Plant Cultural Infrastructure and Harvest Urban Growth: Evidence from the Kingdom of Alexander the Great

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9 July 2025

Motivation

- Cultural policy discussions often focus on intangible factors:
  - Values, norms, beliefs, political traits, religion, attitudes, trust
- But the role of **physical cultural infrastructure** remains underexplored.
- This study shifts focus to how built cultural spaces can:
  - Foster civic and cultural activity
  - Spur long-term urban growth
- Cultural infrastructure may trigger a **self-reinforcing cycle**:
  - Cultural engagement → more infrastructure → economic transformation

Literature

- Prior research links cultural traits to socio-economic outcomes:
  - Income redistribution, trade, fertility, education demand
  - Labor participation, gender norms, political preferences
- Key contributions:
  - Acemoglu et al. (2021): Cultural characteristics and economic behavior
  - Alesina et al. (2015): Culture's role in economic development
- Yet, little attention to:
  - Policies focused on **cultural infrastructure**
  - Their role in shaping **urban and economic dynamics**
- This paper adds to the literature by addressing this missing link

What We Do

- We study the long-term impact of **ancient cultural infrastructure** on urban growth.
- Historical "natural" experiment during the **Hellenistic period** (c. 330 BCE onward).
- Alexander the Great and successors promoted "Hellenization" by building:
  - Gymnasia
  - Theatres and libraries
- We examine how these investments influenced:
  - Urban expansion
  - Cultural and economic transformation

The Role of Gymnasia

- Gymnasia were **educational and cultural hubs promoting Greek identity** via intellectual, military, and religious training.
- **Founded not only in major cities** but also in non-Greek towns and rural settlements.
- Established by military officials, settlers, and local benefactors to spread Greek values and **foster cultural assimilation** (Stavrou, 2016).
- Hellenistic rulers supported gymnasia as tools of loyalty and civic cohesion.
- Often named after ruling dynasties: e.g., "Antiocheion" and "Ptolemaion" in Iasos.
- Gymnasia hosted festivals and dedications honoring kings — linking civic life with royal authority.
- In **Ptolemaic Egypt and the Seleucid kingdom, they acted as cultural bridges blending Greek and local customs**.
- Adapted to regional contexts while preserving a Greek educational framework.

The Role of Theatres

- Theatres were powerful agents of Greek cultural transmission during the Hellenistic period.
- **Helped establish Greek language, customs, and education in foreign lands**.
- Fostered political awareness and integration by **bringing together diverse audiences**.
- Theorikon (state subsidy) ensured **broad public access to theatrical performances** (Chaniotis, 1997).
- Plays reflected key political and social issues, often satirical in nature.
- Touring troupes and the Artists of Dionysus spread drama throughout the Hellenistic world.
- **Theatres helped reinforce Greek ideals while integrating local elements**.

The Role of Libraries

- **Libraries (Bibliothēkai) were centers of scholarship and cultural transmission**.
- The Library of Alexandria aimed to collect and preserve all Greek knowledge.
- Became a hub for grammar, philosophy, science, and textual criticism (Montana, 2015).
- The Library of Pergamum (est. under Eumenes II) rivaled Alexandria with 200,000 scrolls.
- Developed parchment (pergamini) in response to Egypt's papyrus monopoly.
- Other important libraries: Pella, Sinope — integrated into civic and gymnasial spaces.
- **Chaniotis (1997) emphasizes libraries as venues for shared knowledge and debate**.
- **Helped ensure the endurance and spread of Greek educational traditions**.

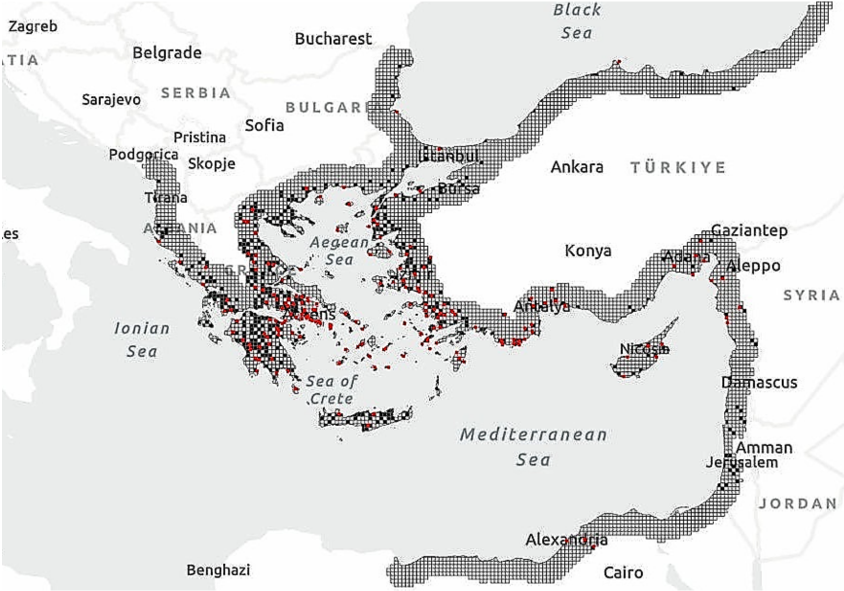
Data (1/2) – Overview and Context

- We study the effects of Alexander the Great's cultural policy and that of his successors in the Eastern Mediterranean.
- Method: Generalized Difference-in-Differences across four historical periods:
  - Bronze Age Collapse and Archaic (1200–550 BCE)
  - Classical (550–330 BCE)
  - Hellenistic (330–1 BCE)
  - Roman to Late Antiquity (0–500 CE)
- The policy intervention begins in the Hellenistic period (330 BCE).
- The Eastern Mediterranean is divided into 100 km^2 grid cells (Jedwab Moradi, 2016; Bakker et al., 2020).
- Coastal sample includes areas of modern-day Greece, Cyprus, Turkey, Albania, Bulgaria, Egypt, Israel, Lebanon, and Syria — up to 50 km inland.
- Focus is on consistent environmental zones and urban comparability (coast vs. coast).

Data (2/2) – Variables and Sources

1. **Cultural Infrastructure (Main Independent Variable):**
   - Based on WittkeA (2010), covering sites with gymnasia, theatres, and libraries.
   - Binary variable per grid cell: presence of at least one Hellenistic cultural institution.
2. **Urban Works (Dependent Variable):**
   - Source: Pleiades Database.
   - Includes temples, plazas, gates, bridges, baths, acropolises, etc.
   - Excludes records marked "unknown" or only "settlement".
3. **Evidence of Urbanization:**
   - Combines data from WittkeA B (2010), Polis Stanford database, and Pleiades.
   - Urban grid cells include cities with cultural institutions, cities developed by successors, poleis, or Pleiades-documented settlements.
4. **Control Variables:**
   - From Chronopoulos et al. (2021): temperature, elevation, distance from sea.
   - Controls help isolate geo-climatic effects from policy-driven outcomes.

Sample


Zagreb
Belgrade
Bucharest
Black Sea
Sarajevo
SERBIA
BULGARIA
Sofia
Pristina
Podgorica
Skopje
Istanbul
Ankara
TÜRKIYE
Bursa
Tirana
ALBANIA
Aegean Sea
Konya
Gaziantep
Adana
Aleppo
SYRIA
Antalya
Ionian Sea
Nicosia
Sea of Crete
Damascus
Mediterranean Sea
Amman
Jerusalem
JORDAN
Alexandria
Benghazi
Cairo

Selection Bias?

	1	2	3	4	5	6	7	8	9	10
Temperature	0.039***									
	(0.008)									
Elevation (log)		-0.030*								
		(0.015)								
Slope			-0.007							
			(0.006)							
Caloric Suitability				-0.065***						
				(0.013)						
Rainfall					-0.000**					
					(0.000)					
Coast Dummy						0.008				
						(0.033)				
Dummy Variable							0.050			
							(0.046)			
Presence of Port								0.110		
								(0.076)		
Ancient Colony									-0.010	
									(0.066)	
City-State (Polis)										-0.139***
										(0.031)
R-squared	0.036	0.005	0.002	0.032	0.006	0.000	0.002	0.003	0.000	0.045
Observations	721	721	721	721	721	721	721	721	721	721

Selection Bias?

Variable	Mean (No Cultural Infrastructure)	Mean (Cultural Infrastructure)	Difference	Significance
Temperature	15.683	16.603	-0.919	***
Elevation	5.224	5.051	0.173	*
Average Slope	4.128	3.849	0.279	
Soil Quality Index	7.365	6.876	0.488	***
Precipitation	696.729	663.417	33.312	**
Coastal Proximity	0.570	0.581	-0.011	
River Proximity	0.135	0.168	-0.033	
Sheltered Terrain	0.041	0.067	-0.026	
Ancient Colony	0.065	0.061	0.003	
Distance to Trade Nodes	11.432	11.368	0.064	
Presence of Greek City-States	1.024	0.704	0.320	***

Difference-in-Differences Estimator

In our baseline specification, we compare the number of urban constructions before and after the start of the Hellenistic period, and between grid cells with and without Cultural Infrastructure.

The equation estimated is:

$$\text{UrbanConstr}_{it} = \alpha_0 + \beta_1 \left(\text{CultInf}_i \times \text{Post}_t\right) + \gamma \mathbf{X}_i + \gamma_i + \rho_t + \varepsilon_{it}$$

- $\textbf{UrbanConstr}_{it}$: Number of urban constructions in grid cell i during period t.
- $\textbf{CultInf}_i \times \textbf{Post}_t$: Interaction term — indicates whether Cultural Infrastructure exists in cell i after 330 BCE.
- $\mathbf{X}_i$: Time-invariant geographical controls (e.g., elevation, climate).
- γ_i: Fixed effects for ancient region-level heterogeneity.
- ρ_t: Period fixed effects capturing period-specific shocks.
- ε_{it}: Error term; standard errors are clustered at the grid cell level.

Goal: Estimate β_1, capturing differential trends in urban construction between grid cells with and without Cultural Infrastructure.

Interpretation:

- $\beta_1 > 0$: Urban growth more pronounced in treated areas.
- $\beta_1 < 0$: Untreated areas experienced relatively higher urban expansion post-policy.

Difference-in-Differences – Event Study

To examine the dynamic impact of Cultural Infrastructure on local urban development, we apply a Difference-in-Differences approach in an **event study framework**, estimating the following:

$$\text{UrbanConstr}_{it} = \alpha_0 + \sum_{\tau \in (-2,2), \tau \neq -1} \beta_\tau \left(\text{CultInf}_i \times 1(t+\tau) \right) + \gamma \mathbf{X}_i + \gamma_i + \rho_t + \varepsilon_{it}$$

Components:

- β_τ: Coefficients capturing dynamic treatment effects for each historical period τ, relative to the base period.
- $\mathbf{X}_i$: Geographical control variables.
- γ_i: Ancient region fixed effects.
- ρ_t: Period fixed effects.
- ε_{it}: Error term, clustered at the grid cell level.

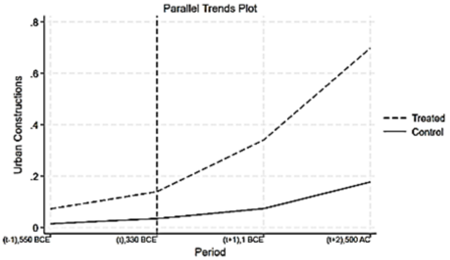
Reference Period: Classical period (550–330 BCE)
Time Windows:

- **Pre-treatment:** Archaic and Classical (= –2, –1)
- **Post-treatment:** Hellenistic and Roman (= +1, +2)

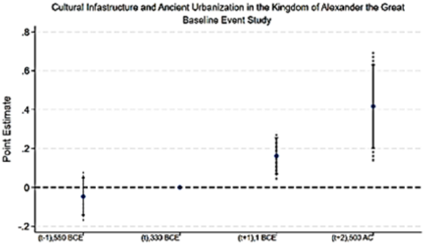
Main Results

	(1)	(2)	(3)	(4)
Cultural Infrastructure × Post	0.288***	0.313***	0.313***	0.313***
	(0.081)	(0.077)	(0.076)	(0.076)
Large Areas FE	NO	YES	YES	YES
Period FE	NO	NO	YES	YES
Baseline Controls	NO	NO	NO	YES
R-squared	0.090	0.096	0.104	0.111
Observations	2884	2884	2884	2884

Event Study



Parallel Trends Plot
.8
.6
.4
.2
0
Urban Constructions
(t-1),550 BCE
(t),330 BCE
(t+1),1 BCE
(t+2),500 AC
Period
Treated
Control



Cultural Infastructure and Ancient Urbanization in the Kingdom of Alexander the Great
Baseline Event Study
.8
.6
.4
.2
0
-.2
Point Estimate
(t-1),550 BCE
(t),330 BCE
(t+1),1 BCE
(t+2),500 AC

Robustness

	Synthetic Difference-in-Differences	All Sample	Excluding Athens, Sparta, and Macedonia	Coastal Part	Inner Places	Exclude Places with City-States
	(1)	(2)	(3)	(4)	(5)	(6)
Cultural Infrastructure × Post	0.310***	0.383***	0.265***	0.190**	0.483***	0.199***
	(0.045)	(0.077)	(0.060)	(0.080)	(0.137)	(0.058)
Large Areas FE	YES	YES	YES	YES	YES	YES
Period FE	YES	YES	YES	YES	YES	YES
Baseline Controls	YES	YES	YES	YES	YES	YES
R-squared	0.328	0.080	0.114	0.093	0.160	0.171
Observations	2884	21484	2828	1652	1232	892

Exploring the Mechanism

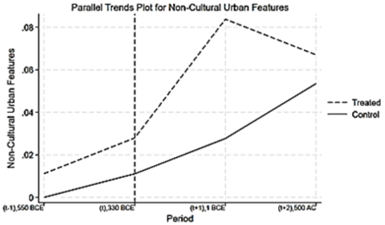
We explore the channels through which Cultural Infrastructure established by Alexander the Great and his successors influenced urban growth.

1. **"Pure Urban"**
   - Cultural Infrastructure may have attracted larger populations.
   - This population increase likely boosted demand for urban infrastructure: houses, roads, walls, sewage systems.
2. **Cultural**
   - Cultural Infrastructure could have drawn individuals involved in politics, religion, arts, and scholarship.
   - This influx promoted intellectual and cultural life, increasing demand for communal structures like temples and plazas.

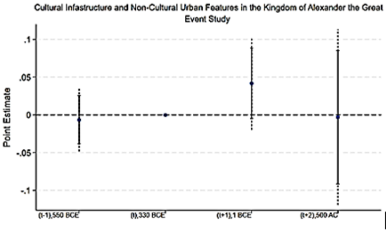
To test these channels, we divide urban features into two groups:

- **Pure Urban Works:** Aqueducts, bridges, city gates, walls, blocks, and defenses.
- **Cultural Works:** Odeons, stoas, temples, synagogues, stadia.

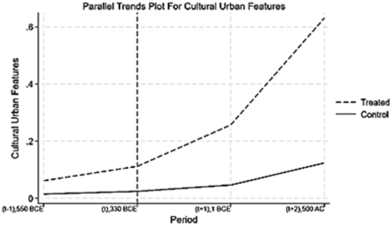
Exploring the Mechanism



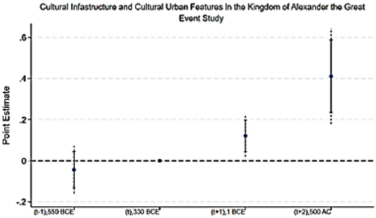
PANEL A



PANEL B



PANEL C



PANEL D

Cultural Infrastructure and Notable Personalities

Building on our prior results linking cultural infrastructure to long-term urban growth, we now explore whether such institutions fostered human capital by shaping local elites.

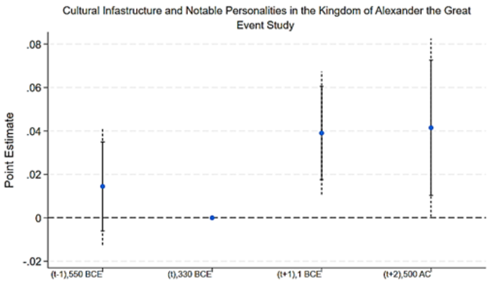
Notable Individuals as a Channel

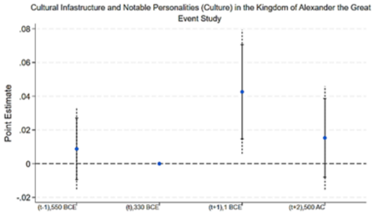
- We use birthplace data for "notable people" from Laouenan et al. (2022).
- Our hypothesis: locations with at least one Hellenistic cultural institution produced more prominent individuals.
- This would imply that early cultural investments nurtured talent and intellectual life long after their founding.

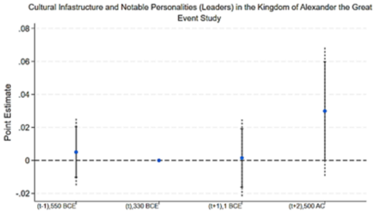
Empirical Strategy

- Outcome: number of notable individuals per location.
- Key explanatory variable: presence of cultural infrastructure.
- Controls: fixed effects and a synthetic notability index to account for pre-existing regional prominence.

Exploring the Mechanism 2







PANEL A **PANEL B**

Conclusions

- We study the long-term effects of Cultural Infrastructure established during the Hellenistic period on urban growth in the Eastern Mediterranean.
- Using a Difference-in-Differences approach, we find that grid cells with gymnasia, theatres, and libraries experienced a significantly higher number of urban constructions after the introduction of Hellenization policies.
- These results are robust across several specifications, time periods, and balancedness checks.
- Event study estimates confirm the dynamic and sustained impact of Cultural Infrastructure on urban development over time.
- We find evidence supporting two mechanisms:
    - **Pure urban growth:** population-led demand for infrastructure (e.g., roads, gates, walls).
    - **Cultural growth:** intellectual and civic activity driving the construction of temples, stoas, and communal buildings.
- Overall, our findings suggest that cultural policy—implemented through infrastructure—played a foundational role in fostering long-term urban transformation.