate or a non-rehabilitated road does not affect the impact of PDPC on output commercialization.

Table 2: **Impact of treatment on production commercialization in Bas-Congo province (2016-2019), gender disaggregated analysis**

Panel A: Female plot manager			
	Production sold$_{i,t}$		
	(1)	(2)	(3)
Treatment$_{i,t}$	2.659***	2.691***	2.697**
	(0.260)	(0.353)	(0.337)
Final survey indicator$_{i,t}$	0.107	0.711	−0.049
	(0.153)	(0.479)	(0.052)
Sample	All female	Close RR	Close NR
Observations	676	211	465
Panel B: Male plot manager			
	Production sold$_{i,t}$		
	(1)	(2)	(3)
Treatment$_{i,t}$	3.135***	2.892**	3.271***
	(0.191)	(0.337)	(0.228)
Final survey indicator$_{i,t}$	0.092	−0.064	−0.057
	(0.077)	(0.275)	(0.052)
Sample	All male	Close RR	Close NR
Observations	1,606	374	713
Impact of Treatment (Female vs Male)	−0.476	−0.476	−0.476
(P-value)	0.140	0.140	0.140

Notes.(* p-value< 0.1; ** p-value<0.05; *** p-value<0.01) The unite of observation is the household. Standard errors in parenthesis, are robust and clustered at household level.The

Mechanism – empirical strategy

First stage

Estimate the impact of PDPC on the purchase of agricultural inputs, including seeds, fertilizers and pesticides, in the local market:

- DiD approach
- Conditional/logit regression model → the target variable is a dummy.

$$Input\ accessibility_{i,t} = \alpha + \beta Tratement_{i,t} + \gamma Final\ Survey\ Indicator_{i,t} + u_{i,t}$$

where $Input\ accessibility_{i,t}$ is a dummy assuming value 1 if the households purchased at least one type of input and 0 otherwise.

β is the causal impact of PDPC on input accessibility, capturing the difference between the variation between treated and untreated groups.

Mechanism – empirical strategy

Second stage

Estimate the impact of input accessibility on the commercialization of agricultural output:

- Instrumental Variable (IV) approach → $Road\ speed_{i,t}$ (average speed in m/s measured for each road track)
- Two Stage OLS (TSLS) regression model

$$Production\ sold_{i,t} = \alpha + \beta Input\ accessibility_{i,t}^{IV} + \gamma Final\ Survey\ Indicator_{i,t} + u_{i,t}$$

β is the causal impact of input accessibility on the share of agricultural production sold to the local market.

Table A.4: **Instrument validation**

	Input accessibility$_{i,t}$	*Production sold*$_{i,t}$
	(1)	(2)
Road speed$_{i,t}$	0.046***	−22.314
	(0.012)	(15.072)
Final survey indicator $_{i,t}$	−0.002	17.158
	(0.015)	(13.078)
Sample	Full	Full
Additional controls	YES	YES
Observations	1,805	1,805

Notes.(* p-value< 0.1; ** p-value<0.05; *** p-value<0.01) The unite of observation is the household. Standard errors in parenthesis, are robust and clustered at village level. The dependent variable *Production sold*$_{i,t}$ is the logarithm of the share of harvested output sold to the local market over total harvested output. *Input accessibility*$_{i,t}$ is a dummy variable assuming value 1 if the household reported having purchased at least on input in the local market and 0 otherwise. *Road speed*$_{i,t}$ is the average road speed (m/s) recorded for each road track. *Final Survey Indicator*$_{i,t}$ is a dummy variable assuming value 1 to indicate the post-treatment period, while 0 to indicate the period before the treatment

Mechanism – Results

First stage

Table 3: **Impact of treatment on input accessibility in Bas-Congo province (2016-2019)**

	Input accessibility$_{i,t}$		
	(1)	(2)	(3)
Treatment$_{i,t}$	0.533***	0.155*	0.715**
	(0.057)	(0.072)	(0.075)
Final survey indicator $_{i,t}$	0.016	0.076	0.018
	(0.018)	(0.052)	(0.012)
Sample	Full	Close RR	Close NR
Additional controls	YES	YES	YES
Observations	1,805	593	1,212

Notes.(* p-value< 0.1; ** p-value<0.05; *** p-value<0.01) The unite of observation is the household. Standard errors in parenthesis, are robust and clustered at village level. The dependent variable *Input accessibility*$_{i,t}$ a dummy variable assuming value 1 if the household has purchased at least one agricultural input and 0 otherwise. *Treatment*$_{i,t}$ is the indicator for the impact of road rehabilitation interventions, as in equation 1. *Final survey indicator*$_{i,t}$ is an indicator for the survey (baseline vs endline). **Controls**: *Distance from market*$_{i,t}$ is the distance (in walking minutes) from the local market of reference. *Car access*$_{i,t}$ is the number of times per month a car accessed the village. The initial sample is the original sample of all households. The final sample is the households reporting to cultivate at least one of the target crops (cassava, rice, palm oil).

Second stage

Table 4: **Impact of input accessibility on production commercialization in Bas-Congo province (2016-2019) — IV estimation**

	Production sold$_{i,t}$
	(1)
Input accessibility$_{i,t}$ (IV)	5.110**
	(2.251)
Final survey indicator$_{i,t}$	-0.040
	(0.129)
Observations	1,805
F-test first stage	13.12***
Wu-Hausman test	14.56***

Notes.(* p-value< 0.1; ** p-value<0.05; *** p-value<0.01) The unit of observation is the household. Standard errors in parentheses are clustered at village level. The dependent variable *Production sold*$_{i,t}$ is the logarithm of the share of agricultural production sold. *Input accessibility*$_{i,t}$ is a dummy variable assuming value 1 if the household has purchased at least one input and 0 otherwise. The endogenous variable is instrumented by *Roadspeed*$_{r,t}$, the average travel speed of the road. *Final survey indicator*$_{i,t}$ is an indicator for the survey (baseline vs endline).

Local Level Impact of PDPC

Regression model

Investigate the impact of commercialization of agricultural output on violence:

- Instrumental Variable (IV)
- OLS regression model

$$Violence_{i,t} = \alpha + \beta Production\ sold_{i,t}^{IV} + \gamma Final\ Survey\ Indicator_{i,t} + u_{i,t}$$

where $Violence_{i,t}$ is the logarithm of the number of conflicts occurring in a 20km radius around each village centroid during the period of analysis and categorized as "Protests" "Riots", or "Violence against civilians".

Results

Output commercialization is associated with a generalized increase in violent appropriation of surplus (column 1). However, being located close to a rehabilitated road tenc to mitigate the risk of exposition to surplus-related violence (columns 2, 3).

Table 5: **Impact of agricultural production commercialization on violence in Bas-Congo province (2016-2019) — IV estimation**

	Number of conflicts$_{i,t}$		
	(1)	(2)	(3)
Production sold$_{i,t}$ (IV)	0.036**	0.088	0.035***
	(0.012)	(0.012)	(0.012)
Sample	Full	Close RR	Close NR
Observations	1,805	600	1,122

Notes.(* p-value< 0.1; ** p-value<0.05; *** p-value<0.01) The unit of observation is the household. Standard errors in parentheses are clustered at village level. The dependent variable *Production sold*$_{i,t}$ is the logarithm of the share of agricultural production sold. *Final survey indicator*$_{i,t}$ is an indicator for the survey (baseline vs endline).

Concluding remarks

PDPC project has a *positive* impact on the commercialization of agricultural output, suggesting a possible structural change in production habits and potentials of farmers of cassava, rice and palm oil of Bas-Congo (DRC).

Mechanism: PDPC *increases* the likelihood of agricultural input purchase of *treated* farmers. In turn, purchasing inputs *increases* the share of agricultural production sold to the market. → Suggestive evidence that road rehabilitation is crucial for market access and integration

Additional evidence: local level impact of PDPC

- *Positive* relationship between variation in surplus commercialization and violent events.
- Rural road rehabilitation interventions *mitigate* agricultural surplus-induced violence.