Inflation and Exchange Rate Shocks in the Presence of Parallel Markets*

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Abstract

Prior studies document the puzzle of limited retail price inflation following large exchange rate shocks in emerging markets. This paper offers another partial solution: the presence of a parallel market. Using Nigerian data, we show that estimates that only account for the official rate understate true pass-through, as parallel rate shocks have already transmitted to inflation. Contrasting the official market, the parallel market has robust pass-through across all sectors, especially food and energy. This broad-based impact also implies that the disparities in pass-through between the lowest- and highest-wealth households are smaller for parallel rate movements than official rate adjustments.

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1 Introduction

Low estimated pass-through from exchange rate movements to retail prices has been a puzzle in international economics for many years (Mussa, 1986; Burstein and Gopinath, 2014; Itskhoki and Mukhin, 2021). Several theories have been posited, including large non-tradeable components within tradeable goods and the presence of local goods produced only for the domestic market (Burstein, Eichenbaum, and Rebelo, 2005), as well as variations in the extent of dollar invoicing (Boz, Gopinath, and Plagborg-Møller, 2019; Gopinath et al., 2020). This paper empirically assesses a factor that is relevant for several emerging market and developing countries but has generally been ignored in the pass-through literature: the presence of a large parallel market for foreign exchange. When the official exchange rate is managed by the central bank at an unsustainable peg, the parallel rate often moves first before the official rate is adjusted. Therefore, by the time that the official rate eventually changes, it is plausible that a significant proportion of inflation has already happened due to prior parallel rate movements. This can help to explain why pass-through from official devaluations appears to be low. Indeed, accounting for the presence of the parallel market provides another partial solution to this low pass-through puzzle, especially in non-advanced economies with managed exchange rates.

The phenomenon of meaningful parallel and/or multiple markets for foreign exchange is not as rare as it might seem, especially from a historical perspective. Reinhart and Rogoff (2004)[1] state that: "In 1950, 45 percent of the countries in our sample had dual or multiple rates; many more had thriving parallel markets. Among the industrialized economies, dual or multiple rates were the norm in the 1940s and the 1950s, and in some cases, these lasted until much later." In 2021, according to the IMF, 23% of countries had some form of multiple currency practice or foreign exchange restriction, which may lead to the existence of parallel markets. All of these are emerging market and developing countries. Furthermore, the appreciation of the dollar in 2022 and the advent of a new era of higher interest rates are likely to have strengthened parallel markets, particularly if official rates have not been allowed to fully adjust.

In the case of Nigeria, which is the focus of this paper, the role played by the parallel market is significant. Over the sample period from August 2014 to August 2022, the premium of the parallel rate above the highest official rate averages 18%, with a maximum of 71% and two distinct periods exceeding 50%. Large parallel markets can have several negative economic consequences, especially when the premium is high. These include disincentives for exports, reduced attractiveness to foreign investors, and damaged policy

[1] Ilzetzki, Reinhart, and Rogoff (2019) also provide a complementary and updated analysis.

credibility. However, for countries that find themselves in this state, one major question is whether an official devaluation might lead to undesirably high inflation. One of the motivations of this paper is to quantify the extent to which such high inflation has already occurred.

Our major finding is that the parallel market can be systemically important and, as a result, can often translate to an early increase in retail prices. The parallel rate must therefore be considered in any estimation of exchange rate pass-through, especially when a large devaluation takes place under a managed regime. Indeed, analysis that only takes into account the official rate underestimates the true pass-through effect. In Nigeria, 18-month pass-through from bilateral dollar-to-naira parallel premium movements to aggregate retail prices is estimated to be 0.35 (and possibly more), which is higher than estimated pass-through from official rate movements alone. Furthermore, in contrast to the official market, the parallel market has robust pass-through to retail inflation across all sectors, especially food and energy. This broad sectoral impact means that the disparity in pass-through faced by relatively rich households and by relatively poor households (as shown in Cravino and Levchenko, 2017) is smaller for parallel rate movements than for official rate adjustments.

This paper connects two hitherto distinct strands of literature. The first strand focuses on the aforementioned puzzle of low and incomplete pass-through from exchange rate movements to retail prices, but does not account for the parallel market. For a sample of eight advanced economies, Burstein and Gopinath (2014) estimate two-year pass-through to *tradeable* CPI to be no more than 0.36, although varying greatly across countries. Auer, Burstein, and Lein (2021) estimate one-year pass-through to be less than 0.10 for retail prices in Switzerland. Based on a broader sample of 55 countries, Gopinath et al. (2020) find that countries invoicing more in dollars experience significantly higher pass-through into consumer prices. This would suggest higher pass-through in emerging market and developing countries. However, Burstein, Eichenbaum, and Rebelo (2005) analyze several large devaluation episodes in this context (supplemented by Burstein and Gopinath, 2014), similarly finding large movements in the real exchange rate due to limited consumer price pass-through.

They posit a number of reasons for this. First, tradeable goods often have a large non-tradeable component (local distribution costs), which include wholesale and retail services, marketing, and transportation. Second, even though some goods are tradeable, they might only be produced for the domestic market (local goods). Third, consumer price indices might not fully account for the substitution of household consumption towards lower quality goods after a large devaluation. Cravino and Levchenko (2017) ex-

plore these factors further for Mexico's 1994 devaluation. They find that the non-tradeable component of consumption varies across the income distribution, both across and within detailed product categories. The poor spend more on tradeable goods (such as food), on tradeable goods with a lower non-tradeable component, and on lower-priced varieties within each category of goods. As a result, they experience a higher rise in prices (1.48-1.62 times, comparing the lowest- and highest-income deciles).

Curiously, none of these papers mention parallel markets for foreign exchange and the potential impact that they might have on inflation, despite their thorough exposition of large devaluations in emerging market countries with managed exchange rates. Burstein, Eichenbaum, and Rebelo (2005) note that their findings of lower inflation are consistent with prices being too high to start with, although this is attributed to an overvalued currency, rather than explicitly to the parallel market. Indeed, the parallel market has generally been ignored in this strand of the exchange rate literature. Furthermore, even when it is acknowledged (Dornbusch et al., 1983), its tangible impact on consumer prices is assumed to be low. This paper's major contribution is to incorporate the parallel market into analysis of direct pass-through and, in doing so, to highlight its importance in driving inflation prior to movements in the official rate.

By contrast, the second strand of literature recognizes the significant contribution of the parallel rate in emerging market and developing countries, especially when a large premium exists over the official rate (Pinto, 1988, 1989, 1991; Morris, 1995; Kaufmann and O'Connell, 1999). These papers instead focus on the inflationary implications of unifying the two rates (i.e., devaluing the official rate to make it align with the parallel rate), and a potential tradeoff between the economic benefits of unification and the costs of inflation. Consistent with Reinhart and Rogoff (2004), who argue that the parallel rate is "often the most economically meaningful rate," their theoretical models make the assumption that pass-through from the parallel market to inflation has already occurred (i.e., the official rate is infra-marginal). This implies that an official devaluation itself has no direct pass-through effect. Instead, these papers suggest that the inflationary impact depends on fiscal dynamics. Schmitt-Grohé and Uribe (2023) provide a modern and thorough exposition of the fiscal impact of exchange controls and parallel markets, and their negative welfare effects. Whilst only briefly discussing the fiscal implications, our paper seeks to empirically test the critical assumption of many of these earlier models: that the parallel market drives prior inflation to such an extent that official rate movements have no direct pass-through.

More broadly, this paper attempts to unify these two strands of literature, specifically estimating exchange rate pass-through in the presence of parallel markets and providing

a novel perspective on the various sectoral channels through which it operates. It also seeks to contribute to the broader literature on emerging market monetary policymaking in response to global shocks (for example, De Leo, Gopinath, and Kalemli-Özcan, 2024 and Das, Gopinath, and Kalemli-Özcan, 2022). Furthermore, despite a renewed interest in parallel markets, it still remains the case that the majority of studies focus on time periods prior to the Global Financial Crisis. This paper draws on more modern data from 2014 to 2022, during a period of much higher financial integration and international capital mobility, and with reliable records of the parallel market rate at a near-daily frequency.

The rest of the paper proceeds as follows: Section 2 provides context on parallel markets for foreign exchange, both globally and in Nigeria; Section 3 describes the data and outlines the empirical framework; Section 4 reviews the results; and Section 5 discusses broader implications and concludes.

2 Parallel Markets for Foreign Exchange

2.1 Global Context

Parallel markets for foreign exchange typically occur under two conditions: (i) a country has some form of managed exchange rate, and (ii) the central bank requires that certain foreign exchange transactions take place at a rate that differs from the official rate, or imposes restrictions on access to foreign exchange for certain transactions (incentivizing them to occur outside of the official market).

Globally, according to the International Monetary Fund's (IMF) Annual Report on Exchange Arrangements and Exchange Restrictions (IMF, 2022), 69% of countries had some form of managed exchange arrangement in 2021. These countries are predominantly emerging market and developing countries; 84% of advanced economies had a floating exchange rate. Only 11% of countries, all of which are emerging market and developing countries, are explicitly documented to have multiple currency practices, although there is reason to believe that this may have increased with the appreciation of the dollar and rising interest rates in 2022. Given the unofficial nature of the parallel market in many cases, it is also possible that its prevalence is underreported. An additional 12% of countries (also emerging market and developing countries) have some form of foreign exchange restrictions, which may lead to the existence of parallel markets during periods of distress. Typical restrictions include: different exchange rates used for the government compared to the private sector; limits on access to foreign exchange and/or taxes for certain transactions; requirements for importers to submit documentation to receive foreign

exchange; limitations on repatriation of profits and dividends; and prioritization and rationing of foreign exchange to certain sectors and companies (often arbitrarily determined by the central bank).

2.2 Economic Implications

For those countries where parallel markets exist, the economic consequences can be negative, especially when the premium above the official rate is large. Agénor (1992), Kiguel and O'Connell (1995), and Reinhart and Rogoff (2003), for example, outline a range of implications. First, this premium essentially acts as a tax on exports, which must be sold at the official rate at a discount compared to the parallel rate. This acts as a disincentive to export growth, an important driver of economic development. Second, this export tax can push exporters to transact through the black market and/or hold money abroad, limiting the official flow of export receipts and lowering official reserves. Third, restrictions can reduce foreign investment, as investors and international companies have less certainty about their ability to access foreign exchange to repatriate profits and dividends, or even to repay foreign currency debt. Fourth, large parallel premiums increase the incentives for informality, diminishing the influence of monetary policy. Fifth, large premiums also increase the arbitrage incentive for corruption, where those who have preferential access buy dollars at the official rate and sell at the parallel rate ("round-tripping"). Sixth, each of these implications damages the credibility of economic policy, which in turn further reinforces their negative effects. Schmitt-Grohé and Uribe (2023) discuss some of these factors and show that, despite the potential fiscal benefits of exchange controls, the policy reduces welfare by creating large relative price distortions that lead to sectoral misallocation of factor inputs and an underprovision of consumption goods. Other papers (see Alfaro, Chari, and Kanczuk, 2017, and Chari, Henry, and Reyes, 2021, for example) similarly discuss the adverse economic consequences of the capital controls that give rise to parallel markets.

Therefore, from an economic efficiency, if not political economy, perspective, it appears to be suboptimal to maintain an official rate alongside a large parallel premium. However, for countries that find themselves in this state, one major question is whether an official devaluation to unify the rates might lead to undesirably high inflation. One of the motivations for this paper is to quantify the extent to which such high inflation has already occurred due to pass-through from movements in the parallel rate.

2.3 Nigeria's Foreign Exchange Market

As discussed above, the unofficial nature of parallel markets has made it challenging to find high frequency data on its exchange rates. Nigeria, therefore, provides a useful setting, as its heavily controlled foreign exchange regime has given rise to a well-documented parallel market. It is also Africa's largest country by population, with over 200 million people, and largest economy, at official exchange rates (during the period of this study). Nigeria's foreign exchange market is managed by the Central Bank of Nigeria (CBN) and has a high degree of complexity. As of August 13, 2021, there were multiple official foreign exchange windows, as follows (IMF, 2022):

1. The CBN's official window, the Interbank Foreign Exchange Market (IFEM), is used primarily for monetization, government letters of credit transactions, and purchases of oil proceeds from oil and oil services companies.

2. The Investors & Exporter's (I&E) is used to provide liquidity to investors and exporters. It was part of the IFEM window until April 2017, when it was split out as a separate window in a partial devaluation of the official rate. From then, it became the de facto official rate for most private sector transactions.

3. The Invisibles window is for foreign exchange when traveling abroad (Personal Travel Allowance and Business Travel Allowance). The rate for this market is derived from the I&E window.

4. The Small and Medium Enterprise (SME) window is where the CBN intervenes to enable SMEs to pay for eligible imports up to $20,000 per customer per quarter. The rate for this market is also derived from the I&E window.

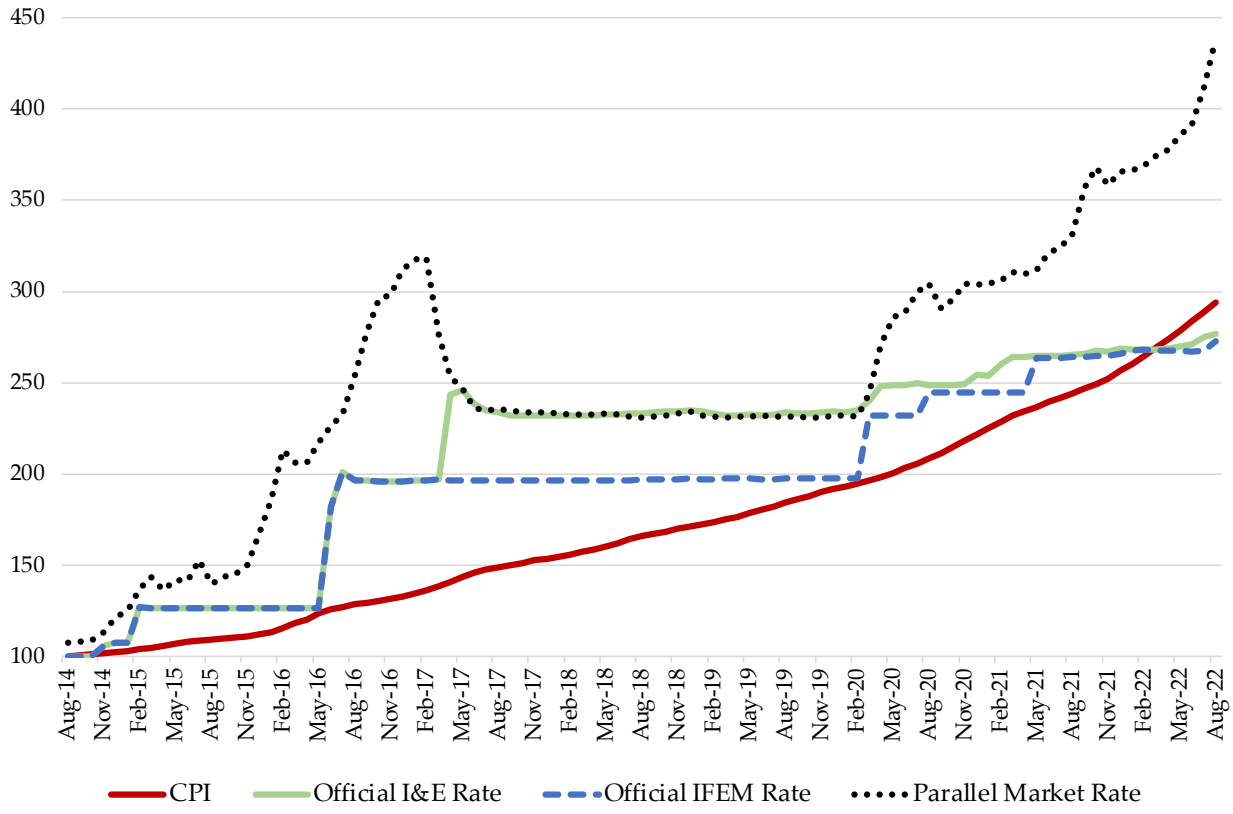
5. The Retail Secondary Market Intervention Sales (SMIS) window is where the CBN intervenes to auction foreign exchange to critical sectors. The wholesale SMIS window for banks was suspended in March 2020.

The CBN also imposed a range of foreign exchange restrictions, including prohibitions on access to its official windows for imports of over 40 categories of items. Even outside of these categories, the CBN would use its discretion to ration the limited supply of foreign exchange. This meant that many businesses and individuals struggled to access their required amounts of foreign currency. Such excess demand at the official rate gave rise to a large parallel market.

To give a sense of the scale of this parallel market, Figure 1 documents the Consumer Price Index (CPI), the official IFEM rate, the official I&E rate, and the parallel market

rate over this paper's sample period of August 2014 to August 2022. Throughout this paper, nominal bilateral dollar-to-naira exchange rates are used for both the official and parallel rates. Over this time, the parallel premium over the I&E rate averages 18%, with a maximum of 71% and two distinct periods exceeding 50%. The mere existence and online availability of high-frequency data on parallel market rates, discussed in Section 3.1, is further evidence of its significance in Nigeria's economy.

Figure 1: Consumer Price Inflation and Exchange Rate Movements



Notes: This figure plots the evolution of Nigeria's consumer prices, indexed at the August 2014 value, and multiple nominal bilateral dollar-to-naira exchange rates, indexed at the August 2014 value for the official IFEM rate. CPI is the aggregate consumer price index. As discussed in Section 2.3, the Investors & Exporters (I&E) rate was part of the Official IFEM window, until it was split out as a separate window in April 2017.

3 Empirical Framework

3.1 Data Description

Exchange rates: The uniqueness of this analysis is that it includes reliable, high-frequency records of the parallel market. From August 2014, there has been almost daily informa-

tion on the bilateral dollar-to-naira parallel market rate. Until March 2021, the source of this data is AbokiFX, a popular website used by the general public, which monitors the parallel rate based on surveys of foreign exchange dealers in the country. This is the longest time series of high frequency data available. In September 2021, the site suspended publication of parallel market rates online after being accused of "illegal activity that undermines the economy" by the Governor of the CBN. Therefore, from March 2021, we use an alternative dataset provided by a financial institution[2] that has tracked the parallel rate through surveys of foreign exchange dealers since early 2018. This daily data almost exactly matches that of AbokiFX during the period where both sources are available, providing confidence for the period after its suspension. We further cross-verify this series with data from daily online news articles on the parallel market. The CBN and FMDQ Group publish almost daily information on the official dollar-to-naira exchange rates. For each exchange rate, we use the mean of the bid-ask spread and aggregate the daily rates using a monthly mean, thus limiting the influence of outliers.

Consumer prices: Nigeria's National Bureau of Statistics (NBS) publishes information on aggregate-, sectoral- and State-level consumer price indices, as part of its monthly inflation report. For context, year-on-year inflation averages 14% over the sample period. In addition, we received access to some underlying raw data from the NBS on prices of over 700 goods in over 70 locations across the country from 2015 to 2021. Unfortunately, the consistency and comprehensiveness of this raw data is limited, which prevents its use for rigorous estimation purposes. Nevertheless, we still use the data to provide some high-level, qualitative insights in order to contextualize the sectoral-level results.

Household consumption: The NBS also provides detailed information on household expenditure for Nigerians across the country, as part of its National Living Standards Survey 2018/19 that was carried out in collaboration with the World Bank[3]. We use total household consumption per capita (as a proxy for wealth) to construct consumption baskets for each decile of the wealth distribution. In lower income countries, consumption is generally found to be a more reliable and accurate proxy for living standards than income; this is because many people are self-employed in agriculture or informal services, whereas the majority of people in higher income countries are wage earners (see Deaton, 2003 and Deaton, 2005 for a further discussion). World Bank (2020) describes in detail the aggregation process from individual household responses to a range of consumption aggregates across a variety of categories. Segmenting the data into deciles based on total consumption, we calculate the average percentage of consumption on each category for

[2]This institution has requested to remain anonymous.

[3]Full information about the survey can be found here:
https://microdata.worldbank.org/index.php/catalog/3827.

each decile. We then match these categories with the consumer price inflation sectors, to create decile specific price indices as follows:

$$p_{dt} = \sum_{i=c}^{C} w_{di}\, p_{it}, \tag{1}$$

where p_{dt} is a price index for decile d in month t, w_{di} is the percentage of total consumption expenditure for decile d on category i, and p_{it} is the corresponding sectoral price index that maps to category i in month t. The mapping of expenditure categories to sectoral price indices is outlined in Appendix Table A9. This combination enables me to construct decile-specific price indices, which are used to assess the impact of pass-through across the wealth distribution.

It is possible to match all sectors using these categories, apart from Communication, which is likely contained within Miscellaneous Goods & Services. Communication price movements are therefore excluded from our decile-specific price indices. Overall, these decile-specific price indices are only an approximation, due to the limited data on prices for individual goods, which necessitates matching at the category-level rather than the item level. It must also be noted that, when aggregated, our constructed price index differs slightly from the published aggregate consumer price index. This is because the NBS makes use of a different household consumption dataset to construct the consumption weights. Unfortunately we have been unable to gain access to the official consumption weights by decile; however, our aggregate results are robust to using our constructed index.

3.2 Estimating Pass-Through

Several studies use a standard distributed-lag regression to estimate exchange rate pass-through, as outlined in Burstein and Gopinath (2014):

$$\Delta p_t = \alpha + \sum_{k=0}^{18} \boldsymbol{\beta_k} \Delta e_{t-k} + \delta_t X_t + \epsilon_t, \tag{2}$$

where Δp_t is the log change in prices in month t, Δe_{t-k} is the log change in the nominal bilateral dollar-to-naira official rate in month $t-k$ and X_t is a vector of controls. Exchange rate pass-through (ERPT) is estimated as $\sum_{k=0}^{18} \boldsymbol{\beta_k}$.

Appendix Section A outlines a simple framework that explains how this specification understates the true pass-through impact when a parallel market exists. We therefore

specify a modified regression that takes this additional rate into account:

$$\Delta p_t = \alpha + \sum_{k=0}^{18} \boldsymbol{\gamma_k} \Delta e_{t-k} + \sum_{k=0}^{18} \boldsymbol{\theta_k} (\Delta b_{t-k} - \Delta e_{t-k}) + \delta_t X_t + \epsilon_t, \tag{3}$$

where Δb_{t-k} is the log change in the nominal bilateral dollar-to-naira parallel market exchange rate and $\Delta b_{t-k} - \Delta e_{t-k}$ is the log change in the parallel market premium at month $t-k$. ERPT is estimated as $\sum_{k=0}^{18} \boldsymbol{\gamma_k}$ for the official rate (assuming no change in premium) and $\sum_{k=0}^{18} \boldsymbol{\theta_k}$ for the parallel market premium. In cases where official rate movements entirely eliminate the premium, then ERPT is estimated as the difference: $\sum_{k=0}^{18} (\boldsymbol{\gamma_k} - \boldsymbol{\theta_k})$.

In our baseline regressions, we use the I&E rate as the official exchange rate. Based on central bank and market participant interviews, it is apparent that this rate is the de facto reference rate for many private sector transactions in the CBN's foreign exchange windows. It was also the same as the IFEM rate until April 2017, when it split out as a separate window. After April 2017, the IFEM rate was mainly only used for government- and oil-related transactions. However, for completeness, we show results using the IFEM official rate and using both official rates at the same time in Appendix Section B.

Because our sample is limited to eight years of available parallel market data, we can only robustly include a maximum of 18 lagged months compared to typical long-run ERPT estimates of up to two years (Burstein and Gopinath, 2014). As such, our estimates can be seen as a lower-bound on total long-run ERPT. We include three important controls in our regression. The 18-month log change in the money supply, M3 (from the CBN), accounts for the significant amount of central bank financing, both to the government (commonly referred to as "ways-and-means" financing) and the private sector; there was a 134% increase in M3 over the sample period. We also include the 18-month log change in global agricultural prices and the 6-month log change[4] in global fuel and energy prices (both using data from the IMF's Primary Commodity Price System) to control for global shocks that originate outside of Nigeria but affect major components of the country's consumption basket. Unfortunately, it is challenging to include other controls (such as GDP growth and producer prices) that are typically found in in standard pass-through regression, such as Burstein and Gopinath (2014); this is because many of these series are unavailable for Nigeria at a monthly level, and the limited sample and multiple exchange rates mean that the regression cannot be aggregated to the quarterly level.

The specifications in Equations (2) and (3) are applied to the aggregate consumer price indices, as well as to sectoral price indices and wealth-specific price indices, in order to

[4] A shorter lag-length is used because of higher frequency price fluctuations in fuel and energy markets.

empirically assess the importance of the parallel market in addressing the puzzle of low pass-through and to better understand how it affects different sectors and wealth groups.

It is clear that price and exchange rate movements are jointly determined, and therefore our specification is not immune to endogeneity concerns and must ultimately be interpreted as correlational. It is also possible that the channel of pass-through is related to the parallel market rate acting as an anchor for price-setting inflation expectations, as opposed to causing inflation through directly affecting the costs of production and trade. Nevertheless, our specification is an extension to similar work in the literature (e.g., Burstein and Gopinath, 2014) and builds on other papers that rely on a simple empirical framework with limited controls in order to comprehensively evaluate price changes following a devaluation (e.g., Burstein, Eichenbaum, and Rebelo, 2005, and Cravino and Levchenko, 2017). Appendix Section B also includes a discussion of alternative lag lengths and specifications, as well as cointegration, for robustness. In future versions of this paper, we would like to supplement these unconditional estimates of pass-through with conditional estimates, exploiting exogenous exchange rate movements (for example, exogenous appreciations/depreciations in the dollar, as in Fukui, Nakamura, and Steinsson, 2023).

4 Results

4.1 Aggregate Impact: To What Extent Does the Parallel Market Matter?

Table 1 outlines the aggregate results, demonstrating that ignoring the parallel rate understates true pass-through to inflation in this context. In each of the panels, columns (1) and (2) show results from regressions that only include the official rates. Here pass-through is estimated to be generally insignificant and slightly negative. By contrast, when the parallel premium is included in columns (3) and (4), both coefficients are positive and significant, although (insignificantly) larger for the parallel market premium. 18-month pass-through from movements in the parallel premium to aggregate retail prices is 0.35. This implies that, even before any official devaluation occurs, inflation has already been caused by movements in the parallel rate. This explains why, when analyzed in isolation, pass-through from the official rate appears to be much lower.

In columns (3) and (4), pass-through for the official rates is positive and significant, if there are no contemporaneous changes in the parallel premium[5]. That said, pass-through

[5]I.e., if the parallel market rate adjusts by the same amount as the official rates.

Table 1: Aggregate Exchange Rate Pass-Through (18 month lag-length)

	A. All Items			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.085	-0.118	0.225***	0.237***
	(0.058)	(0.079)	(0.049)	(0.041)
ERPT Parallel Premium			0.323***	0.347***
			(0.060)	(0.037)
Controls	No	Yes	No	Yes
Observations	78	78	78	78
R-Squared	0.352	0.524	0.891	0.928

	B. All Items (less Farm Produce)			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.094**	-0.135**	0.134***	0.119***
	(0.045)	(0.066)	(0.042)	(0.036)
ERPT Parallel Premium			0.270***	0.243***
			(0.054)	(0.039)
Controls	No	Yes	No	Yes
Observations	78	78	78	78
R-Squared	0.422	0.626	0.847	0.883

	C. All Items (less Farm Produce and Energy)			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.055	-0.091	0.154***	0.146***
	(0.043)	(0.067)	(0.045)	(0.043)
ERPT Parallel Premium			0.238***	0.215***
			(0.055)	(0.046)
Controls	No	Yes	No	Yes
Observations	78	78	78	78
R-Squared	0.274	0.460	0.765	0.801

Notes: This table reports cumulative exchange-rate pass-through estimates following 18 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (2) and (3), using the I&E official rate. Controls include the 18-month change in M3, the 18-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

inflation appears to be primarily driven by the parallel market, hence the (insignificantly) higher ERPT coefficients. In an extreme case where an official devaluation eliminates a parallel premium that has existed for enough time to fully transmit to inflation, then total ERPT from this official devaluation would be (insignificantly) negative[6]. In other words, all of the direct[7] positive pass-through from exchange rate movements to inflation will have already occurred. Appendix Section B provides further support to these results, by showing estimates with 12-month-lags (Appendix Table A1) and with the official IFEM rate, instead of the I&E rate (Appendix Tables A3 and A4). We also find similar results after excluding the period following the invasion of Ukraine, which led to a discontinuous rise in inflation and interest rates globally (Appendix Table A2). Furthermore, whilst only one official rate is used in the baseline regression, for ease of comparison and due to limited sample size, this may lead to some omitted variable bias. Appendix Tables A5 and A6 show 12-month-lag results that include both official rates (with 9-month- and 6-month-lag results for robustness in Appendix Tables A7 and A8), finding that the pass-through coefficients are even higher (0.49 12-month ERPT) than in Table 1. This indicates that our baseline result of 0.35 18-month parallel market pass-through could be a lower bound of the true effect. All of these results support the conclusion that, once an official devaluation actually occurs, much of the inflation has already happened. Therefore, prior work that fails to take into account existing parallel markets will generate artificially low estimates of true pass-through.

Compared to other countries, these estimates of ERPT to retail prices are higher, which is understandable given Nigeria's context. Across a sample of eight advanced economies, Burstein and Gopinath (2014) estimate two-year pass-through to tradeable CPI to be no more than 0.36, although much lower in certain countries. Auer, Burstein, and Lein (2021) estimate one-year pass-through to be less than 0.10 for retail prices in Switzerland. Emerging market and developing economies, however, are likely to experience more pass-through, due to a greater reliance on dollar invoicing. Based on a broader sample of 55 countries, Gopinath et al. (2020) find that countries invoicing more in dollars experience significantly higher pass-through into consumer prices. Lariau, El-Said, and Takebe (2016), for example, estimate long-run pass-through of 0.64 in Angola on a 10-year sample; they find insignificant pass-through in Nigeria on a 16-year sample, but do not take into account the parallel market. Albeit over different time periods, both of these findings are consistent with our results.

[6]This is the difference between the two estimates.

[7]In our regression, we control for changes in the money supply to take into account the potential indirect inflationary impacts of increased central bank financing (as discussed in Sections 1 and 3).

4.2 Impact Across Sectors: How Does Pass-Through Vary for Different Goods and Services?

Table 2 shows estimates of pass-through to different sectors within the consumer price index, revealing several insights that provide a greater understanding of the channels through which the parallel market operates. First, there is strong and robust pass-through from movements in the parallel premium across all the sectors of the economy, unlike for the official rate where there are some sectors with pass-through of limited significance. Second, across all sectors, the parallel premium has higher estimated pass-through than the official rate (significantly in many cases), indicating that initial pass-through from the parallel market prior to any delayed official devaluation is more important than pass-through after devaluation. Third, the strongest pass-through from both the official and parallel rates is for food, due to the fact that many items under this category are essential, tradeable and priced in dollars. Fourth, whilst each sector has both tradeable and non-tradeable components, there is generally greater pass-through to sectors with a greater tradeable component. Fifth, the sectors where the parallel premium has the highest difference in pass-through vis-à-vis the official rates tend to be those with regulated prices, such as subsidies for energy and duties on alcohol and tobacco.

Whilst the data limitations described in Section 3.1 make it challenging to provide a detailed explanation of the differences between sectors, it remains possible to use item-level regressions to contextualize the findings in Table 2 (for sectors where enough data is available). For *Food & Non-Alcoholic Beverages*, the impact of the parallel premium is highest for some forms of vegetable oils, coffee drinks, meat, vegetables, and fruit. For *Housing, Water, Electricity, Gas & Other Fuel*, parallel premium ERPT is large for certain building materials, gas, and charcoal, with large discrepancies with official rate ERPT for certain fuels that are subsidized. For *Furnishing & Household Equipment Maintenance*, there is high parallel premium pass-through for certain non-durable goods and some furniture items (especially mirrors). For *Transport*, there is high parallel premium pass-through for vehicles and vehicle parts. For *Clothing & Footwear*, clothing materials (rather than stitched clothing items) and accessories are most impacted by the parallel market. For *Education*, there is high parallel premium pass-through for private primary, secondary, and vocational school fees. For *Miscellaneous Goods & Services*, insurance and personal care are most impacted by the parallel market. For *Recreation & Culture*, there is high parallel premium pass-through for paper-based products. For *Communication*, pass-through is greatest for hardware, such as mobile phones. For *Alcoholic Beverages, Tobacco & Kola*, *Health*, and *Restaurants & Hotels*, data limitations prevent conclusions from being drawn.

Table 2: Sectoral Exchange Rate Pass-Through (18-month lag length)

		ERPT		
A. More Tradeable Goods and Services				
	CPI Weight	I&E Rate	Parallel Premium	Difference
Food & Non-Alcoholic Beverages	*52%*	0.370***	0.406***	0.036
		(0.067)	(0.055)	(0.067)
Housing, Water, Electricity, Gas & Other	*17%*	-0.023	0.307***	0.330***
		(0.041)	(0.029)	(0.038)
Transport	*7%*	0.171***	0.298***	0.127***
		(0.039)	(0.029)	(0.042)
Furnishing & Household Equipment Maintenance	*5%*	0.109***	0.212***	0.102***
		(0.031)	(0.021)	(0.028)
Clothing & Footwear	*8%*	0.134***	0.207***	0.072***
		(0.027)	(0.019)	(0.024)
Alcoholic Beverages, Tobacco & Kola	*1%*	-0.029	0.145***	0.174***
		(0.047)	(0.033)	(0.044)
B. Less Tradeable Goods and Services		ERPT		
		I&E Rate	Parallel Premium	Difference
Health	*3%*	0.212***	0.254***	0.042
		(0.035)	(0.024)	(0.035)
Miscellaneous Goods & Services	*2%*	0.102***	0.213***	0.111***
		(0.036)	(0.030)	(0.036)
Recreation & Culture	*1%*	0.079**	0.149***	0.069**
		(0.029)	(0.030)	(0.034)
Restaurants & Hotels	*1%*	0.098**	0.154***	0.056
		(0.040)	(0.025)	(0.034)
Education	*4%*	0.044	0.118***	0.074**
		(0.029)	(0.027)	(0.032)
Communication	*1%*	-0.026*	0.116***	0.142***
		(0.014)	(0.018)	(0.020)

Notes: This table reports cumulative exchange-rate pass-through estimates following 18 months of lags for Nigeria's sectoral consumer price indices, from OLS Equation (3), using the I&E official rate. Kola is a caffeine-containing nut that is a stimulant. Controls include the 18-month change in M3, the 18-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Furthermore, even for those sectors listed here with enough data, the impact on the specific items identified must be considered as only suggestive and not conclusive.

4.3 Impact Across the Wealth Distribution: Are the Poorest Differentially Affected?

The varying impact of official and parallel rate movements between sectors has implications for households across different segments of the income or wealth distribution. Cravino and Levchenko (2017) find that households in the poorest decile faced 1.48 to 1.62 times higher cost of living increases than those in the richest decile, two years after Mexico's 1994 devaluation. They decompose this differential effect into two parts: (i) an Across effect, where households across the income distribution consume different product categories (e.g., low-income households consume more food); and (ii) a Within effect, where within the same product category, households across the income distribution differ in the quality of goods that they consume. Given the limitations of the household survey and price data for Nigeria, it is only possible to explore the Across effect. Nonetheless, it remains informative to understand the extent to which the distributional impact is pronounced or mitigated by parallel pass-through prior to an official devaluation.

Table 3 outlines these results. Pass-through decreases monotonically across the wealth distribution for both the official rate and parallel premium[8]. For the official rate ERPT is 1.27 times higher for the poorest decile than the richest decile, whereas parallel ERPT is 1.09. This is consistent with 1.25 times for the Across effect in Cravino and Levchenko (2017) after two years. The largest driver of this decline in pass-through across the wealth distribution is driven by food, which constitutes a larger share of consumption for poorer households compared to richer households (Table 4), and is where both official and parallel pass-through are strongest. However, we also find that the distributional impact is stronger for the official rate than the parallel rate. This is primarily for two reasons, building on the results in Table 2. First, prices of food are much more sensitive to movements in the official rate than prices of other categories of goods. By contrast, the parallel rate has robust pass-through impact across all categories. Therefore, even though food price pass-through is highest, the disparity in ERPT between food and other categories is lower for the parallel rate than for the official rate. Secondly, housing and utilities (including energy) is the second largest category of expenditure and is increasing in wealth. This category experiences insignificant pass-through from the official rate (likely due to

[8]The coefficients are differ slightly from what is implied by the aggregate results in Table 1. Section 3.1 includes a discussion of why our constructed price indices might differ from the published indices. The regression controls also have a marginally different effect on each of the decile-specific indices.

Table 3: Exchange Rate Pass-Through Across Wealth Deciles (18-month lag length)

	ERPT	
	I&E Rate	Parallel Premium
Decile 1 (Bottom 10%)	0.243***	0.299***
	(0.046)	(0.050)
Decile 2	0.244***	0.297***
	(0.045)	(0.049)
Decile 3	0.242***	0.295***
	(0.044)	(0.049)
Decile 4	0.238***	0.293***
	(0.043)	(0.047)
Decile 5	0.234***	0.291***
	(0.041)	(0.047)
Decile 6	0.230***	0.289***
	(0.040)	(0.045)
Decile 7	0.225***	0.287***
	(0.038)	(0.044)
Decile 8	0.218***	0.285***
	(0.036)	(0.043)
Decile 9	0.209***	0.282***
	(0.033)	(0.041)
Decile 10 (Top 10%)	0.192***	0.274***
	(0.029)	(0.036)
Percentile 99 (Top 1%)	0.168***	0.264***
	(0.027)	(0.029)

Notes: This table reports cumulative exchange-rate pass-through estimates following 18 months of lags for Nigeria's decile-specific price indices, from OLS Equation (3), using the I&E official rate. Section 3.1 outlines the construction of these decile-specific price indices. Kola is a caffeine-containing nut that is a stimulant. Controls include the 18-month change in M3, the 18-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

subsidies), unlike for the parallel rate where pass-through is relatively high. This factor also causes a steeper decline in pass-through as wealth increases.

Table 4: Household Consumption

	Decile 1 *Bot. 10%*	Decile 5	Decile 10 *Top 10%*	Pctile 99 *Top 1%*	Mean
Food & Non-Alcoholic Beverages	58%	53%	34%	21%	48%
Housing, Water, Electricity, Gas & Other Fuel	9%	9%	13%	15%	10%
Health	8%	7%	6%	9%	7%
Restaurants & Hotels	6%	10%	15%	16%	11%
Clothing & Footwear	5%	4%	4%	4%	4%
Furnishing & Household Equipment Maintenance	5%	4%	4%	4%	4%
Education	3%	5%	6%	4%	6%
Miscellaneous Goods & Services	3%	4%	9%	17%	5%
Transport	2%	4%	6%	6%	4%
Alcoholic Beverages, Tobacco & Kola	0%	0%	0%	0%	0%
Recreation & Culture	0%	0%	1%	2%	1%

Notes: This table reports the breakdown of consumption across various sectors. It is based on consumption aggregate data from the Nigeria Living Standards Survey 2018/19, which is matched to the consumer price index sectoral categories (this differs from the older consumption weights used in the inflation basket, as discussed in Section 3.1). Communication is excluded, as it is likely contained within the category that relates to Miscellaneous Goods & Services.

These results, therefore, suggest that the robust impact of the parallel market across all consumption sectors mitigates some, but not all, of the distributional consequences of exchange rate movements found in Cravino and Levchenko (2017). As such, inflation caused by parallel market movements prior to official adjustments have a less unequal impact. It must also be noted that, within the highest-wealth decile, there is a large differ-

ence in pass-through between the top 1% and the remainder of the decile. The magnitude of this within-decile difference is greater than the magnitude of every other difference between deciles, for both official and parallel rate movements.

5 Implications and Conclusion

This paper emphasizes the importance of the parallel market in understanding exchange rate pass-through from official devaluations in emerging market and developing countries. It offers another partial explanation for the puzzle of low pass-through to retail prices: only taking into account the official rate will underestimate the true extent of pass-through. Burstein, Eichenbaum, and Rebelo (2005) and Burstein and Gopinath (2014) also discuss the disparity between import prices and retail prices of tradeable goods. Unfortunately, due to limited data on prices at the dock in Nigeria, we have been unable to explore how this relates to the parallel market. There also remain open questions on product-level pass-through and the geographic distribution of pass-through (Appendix Section C presents some initial findings for the latter), which could give insights into the interaction between the parallel market and local distribution costs.

Our results do provide evidence that, depending on how long it takes for the central bank to adjust the official rate, it is possible for all of the pass-through from exchange rate movements to be driven by the parallel rate alone. This empirically supports the critical assumption in Pinto (1988, 1989, 1991) and Morris (1995) that there is no direct pass-through from an official devaluation. Their framework suggests, therefore, that only fiscal considerations determine the inflationary impact of unifying the official and parallel rates. By having to export crude oil at a discounted official rate, Nigeria's government could have benefitted fiscally from such an adjustment. However, during the time period of this study, the government was also subsidizing the retail price of imported fuel products, which were therefore cheaper when using an artificially strong official rate. As such, without removing these subsidies, it is possible that unifying the rates would have increased the fiscal deficit and driven increased central bank financing of the budget.

Moreover, future work on parallel markets could be integrated into the growing literature on foreign exchange interventions and capital controls in the context of optimal policymaking, as in Schmitt-Grohé and Uribe (2023). Rey (2015) documents the importance of the global financial cycle, which she argues "transforms the trilemma [between independent monetary policy, free capital mobility, and floating exchange rates[9]] into a "dilemma" or an "irreconcilable duo": independent monetary policies are possible if and

[9]Obstfeld, Shambaugh, and Taylor (2005) provide a historical and empirical review of this trilemma.

only if the capital account is managed." Similar conclusions have been drawn in various other studies, highlighting limits to the effectiveness of monetary policy in mitigating the transmission of shocks through financial markets and presenting a range of potential benefits to capital controls (Farhi and Werning, 2016; Kalemli-Özcan, 2019; Basu et al., 2020; Adrian et al., 2020; Chari, Dilts Stedman, and Lundblad, 2021; Choi and Taylor, 2022; Itskhoki, 2022; Itskhoki and Mukhin, 2022; Chari, 2023). In non-advanced economy settings, however, the "optimal" use of foreign exchange intervention and capital controls might lead to the adverse consequence of creating parallel markets. Furthermore, in contexts where parallel markets already exist, any unification of rates will likely only be temporary if not accompanied by full liberalization of the foreign exchange market and a permanent removal of capital controls. It would thus be worthwhile to deepen and formalize our understanding of the relationship between parallel markets and various exchange rate policy instruments.

Indeed, more broadly, the phenomenon of parallel markets is likely to have increased in relevance for many countries, especially given the strengthening of the dollar during this period of global tightening and higher interest rates. Online platforms, such as the one used in this study, have made it easier to collect high quality data on the parallel market. A more comprehensive cross-country analysis of the parallel market would therefore be highly informative and provide a more comprehensive picture of exchange rate pass-through in emerging market and developing countries.

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Appendices

A Conceptual Framework

This section presents a simple conceptual framework that outlines the potential impact of parallel market exchange rate movements on inflation and provides additional context for our empirical analysis.

Abstracting away from the influence of domestic monetary policy, external shocks to prices, and inflation expectations, let inflation in a one-good economy[10] be determined by the following equation:

$$\Delta p_t = \gamma_j \Delta e_t + \gamma_{j-1} \Delta e_{t-1} + \theta_j (\Delta b_t - \Delta e_t) + \theta_{j-1} (\Delta b_{t-1} - \Delta e_{t-1}), \tag{A1}$$

where Δp_t is the change in prices in year t, Δe_t is the depreciation in the official exchange rate in year t, and Δb_t is the depreciation in the parallel market exchange rate in year t. $\Delta b_t - \Delta e_t$ is the change in the parallel market premium in year t.

For simplicity, assume that pass-through from exchange rate movements in year t only occurs in years t and $t+1$, consistent with the two-year pass-through examined in the literature (Burstein and Gopinath, 2014). Therefore, total pass-through is (i) $\gamma_j + \gamma_{j-1}$ for official rate movements in the absence of a parallel market premium, (ii) $\theta_j + \theta_{j-1}$ for parallel rate movements when the official rate is fixed and (iii) a linear combination of these parameters when both the official and parallel rates are in movement.

Case 1: There is no parallel market, and the central bank decides to devalue the official rate by $2D$ in year t (i.e., $\Delta e_t = 2D$). Assuming no change in prior or preceding years, it follows that:

$$\Delta p_t^* = 2\gamma_j D \quad \text{and} \quad \Delta p_{t+1}^* = 2\gamma_{j-1} D. \tag{A2}$$

Case 2: There is a parallel market, whose rate depreciates by D in both year $t-2$ and year $t-1$, before the central bank decides to devalue the official rate by $2D$ in year t (i.e., $\Delta b_{t-2} = D$, $\Delta b_{t-1} = D$, and $\Delta e_t = 2D$). In this case, a parallel premium of $2D$ builds up until the central bank decides to unify the two rates. Assuming no other official and parallel exchange rate movements, it follows that:

$$\Delta p_t^b = (2\gamma_j - 2\theta_j + \theta_{j-1}) D \quad \text{and} \quad \Delta p_{t+1}^b = (2\gamma_{j-1} - 2\theta_{j-1}) D. \tag{A3}$$

[10] This assumption is made for simplicity. A more comprehensive model could include some goods that are not sensitive to exchange rate movements.

Under reasonable assumptions[11], in years t and $t+1$ following the official devaluation, inflation is higher in Case 1 (with no parallel market) than in Case 2 (with a parallel market). But the critical reason for this is that, in Case 2, the parallel market causes inflation in periods $t-2$ and $t-1$ prior to the official devaluation: $\Delta p^b_{t-2} = \theta_j D$ and $\Delta p^b_{t-1} = (\theta_j + \theta_{j-1})D$. By comparison, there is no early inflation during these periods in Case 1: all of the inflation happens after the official devaluation.

This highlights the key implication of this paper. The inflationary impact of official exchange rate devaluations is lower in the presence of a parallel market, as movements in the parallel rate have already caused some inflation to occur[12]. Therefore, by only focusing on official devaluations and not taking into account the parallel market, estimates will systematically understate the total pass-through impact of exchange rate movements.

[11]This assumes that $2\theta_t > \theta_{t-1}$ and that all coefficients are positive.

[12]Viewed through another lens, the parallel market rate can be interpreted as a proxy for inflation expectations that drive price-setting behavior.

B Aggregate Impact: Robustness Checks

B.1 Using an Alternative Lag Length

Because of the limited sample size, it is not possible to robustly estimate pass-through over two years, as in Burstein and Gopinath (2014). Generating 24 lags reduces the available sample size to 72 months over which to estimate over 50 parameters, and also removes the major IFEM rate adjustment in June 2016 (see Figure 1). Even using 18 lags requires estimating around 40 parameters over 78 observations. To verify that the results in Table 1 are robust to alternative lag lengths, we therefore replicate the analysis using a 12-month lag length. Given that pass-through can impact prices with a lag, it is understandable that these estimates (Table A1) are generally lower than for 18-month pass-through (Table 1). However, the key conclusion remains that ignoring the parallel market understates true pass-through.

B.2 Excluding the Ukraine War Period

The time period of August 2014 to August 2022 included global shocks that led to a discontinuous rise in inflation and interest rates across the world. Given the sample size limitations, it is not possible to exlude Covid-19 as a robustness check. However, we are able to exclude the period following the invasion of Ukraine in February 2022. This has a limited impact on our pass-through estimates (Table A2) and does not affect the conclusion.

B.3 Using the Official IFEM Rate instead of the I&E Rate

As discussed in Section 3.2, we use the I&E rate, rather than the IFEM rate, as the official exchange rate in our analysis, as this is the de facto reference rate for many private sector transactions. Following their separation in April 2017, the official IFEM rate was only mainly used for government- and oil-related transactions. However, to check that this choice does not impact our results, we rerun our baseline regressions using the IFEM rate instead of the I&E rate. Tables A3 and A4 show that this modification does not affect the paper's conclusions. Interestingly, comparing Tables 1 and A3 shows that food is relatively more sensitive to movements in the IFEM rate than the I&E rate, despite not being eligible for the IFEM window (and for many food items, not even being eligible for the I&E window). That said, this estimate is not significantly different from that of the parallel premium.

Table A1: Aggregate Exchange Rate Pass-Through (12-month lag length)

	A. All Items			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.042	-0.149	0.139*	0.083
	(0.086)	(0.091)	(0.079)	(0.079)
ERPT Parallel Premium			0.230***	0.222***
			(0.055)	(0.042)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.137	0.378	0.599	0.656

	B. All Items (less Farm Produce)			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.083	-0.176**	0.076	-0.022
	(0.076)	(0.085)	(0.090)	(0.074)
ERPT Parallel Premium			0.161***	0.118***
			(0.056)	(0.040)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.252	0.472	0.540	0.636

	C. All Items (less Farm Produce and Energy)			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.038	-0.120	0.086	0.001
	(0.062)	(0.072)	(0.075)	(0.066)
ERPT Parallel Premium			0.142***	0.103***
			(0.049)	(0.035)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.134	0.372	0.460	0.555

Notes: This table reports cumulative exchange-rate pass-through estimates following 12 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (2) and (3), using the I&E official rate. Controls include the 12-month change in M3, the 12-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A2: Aggr. Exchange Rate Pass-Through, excl. Ukraine War (18-month lag length)

	A. All Items			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.062	-0.017	0.205***	0.281***
	(0.053)	(0.084)	(0.063)	(0.042)
ERPT Parallel Premium			0.269***	0.346***
			(0.051)	(0.042)
Controls	No	Yes	No	Yes
Observations	71	71	71	71
R-Squared	0.465	0.535	0.921	0.942

	B. All Items (less Farm Produce)			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.075*	-0.073	0.127***	0.118***
	(0.040)	(0.050)	(0.034)	(0.039)
ERPT Parallel Premium			0.217***	0.200***
			(0.021)	(0.027)
Controls	No	Yes	No	Yes
Observations	71	71	71	71
R-Squared	0.573	0.698	0.901	0.914

	C. All Items (less Farm Produce and Energy)			
	(1)	(2)	(3)	(4)
ERPT I&E Rate	-0.038	-0.025	0.154***	0.152***
	(0.037)	(0.047)	(0.038)	(0.048)
ERPT Parallel Premium			0.187***	0.168***
			(0.026)	(0.030)
Controls	No	Yes	No	Yes
Observations	71	71	71	71
R-Squared	0.402	0.528	0.818	0.840

Notes: This table reports cumulative exchange-rate pass-through estimates following 18 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (2) and (3), using the I&E official rate. This regression excludes observations from February 2022 onwards, after Russia's invasion of Ukraine. Controls include the 12-month change in M3, the 12-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A3: Aggregate Exchange Rate Pass-Through, IFEM Rate (18-month lag length)

	A. All Items			
	(1)	(2)	(3)	(4)
ERPT IFEM Rate	-0.033	-0.051	0.227***	0.307***
	(0.117)	(0.129)	(0.082)	(0.064)
ERPT Parallel Premium			0.268***	0.257***
			(0.091)	(0.065)
Controls	No	Yes	No	Yes
Observations	78	78	78	78
R-Squared	0.322	0.503	0.855	0.886

	B. All Items (less Farm Produce)			
	(1)	(2)	(3)	(4)
ERPT IFEM Rate	-0.070	-0.100	0.126**	0.145***
	(0.097)	(0.092)	(0.059)	(0.048)
ERPT Parallel Premium			0.263***	0.220***
			(0.079)	(0.051)
Controls	No	Yes	No	Yes
Observations	78	78	78	78
R-Squared	0.354	0.573	0.823	0.840

	C. All Items (less Farm Produce and Energy)			
	(1)	(2)	(3)	(4)
ERPT IFEM Rate	-0.026	-0.056	0.132**	0.149***
	(0.081)	(0.081)	(0.061)	(0.052)
ERPT Parallel Premium			0.224**	0.184***
			(0.085)	(0.062)
Controls	No	Yes	No	Yes
Observations	78	78	78	78
R-Squared	0.262	0.445	0.713	0.732

Notes: This table reports cumulative exchange-rate pass-through estimates following 18 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (2) and (3), using the IFEM official rate. Controls include the 18-month change in M3, the 18-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A4: Aggregate Exchange Rate Pass-Through, IFEM Rate (12-month lag length)

	A. All Items			
	(1)	(2)	(3)	(4)
ERPT IFEM Rate	0.038	-0.043	0.123**	0.142**
	(0.104)	(0.131)	(0.053)	(0.062)
ERPT Parallel Premium			0.301***	0.312***
			(0.066)	(0.048)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.134	0.276	0.699	0.749

	B. All Items (less Farm Produce)			
	(1)	(2)	(3)	(4)
ERPT IFEM Rate	-0.048	-0.137	0.045	0.025
	(0.088)	(0.102)	(0.063)	(0.060)
ERPT Parallel Premium			0.254***	0.230***
			(0.066)	(0.050)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.210	0.405	0.643	0.714

	C. All Items (less Farm Produce and Energy)			
	(1)	(2)	(3)	(4)
ERPT IFEM Rate	-0.008	-0.087	0.048	0.024
	(0.071)	(0.083)	(0.056)	(0.059)
ERPT Parallel Premium			0.211***	0.186***
			(0.060)	(0.046)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.125	0.329	0.523	0.591

Notes: This table reports cumulative exchange-rate pass-through estimates following 12 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (2) and (3), using the IFEM official rate. Controls include the 12-month change in M3, the 12-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

B.4 Using Both Major Official Rates

Furthermore, whilst only one official rate is used in the baseline regression, for ease of comparison and due to limited sample size, this may lead to some omitted variable bias. We therefore extend the regression framework outlined in Section 3.2, building on Equations (2) and (3) to include both major nominal bilateral dollar-to-naira official exchange rates, as follows:

$$\Delta p_t = \alpha + \sum_{k=0}^{12} \boldsymbol{\beta_k^{IFEM}} \Delta IFEM_{t-k} + \sum_{k=0}^{12} \boldsymbol{\beta_k^{IE}} \Delta IE_{t-k} + \delta_t X_t + \epsilon_t, \tag{A4}$$

and

$$\Delta p_t = \alpha + \sum_{k=0}^{12} \boldsymbol{\gamma_k^{IFEM}} \Delta IFEM_{t-k} + \sum_{k=0}^{12} \boldsymbol{\gamma_k^{IE}} \Delta IE_{t-k} + \sum_{k=0}^{12} \boldsymbol{\theta_k} (\Delta b_{t-k} - \Delta IE_{t-k}) + \delta_t X_t + \epsilon_t, \tag{A5}$$

where $\Delta IFEM_{t-k}$ is the log change in the central bank's IFEM rate and ΔIE_{t-k} is the log change in the central bank's I&E rate at month $t-k$. ERPT for the official rates (assuming no change in premium) is estimated as $\sum_{k=0}^{12} (\boldsymbol{\gamma_k^{IFEM}} + \boldsymbol{\gamma_k^{IE}})$, whereas ERPT for the parallel premium remains $\sum_{k=0}^{12} \boldsymbol{\theta_k}$. Similarly, in cases where official rate movements entirely eliminate the premium, total ERPT is $\sum_{k=0}^{12} (\boldsymbol{\gamma_k^{IFEM}} + \boldsymbol{\gamma_k^{IE}} - \boldsymbol{\theta_k})$.

The drawback is that this specification limits the available degrees of freedom, since it requires distributed lags for three variables. Given the limited time series of 97 months (August 2014 to August 2022) and the three exchange rate coefficients, increasing the lag length beyond 12 months is challenging, as it reduces the number of available time periods and increases the number of estimated parameters at a rate of 3-per-lag (from a baseline of over 40 parameters for 12 lags). However, Tables A5 and A6 show strong 12-month lag effects, with ERPT estimates for official and parallel rates of 0.43 and 0.49, respectively. This indicates that our baseline result of 0.35 18-month parallel market pass-through (Table 1) could be attenuated by omitted variable bias from only using one official (R^2 values are also much higher when both official rates are included). We also show that these findings are robust to shorter lag lengths: 9 months (Table A7) and 6 months (Table A8).

Table A5: Aggr. Exchange Rate Pass-Through, Two Official Rates (12-month lag length)

A. All Items				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.051	-0.124	0.321***	0.425***
	(0.115)	(0.128)	(0.051)	(0.085)
ERPT Parallel Premium			0.392***	0.485***
			(0.074)	(0.073)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.361	0.488	0.844	0.880
B. All Items (less Farm Produce)				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.099	-0.178	0.283***	0.327***
	(0.103)	(0.108)	(0.045)	(0.049)
ERPT Parallel Premium			0.393***	0.429***
			(0.055)	(0.053)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.336	0.521	0.870	0.896
C. All Items (less Farm Produce and Energy)				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.052	-0.118	0.264***	0.289***
	(0.089)	(0.093)	(0.045)	(0.045)
ERPT Parallel Premium			0.336***	0.356***
			(0.069)	(0.065)
Controls	No	Yes	No	Yes
Observations	84	84	84	84
R-Squared	0.232	0.412	0.789	0.810

Notes: This table reports cumulative exchange-rate pass-through estimates following 12 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (A4) and (A5). Controls include the 12-month change in M3, the 12-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A6: Sectoral Exchange Rate Pass-Through, Two Official Rates (12-month lag length)

		ERPT		
A. More Tradeable Goods and Services				
	CPI Weight	Official Rates	Parallel Premium	Difference
Food & Non-Alcoholic Beverages	*52%*	0.521***	0.470***	0.051
		(0.117)	(0.100)	(0.131)
Housing, Water, Electricity, Gas & Other	*17%*	0.399***	0.623***	-0.224**
		(0.110)	(0.077)	(0.090)
Clothing & Footwear	*8%*	0.264***	0.405***	-0.141***
		(0.036)	(0.032)	(0.040)
Transport	*7%*	0.249***	0.475***	-0.227***
		(0.046)	(0.065)	(0.072)
Furnishing & Household Equipment Maintenance	*5%*	0.284***	0.441***	-0.157***
		(0.038)	(0.045)	(0.039)
Alcoholic Beverages, Tobacco & Kola	*1%*	0.098*	0.366***	-0.268***
		(0.048)	(0.063)	(0.085)
B. Less Tradeable Goods and Services				
		ERPT		
	CPI Weight	Official Rates	Parallel Premium	Difference
Education	*4%*	0.220***	0.313***	-0.093
		(0.037)	(0.053)	(0.073)
Health	*3%*	0.256***	0.355***	-0.099
		(0.039)	(0.056)	(0.060)
Miscellaneous Goods & Services	*2%*	0.179***	0.368***	-0.190***
		(0.048)	(0.060)	(0.069)
Recreation & Culture	*1%*	0.171***	0.323***	-0.152**
		(0.030)	(0.056)	(0.063)
Restaurants & Hotels	*1%*	0.112**	0.303***	-0.190***
		(0.050)	(0.063)	(0.067)
Communication	*1%*	-0.013	0.122***	-0.135***
		(0.020)	(0.041)	(0.039)

Notes: This table reports cumulative exchange-rate pass-through estimates following 12 months of lags for Nigeria's sectoral consumer price indices, from OLS Equation (A5). Kola is a caffeine-containing nut that is a stimulant. Controls include the 12-month change in M3, the 12-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A7: Aggr. Exchange Rate Pass-Through, Two Official Rates (9-month lag length)

A. All Items				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.046	-0.134	0.247***	0.277***
	(0.097)	(0.110)	(0.038)	(0.065)
ERPT Parallel Premium			0.433***	0.456***
			(0.049)	(0.060)
Controls	No	Yes	No	Yes
Observations	87	87	87	87
R-Squared	0.238	0.414	0.761	0.763
B. All Items (less Farm Produce)				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.094	-0.180*	0.184***	0.201***
	(0.092)	(0.101)	(0.045)	(0.066)
ERPT Parallel Premium			0.396***	0.409***
			(0.065)	(0.079)
Controls	No	Yes	No	Yes
Observations	87	87	87	87
R-Squared	0.216	0.404	0.745	0.756
C. All Items (less Farm Produce and Energy)				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.044	-0.114	0.180***	0.175***
	(0.070)	(0.080)	(0.040)	(0.053)
ERPT Parallel Premium			0.322***	0.312***
			(0.061)	(0.066)
Controls	No	Yes	No	Yes
Observations	87	87	87	87
R-Squared	0.165	0.364	0.630	0.645

Notes: This table reports cumulative exchange-rate pass-through estimates following 9 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (A4) and (A5). Controls include the 9-month change in M3, the 9-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A8: Aggr. Exchange Rate Pass-Through, Two Official Rates (6-month lag length)

A. All Items				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.030	-0.075	0.156***	0.113**
	(0.052)	(0.050)	(0.030)	(0.046)
ERPT Parallel Premium			0.258***	0.218***
			(0.043)	(0.046)
Controls	No	Yes	No	Yes
Observations	90	90	90	90
R-Squared	0.144	0.406	0.592	0.644
B. All Items (less Farm Produce)				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.034	-0.072	0.132***	0.101***
	(0.053)	(0.056)	(0.029)	(0.035)
ERPT Parallel Premium			0.222***	0.190***
			(0.045)	(0.043)
Controls	No	Yes	No	Yes
Observations	90	90	90	90
R-Squared	0.140	0.328	0.555	0.597
C. All Items (less Farm Produce and Energy)				
	(1)	(2)	(3)	(4)
ERPT Official Rates	-0.016	-0.045	0.118***	0.098***
	(0.038)	(0.041)	(0.025)	(0.033)
ERPT Parallel Premium			0.184***	0.162***
			(0.038)	(0.040)
Controls	No	Yes	No	Yes
Observations	90	90	90	90
R-Squared	0.115	0.287	0.462	0.500

Notes: This table reports cumulative exchange-rate pass-through estimates following 6 months of lags for Nigeria's aggregate consumer price indices, from OLS Equations (A4) and (A5). Controls include the 6-month change in M3, the 6-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE) are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

B.5 Using a Vector Error Correction Model

An alternative to the dynamic lag regression would be to estimate a vector error correction model (VECM), as in Burstein and Gopinath (2014) and Lariau, El-Said, and Takebe (2016), for example. This would be specified as follows:

$$\Delta \mathbf{y}_t = A\left(B\mathbf{y}_{t-1} + \alpha\right) + \sum_{k=0}^{n} \Delta \mathbf{y}_{t-k} + \delta + \epsilon_t, \tag{A6}$$

where $\mathbf{y}$ is a four-dimensional VECM in the log consumer price index, log IFEM rate, log I&E rate and log parallel rate. The lag length, n, is determined by the Schwarz-Bayesian Information Criterion. Whilst the Johansen test for cointegration indicates a rank of 1, the 8-year time period is too short to assess long-run relationships, especially as full adjustments following exchange rate movements can take multiple years. As a result of this, the VECM results are very sensitive to the inclusion of time trends and other variables. Moreover, to an approximation, the official IFEM rate is just a smoother version of the official I&E rate, which is just a smoother version of the parallel market rate. This makes it difficult to disentangle their relative long-run effects. The parallel premium could be used instead, but this presents a further complication as it is $I(0)$ whereas the official rates and prices are $I(1)$. Additionally, to ensure comparability across sectors, cointegration would have to hold not just at the aggregate level but also across each of the sectoral price indices. Following Burstein and Gopinath (2014), who also find unstable results using VECMs (despite a longer time period and only one exchange rate), these results are not reported.

C Geographic Impact: How Does Pass-Through Vary Across States?

There is likely to be a geographic dimension to pass-through, especially given the importance of local distribution costs (Burstein, Eichenbaum, and Rebelo, 2005) that may affect sensitivity to exchange rate movements. Cravino and Levchenko (2018) also explore the geographic spread of Mexico's 1994 devaluation, focusing both on differences in prices and in consumption baskets across the country.

Before exploring the impact of official and parallel market pass-through across Nigeria's States, Figure A1 provides some context on the country's geography. Only the southern border is coastal (the Atlantic Ocean), which means that it hosts all of the country's

shipping entry ports. Trade, official and unofficial, does also occur over the northern, eastern and western land borders, with some international goods shipped to ports to the west of Nigeria and then smuggled across the borders into the country.

Figures A2 and A3 illustrate the geographic distribution of pass-through (insignificant estimates are coded as zero), using State-level price indices for all items and food only, respectively. Theory might suggest that the prices of goods in more inland areas of the country would be less sensitive to exchange rate movements due to a larger component of local distribution costs. This pattern is not immediately obvious in the data, although pass-through appears to be strongest in some States towards the western border. It also appears that significant parallel rate pass-through is not ubiquitous across all States in the country, even though this is the case for all economic sectors (Table 2). Further analysis and more detailed data would be required to decompose these effects further and more convincingly explain these trends.

Figure A1: Map of Nigeria

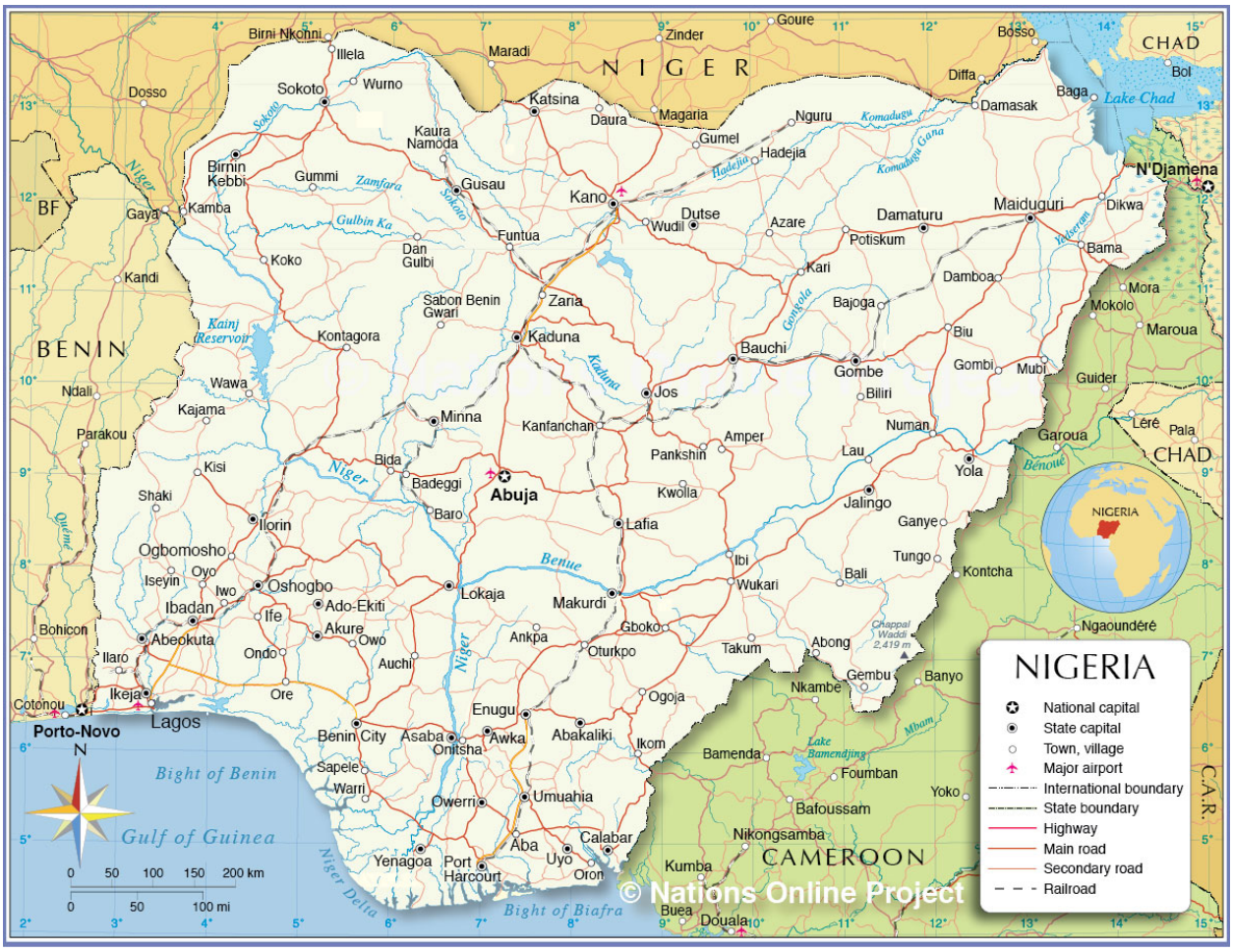
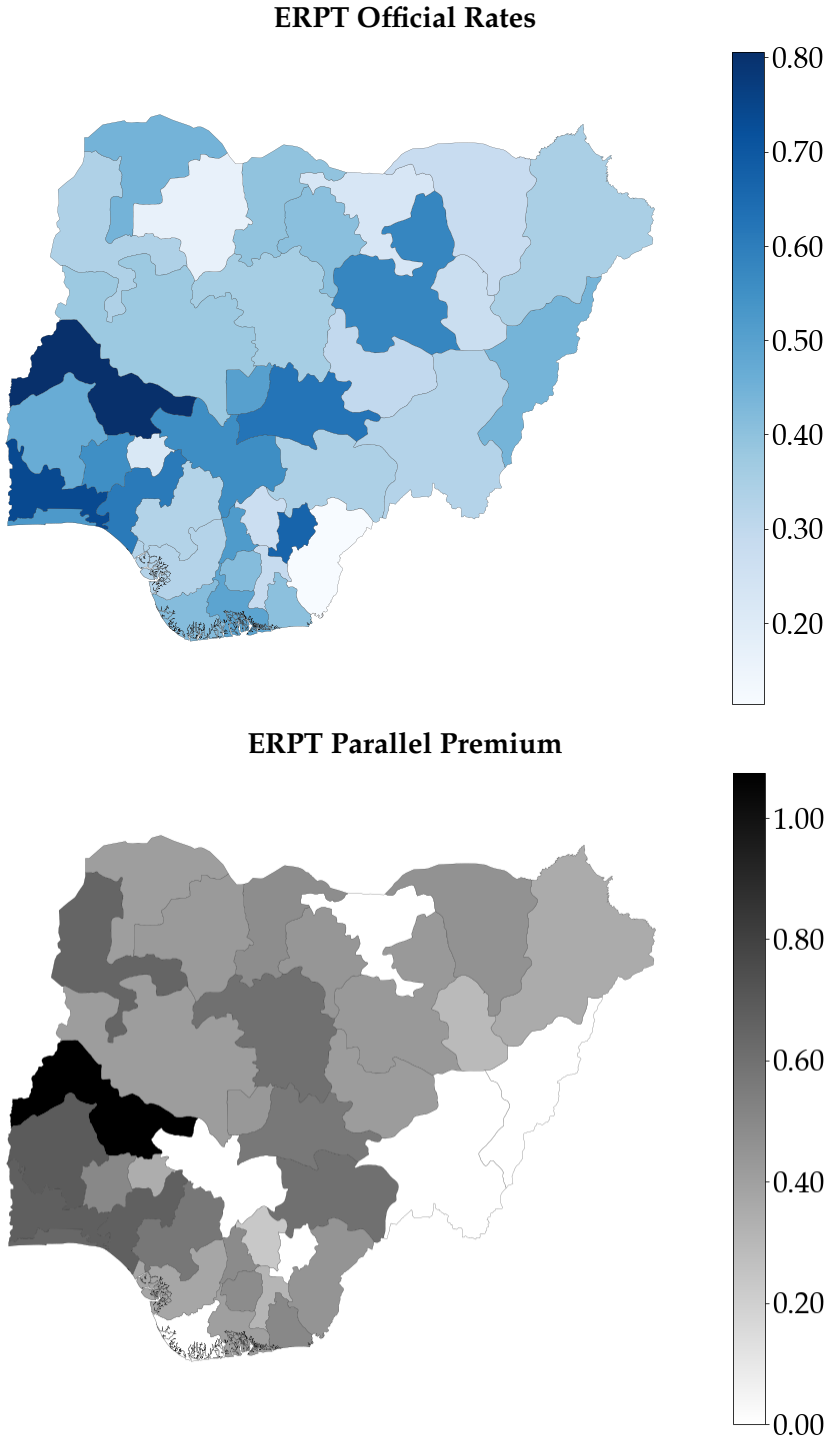
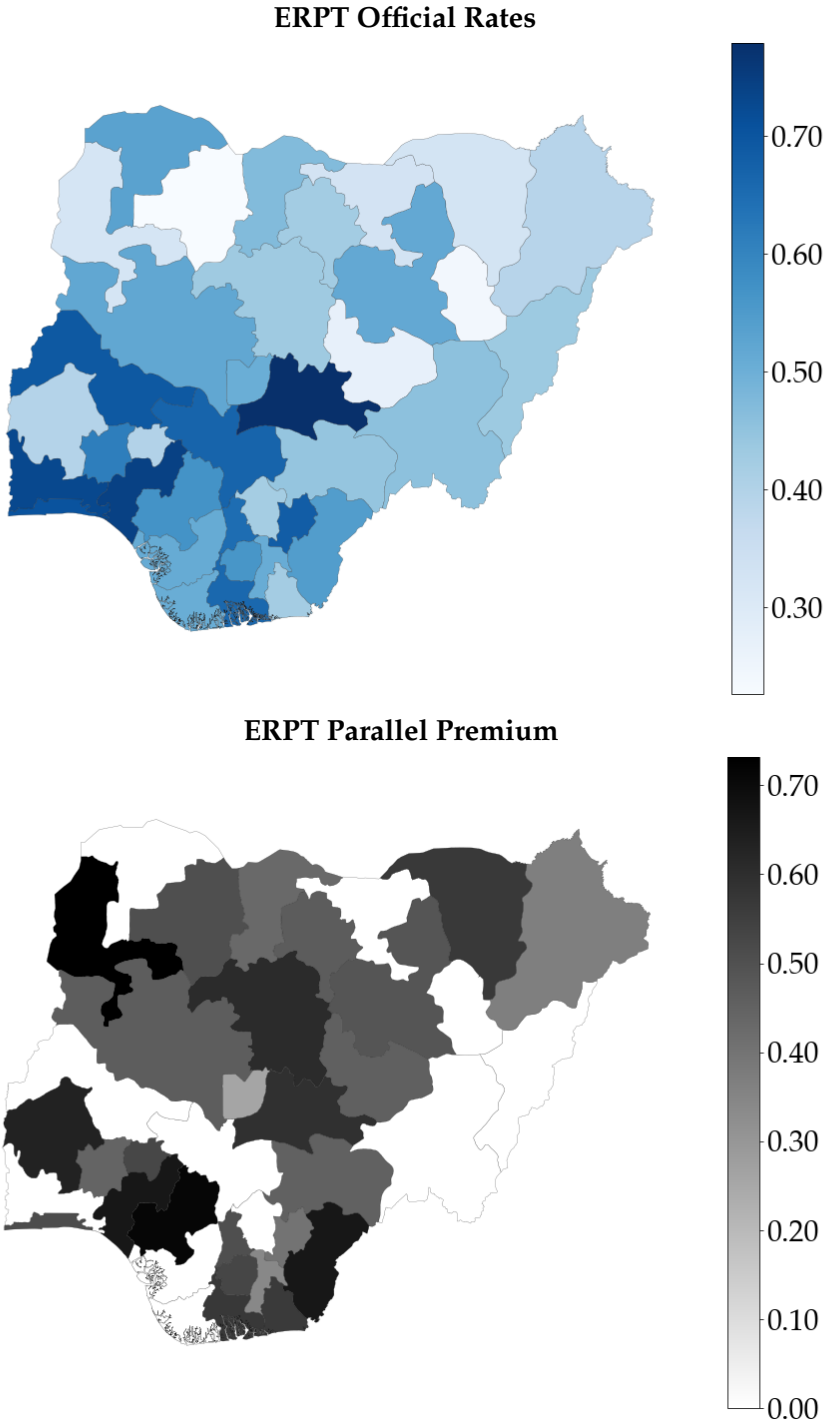


Figure A2: Exchange Rate Pass-Through by State (All Items)



Notes: These figures report cumulative exchange-rate pass-through estimates following 12 months of lags for Nigeria's State-level consumer price indices, from OLS Equation (A5). Insignificant values are coded as 0. Controls include the 12-month change in M3, the 12-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE), used for inference, are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4.

Figure A3: Exchange Rate Pass-Through by State (Food Only)



Notes: These figures report cumulative exchange-rate pass-through estimates following 12 months of lags for Nigeria's State-level consumer food price indices, from OLS Equation (A5). Insignificant values are coded as 0. Controls include the 12-month change in M3, the 12-month change in global agricultural prices, and the 6-month change in global fuel and energy prices, as well as a dummy for the time period following the introduction of the I&E official rate. Standard errors (SE), used for inference, are calculated using the Newey-West (1987) HAC estimator with a bandwidth of 4.

D Additional Table

Table A9: Matching the Consumer Price Index and Household Consumption Survey

Consumer Price Index Sector	**Household Consumption Expenditure Categories**
Food & Non-Alcoholic Beverages	Food from self-production or received as a gift (18 different groups); Food purchased (18 different groups)
Housing, Water, Electricity, Gas & Other Fuel	Fuel; Electricity; Petrol; Rent/housing expenditures
Health	Healthcare consultations and drugs; Hospitalization
Restaurants & Hotels	Food consumed outside of home
Clothing & Footwear	Clothing; Footwear
Furnishing & Household Equipment Maint.	Household nonfood items
Education	School Tuition; Other education related goods and services
Miscellaneous Goods & Services	Personal Services
Transport	Transport and other fares
Alcoholic Beverages, Tobacco & Kola	Alcoholic drinks from self-production or received as a gift; Alcoholic drinks purchased
Recreation & Culture	Entertainment
Communication	-

Notes: This table reports the matching of categories between the Consumer Price Index and the aggregated National Living Standards Survey 2018/19, as discussed in Section 3.2.