Plant Cultural Infrastructure and Harvest Urban Growth: Evidence from Alexander's the Great Kingdom.

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Abstract

This paper examines the impact of cultural infrastructure on urban growth by analyzing the policies of Alexander the Great and his successors during the Hellenistic period (323 BCE–31 BCE). To explore this, we exploit their policy of establishing cultural infrastructure—such as gymnasia (cultural training centers), theatres, and libraries—across the Eastern Mediterranean in a quasi-random manner, primarily aimed at uniting populations under a shared Greek cultural identity. We apply a differences-in-differences approach to compare populated areas that received cultural infrastructure - as a treatment group - with those that did not. The results show that areas with at least one cultural infrastructure experienced sustained urban growth, averaging 30.1% more urban infrastructure than those without. Moreover, the findings indicate that the growth was primarily based on cultural related constructions, such as temples, rather than on "pure urban" constructions like roads. This suggests that cultural infrastructure played a significant role in promoting urban economic growth during the Hellenistic and Roman periods by fostering cultural activity.

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In this paper, we study the effects of Cultural Infrastructure on urban growth. We exploit a unique historical experiment on the Eastern Mediterranean, where Alexander the Great and his successors, starting at the beginning of the Hellenistic period in 323 BCE, established Cultural Infrastructure — such as cultural training centres (gymnasia), theatres, and libraries—to promote the "Hellenization" of local communities.

To evaluate the impact of their policies on urban development, we begin by dividing the Eastern Mediterranean region—including present-day Greece, Cyprus, Turkey, Albania, Bulgaria, Egypt, Israel, Lebanon, and Syria—into 10×10 km grid cells, extending up to 50 km from the coast. We then compile data on the number of urban features within each grid cell for the Archaic, Classical, Hellenistic, and Early Roman eras, which serve as our primary outcome variable. To quantify the presence of Cultural Infrastructure, we digitize a historical map identifying locations that hosted such Infrastructure during the Hellenistic period, established by Alexander the Great and his successors. Additionally, we collect a range of environmental variables for each grid cell to account for geographical and climatic factors.

Using the Hellenistic period starting in 323 BCE as the treatment period and the populated grid cells as a sample—where treated observations are the grid cells that hosted Cultural Infrastructure — we implement a difference-in-differences analysis. The results indicate that grid cells with Cultural Infrastructure experienced, on average, a 30.1% increase in urban construction in later years.

A major challenge is that grid cells with a higher concentration of urban constructions, emerging institutions, or more favourable environmental conditions before the Hellenistic period may have been more likely to attract Cultural Infrastructure. Although historical evidence suggests that this was not the primary motivation behind the policies of Alexander the Great and his successors, we conduct a series of tests to confirm that their decisions were not influenced by any of the aforementioned factors.

To establish a causal interpretation of our basic difference-in-differences results, we test the parallel trends assumption using an event study setup, examining whether pre-treatment trends differ between treated and control groups. Our findings suggest that in the pre-Hellenistic periods, the trend in urban construction for grid cells without Cultural Infrastructure closely mirrors that of grid cells with Cultural Infrastructure.

We also run a series of robustness tests to corroborate that our results show a causal effect of the Cultural Infrastructure on urban development. More specifically, we use the Synthetic Difference-in-Differences method proposed by Arkhangelsky et al. (2021) to validate the treatment effect by comparing it against placebo effects generated through random treatment assignment within the control group of grid cells. Moreover, we expand the sample to include all grid cells, both populated and non-populated at the start of the Hellenistic period in 323 BCE; we exclude grid cells associated with the most influential Classical-era cities, namely Athens, Sparta, and Macedonia; we examine whether Cultural Infrastructure have higher impact in the most coastal areas of the Mediterranean; and we remove from the sample all grid cells that hosted a city-state during the Classical era. All results consistently show a significant effect of Cultural Infrastructure on urban construction, addressing concerns about their potential non-random placement by Alexander the Great and his successors.

As a final step, we examine the mechanisms through which Cultural Infrastructure influenced urban growth. To do this, we divide our dataset on urban features at the grid cell level into two categories: constructions related to culture, such as temples and synagogues, and those with a purely urban function, such as roads and city gates. We then replicate our event study analysis, revealing that cultural constructions followed parallel trends in the pre-treatment period but deviated significantly after 323 BCE. In contrast, purely urban constructions neither exhibit parallel trends before treatment nor show a significant deviation after 323 BCE. This implies that the establishment of Cultural Infrastructure primarily fostered cultural development rather than general urban expansion.

This work sheds light on a different aspect of how policies related to culture can affect urban development with long term impacts. Although, previous work emphasises the role of culture as a series of intangible characteristics such as values, norms, beliefs, political attributes, behavioural characteristics, religion, traits, gender norms, attitudes, trust etc on socio-economic outcomes such as redistribution, trade, fertility behavior, labor force participation, demand for education, misbehavior by workers (Acemoglu et al. (2021); Alesina et al. (2015)), there is still limited research on how and whether policies related to the construction of infrastructure that promotes cultural activities can affect economic growth. This paper contributes to this literature by addressing this gap and showing that the creation of cultural infrastructure not only fosters cultural activity but also acts as a foundation for sustained urban growth. The findings suggest that investing in cultural spaces can trigger a self-reinforcing cycle of development, where cultural engagement drives further infrastructure expansion and long-term economic transformation.

I. Cultural Infrastructure as a Pillar of Greek Identity

A. The Role of Gymnasia

Gymnasia were educational and cultural centers in the Hellenistic world, promoting Greek culture through intellectual education, military training, and religious activities. Their establishment was not only limited to wealthy urban centers but also to a non-Greek towns, villages, and settlements. Military officials, settlers, and local benefactors often played a significant role in founding gymnasia. Their main purpose was to spread the Greek culture and identity as well as to achieve cultural assimilation of different populations in the Hellenistic world, fostering a shared identity (Stavrou, 2016).

Hellenistic rulers actively supported gymnasia as a means of fostering loyalty and strengthening Greek civic life. These institutions were not only spaces for education and physical training but also served as centers for royal ideology. In many gymnasia, dedications and inscriptions honoring kings were prominently displayed, and the institutions themselves often bore the names of ruling dynasties or benefactors. For example, in Iasos, gymnasia were named “Antiocheion” and “Ptolemaion” in recognition of the Seleucid and Ptolemaic rulers who had contributed to their establishment. Additionally, festivals, processions, and sacrifices were held in honor of Hellenistic rulers, strengthening the connection between civic life, Greek identity, and royal authority.

The construction of gymnasia extended beyond bigger cities such as city-states (poleis). In Ptolemaic Egypt, they were established in provincial centers and rural settlements, where they became focal points of social and religious life (Fischer-Bovet, 2014). In the Seleucid kingdom, gymnasia served as cultural bridges, blending Greek customs with local traditions while maintaining a Greek educational framework.

Rather than being uniform institutions, gymnasia adapted to regional contexts, serving as tools of cultural transmission. Their widespread establishment underscores their role in shaping civic identity and integrating diverse populations into the Hellenistic world through education, military training, and communal activities.

B. The Role of Theatres

During the Hellenistic period (323–31 BCE), theatres (Theatra) were more than just venues for entertainment—they were active agents in spreading Greek culture and identity. As Greek influence expanded, theatres were built in newly founded cities across Asia Minor, Egypt, and the Near East, often alongside gymnasia, reinforcing Greek traditions in regions with diverse populations. Their

presence signified not only the continuation of Greek drama but also the establishment of Greek language, customs, and education in foreign lands.

Beyond cultural transmission, theatres played a crucial role in social integration. They were spaces where Greek and non-Greek populations gathered, absorbing the values embedded in tragedies, comedies, and public ceremonies. Unlike other elite institutions, theatres were designed to be accessible to all. The introduction of the theorikon, a public subsidy, ensured that theatre attendance was not limited to the wealthy but open to citizens of all social backgrounds (Chaniotis, 1997).

Moreover, travelling theatre troupes and the Artists of Dionysus, a guild of professional performers, helped spread Greek drama far beyond its origins. Through festivals and performances, Greek culture became an integral part of civic life in Hellenistic cities, fostering a shared identity across the Mediterranean. In this way, theatre became a powerful tool of cultural assimilation, reinforcing Greek ideals while incorporating local influences, making it a defining element of the Hellenistic world.

C. The Role of Libraries

Libraries (Bibliothēkai) in the Hellenistic period were more than just book collections; they were centers of scholarship, cultural transmission, and intellectual exchange. The most renowned was the Library of Alexandria, founded by the Ptolemies, which aimed to gather and preserve all Greek knowledge. Housing thousands of scrolls, it became a hub for textual criticism, grammar, philosophy, and scientific inquiry, attracting scholars from across the Mediterranean (Montana, 2015).

Moreover, the Library of Pergamum, established under Eumenes II, was another major intellectual center, second only to Alexandria. It contained around 200,000 scrolls and played a key role in advancing scholarship. To counter Egypt's papyrus monopoly, Pergamum's scholars innovated parchment (περγαμηνή) as a new writing material. Other libraries were established in Pella and Sinope also housed significant collections, reinforcing the importance of written knowledge across the Hellenistic world.

Beyond royal institutions, libraries were also integrated into gymnasia, fostering education and public discourse. The Lyceum in Athens housed a significant collection, reflecting how libraries became institutionalized spaces of learning. Chaniotis (1997) highlights that these spaces were not just repositories of books but part of the public intellectual life, where knowledge was shared, debated, and performed.

By preserving and expanding Greek literary and scientific traditions, Hellenistic libraries played a crucial role in cultural transmission, ensuring that Greek education and scholarship continued to thrive across a rapidly expanding world.

II. Data collection and Early Analysis

A. Data

In this section, we present the data used to evaluate the impact of Alexander the Great's policy, along with that of his successors, in the Eastern Mediterranean, aimed at unifying diverse populations under a shared cultural identity. As noted, we apply a generalized Difference-in-Difference approach across four reference historical periods, with the policy starting at the beginning of the third period. This approach allows me to compare urbanized areas where the policy was implemented with those where it was not. The reference historical periods covered are: Bronze Age Collapse and Archaic (1200 BCE to 480 BCE), Classical (480 BCE to 323 BCE), Hellenistic (323 BCE to 31 BCE), and Roman through the end of Late Antiquity/Early Byzantine Period (31 BCE to 500 CE).

To conduct this analysis, we divide the region surrounding the Eastern Mediterranean and Southern Black Sea into a grid of cells, each spanning 100 km² (Jedwab and Moradi, 2016; Bakker et al., 2020). The sample specifically includes coastal grid cells from present-day Greece, Cyprus, Turkey, Albania, Bulgaria, Egypt, Israel, Lebanon, and Syria, extending up to 50 km inland from the coast. For simplicity, we refer to this combined area as the Eastern Mediterranean. This sample choice serves two purposes: it ensures consistent environmental conditions across the study area and prevents comparisons between inland urban centers in Eastern Anatolia and those on the Mediterranean coast. With these coastal areas defined, we proceed to gather the following data:

1. **Cultural Infrastructure (main independent variable)**: To identify locations where Alexander the Great and his successors established Cultural Infrastructure, we refer to the WittkeA (2010) map, which documents sites with gymnasia, libraries (*bibliothēkai*), and theatres intended to "Hellenize" local communities. We then compile a list of coordinates for all locations hosting at least one such establishment. A binary variable showing whether each grid cell accommodates at least one Hellenistic Cultural Infrastructure is our main variable of interest.

2. **Urban Constructions**: For each period under study, we gather data from the Pleiades Database, a comprehensive gazetteer of ancient places that includes unique descriptions and coordinates. This dataset covers various features, such as walls, temples, quarries, streets, ports, gateways, plazas, bridges, baths, and acropolises. To focus on constructions indicative of urban development, we exclude entries having description "unknown" as well as those labeled merely as "settlement." The dependent variables are the sum of urban constructions within each grid cell for each reference period under examination.*

3. **Urbanization Evidence**: Using multiple sources, we aim to compare cities-urban places that were granted a cultural institution by Alexander the Great or his successors with those that were not. To retain only "urban grid cells" in our final sample, we identify locations with evidence of urbanization the era surrounding the Hellenistic period. "Urban grid cells" include those documented in WittkeB (2010) as cities developed by Alexander's successors, those in WittkeA (2010) as locations with cultural institutions, those marked as *polis* in the Polis Stanford database, and any with a "settlement" designation in the Pleiades database, covering 550 BCE to 0 AC.

4. **Control Variables**: Additionally, we collect a range of environmental variables for each grid cell, including temperature, elevation, and distance from the sea from Chronopoulos et al. (2021). Given that this study focuses on ancient times—long before the Industrial Revolution—when economic development was largely shaped by geo-climatic factors, incorporating these variables is essential for a thorough analysis.

In conclusion, the dataset is structured into grid cells that record Hellenistic-period Cultural Infrastructure as the main independent variable, with urban constructions from various historical periods serving as the dependent variables. Each cell is further characterized by urbanization indicators spanning 1200 BCE to 500 CE. This setup enables a comparative analysis between urbanized/settled locations that hosted Hellenistic Cultural Infrastructure and those that did not, allowing for an assessment of how this infrastructure influenced patterns of urban development.

* For each urban construction, the Pleiades dataset provides both the earliest and latest recorded dates of existence. To calculate the number of urban constructions for each reference period, we filter the data to align with the relevant timeframe. For example, for the Classical period, we include urban features with a minimum date earlier than 323 BCE and a maximum date later than 480 BCE. This approach ensures that the sample captures all urban features that existed during the Classical period.

B. First Look at the Data

The dataset includes a total of 5,378 coastal grid cells around the Eastern Mediterranean, as illustrated in *Figure 1*. Among these, 721 cells (or about 13.5%) show evidence of urbanization during the examined periods. Within this subset of urbanized areas, 179 cells—nearly 25%—contain at least one Hellenistic Cultural Infrastructure, such as a gymnasium, theatre, or library. Of the 179 locations with Cultural Infrastructure, 97 did not experience further urban construction, while 82—nearly 46%—demonstrated additional urban construction growth during the Hellenistic and Roman period, indicating a possible link between the presence of Hellenistic Cultural Infrastructure and urban growth.

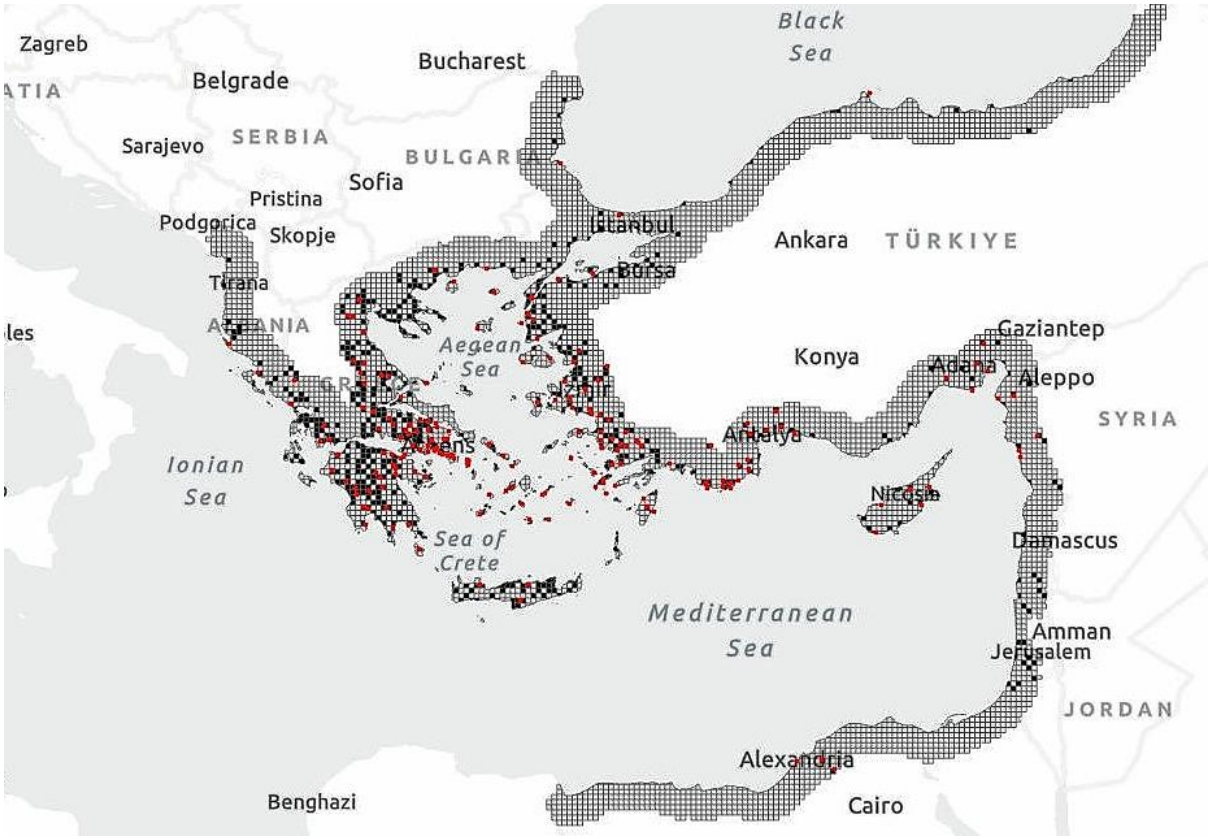


FIGURE 1. POPULATED AREAS AND CULTURAL INFASTRUCTURE IN THE HELLENISTIC PERIOD

Notes: This Figure shows the spatial distribution of Cultural Infrastructure established by Alexander the Great and his successors. The Black areas are populated areas during the Hellenistic Period. The Red areas are populated areas during the Hellenistic Period which also host an established Cultural Institution.

A key concern regarding our hypothesis is the possibility that Alexander the Great and his successors established Cultural Infrastructure in regions that were already more prosperous prior to their policy implementation. In other words, areas with pre-existing economic activity or strong institutions—driven by demand for education from wealthy local elites—might have been more likely to attract this Infrastructure, thereby reinforcing their economic growth. To address this concern, we investigate whether Cultural Infrastructure were disproportionately founded in areas with favourable conditions for agriculture or related activities, which were critical in pre-industrial societies. Specifically, we regress our binary variable for Cultural Infrastructure on each environmental control variable explained above in the same *Section*. Additionally, to explore whether Cultural Infrastructure were established in response to pre-existing demand from local elites before Alexander's time, we examine the relationship between Cultural Infrastructure and the presence of ancient city-states (poleis)

or colonies. These city-states (poleis) or colonies often featured complex institutional environments, including advanced political and economic structures, during the classical period.

Table A.1 in the Appendix presents the correlations for grid cells with evidence of urbanization during the examined periods. Interestingly, with the exception of the relationship with temperature, most correlations are either insignificant or have the opposite sign from what might be expected. For example, the correlations between Cultural Infrastructure and variables like rainfall or caloric suitability of the land are negative. This is surprising, as one might assume that more fertile areas, likely home to an elite population, would have been more attractive locations for Cultural Infrastructure. Similarly, the relationship between Cultural Infrastructure and city-states (poleis)—which reflect the presence of advanced institutions in the pre-Hellenistic period—is also negative. This suggests that regions with superior institutions prior to the Hellenistic era were not necessarily chosen for the establishment of Cultural Infrastructure. These findings align with the historical accounts discussed in *Section I*, which indicate that Alexander the Great and his successors prioritized spreading Greek culture and unifying the "Barbarian" populations under a common cultural identity, rather than focusing on pre-existing institutional or economic advantages.

III. Identification Strategy, Empirical analysis, and Results

A. Educational Establishments as an Exogenous Quasi-Experiment

In this section, we examine the impact of Alexander the Great's policies, and those of his successors, on urban growth. We begin with a cross-sectional analysis to evaluate the association of Cultural Infrastructure on urban development across the four historical periods discussed earlier. Since the policy of promoting the Greek culture began at the onset of the Hellenistic period (around 334 BCE, when Alexander crossed into Asia Minor to launch his campaign against the Persian Empire), we anticipate its influence on the urban system throughout the Hellenistic period, with long-term effects extending into the Roman period. Conversely, we do not expect to find any significant correlation between these policies and urban construction during the pre-treatment periods—namely, the Classical and Archaic periods (i.e. before 323BCE). In this case, the construction of Cultural Infrastructure would be endogenous to local urban construction level. In order to test this hypothesis, we employ the following regression:

$$Y_{it} = \alpha + \beta\, G_{it} + \gamma\, X_i + \rho_i + \varepsilon_{it} \quad (1)$$

Where Y_{it} is the number of urban constructions in the grid cell i in period t. The coefficient of interest is β, while X_i denotes the time invariant control variables. ε_{it} is an error term. The time-invariant characteristics include latitude, longitude, temperature, elevation, slope of terrain, soil quality, precipitation, a binary variable showing whether the grid cell i is coastal, a dummy variable indicating whether a river at least 50-meter width passes through the grid cell, a dummy variable indicating whether the grid cell contains an ancient port classified as excellent shelter by modern nautical guides, the distance (in logs) to the nearest node of the maritime trade routes in the Mediterranean during the Roman period, and a dummy variable showing whether there is at least one ancient Phoenician or Greek colony in the grid cell i until the 5th century BCE. Furthermore, ρ_i is large areas fixed effects borrowing current country borders.[†] Lastly, standard errors are clustered at the grid cell level.

[†] We use modern country borders to construct large-area fixed effects for the ancient Eastern Mediterranean, as they may correspond to historical geographic regions. For example, the borders of present-day Greece encompass key ancient Greek city-states (poleis) such as Athens, Sparta, and Macedonia. Similarly, modern Turkey aligns with the ancient region of Asia Minor (Anatolia), and contemporary Egypt includes the territory of the ancient Kingdom of Egypt.

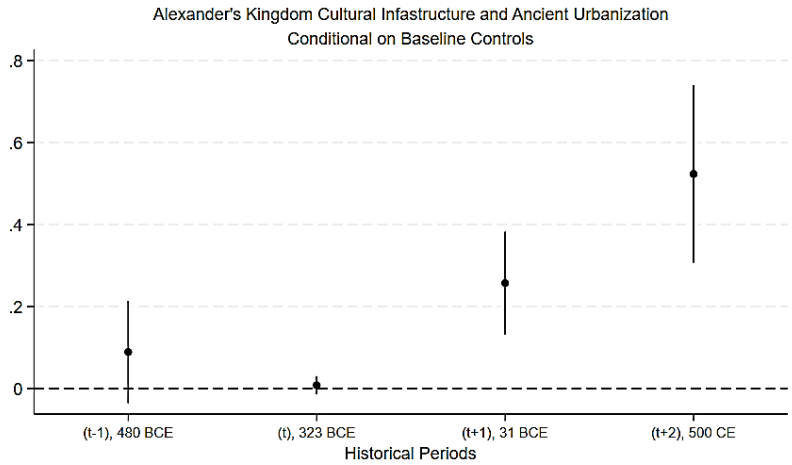


FIGURE 2. OLS ESTIMATIONS BETWEEN CULTURAL INFASTRUCTURE AND URBAN FEATURES

Notes: This Figure shows OLS estimations between Cultural Infrastructure and urban features before and after the Hellenistic period conditional on the baseline controls.

Figure 2 indicates that the policy implemented by Alexander the Great and his successors to promote the adoption of Greek culture among local ethnicities in the Eastern Mediterranean was not directly associated with urban construction prior to the Hellenistic period. However, during the Hellenistic and Roman periods, this policy appears to have significantly boosted the development of urban features and construction activity. In different words, it seems that the construction of Cultural Infrastructure is likely exogenous to local urban construction during the pre-Hellenistic period. This evidence, combined with the findings in the *Appendix Table A.1*, supports the historical analysis presented in *Section I*, indicating that the construction of Cultural Infrastructure was not influenced by local socio-economic factors. Instead, their primary objective was to promote the "Hellenization" of non-Greek populations.

B. Difference-in-Difference Estimator

In a baseline difference-in-differences specification, we compare the number of urban constructions before and after the beginning of the Hellenistic period, and between areas (grid cells) with and without Cultural Infrastructure. The baseline Difference-in-Difference equation is the following:

$$UrbanConstr_{it} = \alpha_0 + \beta_1\, CultInf_i \times Post_t + \gamma\, X_{it} + \gamma_i + \rho_t + \varepsilon_{it} \quad (2)$$

where $UrbConstr_{it}$ is the number of urban constructions in the grid cell i in historical period t, X_{it} are time-invariant grid cell geographical characteristics as in equation (1), γ_i is fixed effects for time-invariant heterogeneity at the ancient large areas level as in equation (1), ρ_t denotes year fixed effects for common shocks across grid cells , and ε_{it} is an error term. The source of cross-sectional and time variation is given by the indicator for the Cultural Infrastructure $CultInf_i \times Post_t$. Since policy variation takes place at the ancient urban place level (urban grid cells), errors within the spatial units may be correlated. Thus, standard errors are clustered at the grid cell level.

The aim is to estimate the parameter β_1 which reflects different trends in the number of urban constructions between urban places (urban grid cells) with and without Cultural Infrastructure after the beginning of Alexander the Great's Hellenization Policy. Therefore, positive values of the parameter β_1 would imply that the policy effect is more pronounced in grid cells with Cultural Infrastructure compared to those without, while a negative β_1 would imply that grid cells without Cultural

Infrastructure experienced a relatively higher increase in urban constructions after the policy was implemented.

C. Difference-in-Differences-An Event Study Setup

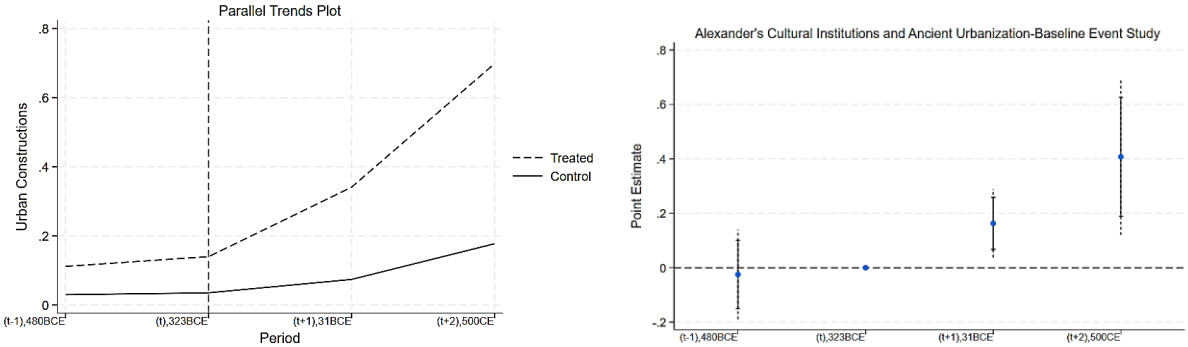
To assess the causal impact of educational establishments on local urban development, we also utilize a Difference-in-Differences methodology within an event study framework, modeled as follows:

$$UrbanConstr_{it} = \alpha_0 + \sum_{\tau\in(-2,2),\tau\neq-1} \beta_t CultInf_i \times \mathbf{1}(t+\tau) + \gamma X_{it} + \gamma_i + \rho_t + \varepsilon_{it} \quad (3)$$

In this case, the inclusion of $\sum_{\tau\in(-2,2),\tau\neq-1} \beta_t CultInf_i \times \mathbf{1}(t+\tau)$ allows for the estimation of dynamic treatment effects, capturing how the effect of Cultural Infrastructure evolves over time. The pre-Hellenistic period covers the Archaic and Classical periods (t-1 and t) until 323BCE, while the post-Hellenistic period covers the Hellenistic and Roman periods until 500AC (t+1 and t+2). We consider the Classical period as the reference period.

D. Parallel Trends Assumption

As detailed in *Section II*, the sample consists of urbanized areas divided into two groups: those that received a Cultural Infrastructure and those that did not. The treatment group includes urbanized areas with a Cultural Infrastructure, while the control group comprises urbanized areas without one. The DiD estimation strategy requires the parallel trends assumption to hold, that is, the trends in the number of urban constructions for grid cells with and without Cultural Institutions need to be parallel in the pre-Hellenistic era. *Figure 3 Panel A* provides a graphical test for the parallel trends assumption. More specifically, the figure shows the evolution over time of the total number of urban constructions between grid cells with and without Cultural Infrastructure. In the pre-Hellenistic period, the trend for the number of urban constructions for grid cells with no Cultural Infrastructure fairly mimics the trend for grid cells with Cultural Infrastructure. Nevertheless, the dotted line, which shows the trend of the treated sample, diverges significantly from the solid line, which shows the trend of the control group, after the start of the Hellenization period in 323 BCE.



PANEL A **PANEL B**

FIGURE 3. EVENT STUDY AND PARALLEL TRENDS

Notes: Figure 3 Panel A shows that in the pre-Hellenistic period, the trend in the number of urban constructions for grid cells without Cultural Infrastructure closely follows the trend observed in grid

cells with Cultural Infrastructure. Figure 3 Panel B shows the effect of Cultural Infrastructure on urban construction.

E. Balancing Test

Although the parallel trends assumption hold, it is essential to examine whether the two groups of urban grid cells (with and without Cultural Infrastructure) are fairly similar with respect to a set of observables characteristics. *Table 1* compares the average values of important control variables for grid cells with versus without Cultural Infrastructure. Areas with and without Cultural Infrastructure are similar in terms of slope, coastal and river proximity, excellent shelters, existence of ancient Greek and Phoenician colonies until the 5th century BCE, and distance to trade nodes. The columns related to soil quality, precipitation, and the presence of pre-Hellenistic Greek city-state (poleis) suggest that Cultural Infrastructure are more likely to be found in areas with lower soil quality, drier regions, or without progressive existing institutions. These results are opposite to what someone expect. In contrast, areas with higher temperature and lower elevation seem to have attracted Cultural Infrastructure. These two imbalances which are against our hypothesis (that Alexander the Great and his successors did not choose the best places in terms of environment and institutions to establish their Cultural Infrastructure) do not constitute a threat to the identification strategy. First, all specifications include all the above variables as controls. Second, the sample is intentionally restricted to areas within 50 km of the coast, which minimizes climatic variability across the regions. Consequently, while there is a statistically significant difference in two variables which is against our hypothesis, the actual difference in magnitude remains relatively small and unlikely to meaningfully impact the results.

TABLE 1-BALANCING TEST

Variable	Mean (No Cultural Institutions)	Mean (Cultural Institutions)	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	***

Notes: Comparison of Means Between Groups (No Cultural Infrastructure and Cultural Infrastructure). Significance levels are represented as: *** ($p \leq 0.01$), **($p \leq 0.05$), * ($p \leq 0.1$).

F. Baseline Results

Table 2 shows the effects of Cultural Infrastructure which were established by Alexander the Great and his successors after 323 BCE in the Eastern Mediterranean on the construction of urban features. The specification in column (1) does not incorporate any fixed effects or control variables. Column (2) includes only large areas (as they are defined in *Section II*) fixed effects, while the specification in column (3) incorporates both large areas fixed effects as well as Period fixed effects. In column (4), we control for all fixed effects and the set of the baseline controls. Moreover, we use Conley spatial HAC standard errors (Conley, 1999, 2008) to consider both spatial and serial correlations of Cultural

Infrastructure. [‡] We set the spatial lag to 50km which is the maximum distance of the grid cells from the sea in our analysis, and we also set the temporal lag to 4 which is the number of Periods we use in our analysis.

All estimations suggest that in places where Alexander the Great and his successors established Cultural Infrastructure since the beginning of the Hellenistic period experienced an increasing number of urban constructions during the Hellenistic and early Roman Periods. The effect is almost the same in all specifications, especially after including the fixed effects and control variables. In the last column (4), we present the most complete model which shows a positive and highly significant effect. This effect indicates that after the Classical period (post-323 BC), grid cells with at least one Cultural Infrastructure had, on average, a 30.1% higher number of urban constructions compared to grid cells without Cultural Institutions.

Figure 3 Panel B, which presents the results of the event study setup, suggests that the point estimates for the effect of Cultural Infrastructure on urban construction in the pre-Hellenistic periods are very close to 0 and not statistically distinguishable from 0. From the beginning of the Hellenistic Period, i.e. after 323 BC, the positive coefficients suggest that there is a much higher increase of urban constructions in cities where Alexander the Great and his successors built Cultural Infrastructure. In the Roman period, the effect becomes even larger than 40%.

TABLE 2- CULTURAL INFRASTRUCTURE AND URBAN FEATURES

	(1)	(2)	(3)	(4)
Cultural Infrastructure × Post	0.268***	0.301***	0.301***	0.301***
	(0.084)	(0.080)	(0.079)	(0.080)
Large Areas FE	NO	YES	YES	YES
Period FE	NO	NO	YES	YES
Baseline Controls	NO	NO	NO	YES
R-squared	0.088	0.095	0.102	0.107
Observations	2884	2884	2884	2884

Notes: The table shows the effect of cultural infrastructure on the number of urban features after the end of the Classical period in 323 BCE. The independent variable is the number of urban constructions in each grid cell i (observation). The variable Cultural Infrastructure × Post represents the interaction of cultural infrastructure—an indicator variable taking the value of 1 for grid cells with at least one cultural infrastructure—with an indicator variable for the post-Classical period (after 323 BCE). Controls include geo-climatic variables such as latitude, longitude, temperature, elevation, slope of terrain, soil quality, precipitation, a binary variable showing whether the grid cell i (observation) is coastal, a dummy variable indicating whether a river at least 50 meters wide passes through the grid cell, a dummy variable indicating whether the grid cell contains an ancient port classified as excellent shelter by modern nautical guides, the distance (in logs) to the nearest node of the maritime trade routes in the Mediterranean during the Roman period, a dummy variable showing whether there is at least one ancient Phoenician or Greek colony in the until the 5th century BC, and a dummy variable showing whether there is at least one city-state (poleis) in the grid cell at the beginning of the Hellenistic Period

[‡] We compute Conley spatial HAC standard errors with the code developed by Jesse Anttila-Hughes and Solomon Hsiang provided here: http://www.fight-entropy.com/2010/06/standard-error-adjustment-ols-for.html

in 323 BCE. Standard errors are adjusted for spatial (50 km) and serial (4 periods) correlation. Significance levels are represented as: *** ($p \leq 0.01$), ** ($p \leq 0.05$), * ($p \leq 0.1$).

G. Robustness Tests

To test the robustness of our results, we conduct the following checks. First, we apply the ‘‘Synthetic Difference in Differences’’ method introduced by Arkhangelsky et al. (2021). This approach blends elements from both the difference-in-differences (DID) and synthetic control (SC) methods (Abadie et al., 2010, 2015). By design, the synthetic counterfactual ensures parallel trends in outcome variables before treatment. [§] Second, we repeat the basic Difference-in-Differences analysis using the full set of grid cells from the initial sample, without restricting it to urban grid cells. Third, we exclude all urban grid cells having and being adjacent to the major city-states (poleis) of the pre-Hellenistic period, namely Athens, Sparta, and Pella (the ancient capital of Macedonia). Fourth, we examine whether the impact of Cultural Infrastructure is primarily driven by the coastal areas of our sample, as these regions may have prospered for centuries through trade and wealthier populations, making them more likely to attract Cultural Infrastructure. Fifth, we exclude city-states (poleis) that existed in 323 BCE, at the start of the Hellenistic period, as they may have attracted Cultural Infrastructure due to external influences beyond the policy of Alexander and his successors. In *Table 3*, all columns follow the above order of tests. Column 1 tests the validity of the actual treatment effect by assessing whether it is significantly different from effects generated by random treatment assignments within the control group. In other words, the coefficient in Column 1 indicates that the observed treatment effect is statistically significant and unlikely to result from random noise or chance. This confirms that the estimated ATT (*Average Treatment Effect on the Treated*) is robust and not driven by arbitrary treatment assignment. Column 2 suggests that when we loosen these selection criteria of the sample, we still obtain a positive and statistically significant coefficient at the 1% level. In Column 3, the coefficient indicates that our results are not influenced by the presence of the most powerful ancient cities of the Eastern Mediterranean. Moreover, the coefficients in Columns 4 and 5 suggest that the effect of Cultural Infrastructure on urban construction is not only (and mainly) observed in coastal areas, where economic activity may have been more prosperous at the onset of Alexander the Great's policies. Lastly, in Column 6, the positive and highly significant coefficient suggests that places (city-states) with pre-Hellenistic institutional development, which could have uniquely attracted Cultural Infrastructure, do not drive our overall results.

TABLE 3-ROBUSTNESS: CULTURAL INFRASTRUCTURE AND URBAN FEATURES

	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 x Post	0.295***	0.367***	0.255***	0.164*	0.490***	0.176***
	(0.045)	(0.078)	(0.062)	(0.084)	(0.137)	(0.066)
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	0.342	0.078	0.109	0.088	0.160	0.150
Observations	2884	21484	2828	1652	1232	892

[§] In order to employ the Syntetic Difference in Differences method in Stata, we use the command SDID with 1000 placebo replications, constructed by Clarke et al. (2024).

Notes: The table presents the effect of cultural infrastructure on the number of urban features after the end of the Classical period in 323 BCE. The dependent variable is the number of urban constructions in each grid cell. The variable Cultural Infrastructure × Post represents the interaction of Cultural Infrastructure—an indicator variable for grid cells with at least one cultural institution—with a post-Classical period dummy. Controls include geographic and climatic factors, coastal status, river presence, ancient port quality, distance to maritime trade routes, and presence of ancient colonies. Standard errors are adjusted for spatial (50 km) and serial (4 periods) correlation. Significance levels are represented as: *** ($p \leq 0.01$), ** ($p \leq 0.05$), * ($p \leq 0.1$).

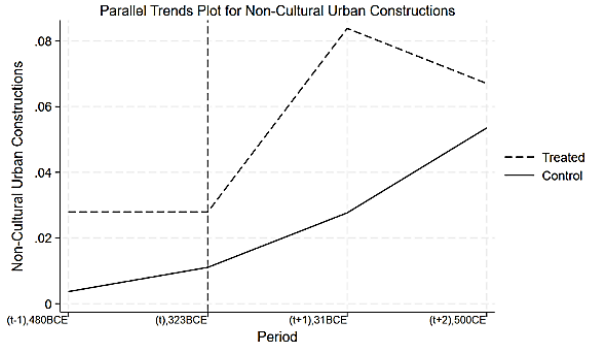
IV. Exploring the Mechanism

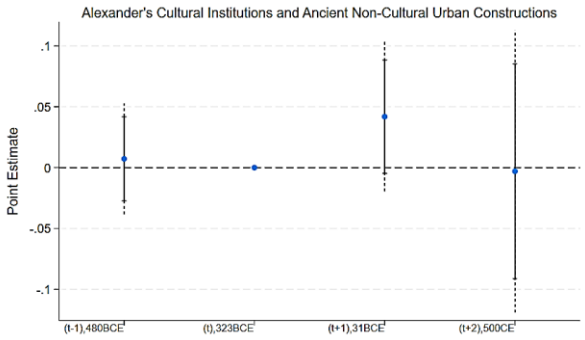
In this section, we extend our baseline analysis to explore the channels through which Cultural Infrastructure established by Alexander the Great and his successors influenced urban growth. Specifically, this study aims to disentangle the observed increase of urban constructions into two components: "pure urban" constructions and cultural constructions.

The first channel—"pure urban" construction—suggests that these Cultural Infrastructure may have attracted larger populations, which, in turn, increased the demand for urban infrastructure such as houses, roads, walls, and sewage systems. The second channel—cultural construction—posits that this Cultural Infrastructure may have drawn individuals involved in politics, the arts, religion, and other cultural spheres. This influx would have spurred the construction of structures such as temples and plazas, which were primarily used for cultural and communal purposes.

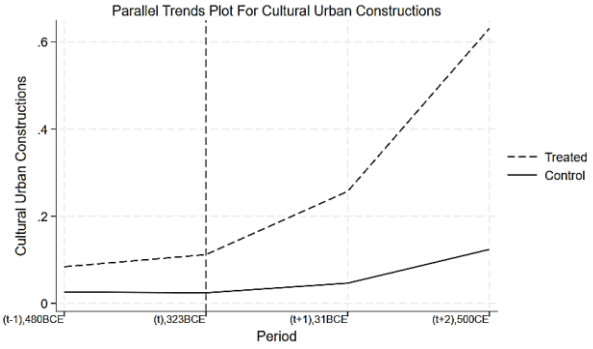
To determine which of the two scenarios occurred, we divided the sample of urban features into two distinct groups. The first group, representing "pure urban" construction, includes features such as aqueducts, bridges, city gates, city walls, city blocks, and defensive walls. The second group, reflecting cultural construction, consists of structures like odeons, stoas, temples, synagogues, and stadia.

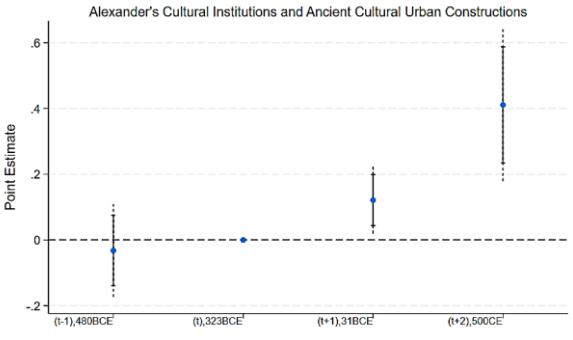
Then, we replicate the analysis using our event study analysis using the two distinct samples.





PANEL A **PANEL B**





PANEL C **PANEL D**

FIGURE 4. EVENT STUDY AND PARALLEL TRENDS FOR CULTURAL VS "PURE URBAN" FEATURES

Notes: Figure 4 Panels A and C show the parallel trends using cultural and "pure urban" features as outcome variables, correspondingly. Panels B and D shows the effect of Cultural Infrastructure on cultural and "pure urban" features as outcome variables, correspondingly.

Figure 4 Panel A denies the existence of parallel trends when "pure urban" features are used in the analysis. Besides, in *Figure 4 Panel C*, we plot the trends in the number features related to cultural urban growth as explained above for both groups of grid cells with and without established Cultural Infrastructure. In this case, the trend in the number of constructions in grid cells without a Cultural Infrastructure presence closely resembles that of grid cells with Cultural Infrastructure. The event study setups in *Figure 4 Panel B and Panel D* corroborate the previous findings. Based on the above results, it seems that the overall impact of the Cultural Infrastructure established by Alexander the Great and his successors was largely driven by the cultural constructions during the Hellenistic and early Roman periods.

V. Conclusion

This paper investigates the impact of Cultural Infrastructure on urban development, leveraging a quasi-natural experiment from the establishment of cultural institutions by Alexander the Great and his successors. Their efforts to Hellenize the population in the eastern Mediterranean led to the creation of theatres, gymnasia, and libraries across the region. The findings indicate a positive and significant effect of these establishments on urban growth, even after accounting for pre-Hellenistic environmental and cultural factors. Robustness tests confirm that the placement of Cultural Infrastructure stimulated urban expansion, with a stronger impact on additional cultural constructions—such as theatres and gymnasia—rather than purely functional urban structures.

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Appendix

TABLE A.1-BALANCEDNESS TEST

	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