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Urbanization without Industrialization: Evidence from US Bases in Okinawa

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Urbanization without Industrialization: Evidence from US Bases in Okinawa*

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Abstract

We examine how the inflow of external income shapes the pattern of urbanization and the economic structure. We focus on the unique case of Okinawa in Japan, where many US military bases were constructed for strategic reasons and the income inflow from them accounted for up to 40% of the aggregate income. Using newly digitized data, we first document rapid urbanization near the bases, driven by service sector expansion rather than manufacturing. We then develop a new quantitative spatial model and calibrate it to the Okinawan economy in 1970. Our counterfactual analysis highlights that the US-base related income was crucial to urbanization without industrialization. Contrary to Dutch disease concerns, we find that such urbanization without industrialization significantly increased aggregate income and welfare.

Keywords: Urbanization, Service sector, Quantitative spatial model, Military bases, Okinawa

JEL classification: O14, O18, N40, R11, R12

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1 Introduction

Although urbanization and industrialization have been considered to occur typically in tandem, there are various examples, especially from the recent experiences of today's developing countries, where urbanization occurs without a salient industrialization process. Indeed, countries such as Kuwait, Saudi Arabia, Libya, and Nigeria are as urbanized as Uruguay, Malaysia, Mexico, and China, the former countries have not industrialized to the same extent as the latter (Gollin, Jedwab and Vollrath 2016). While urbanization is typically associated with better economic outcomes and policymakers may find it desirable to promote it, it also comes with urban costs, such as sanitation and pollution, and policymakers may want to prepare for it (Bryan, Glaeser and Tsivanidis 2020; Henderson and Turner 2020; Bryan, Frye and Morten 2025). Moreover, there is a concern that urbanization without industrialization can be associated with worse economic outcomes than the traditional urbanization with industrialization because it may cause the "Dutch disease" by shifting employment away from manufacturing and forgoing agglomeration economies (Gollin et al. 2016; Allcott and Keniston 2018). Understanding the causes and consequences of urbanization without industrialization is important in allowing policymakers to design a development policy that promotes such urbanization or to prepare for its negative effects.

This paper investigates how the inflow of external income shapes the pattern of urbanization and the economic structure. To this end, we use the unique case of Okinawa in Japan, where the US military bases have accounted for a large share, almost nearly half at its peak, of its aggregate income. Since the location of the US bases was determined for a military reason, we view that the distribution of income inflow due to the US bases was exogenous to pre-existing economic conditions, for which we also find supportive evidence. Using newly collected and digitized data, we first document that municipalities around the US bases experienced rapid urbanization, which was driven by service sector expansion rather than manufacturing. We then develop an intra-city quantitative spatial model that accommodates the US bases as consumer, employer, and land-user, which all induce higher demand for non-tradable service goods. We then calibrate it to the Okinawan economy in 1970 and conduct a counterfactual analysis that shuts down the income inflow into Okinawa due to the US bases. We find that compared with the counterfactual economy with no US-base income, a municipality with the highest exposure to the US-base income gained about 60% in population density and 25 percentage points in the service employment share. This result suggests that the income inflow due to the US bases has caused significant urbanization without industrialization in areas around the US bases. We also find that shutting down the US-base income would reduce workers' welfare by about 17% and the aggregate income by around 27%. This suggests that despite the concern that urbanization without industrialization might be inefficient due to the "Dutch disease," it could actually be welfare-improving. The negative welfare effect would remain even when the US base areas were returned to Okinawa for private use, implying that in 1970, eliminating the US bases would reduce Okinawans' welfare.

Okinawa island is located to the southwest of mainland Japan. After the fierce Battle of Okinawa in 1945 in World War 2 (WW2), it was occupied by the US until its return to Japan in 1972. During its occupation, the US constructed many bases for its strategic purpose. They induced a large income inflow into Okinawa because the US demanded various goods, especially non-tradable services, employed many Okinawan people, and paid land rents for operating the bases. The income inflow due to the US bases accounted for a substantial part of the Okinawan economy, reaching up to 40% of the Gross National Income (GNI) around 1960.[1] Importantly, since the location of the US bases was determined primarily based on militaristic objectives without paying attention to the impact on the Okinawan economy (Taira 2012; Toriyama 2013; Franks 2023), the spatial distribution of the US bases in Okinawa was plausibly exogenous to economic conditions. This provides us with an ideal setting for studying whether such substantial income inflow due to the US bases induces urbanization and whether it accompanies industrialization, utilizing the exogenous variation of the US base locations within the Okinawa island.

We collect and digitize a comprehensive dataset of the Okinawan economy, dating back to the pre-WW2 period, which allow us to observe various economic variables within the Okinawa island at the municipality level. Using these data, we first conduct a reduced-form analysis to document two stylized facts. First, while the pre-WW2 Okinawa was largely an agricultural economy, areas around the US bases urbanized substantially in that population density more than doubled from the pre-war level. Second, urbanization was associated with a substantial growth in the service employment share, which increased by more than 50 percentage points in municipalities with the most exposure to the US bases. In stark contrast, almost no change in the manufacturing employment share was observed. These results highlight the substantial urbanization without industrialization around the US bases in Okinawa.

Motivated by this reduced-form result, we construct a quantitative spatial model that explicitly incorporates income from the US bases. Relative to the reduced-form approach, our model allows us to distinguish the role of the US-base income, rather than other factors such as infrastructure investment that might correlate with the location of the US bases, in inducing urbanization without industrialization. Moreover, the model also allows us to consider the general equilibrium effects and the aggregate impact of the US bases on the gross national income and welfare. The model has many locations and people choose their residence and workplace to maximize their utility, which can be different by incurring commuting costs. Each location has four sectors: agriculture, manufacturing, non-tradable services, and the US military base sector. We assume that agriculture and manufacturing goods are tradable across locations while non-tradable services are not, although we allow workers to consume differentiated non-tradable services at different locations through costly consumption trips. Workers at the US military base do not produce any good in the Okinawan economy as their work has a militaristic value that is not traded in a market. The US base takes up a certain fraction of land in a location and pay rents

[1]Although we recognize that Okinawa belongs to Japan, we use in this paper the well-known word "Gross *National* Income" for meaning the aggregate income of Okinawa.

for it, employs Okinawan residents, and demands tradable and non-tradable goods. In addition, developers provide floor space using tradable goods and land, implying that the presence of US bases may increase floor space prices by reducing available land for the private sector.

We calibrate our model to the Okinawan economy in 1970. Our calibration goes in steps. First, we calibrate several model parameters from existing studies. Second, we estimate the gravity equations in commuting and shopping, which is implied by the model, to estimate the travel cost parameters. Third, we back out sector-specific wages and floor space rents in each municipality, using data on the distribution of population and employment by sector and the floor space market clearing condition. Fourth, using information on wages and floor space rents, we estimate the amenity level of each location, inclusive of the local non-tradable price level, using the observed population distribution. Fifth, we compute the local non-tradable price level using the non-tradable goods market clearing condition. Finally, we back out the fundamental location-specific amenities and productivity by sector. Using this calibration procedure, our model exactly matches the observed population and employment distribution by sector. Moreover, reassuringly, our model exhibits a good performance in matching the observed income level and floor space rents by municipality, which we do not use for our calibration.

Having calibrated our model, we perform a counterfactual analysis in which we shut down the US-base income through goods consumption, employment of Okinawan residents, and land rent payment. We find that without the US-base income, areas around the US bases are much less urbanized: in municipalities that are most exposed to the US-base income, the population density is about 60% higher in the observed economy with the US-base income than the counterfactual economy without it. Moreover, in municipalities that are most exposed to the US-base income, the service employment share is about 25 percentage points higher in the observed economy with the US-base income than in the counterfactual economy without it. This result suggests that the US-base income has substantially contributed to urbanization without industrialization around the US bases. In the aggregate, eliminating the US-base income harms the efficiency, measured either by the model-implied welfare (17% decline) or the gross national income (27% decline). This result suggests that urbanization without industrialization due to the inflow of the US-base income was welfare-improving, despite the concern that urbanization without industrialization may shift employment away from manufacturing and induces the "Dutch disease" by foregoing agglomeration economies. The negative welfare effect would remain even when the US base areas were returned to Okinawa for private use. This implies that in 1970, eliminating the US bases would reduce the Okinawans' welfare, consistent with the widespread concern that Okinawa's economy would be substantially damaged if the US bases in Okinawa were eliminated when Okinawa was returned to Japan (c.f., Toriyama 2009).

Our paper contributes to several strands of literature. First, our paper contributes to the literature on the relationship between urbanization and industrialization. While urbanization and industrialization are typically considered to occur in tandem (Kuznets 1973; Glaeser, Kallal, Scheinkman and Shleifer 1992; Michaels, Rauch and Redding 2012; Henderson and Turner 2020; Bryan et al. 2025), there are various examples, especially from recent experiences of today's developing countries, where urbanization occurs without a salient industrialization process (Jedwab and Vollrath 2015; Gollin et al. 2016; Rodrik 2016; Fan, Peters and Zilibotti 2023; Huneeus and Rogerson 2024; Fujiwara and Matsuyama 2024). Although the literature has identified several potential causes of the urbanization without industrialization, such as labor-saving technological progress (Rodrik 2016), differences in growth rates by sector (Huneeus and Rogerson 2024; Fan et al. 2023; Fujiwara and Matsuyama 2024) and discovery of natural resources (Gollin et al. 2016), there is still relatively little consensus as to the mechanism behind urbanization without industrialization. By analyzing the unique case of Okinawa with extremely large and spatially heterogeneous income inflow from the US bases, we highlight the potential importance of the inflow of external income in inducing urbanization without industrialization. This result implies that the inflow of external income, such as the operation of large facilities like the military bases and universities, tourism, natural resources, fiscal transfers, and foreign aid, could play an important role in inducing urbanization without industrialization.[2] We also find that urbanization without industrialization caused by the US-base income could be welfare-improving, despite the concerns that such urbanization might shift employment away from manufacturing and harm productivity by inducing the Dutch disease (Gollin et al. 2016; Allcott and Keniston 2018).[3]

Second, in terms of the focus of our study on the US bases in Okinawa, our paper relates to the literature on the impact of the income inflow due to the military spending or military bases. In particular, as in our paper, several papers have viewed them as local economic shocks and analyzed their economic impacts (e.g., Hooker and Knetter 2001; Nakamura and Steinsson 2014; Zou 2018; Biolsi 2019; Komarek and Wagner 2021). Since these papers have asked different questions than ours, they have not focused on urbanization and spatial structural transformation in analyzing the localized military shocks. Meanwhile, quantitative studies on the economic impact of the US bases in Okinawa have mostly focused on the aggregate-level data of Okinawa and used the input-output analysis (e.g., Okinawa Prefecture Government 2007; Kusuyama 2012; Tomikawa 2018). This paper views the income related to the US bases in Okinawa as an exogenous local shock and analyzes how it affects urbanization and spatial structural transformation using a general-equilibrium quantitative spatial model. For this purpose, we have collected and digitized comprehensive municipality-level data on the Okinawan economy, which is new to the literature of the Okinawan economy.

Third, our paper relates to the literature analyzing structural transformation in a quantitative spatial model (e.g., Michaels et al. 2012; Desmet and Rossi-Hansberg 2014; Faber and Gaubert 2019; Hao, Sun, Tombe and Zhu 2020; Fajgelbaum and Redding 2022; Eckert and Peters 2023; Takeda 2023; Coeurdacier, Oswald and Teignier 2025). Building on this literature, we propose a novel quantitative spatial model that accommodates a facility (the US base in our context) that brings in income from the outside economy through purchasing goods, employing labor, and

[2] For an analysis of these examples in the spatial economy, see Liu (2015) for universities, Gollin et al. (2016) for natural resources, and Faber and Gaubert (2019) for tourism.

[3] The Dutch disease due to the US bases has been a major concern for many observants of the Okinawan economy (c.f., Oshiro 2023).

renting land for its operation.[4] Applying this model to the case of Okinawa, which experienced a large and spatially heterogeneous income inflow from the US bases, we highlight the role of external income inflow as a potential factor inducing urbanization without industrialization. More methodologically, our model incorporates commuting as it is a salient feature of the Okinawan economy that is not geographically large. While various studies have developed an intra-city quantitative spatial model that accommodates commuting (e.g., Ahlfeldt, Redding, Sturm and Wolf 2015; Monte, Redding and Rossi-Hansberg 2018; Heblich, Redding and Sturm 2020; Miyauchi, Nakajima and Redding 2022, Dingel and Tintelnot 2023, Tsivanidis 2023; Takeda and Yamagishi 2025; see Redding 2024 for a recent survey), to our knowledge, ours is the first intra-city quantitative spatial model for analyzing spatial structural transformation. This feature of our model could also be useful in other contexts where commuting is salient.

The rest of this paper is organized as follows. Section 2 introduces the institutional background of Okinawa and our data. Section 3 presents our reduced-form documenting the relationship between the US bases and urbanization without industrialization. Section 4 introduces our quantitative spatial model that incorporates the US-base income. Section 5 calibrates our model using the data from Okinawa in 1970. Section 6 presents the counterfactual results that hypothetically eliminate the US-base income. Section 7 concludes.

2 Institutional Background and Data

Section 2.1 introduces the institutional background of this study and Section 2.2 introduces our data.

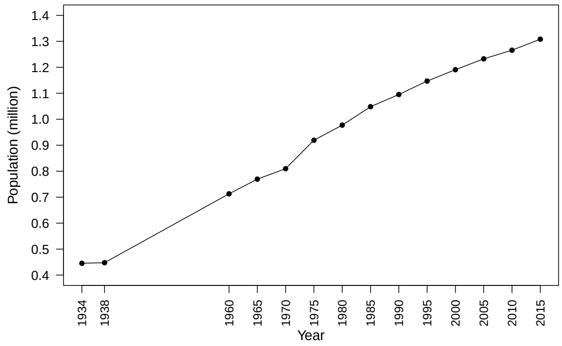
2.1 Institutional background

To facilitate the understanding of our study context, we provide a brief introduction of the institutional background of Okinawa and its relationship to the US bases.[5] The Okinawa island is located to the south-west of the main island of Japan.[6] Although Okinawa Prefecture of Japan contains islands other than the main island, we mean by "Okinawa" or "Okinawa Island" the Okinawa main island in this paper unless explicitly noted. As of 2020, the population is around 1.3 million and its size is around 1,200 square kilometers. Figure 1a plots the long-run trend of the total population of Okinawa island, showing the increasing trend throughout the post-WW2 period. The growth in the total population accompanied substantial urbanization, especially in

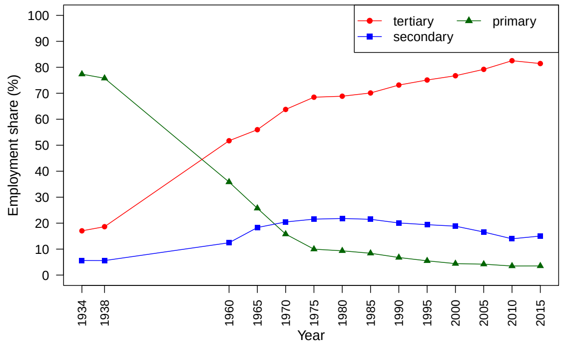
[4] Other military bases around the world, including the US bases in the US and other countries such as Germany, Italy, and South Korea, can be direct application of our model. A university or a prison could also be an example that fits this situation (c.f., Liu 2015; Chirakijja 2024). To evaluate different types of public facilities, Loumeau (2023) and Ducruet, Juhász, Nagy and Steinwender (2024) develop a quantitative spatial model to evaluate the welfare effect of schools and ports, respectively.

[5] See, for instance, Okinawa Prefecture Government (2000), Taira (2012), Toriyama (2013), Franks (2023), and Oshiro (2023) for more detailed description.

[6] Okinawa was also historically called "Ryukyus." In this paper, we use the name "Okinawa" throughout the paper.



(a) Total population



(b) Employment share by sector

Figure 1: Long-run dynamics of the total population and employment share in Okinawa

Note: Figures 1a and 1b plot the long-run trends of the total population and the sectoral employment share from 1934 to 2015 in the Okinawa main island, respectively. In Figure 1b, the lines with red circles, blue squares, and green triangles represent the employment shares of the tertiary, secondary, and primary sectors, respectively.

the central and southern parts of the city, such as Naha city and Koza city. Figure 1b documents that such an urbanization process entailed substantial growth in the service employment share. Notably, the manufacturing employment share did not see a substantial growth and hit a plateau as early as in the 1960's. This development process is quite different from that of other Japanese regions. The post-war economy of Mainland Japan experienced a major shift of manufacturing sectors from light to heavy industries between the mid 1950's and the early 1970's, and then shifted to a service economy after the mid 1970's (Fujita and Tabuchi 1997), which is in line with Petty's law and is a widely observed pattern of economic development. Thus, Figure 1b highlights the uniqueness of Okinawa's development process.

Compared with other Japanese regions, what is unique about Okinawa is the remarkable salience of the US bases. In the WW2, the Okinawa island became a major battlefield between the US and Japan (the Battle of Okinawa). The battle ended in June 1945 when the US occupied the entire island. During and after the war, the US constructed many bases due to Okinawa's strategic importance. In deciding where to construct the bases, militaristic values were emphasized while local economic conditions were not well considered. For example, in 1950's the US administration adopted a forceful strategy in confiscating land to construct bases (so called "bulldozers and bayonets") to facilitate operations in the Korean war and other future conflicts, paying little attention to the economic values of each land plot (Taira 2012; Toriyama 2013; Franks 2023). The US occupied the island until the Okinawa island was returned to Japan in 1972, but the US retained the right to operate their military bases in Okinawa even after the return.

Notably, the US bases have exhibited their substantial presence in the Okinawa island.[7] In

[7]Despite the fact Okinawa's conditions were promised to be made equal to the mainland Japan by the 1969 agreement of Eisaku Sato and Richard Nixon, in reality the presence of the US bases in Okinawa remained substantially larger than that of the mainland (Taira 2012).

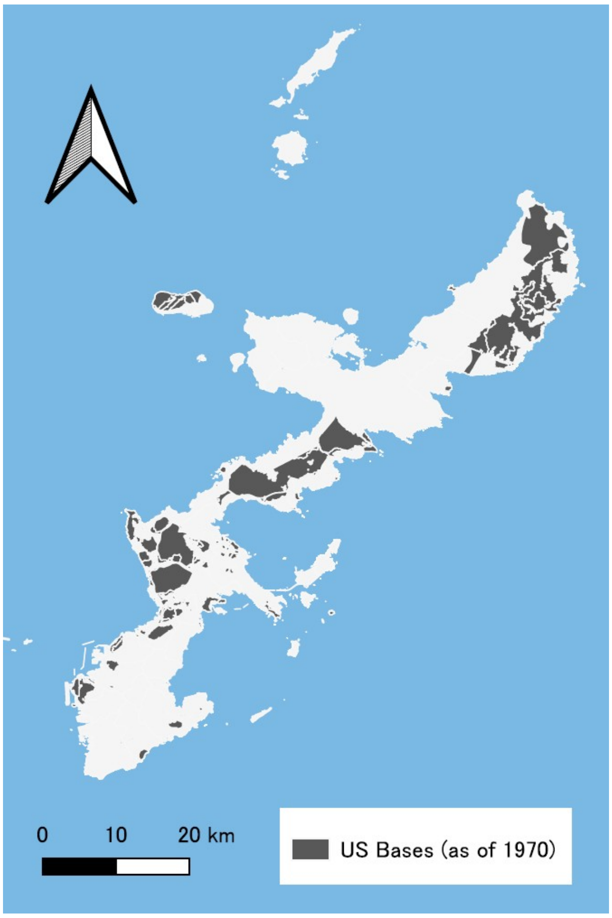


Figure 2: Okinawa island and the US bases (as of 1970)

Note: The area of the US bases is taken from the Okinawa Prefecture (http://gis.pref.okinawa.jp/OpenData/, in Japanese. Last accessed on May 11 2024). We show the US bases that existed in 1970. The shape file of the Okinawa island is taken from the Digital National Land Information (*kokudo suchi joho*).

total, as of 2020, they constitute around 15% of the geographical area of the Okinawa island.[8] The US bases constitute a large share of the geographical area of Okinawa Island. Figure 2 shows the location of the US bases on Okinawa Island as of 2020. In particular, the middle part of the island has large US bases (e.g., Kadena Air Base and Camp Hansen), while the southern part of the island does not have large US bases. As long as the economic activities of the US bases occur around the bases, we expect that the US bases will have a larger economic impact in areas closer to the US bases. We exploit these geographical variations in the salience of the US bases for analyzing their impact on economic development.

Not only in their large geographical size, the US bases are also an important economic actor that has greatly affected the Okinawan economy. Broadly speaking, the US bases are important as the consumer, the employer, and the tenant. As consumers, the US military personnel

[8]This number used to be somewhat higher at around 23% as of 1972 because some US bases were returned after Okinawa's return to Japan. Our structural analysis primarily focuses on 1970, a year before most US base returns took place. We assess how the endogeneity of the US base return decisions might affect our reduced-form results in Section 3.3, concluding that it does not affect our main conclusion. See https://www.nikkei.com/article/DGXZQOJC142GJ0U2A510C2000000/ for a map of the US bases as of 1972 and 2022 (in Japanese, last accessed on May 13 2025).

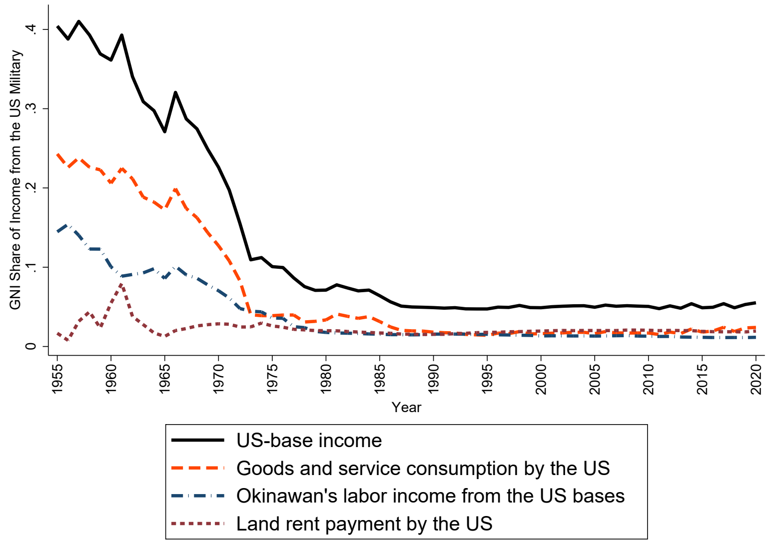


Figure 3: GNI share of the US bases in Okinawa island

Note: This figure plots the income sourced from the US military as the share of Okinawa's Gross National Income from 1955 to 2020. We used statistics from the Ryukyus Statistical Yearbook (*Ryukyus Toukei Nenkan*) and Okinawa Statistical Yearbook (*Okinawa Toukei Nenkan*). The black solid line is the sum of the three sources of US-base income: goods and service consumption by the US, Okinawan's labor income who are employed at the US bases, and land rent the US pays to Okinawan landowners for their bases.

consume goods and services provided by the Okinawan people, such as foods, restaurants, and daily commodities. As the employer, the US bases employ Okinawan people for their daily operations, such as cleaning and babysitting. As the tenant, the US bases pay the land rents to landowners. In all these three dimensions, the US bases induced a large demand for consumption goods, which is likely to be particularly important near the bases.

In total, the US bases have played an important role in the economic activities in Okinawa. Importantly for our analysis, Okinawa has a unique advantage for measuring the economic salience of the US bases because the Okinawa maintains the GDP statistics and the income sourced from the US bases is separately recorded. Figure 3 shows the remarkable importance of the US bases in the Okinawan economy. The US bases constituted around 40% of Okinawa's GNI in 1955. The share declined sharply in the 1960's and 1970's. The share has been around 5% for the past 40 years. Unpacking the US-base income before the return of Okinawa to Japan in 1972, the income from consumption of goods and services took up the highest share, the labor income of Okinawan residents at the US bases came next, and the land rent payment had the lowest share. After the return, however, the GNI shares of these three sources of income are close to each other due to the substantial drop in the first two. Given the very large share of the US-base income in the GNI, reaching up to 40% in 1950's, we may reasonably hypothesize that the US bases have shaped the pattern of urbanization and the economic structure of Okinawa. Motivated by this, we analyze how the US bases have shaped Okinawa's urbanization and economic structure by combining reduced-form and structural approaches.

2.2 Data

We collect, and newly digitize when needed, the municipality-level data on various outcomes, covering the pre-WW2 period (1938–1945), the US occupation period (1945–1972), and the period after the reversion to Japan (1972–current). See also Appendix A for more details on the data description.

Spatial unit and scope of the analysis. We focus on the data of Okinawa Prefecture. Okinawa Prefecture consists of the main island, which accounts for about 50% of the total area and about 90% of the population as of today, and the other smaller islands. Since most US bases are located in the Okinawa main island and by far a large part of economic activities take place there, we focus on the Okinawa main island in our main analysis unless explicitly noted.

Throughout the paper, our analysis is conducted at the municipality level. There are about 40 municipalities on Okinawa Island, although the number of municipalities changes over time due to mergers and divisions (see Figure 6 for an illustration of municipal boundaries in 1970). To address the mergers and divisions of municipalities during our sample period, we aggregate municipalities to the largest definitions of municipalities when our analysis involves different years (see Appendix A for details).

Population. For population at the municipality level after 1945, we use the Population Census data, which is available every five years since 1950. The occupation-period data are newly digitized. The population includes only the Japanese population, implying that the US citizens are not covered by the Census. The population census also reports the number of workers by industry category living in each municipality. The census also tells us the number of people working for the US bases. In addition, we obtain population data by industry category in 1934 and 1938 from the Okinawa Prefectural Statistical Yearbook (*Okinawa-ken toukei sho*).

Employment. At the workplace level, the amount of employment in a municipality by industry category is available in the post-WW2 period. The main data source is the Establishment and Enterprise Census, which has been merged into the Economic Census since 2009. Since the Establishment and Enterprise Census does not cover workers at the US bases, we take this information from the Population Census. It counts the number of establishments and employed workers in each municipality. Note that employment by sector is different from the population by sector because of commuting across municipalities.

Size of the US bases. In our reduced-form analysis, we use the area share of the US bases in a municipality as an exposure index to the US-base income taken from official statistics. This measure is motivated by the assumption that the amount of demand of the US bases is proportional to the size of each base, and each base spends their money locally. We also use the shape file of the US bases constructed, created by the Okinawa Prefecture government, which we illustrate in Figure 2. We also observe in Komeito (1969) the amount of the US military personnel and Okinawan workers at each base. We use this data to confirm our assumption that the US base area share indeed captures its economic importance (see Section 3.3).

GNI information of the Okinawa and the GNI share of the US bases. The Gross National Income statistics of Okinawa are reported in the Ryukyus (Okinawa) Statistical Yearbook, annually from 1955.[9] Importantly for our purpose, it also reports the GNI share of income sourced from the US bases.[10] It is disaggregated into three categories: the purchase of goods and services, salaries of the Okinawan people working for the US bases, and land rents they pay for the US bases.[11] Such unique and detailed information on the GNI share of the US bases is crucial for our study. See Figure 3 for the illustration of our GNI data over time.

Road network and trip data. We use the travel-level microdata of the Okinawa Main Island Central and Southern Urban Area Person Trip Survey in 1977.[12] For each respondent, the survey asks the details of the travels they make in a day. The survey asks about the purpose of each trip, allowing us to identify commuting trips and shopping trips. Based on these data, we construct a bilateral commuting and shopping matrix between municipalities and use it to estimate gravity models. The bilateral travel distance is calculated based on the newly-digitized road network data in 1973, which are taken from the Geospatial Information Authority of Japan Map.

3 Reduced-form Evidence

We provide reduced-form evidence to motivate our analysis. Section 3.1 presents our empirical specification. Section 3.2 presents our main reduced-form results. Section 3.3 presents results of the robustness checks and additional analyses.

3.1 Reduced-form specification

We consider the following reduced-form model:

$$y_{ijt} = \beta_t \text{USBaseShare}_{it} + \Gamma_{ij} + \tau_{jt} + \epsilon_{ijt}, \tag{1}$$

[9]Strictly speaking, the GNI statistics are for the Okinawa *prefecture*, not the Okinawa main island that we focus on in this study. We ignore this difference on the ground that the Okinawa main island has 90% of the population share of Okinawa Prefecture today, and presumably even higher share of the GNI given its relatively advanced economic development. Therefore, we believe that the error from this approximation does not change our main conclusion.

[10]Technically, this income is different from the US-sourced income because since 1978, the wages of Okinawan workers in the US base and the land rents for the US bases are paid by the Japanese government, rather than the US (so called *omoiyari yosan*, or the "Sympathy Budget"). These are not sourced from the US but are counted as income sourced from the US base. We therefore use the term "US-base income" in this paper.

[11]From 1966 to 1971, the US-base income shares by disaggregated category are not reported. To approximate them, we use the linear interpolation for the GNI share of these three categories.

[12]The data do not cover the northern part of the Okinawa island. We have also used the same survey conducted in 1989 and 2006 and found that our results are hardly affected.

where i is the municipality, j is the industry, and t is the year. y_{ijt} may represent the log population or population density of municipality i in year t, or the sector j's share of workers in municipality i and year t. Γ_{ij} is the municipality-industry fixed effect and τ_t is the time-fixed effect. ϵ_{ijt} is the error term. USBaseShare_{it} is the outcome of interest and β_t is the associated coefficient of interest. That is, we are interested in the relationship between the spending amount of the US military forces in municipality i in year t and the outcome variable y_{ijt}.

Note that estimating (1) may suffer from a bias because unobserved municipality or industry characteristics, such as topographical conditions, may affect the population density. To address this, we consider a difference-in-difference (DID) specification. As a base period, we choose $t = 1938$, in which the following model holds:

$$y_{ij1938} = \Gamma_{ij} + \tau_{j1938} + \epsilon_{ij1938}. \tag{2}$$

This relationship naturally follows from equation (1) since in 1938, there was no US base in Okinawa (i.e., $\text{USBaseShare}_{i,1938} = 0$).

Subtracting equation (2) from equation (1), we obtain the following DID model:

$$y_{ijt} - y_{ij1938} = \beta_t \text{USBaseShare}_{it} + \tilde{\tau}_{jt} + \tilde{\epsilon}_{ijt}, \tag{3}$$

where $\tilde{\tau}_{jt} = \tau_{jt} - \tau_{j1938}$ and $\tilde{\epsilon}_{jt} = \epsilon_{jt} - \epsilon_{j1938}$. In the estimating equation (3), we conduct an OLS estimation for each industry j and year t, implying that we treat $\tilde{\tau}_{jt}$ as the constant term and $\tilde{\epsilon}_{ijt}$ as the error term. We use all municipalities in the Okinawa main island in year t as our estimation sample.[13]

The endogeneity concern is likely to be limited in our context because the location of the US bases is likely to be determined based primarily on the basis of military considerations, not on the economic conditions of Okinawa. Consistent with this idea, the US military spending and base locations have been considered exogenous in investigating its effect on various economic outcomes (e.g., Nakamura and Steinsson 2014; Zou 2018). The case for exogeneity is likely even stronger in our context because the US might have a strong incentive to consider the economic conditions of Okinawan residents as they are not US citizens and could not vote in the US elections. In line with this, as discussed in Section 2.1, anecdotal evidence documents the cases in which the US confiscated Okinawans' land that seemed economically valuable (Taira 2012; Toriyama 2013; Franks 2023).

This institutional background motivates us to make our identification assumption that USBaseShare_{it} is orthogonal to the error term, which makes the ordinary-least-square estimation of the DID model (3) have a causal interpretation. That said, despite the exogenous nature of the base locations, there remains a concern that the estimation of the model (3) may entail endogeneity. For instance, the US might have chosen to locate their bases in locations that

[13]As a robustness check, we also tried estimating it using all municipalities in Okinawa *prefecture*, while additionally controlling for a dummy indicating that municipality i is outside the Okinawa main island. Our conclusion remains the same.

already had increasing trends in population density even prior to the WW2. We address such endogeneity concerns in Section 3.3, finding evidence consistent with the exogeneity of the US base locations.

3.2 Reduced-form results

We first document the cross-sectional relationship between the economic outcomes and the area share of the US bases in 1970, when the US-base income accounted for around 40% of the Gross National Income of Okinawa. Figure 4 presents the scatterplot of each municipality, where the horizontal axis is the US base area share in 1970 and the vertical axis shows the changes in various economic outcomes from 1938 to 1970. We also show a regression line, which comes from estimating the equation (3) by the OLS.

Figure 4a shows the impact on log population density and Figure 4b shows the impact on log population.[14] Although population might be more negatively affected by the US bases than population density because they reduce habitable area by occupying some areas, both suggest that the large positive impact: the US bases caused urbanization. In addition, the estimated β_t are statistically significant, and their magnitude is remarkably large. To illustrate this point, note that the estimated β_t for population density in Figure 4a is 3.045. Then, the 10 percentage points increase in the US base share is associated with about 36% higher population density.[15] This provides evidence that substantial urbanization occurred in areas close to the US bases.

Such rapid urbanization around the US bases accompanied significant growth of the service sector *without* manufacturing growth. Figure 4c shows that municipalities with higher US base experienced rapid growth in the service sector. The association is strong: about 10 percentage point increase in the US bases is associated with 5 percentage points increase. In stark contrast, Figure 4d shows no association between manufacturing growth and the US base area share. As a result, almost the entire decline in the agricultural employment share around the US bases, shown in Figure 4e, was absorbed by the increase in the service employment share.

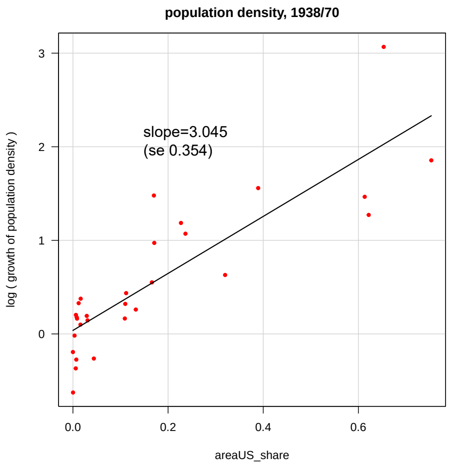
We summarize our findings, which come from looking at the changes from 1938 to 1970, as follows:

Result 1 (Urbanization and the US bases). *In municipalities with a higher share of the US military bases, the population density increased significantly more. A similar increase is also observed in the population level.*

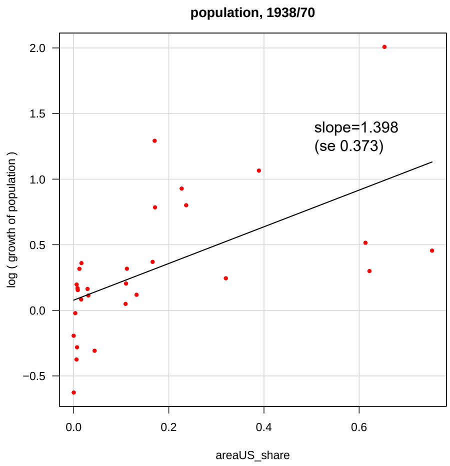
Result 2 (Service-sector growth without industrialization and the US bases). *Municipalities with a higher share of the US bases were characterized by the rapid growth in the employment share of the service sector and the decline of the agriculture employment share. In contrast, the change in the manufacture employment share had little association with the US base share.*

[14] Changes in log population density and log population are different in our context because habitable land area shrank due to the US bases.

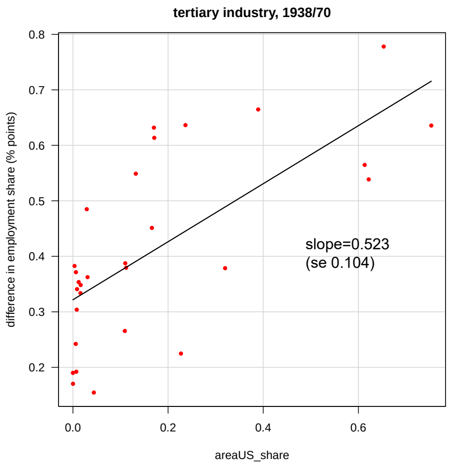
[15] To verify this, let y^{high} (y^{low}) be the population density of a municipality with the 10 percentage point higher (lower) share of the US bases. Then, $\ln(y^{high}) - \ln(y^{low}) = \ln(1 + \frac{y^{high} - y^{low}}{y^{low}}) = 0.1\beta_t$. Taking the exponential of this and rearranging, $\frac{y^{high} - y^{low}}{y^{low}} = e^{0.1\beta_t} - 1$.



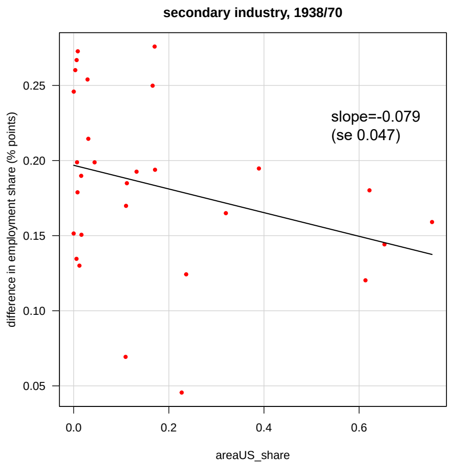
(a) Population density



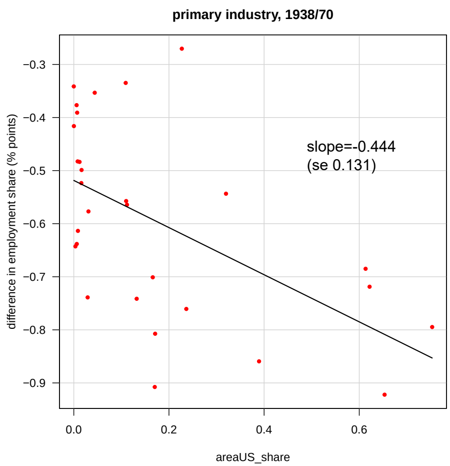
(b) Population level



(c) Service share



(d) Manufacturing share



(e) Agriculture share

Figure 4: Urbanization without industrialization around US bases: 1970 cross-section

Note: We present a scatterplot of each municipality using the 1970 data, where the horizontal axis is the US base area share. Each dot represents a municipality. As the vertical axis, Figure 4a takes the change in the log population density, Figure 4b takes the change in the log population, Figure 4c takes the change in the service employment share, Figure 4d takes the change in the manufacturing employment share, and Figure 4e takes the change in the agriculture employment share. The linear fitted lines are also shown.

3.3 Robustness checks and additional analyses

The impact of the US bases in different years While our main reduced-form result in Figure 4 comes from 1970, we examine the association between the US bases and various economic outcomes in different years. In particular, we may expect the association to remain qualitatively similar but quantitatively weaker in recent years because, as shown in Figure 3, the importance of the US bases in the aggregate Okinawan economy has declined over time. Our findings in Figure B.1 are consistent with this conjecture: Results 1 and 2 qualitatively remain, but the coefficient has become smaller in recent years.

Testing the pre-trends A concern for our DID model (3) is the common trend assumption. In our context, even if the US bases actually have no impact, the regression coefficient might be non-zero when trends in outcome variables happen to be correlated with the US bases. To address this possibility, we analyze whether the pre-trend is associated with the US bases by analyzing the changes in outcome variables from 1934 to 1938, about 10 years before the occupation of Okinawa by the US, using the regression model (3). Figure B.2 reports the results in the same format as Figure 4 for the change from 1938 to 1970. Overall, we find little pre-trend that could spuriously induce the association with the US bases.

Addressing endogeneity of US base returns In addition to the common trend assumption discussed above, another potential concern for endogeneity is that some US bases were returned to Okinawa. As long as which bases to return is responsive to economic conditions, then the US base area share in year t might be correlated with the error term in equation (3). To address this, we use the pre-determined 1956 base share as an instrument in estimating the equation (3). At least until 1950's, the US constructed bases for facilitating military operations without paying much attention to the economic values of each land plot (Taira 2012; Toriyama 2013; Franks 2023). Therefore, while Okinawan residents could call for the return of economically valuable US bases more actively, the US base area in the 1950's is more plausibly exogenous to local economic trends. Figure B.3 presents the estimation results of equation (3) using the instrumental variable. Overall, although the quantitative impacts of the US bases might seem somewhat magnified, our main conclusions (Results 1 and 2) remain the same.

Using alternative measure of base importance While we use the US base area share as a measure of the economic importance of the US bases in equation (3), a potential concern is that the geographical size of the US base may not necessarily capture the economic importance of the US base. To address this concern, we use alternative measures of the importance of each US base, based on the number of Japanese workers or the US military personnel reported in Komeito (1969). In Figures B.4 and B.5, we use, respectively, the number of Japanese (Okinawan) workers at the US bases and the US military personnel in each municipality. Overall, we find that in both cases, our main qualitative conclusion (Results 1 and 2) does not change. Therefore, we use the area share of the US bases as the main measure of the economic importance of the US bases in each municipality.

Disaggregating the impact on service-sector employment Given the anecdotal evidence that the US personnel demanded consumer services such as shops and restaurants, we expect that the US bases would have a particularly strong impact on the employment share of consumer services.[16] Unfortunately, our data until 1970, when the US bases had a positive impact on the service-sector employment share, do not allow us to accurately classify service employment into consumer and producer services. Despite such data limitations, we provide suggestive evidence that the US bases are indeed associated with consumer services using the cross-sectional data in 1970. In Table B.1, we find that two major sectors that have a close association with consumers, Wholesale&Retail and Intangible Service, are strongly associated with the US base area share. This is consistent with our expectation that the US bases induce a large consumption demand.

Given these reduced-form analyses, we conduct a structural analysis. The structural model allows us to analyze counterfactual questions while explicitly considering the US-bases and various general-equilibrium effects in the spatial economy. Comparison of the observed data with a counterfactual scenario with no US base clarifies how much it has induced urbanization without industrialization. The isolation of the role of the US-base income in the structural approach is important because the US bases may have other effects, such as infrastructure investment, that are not necessarily related to the US-base income. The structural model also allows us to investigate the impact of the US base on the GNI and the welfare, which provides valuable informative about the aggregate efficiency of urbanization without industrialization. In the next section, we introduce our structural model that allows us to answer these questions.

4 Model

To explicitly analyze the role of the US-base income in shaping the pattern of urbanization and sectoral development in Okinawa, consider an economy (the Okinawa main island) consisting of several locations (municipalities). The total number of locations in this economy is I, and each location is indexed by $i = 1, 2, \cdots, I$. The economy as a whole is inhabited by a measure L of workers, which is exogenously given as we assume a closed city in the baseline model.[17] Workers inelastically supply a unit of labor and earn the wage. Each worker is allowed to reside in a location different from their workplace, implying that the mass of residents in location i (R_i) may differ from that of workers working in location i (L_i).

The present model has four sectors: agriculture (A), manufacturing (M), non-tradable services (N), and the US military base sector (B). The agricultural and manufacturing sectors

[16] Fan et al. (2023) finds the importance of separating consumer services and business services in the context of Indian economic growth.

[17] Appendix D.2 extends the model to the small-open city setting, wherein the total population of the economy is endogenously determined.

are perfectly competitive and produce homogeneous goods that can be freely traded across locations. The non-tradable service sector is monopolistically competitive, implying that firms in this sector produce horizontally differentiated goods. These goods cannot be traded across locations and are consumed only locally. The US military base sector does not produce any good, but some labor force is required to support the operation of the US army stationed in Okinawa.

Each location is endowed with a fixed amount of land, S_i. However, some parts of the land may be occupied by the US military bases. Let $m_i \in [0, 1]$ represent the share of land used as US military bases in location i. We posit that m_i is determined for a military reason and is exogenously given to the model. Then, a fraction $1 - m_i$ of the land is available for developing floor space that can be used for private purposes, including housing and the production of both tradable goods and non-tradable services. The floor space is supplied by perfectly competitive developers, and we let H_i represent the amount of floor space in location i.

4.1 Consumption

Workers. Workers derive utility from consuming agricultural and manufacturing goods, non-tradable services and housing. We assume that the preference of a worker ν residing in location i and working for sector $s \in \{A, M, N, B\}$ in location j is represented by a Cobb-Douglas function, such that the indirect utility is given by

$$U_{ijs}(\nu) = \frac{\varepsilon_{ijs}(\nu) A_i w_{js}}{\tau_{ij} \mathbb{P}_i^{\alpha} Q_i^{1-\alpha}}, \tag{4}$$

where $\alpha \in (0, 1)$ is a positive parameter capturing the expenditure share on consumption of goods and services; $\mathbb{P}_i$ is the price index of goods and services in location i; Q_i is the floor space rent in location i; w_{js} is the wage earned by workers engaged in sector s in location j; τ_{ij} is the utility costs of commuting from residence i to workplace j; A_i controls the average amenities from residing in location i; and $\varepsilon_{ijs}(\nu)$ is an idiosyncratic preference shock for the pair of residence, workplace, and sector of employment, which captures idiosyncratic reasons for living and working in particular locations and sectors. We let $\varepsilon_{ijs}(\omega)$ be drawn from a Fréchet distribution, $F(\varepsilon) = \exp(-\varepsilon^{-\theta})$, where $\theta > 1$ is the (inverse) measure of the dispersion of idiosyncratic preferences. Workers are assumed to realize their own values of $\varepsilon_{ijs(\nu)}$ before choosing the locations to live and work and the sector to work.

The price index, $\mathbb{P}_i$, is defined as

$$\mathbb{P}_i \equiv \left[\left(P_i^T \right)^{1-\kappa} + \left(\mathbb{P}_i^N \right)^{1-\kappa} \right]^{\frac{1}{1-\kappa}}, \tag{5}$$

where P_i^T is the price index of tradable goods (i.e., agricultural and manufacturing goods); $\mathbb{P}_i^N$ is the price index of non-tradable services faced by residents in location i; and $\kappa > 0$ is the elasticity of substitution between tradable goods and non-tradable services.[18] In our quantitative analysis, we normalize the price index of tradable goods to one, i.e., $P^T = 1$.

The price index of tradable goods, P_i^T, is defined over the prices of agricultural goods in location i (P_i^A) and manufacturing goods in location i (P_i^M) as follows: $P_i^T \equiv \Upsilon(P_i^A, P_i^M)$, where $\Upsilon(\cdot,\cdot)$ is a homothetic aggregator.

We assume that workers can consume non-tradable services not only at their residence but also in other locations. That is, residents in location i can make trips for shopping and enjoy non-tradable services provided in locations other than their residence. For simplicity, it is assumed that the set of destinations and the itinerary of shopping trips are identical across all residents in location i. Based on this assumption, the non-tradable price index $\mathbb{P}_i^N$ takes the following form:

$$\mathbb{P}_i^N \equiv \left[\sum_j \xi_{ij}(P_j^N)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{6}$$

$$\text{with} \quad P_j^N \equiv \left[\int_0^{n_j} (p_j^N(\iota))^{1-\sigma} \mathrm{d}\iota\right]^{\frac{1}{1-\sigma}}, \tag{7}$$

where P_j^N is the price index of non-tradable services in location j; $p_j^N(\iota)$ is the price of a non-tradable service indexed by ι and produced in location j; $\sigma > 1$ is the elasticity of substitution among non-tradable varieties; $\xi_{ij} \in [0,1]$ satisfies $\sum_j \xi_{ij} = 1$ and measures the extent to which residents in location i spend on consumption activities in location j; and n_j is the mass of varieties produced in location j.[19] It is straightforward to assume that the farther away the locations i and j, the smaller ξ_{ij}. If locations i and j are too distant to travel for shopping, it is possible to let $\xi_{ij} = 0$. Note that if we let $\xi_{ii} = 1$ and $\xi_{ij} = 0$ for $j \neq i$, the consumption of non-tradable services becomes purely local.

By Roy's identity, the shares of expenditure on agricultural goods (χ_i^A), manufacturing goods (χ_i^M) and non-tradable services (χ_i^N) are derived from (4) as follows:

$$\chi_i^A = \alpha \left(\frac{P_i^T}{\mathbb{P}_i}\right)^{1-\kappa} \frac{\partial \ln \Upsilon(P_i^A, P_i^M)}{\partial \ln P_i^A},$$

$$\chi_i^M = \alpha \left(\frac{P_i^T}{\mathbb{P}_i}\right)^{1-\kappa} \frac{\partial \ln \Upsilon(P_i^A, P_i^M)}{\partial \ln P_i^M},$$

[18] More generally, the price index can be written as $\mathbb{P}_i \equiv \left[\beta_T \left(P_i^T\right)^{1-\kappa} + \beta_N \left(\mathbb{P}_i^N\right)^{1-\kappa}\right]^{\frac{1}{1-\kappa}}$, where $\beta_T, \beta_N \in (0,1)$ represent the relative strength of preferences for tradable goods and non-tradable services, respectively. However, since these demand weights β_T and β_N are not separately identified from the productivity differences between the tradable and non-tradable sectors, we follow Faber and Gaubert (2019) and assume that $\beta_T = \beta_N = 1$. This implies that the productivity we calibrate captures both the productivity effect and the demand weights.

[19] It is easy to introduce the utility costs of shopping trips in the same vein as the commuting costs. The present framework assumes that the pattern of shopping trips from location i is common across all residents in location i, implying that there is no heterogeneity in the utility costs of shopping trips conditional on residing in the same location. Therefore, we can let the utility costs of shopping trips be absorbed in the amenities, A_{ij}.

$$\chi_i^N = \alpha \left(\frac{\mathbb{P}_i^N}{\mathbb{P}_i} \right)^{1-\kappa}. \tag{8}$$

The homotheticity of Υ implies that $\partial \ln \Upsilon / \partial \ln P_i^A + \partial \ln \Upsilon / \partial \ln P_i^M = 1$ holds and that the share of expenditure on tradable goods is $\chi_i^A + \chi_i^M = \alpha \left(P_i^T / \mathbb{P}_i \right)^{1-\kappa}$. Note also that the share of expenditure on non-tradable services provided in location j spent by residents in location i is $\xi_{ij} \chi_i^N \left(P_j^N / \mathbb{P}_i^N \right)^{1-\sigma}$.

Landowners. We assume that the land is owned by local landowners. Unlike workers, local landowners neither supply labor to any sector nor commute to other locations. The total income of local landowners in location i is the aggregate land rents from the land owned by them, which we denote by Ω_i. Let $\mathbb{Q}_i^{US}$ represent the land rent for the US military bases in location i, which is exogenously given to the model. Since location i's total land endowment is S_i and a fraction m_i of it is occupied by the US bases, Ω_i is determined as follows:

$$\Omega_i = [(1 - m_i)\mathbb{Q}_i + m_i \mathbb{Q}_i^{US}] S_i, \tag{9}$$

where $\mathbb{Q}_i$ is the land rent for private uses in location i.

We assume that local landowners consume the same set of goods and services as workers except for housing and that the expenditure shares are also the same, implying that they spent a fraction χ_i^A / α of income on agricultural goods, a fraction χ_i^M / α on manufacturing goods, and a fraction χ_i^N / α on non-tradable services.

The US military personnel. The US military bases are extensively distributed in Okinawa Island. Each base hosts some American military personnel for operation, and the mass of those working in the base in location i is denoted by L_i^{US}, which is determined by military considerations and exogenously given to the model.[20]

We assume that they are endowed with a fixed amount of housing in the base area where they work. This implies that they do not account for housing when they make a consumption decision and that their residence and workplace are in the same location. We also assume that they consume both tradable goods and non-tradable services and that their expenditure shares are the same as those of workers. Therefore, they spent a fraction χ_i^A / α of income on agricultural goods, a fraction χ_i^M / α on manufacturing goods, and a fraction χ_i^N / α on non-tradable services.[21] We denote by e_{US} the individual expenditure of the US military personnel in Okinawa Island.[22]

[20] The number of workers is the same as the total working hours because we assume each provides one unit of labor.

[21] Note that their spending pattern is similar to that of landowners. Landowners receive their income from their land while the US military personnel receive their income from the foreign source (the US), but they are similar in that they do not commute to a location different from their residence and do not consume housing in the Okinawan private market.

[22] The US personnel may also receive income spent elsewhere (e.g., remittance to the US mainland). We do not consider such income to focus on the Okinawan economy.

4.2 Production

In location i, sector $s \in \{A, M, N\}$ hires a measure L_{is} of workers and uses a measure H_{is} of floor space as production factors. Agricultural and manufacturing goods are produced in a perfectly competitive market. We assume that Okinawa is a small open economy and both goods are freely traded, indicating that the prices of agricultural and manufacturing goods are exogenously determined in the outside market, which we denote by P^A and P^M, respectively. Since both goods are also assumed to be costlessly traded across locations within Okinawa, $P_i^A = P^A$ and $P_i^M = P^M$ hold for any i.

Agricultural sector. We assume that the agricultural sector's production technology is represented by a Cobb-Douglas function and exhibits constant returns to scale. Then, profit maximization and free entry imply that the unit cost of production is equal to the price of agricultural goods:

$$P^A = \frac{w_{iA}^{1-\gamma^A} Q_i^{\gamma^A}}{b_i^A}, \tag{10}$$

where b_i^A is productivity of agricultural goods in location i and $\gamma^A \in [0, 1]$ is the agricultural sector's cost share of floor space. We do not consider agglomeration economies in the agricultural sector, indicating that b_i^A is an exogenous parameter that reflects location i's geographic condition such as soil and terrain.

Manufacturing sector. Similar to the case of the agricultural sector, we assume that the manufacturing sector's production technology is given by a Cobb-Douglas function and exhibits constant returns to scale. Then, the unit cost of production is equal to the price of the manufacturing goods:

$$P^M = \frac{w_{iM}^{1-\gamma^M} Q_i^{\gamma^M}}{B_i^M}, \tag{11}$$

where B_i^M is productivity of manufacturing goods in location i and $\gamma^M \in [0, 1]$ is the manufacturing sector's cost share of floor space.

To incorporate the agglomeration economy in the manufacturing sector, we assume that B_i^M takes the following form:

$$B_i^M = b_i^M L_{iM}^{\eta}, \tag{12}$$

where b_i^M is the exogenous production fundamentals that capture the geographic features such as good access to rivers or the sea, and $\eta > 0$ measures the strength of agglomeration forces.[23]

[23]We assume that there is no spillover from the US military personnel and Okinawans working for the US bases. We believe that no spillover is natural given that the military activities are largely unrelated to private economic activities. Indeed, Okinawan residents were not even permitted to enter the US bases except for special circumstances. That said, in Section 6.3 we consider the possibility that the US bases might affect fundamental productivity and amenities, which might be interpreted as capturing the spillover from the US bases.

Non-tradable service sector. The non-tradable service sector is characterized by monopolistic competition, and each variety is produced by a single firm under increasing returns to scale. To start production, f_i^N units of a Cobb-Douglas composite of labor and floor space are needed as a fixed input. Then, producing a unit of output requires $1/b_i^N$ units of the same Cobb-Douglas composite of labor and floor space, where b_i^N is an exogenous parameter that measures productivity of non-tradable services in location i. We let $\gamma^N \in [0,1]$ represent the non-tradable service sector's cost share of floor space, implying that the total costs of producing $x_i^N(\iota)$ units of output of variety ι are given by

$$c_i^N(\iota) = \left(f_i^N + \frac{x_i^N(\iota)}{b_i^N} \right) w_{iN}^{1-\gamma^N} Q_i^{\gamma^N}. \tag{13}$$

Since consumers' preferences are characterized by the constant elasticity of substitution among varieties, the profit-maximizing price set by a firm in location i exhibits the constant-markup property:

$$p_i^N = \frac{\sigma}{\sigma - 1} \frac{w_{iN}^{1-\gamma^N} Q_i^{\gamma^N}}{b_i^N}, \tag{14}$$

where we omit the firm index ι because there is no longer heterogeneity across firms in the same location. Thus, the zero profit condition implies that the equilibrium output for each firm in location i is $x_i^N = (\sigma - 1) f_i^N b_i^N$. Plugging this into (13), the total costs incurred by a firm in location i can be calculated as $\sigma f_i^N w_{iN}^{1-\gamma^N} Q_i^{\gamma^N}$. Because each variety is produced by a single firm, the total mass of firms producing non-tradable services in location i is represented by n_i. The aggregate payments to labor and floor space are $w_{iN} L_{iN} = \sigma(1-\gamma^N) f_i^N n_i w_{iN}^{1-\gamma^N} Q_i^{\gamma^N}$ and $Q_i H_{iN} = \sigma \gamma^N f_i^N n_i w_{iN}^{1-\gamma^N} Q_i^{\gamma^N}$, respectively. From these two equations, the equilibrium mass of firms in the non-tradable service sector in location i can be expressed as follows:

$$n_i = \frac{1}{\sigma f_i^N} \left(\frac{L_{iN}}{1-\gamma^N} \right)^{1-\gamma^N} \left(\frac{H_{iN}}{\gamma^N} \right)^{\gamma^N}. \tag{15}$$

Substituting (14) and (15) into (7), the price index of non-tradable services in location i can be written as

$$P_i^N = \frac{w_{iN}^{1-\gamma^N} Q_i^{\gamma^N}}{B_i^N}, \tag{16}$$

where B_i^N is given by

$$B_i^N = \widetilde{b}_i^N L_{iN}^{\frac{1-\gamma^N}{\sigma-1}} H_{iN}^{\frac{\gamma^N}{\sigma-1}}, \tag{17}$$

and $\widetilde{b}_i^N$ is defined as $\widetilde{b}_i^N \equiv (\sigma - 1) \left[\sigma^\sigma (1-\gamma^N)^{1-\gamma^N} (\gamma^N)^{\gamma^N} f_i^N \right]^{1/(1-\sigma)} b_i^N$.[24] Finally, substi-

[24]Note that B_i^N increases in L_{iN} because $(1-\gamma^N)/(\sigma-1) > 0$ holds, implying that non-tradable service sector also exhibits agglomeration economy.

tuting equation (16) into equation (6) gives the price index for workers living in i as follows:

$$\mathbb{P}_i^N = \left[\sum_j \xi_{ij} \left(\frac{w_{jN}^{1-\gamma^N} Q_j^{\gamma^N}}{B_j^N} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{18}$$

The US military base sector. Although the US military base sector does not produce any good, it needs to employ some Okinawan people to support the operation of the US army. Note the distinction between the Okinawan people working in the US bases and the US military personnel, who are Americans. The mass of Okinawan workers demanded by the base in location i is represented by L_{iB}, which is exogenously given to the model because they are determined based on military considerations.

We denote the set of locations hosting the US bases by $\mathcal{I}_B$ and let the number of such locations be I_B (i.e., $|\mathcal{I}_B| = I_B$). For locations included in $\mathcal{I}_B$, the wage in the base in location i, w_{iB}, is endogenously determined such that the labor supply matches the demand in each location. On the other hand, for locations without bases, we let $w_{iB} = 0$ hold because there is no demand for labor in the base sector in such locations.

4.3 Floor space supply

Floor space is supplied by a perfectly competitive construction sector that uses land and capital as inputs. Following Epple, Gordon and Sieg (2010) and Combes, Duranton and Gobillon (2021), we assume that the production function for the floor space takes a Cobb-Douglas form: $H_i = \varkappa K_i^{\mu}[(1-m_i)S_i]^{1-\mu}$, where K_i and μ are the amount of capital used in location i and the cost share of capital, respectively, and $\varkappa$ is a positive constant that governs the level of construction technology.[25] Although the land endowment of location i is S_i, a fraction m_i is occupied by the US bases, indicating that the amount of land available for development is $(1 - m_i)S_i$. We assume that capital is freely mobile across regions and countries. Thus, the price of capital is determined in the world market and is exogenous to the present model.

The profit-maximizing amount of capital satisfies $K_i = \mu Q_i H_i/\rho$, where ρ is the price of capital. Substituting this back into the production function and arranging the equation, we obtain the following floor-space supply function:

$$H_i = (1 - m_i)S_i Q_i^{\phi},$$

where $\phi \equiv \mu/(1 - \mu)$ represents the floor space supply elasticity. Here, without loss of generality, we simplify notations by setting the unit of floor space such that $\varkappa = (\rho/\mu)^{\mu}$ holds.[26] Furthermore, since the land rent for private uses in location i is represented by $\mathbb{Q}_i$, the zero-profit

[25] Yoshida (2018) and Kii, Tamaki, Kajitani and Suzuki (2022) show evidence that the Cobb-Douglas housing production function is also a good approximation of reality in Japan.

[26] This form of floor space supply function is also adopted in Heblich et al. (2020) and Takeda and Yamagishi (2025).

condition yields

$$(1 - m_i)\mathbb{Q}_i S_i = (1 - \mu) Q_i H_i. \tag{19}$$

This equation allows us to compute the land rents, given the floor space rents and the total floor space supply.

4.4 Market equilibrium

Labor market. Each worker chooses the pair of residence and workplace that maximizes their utility (4). Since $\varepsilon_{ijs}(\nu)$ follows a Fréchet distribution, the probability that a worker chooses to live in location i and work for sector s in location j is calculated as follows:

$$\lambda_{ijs} = \frac{\left(A_i w_{js} \mathbb{P}_i^{-\alpha} Q_i^{-(1-\alpha)}\right)^{\theta} \tau_{ij}^{-\theta}}{\sum_k \sum_l \left(A_k \widetilde{w}_l \mathbb{P}_k^{-\alpha} Q_k^{-(1-\alpha)}\right)^{\theta} \tau_{kl}^{-\theta}}, \tag{20}$$

where $\widetilde{w}_j \equiv \left(\sum_s w_{js}^{\theta}\right)^{1/\theta}$ summarizes an average wage rate of location j.[27] Summing these probabilities across all workplaces for a given pair of residence i and sector s, we obtain the probability that a worker chooses to live in location i and work for sector s:

$$\lambda_{is}^{R} \equiv \sum_j \lambda_{ijs}. \tag{21}$$

Therefore, the probability that a worker commutes to location j conditional on working for sector s and living in location i is expressed as follows:

$$\lambda_{ij|is} \equiv \frac{\lambda_{ijs}}{\lambda_{is}^{R}} = \frac{w_{js}^{\theta} \tau_{ij}^{-\theta}}{\sum_l w_{ls}^{\theta} \tau_{il}^{-\theta}}. \tag{22}$$

Let R_{is} represent the mass of workers who work for sector s and live in location i. By (21), R_{is} is determined as follows:

$$R_{is} = \lambda_{is}^{R} L. \tag{23}$$

Using (22), we obtain the mass of workers in location i for each sector:

$$\begin{aligned} L_{is} &= \sum_k \lambda_{ki|ks} R_{ks} \quad \text{for all } i \text{ and } s \in \{A, M, N\}, \\ \text{and} \quad L_{iB} &= \sum_k \lambda_{ki|kB} R_{kB} \quad \text{for } i \in \mathcal{I}_B. \end{aligned} \tag{24}$$

Note that the mass of US-base workers in location i, L_{iB}, is exogenously given and locations without bases exhibit $L_{iB} = 0$. For this reason, the second equation in (24) is restricted to locations that belong to $\mathcal{I}_B$. The masses of workers living and employed in location i are,

[27] Specifically, $\widetilde{w}_j$ is proportional to the power mean, with exponent θ, of wages across sectors in location j.

respectively, expressed as

$$R_i = \sum_s R_{is} \quad \text{and} \quad L_i = \sum_s L_{is}. \tag{25}$$

We now turn to describing wages. We can express private-sector wages by using (10), (11), (12), (16), (17) as follows:

$$w_{iA} = (\widetilde{b}_i^A)^{\frac{1}{1-\gamma^A}} Q_i^{-\frac{\gamma^A}{1-\gamma^A}}, \tag{26}$$

$$w_{iM} = (\widetilde{b}_i^M)^{\frac{1}{1-\gamma^M}} Q_i^{-\frac{\gamma^M}{1-\gamma^M}} L_{iM}^{\frac{\eta}{1-\gamma^M}}, \tag{27}$$

$$w_{iN} = (\widetilde{b}_i^N)^{\frac{1}{1-\gamma^N}} (P_i^N)^{\frac{1}{1-\gamma^N}} Q_i^{-\frac{\gamma^N}{1-\gamma^N}} L_{iN}^{\frac{1}{\sigma-1}} H_{iN}^{\frac{\gamma^N}{(\sigma-1)(1-\gamma^N)}}, \tag{28}$$

where $\widetilde{b}_i^A \equiv P^A b_i^A$ and $\widetilde{b}_i^M \equiv P^M b_i^M$ are price-adjusted productivity of agricultural and manufacturing goods in location i, respectively.[28] In locations with US bases, the wage rate of US-base workers is determined so that it solves the second equation of (24).

Floor space market. Since (4) implies that the share of expenditure on housing is $1-\alpha$, the total amount of floor space demanded by residents in location i, denoted by H_{iR}, is given by

$$H_{iR} = (1-\alpha) \sum_j \sum_s \frac{\lambda_{ij|is} w_{js} R_{is}}{Q_i}. \tag{29}$$

Private uses of floor space include not only housing but also the production of both tradable goods and non-tradable services. Because each sector exhibits a Cobb-Douglas production technology, the amount of floor space used for production in sector $s \in \{A, M, N\}$ can be written as follows:

$$H_{is} = \frac{\gamma^s w_{is} L_{is}}{(1-\gamma^s) Q_i}. \tag{30}$$

In location i, the equilibrium of the floor space market is characterized by $H_i = H_{iR} + \sum_{s\in\{A,M,N\}} H_{is}$. Combining this equation with (29) and (30), we obtain the following condition for floor space market clearing:

$$Q_i H_i = (1-\alpha) \sum_j \sum_{s\in\{A,M,N,B\}} \lambda_{ij|is} w_{js} R_{is} + \sum_{s\in\{A,M,N\}} \frac{\gamma^s w_{is} L_{is}}{1-\gamma^s}, \tag{31}$$

where the first and second terms on the right-hand side represent the aggregate rents from housing and production, respectively. Note that the Okinawan residents working for US bases consume floor space for their housing. This is the reason why the set for the summation index s contains B in the first term of the right-hand side of (31), while it does not in the second term. Note also that we can rewrite equation (31) as a function of land rents, $\mathbb{Q}_i$, by using equation (19).

[28] We cannot identify P^A and b_i^A (resp. P^M and b_i^M) separately in our calibration process. Instead, we recover the value of $\widetilde{b}_i^A$ (resp. $\widetilde{b}_i^M$) such that it rationalizes the observed equilibrium.

Non-tradable service market. In each location, the total revenue of firms producing non-tradable services must be equal to the total expenditure on non-tradable services spent by workers living or working there, local landowners, and the US military personnel in that location.

Note that the total costs incurred by all firms in location i are expressed as $\sigma f_i^N n_i w_{iN}^{1-\gamma^N} Q_i^{\gamma^N}$. As the present model features free entry, the total revenue equals the total costs. Then, using (15), the total revenue of firms in location i can be written as $\left[w_{iN}L_{iN}/(1-\gamma^N)\right]^{1-\gamma^N}(Q_i H_{iN}/\gamma^N)^{\gamma^N}$.

Workers living in location i spend a fraction $\xi_{ij}\chi_i^N(P_j^N/\mathbb{P}_i^N)^{1-\sigma}$ of their income on non-tradable services served in location j. Multiplying this expenditure share by $1/\alpha$, we obtain the shares of expenditure spent by local landowners and the US military personnel in location i on non-tradable services produced in location j. Thus, the market clearing condition for non-tradable services in location i can be expressed as follows:

$$\begin{aligned}\left(\frac{w_{iN}L_{iN}}{1-\gamma^N}\right)^{1-\gamma^N}\left(\frac{Q_i H_{iN}}{\gamma^N}\right)^{\gamma^N} =& \sum_k\sum_j\sum_s \xi_{ki}\chi_k^N\left(\frac{P_i^N}{\mathbb{P}_k^N}\right)^{1-\sigma}\lambda_{kj|ks}w_{js}R_{ks} \\ &+\sum_k \frac{\xi_{ki}\chi_k^N}{\alpha}\left(\frac{P_i^N}{\mathbb{P}_k^N}\right)^{1-\sigma}\left(\Omega_k+e_{US}L_k^{US}\right),\end{aligned} \tag{32}$$

where the first and second terms on the right-hand side represent the total expenditure on non-tradable services in location i from all workers and that from local landowners and the US military personnel, respectively.

From (9), (19), (30) and (31), the market clearing condition (32) can be transformed into

$$\begin{aligned}\frac{w_{iN}L_{iN}}{1-\gamma^N} =& \frac{1-\mu+\alpha\mu}{\alpha}\sum_k\sum_j\sum_{s\in\{A,M,N,B\}}\xi_{ki}\chi_k^N\left(\frac{P_i^N}{\mathbb{P}_k^N}\right)^{1-\sigma}\lambda_{kj|ks}w_{js}R_{ks} \\ &+\frac{1-\mu}{\alpha}\sum_k\sum_{s\in\{A,M,N\}}\xi_{ki}\chi_k^N\left(\frac{P_i^N}{\mathbb{P}_k^N}\right)^{1-\sigma}\frac{\gamma^s w_{ks}L_{ks}}{1-\gamma^s}+\frac{1}{\alpha}\sum_k\xi_{ki}\chi_k^N\left(\frac{P_i^N}{\mathbb{P}_k^N}\right)^{1-\sigma}\Phi_k,\end{aligned} \tag{33}$$

where $\Phi_k \equiv m_k\mathbb{Q}_k^{US}S_k + e_{US}L_k^{US}$ is an exogenous parameter capturing the expenditure from foreign sources. That is, Φ_k is also interpreted as the transfer from the outside economy to the location k.

Workers' welfare. Prior to the realization of the idiosyncratic preference shock $\varepsilon_{ijs}(\nu)$, the expected utility of workers from living in Okinawa, which we interpret as workers' welfare $\mathbb{W}$, equals

$$\mathbb{W} = \Gamma\left(\frac{\theta-1}{\theta}\right)\left[\sum_i\sum_j\left(A_i\widetilde{w}_j\mathbb{P}_i^{-\alpha}Q_i^{-(1-\alpha)}\right)^{\theta}\tau_{ij}^{-\theta}\right]^{\frac{1}{\theta}}, \tag{34}$$

where $\Gamma(z)=\int_0^\infty t^{z-1}\mathrm{e}^{-t}\mathrm{d}t$ is the Gamma function. In our baseline model, we assume a closed city so that the total population L is exogenously determined. In an extension in Section 6.3, we consider a small-open city situation in which workers choose whether to live in Okinawa, which

Parameter	Value	Description	Source
$1-\alpha$	0.25	Housing expenditure share	Davis and Ortalo-Magné (2011)
σ	5.3	Elasticity of substitution among non-tradable varieties	Miyauchi et al. (2022)
κ	2.07	Elasticity of substitution between tradable and non-tradable goods	Own estimation
θ	2.19	Fréchet shape parameter	Hayakawa, Koster, Tabuchi and Thisse (2021)
ζ	0.78	Commuting cost elasticity	Own estimation
ψ_S	2.3	Travel cost elasticity for shopping	Own estimation
γ^A	0.3	Cost share of floor space in the agricultural sector	Hayashi and Prescott (2008)
γ^M	0.2	Cost share of floor space in the manufacturing sector	Ahlfeldt et al. (2015)
γ^N	0.2	Cost share of floor space in the non-tradable service sector	Ahlfeldt et al. (2015)
η	0.05	Agglomeration elasticity in the manufacturing sector	Rosenthal and Strange (2004)
ϕ	2	Floor space supply elasticity	Heblich et al. (2020)
m_i	-	Land share of the US bases of each location	Okinawa Statistical Yearbook
Φ_i	-	US-base income of each location	Okinawa Statistical Yearbook
A_i	-	Exogenous residential amenities of each location	Own estimation
$\widetilde{b}_i^s$	-	Sector-specific adjusted productivity of each location	Own estimation

Table 1: Values of exogenous parameters in the model calibration

gives the expected utility $\mathbb{W}$, or live outside Okinawa.

Equilibrium Conditions. The present model has $19 \times I + I_B$ endogenous variables: the spatial distribution of residents and employments, $\{R_i, L_i\}_{i=1}^I$; the masses of residents and employments by sector, $\{R_{is}\}_{i=1}^I$ for $s \in \{A, M, N, B\}$ and $\{L_{is}\}_{i=1}^I$ for $s \in \{A, M, N\}$; the total amount of floor space used for housing, $\{H_{iR}\}_{i=1}^I$; the total amount of floor space used for production in each sector, $\{H_{is}\}_{i=1}^I$ for $s \in \{A, M, N\}$; the wages in private sectors, $\{w_{is}\}_{i=1}^I$ for $s \in \{A, M, N\}$; the wages in the US base sector, $\{w_{iB}\}_{i\in\mathcal{I}_B}$; the floor space rent, $\{Q_i\}_{i=1}^I$; the land rent, $\{\mathbb{Q}_i\}_{i=1}^I$; and the price index of non-tradable services in location i, $\{P_i^N\}_{i=1}^I$. These variables are determined in equations (19), (23), (24), (25), (26), (27), (28), (29), (30), (31), and (33).

5 Calibration

In this section, we calibrate the model parameters to match the Okinawan economy around 1970. We choose 1970 as our target of calibration in light of the substantial fraction of Okinawa's GNI in 1970 (see Figure 3) and rich data availability. The calibration is done in steps, which we describe below. For convenience, Table 1 summarizes calibrated parameter values and their sources.

Step 1: Calibrating parameters from external information. We first determine some parameter values based on external studies. The housing expenditure share $(1-\alpha)$ is set at 0.25 based on Davis and Ortalo-Magné (2011).[29] The elasticity of substitution among non-tradable varieties (σ) is set at 5.3 based on Miyauchi et al. (2022), which is also consistent with Hobijn and Nechio (2019). We set the Fréchet shape parameter $\theta = 2.19$, following Hayakawa et al.'s

[29]This is also consistent with the 1999 National Survey of Family Income and Expenditure in Okinawa Prefecture (https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00200564&tstat=000000640001&cycle=0&tclass1=000000640041&tclass2=000000640134&tclass3=000000640135&iroha=9&tclass4val=0, in Japanese, last accessed on May 16 2025).

(2021) estimate using across-municipality Japanese data.[30] The cost share of floor space in the agricultural sector (γ^A) is set at 0.3 following Hayashi and Prescott (2008). The cost share of floor space in the manufacturing sector and the non-tradable service sector (γ^M, γ^N) is set at 0.2 following Ahlfeldt et al. (2015). The agglomeration elasticity in manufacturing productivity (η) in each municipality is set at 0.05, which is consistent with Rosenthal and Strange (2004) and Ahlfeldt and Pietrostefani (2019). Finally, the floor-space supply elasticity is set at 2 following Heblich et al. (2020), which is consistent with Japanese floor-space supply technology in land-scarce environments like Okinawa (Yoshida 2018).

Step 2: Gravity equation estimation. We estimate the commuting cost parameter by estimating the commuting gravity equation. Summing (20) across all sectors, we obtain the following commuting gravity equation:

$$\lambda_{ij} = \frac{\left(A_i \widetilde{w}_j \mathbb{P}_i^{-\alpha} Q_i^{-(1-\alpha)}\right)^{\theta} \tau_{ij}^{-\theta}}{\sum_k \sum_l \left(A_k \widetilde{w}_l \mathbb{P}_k^{-\alpha} Q_k^{-(1-\alpha)}\right)^{\theta} \tau_{kl}^{-\theta}}, \tag{35}$$

where λ_{ij} is the share of workers living in i and working in j. We assume that the commuting cost is written as $\tau_{ij} = d_{ij}^{\zeta}$, where d_{ij} is the commuting distance from residence i to workplace j and ζ is the commuting cost elasticity with respect to commuting distance. Then, the gravity equation implied by (35) is rewritten as

$$\ln \lambda_{ij} = -\zeta\theta \ln d_{ij} + o_i^R + o_j^L + \epsilon_{ij}, \tag{36}$$

where o_i^R is the residence fixed effect, o_j^L is the workplace fixed effect, and ϵ_{ij} is the measurement error. Using the data on intermunicipal commuting flows, we estimate the gravity equation (36) and obtain the estimate of ζ. Table C.1 presents estimation results, which yield our preferred estimate of 1.7. Given that we have set $\theta = 2.19$, this implies $\zeta = 1.7/2.19 \simeq 0.78$.

We next turn to estimating the travel cost for shopping (ψ_S) by estimating the gravity equation in the shopping behavior. We suppose that ξ_{ij}, which governs the non-tradable spending share of municipality i residents on the non-tradable services in municipality j, is written as follows:

$$\xi_{ij} = \frac{M_j d_{ij}^{-\psi_S}}{\sum_k M_k d_{ik}^{-\psi_S}}, \tag{37}$$

where d_{ij} is the travel distance between municipality i and j, ψ_S is the parameter governing travel costs, and M_j is the exogenous attractiveness of municipality j as consumption place.[31]

[30] We also experimented with estimating θ to match the observed dispersion of residential income across municipalities, analogously to Ahlfeldt et al. (2015). While this procedure has limitations in our context due to the relatively small sample size, it yields a value close to $\theta = 2.19$.

[31] Equation (37) can be obtained if people in municipality i evaluate the attractiveness of municipality j as $(d_{ij})^{-\zeta_S} M_j^{1/\theta_S}$ with the travel cost elasticity with respect to distance $\zeta_S > 0$, and chooses consumption location under the Fréchet shock with the dispersion parameter $\theta_S > 0$. The frequency of shopping at j converges to ξ_{ij} as

Taking the log, equation (37) implies the following gravity equation for shopping behavior:

$$\ln \xi_{ij} = -\psi_S \ln d_{ij} + \Psi_i^R + \Psi_j^D, \tag{38}$$

where $\Psi_i^R = \ln \left(\sum_j M_j d_{ij}^{-\psi_S} \right)$ and $\Psi_j^D = \ln M_j$. Interpreting ξ_{ij} as the share of shopping trips from i to j, we estimate the shopping gravity equation (38) using the Okinawa person trip data while assuming there is also an additive error term. The estimation results are reported in Table C.2, and we use $\psi_S = 2.3$ as a benchmark.

Step 3: Wages and rents. By combining (22) and (24), the labor market clearing condition for each sector is given by

$$L_{is} = \sum_k \frac{\omega_{is} d_{ki}^{-\vartheta}}{\sum_l \omega_{ls} d_{kl}^{-\vartheta}} R_{ks}, \tag{39}$$

where ϑ is defined as $\vartheta \equiv \zeta\theta$ and $\omega_{is} \equiv (w_{is})^\theta$ is the transformed wage of sector s in location i. Using the estimate of ϑ and the values of L_{is} and R_{ks} observed from the data, we can solve (39) for ω_{is}, up to scale. Without loss of generality, we normalize the geometric mean of ω_{iA} to one by suitably choosing the unit of labor. The scale of $\omega_{iM}, \omega_{iN}, \omega_{iB}$ is chosen to match the employment share of each sector.[32] Finally, we recover the local wage rate in each sector, w_{is}, by $w_{is} = \omega_{is}^{1/\theta}$.

Given the recovered wages w_{is}, we can back out the floor space price Q_i from the floor space market clearing condition (31). We also back out the land prices $\mathbb{Q}_i$ by using the equation (19).

Step 4: Price-adjusted residential amenity. By (21), the share of workers who reside in location i can be written as

$$\lambda_i^R = \frac{\mathbb{A}_i W_i Q_i^{-(1-\alpha)\theta}}{\sum_k \mathbb{A}_k W_k Q_k^{-(1-\alpha)\theta}}, \tag{41}$$

where $W_i \equiv \sum_j \sum_s \omega_{is} d_{ij}^{-\vartheta}$ measures location i's commuting market access and $\mathbb{A}_i \equiv (A_i \mathbb{P}_i^{-\alpha})^\theta$ is the price-adjusted residential amenity in location i. Because W_i is immediately calculated using the values of ϑ and ω_{is}, (41) can be solved for $\mathbb{A}_i$, given the observed values of λ_i^R and Q_i.

Step 5: Price index of non-tradable services. Given the values of w_{is} for any pair of i and s and ξ_{ij} for any pair of i and j, we can back out the equilibrium values of P_i^N that rationalize the observed patterns of shopping and commuting trips. Specifically, we solve the goods market clearing condition (33) with respect to P_i^N.[33] In solving equations (33), we need the value of Φ_i,

the number of such shopping location choices increases to infinity, where $\psi_S = \zeta_S \theta_S$

[32]More specifically, we determine the scale of $\omega_{is}, s = M, N, B$ to satisfy $\lambda_s/\lambda_A = L_s/L_a$, that is,

$$\sum_i \sum_j \omega_{js} d_{ij}^{-\vartheta} = \frac{L_s}{L_A} \sum_i \sum_j \omega_{jA} d_{ij}^{-\vartheta}, \tag{40}$$

[33]Although (33) also contains other unknown values $\mathbb{P}_k^N$ and χ_k^N, these can be expressed by using P_i^N. As shown in (6), $\mathbb{P}_k^N$ is defined as a bundle of P_i^N for all locations i. Furthermore, combining (5), (6) and (8), we obtain an

which is defined as $\Phi_i = m_i \mathbb{Q}_i^{US} S_i + e_{US} L_i^{US}$. That is, Φ_i is the US-base related total consumption spending in municipality i by landowners and the US military personnel. We calibrate Φ_i by matching the observed GNI share of the US-base income from goods consumption and land rents. See Appendix C.2 for more details.

In solving the goods market clearing condition (33) with respect to P_i^N, we also need to determine the value of κ, governing the substitutability between tradable and non-tradable goods. After solving the equation (33) under many values of κ, we set κ to match the relative spending share for restaurants in the largest urban place (Naha) and the entire Okinawan economy, which is 1.16 according to the Okinawa Household Expenditure Survey in 1970. We find $\kappa = 2.07$, which is well within the 95% confidence interval reported by Hobijn and Nechio (2019).[34]

Step 6: Locational fundamentals. We back out the parameters on the exogenous amenities and productivity. First, although the price of agricultural goods, P^A, is not available, equation (10) enables us to identify the price-adjusted productivity of agricultural goods in location i, defined as $\widetilde{b}_i^A \equiv P^A b_i^A$, because the values of w_{iA} and Q_i are already known. Similarly, we define the price-adjusted productivity of manufacturing goods in location i as $\widetilde{b}_i^M \equiv P^M b_i^M$, and combine (11) and (12) to obtain the following expression: $\widetilde{b}_i^M = w_{iM}^{1-\gamma^M} Q_i^{\gamma^M} L_{iM}^{-\eta}$. Substituting the values of w_{iM}, Q_i, and L_{iM}, we can recover the value of $\widetilde{b}_i^M$. For the non-tradable service sector, we can solve equation (18) with respect to B_i^N, given the values of w_{iN}, Q_i, and $\mathbb{P}_i^N$. After obtaining the value of B_i^N, we can readily back out $\widetilde{b}_i^N$ from (17). Finally, it is also straightforward to recover the value of A_i because it satisfies $A_i = (\mathbb{A}_i)^{1/\theta} \mathbb{P}_i^{\alpha}$, where $\mathbb{A}_i$ is the price-adjusted residential amenity obtained in Step 4.

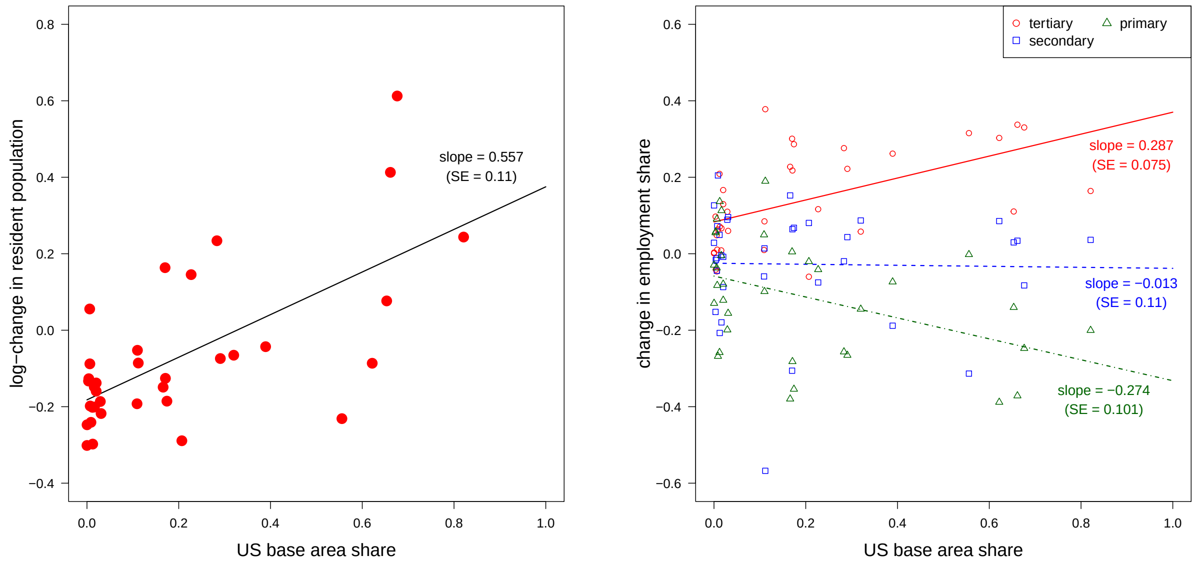
Model fit. As we have used information on the population and employment of each sector in each municipality in our calibration, our model prediction perfectly matches the observed values. To validate that our model exhibits a good performance for variables not used for our calibration, we compare the model-predicted residential income and floor space rents with their observed values. Figure C.1 shows that for both variables, the model prediction and the observed data exhibit a strong correlation (0.604 for residential income and 0.862 for floor space rent), which supports the idea that our model is a reasonable approximation of the Okinawan economy.

expression for χ_k^N as follows:

$$\chi_k^N = \frac{\alpha \left[\sum_l \xi_{kl} (P_l^N)^{1-\sigma}\right]^{(1-\kappa)/(1-\sigma)}}{1 + \left[\sum_l \xi_{kl} (P_l^N)^{1-\sigma}\right]^{(1-\kappa)/(1-\sigma)}},$$

which is based on our normalization, $P^T = 1$.

[34]Note that in our model, housing consumption is excluded from the non-tradable sector in defining the substitutability between tradable and non-tradable sectors. Hobijn and Nechio's (2019) estimate is conceptually in line with ours in distinguishing housing consumption from other non-tradable goods. Studies that include housing as a non-tradable good (e.g., Duarte and Restuccia 2010; Fajgelbaum and Redding 2022; Buera, Kaboski, Rogerson and Vizcaino 2022) tend to find a smaller elasticity of substitution between tradable and non-tradable goods.



(a) Resident population

(b) Employment share

Figure 5: The effects of US bases on urbanization and industrial structure

Note: We present a scatterplot of each municipality, where the horizontal axis is the US base area share. As the vertical axis, Figure 5a takes the change in the log of the residential population, and Figure 5b takes the changes in the sectoral employment share. Each point in the figures shows the changes from the counterfactual to the observed equilibrium. In Figure 5b, the red circles, blue squares, and green triangles represent the changes in the tertiary, secondary, and primary employment shares, respectively. Each figure also contains the linear fitted lines.

6 Counterfactuals

We consider a counterfactual situation in which the income inflow from the US bases is eliminated. Specifically, in our main counterfactual exercise in Section 6.1, we exclude all goods and service consumption of the US personnel and land rents from the US bases ($\Phi_i = 0$) and employment of Okinawans at the US bases ($L_{iB} = 0$ for all locations i) and compute the counterfactual equilibrium, holding other exogenous parameters at the observed levels.[35] In Section 6.2, we further assume that the land area occupied by US bases was returned for private use ($m_i = 0$ for all i). This counterfactual analysis corresponds to the case of fully eliminating the US bases from Okinawa Island. Section 6.3 reports additional results of our counterfactual analysis. Appendix D provides further details on our counterfactual analysis, including our computation procedure for the counterfactual equilibrium.

6.1 Main counterfactual results: No US-base income

We first analyze whether the US-base income induces urbanization and whether it accompanies industrialization by comparing the observed equilibrium and the counterfactual one. Figure 5 plots changes in population density and employment shares from the counterfactual equilibrium with no US-base income to the observed equilibrium with the US-base income. Thus, the figure

[35]Note that in a situation with $L_{iB} = 0$, it naturally follows that $w_{iB} = 0$ holds for all locations i.

visualizes the effects of the US-base income on each municipality, in a format comparable to our reduced-form results shown in Figure 4.[36]

Figure 5a reveals that the US-base income increases the population: a 10 percentage points increase in the US base area share, which is a measure of exposure to the US-base income, increases the population by 5.5%. This implies that a municipality with the highest area share of the US base is predicted to gain around 60% higher population because of the US-base income. Note that since our counterfactual analysis in this section assumes that the US base area cannot be used for private use (i.e., m_i is held the same as the observed value), the impact on the log population level equals that on the log population density. Therefore, measured either by population level or density, the US-base income contributes to urbanization in municipalities strongly exposed to it. Figure 5b shows that such urbanization was driven by substantial service growth: A municipality with the highest area share of the US base is predicted to have around 25 percentage points higher service employment share in the presence of the US-base income. However, it does not accompany manufacturing growth. Indeed, there is no statistically significant association between the manufacturing employment share and the exposure to the US-base income.

We visualize changes in the population distribution within the Okinawa island. In Figure 6, we illustrate changes in the population in each municipality by eliminating the US-base income. We observe that the middle part of the island, which is highly exposed to the US bases due to the presence of Kadena air base and other large camps (Figure 2), loses much of its population. Areas in the southern and northern part of the island, which are less exposed to the US-base income, gain population. This is consistent with Figure 5 that areas around the US bases urbanized due to the US-base income.

Overall, these results suggest that the US-base income could be an important driver of urbanization without industrialization. In our reduced-form analysis in Section 3.2, we find that areas highly exposed to the US bases were substantially urbanized, and this was driven by the growth of the service sector but not by manufacturing. Our counterfactual analysis reveals that the US-base income is an important reason behind this observed pattern. That said, the coefficients in Figures 5 are quantitatively smaller, in absolute value, than the reduced-form counterparts in Figure 4, implying that in addition to the US-base income, US bases also entail something else that induces further urbanization without industrialization. In Section 6.3, we come back to this issue, finding that the positive impact of the US bases on non-tradable productivity could be an important additional factor behind urbanization without industrialization.

We also analyze how floor space rents, non-tradable prices, and wages are associated with the US bases. In Figure 7a, we find that the US-base income increases floor space rents, consistent with the higher demand for residential and production floor spaces due to urbanization in areas highly exposed to the US-base income. Figure 7b shows that the non-tradable price index is also increasing in exposure to the US-base income. Intuitively, the US-base income may affect

[36]Note that Figure B.2 represents the changes from the situation without the US-base income (the pre-war observation) and the situation with the US-base income (the observation in 1970), which is the same as Figure 5.

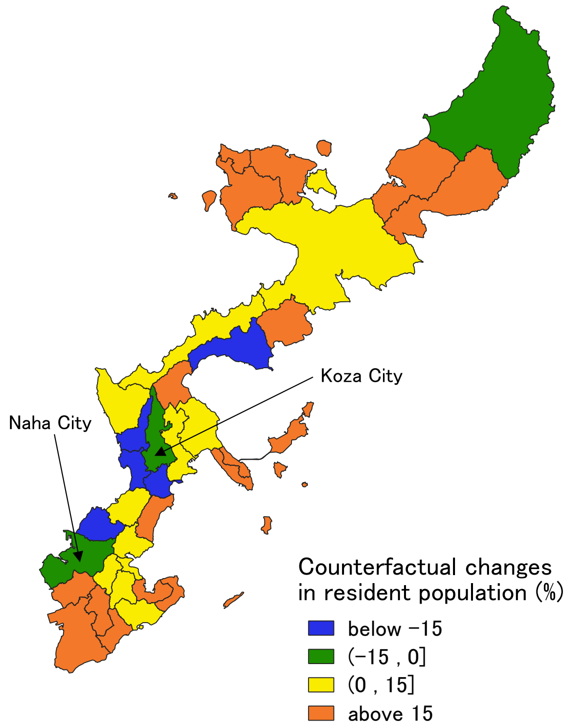
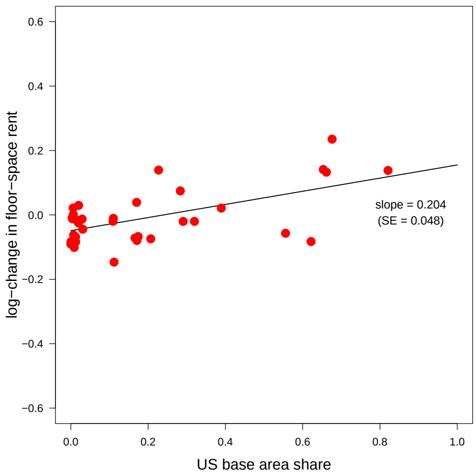


Figure 6: Counterfactual change in the population distribution

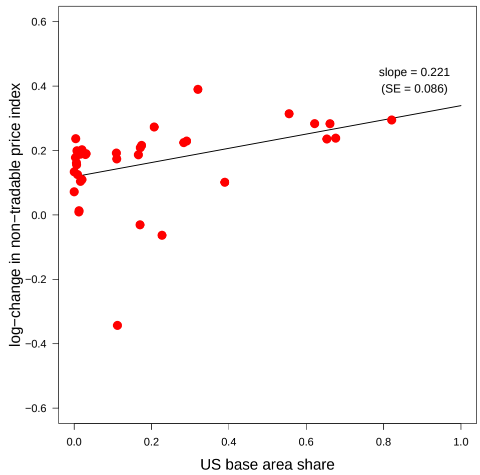
Note: The figure visualizes each municipality's change in the residential population from the observed to counterfactual equilibrium. The municipalities that experience an increase over 15%, an increase less than 15%, a decrease less than 15%, and a decrease over 15% are colored orange, yellow, green, and blue, respectively. The figure also indicates the locations of Naha and Koza cities, which were the first and second most populous cities in Okinawa as of 1970. The shape file of the Okinawa island is taken from the Digital National Land Information (*kokudo suchi joho*).

the non-tradable price index in two ways. First, by inducing the agglomeration of non-tradable services, it reduces the non-tradable service price index through the love of variety. Second, by increasing the floor space rents as in Figure 7a, the non-tradable price may rise due to the higher production cost. Here, the latter force dominates and we observe the upward-sloping relationship in Figure 7b. In Figure 7c we observe a very strong positive association of non-tradable wages with the exposure to the US-base income, a moderate negative association of agricultural wages with it, and almost no association of manufacturing income with it. While the higher floor space rents tend to dampen the wages, the non-tradable wages rise because of economies of scale in non-tradable goods production and the higher non-tradable prices. These forces lead to higher non-tradable wages in areas highly exposed to the US-base income.

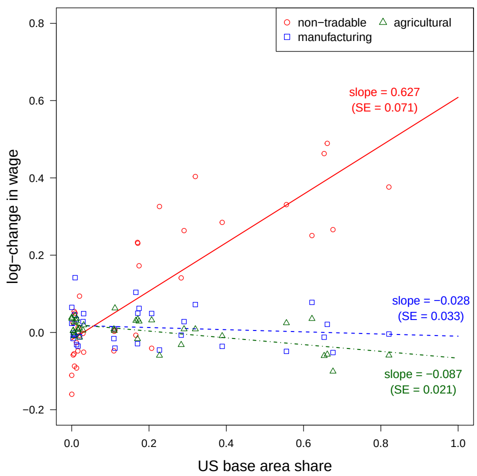
We finally turn to the aggregate outcome. Table 2 presents the model-implied welfare, GNI, and the sector-specific employment share in the whole Okinawan economy. Relative to the observed value in the first row, both the welfare and the GNI are lower in the counterfactual economy in the second row: the welfare is about 16.9% lower and the GNI is 27.3% lower. Behind this, there is a substantial reversal in the development process: the agricultural employment share increases by about 60% compared with the data. Moreover, the non-tradable



(a) Floor space rent



(b) Non-tradable price index



(c) Wages

Figure 7: The effects of the US bases on rent, price, and wages

Note: We present a scatterplot of each municipality, where the horizontal axis is the US base area share. As the vertical axis, Figure 7a takes the change in the log of the floor space rent, Figure 7b takes the change in the log of the non-tradable price index, and Figure 7c takes the changes in the log of the sectoral wage. Each point in the figures shows the changes from the counterfactual to the observed equilibrium. In Figure 7c, the red circles, blue squares, and green triangles represent the changes in the log of wages in the tertiary, secondary, and primary sectors, respectively. Each figure also contains the linear fitted lines.

	Welfare (Observed=100)	GNI (Observed=100)	Employment share (%)			
			Agricultural	Manufacturing	Non-tradable	US base
Observed values in 1970	100.0	100.0	18.5	17.3	51.6	12.6
No US-base income (Section 6.1)	83.1	72.7	30.4	23.8	45.8	0.0
No US-base income + land return (Section 6.2)	87.8	73.5	30.9	23.1	46.0	0.0

Table 2: Summary of the changes in welfare, GNI, and industrial structure

Note: The table reports welfare, GNI, and the sectoral employment share in the entire Okinawa. The first row shows those in the observed equilibrium as of 1970. The second row shows those in our baseline counterfactual equilibrium that eliminates US-base income, which we consider in Section 6.1). The third row shows those in the counterfactual equilibrium that allows the US-base land to be available for private uses in addition to eliminating US-base income, which we consider in Section 6.2). We normalize the welfare and GNI such that the observed values in 1970 are 100.

employment share also declines while the manufacturing employment share increases by around 30%. These results suggest that the reversal of "urbanization without industrialization" involves some industrialization, but also a substantial step back in the growth of the modern sector and the aggregate loss in the welfare and income. To some degree, this is consistent with some concern in the late 1960's that the life in Okinawa would substantially worsen if the US bases were eliminated due to the reversion of Okinawa to Japan in 1972. For example, US Army Lieutenant General Ferdinand T. Unger, the High Commissioner of the Ryukyu Islands, stated in 1968 that "if all the US military retreats from the Okinawa at once..., the living standard of Okinawa would necessarily be less than the half of its current level" (Toriyama 2009).[37] The aggregate negative economic impact presented in Table 2 is not as drastic as what Lieutenant General Unger imagined, but our model predicts substantial negative economic impacts: nearly 30% of the aggregate income would be lost.

6.2 Counterfactual results when the US base area was returned to the Okinawans

The counterfactual result suggests the importance of the US-base incomes and expenditures in explaining "urbanization without industrialization" in Okinawa. However, a notable feature of the US bases is that the land for the bases is unavailable for private uses, including production and housing consumption. With this *land-occupying effect* the US bases may adversely affect the economy around the US bases. We analyze whether the US-base income induces urbanization without industrialization even in the presence of the land-occupying effect. Moreover, the land-occupying effect is a central issue in today's discussion of the economic benefits of the US bases: some emphasize that the land-occupying effect is large (e.g., Okinawa Prefecture Government 2007), while others suggest it may be smaller (e.g., Kusuyama 2012). Our analysis in this section also contributes to this debate.

[37]After Junji Nishime, a famous Okinawan politician, mentioned this type of argument in his speech in 1968, it became popular in Okinawa as the "potatos and barefoot" argument, meaning that the quality of life in Okinawa would return to that right after the devastation in the WW2 if the US bases were eliminated (Toriyama 2009).

Specifically, we repeat the counterfactual analysis in Section 6.2 by setting $\Phi_i = 0$ and $L_{iB} = 0$ for all i, but now we additionally set $m_i = 0$ for all i so that all the land area occupied by the US bases is now available for private use. Results are reported in Appendix D.3. The impact of the US bases on population density magnifies because the US bases reduce the amount of the available land, although the impact on the population level somewhat shrinks. The impact of the US bases on the employment share is almost unchanged. The impact on floor space rents, non-tradable price index, and wages are also qualitatively the same, although the floor space rent tends to rise more with the US bases because of fewer available land, which tends to increase the non-tradable price indices and wages around the US bases. Table 2 presents the aggregate impacts on this counterfactual scenario. Compared with the counterfactual results in Section 6.1, there is little impact on the employment share. The GNI increases because more land is used for production rather than the US bases that do not produce goods, and the welfare also improves thanks to the higher income and lower floor space rents. That said, the counterfactual of the no US bases predicts worse welfare and GNI than the observed equilibrium with the US bases. Overall, although there are some quantitative differences, our qualitative conclusion in Section 6.1 about the impact of the US bases remains unchanged.

In Appendix D.3, we provide a formal decomposition of the importance of the US-base income effect and the land-occupying effect, using the method of Hottman, Redding and Weinstein (2016). We find that the higher population density around the US bases comes both from the land-occupying effect and the US-base income, which is natural because it directly reduces the habitable land area. Importantly, land-occupying effect does not explain why service-sector employment is higher and agriculture employment is lower around the US bases, implying that variation in the economic structure is explained almost entirely by the US-base income. Overall urbanization around the US bases, if measured by population density, is partially explained by the land-occupying effect, but it does not explain the growth of the service sector or the absence of manufacturing growth.

6.3 Additional analyses

The effect of the US bases on fundamental productivity and amenities. In addition to introducing the US-base income through goods consumption, employment, and land rents, the US bases may affect fundamental productivity and amenities. For example, they may come with infrastructure development in nearby areas, enhancing the productivity and residential amenity. While we remain agnostic about the mechanism behind how the US bases affect fundamental amenities and productivity, here we assess how significant these effects are and how they affect urbanization without industrialization.

To account for this possibility in a simple way, we assume that each location's exogenous productivity and residential amenity are affected by the area share of the US bases in each

	Productivity			Amenities
	Non-tradable	Manufacturing	Agricultural	
US base area share	1.117*	0.012	0.050	0.078
	(0.569)	(0.517)	(0.151)	(0.246)
Observations	35	35	35	35
R^2	0.105	0.000	0.003	0.003

Standard errors are reported in parentheses.
* p < 0.1, ** p < 0.05, *** p < 0.01

Table 3: Effects of the base construction on local fundamentals

Note: The table reports the results of the estimating equations (43) by the OLS. The first, second, and third columns present the results when we take the log of fundamental productivity in the non-tradable, manufacturing, and agricultural sectors, respectively. The fourth column shows the result when we take the log of the residential amenities.

location and take the following forms:

$$\begin{aligned} \widetilde{b}_i^s &= \mathcal{B}^s \widetilde{\mathcal{B}}_i^s \exp\left(\varsigma_b^s m_i\right) \quad \text{for } s \in \{A, M, N\}, \\ \text{and} \quad A_i &= \mathcal{A}\widetilde{\mathcal{A}}_i \exp\left(\varsigma_a m_i\right), \end{aligned} \tag{42}$$

where $\mathcal{B}^s$ and $\mathcal{A}$ are identical across locations and control the average levels of productivity and amenity; $\widetilde{\mathcal{B}}_i^s$ and $\widetilde{\mathcal{A}}_i$ are the location-specific terms; and ς_b^s and ς_a govern the effects of base construction on productivity of sector s and residential amenity, respectively. Under this specification, the productivity and residential amenity net of the effects of base construction are $\mathcal{B}^s\widetilde{\mathcal{B}}_i^s$ and $\mathcal{A}\widetilde{\mathcal{A}}_i$, respectively.

To exclude the effects of base construction from local fundamentals, we take the log of both sides in equation (42) and obtain the following linear regression formula:

$$\begin{aligned} \ln \widetilde{b}_i^s &= \ln \mathcal{B}^s + \varsigma_b^s m_i + \ln \widetilde{\mathcal{B}}_i^s, \\ \ln A_i &= \ln \mathcal{A} + \varsigma_a^s m_i + \ln \widetilde{\mathcal{A}}_i, \end{aligned} \tag{43}$$

where we treat $\ln \mathcal{B}^s$ and $\ln \mathcal{A}$ as constants and $\ln \widetilde{\mathcal{B}}_i^s$ and $\ln \widetilde{\mathcal{A}}_i$ as the error terms. Estimating these regression equations by the OLS, the values of the local fundamentals net of the effects of base construction can be calculated by taking the exponential of the sum of the constant term and the residuals. Motivated by the same logic of our instrumental variable strategy in Section 3.3, although our counterfactual simulations focus on the Okinawan economy as of 1970, we use the area share of the US bases as of 1956 when conducting these regressions to mitigate the endogeneity that the contemporaneous US base area is correlated with contemporaneous productivity or amenities.[38]

Table 3 shows the results of the regressions based on equation (43). Although the coefficients of the US base area share (i.e., ς_b^N, ς_b^M, ς_b^A, and ς_a) are all positive, only ς_b^N is large and marginally

[38]That said, using the 1970 US base area share to measure m_i hardly changes our results.

statistically significant while the remaining three coefficients are near zero and insignificant.[39] This suggests the possibility that the construction of the US bases accompanied factors favoring the productivity of the non-tradable sector productivity. For example, anecdotal evidence suggests that near the US bases, the US invested in the infrastructure suitable for commercial activities near the US bases, such as Koza city (Kato 2014). Another possibility is that the US bases likely provided opportunity to engage in service sector jobs, and such experiences raised workers' productivity in non-tradable sectors through learning by doing or accumulation of sector-specific human capital (c.f., Neal 1995; Autor, Dorn and Hanson 2016). While we unfortunately do not have enough data to unpack the cause of non-tradable productivity growth around the US bases, our results in Table 3 suggest the potential importance of these channels.

In Section 6.1, we have seen that the US-base income causes substantial urbanization without industrialization in areas highly exposed to the US-base income. However, relative to our reduced-form analysis of the observed data in Section 3.2, the degree of urbanization without industrialization caused by the US-base income is weaker than the observed degree of urbanization without industrialization around the US bases. Moreover, while our counterfactual analysis of the US-base income in Section 6.1 does not consider the land-occupying effect of the US bases, considering it in Section 6.2 does not change this undershooting result. To assess the role of the effect of the US bases on fundamentals in solving this puzzle, we conduct a counterfactual analysis as in Section 6.2 but now using the fundamental productivity $\mathcal{B}^s\widetilde{\mathcal{B}}_i^s$ and amenities $\mathcal{A}\widetilde{\mathcal{A}}_i$, which net out the effect of the US bases on fundamentals by setting $m_i = 0$ in regression equations (43).[40] Figure D.4 reports the regression coefficients from regressing the fundamentals on the area share of the US bases, which correspond to the coefficients reported in Figure 4. We find that the coefficients are now close to the reduced-form counterparts in Figure 4, suggesting that the observed degree of urbanization without industrialization due to the exposure to the US bases is now almost fully explained by our model.[41] Overall, the effect of the US bases on fundamental non-tradable productivity and the US-base income are both important drivers of urbanization without industrialization.

Endogenizing total population of Okinawa. Although our baseline framework builds on a closed city model so that the total population of Okinawa is given exogenously, it is straightforward to endogenize it by extending the framework to a small-open city model, in which the total population can change in response to changes in the welfare level. Appendix D.2 describes the equilibrium condition and the computational procedure for the small-open city setting.

[39]While disamenities of the US bases, such as accidents, noise, pollution, and incidents of sexual offenses, have been a major political issue in Okinawa (Toriyama 2009; Taira 2012), the null effect on the model-implied fundamental amenities might imply some offsetting positive amenity effects of the US bases, such as better infrastructure investment.

[40]Consistent with Table 3 that only the non-tradable productivity exhibits strong association with the US bases, applying this procedure only to the non-tradable productivity yields similar results.

[41]Note, however, that this analysis does not eliminate the effect of the US bases that are uniform throughout Okinawa. In other words, since the regression analysis in equation (43) utilizes the variation in the US base area share across municipalities, we cannot identify the effect of the US bases on the overall productivity and amenity levels of Okinawa. This is a limitation of our analysis.

We conduct the same analysis as in Section 6.1 under the small-open city setting and examine the effects of the US bases on the residential population and industrial structure in each municipality. First, the total population decreases by around 25% relative to the observed value. This is consistent with the decline in welfare when the US-base income is eliminated, as seen in Table 2. The lower welfare induces migration out of Okinawa to the outside economy, leading to a lower total population. However, it does not affect our main results that within the Okinawa island, areas that are more exposed to the US-base income are more urbanized by service sector growth. Indeed, Figure D.5 repeats the same analysis as Figure 5 in Section 6.1 with endogenous total population, showing that the association between the US-base area share and the population or employment share remains almost the same. Overall, while endogenizing the total population predicts a reduced total population when the US-base income is eliminated, it does not affect our conclusion that urbanization without industrialization is induced by the US-base income.

7 Conclusion

This paper investigates how the inflow of external income shapes the pattern of urbanization and the economic structure. We focus on the unique case of Okinawa, Japan, where US military bases have historically constituted a substantial portion of aggregate income-at times, nearly half. The locations of these bases were determined by military considerations, rendering the resulting income inflows exogenous to pre-existing local economic conditions, for which we provide supporting evidence. Using newly collected and digitized municipal-level data, we first document that areas surrounding US bases experienced rapid urbanization, primarily driven by expansion in the service sector rather than manufacturing. To analyze these dynamics, we develop an intra-city quantitative spatial model that incorporates the US bases as consumers, employers, and land users, thereby generating increased demand for non-tradable service goods. We calibrate this model to the Okinawan economy in 1970 and conduct counterfactual analyses by removing the income associated with US bases. Our findings indicate that, relative to the counterfactual scenario, municipalities with the highest exposure to US-base income experienced approximately a 60% increase in population density and a 25 percentage point rise in the share of service sector employment. These results suggest that the income inflows from US bases significantly contributed to urbanization without industrialization in areas around the US bases. Furthermore, we find that eliminating US-base income would reduce worker welfare by around 17% and the aggregate income by 27%. This indicates that such urbanization, while potentially inefficient from a "Dutch disease" perspective, can nonetheless enhance welfare. Notably, the negative welfare effect remains even when the land occupied by US bases is hypothetically returned for private use, implying that, in 1970, the removal of US bases would have diminished welfare in Okinawa.

Our conclusion that income inflows from the outside economy lead to urbanization without industrialization might be informative of the consequences of such inflow of external income in other contexts, including the operation of large facilities like the military bases and universities, tourism, natural resources, fiscal transfers, and foreign aid. Our result also suggests that such urbanization without industrialization would be welfare-enhancing despite the concerns for the Dutch disease, implying that policymakers might want to invite income inflows to promote it. That said, it is also well-known that urbanization entails costs such as worsening sanitation and slums (Bryan et al. 2020), and the welfare implication of urbanization without industrialization could be different if the government is less prepared for such urban costs than in the case of Okinawa. A more detailed analysis of the potential urban costs in the process of urbanization without industrialization is an important issue left for future research.

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Appendix to “Urbanization without Industrialization: Evidence from US Bases in Okinawa” (Not for Publication)

A Details on the data

Okinawan workers at the US bases. While the number of Japanese workers at the US bases in each municipality is not typically available in Japanese Census Tabulations, such information is available in the 1970 census from https://www2.archives.pref.okinawa.jp/opa/OPA600_RESULT_BUNSYO.aspx?cont_cd=R00008312B (in Japanese, May 1 2025). We also obtain such information from 1980 and onward using the Custom-made Tabulation (https://www.e-stat.go.jp/microdata/jisseki/order/30020020240003, in Japanese, last accessed on May 1 2025). In addition to the residence-based counts of the US base workers, these data provide the amount of employment of Okinawan US base workers in each municipality.

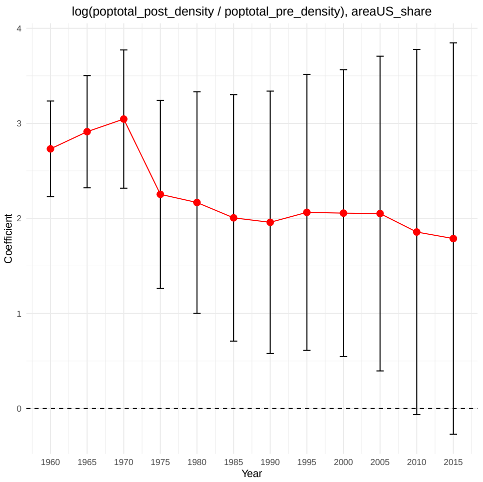
US base areas. The US base area in 1956 is obtained from *Okinawa Nenkan* (https://www2.archives.pref.okinawa.jp/opa/OPA600_RESULT_BUNSYO.aspx?cont_cd=T00017797B&src_keyword=&keyword_hit=&lang=jp), while that during the occupation period is obtained from the Ryukyus (Okinawa) Statistical Yearbook, and that after Okinawa's return to Japan is obtained from *Okinawa-no beigun kichi* and *Okinawa-no beigun oyobi jieitai kichi*. We also use the shape file of the US bases constructed by the Okinawa Prefecture government, as illustrated in Figure 2. The data are available online at http://gis.pref.okinawa.jp/OpenData/ (in Japanese, last accessed on May 2 2025).

Addressing municipal mergers and divisions. We create a correspondence table between the municipality definitions of years t_1 and t_2 and use the municipality definitions by suitably aggregating municipalities. In general, municipalities have tended to merge since 1950, implying that when $t_2 > t_1$, we can use the municipality definition of t_2 by suitably aggregating municipalities in year t_1. When t_1 is the pre-WW2 period and t_2 is the post-WW2 period, we also adjust the t_2 municipality definition by aggregating municipalities belonging to the same municipality at t_1 but divided as of t_2. There were two exceptional municipalities in the pre-WW2 period (*misato-son* and *oozato-son*) that got divided into two around 1950, and each was later merged into different municipalities. We address this by distributing the 1938 variable (e.g., population) in proportion to the shares of each variable as defined after the 1950 division, and then aggregate them into the municipality definition after the mergers.

B Supplementary reduced-form results

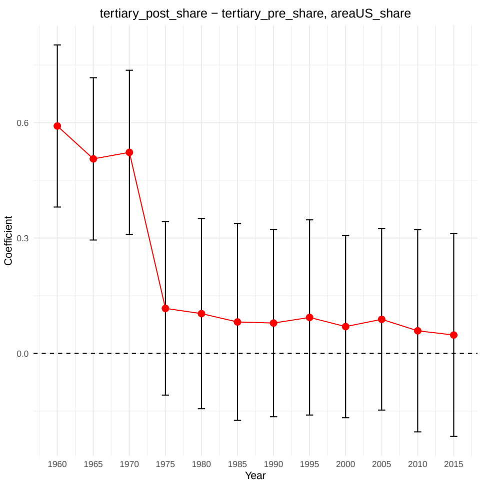
B.1 The impact of the US bases in different years

We examine how the association between US bases and various economic outcomes has changed over time. In Figure B.1 we present the estimated regression coefficient β_t in equation (3) for different years $t = 1960, 1965, \ldots, 2015$. In Figures B.1a and B.1b we find that the effect on population density and population is estimated to be positive in all periods, although the coefficient becomes much smaller after the reversion of Okinawa in 1972, where the GNI share of the US-base income dropped substantially (see Figure 3). Similarly, Figure B.1c suggests the positive impact of the US bases on the service employment share is observed in all years, although the magnitude is substantially smaller after 1972. This trend is mostly due to the growth of the service employment share in municipalities away from the US bases, rather than the decline in municipalities around the US bases. The agricultural employment share in Okinawa is less than 5% today, while services account for 80% (Figure 1b). Figure B.1d shows little association between manufacturing employment share and US bases throughout the sample period. As a result, a negative association between agricultural employment share with the US base is also observed in all years in Figure B.1e, albeit statistical significance is limited after 1972.



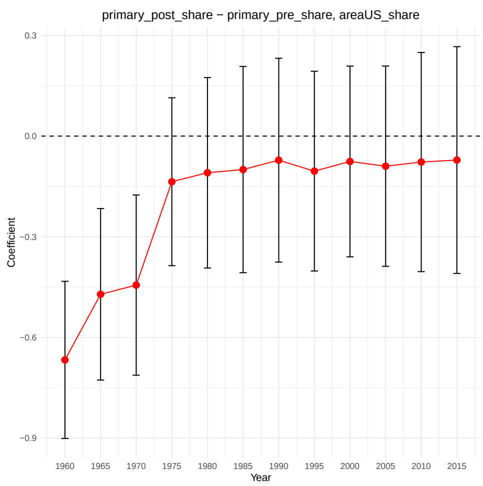
(a) Population density

(b) Population level



(c) Service share

(d) Manufacturing share



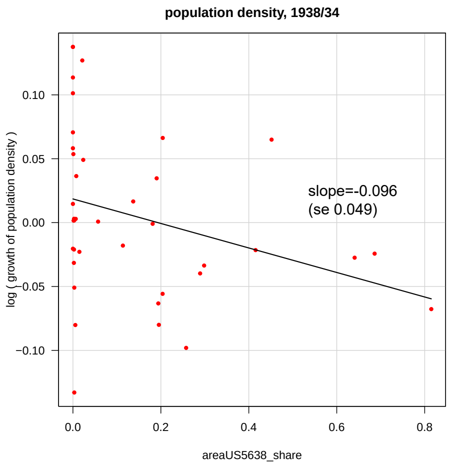
(e) Agriculture share

Figure B.1: Urbanization without industrialization around the US bases: Long-run Perspective

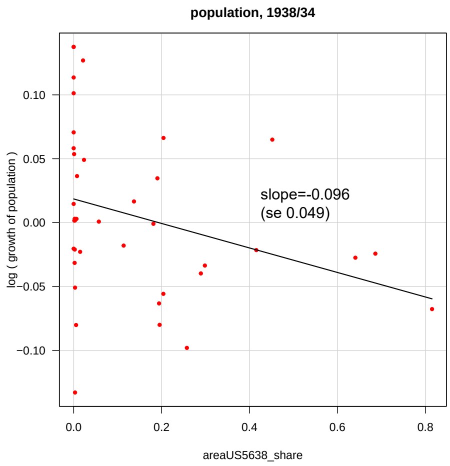
Note: We report the estimated β_t in the first-difference specification (3) by the ordinary-least-squares for $t = 1960, 1965, \cdots, 2015$. As the outcome variable, Figure B.1a takes the change in the log population density, Figure B.1b takes the change in the log population, Figure B.1c takes the change in the service employment share, Figure B.1d takes the change in the manufacturing employment share, and Figure B.1e takes the change in the agriculture employment share. The black bars represent the 95% confidence intervals.

B.2 Testing the pre-trends

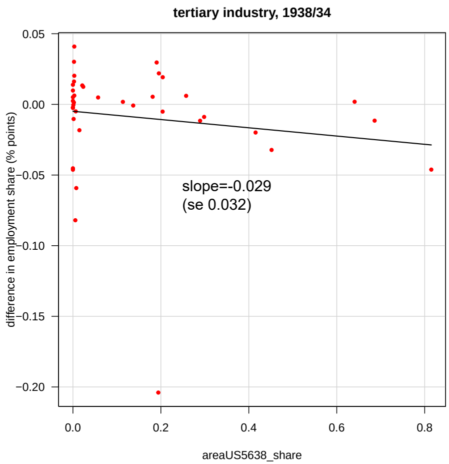
Figure B.2 presents the scatterplots and egression results of equation (3), where the outcome variable is the change from 1934 to 1938 and the explanatory variable is the area share of the US bases in 1956. As this period was prior to the actual placement of US bases, this analysis examines whether the pre-existing trends were correlated with the US base area share in 1956. We find, if any, noisy but negative trends for population variables, in contrast to the post-war positive association found in Figure 4. We do not find any trend in employment share by industry. Overall, there is little evidence that our main findings (Results 1 and 2) are spuriously driven by the pre-trend.



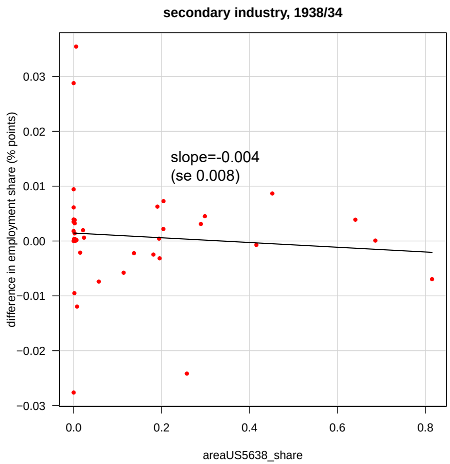
(a) Population density



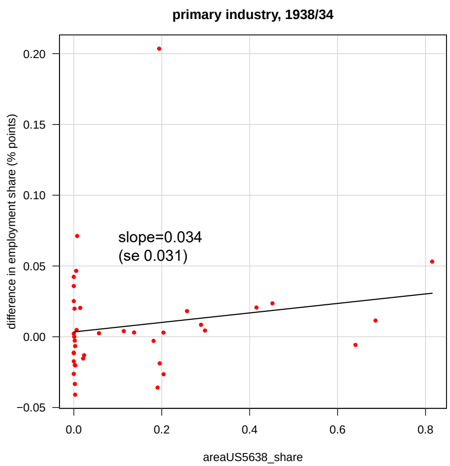
(b) Population level



(c) Service share



(d) Manufacturing share



(e) Agriculture share

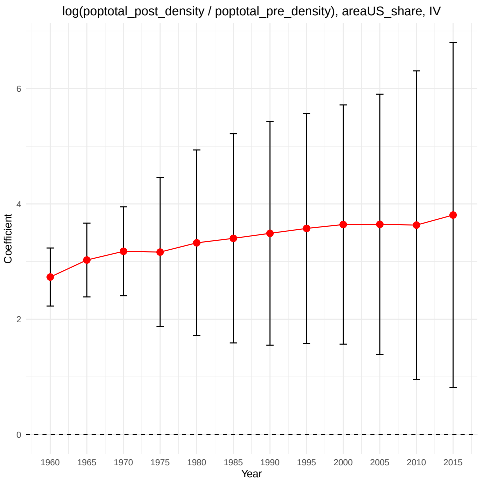
Figure B.2: Placebo test: 1938 cross-section

Note: We present a scatterplot of each municipality, where the horizontal axis is the US base area share. The format is the same as Figure 4 but the outcome variables are changes from 1934 to 1938, prior to the actual installation of the US bases. Note that Figures B.2a and B.2b look exactly the same (except for the scale of the vertical axis) because the actual US base area was 0 in both 1934 and 1938, keeping the habitable area constant. The linear fitted lines are also shown.

B.3 Addressing endogeneity of US base returns

To address the concern that changes in the US base area share might be endogenous, we use the pre-determined 1956 base share as an instrument in estimating the equation (3). Figure B.3 replicate Figure B.1 using this instrumental variable strategy.[B.1] Overall, although the quantitative impacts of the US bases might seem somewhat magnified, our main qualitative conclusions (Results 1 and 2) remain the same.

[B.1] In estimating by the two-stage least squares, we find little indication of the weak instrument. In our regressions from 1960 to 2015, first-stage F statistics is highest in 1965 at 226.16 and lowest in 2015 at 27.63.

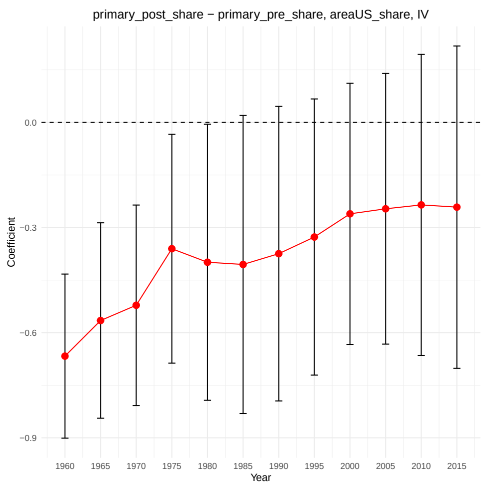


(a) Population density

(b) Population level

(c) Service share

(d) Manufacturing share



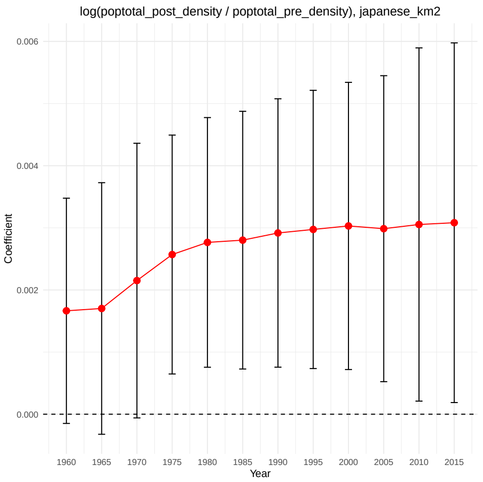
(e) Agriculture share

Figure B.3: Urbanization without industrialization around the US bases (IV estimation)

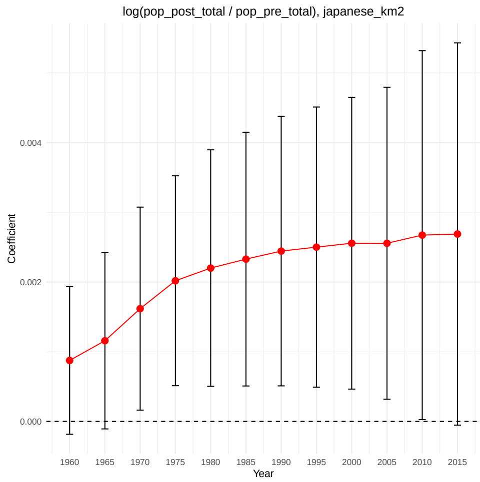
Note: We report the estimated β_t in the first-difference specification (3) by the two-stage least squares for $t = 1960, 1965, \cdots, 2015$, where the US base area share in 1956 is used as an instrument. Note that since our 1960 analysis uses the 1956 base area due to data availability, the first-stage is degenerate, so the estimate equals the OLS. The black bars represent the 95% confidence intervals. Other details follow Figure B.1.

B.4 Using alternative measure of base importance

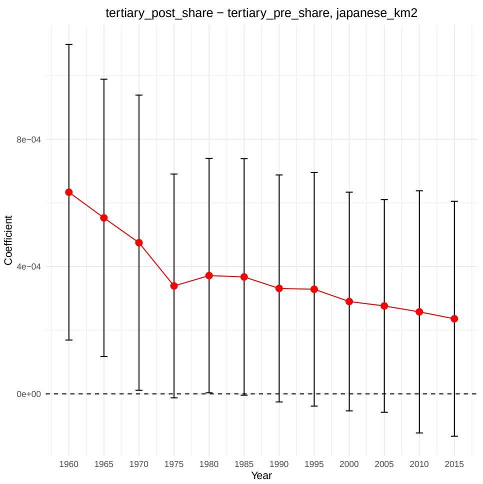
Instead of the US base area share in the specification (3), we use alternative measures of the importance of each US base, based on the number of Japanese workers or US military personnel. The data are taken from Komeito (1969), which reports the number of Japanese workers and US military personnel at each base. Note that since Komeito (1969) is not based on the official statistics but rather information gather by a political party, there could be a significant measurement error. We aggregate this information at the municipality level and divide it by the municipality's habitable area. In Figures B.4 and B.5 we use the number of Japanese (Okinawan) workers at the US bases and the US military personnel in each municipality, respectively. Although the estimates are noisy and we cannot make a strong conclusion, a positive impact on population density and service employment share is observed in both cases, at least before the reversion of Okinawa in 1975.



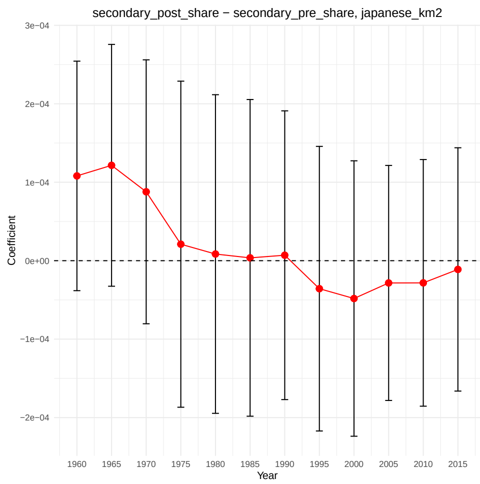
(a) Population density



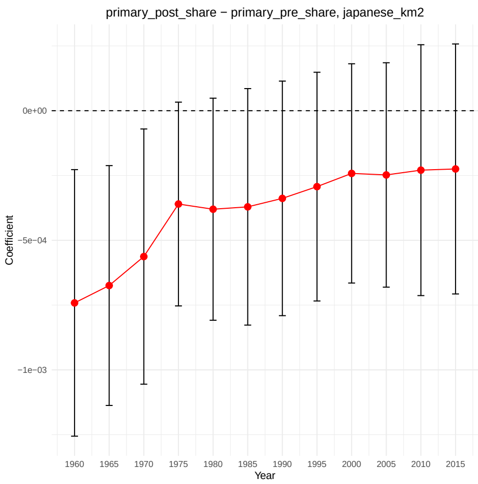
(b) Population level



(c) Service share



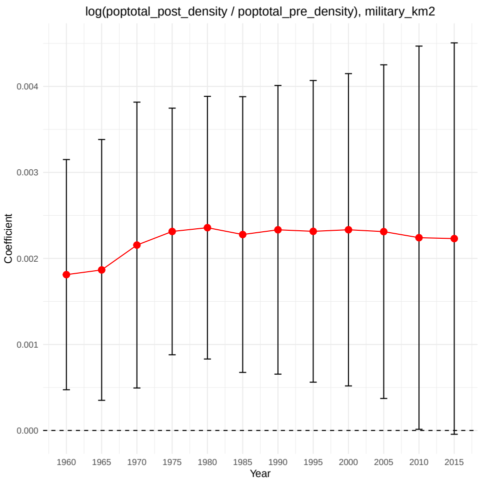
(d) Manufacturing share



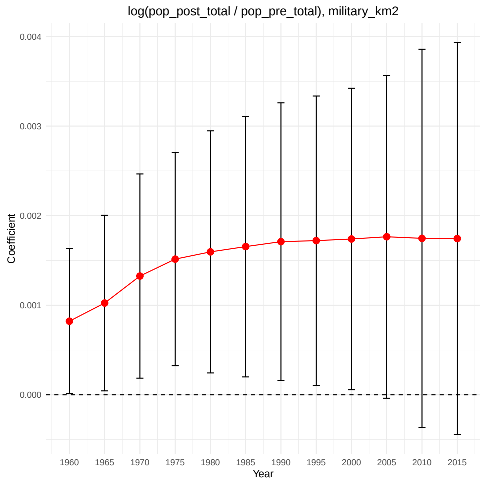
(e) Agriculture share

Figure B.4: Urbanization without industrialization and the US bases (Japanese worker)

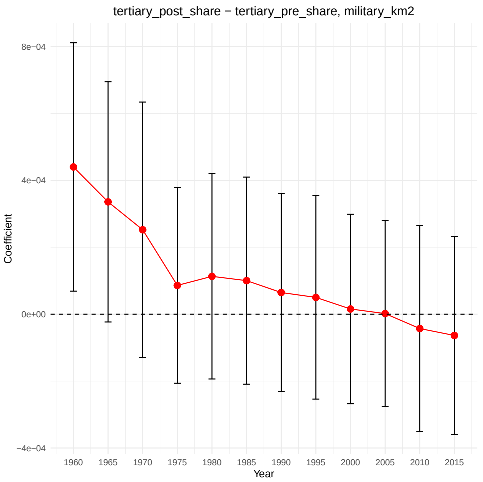
Note: We report the estimated β_t in the first-difference specification (3) by the OLS for $t = 1960, 1965, \cdots, 2015$, where we replace the explanatory variable with the number of Japanese workers per square kilometers taken from Komeito (1969). Other details follow Figure B.1.



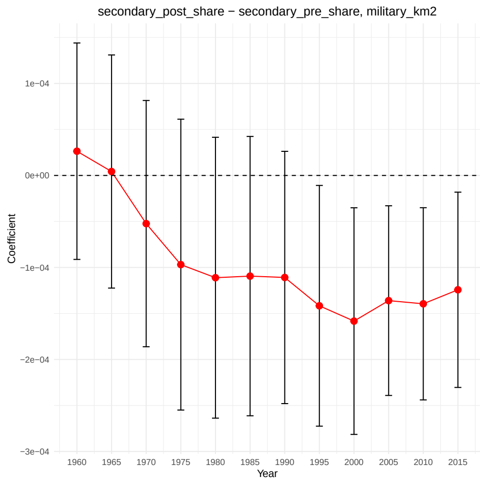
(a) Population density



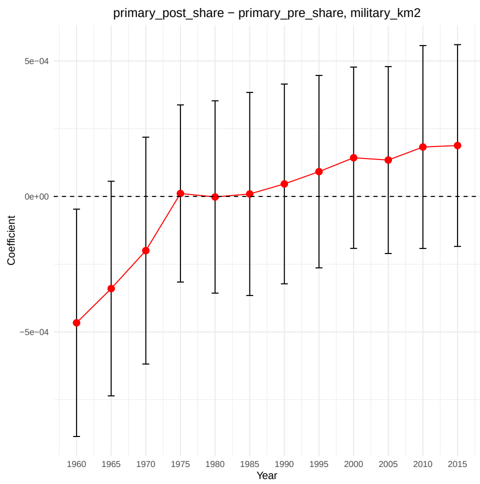
(b) Population level



(c) Service share



(d) Manufacturing share



(e) Agriculture share

Figure B.5: Urbanization without industrialization and the US bases (US military personnel size)

Note: We report the estimated β_t in the first-difference specification (3) by the OLS for $t = 1960, 1965, \cdots, 2015$, where we replace the explanatory variable with the number of US military personnel taken from Komeito (1969). Other details follow Figure B.1.

B.5 Disaggregating the impact on service-sector employment

In order to analyze which service sector is particularly associated with US base area growth, we analyze the employment share of the disaggregated service sector in 1970. Specifically, we examine the employment share of wholesale&retail, finance, real estate, transportation, infrastructure, intangible service, public work, and other unclassified jobs. Because pre-war employment share data are not available in the same industry classification, we estimate the following simple cross-sectional regression for each sector j:

$$y_{ij1970} = \beta_t \text{USBaseShare}_{i1970} + \tau_{j1970} + \epsilon_{ij1970}. \tag{B.1}$$

Table B.1 presents the results. We find that two major sectors that have close association with consumers, Wholesale&Retail and Intangible Service, are strongly associated with the US base area share. This is consistent with our expectation that the US base will stimulate a large consumption demand. The third largest sector, transportation, has no significant association with US bases, which might be expected given that transportation probably matters more for businesses than the above two sectors. The remaining sectors are not very important in terms of the employment share in the entire economy, but we also find a significant positive association for finance and infrastructure, which would matter for both consumers and businesses.

	Service employment share							
	Wholesale&Retail	Finance	Real Estate	Transportation	Infrastructure	Intangible Service	Public Work	Unclassified
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
US base area share	0.214^{***}	0.009^{*}	0.004^{***}	-0.035	0.013^{***}	0.339^{***}	-0.007	0.0001
	(0.047)	(0.005)	(0.001)	(0.023)	(0.003)	(0.054)	(0.008)	(0.0001)
Averate employment share	0.162	0.009	0.002	0.056	0.006	0.220	0.038	0.000
Observations	29	29	29	29	29	29	29	29
R^2	0.434	0.111	0.318	0.082	0.442	0.593	0.027	0.061

*p<0.1; **p<0.05; ***p<0.01

Table B.1: Service employment share by sector and the US base area share (1970)

Note: We report the regression results from estimating equation (B.1), where the outcome variable is the employment share of wholesale&retail, finance, real estate, transportation, infrastructure, intangible service, public work, and other unclassified jobs in 1970. To be comparable with our main reduced-form analysis in Section 3.2, we aggregate municipalities in 1970 that belong to the same municipality in 1938.

C Calibration details

C.1 Gravity equation estimation

Commuting gravity equation. We estimate the commuting and shopping gravity equations. We use microdata of the Okinawa person trip survey in 1977. We measure the bilateral travel distance between the centroid of municipality i and k, d_{ij}, by using the newly-digitized road network data from 1973. We then assume that the commuting cost is written as $\tau_{ij} = d_{ij}^{\zeta}$, where ζ represents the elasticity of the commuting cost with respect to commuting distance. Given this, we estimate the commuting gravity equation (36) by the Pseudo-Poisson Maximum Likelihood, which is our preferred specification given the desirable theoretical properties (Silva and Tenreyro 2006). We also estimate the equation (36) using the OLS.

Table C.1 presents estimation results. In Column 1, our preferred specification, the commuting cost elasticity times the Fréchet dispersion parameter ($\zeta\theta$) is estimated to be 1.71. This estimate is consistent with previous estimates of commuting gravity equations, such as Persyn and Torfs (2016) and Kreindler and Miyauchi (2023). Using the OLS in Column 2 yields 1.81. which is close to our baseline estimate of 1.71. We therefore use 1.7 as our preferred estimate. Given that we set $\theta = 2.19$, we have $\zeta = 1.7/2.19 \simeq 0.78$.

Shopping gravity equation. We estimate the shopping gravity equation (38). We use the 1977 Person Trip Survey, restricting the sample to shopping and leisure trips. See Table C.2 for estimation results. The estimate is -2.62 in PPML and 1.48 in OLS. We use the value $\psi_S = 2.3$ in our calibration, which is consistent with our preferred PPML specification but takes account of the fact that the OLS yields a smaller elasticity.[C.1]

[C.1] Moreover, the value $\psi_S = 2.3$ equals the PPML estimate from the 1989 Person Trip Survey, which yields (standard error=0.10).

	(1)	(2)
Log distance ($-\zeta\theta$)	-1.7109^{***}	-1.8185^{***}
	(0.0716)	(0.0813)
Method	PPML	OLS
N	552	355
R^2		0.811

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.1: Commuting gravity estimates

Note: We estimate the commuting gravity equation (36) using the 1977 person-trip survey data in Okinawa. We restrict the sample to commuting trips. Column 1 uses the Pseudo Poisson Maximium Likelihood and Column 2 uses the OLS.

	(1)	(2)
Log distance ($-\psi_S$)	-2.6220^{***}	-1.4777^{***}
	(0.1661)	(0.1958)
Method	PPML	OLS
N	529	118
R^2		0.693

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.2: Shopping gravity estimates

Note: We estimate the commuting gravity equation (38) using the 1977 person-trip survey data from Okinawa. We restrict the sample to shopping or leisure trips. Column 1 uses the Pseudo Poisson Maximium Likelihood and Column 2 uses the OLS.

C.2 Calibrating Φ_i

In solving equations (33), we need the value of Φ_i, which is defined as $\Phi_i = m_i \mathbb{Q}_i^{US} S_i + e_{US} L_i^{US}$. In other words, Φ_i is the US-base related total consumption spending in municipality i by landowners and US military personnel. We suppose that the observed land rents of US bases, $\mathbb{Q}_i^{US,obs}$, and the income of US personnel, $e_{US,obs}$ are transformed into the units in the model by the normalization factor ϖ so that $\mathbb{Q}_i = \varpi \mathbb{Q}_i^{US,obs}$ and $e_{US} = \varpi e_{US,obs}$.[C.2] Here, we obtain $\mathbb{Q}_i^{US,obs}$ as

$$\mathbb{Q}_i^{US,obs} = \mathbb{Q}_i \times \frac{\text{Observed total land rent of the US bases}}{\text{Total land rent of the US bases in the model}},$$

which implicitly assumes that the US land rent is proportional to the private-sector land rent obtained in Step 2. $e_{US,obs}$ is given as the observed value of the spending by the US military personnel in the GNI statistics. L_i^{US} is obtained by assuming that the observed total number of the US military personnel in Okinawa is allocated to each municipality proportional to the share of the US base area in that municipality.[C.3] To determine the value of ϖ, we then compute in the model the Okinawan people's total income, denoted by Y, is written as $Y = \sum_i \sum_s (w_{is} L_{is} + \Omega_i) = \sum_i \sum_{s \in \{A,M,N\}} \frac{(1-\mu\gamma^s) w_{is} L_{is}}{1-\gamma^s} + \sum_i (w_{iB} L_{iB} + m_i \mathbb{Q}_i^{US} S_i) = Y_P + Y_B$, where $Y_P \equiv \sum_i \sum_{s \in \{A,M,N\}} \frac{(1-\mu\gamma^s) w_{is} L_{is}}{1-\gamma^s}$ is the private-sector income and $Y_B \equiv \sum_i (w_{iB} L_{iB} + m_i \mathbb{Q}_i^{US} S_i)$ is the US-base income. Since we can observe the GNI share of the US-base income ($Y_B / Y \equiv s_{B,obs}$) in the data, we can back out Y_B as $Y_B = \frac{s_{B,obs}}{1-s_{B,obs}} Y_P$. With the value of Y_B, we compute the normalization factor as $\varpi = \frac{Y_B - \sum_i w_{iB} L_{iB}}{\sum_i m_i \mathbb{Q}_i^{US,obs} S_i}$. Finally, we compute the value of Φ_i as $\Phi_i = \mathbb{Q}_i^{US} m_i S_i + e_{US} L_i^{US} = \varpi (\mathbb{Q}_i^{US,obs} m_i S_i + e_{US,obs} L_i^{US})$.

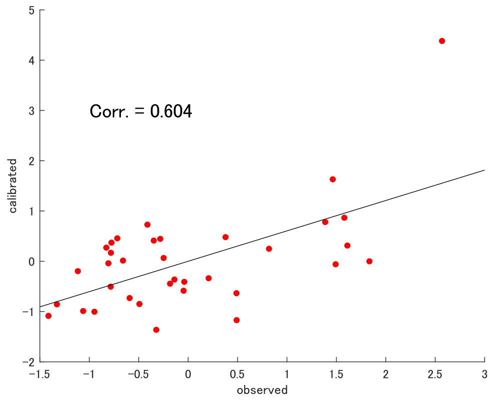
[C.2] ϖ is the common normalization factor for the land rents and the US personnel wages. To understand this point, note that the ratio between the total US labor income and the total base rents must be common across the real world and the model, that is,

$$\frac{\sum_i e_{US,obs} L_i^{US}}{\sum_i m_i \mathbb{Q}_i^{US,obs} S_i} = \frac{\sum_i e_{US} L_i^{US}}{\sum_i m_i \mathbb{Q}_i^{US} S_i}$$

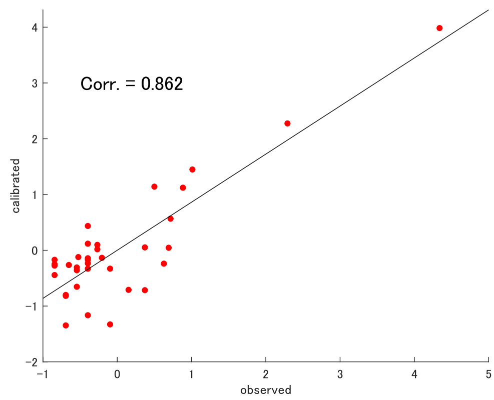
holds. After substituting $\mathbb{Q}_i^{US} = \varpi \mathbb{Q}_i^{US,obs}$ and arranging the equation, we obtain $e_{US} = \varpi e_{US,obs}$.

[C.3] For example, if there are 10,000 US military personnel, the total area size of the US bases is 100 km^2, and the area size of the US bases in municipality i is 10 km^2, then municipality i is estimated to have 1,000 military personnel.

C.3 Model fit



(a) Residence-based per capita income



(b) Floor-space rent

Figure C.1: Comparison of the observed and calibrated values

Note: Figure C.1a compares the observed data on residential per capita income and the calibrated values in our model. Figure C.1b compares the observed housing rents and the calibrated values in our model. Each dot represents a municipality and the solid line represents the fitted line. The plotted are standardized such that the mean equals zero and the standard deviation equals one. Figure C.1a uses the per capita taxable income in each municipality, taken from the 1969 *shichoson koufuzei seido kaisetsu* (https://ndlsearch.ndl.go.jp/books/R100000002-I000001208323). Figure C.1b uses the house price data taken from the 1970 *shichoson koufuzei seido kaisetsu* (https://ndlsearch.ndl.go.jp/books/R100000002-I000001206601).

D Counterfactual details

D.1 Computational procedure

In this section, we describe our algorithm for computing a counterfactual equilibrium. It consists of the "inner-loop," which computes sector-specific wages given the population distribution, and the "main loop" that updates the population distribution. A counterfactual equilibrium in the closed city analysis with the fixed total population, which is our main specification, can be obtained by this. When we additionally endogenize the total population by considering migration between Okinawa and the outside economy, we further consider an "outer loop," which is described in Appendix D.2.

Inner loop: We fix the distribution of residents, $\{R_{is}\}$, in this step.

1. Set $w_{iB} = 0$ for all locations. Give an initial guess for $\{w_{iA}, w_{iM}, w_{iN}\}$.
2. Given the wages, calculate $\{L_{iA}, L_{iM}, L_{iN}\}$ using the first equation of (24).
3. Derive $\{Q_i\}$ using (31). Then, compute $\{P_i^N\}$ using (28). Here, H_i in (31) should be replaced with $H_i = (1 - m_i) S_i Q_i^{\phi}$. Note also that $\{P_i^N\}$ can be calculated by transforming (28) into $P_i^N = \left(\widetilde{b}_i^N\right)^{-1} w_{iN} Q_i^{\gamma^N} L_{iN}^{\frac{1-\gamma^N}{1-\sigma}} H_{iN}^{\frac{\gamma^N}{1-\sigma}}$, where $\{H_{iN}\}$ is readily obtained from (30) after deriving $\{Q_i\}$.
4. Update $\{w_{iA}, w_{iM}\}$ using (26) and (27). Substituting the guessed value of $\{w_{iN}\}$ and the updated values of $\{w_{iA}, w_{iM}\}$ into the right-hand side of (33), update $\{w_{iN}\}$.
5. Repeat steps 2–4 until the wages converge.
6. If the wages converge, move on to the "main loop" step.

Main loop:

1. Given the equilibrium values obtained in the "inner loop" step, update $\{R_{is}\}$ using (23).
2. If the updated distribution of residents does not change from that in the previous stage of iteration, we successfully reach the closed city equilibrium. Otherwise, return to the "inner loop" step, and repeat it under the updated distribution of residents.

If we want to consider the small-open city equilibrium, we move on to the "outer loop" step described in Appendix D.2.

D.2 Computing the small-open city equilibrium

Assume that the elasticity of migration in and out of Okinawa is the same as that of migration within Okinawa, i.e., $\theta = 2.19$. Then, the fraction of Japanese people who choose to live in Okinawa, denoted by Λ, is expressed as follows:

$$\Lambda = \frac{\mathbb{W}^{\theta}}{\mathbb{W}^{\theta} + \overline{u}^{\theta}}, \tag{D.1}$$

where $\mathbb{W}$ is the expected welfare of living in Okinawa, defined by (34), and $\overline{u}$ is the welfare obtained by residing in the outside economy (e.g., the Mainland Japan), which we regard as a constant.

Let $\widehat{\mathbb{W}}$ represent the relative change in the Okinawan welfare from an "old" equilibrium to a "new" equilibrium. Then, (D.1) indicates that the corresponding change in the population share of Okinawa can be written as

$$\widehat{\Lambda} = \frac{\widehat{\mathbb{W}}^{\theta}}{\Lambda\widehat{\mathbb{W}}^{\theta} + 1 - \Lambda}. \tag{D.2}$$

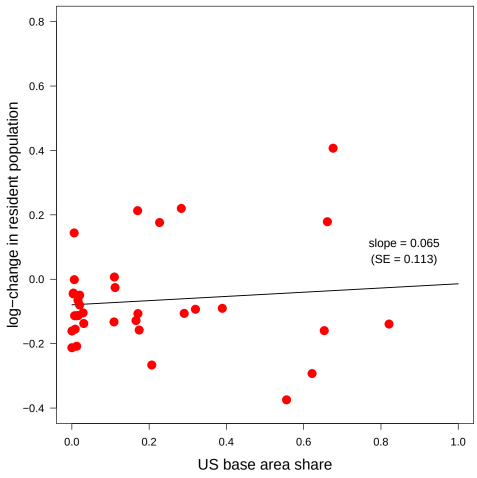
Note that $\widehat{\Lambda}$ is equivalent to the relative change in the total population in Okinawa.

According to the 1970 census, the share of Japanese people who live in the Okinawa main island was about 0.77%. Thus, we let the initial value of Λ be 0.0077 and consider the following procedure to endogenously determine the total population in Okinawa.

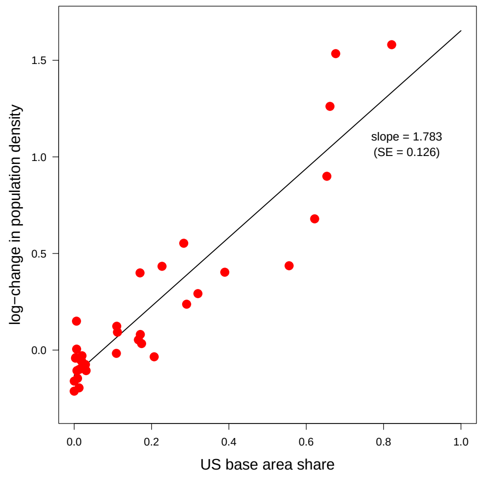
Outer-loop for the small-open city model:

1. Given the equilibrium values obtained from the "main loop" step, multiply R_{is} in all locations by $\widehat{\Lambda}$, which can be computed from equation (D.2).
2. If $\widehat{\Lambda} = 1$, we successfully reach the small-open city equilibrium. Otherwise, redo the "main loop" step under the total updated population.

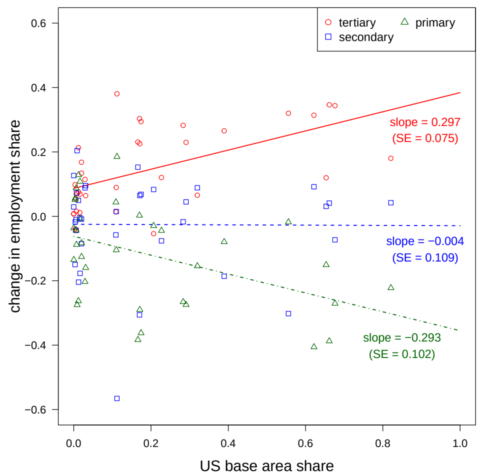
D.3 Details of the counterfactual analysis when the US base land area is returned for the Okinawans' private use



(a) Resident population



(b) Population density



(c) Employment share

Figure D.1: The effects of the US bases on urbanization and industrial structure when the US base land area is returned

Note: We present a scatterplot of each municipality, where the horizontal axis is the US base area share. As the vertical axis, Figure D.1a takes the change in the log of the residential population, Figure D.1b takes the change in the log of the population density, and Figure D.1c takes the changes in the sectoral employment share. Each point in the figures shows the changes from the counterfactual to the observed equilibrium. In Figure D.1c, the red circles, blue squares, and green triangles represent the changes in the tertiary, secondary, and primary employment shares, respectively. Each figure also contains the linear fitted lines.

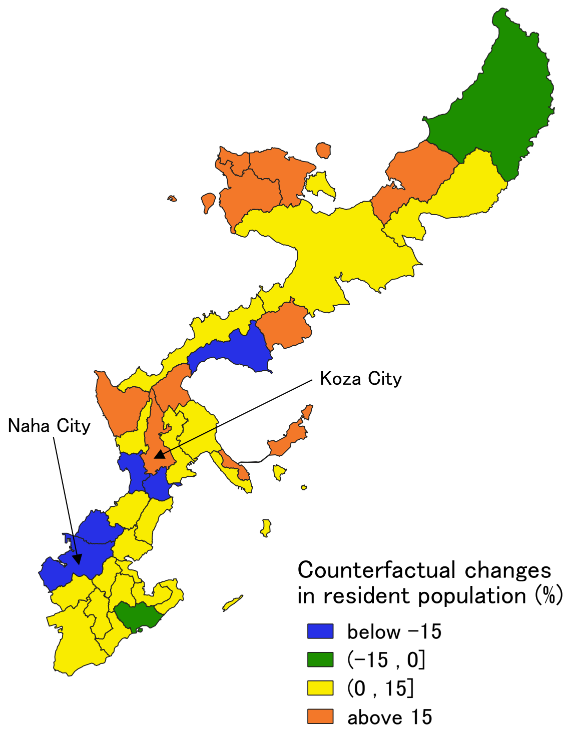
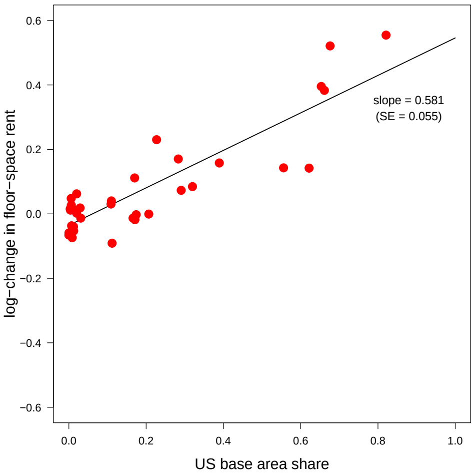
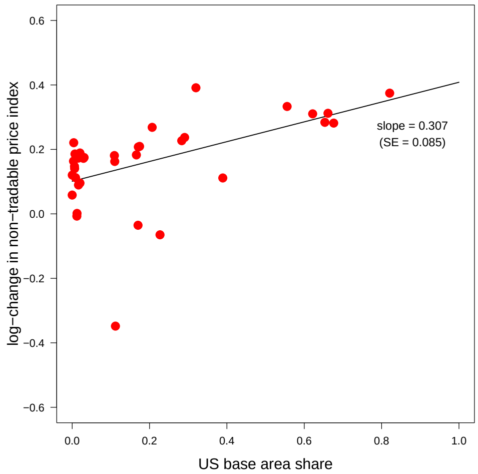


Figure D.2: Counterfactual change in population distribution when the US base land area is returned

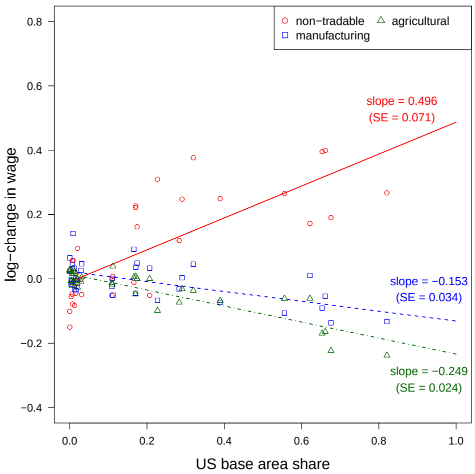
Note: The figure visualizes each municipality's change in the residential population from the observed to counterfactual equilibrium. The municipalities that experience an increase over 15%, an increase less than 15%, a decrease less than 15%, and a decrease over 15% are colored orange, yellow, green, and blue, respectively. The figure also indicates the locations of Naha and Koza cities, which were the first and second most populous cities in Okinawa as of 1970. The shape file of the Okinawa island is taken from the Digital National Land Information (*kokudo suchi joho*).



(a) Floor space rent



(b) Non-tradable price index



(c) Wages

Figure D.3: The effects of the US bases on rent, price, and wages when the US base land area is returned

Note: We present a scatterplot of each municipality, where the horizontal axis is the US base area share. As the vertical axis, Figure D.3a takes the change in the log of the floor space rent, Figure D.3b takes the change in the log of the non-tradable price index, and Figure D.3c takes the changes in the log of the sectoral wage. Each point in the figures shows the changes from the counterfactual to the observed equilibrium. In Figure D.3c, the red circles, blue squares, and green triangles represent the changes in the log of wages in the tertiary, secondary, and primary sectors, respectively. Each figure also contains the linear fitted lines.

Decomposition. Let "OBS" denote the observed outcomes. In addition, let "CF1" and "CF2" denote the counterfactual scenario in Sections 6.1 and Section 6.2, respectively. Then, the *total effect* of the US bases on the growth of population density, calculated in the baseline counterfactual exercise, is decomposed as follows:

$$\underbrace{\ln\left(\frac{PopDensity_i^{OBS}}{PopDensity_i^{CF2}}\right)}_{\text{total effect}} = \underbrace{\ln\left(\frac{PopDensity_i^{OBS}}{PopDensity_i^{CF1}}\right)}_{\text{US-base income effect}} + \underbrace{\ln\left(\frac{PopDensity_i^{CF1}}{PopDensity_i^{CF2}}\right)}_{\text{land-occupying effect}}. \tag{D.3}$$

The decomposition of the effects on the residential population can be done in the same way.

Similarly, changes in the employment share of residents in each municipality can be decomposed as follows:

$$\underbrace{Share_{i,s}^{OBS} - Share_{i,s}^{CF2}}_{\text{total effect}} = \underbrace{Share_{i,s}^{OBS} - Share_{i,s}^{CF1}}_{\text{US-base income effect}} + \underbrace{Share_{i,s}^{CF1} - Share_{i,s}^{CF2}}_{\text{land-occupying effect}}, \tag{D.4}$$

where the subscript $s \in \{\text{primary, secondary, tertiary}\}$ indicates the sector. Here, the tertiary sector includes the non-tradable service and US base sectors[D.1] The primary and secondary sectors correspond to the agricultural and manufacturing sectors in the model, respectively.

The difference between the observed and CF1 equilibria is whether the model contains the US-base incomes (i.e., wages of the US base sector, the US military personnel's consumption expenditure, and land rent for the US bases), and whether the area of land developable for private uses is the same across these two equilibria. Thus, the first terms of the right-hand sides in equations (D.3) and (D.4) are regarded as capturing the US-base income effect of the US bases. On the other hand, the difference between the CF1 and CF2 counterfactual equilibria is whether the land for the US bases becomes available for private uses. Therefore, the second terms of the right-hand sides in equations (D.3) and (D.4) reflect the land-occupying effect.

Given that the total effect is additively separable into the US-base income and land-occupying effects, we can measure how much of the variation in the total effect is due to variations in the two effects. Specifically, following Hottman, Redding and Weinstein (2016), we regress each of the US-base income and land-occupying effects on the total effect. Then, the estimated slope represents the share of the variation in the total effect that can be attributed to each of the two effects. By construction, the two slopes add up to one.[D.2]

Table D.1 presents the result of this variance decomposition. The third and fourth columns show the decomposition of the variation in the total effect on population density growth. The

[D.1] Note that $Share_{i,tertiary}^{CF1}$ and $Share_{i,tertiary}^{CF2}$ are the same as the employment share of the non-tradable service sector because there is no US base employment in these counterfactual equilibria.

[D.2] Note that the slope estimated in a univariate regression is expressed as $\text{Cov}(x_i, y)/\text{Var}(y)$ when we take x_i and y as the dependent and explanatory variables, respectively. If $y = x_1 + x_2$ holds, we have $\text{Var}(y) = \text{Var}(x_1) + \text{Var}(x_2) + 2\text{Cov}(x_1, x_2)$ and $\text{Cov}(x_i, y) = \text{Var}(x_i) + \text{Cov}(x_i, x_j)$, where $i \in \{1, 2\}$ and $j \neq i$. Thus, the slope corresponds to the fraction of the variance of y explained by the variance of x_i and its covariance with the other determinant of y.

	Population		Density		Primary		Secondary		Tertiary	
	UBIE	LOE	UBIE	LOE	UBIE	LOE	UBIE	LOE	UBIE	LOE
slope	1.040***	−0.040	0.383***	0.617***	0.984***	0.016***	1.005***	−0.005	0.992***	0.008*
	(0.133)	(0.133)	(0.037)	(0.037)	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)
Observations	35	35	35	35	35	35	35	35	35	35
R^2	0.649	0.003	0.763	0.893	0.999	0.217	1.000	0.070	0.999	0.098

Standard errors are reported in parentheses.
* p < 0.1, ** p < 0.05, *** p < 0.01

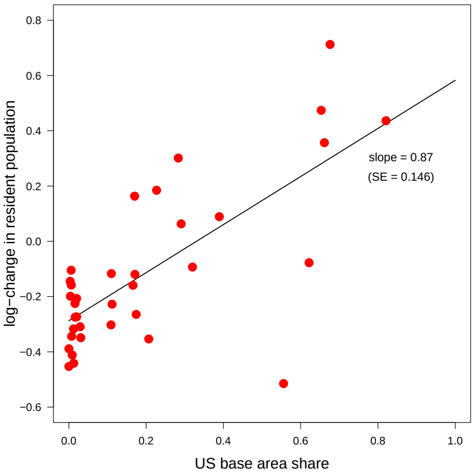
Table D.1: Contributions of the pecuniary and land-occupying effects

Note: The table reports the results of regressing the total effects on either of the US-base income and land-occupying effects. The ten columns in the table are classified into five groups, with each having two columns. From the left to right, each group presents the results of the variance decomposition for the residential population, population density, primary employment share, secondary employment share, and tertiary employment share. In each group, the left and right columns show the contributions of the US-base income and land-occupying effects, respectively.

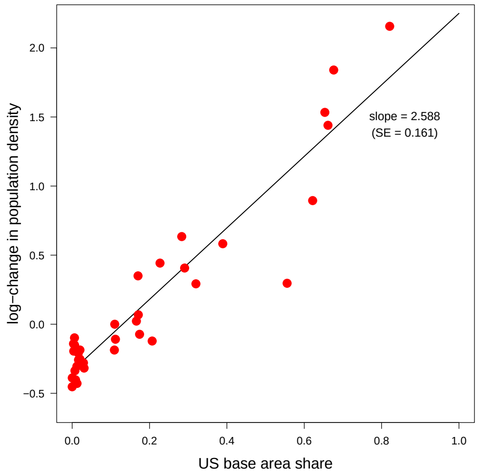
value of the slope reported in the column labeled with UBIE and LOE represents the fraction of variation in the total effect attributed to the variation in the US-base income effect and the land-occupying effect, respectively. According to the results, the US-base income effect accounts for nearly 40% of the observed variation in the total effect. In contrast, for the population level, almost all variance is explained by the US-base income effect.

We also report the decomposition of the effects on changes in the primary, secondary, and tertiary sectors' employment shares. Note that in each sector, the slope for the US-base income effect is close to one and that for the land-occupying effect is negligible, indicating that the land-occupying effect contributes little. Thus, the US-base income effect is considered to be the main driver of structural transformation.

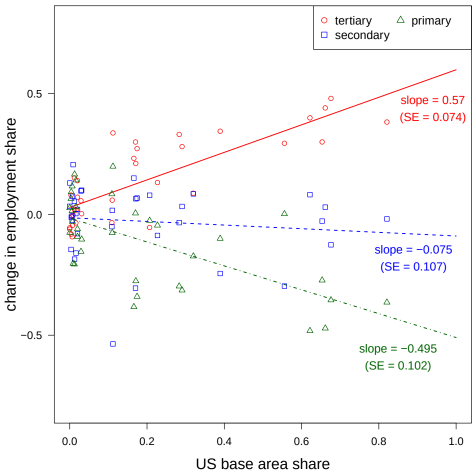
D.4 More details on the additional analyses



(a) Resident population



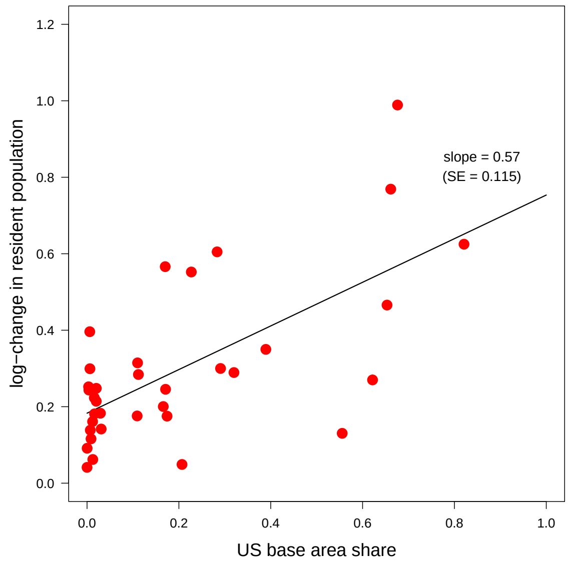
(b) Population density



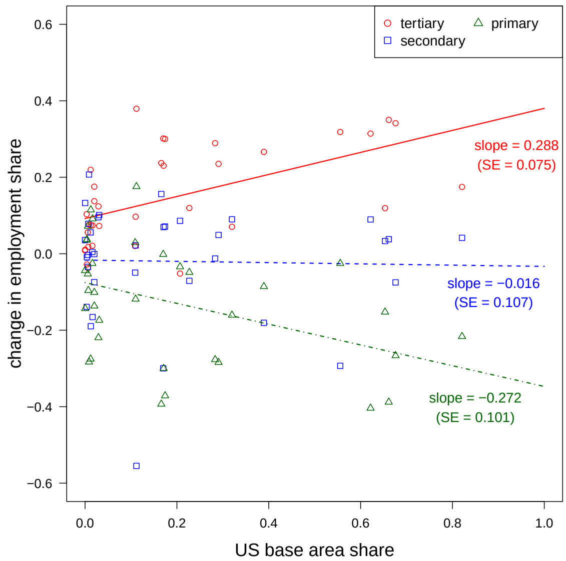
(c) Employment share

Figure D.4: The effects of the US bases on urbanization and industrial structure when accounting for the US-base bias in productivity and amenity

Note: We present a scatterplot of each municipality, where the horizontal axis is the US base area share. As the vertical axis, Figure D.4a takes the change in the log of the residential population, Figure D.4b takes the change in the log of the population density, and Figure D.4c takes the changes in the sectoral employment share. Each point in the figures shows the changes from the counterfactual to the observed equilibrium. In Figure D.4c, the red circles, blue squares, and green triangles represent the changes in the tertiary, secondary, and primary employment shares, respectively. Each figure also contains the linear fitted lines.



(a) Resident population



(b) Employment share

Figure D.5: The effects of the US bases on urbanization and industrial structure when the total population is endogenous

Note: We present a scatterplot of each municipality, where the horizontal axis is the US base area share. As the vertical axis, Figure D.5a takes the change in the log of the residential population, and Figure D.5b takes the changes in the sectoral employment share. Each point in the figures shows the changes from the counterfactual to the observed equilibrium. In Figure D.5b, the red circles, blue squares, and green triangles represent the changes in the tertiary, secondary, and primary employment shares, respectively. Each figure also contains the linear fitted lines.

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