HIAS-E-114

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Evidence from the 1972 Okinawa Reversion

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November, 2021

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Welfare Costs of Exchange Rate Fluctuations: Evidence from the 1972 Okinawa Reversion

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Current Draft: November 12, 2021

Abstract

The main tenet of the New Keynesian (NK) paradigm is that price dispersion caused by nominal price stickiness is the primary source of allocative inefficiency. This study empirically evaluates the welfare implications of NK models by observing how internal and external price dispersion responds to two types of large aggregate shocks: high inflation and sharp currency depreciation. For this purpose, we consider the history of US military deployment on a small southern island in Japan called Okinawa following the Pacific War. We investigate unique data variations in micro-level retail prices surveyed in Okinawa and mainland Japan before and after the Okinawan reversion to Japanese sovereignty in May of 1972. By considering the Okinawan experience of three currency regimes during the high inflation period of the early 1970s as valid quasi-natural experiments, we identify statistically significant deteriorations of currency misalignment associated with the sudden exogenous large USD depreciation versus the JPY following the Nixon Shock. Furthermore, we observe that these massive aggregate shocks left the average absolute size of price changes mostly unchanged, but significantly increased the average frequency of price changes in Okinawa. Because a calibrated small open-economy menu cost model fits these empirical findings better than the Calvo model, the welfare costs of exchange rate fluctuations may be more elusive than suggested by the open-economy NK literature.

Key Words : *Currency regime; Currency misalignment; Welfare cost; Okinawan reversion; Menu cost model*

JEL Classification Number : F31, F41, F45

† We wish to thank Naohito Abe, Martin Berka, Shin-ichi Fukuda, Masazumi Hattori, Munechika Katayama, Junko Koeda, Ryoji Koike, Naoto Jinji, Chiaki Moriguchi, Jim Nason, Nalini Prasad, Andy Rose, Makoto Saito, Moto Shintani, Etsuro Shioji, Masatoshi Shizume, Hajime Tomura, Kozo Ueda, and seminar and conference participants from Massey University, Waseda University, the 2017 Fall Meetings of the Japanese Economic Association, 2019 Canadian Economics Association Meetings, 2019 European and North American Summer Meetings of the Econometrics Society, and 2019 Australasian Conference of International Macroeconomics for their insightful discussion and helpful comments. Tomoya Ozeki, Masaaki Shibata, Kenji Wada, and Haruna Yamada provided excellent research assistance. We wish to express gratitude for a grant-in-aid for scientific research from the Japan Society for the Promotion of Science (Nos. 24330060 and 17H02542) and financial support from the Hitotsubashi Institute for Advanced Study. We are solely responsible for any errors and misinterpretations in this study.

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1. Introduction

Fifty years ago, US President Richard Nixon suddenly announced the suspension of the convertibility of the US dollar into gold. The Nixon Shock in August of 1971 triggered a subsequent collapse of the Bretton Woods system. Since this regime-changing historical event, the international monetary system has witnessed and largely suffered from highly volatile flexible exchange rates. Our experience over the past five decades has led to many fundamental normative questions. Should we control volatile flexible exchange rates? If so, how should we use a set of available policy tools? In particular, should our monetary policies consider exchange rate fluctuations as an explicit policy goal in addition to the conventional goals of business cycle smoothing and price stability?

The past five decades have also provided ample evidence for the essential roles of nominal rigidities in exchange rate fluctuations. As discussed in the seminal observations of Mussa (1986), real exchange rates change in tandem with nominal rates for most advanced currencies and the former rates are much more volatile under flexible regimes than under fixed regimes. These observations are evidence against "nominal exchange regime neutrality." As a result, open economy New Keynesian (NK) models have become the dominant framework for current exchange rate research because they emphasize the crucial roles of price stickiness and monetary policies in exchange rate changes.

To approach the normative questions presented above through the lens of the NK paradigm, it is essential to understand how significant real and nominal exchange rate fluctuations affect the welfare of open economies empirically. In this study, we tackle this empirical task by revisiting the US military history of deployment on a small southern island in Japan called Okinawa following the Pacific War. We investigate unique data variations in micro-level retail prices surveyed during the period around the Nixon shock.

Our monthly dataset contains 178 goods and services retail prices from retail price surveys conducted for the purpose of constructing consumer price indices (CPIs) for Okinawa and the other 46 prefectures in Japan. It covers the period from January of 1970 to December of 1974. Our dataset is made unique by the post-war historical experience of Okinawa. Following the surrender of the Imperial Japanese Army in 1945, the US military government occupied Okinawa for geopolitical reasons until the reversion of Okinawa to Japanese sovereignty in May of 1972. During the US military occupation, Okinawa suffered from multiple currency conversions. In particular, the US military government introduced the US dollar as an Okinawan legal tender in 1958. This US dollar currency regime continued until the reversion, when Okinawa merged with the Japanese yen currency regime. The US dollar fixed-exchange-rate (USD-Fix) regime under the Bretton Woods system occurred first. Next, the US dollar flexible-exchange-rate (USD-Flex) regime after the Nixon Shock occurred. Finally, the Japanese yen common-currency (JPY-Com) regime resulted from the 1972 reversion. This currency history of Okinawa provides us with an excellent opportunity to perform ideal quasi-natural experiments to identify and estimate the effects of flexible exchange rates on two dimensions of retail price dynamics, which are crucial and relevant to the normative questions regarding exchange rate fluctuations.

The first dimension is the degree of currency misalignment between Okinawa and other mainland prefectures in Japan. Currency misalignment, which this study identifies as a deviation from the law of one price (LOP), is relevant to the welfare of open economies because it means that an identical good produced with identical production costs has different regional prices in terms of a common currency unit. After controlling the role of transport costs, currency misalignment implies the inefficiency of cross-regional resource allocation based on the inequality of marginal utility across regions. Based on two-country NK models with pricing to market or local currency pricing (LCP), Engel (2011) and Corsetti et al. (2010) theoretically demonstrated that a global loss function for cooperative monetary policymakers depends negatively on the degree of currency misalignment.

The second dimension we consider in this study is the degree of inefficient price dispersion within a country or region. For example, if an identical good has different regional prices, then the demand for that good can vary within a country. As a result, the marginal disutility of labor for meeting demands for goods could be divergent and lead to inefficient resource allocation. Indeed, the global loss function derived by Engel (2011) in his two-country NK model with LCP depends negatively on the degree of internal dispersion of four prices, namely home and foreign goods prices in home and foreign countries. Therefore, this second dimension is relevant to our motivation of determining if exchange rate fluctuations cause inefficient price dispersion in open economies.

Conventionally, NK models, which depend on the Calvo (1983) technology of price stickiness, focus on inefficient price dispersion because this nominal rigidity implies a greater degree of heterogeneity in price adjustments across firms. Even when they face the same erosion of relative prices caused by aggregate price inflation, some firms can adjust their nominal prices within a fixed period, but others cannot. The higher the inflation rate, the greater the nominal price dispersion and the worse the relative price distortion. In the open-economy NK model with LCP, exchange rate fluctuations affect inflation dynamics by changing the optimal reset price. For example, Benigno (2004) and Engel (2014a, 2019) determined that open-economy NK Phillips curves describe the tight dependence of the inflation rate on the real exchange rate. Therefore, exchange rate fluctuations can have first-order importance in terms of internal relative price distortions because they contribute to inefficient price dispersion.

However, empirical evaluations of these two dimensions of retail price dynamics face significant difficulties. First, as discussed by Engel (2014b), we must extract the degree of inefficient currency misalignment caused solely by exchange rate fluctuations in collaboration with pricing to market and price stickiness while controlling for unobservable heterogeneity in local distribution services in countries or regions. Second, the degree of inefficient internal price dispersion is also difficult to measure. As discussed by Nakamura et al. (2018), we must identify internal price dispersion caused solely by price stickiness and not by other unobservable types of product heterogeneity within a country or region.

Our dataset helps us overcome the first empirical difficulty. We construct a panel dataset containing the degrees of LOP deviation among 47 prefectural capital cities in Japan for 178 individual items reported in retail price surveys. We then implement difference-in-difference (DID) regression by incorporating time-invariant city-pair-specific fixed effects. We expect that these fixed effects empirically capture the possible roles of unobservable heterogeneity in local distribution services under our working assumption that the resource costs of local distribution services were not affected by changes in the currency regimes in Okinawa. Our treatment group consists of the LOP deviations between Naha, which is the capital city of Okinawa, and each of the other 46 prefectural capital cities in mainland Japan, whereas our control group includes those among the 46 mainland prefectural capital cities. Most importantly, we decompose the entire sample period into three subsamples corresponding to the three currency regimes of Okinawa. Then, after controlling for economic developments that are common across the treatment and control groups over the whole sample period, our DID regression estimates whether the shape of the sample distribution of the item-level LOP deviations of the treatment group change with the three currency regimes.

To tackle the second empirical difficulty, we follow the advice of Nakamura et al. (2018). They argued that the average absolute sizes of price changes conditional on price revision can serve as a good proxy for inefficient internal price dispersion. Because the average absolute revision size reflects how long average firms delay in revising current prices to the optimal level, there may be significant internal price dispersion when the average absolute revision size is large. Most importantly, this measure is robust to the effects of unobservable product heterogeneity on price-level dispersion.

Furthermore, the average absolute sizes and corresponding frequencies of price changes are informative for evaluating the empirical validity of the underlying mechanisms of price stickiness in open-economy NK models with LCP, particularly when retail price data are subject to both high inflation and sharp local currency depreciation. On one hand, in the Calvo mechanism, while the frequency of price revision remains constant by construction, the average absolute size of price changes increases rapidly with inflation and local currency depreciation, as does inefficient internal price dispersion. On the other hand, in a state-dependent mechanism with menu costs, the average absolute size of price changes is roughly independent of the range of inflation and local currency depreciation rates. Additionally, the frequency of price changes increases rapidly with these aggregate variables, as demonstrated by the calibration study by Flodén and Wilander (2006). Intuitively, as discussed by Nakamura et al. (2018), prices never drift too far from their optimal levels in the menu cost model because firms find it optimal to pay the menu cost before this occurs. During a high inflation period, exporters will need to raise their local currency prices eventually, meaning they pay the menu cost. Therefore, exporters have a significant incentive to frontload and raise their local currency prices in response to sharp exporter currency appreciation. This property significantly limits the extent to which internal price dispersion increases with inflation and local currency depreciation in the menu cost model with pricing-to-market behavior. As a result, we hypothesize that the welfare loss resulting from inefficient internal price dispersion caused by increasing inflation and depreciating local currency will be relatively small in the open-economy menu cost model with LCP.

This study adopts the average absolute size and frequency of price changes as proxies for inefficient internal price dispersion. First, we construct a panel dataset containing the average absolute sizes and frequencies of price revisions in the prefectural capital cities for all 178 considered goods over the three currency regime periods. By setting the Okinawa sample as the treatment group and the samples of the other prefectures as the control group, we then conduct DID regression exercises with city-specific fixed effects to identify how a change in the currency regime impacts the average absolute sizes and frequencies of price revisions and contributes to inefficient internal price dispersion.

Following the spirit of the study by Nakamura et al. (2018), we investigate micro-level retail prices during the high inflation period of the early 1970s in Japan. Table 1 reports the average annualized CPI inflation rates in Okinawa and the mainland for the three currency regimes in the second and third columns. The aggregate inflation rates are close to 6 % in both Okinawa and the mainland in the USD-Fix regime. The average inflation rate in Okinawa increases to approximately 8% in the USD-Flex regime and more than 24% in the JPY-Com regime. A similar surge in inflation can also be observed in the mainland with an average inflation rate of 16%. Furthermore, as shown in Figure 1, the USD sharply depreciates versus the JPY by 14.5% from 355 JPY/USD to 304 JPY/USD within the nine months between the Nixon Shock and Okinawa reversion. This sudden sharp appreciation of the JPY versus the USD is comparable to that of the recent large appreciation episode of the Swiss Franc versus the Euro in 2015, which was documented and investigated by Auer et al. (2021). Therefore, in conjunction with high inflation, the unexpected sharp depreciation of the USD versus the JPY following the Nixon Shock provides an ideal environment for distinguishing between open-economy Calvo and menu cost models as suitable theoretical frameworks for evaluating the welfare cost of exchange rate fluctuations.

Our quasi-natural experiments reveal the following three findings. First, the sharp USD depreciation in the USD-Flex regime has a statistically significant currency misalignment effect relative to the USD-Fix regime. On average, the item-level LOP deviation deteriorates and shifts toward the Okinawan real depreciation by 10% to 12% in the USD-Flex regime. In contrast, one can see a relatively small effect of the JPY-Com regime on the item-level LOP deviation compared to the USD-Fix regime. Second, the average absolute size of price changes remains almost constant at approximately 8% to 10% in Okinawa and the mainland over the three currency regimes. Third, the average frequency of price changes in Okinawa sharply increases over the sample period, whereas there is no clear upward trend in the average frequency in the mainland. Furthermore, the average frequency of price ups increases with inflation in both Okinawa and the mainland, whereas there is no robust relationship between the average frequency of price downs and inflation.

These empirical findings strongly support the implications of the menu cost model as a sticky price generator. To verify this inference, we calibrate small open-economy variants of the menu cost and Calvo models. Our stochastic simulation exercises demonstrate that the calibrated menu cost model fits all of our empirical findings regarding the external and internal price dispersion better than the Calvo model. Therefore, it is reasonable to infer that firms could pay a relatively small fixed adjustment cost and never allow their prices to drift far from the optimal levels. If this is the case, then the observed 10% to 12% currency misalignment reflects the efficient response of retail prices to sharp USD depreciation and does not necessarily imply a significant welfare loss.

In summary, the US military history in post-war Okinawa provides no solid empirical ground for the NK argument of inefficient internal and external price dispersion caused by price stickiness. When we adopt the inference of Nakamura et al. (2018) as a reference, we can conclude that the welfare costs of exchange rate fluctuations may be more elusive than those expected by the conventional open-economy NK model with Calvo pricing technology.

The remainder of this paper is organized as follows. Section 2 discusses related literature. Section 3 reviews the post-war history of Okinawa to provide evidence for the foundation and validity of our quasi-natural experiments. Section 4 presents the details and results of the empirical exercises. Section 5 introduces small open-economy NK models and discusses the results of our calibration exercises. Finally, Section 6 concludes this paper.

2. Related literature

Past studies have focused on the effects of currency regimes on international price dispersion (i.e., LOP violations) in disaggregated micro data on retail prices. Berka et al. (2018) discovered strong evidence for the Balassa-Samuelson effect in product-level real exchange rates among EU member countries adapting fixed exchange rates or common currency regimes instead of adopting flexible exchange rates like other countries. Their findings imply that a fixed exchange rate or common currency regime that is immune to volatile nominal exchange rate fluctuations may yield more efficient adjustments of real exchange rates to changes in the relative prices between tradable and non-tradable goods.

Cavallo et al. (2014) claimed that a common currency regime has an empirically significant effect on product-level real exchange rate adjustments. By exploiting online internet prices of identical goods sold in various European countries by four large global retailers, they observed that the LOP holds in individual products among countries within the Eurozone. Simultaneously, the LOP is significantly violated among countries outside the Eurozone. Although Berka et al. (2012) also pointed out the same difference in the empirical relevance of the LOP in disaggregate retail prices between countries inside and outside the Eurozone based on different datasets of retail prices, Cavallo et al. (2014) revealed that the LOP is still significantly violated among countries adopting fixed exchange rate regimes. This observation is eye opening because it suggests that the unit of currency is relevant to product-level real exchange rate adjustments.

An essential shortcoming of the past exercises described above is that they compared disaggregated retail prices of identical goods between two countries that were either already in a common currency area or a fixed-exchange-rate regime. However, the resulting inferences may reflect time-invariant country-pair-specific fixed effects that are not necessarily related to any direct effects of participating in a fixed-exchange-rate or common-currency regime. To make our inferences regarding currency regime effects empirically plausible, we must conduct relevant quasi-natural experiments by constructing suitable treatment and control groups.[1] To address this concern, Cavallo et al. (2015) compared the degrees of LOP deviation in retail prices of clothing goods sold by the world's largest clothing retailer, namely ZARA, between Latvia and other Eurozone countries before and after the Latvian adoption of the Euro in 2014. They reported that the distribution of the LOP deviation across a large number of clothing goods shrank to a mass point of zero after 2014. In contrast, because we investigated a much broader set of goods in our CPI construction, our exercise should be robust to the concern that their inferences may reflect the specific international pricing strategy of a single global retailer.

An important predecessor of our study is the study by Takagi et al. (2004), who investigated common currency effects on real exchange rate volatilities by exploiting time series data on the aggregate CPIs of Okinawa before and after the 1972 reversion. They scrutinized aggregate real exchange rate volatilities under three distinct currency regimes. By using the CPI data on Japan, Okinawa, and the US, they calculated the time series variances of the Okinawan real exchange rates for both Japan and the US in each of the three currency regimes. Interestingly, they observed that during the USD currency regime, the volatility of the Okinawan real exchange rate was much lower in the US than in Japan. In contrast, during the JPY currency regime, the Okinawan real exchange rate volatility was much smaller in Japan than in the US. They interpreted their findings as solid evidence of a significant common currency/monetary union effect on real exchange rate adjustments. Our study focuses at the micro data of retail prices, rather than aggregate CPIs, unlike the study by Takagi et al. (2004). This difference in data is essential because we consider the intensive and extensive margins of retail price changes, which are necessary for measuring the welfare loss of price dispersion caused by price stickiness.

Few studies have scrutinized the sensitivity of price dispersion to a surge in inflation as a signif-

[1] Gorodnichenko and Tesar (2009) also discussed the necessity of natural experiments for the identification of any effects of cross-country borders on LOP deviation. Morshed (2007) conducted a DID regression exercise using historical data on disaggregated relative prices before and after the independence of Bangladesh from Pakistan in 1971. Morshed concluded that there are no robust border effects related to the relative price structures of two countries.

icant aggregate shock. The exception was Nakamura et al. (2018), who exploited US BLS micro data by analyzing microfilms dating back to the high inflation period of the late 1970s to identify the welfare costs of inflation. They found that the frequency of price changes increases under high inflation, whereas the average absolute size of price changes remains unchanged. They inferred that the welfare cost of inflation caused by price stickiness is elusive to the lens of the conventional NK model with Calvo pricing technology.

Empirical literature on exchange rate pass-through focuses on the sensitivity of internal price dispersion to another well-identified aggregate shock in the form of exchange rate changes.[2] For example, Gopinath and Rigobon (2008) identified significant price stickiness in the micro data of US import and export prices between 1994 and 2005. In the same US import price dataset, Gopinath and Itskhoki (2010) observed that the long-run exchange rate pass-through is positively related to the frequency of dock price changes, providing robust evidence for the menu cost model with variable markup. Nakamura and Zerom (2010) empirically investigated the role of menu costs in incomplete exchange rate pass-through by developing a structural oligopoly model with micro data on sales and prices in the coffee industry.[3] Another branch of pass-through research exploits large devaluation episodes as quasi-natural experiments and includes studies by Burstein et al. (2005), Alessandria et al. (2010), Gopinath and Neiman (2014), Cravino and Levchenko (2017), and Auer et al. (2021). Our study is related to this research branch because we scrutinize an epoch-marking post-war historical event in international financial markets, namely the Nixon Shock.

The main advantage of our study over previous studies is that our dataset is subject to two significant aggregate shocks of high inflation and large depreciation, which are jointly used to estimate the degree of inefficiency of internal price dispersion and identify the underlying source of price stickiness. In particular, as discussed by Flodén and Wilander (2006), the menu cost model with LCP implies that only under a high inflation environment will a large local currency depreciation yield disproportionally large price adjustments and pass-through to local retail prices.[4] Therefore, our unique dataset on the Okinawa reversion in 1972 has more significant power to analyze the implications of the open-economy menu cost model with LCP.

3. Natural experimental environment: economic and monetary history of the Ryukyu Islands and Okinawa around the 1972 reversion

This section briefly reviews Okinawa's economic and monetary history following the Pacific War and discusses the relevance of the quasi-natural experimental environment exploited in this study. Our historical review focuses on the years from the landing of the US military forces in Okinawa near the end of the Pacific War in April of 1945 to the reversion of Okinawa to Japanese sovereignty in May of 1972. In particular, we emphasize four historical facts. First, the Okinawan separation from and reversion to Japanese sovereignty were the direct consequences of both the end of the Pacific War and subsequent

[2]Burstein and Gopinath (2014) provided an excellent literature survey of exchange rate pass-through.

[3]Early estimation exercises using menu costs in micro retail price data under strategic complementarities can be found in the papers by Slade (1999) and Kano (2013).

[4]Relatively few past studies have investigated state-dependent pricing models in open-economy environments. Other important predecessors are the studies by Midrigan (2007) and Landry (2009, 2010).

increase in the geopolitical importance of Okinawa for the US military. Second, even under US military occupation, the Okinawan economy was highly integrated into the economy of mainland Japan. Third, the US government's political decision to attract foreign investment for the development of the Okinawan economy was approximately neutral in the context of the relative price structure between Okinawa and mainland Japan. Fourth, the shift from the USD fixed-exchange-rate regime to the USD flexible regime as a result of the Nixon shock in August of 1971 was an unanticipated dramatic structural change in the international monetary system, which was a pure exogenous event for the Okinawan economy.

3.1. Economic exogeneity of Okinawan separation and reversion

The US Navy, which was the primary military body of the Allied Forces in the Pacific War, landed in Okinawa on April 1, 1945. On the same day of the landing, it issued the first proclamation that ordered the establishment of the US Navy Military Government in the Ryukyu Islands.[5] Until the 1972 reversion, the Ryukyu Islands and Okinawa were effectively under US military occupation.

The initial goal of the US military occupation and governance over the Ryukyu Islands was to create a group of small islands to act as a bridgehead to capture the Imperial Japanese Army at the end of the Pacific War. Although Japan's unconditional surrender accomplished the initial goal of accepting the Potsdam Declaration on August 14, 1945, the US military government continued to occupy the Ryukyu Islands. On one hand, the Combined Chiefs of Staff (CCS) firmly recognized the strategic military value and geopolitical importance of the Ryukyu Islands. Therefore, they vehemently claimed the continuation of strategic trusteeship by the US military government. On the other hand, the US Department of State argued that the Ryukyu Islands should return to Japanese sovereignty following demilitarization. This political conflict between the CCS and US State Department deferred the official US decision on the territorial rights and the corresponding administrative body of the Ryukyu Islands for several years. The Bank of Ryukyu (1984) argues that this so-called "reservation policy" delayed and threatened the restoration and development policies of Okinawa following the Pacific War. It was not until May 6, 1949, when US President Harry Truman finally approved the long-term retention of the Ryukyu Islands by the US government,[6] that the reservation policy ended and the US government began a total commitment to the restoration policy of the Okinawan economy.

In a Joint Statement from Japanese Prime Minister Eisaku Sato and US President Lyndon Johnson on November 15, 1967, the future possibility of the reversion of the Ryukyu Islands and Okinawa to Japanese sovereignty was officially announced in both countries. At that time, the sentiment of the Ryukyuwan people toward the US military government, which was called the US Civil Administration of the Ryukyu Islands (USCAR), rapidly deteriorated as a result of a military land problem known as "*Gunyochi Mondai*." The USCAR forced land expropriation to construct US military bases around the Ryukyu Islands.[7] The military land problem gave rise to an intense resistance movement acorss the Ryukyu Islands, which was known as "*Shimagurumi Toso*." Anti-US sentiment had grown not only in the Ryukyu Islands, but also in mainland Japan based on the nationwide protest movement against the 1960 revision of the US-Japan Security Treaty (*"Anpo Toso"*). To repair and improve political relationships with Japan and strengthen

[5] United States Navy Military Government Ryukyu Islands Proclamation No.1.

[6] Report by the National Security Council on Recommendation with respect to US policy toward Japan (NSC13/3), May 6, 1949.

[7] CA Ordinance No.109, "Land Acquisition Procedure."

the Security Treaty, the US Department of State insisted on more concessions to Japan's political and economic requests regarding the Ryukyu Islands. However, the US military force strictly opposed any political concession by arguing that it may damage the strategic value of the US military bases in the Ryukyu Islands and Okinawa. Furthermore, rapidly growing geopolitical tensions in East Asia, including the intensification of the Vietnam War and rise in power of Communist China, increased the strategic importance of the Ryukyu Islands. Therefore, any possibility of Okinawa's reversion required the Japanese government to guarantee the USCAR unconstrained operations of its bases and facilities in Okinawa.

In June of 1966, the "Special Ryukyu Island Working Group," which consisted of members from the US Department of State and US Department of Defense, conducted detailed research on all Ryukyu Island problems and resolved the sharp conflicts of interest between the US Department of Security and US military force. The working group then concluded that the US military government would enable the US military bases in Okinawa to operate under the US-Japan Security Treaty, even if the US returned the administrative rights of the Ryukyu Islands to Japanese sovereignty. This conclusion from the working group softened the rigid attitude of the US military force against the reversion of Okinawa significantly. Simultaneously, while facing the intensification of Okinawa reversion movements and a sharp deterioration in public sentiment toward Okinawa's problems, the Japanese government also started recognizing Okinawa's reversion as a top political priority.

In the Sato and Johnson Joint Statement in 1967, the two countries agreed to continuous joint reviews of the status of the Ryukyu Islands with the goal of returning administrative rights over the islands to Japan, but postponed making a consensus on and officially announcing a specific plan for the return of administrative rights over Okinawa to Japan. In a Joint Statement from Japanese Prime Minister Eisaku Sato and US President Richard Nixon on November 21, 1969, the two countries officially agreed to reversion in 1972. Under the Okinawa Reversion Agreement, which the two countries signed on June 17, 1971, the administrative rights of the Ryukyu Islands and Okinawa would return to Japanese sovereignty on May 15, 1972.[8] The 1971 reversion agreement guaranteed many benefits for the US government such as continuing to use military bases in Okinawa, maintaining and strengthening the political alliance between the two countries, including the US-Japan Security Treaty, and cutting down the fiscal burden associated with the administration of the Ryukyu Islands.

The Japanese government also enjoyed significant political benefits from the reversion agreement, such as regaining sovereignty over the territory separated and occupied following the Pacific War, calming down of domestic political tension and anti-US sentiment, and maintaining the US-Japan Security Treaty. Therefore, Japan and the US had solid political incentives for the Okinawa reversion in 1972. The Bank of Ryukyu (1984) emphasizes this historical event as an essential international political event that supported the alliance of the two countries in the US-Japan Security Treaty, *regardless of the political will and intention of Okinawa.*

The historical fact that the territorial and economic separation of the Ryukyu Islands and Okinawa from mainland Japan happened exogenously for the Okinawan economy is crucial for our natural experiment exercise. It was a pure outcome of the end of the Pacific War and the US government's subsequent political and strategic decisions. Furthermore, it is also crucial to recognize that the Ryukyu Islands and Okinawa returned to Japanese sovereignty concurrently with the withdrawal of US troops from the Viet-

[8] The Okinawa Reversion Agreement was signed officially under the "Agreement between Japan and the United States of America concerning the Ryukyu Islands and the Daito Islands."

nam War under the initiative of President Nixon. The Okinawa reversion resulted from a highly political decision by the US government, which fully understood the strategic and geopolitical importance of these small southern islands. Therefore, the US military history in the Ryukyu Islands and Okinawa following the Pacific War supports our construction of a treatment group that is exogenous for the Okinawan relative price structure. This fact strongly implies that inferences drawn from our natural experiments should be immune to potential bias caused by endogeneity of the treatment group.

3.2. Economic integration of Okinawa and mainland Japan

We confirm that the real sides of the Okinawan and mainland economies were integrated to a great degree, even under US military occupation. In short, the Okinawan economy during the occupation period is well characterized as a "military-base-dependent import-oriented economy." At the end of the Pacific War, the Battle of Okinawa destroyed most of its production capacity. As a result, Okinawa has always suffered from high inflation pressure stemming from severe supply shortages. In particular, the construction boom of US military bases that emerged between 1950 and 1952 following the US decision to retain the Ryukyu Islands in the long term and the resulting end of the reservation policy in May of 1949 worsened the supply shortage problem around the Ryukyu Islands. Furthermore, because the USCAR needed to raise wages for workers in the military bases drastically to attract labor forces for base construction, a sharp increase in labor wages accelerated inflation further.

In response to the inflation pressure, the USCAR decided to set a fixed exchange rate for the legal tender B-Yen to 120 B-Yen per USD by issuing Ordinance No. 6, "Military Conversion Rate of Type B-Yen in the Ryukyu Islands" on April 12, 1950.[9] It is easy for us to understand how drastically the B-Yen was overvalued relative to the JPY when we consider that the fixed exchange rate of the JPY against the USD was 360 JPY/USD in 1950. This policy-induced overvaluation of the B-Yen relative to the JPY and resulting cheaper import prices made it possible for the Ryukyu Islands and Okinawa to import tradable goods from mainland Japan and resolve the supply shortage problem.[10]

The privatization and liberalization of international trade, which was officially allowed by Military Government Ordinance No. 26, "Foreign Exchange and Trade Procedure in the Ryukyu Islands," on October 20, 1950, further fortified the Okinawan import dependence on mainland Japan. As a result, the imports of the Ryukyu Islands in 1958 were seven times larger than those in 1951. The import dependency of the Ryukyu Islands on mainland Japan was readily apparent. Its import-to-RGDP ratio was 65.5% and approximately 72% of the total imports were from mainland Japan. Therefore, the Ryukyu Islands and Okinawa had a tight economic linkage with mainland Japan. The Bank of Ryukyu (1984, p. 1082) provides the following statement:

"[I]n other words, ... the Okinawan economy was included in the mainland economy. It is

[9]The USCAR introduced B-Yen (officially called B-type military scrip) as a unique legal tender in the Ryukyu Islands under Special Proclamation No. 29 "Conversion and Issuance of New Currency" on June 26, 1948 (i.e., the fourth currency conversion). For a detailed investigation of the economic rationale behind the devaluation of B-Yen in 1950, see the monograph by Makino (1993).

[10]Because the primary exportable goods of the Ryukyu Islands were commodity goods of sugar, pineapple, and iron scrap, the Ryukyu Islands had always recorded huge trade deficits versus Japan. The US military budget for military bases and financial and economic aid from the US government through the Government and Relief in Occupied Areas Program financed these trade deficits.

natural that the relative price structure of Okinawa, whose import dependency ratio was close to 70% to 80% on imports from the mainland, was directly affected by the relative price structure of the mainland. Furthermore, labor wages were determined by the supply and demand conditions of the labor market of Okinawa as a local component of the entire labor market of the mainland. Indeed, labor migration between Okinawa and the mainland was substantial. The real side of the Okinawan economy was highly integrated with the mainland economy."

Furthermore, in the introduction of his analysis of aggregate price movements in Okinawa following the 1972 reversion, Tanaka (1980) argued the following:

"[B]efore the reversion, the Okinawan economy relied heavily on imports and exports, which placed enormous weight on mainland Japan. This fundamental characteristic of the Okinawan economy did not change, even after the reversion. When investigating aggregate price movements and their fundamental drivers in Okinawa, by carefully recognizing the high dependence of the Okinawan economy on the mainland, we can presume that there would be no significant difference in aggregate price dynamics between Okinawa and the mainland. The two regions shared common factors driving aggregate prices."

Tanaka 's (1980) argument implies that during the sample period of our study, Okinawa and the mainland shared a common tendency in their aggregate price movements. Figure 2 plots the CPI in Naha as a blue line and the CPI of the mainland as a red line between January of 1970 and December of 1974. In particular, Naha's CPI is in terms of JPY. Before the Nixon shock in August of 1971, the two lines move in tandem and are closely joined. Although Naha's CPI begins declining following the Nixon shock as a result of a sharp depreciation of the USD relative to the JPY, the two lines return to a common trend after the reversion in May of 1972. Therefore, our analysis satisfies the common trend assumption for a valid DID regression exercise on average retail price movements.

3.3. The USD regime following the fifth currency conversion

This subsection discusses why the USD regime was established in the Ryukyu Islands and Okinawa. We demonstrate that strategic and political decisions by the USCAR led to a fifth currency conversion to the USD regime, which was completely unrelated to the relative price structures of both the Ryukyu Islands and mainland Japan.

The USD was adopted as the unique legal tender of the Ryukyu Islands according to the High Commissioner Ordinance No. 14 "Currency" on September 15, 1958. This fifth currency conversion forced B-yen conversion to USD at a rate of 120 B-Yen per USD. The fundamental characteristic of the fourth currency regime with the B-yen was a currency board system that accumulated USD as an official reserve asset. Therefore, the supply of B-yen was backed by the USD reserve one-for-one. This currency board system meant that when the USD reserve was accumulated (decumulated) by the current account surplus (deficit), the money supply in the Ryukyu Islands and Okinawa automatically increased (decreased). In other words, we can recognize the B-Yen currency regime as the "USD exchange standard" system. The USD regime established on September 15, 1958 shares the same essential characteristics as the B-Yen regime. In other words, an increase (decrease) in the USD reserve as a result of the current account surplus (deficit) expanded (shrank) the money supply because the Ryukyu Islands and Okinawa had no right to issue the USD.

A natural question based on these finds is why did the USCAR decide to adopt the USD regime through a fifth currency conversion, even though the two currency regimes with the B-Yen and USD shared the same fundamental characteristics as a currency board system? The Bank of Ryukyu (1984) insisted that the fundamental reason behind the fifth currency conversion is that the USCAR wished to liberalize the Okinawan economy and promote regional economic development by attracting foreign direct investment under the USD currency regime.

The USCAR attempted to manage anti-US movements by improving the economic welfare of the Ryukyu Islands and Okinawa by promoting economic development. The Republican administration under US President Dwight Eisenhower sought fiscal consolidation. This fiscal contraction policy and the resulting shrinkage of the military budget made it difficult for the USCAR to finance economic development policies in Okinawa. In other words, the "military-base-dependent import-oriented economy" that emerged at the beginning of the B-Yen currency regime almost failed by 1955.

In this scenario, the USCAR attempted to attract foreign direct investment as the primary source of economic development by liberalizing international transactions of capital, trade, and foreign currencies in the Ryukyu Islands. Furthermore, as an international vehicle currency with high international liquidity, the USD had a higher practical value than the B-Yen, which was a local currency without general acceptability in international settlements. Therefore, the USCAR considered the USD currency regime as one of the necessary conditions for attracting foreign capital.

Therefore, the USD regime emerged from a' highly political decision by the USCAR, which was unrelated to the relative price structures of the Ryukyu Islands and mainland Japan.

3.4. Exogeneity of the Nixon Shock to the Okinawan economy

The Nixon Shock was a series of emergency economic policies that US President Richard Nixon publicly announced on August 15, 1971. Under the title of "The Challenge of Peace," President Nixon implemented three policy measures: (i) suspending the USD's convertibility to gold, (ii) freezing wages and prices for 90 days, and (iii) imposing an import surcharge of 10% to fix a confidence problem in the USD and reduce US unemployment and inflation rates. As a result, the Nixon Shock had an unprecedented impact on international financial markets.

The Bretton Woods system characterized the international monetary order as a "gold exchange standard" in which the USD was backed by gold at a fixed conversion rate of 35 USD per ounce of gold. All other foreign currencies were fixed relative to the USD. Therefore, the suspension of backing the USD with gold allowed the conversion rate of the USD to gold to float. The 10% import surcharge meant abandoning a fixed exchange rate system by implicitly devaluating the USD relative to all other currencies. Therefore, the Nixon Shock ended the Bretton Woods system. Following the Nixon Shock, the major western countries temporarily closed their foreign exchange markets and began floating their exchange rates. Japan also shifted to a managed floating system by August 28, 1971 and began revaluating JPY from the official rate of 360 JPY/USD. On December 20, 1971, the Smithsonian Agreement revalued JPY up to an official rate of 308 JPY/USD.[11]

The primary factors underlying the Nixon shock are summarized below. After 1958, the US balance of payment continuously recorded a large deficit as a result of the rapid economic recovery of West Germany and Japan from the ruin following WWII and the generous amount of US official development assistance programs for foreign countries to maintain the Western alliance. Furthermore, the US balance of payment further deteriorated as a result of fiscal deficits and the resulting high inflation pressure caused by a sharp increase in military spending as a result of US military intervention in the Vietnam War in 1965.

The US balance of payment deficit resulted in an excess supply of USD relative to the world economy. This excess liquidity of the USD then caused a fundamental credibility problem in the gold exchange standard under the Bretton Woods system.[12] Furthermore, in the 1970s, the US economy suffered from the "stagflation" problem with high inflation and unemployment simultaneously. Therefore, the US government prioritized macroeconomic policy autonomy for the domestic economy through the Nixon Shock, which meant abandoning international commitment to the fixed-exchange-rate system.[13]

The Nixon Shock was the direct result of policy decisions of the US to handle the internal and external imbalances that the US economy suffered and to correct the institutional limitations imposed by the Bretton Woods system. Therefore, it is apparent that the Nixon shock was an exogenous unanticipated historical event for the small island economy of the Ryukyu Islands and Okinawa. On the day of the Okinawa reversion on May 15, 1972, all USD circulated in the Ryukyu Islands were converted into JPY at the official rate of 305 JPY/USD (i.e., the sixth currency conversion). We recognize the unanticipated exogenous transition in the currency regime in Okinawa from the USD fixed regime to the USD flexible regime to the JPY common currency regime as an ideal environment for a quasi-natural experiment to identify the effects of currency regimes on inefficient internal and external price dispersion.[14]

[11] More precisely, the international monetary system returned to a fixed-exchange-rate system through the Smithsonian agreement, even though it admitted intermittent devaluations of the USD. Even under the Smithsonian regime, massive speculative attacks on the USD did not stop. As a result, advanced economies adopted floating exchange rates. After Japan began floating JPY against major currencies in February of 1973, the Smithsonian regime finally collapsed.

[12] As a result of the US balance of payment deficit, other foreign countries with balance of payment surpluses accumulated a massive amount of USD reserves. Once the USD reserves in foreign countries became much larger than the gold reserves held by the US Fed, the USD lost its credibility because it would be impossible for all foreign USD reserves to be converted into gold at the official conversion rate. In contrast, if the US balance of payment had turned into a surplus, a severe shortage of the USD as an international settlement currency would have emerged and would have stifled the growth of the world economy. This inevitable destiny of an international vehicle currency, which is well known as "Triffin's dilemma" (named after Robert Triffin), finally materialized in the form of the Nixon Shock.

[13] According to the thesis of the "open-economy trilemma," US policymakers allowed the USD nominal exchange rates to adjust flexibly by shifting to a floating-exchange-rate regime, which regained monetary policy autonomy and maintained the freedom of international capital flow.

[14] The unexpected shift to the USD flexible regime and resulting sharp devaluation of the USD heavily damaged the Ryukyu Islands economy. In particular, it caused social anxiety and uncertainty as a result of an expected decline in the amount of currency received after the planned currency conversion from the USD to the JPY on the day of reversion. Political negotiations between the government of the Ryukyu Islands and the Japanese government regarding the official conversion rate applied to the sixth currency conversion on the reversion day found it extremely difficult to reach a final agreement. On October 18, 1971, the Japanese government officially announced the establishment of a special benefit program related to currency conversion to compensate for pecuniary losses caused by an expected revaluation of JPY from the official conversion rate of 360 JPY/USD under the Bretton Woods system (*Tsuuka Tou Kirikae Taisaku Tokubetu Kyuhukin*). Because special compensation benefits would be provided to the residents of the Ryukyu Islands following the reversion, the Government of the Ryukyu Islands, on behalf of the Japanese government, implemented currency confirmation for USD assets across the Ryukyu Islands and Okinawa

4. Empirical results

4.1. Data description and construction

In this study, we investigated monthly retail price data surveyed at selected retail stores in the capital cities of the 47 prefectures in Japan, including Naha, which was under US military occupation. The sample period spans five years between January of 1970 and December of 1974. The data for the 46 prefectures in the mainland came from a retail price survey (hereafter referred to as the "mainland survey") conducted by the statistics bureau of the office of the prime minister.[15] However, the mainland survey only contains data for Naha for the period after June of 1972. Fortunately, for the periods before May of 1972, the Statistics Agency of the Government of the Ryukyu Islands, which was the administrative body of the USCAR, conducted a retail price survey for Naha (hereafter referred to as the "Okinawa survey").[16] Most importantly, the Okinawa survey covered most of the same survey items as the mainland survey. This detail of the Okinawa survey makes it possible for us to conduct a DID exercise by identifying equivalent goods and services and comparing retail prices between Okinawa and the other mainland capital cities during the entire sample period. It is noteworthy that the Okinawa survey reports retail prices in terms of the USD before May of 1972 and in terms of the JPY after June of 1972. To measure item-level LOP deviations, we use the JPY/USD market rate (monthly average) to convert USD prices into JPY prices in Naha before May of 1972.[17]

There are three main reasons for choosing a sample period from January of 1970 to December of 1974. First, the Okinawa statistical yearbook for each year before 1969 reports product categories and items that are too coarse to make sufficiently precise matches with mainland counterparts and construct item-level LOP deviations precisely. Second, if we choose a more extended sample period beyond 1974, time series variations in item-level LOP deviations most likely reflect the effects of changes in the currency regime and any other structural changes in the economic environment between Okinawa and mainland Japan.[18] As a result, this study's inferences regarding the JPY common currency effect could have been biased or misleading. Therefore, we limit our attention to a shorter time series sample neighboring the shifts in the Okinawan currency regime to guarantee that other economic aspects in Okinawa and the mainland will not change. We then empirically infer any discontinuous changes in the shapes of the cross-item distributions of LOP deviations between Okinawa and the mainland. Finally, this sample period involves the three different currency regimes experienced by the Ryukyu Islands and Okinawa. Therefore, even with a relatively short sample period, our data contain rich variations in the currency regime of Okinawa that can be used to identify the effects of exchange rate fluctuations on inefficient internal and external price dispersion.

This study investigates the retail prices of 178 goods and services included in both the Okinawa and mainland surveys. The items cover a broad range of goods and services required for daily life in representative households in the two regions. First, we distinguish fresh food items (31) from other items (147). Fresh food items have high price flexibility. The average frequency of price changes over the three

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on October 9, 1971. For the currency confirmation exercise for USD assets, see the studies by Karube (2012) and Kabira (2015) for additional details.

[15] "Retail Price Survey," Bureau of Statistics, Office of the Prime Minister of Japan.

[16] "Retail Price Survey," Agency of Statistics, Planning Department, Government of the Ryukyu Islands.

[17] We use the monthly JPY/USD exchange rate data distributed by the FRED at the Federal Reserve Bank of St. Louis.

[18] Crucial structural changes for our exercise include lowering transport costs between Okinawa and the mainland through improvements in transport technology.

currency regimes is approximately 80%. Furthermore, most of the fresh foods in Okinawa were local products produced and distributed only within the region, meaning they can be considered as non-tradable goods. Therefore, the retail prices of fresh food items are not informative for identifying inefficient internal and external price dispersion.

The other 147 items include processed foods, housing, furniture, household utensils, clothes, footwear, medical care, fuel, light and water charges, transportation, communication, education, culture, recreation, and other services. These items have two notable characteristics. The first characteristic is a high degree of price stickiness. The average frequency of price changes over the three currency regimes is approximately 20%. Thus, these items could be the primary reason for inefficient price dispersion. The second characteristic is that 91 out of the 147 items were produced in mainland prefectures and delivered to Okinawa. The Okinawa survey reports the retail prices of these 91 items together with either brand names of large mainland manufacturers or simply notes of mainland products. Therefore, we identify these 91 items as tradable goods. In contrast, the other 40 items were locally produced and delivered within Okinawa. Because these "island" items are unlikely to be exported to the mainland, we identify these 40 items as non-tradable goods and services. We identified the remaining 16 items as non-fresh products that were imported from the US mainland. Based on these characteristics, we mainly focus on the retail price behavior of 147 non-fresh-food items.

Data on item-level LOP deviations were constructed as follows. Let $p_{j,c}(t)$ denote the natural logarithm of the retail price of item $j(=1,2,\cdots,178)$ in city $c(=1,2,\cdots,47)$ in period $t(=1,2,\cdots,60)$ in terms of the JPY. For Okinawa, we converted the USD prices before the reversion into JPY prices using the JPY/USD spot rate. Let $q_{j,c,s}(t)$ denote the logarithm of the item-level LOP deviation of item j in period t between distinct cities c and $s(\neq c)$. Then, $q_{j,c,s}(t)$ is defined as

$$q_{j,c,s}(t) \equiv p_{j,c}(t) - p_{j,s}(t).$$

From each $q_{j,c,s}(t)$, we extract a time-invariant city pair fixed effect over the three currency regimes. For this purpose, we calculate the time series average of $q_{j,c,s}(t)$ for city pairs (c,s) and j as $\bar{q}_{j,c,s} \equiv T^{-1}\sum_{t=1}^{T} q_{j,c,s}(t)$. Then, we subtract $\bar{q}_{j,c,s}$ from $q_{j,c,s}(t)$ to construct our sample of item-level LOP deviations $\hat{q}_{j,c,s}(t) \equiv q_{j,c,s}(t) - \bar{q}_{j,c,s}$.

For item j in city c under currency regime $r(=$ USD-Fix, USD-Flex, JPY-Com$)$, we construct a frequency of price changes denoted as $\text{Freq}_{j,c}(r)$ by dividing the number of price changes by the number of periods within currency regime r. Similarly, we construct the average absolute size of price changes conditional on price revision, which is denoted as $\text{avPC}_{j,c}(r)$, by calculating the average of the absolute size of price changes conditional on price revision within currency regime r.

4.2. Currency misalignment: item-level LOP deviations

Tables 2(a) and 2(b) report descriptive statistics for the item-level LOP deviations $\hat{q}_{j,c,s}(t)$ over all 178 items. Tables 2(a) and 2(b) correspond to city pairs including Naha as the s city (hereafter referred to as "Okinawa pairs") and those not including Naha (hereafter referred to as "mainland pairs"), respectively, and display the sample size, mean, and standard deviation (S.D.) for the three currency regimes. These tables reveal the following four facts. First, regardless of the currency regime, the mean and S.D. of the Okinawa-pair data are more prominent in terms of absolute values than those of the mainland pair counterparts. Therefore, the Okinawa-pair distribution is subject to a positive fixed effect with heteroskedasticity. Second, the Okinawa-pair distribution shifts its position to the right under the USD-Flex regime. This finding is confirmed by the fact that the mean and S.D. of the Okinawa-pair data are the largest and the smallest, respectively, in the USD-Flex regime. Because we constructed the Okinawa-pair data by subtracting Okinawa prices from mainland prices, this fact also implies that on average, Okinawa's goods and services became cheaper during the USD-Flex regime compared to the mainland. The USD depreciated relative to the JPY during the USD-Flex period. This nominal depreciation led to the real depreciation of the Okinawa currency, which is consistent with Mussa's (1986) observations.

Third, the mean of the Okinawa-pair data under the JPY-Com regime is slightly negative. This indicates that on average, Okinawa's goods and services became more expensive during the JPY-Com regime compared to the mainland. It is worth noting that this appreciation in Okinawa during the JPY-Com regime did not stem from any effects of the JPY common currency regime. Instead, it resulted from a faster rise in the inflation rate in Okinawa compared to the mainland around the end of the sample period, as shown in Figure 1 and Table 1. Finally, as the fourth fact, contrary to the Okinawa-pair data, there are no significant changes in the mainland-pair distribution over the three currency regimes. This guarantees that our exercise is free from placebo effects. A shift in the nominal currency regime should not matter for the mainland distribution of the LOP deviation, which was not exposed to a currency regime change.

To reconfirm the second, third, and fourth facts, Figure 3 plots the kernel-smoothed densities of the item-level LOP deviations for all items.[19] In particular, Figures 3(a) and 3(b) correspond to the Okinawa and mainland pairs, respectively. In each figure, the solid black line plots the distribution under the USD-Fix regime, the dashed blue line plots the distribution under the USD-Flex regime, and the dash-dotted red line plots the distribution under the JPY-Com regime.

Regarding the right shift of the distribution of the Okinawa-pair data under the USD-Flex regime, Figure 3(a) reveals that the USD-Flex regime generates a significant right shift of the distribution compared to the USD-Fix regime. However, the empirical plausibility of the negative effect of the JPY-Com regime on the Okinawa-pair distribution seems unclear because the shape of the solid black line is indistinguishable from that of the dash-dotted red line. Finally, no significant changes in the mainland-pair distribution over the three currency regimes are apparent in Figure 3(b).

It is important to determine the origin of the significant right shift of the distribution of the LOP deviation in the USD-Flex regime. If the implied deterioration of the LOP deviation stems from price stickiness in the local currency, we should observe the same right distributional shift of the LOP deviation for the survey items with a higher degree of price stickiness. Therefore, we split all items into fresh food items with high price flexibility and non-fresh items with high price stickiness.[20]

Tables 2(c) and 2(d) report descriptive statistics for the LOP deviations of the fresh food items for the Okinawa and mainland pairs, respectively. Similarly, Tables 2(e) and 2(f) report descriptive statistics for the LOP deviations of the non-fresh items for the Okinawa and mainland pairs, respectively. From these tables, we can derive at least two clear results. First, for both fresh and non-fresh items, there are no significant changes in the distribution of LOP deviations over the three currency regimes in the mainland

[19] We used the Gaussian kernel for kernel smoothing.

[20] The average frequencies of price changes of the fresh foods items over the entire sample period are 80.3% and 83.4% for the Okinawa and mainland data, respectively, whereas those of the non-fresh items are 25.6% and 20.0%, respectively.

pairs. Second, Table 2(e) reveals that the Okinawa-pair distribution of LOP deviations shifts to the right under the USD-Flex regime for the non-fresh items. The mean LOP deviation has a maximum value of 0.132 in the USD-Flex regime (0.006 in the USD-Fix regime and -0.043 in the JPY-Com regime). We can confirm this finding graphically in Figures 3(a) and 3(b), which plot the kernel-smoothed densities of the item-level LOP deviations for the non-fresh items for the Okinawa and mainland pairs, respectively. As indicated by the dashed blue line in Figure 3(a), the Okinawa-pair distribution shifts to the right under the USD-Flex regime. There are no changes in the shape of the mainland pair distribution over the three currency regimes, as shown in Figure 3(b).

In summary, based on visual comparisons of the distributions of LOP deviations, we can infer that price stickiness leads to currency misalignments in the form of inefficient external price dispersion caused by flexible exchange rates. However, we found no robust evidence that adopting the JPY common currency affected the distribution of item-level LOP deviations. We confirm these inferences by conducting formal econometric analysis with DID regression below.

To explain the econometric model used in our DID regression analysis, we introduce several dummy variables. Let $\mathbf{D}_{c,s}^{\text{Okinawa}}$ denote the dummy variable for the Okinawa-pair data such that for the 47 prefectural capital cities indexed by c and 46 prefectural capital cities (excluding Naha) indexed by $s(=1,2,\cdots,46)$, $\mathbf{D}_{c,s}^{\text{Okinawa}}$ takes a value of one if $c=$ Naha and a value of zero otherwise.

$$\mathbf{D}_{c,s}^{\text{Okinawa}} = \begin{cases} 1 & \text{if} \quad c = \text{Naha}, \\ 0 & \text{otherwise}. \end{cases}$$

Next, we define a dummy variable for the USD-Flex regime $\mathbf{D}^{\text{Flex}}(t)$ that takes a value of one when the time subscript t indicates a period between September of 1971 and May of 1972, and value of zero otherwise. Similarly, $\mathbf{D}^{\text{Com}}(t)$ denotes the dummy variable for the JPY-Com regime, which takes a value of one when the time subscript t indicates a period between June of 1972 and December of 1974, and a value of zero otherwise.

$$\mathbf{D}^{\text{Flex}}(t) = \begin{cases} 1 & \text{if} \quad t = \text{September 1971, ..., May 1972}, \\ 0 & \text{otherwise} \end{cases}$$

$$\mathbf{D}^{\text{Com}}(t) = \begin{cases} 1 & \text{if} \quad t = \text{June 1972, ..., December 1974}, \\ 0 & \text{otherwise} \end{cases}$$

By letting α_j and $u_{j,c,s}(t)$ denote an item-specific fixed effect and an i.i.d. disturbance, respectively, we construct the following econometric model of the item-level LOP deviation $\hat{q}_{j,c,s}(t)$:

$$\begin{aligned} \hat{q}_{j,c,s}(t) = \alpha_j + \beta_0 \mathbf{D}_{c,s}^{\text{Okinawa}} + \beta_1 \mathbf{D}^{\text{Flex}}(t) + \beta_2 \mathbf{D}^{\text{Com}}(t) \\ + \gamma_0 \mathbf{D}_{c,s}^{\text{Okinawa}} * \mathbf{D}^{\text{Flex}}(t) + \gamma_1 \mathbf{D}_{c,s}^{\text{Okinawa}} * \mathbf{D}^{\text{Com}}(t) + u_{j,c,s}(t). \quad (1) \end{aligned}$$

In the DID regression above (1), we intend for the coefficients γ_0 and γ_1 to capture the average treatment effects of adopting the USD-Flex and JPY-Com regimes, respectively, on the item-level LOP deviation in the Okinawa pair data relative to the USD-Fix regime. Our review of the post-war Okinawan history in Section 3 provides narrative evidence that serves as a valid instrument. There are unlikely endogeneity problems that cause correlations between the dummy variables $\mathbf{D}^{\text{Flex}}(t)$ or $\mathbf{D}^{\text{Com}}(t)$ and the disturbance term $u_{j,c,s}(t)$.

Table 3 summarizes the results of our DID analysis. We estimated the econometric model (1) using OLS. To consider the apparent heteroskedasticity in the Okinawa pair data, we calculated White's heteroskedasticity-robust standard errors. The point estimates and standard errors reported below are provided in percentage terms for expositional purposes.

The second column, which is labelled as "Pooled," represents the point estimates and standard errors of the coefficients in Eq. (1) for all items. The estimated average treatment effect of the USD-Flex regime is 9.943%, which has statistical significance. Therefore, the average size of the currency misalignment caused by the sudden, sharp depreciation of the USD following the Nixon shock is approximately 10% over the pooled sample period. The estimated average treatment effect of the JPY-Com regime is -7.104%, which has statistical significance, which suggests that the JPY-Com regime worsens the LOP deviations relative to the USD-Fix regime. An important caveat is that the negative average treatment effect of the JPY-Com regime does not necessarily reflect inefficient currency misalignment caused by price stickiness. The third column, which is labelled as "Fresh Foods," corresponds to the results for the fresh food items with high price flexibility. The estimated average treatment effect of the JPY-Com regime is more negative at -18.646%. Therefore, the price stickiness in local currency cannot be a primary reason for the 7% real appreciation of the Okinawa currency in the JPY-Com regime observed in the pooled sample period.

Next, we investigate if currency misalignment caused by the USD-Flex regime reflects inefficient external price dispersion caused by price stickiness. The fourth column, which is labelled as "Non-fresh," presents the results for the non-fresh items, which have high degrees of price stickiness in local currency, to resolve this fundamental issue. The estimated average treatment effect of the USD-Flex regime significantly increases to 12.457% in this subsample. Therefore, it is plausible to infer that the observed currency misalignments under the USD-Flex regime stem from inefficient local currency price stickiness.

Table 3 further breaks down the non-fresh items into two informative categories. The first is non-fresh items produced in the mainland and is labelled as "Mainland." The crucial property of this category is that most items were produced by large mainland firms and exported to Okinawa. Therefore, this subsample provides an ideal empirical basis for evaluating open-economy NK models in which monopolistically competitive firms export their products to foreign countries following sticky local currency pricing with the menu cost or Calvo technology.

The second category, which is labelled as "Okinawa," includes non-fresh items produced in Okinawa for the Naha samples. Because the Okinawa local producers only distributed their products to the Okinawa market, the three currency regimes are irrelevant to the retail prices of these island items in the local currency. This characteristic of the second category of non-fresh items leads to two hypotheses. First, the average LOP deviation in the second category is worse than that in the first category under the USD-Flex regime because we expect little pass-through of exchange rate fluctuations into local currency retail prices. Second, the degrees of the LOP deviations of the items in the second category are identical under the USD-Fix and JPY-Com regimes with no exchange rate fluctuation.

The sixth and seventh columns in Table 3 correspond to these subsamples. The Mainland subsample yields approximately the same results as the non-fresh subsample, where the estimated average treatment effects of the USD-Flex and JPY-Com regimes are 11.200% and -5.705%, respectively. In contrast, the Okinawa subsample exhibits a more significant average treatment effect of the USD-Flex regime of 15.236%, but no significant average treatment effect of the JPY-Com regime (0.361%). Therefore, the Okinawa subsample indicates the empirical plausibility of the two hypotheses presented above.

Our DID analysis indicates that the USD depreciation relative to the JPY following the Nixon Shock generated an approximately 12% deterioration of the inefficient external price dispersion caused by price stickiness. However, we found no clear evidence that the JPY common currency improved inefficient external price dispersion.

4.3. Inefficient internal price dispersion

Table 4 summarizes the descriptive statistics of the average absolute sizes of price changes conditional on price revisions. Tables 4(a) and 4(b) report the sample numbers, mean, and S.D. values of the average absolute sizes of price changes for the Okinawa and mainland data for all items. Tables 4(c) and 4(d) report the same values for the Okinawa and mainland data for the fresh food items. Tables 4(e) and 4(f) report the same values for the Okinawa and mainland data for the non-fresh items. These descriptive statistics reveal that the average absolute sizes of price changes are approximately flat across the three currency regimes. For example, for the pooled sample of the Okinawa data in Table 4(a), the cross-sectional means of the average absolute sizes of price changes are 16.9%, 14.4%, and 12.1% for the USD-Fix, USD-Flex, and JPY-Com regimes, respectively, and the differences between them are negligible. The SDs also do not appear to exhibit any particular correlation patterns with the currency regimes.

It is noteworthy that as shown in Table 4(e), the cross-sectional means of the average absolute sizes of price changes in the mainland non-fresh items exhibit values of approximately 8% across all three currency regimes. Most importantly, these values are very close to the estimate of 8% for the US sample between 1978 and 2014 reported by Nakamura et al. (2018).[21] This finding indicates that the argument of the elusive cost of inflation by Nakamura et al. (2018) could also apply to the Japanese mainland data from the early 1970s. Even with high inflation, there is no solid evidence for crucial inefficient internal price dispersion in mainland Japan. With this inference regarding the welfare cost of inflation robustly drawn for two countries as the reference, we can econometrically infer how significantly the different currency regimes affected inefficient internal price dispersion in Okinawa by conducting DID regression analysis.

Formal econometric analysis using DID regression can confirm this inference. To explain the econometric model in our DID regression analysis, we introduce several dummy variables as follows. Let $\mathbf{D}_c^{\text{Okinawa}}$ denote the dummy variable for the Okinawa data such that for the 47 prefectural capital cities indexed by c, $\mathbf{D}_c^{\text{Okinawa}}$ takes a value of one if $c = \text{Naha}$ and a value of zero otherwise.

$$\mathbf{D}_c^{\text{Okinawa}} = \begin{cases} 1 & \text{if} \quad c = \text{Naha}, \\ 0 & \text{otherwise} \end{cases}$$

Next, we define the dummy variable for the USD-Flex regime $\mathbf{D}^{\text{Flex}}(r)$ such that for the three currency regimes, it takes a value of one when the regime subscript r indicates the USD-Flex regime and a value of zero otherwise. Similarly, $\mathbf{D}^{\text{Com}}(r)$ denotes the dummy variable for the JPY-Com regime, which takes a

[21]Gopinath and Itskhoki (2010) also reported a median absolute size of price changes ranging from 6% to 7% in US import price data between 1994 and 2005.

value of one when the regime subscript r indicates the JPY-Com regime and a value of zero otherwise.

$$\mathbf{D}^{\text{Flex}}(r)=\begin{cases}1 & \text{if} \quad r=\text{USD-Flex},\\ 0 & \text{otherwise}\end{cases} \qquad \text{and} \quad \mathbf{D}^{\text{Com}}(r)=\begin{cases}1 & \text{if} \quad r=\text{JPY-Com},\\ 0 & \text{otherwise.}\end{cases}$$

By letting α_j and $u_{j,c}(r)$ denote an item-specific fixed effect and an i.i.d. disturbance, respectively, we can construct the following econometric model of the average absolute size of price changes $\text{avPC}_{j,c}(r)$:

$$\begin{aligned}\text{avPC}_{j,c}(r)=\alpha_j+\beta_0\mathbf{D}_c^{\text{Okinawa}}+\beta_1\mathbf{D}^{\text{Flex}}(r)+\beta_2\mathbf{D}^{\text{Com}}(r)\\ +\gamma_0\mathbf{D}_c^{\text{Okinawa}}*\mathbf{D}^{\text{Flex}}(r)+\gamma_1\mathbf{D}_c^{\text{Okinawa}}*\mathbf{D}^{\text{Com}}(r)+u_{j,c}(r).\end{aligned} \tag{2}$$

We estimate the value of Eq. (2) using OLS with item-specific fixed effects. To consider item- and prefectural-specific heteroskedasticity, we calculate White's heteroskedasticity-robust standard errors.

Table 5 reports the results of DID regression analysis for the average absolute size of prices changes. It is noteworthy that except for two estimates, all estimates of the average treatment effects are not statistically significant at any conventional significance levels. The first and second exceptions are in the average treatment effects of the USD-Flex regime on the Non-fresh and Mainland items. Their point estimates are both 0.025 with standard errors of 0.011 and 0.013, respectively. Therefore, we can infer that the sudden sharp USD depreciation relative to the JPY following the Nixon Shock slightly increased the inefficient internal price dispersion by at most 2.5% relative to the USD-Fix regime. As reported in the last column in Table 5, we can infer no significant effects of currency regime changes on the inefficient internal price dispersion of locally produced Okinawa items, even with a high degree of price stickiness.

Nakamura et al. (2018) pointed out that the frequency of price changes is a compensatory factor. If inflation rises, but the size of the price changes does not, then the price change frequency must be adjusted. Similarly, if the exchange rate fluctuates, but the pass-through size does not, then the frequency of price changes in the local currency must change. Importantly, our unique dataset from the large USD depreciation episode during the Great Inflation period has significant power for distinguishing between open-economy NK models with different price-setting mechanisms.

Table 6 presents descriptive statistics of the average frequency of price changes in the local currency. Tables 6(a) and 6(b) report the sample numbers, mean, and S.D. values of the average price change frequencies for the Okinawa and mainland data for all items. Tables 6(c) and 6(d) list the same values for the Okinawa and mainland data for the fresh food items. Table 6(e) and 6(f) list the same values for the Okinawa and mainland data for the non-fresh items. The most outstanding observation from these tables is that the cross-sectional mean of Okinawa's average price change frequency increases over the sample period from the USD-Fix to the JPY-Com regime in all item categories. However, we identified no clear trends in the average price change frequency in the mainland sample.

Our formal DID analysis confirmed the observations discussed above. We constructed the following econometric model of the average price change frequency $\text{Freq}_{j,c}(r)$:

$$\begin{aligned}\text{Freq}_{j,c}(r)=\alpha_j+\beta_0\mathbf{D}_c^{\text{Okinawa}}+\beta_1\mathbf{D}^{\text{Flex}}(r)+\beta_2\mathbf{D}^{\text{Com}}(r)\\ +\gamma_0\mathbf{D}_c^{\text{Okinawa}}*\mathbf{D}^{\text{Flex}}(r)+\gamma_1\mathbf{D}_c^{\text{Okinawa}}*\mathbf{D}^{\text{Com}}(r)+u_{j,c}(r),\end{aligned} \tag{3}$$

where α_j and $u_{j,c}(r)$ denote item-specific fixed effects and i.i.d. disturbances, respectively. We estimate the value of Eq. (3) using OLS with consideration for item-specific fixed effects. To consider item- and prefectural-specific heteroskedasticity, we calculate White's heteroskedasticity-robust standard errors.

Table 7 presents the results of DID regression analysis for the average price change frequency. It is noteworthy that except for the fresh-foods items, all coefficients for the average treatment effects of the USD-Flex and JPY-Com regimes are positive with high statistical significance. For example, the USD-Flex and JPY-Com regimes increase the average price change frequency of Okinawa's non-fresh items by 16.5% and 14.0%, respectively, relative to the USD-Fix regime. Particularly for Okinawa's Mainland items, the USD-Flex regime sharply increases the average price change frequency by 21.6% relative to the USD-Fix regime.

The empirical findings discussed above regarding the average price change frequency support state-dependent pricing technology with menu costs as the underlying mechanism of price stickiness in an open-economy environment. High inflation quickly erodes the relative price of a good. Therefore, according to the menu cost model, high inflation increases the incentives for producers to revise retail prices to the optimal level frequently, even if they must pay fixed adjustment costs. Furthermore, under high inflation, mainland exporters expect to sooner or later increase their local currency prices in Okinawa eventually to compensate for menu costs. Therefore, exporters have a solid incentive to revise and increase their Okinawa local currency prices in response to sharp JPY appreciation. This implication of the menu cost model consistently explains why we observe a significantly large average treatment effect of the USD-Flex regime on the price change frequency of Mainland items in Okinawa.

Table 8 separates the average frequency of price ups and average frequency of price downs. Specifically, the third and fourth columns report the mean and S.D. values of the frequency of price ups, and the fifth and sixth columns report the same values for the frequency of price downs. Interestingly, Table 8 confirms the observation by Nakamura et al. (2018) that the average frequency of price ups increases with inflation both in Okinawa and the mainland, whereas there is no robust relationship between the average frequency of price downs and inflation. This asymmetry of the price change frequency is consistent with the implications of the open-economy menu cost model discussed by in Flodén and Wilander (2006), where retail prices tend to bunch toward the bottom of the inaction (S,s) band under high inflation with rapid local currency depreciation.

All the results for the average absolute size and average frequency of price changes seem to support the implications of the open-economy menu cost model. In the next section, we present simulations of a calibrated small open-economy menu cost model to evaluate how closely the proposed model replicates the empirical findings discussed in this section compared to the conventional Calvo counterpart.

5. Small open-economy NK models

This section introduces sticky price models for item-level real exchange rates between Okinawa and mainland Japan under the three distinct currency regimes. Our targets are the sample moments of the retail prices of non-fresh items in Okinawa and mainland Japan reported in the previous section because these items are characterized by high degrees of price stickiness, which is the source of inefficient internal and external price dispersion. The considered models are small open-economy variants of those proposed by Nakamura et al. (2018). There is a continuum of final goods indexed by z in the unit interval $[0,1]$ produced by monopolistically competitive producers facing idiosyncratic technology shocks $A_t(z)$. We split the unit interval into two subintervals by $\bar{z}$. If z is in the first subinterval $[0,\bar{z}]$, then a monopolistically competitive mainland firm z produces and delivers its product to both the mainland and Okinawa markets. When delivering products to the mainland market, the firm incurs no transport costs. When exporting products to the Okinawa market, the firm must pay product-specific iceberg-type transport costs $\tau(z)$. The firm employs labor from the competitive mainland labor market for goods production and must hire labor from the competitive Okinawa labor market for product delivery in Okinawa.

If z is in the second subinterval $(\bar{z},1]$, then the item z is internationally non-deliverable, meaning the mainland firm z delivers its products only to the mainland market and the Okinawa local firm z delivers its products only to the Okinawa local market. In particular, the Okinawa firm employs labor from the Okinawa labor market and uses intermediate goods imported from the competitive mainland intermediate goods market. These production and delivery structures make the Okinawa market's marginal costs dependent on real exchange rate fluctuations, as indicated in the menu cost model proposed by Gopinath and Itskhoki (2010). Here, $Q_t \equiv \frac{\mathbf{P}_t^o S_t}{\mathbf{P}_t}$ denotes the real exchange rate accompanied by the JPY/USD nominal exchange rate S_t, where $\mathbf{P}_t$ and $\mathbf{P}_t^o$ are the aggregate consumer price levels prevailing in the mainland and Okinawa, respectively, in period t.

All firms set their monopoly prices in terms of local currency with price stickiness. When exporting products to the Okinawa market, the mainland firm $z \in [0,\bar{z}]$ adopts the LCP strategy by setting the monopoly price in terms of the Okinawa local currency, which is the USD for r = USD-Fix/USD-Flex and JPY for r = JPY-Com. We will investigate menu cost and Calvo mechanisms as generators of price stickiness. Furthermore, we assume that all firms must pay variable adjustment costs when choosing to revise their current prices, as discussed by Slade (1998).

Mainland households consume only domestically produced goods. The mainland consumption basket is represented by a Dixit-Stiglitz aggregator defined over a continuum of domestic products $c_t(z)$ for $z \in [0,1]$ with a constant elasticity of substitution θ. The households in Okinawa consume mainland products $z \in [0,\bar{z}]$ and Okinawa local products $z \in (\bar{z},1]$. The corresponding consumption basket is represented by a Dixit-Stiglitz aggregator defined over the product interval with the constant elasticity of substitution θ^o. The aggregate price levels in the mainland and Okinawa during period t, $\mathbf{P}_t$ and $\mathbf{P}_t^o$, are defined as

$$\mathbf{P}_t = \left[\int_0^1 p_t(z)^{1-\theta} dz\right]^{\frac{1}{1-\theta}}, \quad \text{and} \quad \mathbf{P}_t^o = \left[\int_0^{\bar{z}} p_t^*(z)^{1-\theta^o} dz + \int_{\bar{z}}^1 p_t^o(z)^{1-\theta^o} dz\right]^{\frac{1}{1-\theta^o}}, \tag{4}$$

where $p_t(z)$ and $p_t^*(z)$ denote the local currency retail prices of item z in the mainland and Okinawa markets that the mainland firm z produces and delivers. $p_t^o(z)$ denotes the local currency retail price of item z in the Okinawa market that Okinawa firm z produces and delivers.

The mainland firm $z \in [0,1]$ faces a downward-sloping demand curve in the mainland market $c_t(z) = (p_t(z)/\mathbf{P}_t)^{-\theta} C$, where $c_t(z)$ is the quantity demanded for item z in the mainland market during period t and C is the time-invariant consumption basket in the mainland. If z is within $[0,\bar{z}]$, then the mainland firm z faces a downward-sloping demand curve in the Okinawa market $c_t^*(z) = (p_t^*(z)/\mathbf{P}_t^o)^{-\theta^o} C^o$, where $c_t^*(z)$ is the quantity demanded for the deliverable item z in the Okinawa market during period t and C^o is the time-invariant consumption basket in Okinawa. For $z \in (\bar{z}, 1]$, the Okinawa firm z faces a downward-sloping demand curve with a constant price elasticity θ^o in the Okinawa market $c_t^o(z) = \left(p_t^o(z)/\mathbf{P}_t^o\right)^{-\theta^o} C^o$, where $c_t^o(z)$ is the quantity demanded for the non-deliverable item z in the Okinawa market during period t.

The mainland firm $z \in [0, 1]$ is equipped with a linear production function when delivering products to the mainland market.

$$y_t(z) = A_t(z)L_t(z),$$

where $y_t(z)$ is the quantity produced during period t, $A_t(z)$ is the level of labor productivity during period t, and $L_t(z)$ is the amount of labor input during period t. The firm hires labor from a competitive mainland labor market with a competitive real wage $\frac{W_t}{\mathbf{P}_t}$. When delivering products to the Okinawa market, the mainland firm $z \in [0, \bar{z}]$ must use a local distribution service in Okinawa. For simplification, we assume that the mainland firm has the following Cobb-Douglas production function for the Okinawa market:

$$y_t^*(z) = aA_t(z)L_t(z)^\eta L_t^*(z)^{1-\eta}, \quad \eta \in (0, 1),$$

where $y_t^*(z)$ is the quantity produced for the Okinawa market, $L_t^*(z)$ is the labor input of the Okinawa local distribution service, and a is an adjustment constant. The cost minimization problem solved by the firm provides the real marginal cost of delivering products to Okinawa $\left(\frac{1}{A_t(z)}\right)\left(\frac{W_t}{\mathbf{P}_t}\right)^\eta\left(\frac{Q_t W_t^o}{\mathbf{P}_t^o}\right)^{1-\eta}$, where $\frac{W_t^o}{\mathbf{P}_t^o}$ is the real wage in Okinawa. The mainland firm must pay an iceberg-type transport cost $\tau(z)$ when shipping good z from the mainland to the Okinawa market.

For a product $z \in (\bar{z}, 1]$, the Okinawa firm z produces a non-deliverable island item using the Okinawa labor input and mainland intermediate good with the Cobb-Douglas production function

$$y_t^o(z) = a^o A_t^o(z)L_t^o(z)^\nu M_t(z)^{1-\nu}, \quad \nu \in (0, 1),$$

where $y_t^o(z)$ is the output of the Okinawa product, $A_t^o(z)$ is the level of Okinawa labor productivity during period t, $L_t^o(z)$ is the amount of labor input from the Okinawa labor market during period t, and $M_t(z)$ is the amount of the mainland intermediate good during period t. Mainland intermediate goods are produced in the competitive intermediate goods market with a linear production function for the mainland labor input. The real marginal cost of an intermediate good is equal to the mainland real wage $\frac{W_t}{\mathbf{P}_t}$. The cost minimization problem solved by the Okinawa firm provides the real marginal cost $\left(\frac{\tau(z)^{1-\nu}}{A_t^o(z)}\right)\left(\frac{W_t^o}{\mathbf{P}_t^o}\right)^\nu\left(\frac{W_t}{Q_t\mathbf{P}_t}\right)^{1-\nu}$. We assume that the Okinawa firm muts pay the same iceberg-type transport cost $\tau(z)$ when importing intermediate goods from the mainland.

In this partial-equilibrium small open-economy model, we assume that $A_t(z)$, $A_t^o(z)$, $\mathbf{P}_t$, $\mathbf{P}_t^*$, and S_t follow exogenous stochastic processes. First, the labor productivity levels in the mainland and Okinawa, which are denoted as $A_t(z)$ and $A_t^o(z)$, respectively, follow idiosyncratic logarithmic AR(1) processes as follows:

$$\begin{aligned} \ln A_t(z) &= \rho \ln A_{t-1}(z) + \epsilon_t(z), \quad \epsilon_t(z) \sim N(0, \sigma_A), \\ \ln A_t^o(z) &= \rho \ln A_{t-1}^o(z) + \epsilon_t^o(z), \quad \epsilon_t^o(z) \sim N(0, \sigma_A), \end{aligned} \tag{5}$$

where $\rho \in (0, 1)$ and σ_A are the common AR roots and standard deviation of the productivity shocks.

For simplicity, we assume that the stochastic processes of productivity levels are independent of the currency regime r. Second, the stochastic processes of the aggregate price levels of the mainland and Okinawa, which are denoted as $\mathbf{P}_t$ and $\mathbf{P}^o_t$, respectively, are characterized by the following currency-regime-dependent inflation rate processes:

$$\begin{aligned}\Delta \ln \mathbf{P}_t &= \mu(r) + \eta_t, \qquad \eta_t \sim N(0, \sigma_\pi(r)),\\ \Delta \ln \mathbf{P}^o_t &= \mu^o(r) + \eta^o_t, \quad \eta^o_t \sim N(0, \sigma^o_\pi(r)).\end{aligned} \tag{6}$$

In particular, we allow the parameters $\mu(r)$, $\mu^o(r)$, $\sigma_\pi(r)$, and $\sigma^o_\pi(r)$ to depend on the currency regime state r to reflect rapid changes in the inflation rates in mainland Japan and Okinawa over our sample period.

Finally, to replicate the historical path of the JPY/USD nominal exchange rate during our sample period, we adopt the following stochastic logarithmic process for S_t:

$$\ln S_t = \begin{cases} 0, & \text{if } \mathbf{r} = \text{USD-Fix or JPY-Com}, \\ \ln S_{t-1} + \omega + \lambda_t, \quad \lambda_t \sim N(0, \sigma^2_\lambda), & \text{if } \mathbf{r} = \text{USD-Flex} \end{cases}, \tag{7}$$

where ω is the mean depreciation rate during the USD-Flex regime. The stochastic processes of the inflation rate and nominal exchange rate, which are defined in Eqs. (6) and (7), respectively, imply that the real exchange rate Q_t follows

$$\ln Q_t = \ln Q_{t-1} + \zeta(r) + \upsilon_t(r),$$

where $\zeta(r)$ is the currency-regime-dependent mean of the real depreciation rate, where

$$\zeta(r) = \begin{cases} \mu^o(r) - \mu(r), & \text{if } r = \text{USD-Fix or JPY-Com} \\ \mu^o(r) - \mu(r) + \omega, & \text{if } r = \text{USD-Flex} \end{cases},$$

and

$$\upsilon_t(r) = \begin{cases} \eta^o_t - \eta_t, & \text{if } r = \text{USD-Fix or JPY-Com} \\ \eta^o_t - \eta_t + \lambda_t, & \text{if } r = \text{USD-Flex} \end{cases}$$

is the currency-regime dependent shock to the real depreciation rate.

5.2. Flexible price equilibrium

We characterize the flexible price equilibrium as a benchmark without variable adjustment costs. The mainland firm $z \in [0, 1]$ maximizes the static profit function for the mainland market with respect to the local currency price $p_t(z)$ during each period. If $z \in [0, \bar{z}]$, then the firm maximizes the static profit function with respect to the local currency price $p^*_t(z)$ during each period. The optimal flexible prices are

$$p_t(z) = \frac{\theta}{\theta - 1}\frac{W_t}{A_t(z)} \quad \text{and} \quad p^*_t(z) = \frac{\theta^o}{\theta^o - 1}\frac{\tau(z)}{Q_t A_t(z)}\left(\frac{W_t}{\mathbf{P}_t}\right)^{\eta}\left(\frac{Q_t W^o_t}{\mathbf{P}^o_t}\right)^{1-\eta}\mathbf{P}^o_t.$$

Similarly, the Okinawa local firm $z \in (\bar{z}, 1]$ maximizes the static profit function with respect to the local currency price $p^o_t(z)$ during each period. The optimal flexible price is

$$p^o_t(z) = \frac{\theta^o}{\theta^o - 1} \frac{\tau(z)^{1-\nu}}{A^o_t(z)} \left(\frac{W^o_t}{\mathbf{P}^o_t}\right)^{\nu} \left(\frac{W_t}{Q_t \mathbf{P}_t}\right)^{1-\nu} \mathbf{P}^o_t.$$

These optimal flexible prices define markups over the nominal marginal costs.

Given the optimal flexible price for the mainland market $p_t(z)$, the mainland aggregate price $\mathbf{P}_t$ in Eq. (4) becomes $\mathbf{P}_t = \frac{\theta}{\theta-1}\frac{W_t}{A_f}$, where A_f is the aggregate labor productivity. Because the logarithm of labor productivity $\ln A_t(z)$ follows the ergodic stochastic process in Eq. (5), the aggregate productivity A_f converges to a constant value that is approximately equal to one ($A_f \approx 1$). Therefore, the equilibrium competitive real wage $\frac{W_t}{\mathbf{P}_t}$ is equal to $\frac{\theta-1}{\theta}$. For simplicity, we assume that this competitive mainland real wage under the benchmark flexible price equilibrium always holds throughout our exercise below. Additionally, as suggested by our historical review of the Okinawan economy, the labor market in Okinawa was integrated with the mainland labor market to a great degree, even during the U.S. military occupation period, so it is a reasonable approximation that the equilibrium real wage in Okinawa is equal to that in the mainland ($\frac{W^o_t}{\mathbf{P}^o_t} = \frac{W_t}{\mathbf{P}_t} = \frac{\theta-1}{\theta}$).

The item-level real exchange rate in the benchmark flexible price equilibrium for item $z \in [0, \bar{z}]$ is

$$q_t(z) \equiv \frac{p^*_t(z)S_t}{p_t(z)} = \left(\frac{\theta^o}{\theta^o - 1}\right)\left(\frac{\theta - 1}{\theta}\right)\tau(z)Q_t^{1-\eta}.$$

Therefore, if $z \in [0, \bar{z}]$, then the item-level real exchange rate in the flexible price equilibrium can be decomposed into three factors. The first factor originates from the transport cost $\tau(z)$. The Okinawa price is likely to be higher than the mainland price as a result of the transport cost. The second factor is the difference in the degree of markup between the mainland and Okinawa markets based on the pricing-to-market behavior $\left(\frac{\theta^o}{\theta^o-1}\right)\left(\frac{\theta-1}{\theta}\right)$. The third factor is the real exchange rate Q_t, which originates from the real marginal cost of the local distribution service on Okinawa.

The item-level real exchange rate in the benchmark flexible price equilibrium for a non-deliverable product $z \in (\bar{z}, 1]$ is

$$q^o_t(z) \equiv \frac{p^o_t(z)S_t}{p_t(z)} = \left(\frac{\theta^o}{\theta^o - 1}\right)\left(\frac{\theta - 1}{\theta}\right)\left(\frac{A_t(z)}{A^o_t(z)}\right)\tau(z)^{1-\nu}Q_t^{1-\nu}.$$

In this case, the item-level real exchange rate at the flexible price equilibrium is decomposed into four factors. The first three factors are the same as those mentioned above. The fourth factor is the productivity differential between the mainland and Okinawa $\frac{A_t(z)}{A^o_t(z)}$ induced by the real marginal cost differential.

5.3. Menu cost model

Price stickiness in this model stems from fixed adjustment costs combined with variable adjustment costs. In each period, a firm $z \in [0, 1]$ in the mainland determines the current price $p_t(z)$ in the mainland market. The static real profit of this firm is

$$\pi(p_t(z);p_{t-1}(z),A_t(z),\mathbf{P}_t) = \left[\left(\frac{p_t(z)}{\mathbf{P}_t}\right) - \left(\frac{\theta-1}{\theta A_t(z)}\right)\right]\left(\frac{p_t(z)}{\mathbf{P}_t}\right)^{-\theta} - \gamma\left(\frac{p_t(z)}{p_{t-1}(z)}-1\right)^2,$$

where γ is the coefficient of variable adjustment costs. If the firm chooses to revise the price in the mainland market, then it sets the current price $p_t(z)$ to the desired level $\mathbf{p}_t(z)$ by paying real fixed adjustment costs $\frac{\theta-1}{\theta}K$ and quadratic adjustment costs $\gamma\left(\mathbf{p}_t(z)/p_{t-1}(z)-1\right)^2$. If the firm chooses not to revise the price, then it maintains the current price $p_t(z)$ at the one-period past level $p_{t-1}(z)$. Similarly, if z is in the interval $[0,\bar{z}]$, then the mainland firm z delivers its product to the Okinawa local market engaging in the LCP strategy. The static real profit from this product delivery is

$$\pi^*(p^*_t(z);p^*_{t-1}(z),A_t(z),\mathbf{P}^o_t,Q_t) = \\ \left[Q_t\left(\frac{p^*_t(z)}{\mathbf{P}^o_t}\right) - \tau(z)\left(\frac{\theta-1}{\theta A_t(z)}\right)Q_t^{1-\eta}\right]\left(\frac{p^*_t(z)}{\mathbf{P}^o_t}\right)^{-\theta^o} - \gamma\left(\frac{p^*_t(z)}{p^*_{t-1}(z)}-1\right)^2.$$

If the firm chooses to revise the current price $p^*_t(z)$ in the Okinawa market, then z sets $p^*_t(z)$ to the desired level $\mathbf{p}^*_t(z)$ and pays menu costs adjusted by the real exchange rate $\frac{\theta-1}{\theta}Q_tK^o$ and quadratic adjustment costs $\gamma\left(\mathbf{p}^*_t(z)/p^*_{t-1}(z)-1\right)^2$.[22] If the current price is not revised, then the firm sets $p^*_t(z)$ to the one-period past level $p^*_{t-1}(z)$.

If z is in the interval $(\bar{z},1]$, then the Okinawa local firm $z\in(\bar{z},1]$ delivers products to the local Okinawa market. The static real profit of the Okinawa firm is

$$\pi^o(p^o_t(z);p^o_{t-1}(z),A^o_t(z),\mathbf{P}^o_t,Q_t) = \\ \left[\left(\frac{p^o_t(z)}{\mathbf{P}^o_t}\right) - \left(\frac{\tau(z)}{Q_t}\right)^{1-\nu}\left(\frac{\theta-1}{\theta A^o_t(z)}\right)\right]\left(\frac{p^o_t(z)}{\mathbf{P}^o_t}\right)^{-\theta^o} - \gamma\left(\frac{p^o_t(z)}{p^o_{t-1}(z)}-1\right)^2.$$

In this case, the firm sets the current price $p^o_t(z)$ to the desired level $\mathbf{p}^o_t(z)$ and pays menu costs $\frac{\theta-1}{\theta}K^o$ and quadratic adjustment costs $\gamma\left(\mathbf{p}^o_t(z)/p^o_{t-1}(z)-1\right)^2$. If the current price is not revised, the firm keeps the current price at the one-period past level $p^o_{t-1}(z)$.

All firms in the mainland and Okinawa maximize the expected present discounted values of future real profits based on the subjective discount factor $\beta\in(0,1)$. Because the corresponding Bellman equations for firm problems are standard, we provide the details in an online appendix. For the sake of comparison, we also solve a variant of the small open-economy model with Calvo pricing technology with a price non-resetting probability α. The online appendix provides details regarding the construction of the Calvo model.

5.4. Calibration

We calibrate the menu cost and Calvo models based on the information provided by Nakamura et

[22] We assume that the menu costs K^o for price changes in Okinawa are paid to the households in Okinawa in terms of the consumption basket of Okinawa.

al. (2018), and Gopinath and Itskhoki (2010). The time unit of the models was one month. We set the subjective discount factor β to $0.96^{\frac{1}{2}}$. We calibrate the mainland elasticity of substitution θ to four based the benchmark value set by Nakamura et al. (2018), but we slightly adjust the Okinawa elasticity of substitution θ^o to a lower value of three. Because the availability of alternative goods was limited in the Okinawa market, the price elasticity of demand was low in the Okinawa market relative to the mainland market. We also borrow calibrated values for the stochastic processes of the idiosyncratic labor productivity shock in Eq. (5), where $\rho = 0.7$ and $\sigma_A = 0.037$. We derive menu cost parameters K and K^o to match the mean frequency of price changes of 11.4% per month and mean absolute size of price changes of 6.5% in the mainland data during the USD-Fix regime. This moment-matching exercise resulted in 80% of the calibrated level of menu cost with $K = K^o = 0.8 \times 0.019$. For the Calvo model, we conduct the same moment matching exercise and obtained 120% of the calibrated Calvo probability with $\alpha = 1.2 \times 0.087$.

We set the iceberg transport cost $\tau(z)$ to 1.05, which is common across all goods $z \in [0, 1]$. With all other factors being equal, the Okinawa price is 5% higher than the mainland price as a result of shipping costs. We set the factor share of the Okinawa local distribution service in the production function for the mainland firm $z \in [0, \bar{z}]$ to 20% by setting η to 0.8. This value is close to 0.75, which was selected by Gopinath and Itskhoki (2010). Similarly, we also set the factor share of the mainland intermediate goods in the production function of the Okinawa local firm $z \in (\bar{z}, 1]$ to 30% by setting ν to 0.7. This calibration of ν reflects the high dependence of the Okinawa local production structure on the mainland economy, even during the US military occupation, as suggested by our historical review in Section 3. We set the variable adjustment cost parameter γ to 0.5 to reflect Slade's (1998) point estimate of 0.68 based on retail price data.

To calibrate the stochastic processes of the inflation rates in Okinawa and the mainland for the three currency regimes, we fit Eq. (6) to the sample means and standard deviations of the monthly CPI inflation rates of the mainland and Naha: $\{\mu(r), \mu^o(r)\} = \{0.0047, 0.0048\}$ and $\{\sigma_\pi(r), \sigma_\pi^o(r)\} = \{0.0067, 0.0108\}$ for r = USD-Fix; $\{\mu(r), \mu^o(r)\} = \{0.0047, 0.0063\}$ and $\{\sigma_\pi(r), \sigma_\pi^o(r)\} = \{0.0087, 0.0127\}$ for r = USD-Flex; and $\{\mu(r), \mu^o(r)\} = \{0.0124, 0.0185\}$ and $\{\sigma_\pi(r), \sigma_\pi^o(r)\} = \{0.0108, 0.0258\}$ for r = JPY-Com.

As shown in Figure 1, in the USD-Flex regime, the JPY appreciates sharply relative to the USD. Between August of 1971 and May of 1972, the mean monthly appreciation rate is -0.021 with a mean standard deviation of 0.0137. We fit the parameters ω and σ_λ for the stochastic process of the nominal currency return in Eq. (7) to the monthly sample estimates.

We numerically solve the calibrated Bellman equations for the menu cost and Calvo models using the value function iteration method implemented by Nakamura et al. (2018). We then simulated 30,000 repetitions of the synthetic data on retail prices from the resulting policy functions with the same sample lengths as in the real data for each currency regime. In particular, we construct Okinawa's non-fresh sample by merging the synthetic time series generated from the local mainland and Okinawa firms. The simulation results reported in the next subsection are based on the simulated 30,000 target moments of item-level LOP deviations, average absolute size of price changes, and average price change frequencies.

5.5. Simulation results

Table 9 summarizes the results of our calibration exercises. First, Tables 9(a) and 9(b) report the means of the average LOP deviations estimated by the menu cost and Calvo models in the third and fourth columns for the Okinawa and mainland pairs, which are accompanied by the non-fresh data counterparts in the second column.[23] Both the menu cost and Calvo models replicate the mean of the average item-level LOP deviations in the data reasonably well. For example, for the Okinawa pairs, the menu cost model implies average LOP deviations of 0.000, 0.103, and -0.046 for the USD-Fix, USD-Flex, and JPY-Com regimes, which are reasonably close to the data counterparts of 0.006, 0.132, and -0.046. We also found a similar fit of the Calvo model to the average LOP deviation over the three currency regimes. Additionally, both models can reproduce the zero mean of the average LOP deviation in the mainland pairs as observed in the real data.

The most significant difference in statistical dimensions between the two models is the distributional shape. Figures 5(a) and 5(b) plot the kernel-smoothed densities of the average LOP deviation for the Okinawa and mainland pairs simulated by the menu cost model, respectively. Similarly, Figures 6(a) and 6(b) display the same kernel-smoothed densities estimated by the Calvo model. These figures replicate the shifts in the distribution of item-level LOP deviations over the three currency regimes observed in the real data in Figures 3 and 4. In particular, both models capture the right shift of the distribution of Okinawa pairs under the USD-Flex regime, which is caused by the sharp depreciation of the USD. However, the Calvo model distributions plotted in Figures 6(a) and 6(b) are more heavily tailed than those of the menu cost model plotted in Figures 5(a) and 5(b). It is worth recalling that we performed identical calibration on the primitives for both models, except for price stickiness. Therefore, these distributional differences clearly indicate that the Calvo model predicts worse inefficiency in external price dispersion than the menu cost model as a result of the random nature of the timing of price adjustments.

This previously unidentified implication of the Calvo model regarding inefficient external price dispersion stems from its large time series variability in LOP deviations. To highlight this factor, we present time series plots of the means (solid blue line) and 68% probability intervals (dashed blue lines) of the LOP deviations predicted by the menu cost and Calvo models in Figures 7 and 8, respectively. Each figure also plots the real exchange rate Q_t between Okinawa and the mainland as a solid black line.[24] As shown in Figure 7, on average, the menu cost model closely traces the real exchange rate with small simulation variability until the first half of 1973. However, Figure 8 reveals that the Calvo model fails to track the real exchange rate based on large simulation variability throughout the sample period. This result confirms that the Calvo model yields excess time series variability of the LOP deviations as a result of random price adjustments.

Second, the menu cost model has better implications for the average absolute size of price changes compared to the Calvo model. Tables 9(c) and 9(d) present the ensemble means of the average absolute sizes of price changes for the Okinawa and mainland simulations. The menu cost model predicts an almost flat profile around 8% of the average absolute size of price changes over the three currency regimes for the Okinawa and mainland data, as observed in the real data. In contrast, the Calvo model yields much larger values for this statistical moment, particularly for the Okinawa data, which yield a value of 13%. In particular, the Calvo model's average absolute size of price changes jumps up to 19.8% under the USD-Flex regime, which is almost twice the real value of 10.9%. Therefore, the Calvo model produces excessively large adjustments of retail prices to the desired levels in response to the sharp depreciation of the USD

[23]For each simulation, we first calculate the time series average of the LOP deviations for each currency regime. We then calculate the mean value of the average LOP deviations over 30,000 repetitions. This construction of the average LOP deviation reflects no item-specific heterogeneity that should be included in the actual data.

[24]We constructed the real exchange rate plots using the average CPIs of Naha and the mainland.

under the calibrated high-inflation environment, which is inconsistent with the real retail price behavior.

Finally, Tables 9(e) and 9(f) report the ensemble means of the average price change frequencies for the Okinawa and mainland samples. Again, the menu cost model successfully generates an upward trend in the average price change frequency over time, as observed in the real data. In contrast, based on its construction, the Calvo model derives no meaningful implications regarding this statistical moment. The average price change frequency of the Calvo model is almost independent of inflation and exchange rates. Therefore, as suggested by Flodén and Wilander (2006), the extensive margin of price changes by firms should be state dependent on inflation and exchange rates.

The results of our calibration exercises presented in this section strongly favor the menu cost model over the Calvo model. To understand retail price behavior in Okinawa and the mainland in the early 1970s, it is highly plausible to infer that firms had the option to pay a relatively small fixed adjustment cost and never allowed their prices to drift far from the optimal levels, as indicated by the menu cost model.

6. Conclusions

Our findings in this study seem to support Friedman's (1953) case for flexible exchange rates in the LCP environment. In our data, the firms were likely to adjust the degree of price stickiness flexibly in response to the large USD depreciation relative to the JPY following the Nixon Shock, as predicted by the menu cost model. Therefore, the inefficiency of domestic and international price dispersion caused by local currency price stickiness should be more subtle than expected under flexible exchange rates according to the conventional Calvo model.

This study's solid empirical micro foundation required us to evaluate recent conclusions in the literature regarding the optimality of fixed exchange rate or common currency regimes drawn from the open-economy Calvo model. It is certainly possible that flexible exchange rates and high inflation have other essential costs. Therefore, the argument for the optimality of fixed exchange rates or common currency regimes must depend on these other costs outweighing the benefits of flexible exchange rates.

The unique US military history of deployment in post-war Okinawa demonstrates that any discussion on optimal monetary policy in the open-economy NK framework should be recast in the light of a global social welfare function originating from a state-dependent mechanism of price stickiness. We leave this crucial task as an important future research agenda.

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Table 1: Mean CPI Inflation Rates in Okinawa and Mainland (% at annual rate)

	Okinawa	Mainland
USD-Fix	5.91	5.78
USD-Flex	7.82	5.78
JPY-Com	24.6	15.9

Table 2: Descriptive Statistics: Item-level LOP Deviations

Currency regime	Sample size	Mean	S.D.
(a) *Okinawa pair: Pooled*			
USD-Fix	156,536	0.022	0.285
USD-Flex	69,638	0.123	0.264
JPY-Com	236,387	-0.051	0.300
(b) *Mainland pair: Pooled*			
USD-Fix	3,546,841	0.001	0.162
USD-Flex	1,595,531	0.002	0.153
JPY-Com	5,524,948	-0.001	0.162
(c) *Okinawa pair: Fresh Foods*			
USD-Fix	25,320	0.105	0.388
USD-Flex	11,407	0.078	0.358
JPY-Com	39,253	-0.09	0.393
(d) *Mainland pair: Fresh Foods*			
USD-Fix	300,736	0.005	0.272
USD-Flex	222,166	0.007	0.273
JPY-Com	702,269	-0.005	0.257
(e) *Okinawa pair: Non-fresh*			
USD-Fix	131,216	0.006	0.258
USD-Flex	58,231	0.132	0.240
JPY-Com	197,134	-0.043	0.277
(f) *Mainland pair: Non-fresh*			
USD-Fix	2,968,758	0.000	0.129
USD-Flex	1,335,041	0.002	0.117
JPY-Com	4,611,551	-0.001	0.135

Table 3: Results of DID Analysis: Item-level LOP deviation

Variable	Pooled est/s.e.	Fresh Foods est/s.e.	Non-fresh est/s.e.	Mainland est/s.e.	Okinawa est/s.e.
$\mathrm{D}^{\text{Okinawa}}_{c,s}$	2.131	10.078	.598	1.198	–2.503
	(.073)	(.247)	(.072)	(.103)	(.105)
$\mathrm{D}^{\text{Flex}}(t)$	.135	.237	.115	.207	.028
	(.015)	(.065)	(.013)	(.018)	(.021)
$\mathrm{D}^{\text{Com}}(t)$	–.256	–.945	–.121	–.075	–.278
	(.011)	(.045)	(.010)	(.014)	(.017)
$\mathrm{D}^{\text{Okinawa}}_{c,s} * \mathrm{D}^{\text{Flex}}(t)$	9.943	–3.011	12.457	11.200	15.236
	(.124)	(.420)	(.123)	(.172)	(.187)
$\mathrm{D}^{\text{Okinawa}}_{c,s} * \mathrm{D}^{\text{Com}}(t)$	–7.104	–18.646	–4.855	–5.705	.361
	(.096)	(.318)	(.095)	(.135)	(.147)
Constant	.163	.479	.087	.055	.141
	(.013)	(.081)	(.012)	(.014)	(.037)
Adj. R^2	.006	.005	.008	.006	.008
Log-L.	–4.72e+07	–8.62e+06	–3.77e+07	–2.36e+07	–1.02e+07
N	11,129,881	1,827,950	9,301,931	5,694,520	2,584,656

TABLE 4: DESCRIPTIVE STATISTICS: AVERAGE ABSOLUTE SIZE OF PRICE CHANGES

Currency regime	Sample size	Mean	S.D.
(a) *Okinawa: Pooled*			
USD-Fix	668	0.169	0.277
USD-Flex	541	0.144	0.232
JPY-Com	2,138	0.121	0.253
(b) *Mainland: Pooled*			
USD-Fix	38,134	0.166	0.269
USD-Flex	17,633	0.175	0.301
JPY-Com	85,024	0.148	0.230
(c) *Okinawa: Fresh Foods*			
USD-Fix	370	0.238	0.344
USD-Flex	197	0.205	0.290
JPY-Com	721	0.190	0.382
(d) *Mainland: Fresh Foods*			
USD-Fix	19,643	0.243	0.335
USD-Flex	9,240	0.257	0.377
JPY-Com	34,270	0.235	0.314
(e) *Okinawa: Non-fresh*			
USD-Fix	298	0.083	0.111
USD-Flex	344	0.109	0.182
JPY-Com	1,417	0.085	0.137
(f) *Mainland: Non-fresh*			
USD-Fix	18,491	0.083	0.130
USD-Flex	8,393	0.086	0.137
JPY-Com	50,754	0.089	0.114

Table 5: Results of DID Analysis: Average Absolute Size of Price Changes

Variable	Pooled est/s.e.	Fresh Foods est/s.e.	Non-fresh est/s.e.	Mainland est/s.e.	Okinawa est/s.e.
$\mathbf{D}_s^{\text{Okinawa}}$	–.004	–.002	–.006	–.018	.030
	(.010)	(.016)	(.006)	(.008)	(.015)
$\mathbf{D}^{\text{Flex}}(r)$	.005	.009	.000	.000	.006
	(.002)	(.004)	(.002)	(.002)	(.002)
$\mathbf{D}^{\text{Com}}(r)$	–.000	–.003	.002	–.005	.01
	(.001)	(.003)	(.001)	(.002)	(.001)
$\mathbf{D}_s^{\text{Okinawa}} * \mathbf{D}^{\text{Flex}}(r)$	.002	–.030	.025	.025	.033
	(.014)	(.027)	(.011)	(.013)	(.036)
$\mathbf{D}_s^{\text{Okinawa}} * \mathbf{D}^{\text{Com}}(r)$	–.012	–.035	.001	.012	–.029
	(.011)	(.021)	(.007)	(.010)	(.016)
Constant	.135	.095	.132	.139	.038
	(.011)	(.003)	(.011)	(.011)	(.002)
Adj. R^2	.213	.138	.110	.079	.184
Log-L.	11917.187	–1.55e+04	59544.054	31192.573	20052.091
N	144,138	64,441	79,697	47,565	22,424

Table 6: Descriptive Statistics: Average Frequency of Price Changes

Currency regime	Sample size	Mean	S.D.
(a) *Okinawa: Pooled*			
USD-Fix	178	0.212	0.278
USD-Flex	178	0.356	0.301
JPY-Com	176	0.441	0.283
(b) *Mainland: Pooled*			
USD-Fix	8,183	0.264	0.316
USD-Flex	8,129	0.356	0.301
JPY-Com	8,185	0.353	0.302
(c) *Okinawa: Fresh Foods*			
USD-Fix	31	0.703	0.307
USD-Flex	31	0.769	0.220
JPY-Com	31	0.877	0.196
(d) *Mainland: Fresh Foods*			
USD-Fix	1,425	0.813	0.284
USD-Flex	1,417	0.810	0.290
JPY-Com	1,423	0.853	0.229
(e) *Okinawa: Non-fresh*			
USD-Fix	147	0.109	0.113
USD-Flex	147	0.269	0.236
JPY-Com	145	0.348	0.199
(f) *Mainland: Non-fresh*			
USD-Fix	6,758	0.148	0.166
USD-Flex	6,712	0.143	0.180
JPY-Com	6,762	0.248	0.189

Table 7: Results of DID Analysis: Average Frequency of Price Changes

Variable	Pooled est/s.e.	Fresh Foods est/s.e.	Non-fresh est/s.e.	Mainland est/s.e.	Okinawa est/s.e.
$\mathrm{D}_s^{\text{Okinawa}}$	–.052	–.110	–.039	–.023	–.096
	(.010)	(.034)	(.010)	(.013)	(.017)
$\mathrm{D}^{\text{Flex}}(r)$	–.005	–.002	–.006	–.010	–.004
	(.002)	(.005)	(.002)	(.003)	(.005)
$\mathrm{D}^{\text{Com}}(r)$	.089	.040	.099	.097	.080
	(.002)	(.004)	(.002)	(.003)	(.005)
$\mathrm{D}_s^{\text{Okinawa}} * \mathrm{D}^{\text{Flex}}(r)$	.148	.069	.165	.216	.075
	(.020)	(.054)	(.021)	(.026)	(.032)
$\mathrm{D}_s^{\text{Okinawa}} * \mathrm{D}^{\text{Com}}(r)$	.139	.134	.140	.140	.154
	(.016)	(.044)	(.017)	(.020)	(.031)
Constant	.009	.836	.006	.007	.315
	(.004)	(.014)	(.004)	(.004)	(.023)
Adj. R^2	.809	.781	.428	.384	.420
Log-L.	13941.070	2843.593	11239.023	6990.182	2959.956
N	25,029	4,358	20,671	12,780	5,638

Table 8: Descriptive Statistics: Average Frequency of Price Up and Down

		Price Up		Price Down	
Currency regime	Sample size	Mean	S.D.	Mean	S.D.
		(a) *Okinawa: Pooled*			
USD-Fix	178	0.121	0.140	0.092	0.157
USD-Flex	178	0.209	0.175	0.146	0.181
JPY-Com	176	0.287	0.162	0.154	0.159
		(b) *Mainland: Pooled*			
USD-Fix	8,183	0.160	0.173	0.104	0.176
USD-Flex	8,129	0.148	0.183	0.111	0.186
JPY-Com	8,185	0.236	0.171	0.117	0.164
		(c) *Okinawa: Fresh Foods*			
USD-Fix	31	0.337	0.151	0.366	0.200
USD-Flex	31	0.373	0.148	0.396	0.200
JPY-Com	31	0.481	0.117	0.396	0.183
		(d) *Mainland: Fresh Foods*			
USD-Fix	1,425	0.410	0.179	0.403	0.196
USD-Flex	1,417	0.400	0.188	0.411	0.219
JPY-Com	1,423	0.461	0.127	0.392	0.175
		(e) *Okinawa: Non-fresh*			
USD-Fix	147	0.075	0.084	0.034	0.050
USD-Flex	147	0.175	0.160	0.094	0.124
JPY-Com	145	0.246	0.139	0.102	0.091
		(f) *Mainland: Non-fresh*			
USD-Fix	6,758	0.107	0.116	0.041	0.082
USD-Flex	6,712	0.095	0.130	0.048	0.094
JPY-Com	6,762	0.189	0.138	0.059	0.083

Table 9: Simulation Results: Menu Cost and Calvo Models

Currency regime	Data (Non-fresh)	Menu Cost	Calvo
	(a) *Average LOP Deviation: Okinawa*		
USD-Fix	0.006	0.000	0.000
USD-Flex	0.132	0.103	0.123
JPY-Com	-0.043	-0.046	-0.067
	(b) *Average LOP Deviation: Mainland*		
USD-Fix	0.000	0.000	0.000
USD-Flex	0.002	0.000	0.000
JPY-Com	-0.001	0.000	0.000
	(c) *Average Absolute Size: Okinawa*		
USD-Fix	0.083	0.075	0.131
USD-Flex	0.109	0.081	0.198
JPY-Com	0.085	0.090	0.141
	(d) *Average Absolute Size: Mainland*		
USD-Fix	0.083	0.065	0.053
USD-Flex	0.086	0.065	0.051
JPY-Com	0.089	0.077	0.141
	(e) *Average Frequency: Okinawa*		
USD-Fix	0.109	0.087	0.117
USD-Flex	0.269	0.146	0.121
JPY-Com	0.348	0.206	0.119
	(f) *Average Frequency: Mainland*		
USD-Fix	0.148	0.114	0.116
USD-Flex	0.143	0.120	0.116
JPY-Com	0.248	0.182	0.118

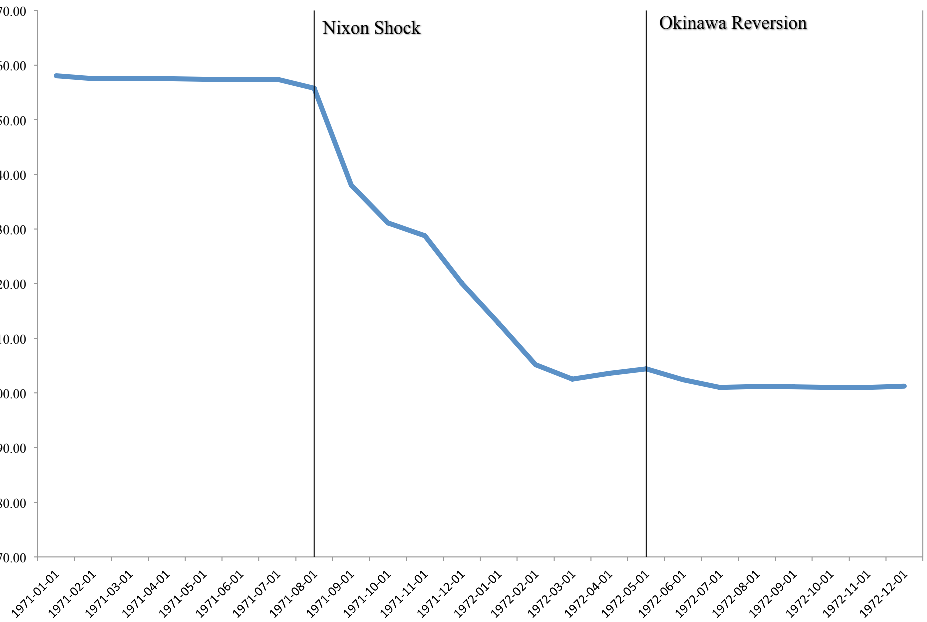

Figure 1: The JPY/USD exchange rate around the Nixon Shock and the reversion

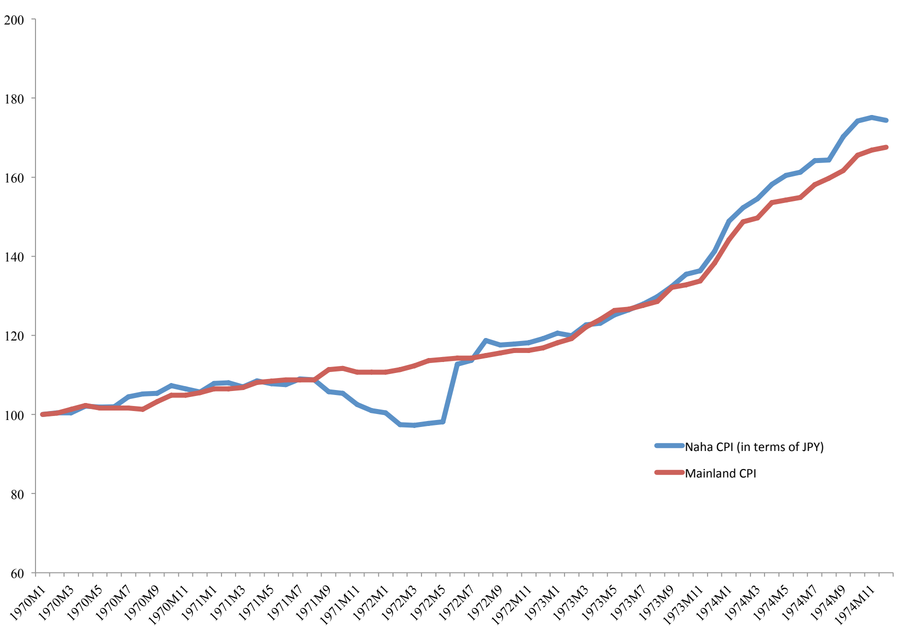

Figure 2: CPI: Okinawa and the mainland

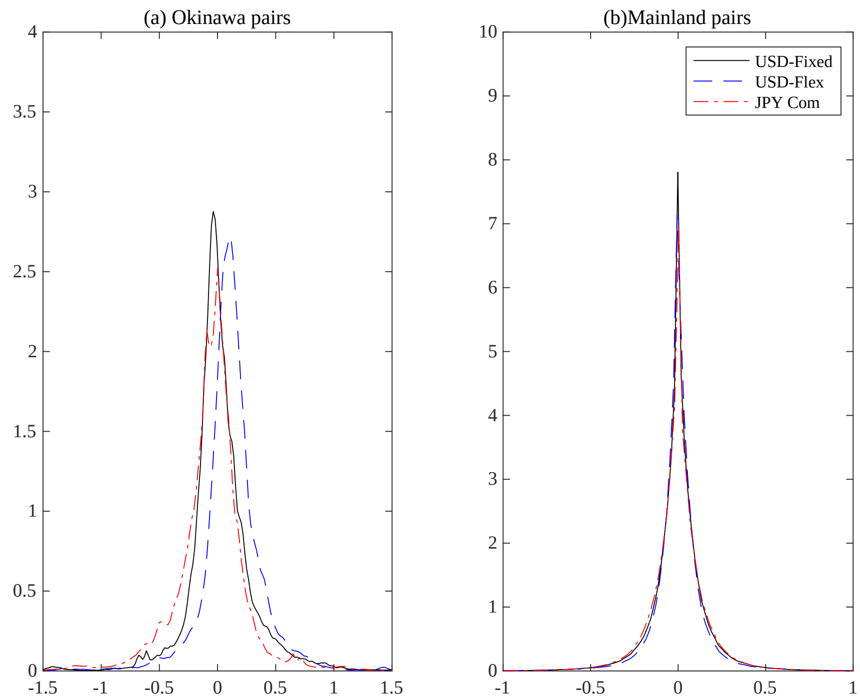

Figure 3: Kernel-smoothed densities of item-level LOP deviation: pooled sample

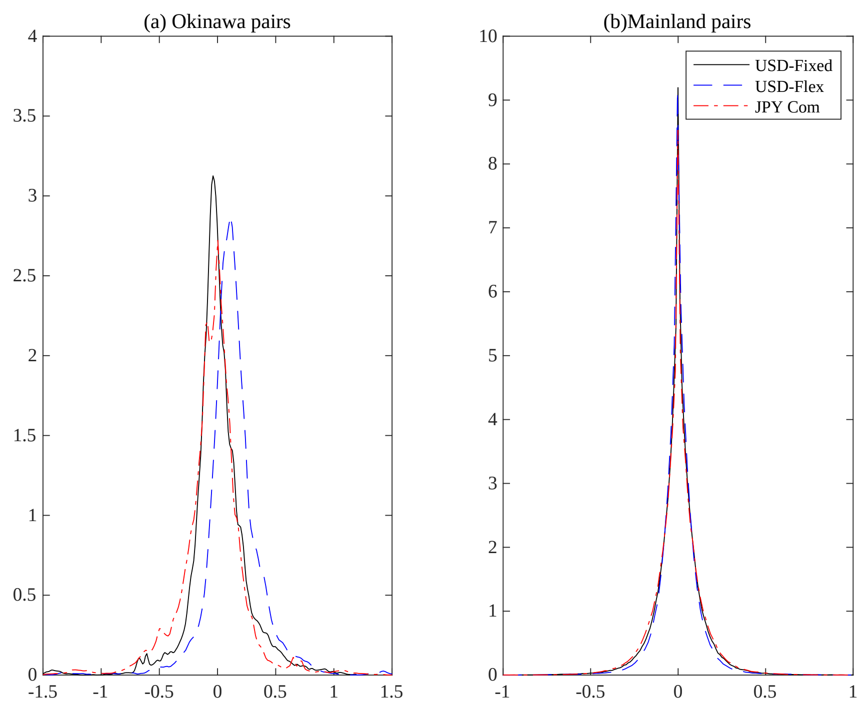

Figure 4: Kernel-smoothed densities of item-level LOP deviation: Non-fresh items

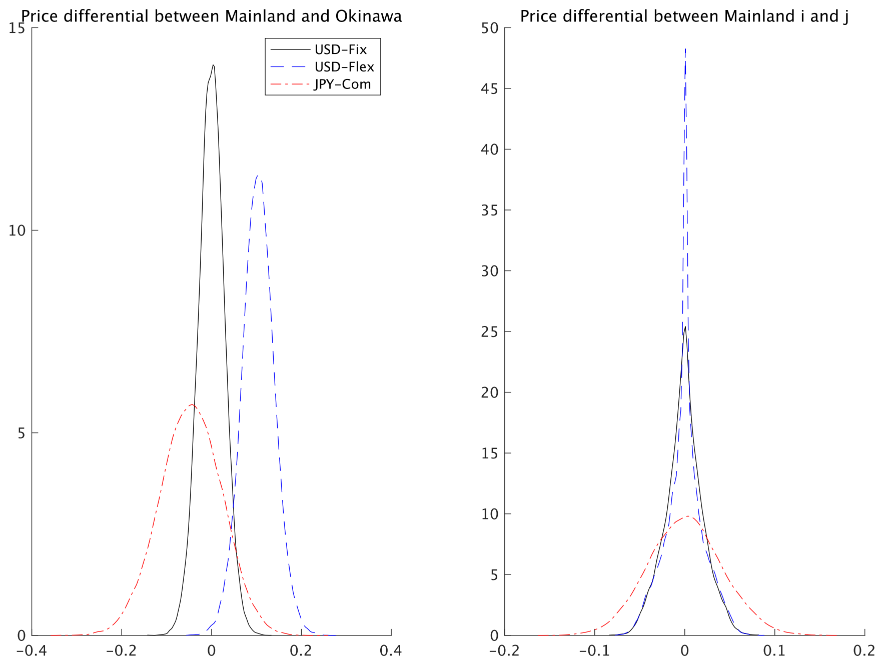

Figure 5: Item-level LOP deviation: Menu cost model

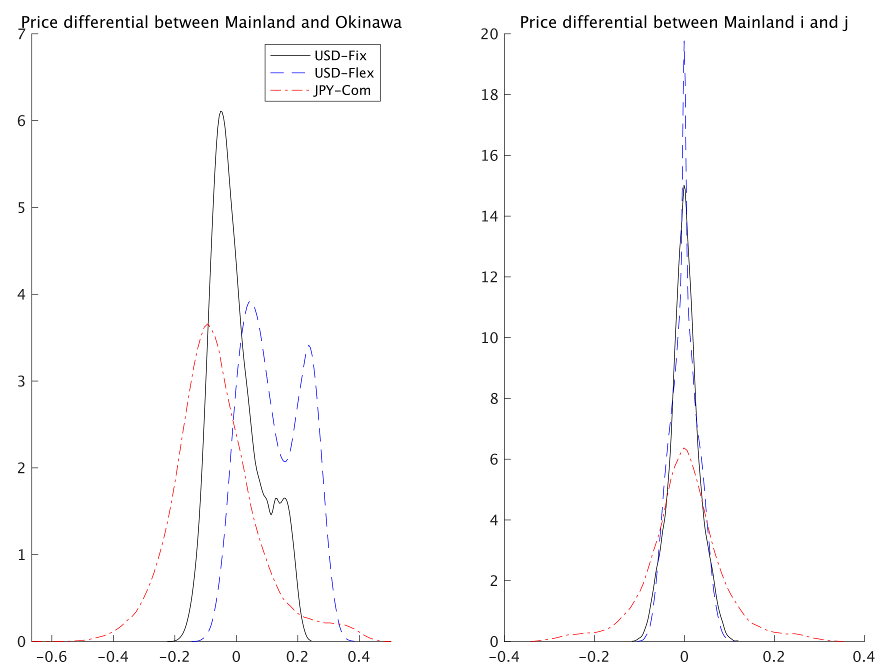

Figure 6: Item-level LOP deviation: Calvo model

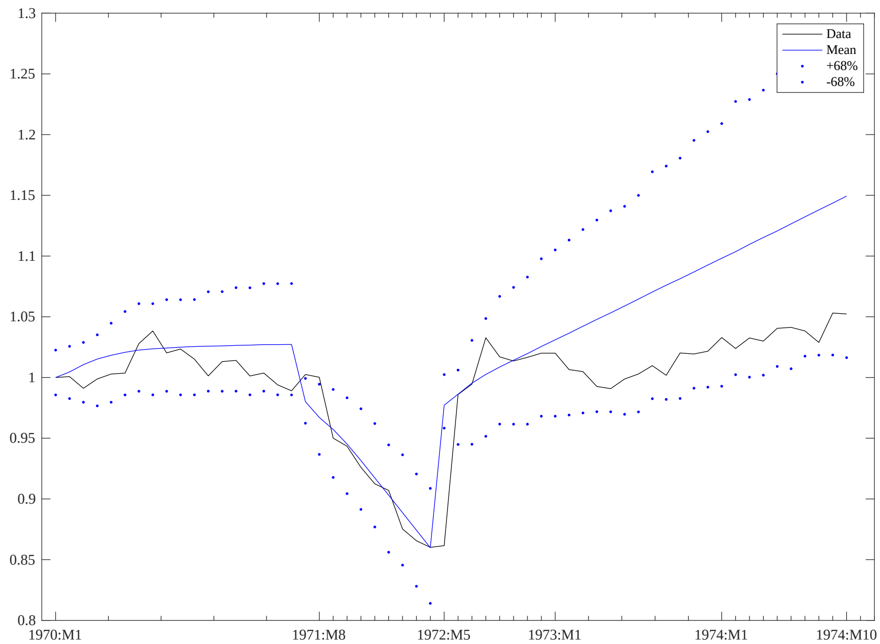

Figure 7: Real exchange rate simulation: Menu cost model

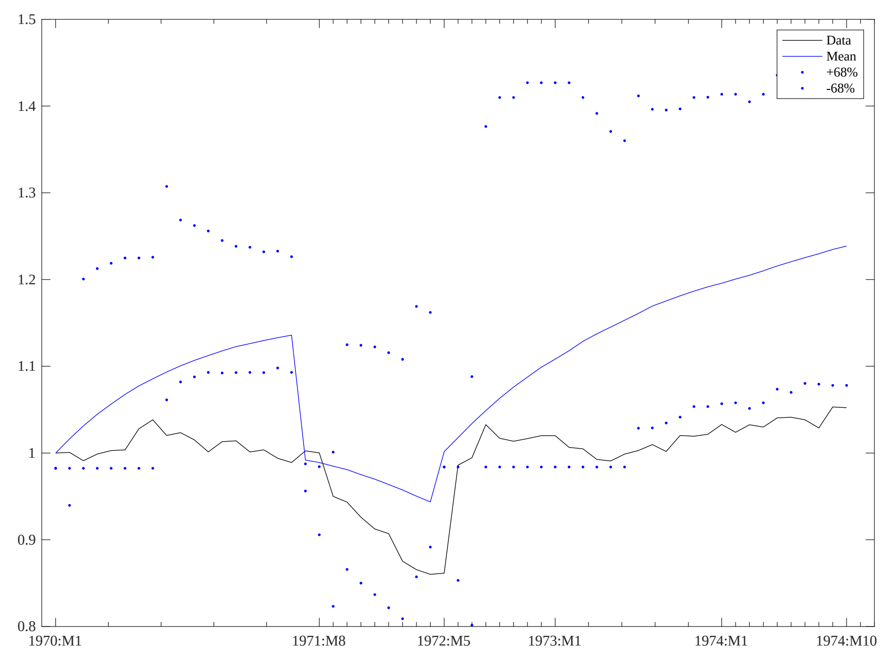

Figure 8: Real exchange rate simulation: Calvo model